MARYLAND
GEOLOGICAL
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MARYLAND GEOLOGICAL SURVEY

VOLUME TWO

MARYLAND

GEOLOGICAL SURVEY

VOLUME TWO

BALTIMORE
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1898

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ALSO WITH THE COÖPERATION OF

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F. H. NEWELL, ...

CHIEF OF DIVISION OF HYDROGRAPHY, U. S. GEOLOGICAL SURVEY.

MILTON WHITNEY, ...

CHIEF OF DIVISION OF SOILS, U. S. DEPARTMENT OF AGRICULTURE.

LETTER OF TRANSMITTAL.

To His Excellency Lloyd Lowndes,

Governor of Maryland and President of the Geological Survey Commission.

Sir:—I have the honor to present herewith the second volume of the reports of the Maryland Geological Survey. The several scientific articles dealing with subjects of economic and historical interest add largely to existing knowledge along these various lines. I feel confident that the information contained in the volume will prove of substantial value to the people of the state.

Very respectfully,

William Bullock Clark,

State Geologist.

Johns Hopkins University,
Baltimore, *October, 1898.*

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PREFACE

The second volume of Survey reports contains additional information regarding the physical features of the state of Maryland. The subjects here discussed were treated in a preliminary manner in the first volume, but their more exhaustive study renders possible the fuller discussion of the present report.

The *Administrative Report*, by Wm. Bullock Clark, comprises Part I of the volume, and is given up to a summary of the operations of the Survey during 1896 and 1897. To this is appended an account of the additional legislation enacted by the last General Assembly under which the bureau has since been operating.

The *Report on the Building and Decorative Stones of Maryland*, by George P. Merrill and Edward B. Mathews, forming Part II of the volume, embraces a full account of one of the most important of our mineral industries. Professor Merrill, who is in charge of the Department of Geology of the U. S. National Museum, is the recognized authority on American building-stones. It should be a source of much satisfaction to the people of the state that Professor Merrill has consented to supervise the study of our building stones and has prepared for the report a discussion of The Physical, Chemical and Economical Properties of Building Stones. This chapter cannot fail to be of much value to our quarriers and contractors. The more detailed study, presented in An Account of the Character and Distribution of Maryland Building Stones, together with a History of the Quarrying Industry, has been admirably prepared by Dr. Mathews, who has carefully investigated the subject both in the field and in the laboratory.

The *Report on the Cartography of Maryland*, by Henry Gannett and Edward B. Mathews, constituting Part III of the volume, is divided into chapters on the Aims and Methods of Cartography, by Mr. Gannett, and on the Maps and Map-makers of Maryland, by Dr.

Mathews. Mr. Gannett was for many years the Chief of Division of Topography of the U. S. Geological Survey, and is to-day the Geographer of that bureau. He has had great experience in cartographic matters, and his report will be of much value to those who are desirous of employing intelligently the topographic maps now under construction in Maryland. The report comprises a complete digest of topographic methods, which will serve as a valuable treatise for the engineers of the state contemplating topographic surveying. Much of this report was published by Mr. Gannett a few years ago as Monograph XXII of the U. S. Geological Survey. It was prepared in its present form by the author with a view to its publication as a text-book, but has instead been kindly placed at the disposal of the Maryland Geological Survey. To the student of Maryland history Dr. Mathews' chapter on the Maps and Map-makers of Maryland will have peculiar interest, while a knowledge of our leading maps cannot fail to be of value to every citizen of the state. The study of the early maps reveals many interesting facts regarding the physiographic changes which have occurred in historic time along the Chesapeake and Atlantic coast-line.

The illustrations contained in this volume have been secured from many sources. The Survey especially desires to thank the officials of the several railroad companies of the state for the liberal offers of photographs and other illustrations. The Pennsylvania, Baltimore and Ohio, Western Maryland, Cumberland Valley and West Virginia Central roads have been especially helpful in this matter.

The U. S. Geological Survey has permitted the use of transfers from several of its topographic atlas sheets, as well as the publication, for the first time, of the Frostburg sheet as a base for illustrating the diagrams of triangulation and control. The plates and figures used by Mr. Gannett in his report were also secured from the same source.

Several of the commercial houses, dealing in building-stone machinery, have been particularly generous in allowing the use of their private plates, notably the Ingersoll-Sargeant Drill Company of New York, the American Hoist and Derrick Company of St. Paul, Minnesota, the Lincoln Iron Works and the Wardwell Steam Channelling Company of Rutland, Vermont.

Other illustrations of much value have been secured from Dr. Harry Fielding Reid, Mr. A. B. Hoen, Dr. E. B. Mathews, Dr. E. Oliver Belt, Dr. Cleveland Abbe, Jr., Dr. G. O. Smith, Mr. A. Bibbins, McClanahan & Brother Granite Company, Riehlè Brothers of Philadelphia, and Beaver Dam Quarry Company. Houghton, Mifflin & Company of Boston, and Harper Brothers of New York, have kindly allowed the reproduction of several illustrations from their publications as indicated on the cuts employed.

Dr. Wm. Hand Browne has carefully reviewed the chapter by Dr. Mathews upon the Maps and Map-makers of Maryland, which sufficiently assures the historical accuracy of the statements therein contained.

Particular attention should be called to the extensive coöperation granted to the Maryland Geological Survey by the Director of the U. S. Geological Survey, Hon. Charles D. Walcott. The active support which has thus been given since the organization of the State Survey along nearly every line has largely increased the efficiency of the local bureau and has been of great service in the preparation of the present report.

PART I

ADMINISTRATIVE REPORT

CONTAINING AN ACCOUNT OF THE

OPERATIONS OF THE SURVEY DURING 1896 AND 1897

AND

ADDITIONAL LEGISLATION

THE HELIOTYPE PRINTING CO. BOSTON

THE POTOMAC RIVER, NEAR CHERRY RUN.

AT THE JUNCTION OF THE WESTERN MARYLAND AND BALTIMORE & OHIO RAILROADS.

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ADMINISTRATIVE REPORT

CONTAINING AN ACCOUNT OF THE

OPERATIONS OF THE SURVEY DURING 1896 AND 1897

AND

ADDITIONAL LEGISLATION.

Introduction.

The great diversity in the natural features of the state of Maryland opens up many interesting fields of investigation in geology and its allied branches, the results of the study of which cannot fail to be of lasting value to the people of the state. With the large number of subjects presented, it has been somewhat difficult to determine the order in which the several investigations should be undertaken. Many things have tended to influence the decision of the Survey in this matter, among others, the existence of topographic maps to serve as a base for the work, time and money necessary to complete the particular investigation and the amount of available knowledge of the subject as the result of earlier study. The final selection has been made only after a reconnoissance of the entire state, preparatory to the detailed work of the Survey which is now well under way.

It was also found advisable from economic considerations to project those lines of investigation which might, on account of their interdependence, be contemporaneously conducted. By this method less rapid publication of the results of the work will be possible in the earlier days of the Survey than later on, but the results obtained will be less liable to modification by subsequent discoveries. The geological investigations have not been confined to any one section of Maryland, but work has been started in widely separated counties in order that the Survey might be in a position to give at least preliminary information in regard to the varied mineral products of the state.

It has been found essential to the proper interpretation of the geological problems presented to devote much attention to the construction of topographic maps and to the conduct of magnetic observations, while many other subjects, particularly those of physiography, hydrography, and agricultural soils are so closely related to the primary object of the Survey as to require careful consideration.

Much has been accomplished as the result of the work of the first two years, and the Survey is to-day in a position to make much more rapid advance in the future. New lines of investigation are presented as the results of the observations already made, and the opportunities are excellent for securing still more valuable results in the immediate future.

Operations of the Survey during 1896.

The organization of the Survey upon March 25, 1896, prior to the adjournment of the Legislature which had made provision for it, rendered it possible for the State Geologist and his corps of assistants to take advantage of the entire field season of 1896. Plans were early formulated for the work, both by the selection of an independent corps of trained geologists and by the perfection of a plan of coöperation with those state and national bureaus, whose work is closely related to that of the State Survey.

The rooms granted, free of all charges, by the Johns Hopkins University in its front building on Howard Street, readily accessible to the public, were immediately made ready for occupancy and properly equipped with the apparatus necessary for conducting the operations of the Survey. It was possible from the beginning for the Survey to avail itself of the geological equipment—collections, books, maps and apparatus—which belonged to the Johns Hopkins University, so that a very small outlay was made necessary in this direction. The various lines of investigation undertaken during the season of 1896 may be considered under the following heads:

TOPOGRAPHIC WORK.

The topographic work was carried on almost entirely at the expense and by the engineering staff of the U. S. Geological Survey as the result of a plan of coöperation which was early effected. The National Survey had, during several seasons since 1883, conducted a greater or less amount of topographic work within the limits of the state of Maryland, but it was not until the State Survey was organized and showed the necessity of expediting the work that the U. S. Geological Survey aggressively took up the matter.

During the season of 1896 complete surveys, based on earlier triangulation, were made of portions of Cecil, Kent, Queen Anne's and Caroline counties, covering an area of about 650 square miles. The work in Cecil county, north of 39° 30′, was done in a form to admit of publication upon the scale of one mile to the inch (1:62500), and will comprise the Elkton sheet of the Geologic Atlas of the United States. The remainder of the district south of 39° 30′ was surveyed for publication upon the scale of two miles to the inch (1:125000), and will be embraced within the limits of the Dover sheet. The survey was carried on under the direction of Mr. H. M. Wilson, Chief of the Atlantic Division of Topography of the U. S. Geological Survey. The field-work was done under the immediate charge of Mr. H. S. Wallace and Mr. J. W. Thom.

MAGNETIC WORK.

The magnetic work of the Survey was commenced during the summer of 1896, the direction of the observations being placed in charge of Dr. L. A. Bauer, who had previously been a member of the staff of the U. S. Coast and Geodetic Survey. The successful prosecution of this department of the Survey was largely rendered possible by the loan of the valuable magnetic instruments in the possession of the U. S. Coast and Geodetic Survey. They were secured for the state of Maryland through the courtesy of the Secretary of the Treasury and the Superintendent of the U. S. Coast and Geodetic Survey.

Linden, Montgomery county, the temporary home of Dr. Bauer, was selected as the base station for the magnetic survey. This station had the advantage of being situated in the centre of the area over which the observations were to be made, and was also within a few miles of the Washington Magnetic Observatory and the U. S. Coast and Geodetic Survey office. It was planned to establish one, and, where possible, two magnetic stations in each of the twenty-three counties of the state. By December, forty-six localities had been occupied, the declination having been observed at thirty-eight stations, the inclination at forty-six stations, the horizontal component at thirty-nine stations, while these various elements were observed at the base station on fourteen different days during the period. Six of these localities had been previously occupied by the U. S. Coast and Geodetic Survey. The average air-line distance between the stations thus established averaged between twenty and twenty-five miles. The full distance traveled by Dr. Bauer with his instrumental outfit in the accomplishment of this work aggregated 2000 miles.

Another phase of the magnetic work was the establishment of meridian lines by coöperation with the County Commissioners at the several county seats. An act of the General Assembly passed at the session of 1870 and codified in 1888, authorizes the County Commissioners to establish at their county seats true meridian lines at the expense of the several counties. The cost to the Survey for each meridian line established and properly marked with granite posts and discs was estimated to be about $100. Each county was asked to coöperate to the extent of $50. During 1896 but two counties, Frederick (Frederick) and Wicomico (Salisbury) actually availed themselves of the opportunity offered, although most of them took the matter up for consideration and nine more as a result ordered the Survey to run the lines the following year.

GEOLOGICAL WORK.

The geological work of the Survey will be considered under the three following heads, viz., preliminary work, areal work and economic work.

Preliminary Work.

Immediately upon the organization of the bureau a preliminary survey of the state was started in order that some information concerning all of the counties might be available to those making inquiries regarding the geology and mineral resourses of Maryland. The state was divided into convenient divisions, a geologist with one or more assistants being assigned to a section composed of several counties, in which the geological conditions were more or less similar. In this way every county was visited and information secured regarding each industry that had to do with the mineral wealth of the state. A large comparative collection of minerals, rocks and fossils was secured that has proved of much importance in the subsequent work of the Survey. The intimate knowledge also obtained regarding each mine, quarry and pit has likewise been of great value. This work was participated in by nearly all the members of the Survey, and was conducted under the immediate personal supervision of the State Geologist.

Areal Work.

Detailed investigations of several of the many geological formations found represented within the state were started before the close of the first field season.

The State Geologist was directly employed in a detailed study of the character and distribution of the Cretaceous formations of the eastern and southern counties in conjunction with Messrs. R. M. Bagg, A. Bibbins, and G. B. Shattuck. Dr. Bagg mapped provisionally the distribution of the Upper Cretaceous formations in Kent and Anne Arundel counties, and Mr. Bibbins was engaged for a portion of the summer in a reconnoissance survey of the Lower Cretaceous deposits in Anne Arundel county.

The coöperation of Professors W J McGee of Washington, and R. D. Salisbury of Chicago, was secured for a few weeks in a comparative study of the late Neocene and Pleistocene formations of eastern and southern Maryland. The Board of Public Works of the state put the steamer Governor Thomas at the disposal of the party of geologists, which included, in addition to the gentlemen above mentioned, the State Geologist, and Messrs. Bagg, Shattuck and Abbe. The leading estuaries of the eastern shore of the Chesapeake Bay from North East river to Pocomoke sound were visited, as well as the Patuxent river on the western side of the bay. The results of the eight-day trip were highly significant in bringing out many facts regarding these obscure formations which will be of value in their more detailed investigation later.

Mr. Cleveland Abbe, Jr., spent several weeks in a study of the physiography of the central and lower eastern counties during June and July, before proceeding to the central counties later in the season.

Dr. E. B. Mathews began a study of the several types of crystalline rocks in the Piedmont Plateau area of Cecil county, and traced their distribution southwestward into Harford county. He had as assistants Messrs. C. R. Dirickson and G. W. Merritt. Some work was also done by Professor J. A. Mitchell of Mt. St. Mary's College, Emmitsburg, upon the Triassic rocks of the Frederick valley.

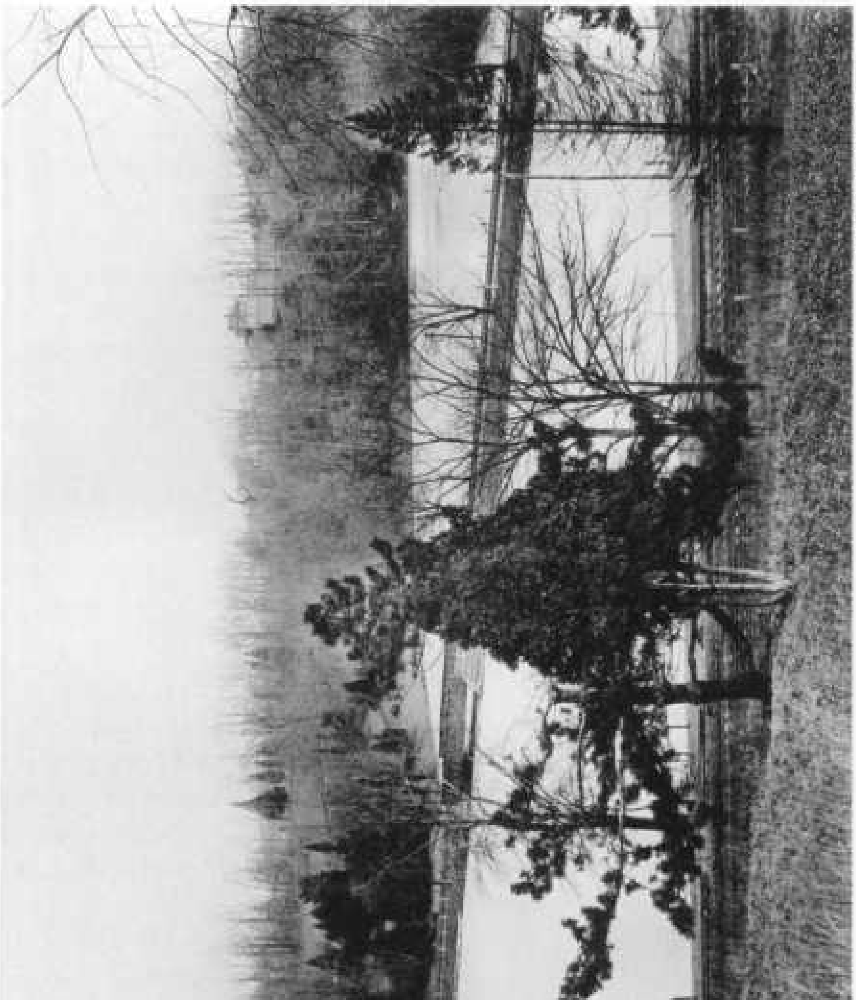
In the Appalachian region Dr. A. C. Spencer began an investigation of the geology of Allegany and Garrett counties with the assistance of Messrs. C. C. O'Harra and A. C. McLaughlin. Later in the season, upon the withdrawal of Dr. Spencer, Mr. O'Harra was placed in charge of the party. Considerable advance was made during the summer in the mapping of the region about Cumberland.

Economic Work.

The study of the economic geology of the state was primarily considered in the conduct of the preliminary survey, and also formed a part of the areal work just described. At the same time a special investigation of the building and decorative stones was early started under the direction of Professor George P. Merrill of the U. S. National Museum. Dr. Mathews was associated with him in this work from the beginning, and a thorough investigation of the central district of the state was completed by him during the season. The work accomplished afforded an admirable basis for the subsequent investigations.

HYDROGRAPHIC WORK.

A study of the drainage basins of the Potomac, Patuxent, Patapsco, and Susquehanna rivers was commenced during the season of 1896 in coöperation with the U. S. Geological Survey, under the direction of Mr. F. H. Newell, Chief of the Hydrographic Division of that



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LAKE ROLAND.

NEAR HOLLINS STATION, ON THE NORTHERN CENTRAL RAILWAY.

bureau. Much of the expense of this work was borne directly by the National Bureau, the Maryland State Weather Service and Maryland Geological Survey aiding to a limited extent. The results derived from this study will prove of much value to the health and industrial interests of the state and will be continued, it is believed, with constantly increasing advantage to the people of Maryland.

STATISTICAL WORK.

It was considered desirable at the beginning of the investigations to have as complete statistical information as possible regarding the various industries dependent upon the mineral wealth of the state, and with that object in view printed forms were prepared in which the exact location of the industry, the amount and character of the mineral products produced in a raw and manufactured state, and other facts of economic interest have been entered. This information, which is annually collected, is regarded as entirely confidential, only county and state totals being given to the public. The forms are kept on file at the Survey office for the use of the scientific staff of the bureau in the compilation of the economic reports.

Operations of the Survey during 1897.

The work which had been so fully inaugurated along various lines during the first season of the Survey's operations was extended during 1897. The first season had shown the possibilities of the work and the more or less detailed examinations carried on in all parts of the state had indicated the best fields for subsequent investigation. Several new lines of study were inaugurated, however, before the close of the second season, as new problems gradually presented themselves.

The following lines of work were undertaken during the season of 1897:

TOPOGRAPHIC WORK.

The topographic work which was continued during 1897 under the plan of coöperation earlier perfected with the U. S. Geological Survey, was carried on mainly in Allegany county, as the purpose of the

Survey to publish at an early date a report upon the coal industry rendered it necessary to provide at once for the requisite base maps. With that object in view, the portions of Allegany county lying to the west of Cumberland, and including the George's creek coal basin, were surveyed for publication upon the scale of one mile to an inch (1:62500). This area will be comprised largely within the limits of the Frostburg sheet of the U. S. Geological Survey. Portions of northeastern Garrett county, as well as of adjoining parts of Pennsylvania and West Virginia, were included within the territory surveyed during the summer. The work was conducted under the direction of Mr. H. M. Wilson and the actual field-work was done by Mr. F. H. Wheat, Mr. H. C. Hall and their assistants.

MAGNETIC WORK.

The magnetic work was continued under the direction of Dr. L. A. Bauer, who had so successfully prosecuted his magnetic investigations during the first field season of the Survey. Through the courtesy of the U. S. Coast and Geodetic Survey, the apparatus which had been loaned to the state during 1896 was still retained in its possession, an arrangement which greatly facilitated the continuance of the work. During 1897 forty different localities were occupied and the various elements determined. Four of these had been earlier occupied by the U. S. Coast and Geodetic Survey. This made the total number of new stations established by the Maryland Geological Survey up to the close of 1897 aggregate seventy-six, while the number of old stations established by the U. S. Coast and Geodetic Survey and others aggregated twenty-eight, making the total magnetic stations in Maryland one hundred and four, or an average of one station to every one hundred and eighteen square miles of the total area of the state.

During 1897 nine additional counties took advantage of the coöperation offered by the Maryland Geological Survey to establish meridian lines at their county seats. These counties were Allegany (Cumberland), Baltimore (Towson), Charles (La Plata), Dorchester (Cambridge), Garrett (Oakland), Harford (Bel Air), Kent (Chestertown), Queen Anne's (Centreville), and Talbot (Easton).

WESTERN BOUNDARY SURVEY.

The determination of the Attorney-General of Maryland, Hon. H. M. Clabaugh, to definitely establish the western boundary of the state, gave the Maryland Geological Survey an exceptional opportunity to render during the summer of 1897 an important public service. At the request of the Attorney-General, the State Geologist detailed during August and September Dr. Bauer and Mr. McLaughlin to the Western Boundary Survey. Dr. Bauer became at once the recognized scientific authority upon the state force, and performed all the astronomical and magnetic work as well as the triangulation from the beginning to the end of the survey. His services were indispensable to the successful running of the line. A full account of the operations of the survey has been prepared by Dr. Bauer, and will be published in a later volume. Mr. McLaughlin carried on his investigations upon the geological structure of the district traversed by the Survey, and was able to be of material assistance to the surveying party.

GEOLOGICAL WORK.

The geological work of the Survey during 1897 embraced the continuance of the areal and economic investigations already inaugurated during the first field season.

Areal Work.

The areal work which had been started during 1896 was much extended during 1897. The State Geologist was engaged during the field season in conjunction with Messrs. R. M. Bagg and A. Bibbins in a continuation of the study of the Cretaceous formations which had been commenced during the previous summer. Much attention was devoted to the Potomac group in connection with Mr. Bibbins, and a classification of its several formations, as shown in Anne Arundel and Prince George's counties, was proposed. Dr. Bagg spent much of his time in the preparation of provisional maps of central and southern Anne Arundel county while Mr. Bibbins was chiefly engaged in the area lying to the north and west of the former district.

Dr. Shattuck was occupied during the months of June and July in a detailed survey of southern Cecil county, devoting his attention largely to the gravel formations about the head of the Chesapeake Bay. Dr. Shattuck had associated with him as assistant Mr. Donald Eversfield.

Dr. E. B. Mathews continued his investigations upon the crystalline rocks of the Piedmont Plateau in the northern counties, but in the absence of proper topographic maps the work was mainly of a provisional nature. Mr. A. G. Leonard was engaged under Dr. Mathews during September in a study of the relations of the basic eruptive rocks of Cecil county to the granites.

Mr. Cleveland Abbe, Jr., spent the months of June and July in the investigation of the physiographic features of the Piedmont district, preparatory to a report upon that subject. Later in the season Mr. Abbe spent several weeks in Allegany and Garrett counties.

The stratigraphic and paleontologic work in the Appalachian region was carried on by Messrs. C. C. O'Harra, A. C. McLaughlin, and R. B. Rowe. Mr. O'Harra devoted the entire field season to a study of the stratigraphy and structure of Allegany county, in which the coal deposits of the George's creek basin commanded careful attention. Mr. O'Harra had associated with him as assistant Mr. J. Morrison Harris. Mr. McLaughlin spent the summer in the investigation of the geology of Garrett county and in tracing out the areal distribution of the extensive coal beds of that area. Mr. Rowe was engaged during August and September in collecting and studying the fossils from the various Paleozoic formations of western Maryland in a preliminary way in order to aid Messrs. O'Harra and McLaughlin in the determination of their horizons.

Economic Work.

The value of the various formations from an economic standpoint was kept constantly in view in the determination of their areal distribution, so that a large amount of additional data was brought together during the field season. The more special investigation of the building and decorative stones, commenced the previous year, was continued by Professor Merrill and Dr. Mathews, and the work practically brought to a conclusion during the early months of the winter. Particular attention was also given the same season to the coal deposits of the western counties of the state by Messrs. O'Harra and McLaughlin under the direction of the State Geologist, preparatory to a report upon that subject.

HYDROGRAPHIC WORK.

Hydrographic work was continued in Maryland during 1897 in coöperation with the U. S. Geological Survey, under the direction of Mr. Newell. A detailed survey was made of the Potomac basin, while measurements were at the same time continued on the other streams and several of their important branches. Mr. E. G. Paul was especially detailed for the Maryland work by the Chief of the Hydrographic Division of the Survey.

AGRICULTURAL WORK.

The close relationship which is to-day recognized to exist between the soils and the underlying geological formations, the former being simply the residual products of the latter intermingled with greater or less amounts of vegetable humus, has led the Survey to inaugurate a systematic study of the soil types of Maryland in coöperation with the U. S. Department of Agriculture, under the direction of Professor Milton Whitney, Chief of the Division of Soils. Mr. C. W. Dorsey of the Maryland Agricultural Experiment Station and Maryland State Weather Service was engaged, under the supervision of Professor Whitney, during the field season of 1897, in the study of the soil types of Western Maryland. The results of this work will be later incorporated in the county reports of this district which the State Geological Survey has in preparation.

STATISTICAL WORK.

The statistical work inaugurated at the beginning of the Survey was continued during 1897, practically complete returns from the several industries being secured. By coöperation with the U. S. Geological Survey this information is annually brought together and published, with the result that the commercial conditions of those industries dependent upon our several mineral products are made available at frequent intervals to the public.

GEOLOGICAL EXPEDITION.

The visit of the eminent British geologist, Sir Archibald Geikie, Director-General of the Geological Surveys of Great Britain and Ireland, to Baltimore in April, 1897, was the occasion for the organization of an extended geological expedition through Maryland under the auspices of the State Survey, the leading geologists of the United States and Canada being invited to participate. More than fifty prominent geologists and mining experts, including the Director of the U. S. Geological Survey and several of his chief associates, many State Geologists and Professors of Geology in our leading universities, accepted the invitation to take part in the expedition. Through the kindness of the Board of Public Works and the presidents of the leading railroad companies and mining corporations, transportation and entertainment were furnished to the distinguished guests, who were thus able to see under advantageous circumstances the important mineral wealth, both developed and undeveloped, which the state of Maryland contains. Their appreciation of the courtesies extended to them is evidenced by the following resolutions:

BALTIMORE, MD., May 1, 1897.

To the Board of Commissioners of the Maryland Geological Survey, and the State Geologist.

Gentlemen:—We have spent the last four days in a most interesting inspection of Maryland geology under conditions which your hospitable forethought has made peculiarly favorable. Our appreciation of the provisions made for the comfort of the party is keen, and our enjoyment of the excursion has been all that you could have wished it.

In twice traversing the state of Maryland an opportunity has been afforded us of observing its mineral wealth and of coming in contact with a wide range of phenomena illustrative of many of the aspects of geology. The field is rich; and it affords opportunities for inquiries which may add honor and profit to the commonwealth, contributing at the same time to the sum of human knowledge. The exploitation

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VIEW IN HAPPY VALLEY.

NEAR PORT DEPOSIT, ON PENNSYLVANIA RAILROAD SYSTEM.

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of these opportunities will be safe under your guidance and we wish you a speedy success.

Thanking you for a very enjoyable and instructive experience, we are, Sincerely yours,

F. D. Adams, McGill College, Montreal.
Cleveland Abbe, Jr., Western Maryland College.
R. M. Bagg, Colorado College.
W. S. Bayley, Colby University.
F. Bascom, Bryn Mawr College.
George F. Becker, U. S. Geological Survey.
L. A. Bauer, University of Cincinnati.
J. M. Clarke, Assistant State Geologist of New York.
Samuel Calvin, State Geologist of Iowa.
N. H. Darton, U. S. Geological Survey.
J. S. Diller, " " "
C. W. Dorsey, U. S. Department of Agriculture.
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O. L. Fassig, U. S. Weather Bureau.
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A. B. Hoen, Baltimore.
J. A. Holmes, State Geologist of North Carolina.
C. W. Hayes, U. S. Geological Survey.
J. C. Hartzell, South Carolina.
E. V. d'Invilliers, State Geologist of Pennsylvania.
Lyman C. Josephs, Newport, R. I.
Arthur Keith, U. S. Geological Survey.
J. F. Kemp, Columbia University.
F. P. King, Portland, Maine.
E. Kirkbridge, Bryn Mawr College.
E. C. E. Lord, Washington, D. C.
F. J. H. Merrill, State Museum, Albany.
W. J. McGee, U. S. Bureau of Ethnology.
S. W. McCallie, Assistant State Geologist of Georgia.
E. B. Mathews, Johns Hopkins University.
J. A. Mitchell, Mt. St. Mary's College, Maryland.
F. H. Newell, U. S. Geological Survey.
W. H. Niles, Massachusetts Institute of Technology.
Edw. Orton, State Geologist of Ohio.
C. C. O'Harra, South Dakota School of Mines.
J. W. Powell, Bureau of American Ethnology.
L. V. Pirsson, Yale University.
F. B. Peck, Lafayette College.
Heinrich Ries, Cornell University.
Harry Fielding Reid, Johns Hopkins University.
R. D. Salisbury, University of Chicago.

A. C. Spencer, U. S. Geological Survey.
T. W. Stanton, " " "
G. O. Smith, " " "
G. W. Stose, " " "
J. Stanley-Brown, Washington, D. C.
G. B. Shattuck, Johns Hopkins University.
Chas. R. Van Hise, University of Wisconsin.
Lester F. Ward, U. S. Geological Survey.
H. S. Williams, Yale University.
Charles D. Walcott, Director U. S. Geological Survey.
T. G. White, Columbia University.
I. C. White, Morgantown, W. Va.
Bailey Willis, U. S. Geological Survey.

President Gilman, the Executor Officer of the Survey, and Professor Clark, the State Geologist, accompanied the expedition. The party was met at Cumberland by Governor Lowndes, the President of the Survey Commission, who gave a reception in honor of Sir Archibald Geikie and the visiting geologists, to which the leading citizens of Western Maryland were invited. A banquet was also given to the party at Frostburg by Mr. C. K. Lord, President of the Consolidation Coal Company. The officers of the Baltimore and Ohio, Western Maryland, and Cumberland and Pennsylvania Railroads did everything in their power to make the expedition a success. By the courtesy of the Board of Public Works one day was spent in an excursion on the state steamboat Governor McLane to Calvert Cliffs.

PUBLICATIONS.

The first volume of the Survey reports was brought out in July, 1897, a preliminary publication of portions of it having been made during the previous April on the occasion of the geological expedition above described. This first volume contains a preliminary statement regarding the resources of the state and is regarded as introductory to the subsequent reports of the Survey. The book has been most favorably commented on by scientific journals at home and abroad, and its value in disseminating knowledge regarding our natural resources has been clearly demonstrated.

Additional Legislation.

The results attained by the Maryland Geological Survey during the first two years of its existence caused the people of the state, through their duly elected representatives at the General Assembly of 1898, to continue the appropriations for geological work for the succeeding two years. Legislation for the extension of the topographic survey and the investigation of the question of highway construction was also enacted by the General Assembly, in each instance the authority for the conduct of the work being vested in the Geological Survey Commission. The following bills were presented and passed by the General Assembly of 1898 and subsequently received the signature of the Governor:

TOPOGRAPHIC BILL.

The bill authorizing the extension of the topographic survey is entitled:

An Act to provide for the making of topographic maps and for the publication of reports of the State Geological and Economic Survey, and to make an appropriation therefor.[1]

Section 1. *Be it enacted by the General Assembly of Maryland*, That the Commission established by the Act of the General Assembly of Maryland at the session of 1896, chapter 51, be and the same is hereby authorized to make provision for the completion of the topographic survey of Maryland in such manner as in the opinion of the Commission will be of the greatest benefit to the agricultural, industrial, geological and military requirements of the State of Maryland.

Sec. 2. *And be it further enacted*, That the said Commission be and the same is hereby authorized to publish special reports dealing with the various mineral products and with the natural resources of each county of the State of Maryland.

Sec. 3. And for the purpose of carrying out the provisions of this Act be it further enacted, that the sum of five thousand dollars annually, in addition to the amount appropriated by the Act of the General Assembly of Maryland at the session of 1896, chapter 51, or so much thereof as may be necessary, be and the same is hereby appropriated, out of any funds in the treasury not otherwise appropriated, and the said amount be drawn from the treasury by the said Commission in the same manner as the other funds of the survey.

[1] Laws of Maryland, 1898, Chapter 129.

Sec. 4. *And be it further enacted,* That this Act shall take effect from the date of its passage.

This bill was introduced in the Senate February 2, was passed by that body upon February 16, by the House upon March 17, and received the signature of the Governor April 2.

HIGHWAY BILL.

The bill authorizing the investigation of the question of highway construction is entitled:

An Act to confer additional powers upon the Commission established by the Act of the General Assembly at the session of 1896, Chapter 51, by providing for the investigation of the question of road construction in this State, and for the preparation of reports thereon, and to make an appropriation therefor.[1]

Section 1. *Be it enacted by the General Assembly of Maryland,* That the commission established by the Act of the General Assembly, at the session of 1896, chapter 51, be and the same is hereby authorized to make provision for the investigation of the question of road construction in Maryland.

Sec. 2. *And be it enacted,* That the said commission be and the same is hereby authorized to appoint, under the direction of the superintendent of the survey, such assistants and other employes as they shall deem necessary, and the said commission shall also determine the compensation of all persons employed, and may remove them at pleasure.

Sec. 3. *And be it enacted,* That the said commission shall see that proper investigation is made of the condition of the roads in this State, and of the best means of improving the same, together with a study of the classification and distribution of the road building materials in the several counties.

Sec. 4. *And be it enacted,* That the said commission shall see that a report upon the state of the roads and the best method of improving, constructing and maintaining the same, with estimates of costs, expenses and plans, be submitted at the next session of the Legislature,

[1] Laws of Maryland, 1898, Chapter 454.

and that special reports be prepared at such times as they are deemed necessary.

Sec. 5. *And be it enacted,* That the said commission shall see that record is kept of all its proceedings, and of all the moneys received and spent under its direction, and for what purposes; which record and account shall be submitted to the said commission at the semi-annual meetings of the same to take place in March and November, such records and accounts to be always open to the inspection of any committee which the Legislature may appoint.

Sec. 6. *And be it enacted,* That all moneys paid out on account of this work shall be paid by the State Treasurer upon the order of the executive officer of the commission, endorsed by the Comptroller.

Sec. 7. *And be it enacted,* That the sum of ten thousand dollars annually, or so much thereof as may be necessary, be and the same is hereby appropriated out of any money in the treasury not otherwise appropriated, for the purpose of carrying out the provisions of this Act.

Sec. 8. *And be it further enacted,* That this Act shall take effect upon the date of its passage.

This bill was introduced in the House February 24, was passed by that body upon April 1, by the Senate April 4, and received the signature of the Governor April 9.

PART II

THE BUILDING AND DECORATIVE STONES OF MARYLAND

BY

GEORGE P. MERRILL AND EDWARD B. MATHEWS

THE PHYSICAL, CHEMICAL, AND ECONOMIC PROPERTIES OF BUILDING STONES

BY

GEORGE P. MERRILL

GENERAL CONSIDERATIONS.

There are, in Maryland, four general classes of stone possessing such natural qualities as to make them available for constructive as well as ornamental purposes. These four are (1) the granites and gneisses, (2) the common limestones and dolomites; the marbles (crystalline limestones and dolomites); (3) the sandstones and conglomerates, and (4) the argillites or slates. In addition to these there are certain basic eruptive rocks used locally for purposes of rough construction, and other altered forms of eruptive rocks like the serpentines, which in some instances are of such color and texture as to render them of value as verdantique marbles. The individual characteristics of each of these groups will be taken up in detail later; in this preliminary chapter we will dwell rather on their geographic distribution in the state; and since this is due to geological causes, we will touch first upon the matter of their origin and the agencies which have been instrumental in making them accessible.

Classification.

From a geological standpoint all those rock types mentioned above may be classed as (1) eruptives, (2) clastic sedimentaries, and (3) metamorphics. The first include only those types which, like granite and the gabbros, have resulted from the crystallization, and subsequent exposure through erosion, of molten matter forced up into overlying strata. The second includes those rocks made up either of fragments of older, pre-existing rocks, or of calcareous materials derived from the shells and stony skeletons of mollusks, corals and other lime-secreting marine animals. They are in short indurated beds of clay, sand, gravel or calcareous mud which have been deposited on ancient sea-bottoms. The third group comprises rocks of both the first and second, which have been changed from their original condition through processes known as metamorphic, and which usually accompany such foldings of the earth's crust as are incidental to the production of mountain chains.

Diversity of Resources.

Such being the case it is evident at once that the more diversified the landscape by hills and valleys, the greater will probably be the variety of materials. In regions abounding with mountain chains

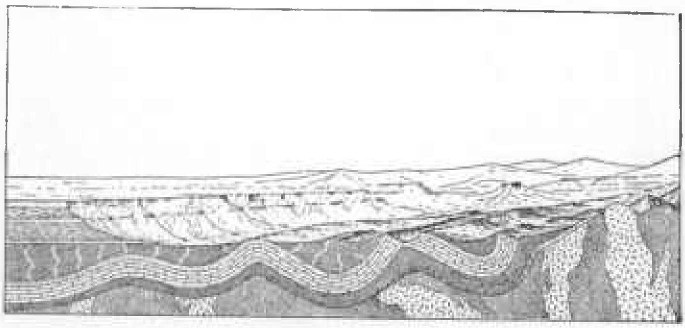


Fig. 1.—Ideal figure showing structure of the earth's crust (after U. S. G. S.).

we may look for a greater variety of materials than in the level plains. This not merely because such have here been formed, but because through uplift and erosion they have been made accessible.

By reference to a map of the United States it will be seen that the state of Maryland, in an east and west direction, stretches almost entirely across the Appalachian Mountain System. It occupies such a position with reference to this uplift and the less disturbed areas to the east and west as to lead us to expect a great diversity of materials even had not actual exploitation already shown them to exist. There is indeed probably no state in the American Union of the same area, that can be made to show a greater diversity in geological resources.

Geological Conditions.

In order to gain a satisfactory idea of the relationship of these various classes of rocks, let us consider for a moment the diagram given below.

FORMATION AND PRESENT POSITION.

The oldest rocks of which we have knowledge, and which seem to form the floor upon which have been built up all those since formed, are rocks of the gneissic and granitoid group. These, through superficial disintegration and decomposition, have yielded silts, sands and gravels, which carried by stream action to the seas have been spread out in approximately horizontal layers to be once more consolidated into stony matter, and perhaps in part metamorphosed, as will be described later. Such being their method of formation, it is easy

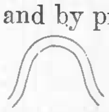
Fig. 2.—Generalized section from Sugar Loaf Mountain to North Mountain (after Williams).

to see that these later formed rocks would naturally lie in parallel beds, the oldest, or first formed, on the bottom and the youngest at the top. And as the character of the material forming these sediments differed from time to time, both in texture and in chemical composition, sometimes being mere clay, sometimes sand, gravel, or calcareous matter, so it will be perceived these beds may differ, and we may have in the same horizontal series, sandstones, shales, limestones, slates and conglomerates. The character, thickness and lateral extent of such beds, vary almost indefinitely. As a rule, the beds of conglomerate are the least extensive, while the sandstones, limestones and shales may cover areas of many square miles.

That these beds of stratified, or sedimentary rocks as they are called, are not in all cases still lying horizontally, the oldest deeply buried and inaccessible, is due to the folding and faulting to which they have been subjected incidental to the formation of the Appalachian Mountains. Their present position is shown in Fig. 2, which represents an actual section across the State between Sugar Loaf Mountain and North Mountain.

Accompanying this uplifting there were in many instances large quantities of igneous rocks forced between the older strata, or into the rifts and fissures by which they were traversed, or in the form of immense domeshaped masses beneath folds, as shown at R in the section. These cooled to form trappean rocks, diabases, peridotites and in some cases granites.

But the uplifting was productive of other effects than that of merely rendering accessible. As is well known, pressure generates heat and heat accelerates chemical action. A series of chemical processes was thereby set in motion which resulted in a more or less complete change in the structure and general textural features of the rocks, as well as, in some cases, in color and in composition. Through these agencies many of the beds of limestone became converted into marbles, the sandstones into schists and the argillites into cleavable slates, suitable for roofing purposes.

In some instances this uplifting and metamorphism has gone on to such an extent as to practically ruin the stone for commercial purposes. The reader can perhaps best gain an idea of what has occurred by taking a pile of writing paper or an ordinary magazine or paper-covered book, a half inch or more in thickness, and by pressing against the back and edges and throwing it into a  shaped fold. By making first a pencil line directly across the edges at the end, it will be observed that, after the folding, this line is no longer at right angles with the leaves, but cuts diagonally across them at an angle dependent upon the amount of folding. This means, of course, that the sheets of paper have moved over one another slightly. Now fancy that each sheet of paper, or page of the book, as the case may be, represents a bed of stone, from a fraction of an inch to it may be several feet in thickness, and that all is weighted down by overlying rocks to such extent that the simple slipping of the beds one over the other as with the paper becomes a matter of great difficulty. When then the folding takes place, it is accompanied by more or less crushing and fracturing, and lines of weakness, if not absolute rifts, are opened. Moreover, if the beds do not slip but remain themselves approximately stationary with relation to one another, it will readily be seen that those in the upper part of the fold will be subjected to a stretching process, perhaps even to the point of fracturing, while those in the lower portion will be correspondingly squeezed and crushed as shown in the figure. Between these two extremes will be a zone practically unaffected, and known to geologists as the zone of *no strain.* Now it is obvious that the condition of the material to be found in one of these folded areas will depend upon what portion of the fold is accessible. If erosion has exposed the materials in the zone of no strain (*A C B*)

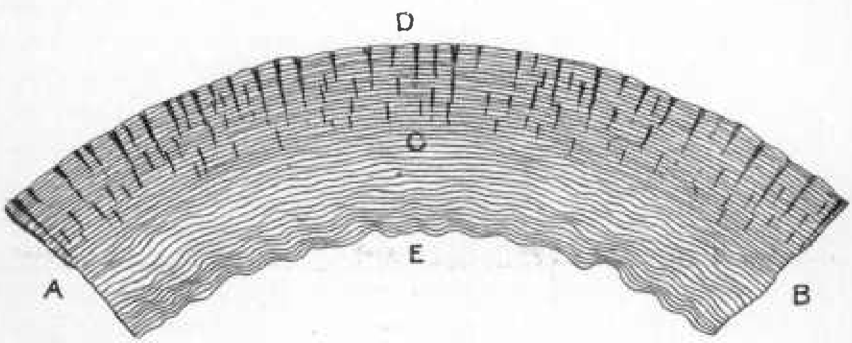


Fig. 3.—Folded rocks (after Van Hise).

it may be good, but if only the superficial beds (*D*) or the very lowest (*E*) are accessible, the materials may be all so seriously shattered as to be full of joints, dry seams and other defects, so as to render the production of blocks of large size an impossibility. Small samples of great beauty may be found in abundance, but the beds as a whole are worthless. This condition of affairs actually exists in many parts of Maryland and Virginia, and in the latter state considerable sums of money have in one instance at least been lost in attempting to develop a quarry.

VARIABILITY IN COMPOSITION AND STRUCTURE.

There are other geological features which are of importance to the quarryman.

Stones which were laid down as sediments on seabottoms are more variable both in composition and structure than are those of eruptive origin. This for the reason that the character of the sediments deposited, from time to time, vary. We may thus have in the same vertical section rocks varying from conglomerates to sandstones, layers of sandstone alternating with shale or with limestone. Sound, firm beds of desirable material may be separated from one another by layers of shale which are absolutely worthless; beds of white homogeneous marble may be interbedded with impure layers carrying pyrite and micaceous minerals which wholly ruin it for commercial purposes. In quarrying, all these matters have to be taken into consideration, since, as waste products they must be removed, and the proportions existing between such and the merchantable stone may be the sole factor in deciding whether any quarry can or cannot be worked successfully.

Again, the amount of tilting and crushing beds have undergone during the process of uplifting is an important item. If the beds lie nearly horizontally and quarrying is commenced upon the upper beds, it is obvious that only one grade of material can be produced at a time. Each layer, as it is passed through successively, as the quarry increases in depth, yields its own grade of material which may or may not agree with that above or below. This is the case in the quarries of brown sandstone in Connecticut. When a quarry is opened in a hillside, or ravine, where a number of beds have been exposed through erosion, or on the upturned edge of beds steeply inclined as in the sketch, it is obvious that the quarry may at the same time be producing a great variety of materials. Some of the marble quarries of Vermont, for instance, which are opened on such upturned edges, produce from the various beds which are being worked simultaneously, marbles of pure white, clouded, dark veined, light water blue and dark bluish or greenish tints, the colors being dependent upon the amount and character of the impurities in the original sediments.

POSITION OF BEDS AND EXPENSE OF QUARRYING.

The position of the beds has, further, an important bearing on the cost of quarrying. It is self-evident that where the beds lie almost horizontally, and quarrying is resolved into merely cutting through

Fig. 4.—Quarry in horizontal rocks (furnished by American Hoist and Derrick Co., St. Paul, Minn.).

one bed after the other, as in the sand and limestone quarries of the upper Mississippi valley. The work can be carried on comparatively cheaply, provided that there is not too much preliminary stripping (Plate IV, Fig. 1). When, however, the beds stand at high angle, or are exposed only in a hillside, quarrying must be carried on either on a highly inclined floor, as in the quarries of gneiss north and west of Baltimore, or directly across the edge of beds, whereby considerable extra trouble and expense are involved.

THICKNESS OF BEDS.

In looking for new quarry sites, the geological structure of the country should always be taken into consideration. When the beds

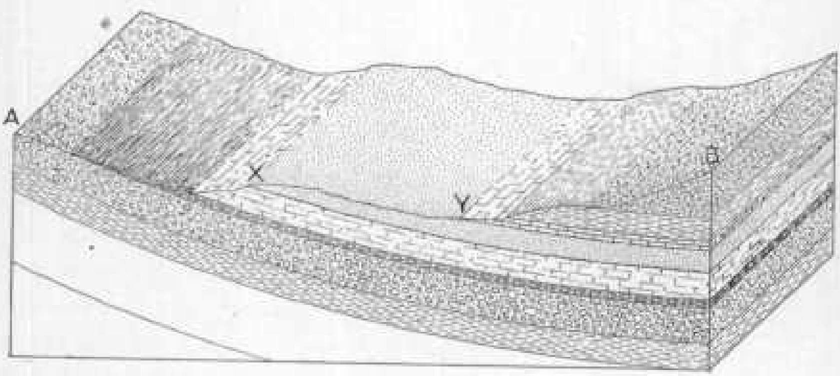


FIG. 5.—Diagram showing relation between thickness and exposure of beds.

lie horizontally it is obvious that the character of any but the uppermost beds can be ascertained only by investigation in hillsides and along the banks of ravines. Where they are highly inclined, it is in many instances sufficient to explore superficially along a line at right angles with the lateral extension, or *strike* of the beds, as it is technically called, that is to say, to follow along the line *A B* in Fig. 5.

The character of the various beds exposed can thus be ascertained, and when one sufficiently promising is found, its extent can be best made out by following it out along the line of strike.

Since the actual thickness of a bed of stone may be a matter of importance, it may be well to state how this can be best ascertained.

It is obvious that with beds inclined as in the figure, the width of exposure on the immediate surface is vastly greater than that of the true thickness of the bed itself. In such cases the apparent thickness is greater the smaller the amount of inclination.

Sir Archibald Geikie, is his Text Book of Geology, gives the following general rule to be followed when the inclination is less than 45°, and it is in such cases that the greatest discrepancies exist. The real thickness of an inclined strata, or bed, may be taken to be 1/12 of its apparent thickness for every five degrees of dip. That is, if, as in the sketch we have a series of beds outcropping on the surface along the line *A B* and dipping as shown, to the right, at an angle of 15°, the actual thickness of one of the beds, *X Y*, will not be the distance—say 100 feet—measured between these points, but 1/12 of 100 multiplied by 3, or 25 feet.

The amount of dip which beds may have and the character of the overlying rock should receive careful consideration before quarrying is commenced. In the case shown in the figure, if $X — Y$ is the workable bed, it is evident at once that the quarry must sometime cease to be an open cut, and must then be followed underground. If the overlying rock forming the roof is sound and strong, this can be done with comparative safety by leaving occasional pillars for support. But if of a weak, or friable nature, it must be continually removed by stripping, thus increasing the cost. It is fortunate that in the majority of cases the amount of area exposed on the immediate surface is so large that it is not necessary to follow the beds to great depths, though in Vermont some of the marble quarries are even now over 200 feet in depth and partake more of the nature of mines than quarries, as the word is commonly understood. Naturally such deep quarries are much more expensive to work since not only must the cost of hoisting both merchantable material and waste be very considerable, but steam pumps must be continually at work to carry off the water which would otherwise collect to a depth of very many feet, even filling the entire quarry to within a few feet of the surface.

BEDDING AND JOINTING.

Among the unaltered eruptive rocks there is a total absence of bedding planes or other like structural features, the rocks being homogeneous and capable of being worked with almost equal facility in any direction, presenting on all sides the same appearance. Such do, it is true, have two definite directions at right angles with one another, along which they can be relied to split most readily. These are known as rift and grain, and though wholly inconspicuous to the ordinary observer, are readily detected by an experienced stone cutter. Bedded and stratified rocks, on the other hand, almost invariably present readily recognizable structural features. It rarely happens that an unaltered or even metamorphosed sedimentary rock is of such uniform composition that the lines of bedding, the original lines of deposition, are not easily traced.. Along these the rock will split more easily than across them. Such lines when too pronounced may be a great detriment, not merely as concerns appearances, but what is of more importance, as affecting the weathering qualities of the stone also.

Such stone, when used in ashlar work, are often sawn or split parallel with the bedding, since not merely can the work be done in this manner at less cost, but a face of more uniform color and texture is thus obtained. That the custom is open to serious objection is noted in another chapter (p. 93).

Joints in rocks are matters of interest for still other reasons than those noted above, since upon their character and abundance is largely dependent the size and shape of blocks that may be extracted. To illustrate this point more fully: Plate IV, Fig. 2, shows a quarry in which the rock is traversed by a series of nearly horizontal joints so strongly developed that very little labor is necessary to free the sheets one from another. Large, flat blocks, with beautifully fresh and even surfaces that can be cut up to any desired size, even to sizes too large for transportation, can thus be readily and cheaply obtained. Such quarries will furnish blocks for building, for monumental work, for monolithic columns or for any purpose to which the rock is lithologically fitted. In other cases, where it may be these horizontal, or *bottom* joints, as they are called, are equally well developed, there exists a second series of vertical joints running at right angles with the first. Such necessarily limit the length or breadth of the blocks

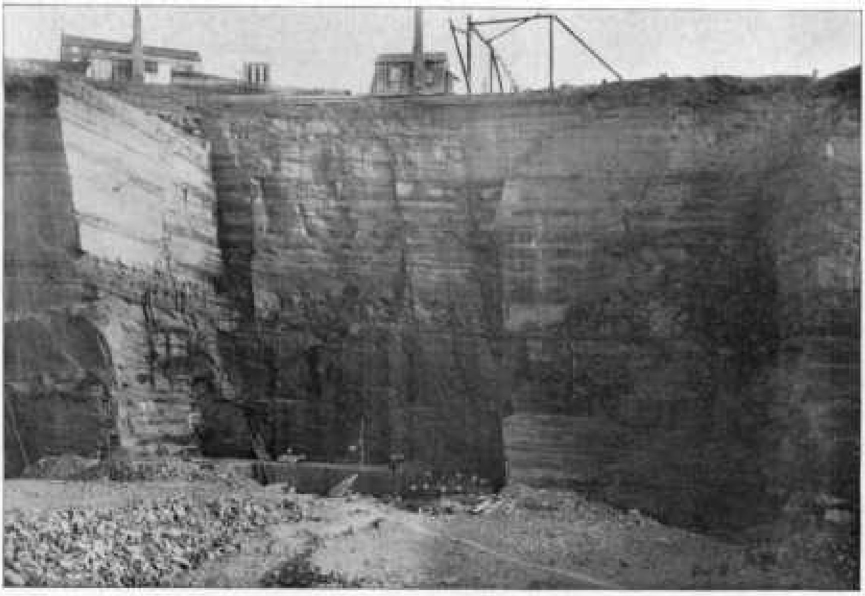


FIG. 1.—HORIZONTAL BEDS.

FIG. 2.—PROMINENT "BEDDING" JOINTS.

P, 56 B

obtainable. These quarries are best suited for the production of ordinary building and monumental material, and are commonly spoken of as block quarries in distinction from the sheet quarries above noted.

It is obvious that in either of the cases above noted, the joints, provided they are not too near together, and not discolored by sap, are of positive benefit to the quarries. It is possible, however, that owing to their abundance and to the angle at which they cut each other they may be decidedly detrimental or even ruin for architectural work what might otherwise be a good quarry. In the view shown in Plate V, Fig. 1, we have a quarry traversed by at least three sets of very conspicuous joints cutting each other at sharp and obtuse angles. The result is that natural blocks, though easily obtained, are of limited size and of such irregular shape that every one must be plugged or otherwise squared and dressed down before it is available. A quarry thus jointed cannot compete in the production of blocks of prescribed size with such as are described above, but can be worked economically only for random rubble, or for square blocks where so situated as to have particularly favorable facilities in the way of extraction and transportation.

Effects of Weathering and Erosion.

All rocks, without exception, when exposed for a sufficient length of time to the atmosphere, undergo a process of disintegration and decomposition, or weathering, as it is commonly called, whereby they become converted superficially it may be into sand, gravel and clay, and on the immediate surface into soil. This process of degeneration, which will be described in detail later, has been going on throughout the many thousands of years which have elapsed since the rocks were raised above the ocean level, and still continues. No portion of the land areas have escaped. By its means, accompanied by the erosive action of running water and of glacial ice, many hundreds and even thousands of feet in vertical thickness of material have been removed from the land areas, and carried seaward. The soil itself is but a transitory phase of this weathering process, being continually removed above by the water of rains, and renewed below by further decay of the underlying rock. Where the erosive action of water and of ice has not been too excessive, there exists a blanket of varying thickness of this rotten material overlying the still sound rock, into which, in many a deep cutting, it may be seen to pass by imperceptible gradations. The fact that all portions of the land are not alike covered by this blanket of soil, clay, sand and gravel, is due to the unequal erosion mentioned above. At a comparatively recent geological period the condition of affairs now existing in Northern Greenland prevailed all over New England, New York and portions of Pennsylvania, and a large portion of the Central States north of the Ohio and east of the Mississippi River. Huge glacial ice sheets, in some cases thousands of feet in thickness, buried the land, and, travelling slowly southward and westward, plowed down through this rotten material, or dragged and pushed it along, even grinding into the hard fresh rock as a workman with file and plane would cut down through the discolored and rotten matter on the surface of a piece of timber till the sound fresh wood was reached. The result is of more than theoretical interest. Throughout the glaciated areas, and particularly along the New England Coast the rocks are found to-day hard and fresh to the very surface, as shown in Plate V, Fig. 2, necessitating no stripping, and scarcely any preliminary work prior to the quarrying of merchantable material. The immediate surface, for the depth, it may be, of but the fraction of an inch, is slightly deadened or discolored. Below this the stone is strong, clear and durable. In the regions beyond the limit of the glacial action, however, the rocks are still covered with the mantle of debris, excepting so far as removed by water. But as the erosive power of water is so much less than that of ice, so here we find the sound stone covered by a mantle of from one to many feet of earthy and discolored material which must all be removed before actual quarrying operations can commence. Even when sound rock is struck it often occurs for a time only in bowlder-like masses, owing to the penetration of the decay most deeply along pre-existing joint planes. This condition of affairs is shown in Plate XIV, Fig. 1. The same condition exists, often in a more exaggerated form throughout the Southern States, as in the marble regions of Tennessee, and to it is due the prevalent idea that the stone here does not occur in true beds, but only in "bowlder formations." When apparently fresh stone is found on the immediate surface, it is often weakened through a loss of cohesion between its particles by the expansion and contraction of ordinary temperatures. This is particularly true of the granitic rocks.

These facts are dwelt upon here in detail, since they must always be taken into consideration in the opening of new quarries. It is due to such causes in part that the northern quarriers are enabled to compete so successfully in the markets of Washington and Baltimore with those nearer at hand. Cheaper transportation by water and ready accessibility to shipping points are, however, important factors, though the advantages thus gained are in part offset by a more rigorous climate, whereby actual quarrying operations must be limited to the warmer season of the year only.

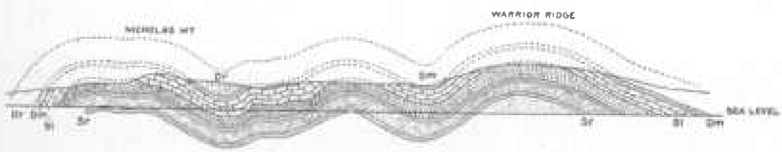


FIG. 6.—Section across Western Maryland showing restored folds.

In all this discussion, it is well to remember that the natural surface of the earth is undergoing constant change through erosion and deposition. Every rainfall and running stream carries from the higher to the lower levels more or less rock detritus, a part of which is even transported to the sea, to be permanently lost from the present land areas. In short, the surface is being constantly lowered, and deeper lying rocks are successively exposed. Just how much the surface has been lowered in bringing about the present condition of affairs, it is perhaps hard to say. What might at one time have been the land surface had no erosion taken place, may be shown in the accompanying section across western Maryland through Warrior Ridge and Nicholas mountain in Allegany county. In this section the continuous lines represent, so far as is possible on so small a scale, the present land surface, while the dotted lines indicate the portions that have been eroded away. Where would have been hills are valleys now, and in regions where but for erosion would have been found monotonous stretches of sand or limestone, each covered by its layer of soil, are now accessible by means of their upturned edges, beds of a great variety of colors, texture and composition belonging it may be to widely different geological horizons.

It may be remarked here that the character of the material on the immediate surface, is not always a sure indication of that which is to be found beneath. This is due to the variability in weathering qualities displayed by rocks of different kinds, a matter which is dwelt upon in some detail in the following pages.

Such imperfections as dry seams and joints in rocks are invariably more conspicuous in the superficial portion of the quarries, than at greater depths simply through the mechanical action of heat and frost or the decomposing action of water. On the surface such may manifest themselves in the form of open cracks, and lines of discoloration, which perhaps wholly disappear or become inconspicuous at comparatively slight depths. It must be remembered, however, that the absence of these defects does not necessarily carry with it an absence of such tendencies as shall cause them to develop under favorable conditions. The writer has in mind a quarry in a more northern state in which on the immediate surface the stone was to be had only in comparatively small, angular blocks owing to the presence of innumerable sharp open joints. At a depth of perhaps 20 feet the open joints had disappeared, and *apparently* sound blocks of almost any size were obtainable. Careful examination of these blocks, however, revealed the presence of sharp, straight lines, as fine as a pen scratch, each one of which would correspond to an open joint on the surface, but which so long as protected from heat and frost, remained quite inconspicuous. It is safe to say that in no case can joints, which are conspicuous as such on the surface, be relied upon to disappear entirely at any depth likely to be reached by quarrying operations. They are a product of deep-seated agencies, and extend to depths which so far as practical quarrying is concerned might as well be without limit.

The solution, discoloration, and decomposition which goes on along such joint planes and lines of weakness may however cease to be appreciable or important at depths comparatively insignificant. The ferruginous discoloration, or so called "sap," which is frequently found penetrating blocks of stone, particularly of granite, for an inch or more along these joints, is due merely to the decomposing action of percolating water, and below the permanent water level, may quite disappear. Once removed from the quarry bed and placed in the walls of a building, the conditions are so changed that there is no probability of this form of staining making its appearance excepting where, it may be, the rock carries appreciable quantities of iron sulphides (see p. 91). In calcareous rocks, the presence of joints is often exaggerated through the solvent action of water, which percolating downward carries away the material in solution. Jointed beds of marble may therefore, on and near the surface, be reduced to disconnected bowlder-like masses, as is sometimes the case in the marble regions of Tennessee. The extent to which such solution has gone on is ever variable, sometimes to a depth beyond the limits of practical quarrying, and sometimes to but the depth of a few feet below the surface. In some cases, even within the limits of Maryland, comparatively thin beds of what was otherwise a most beautiful marble, have been so eaten out by this solvent action as to leave only a fractional part of the original material. Here and there may be found outcrops of very promising stone, but when the beds are traced along for very short distances they are found quite obliterated. To illustrate this point more fully:—The writer was called on not long ago for an opinion relative to the probability of an undeveloped quarry being able to furnish sufficient material of a certain grade to warrant the letting of a contract. On examination, there was found in one locality, and almost on the immediate surface, a bed some two feet in thickness of a beautiful fine white, almost translucent marble. This dipped at a low angle beneath the surface soil and to the inexperienced observer might, and did seem very promising. On careful inspection, however, such an inspection as could be made only by one acquainted with the geological structure of the country and the action of the atmosphere on rocks of this class, it was discovered that, on all sides, everywhere indeed within reach of practical quarrying operations, this bed had become almost entirely dissolved away, leaving only here and there small areas too insignificant to be worthy of consideration. By exploring along a deep trench that had been opened across the face of the bed, it was discovered, too, that the lower beds were not only quite siliceous and hard but variable in color and often carried the deleterious material pyrite. In short, all of the material of any value that the quarry could be relied upon to produce was the small amount actually in sight, aggregating at most but a few thousand cubic feet. Unfortunately the "practical" quarryman was in this case unwilling to accept the conclusions of the geologist and persisted in attempting to develop a quarry, only to discover when too late that he was wrong and that both his money and his energies had been wasted.

As a general rule the solvent and decomposing action of water goes on most rapidly in the softest and weakest portion of the rock, so that the residual bowlder-like masses may represent the better quality of the material. Excepting then that nature's method is extremely wasteful such results can be considered as scarcely detrimental. A quarry under such conditions may be actually producing a better, more uniform class of material, than one which has escaped solution altogether.

In making search for new localities for opening quarries, it is always well to note the manner in which the individual beds have weathered. The soundest and best will as a rule be found standing out in relief while the more perishable have crumbled away.

All stone as it lies in the ground contains a certain amount of interstitial water, which holds in solution more or less mineral matter. This is commonly known as quarry water. When stones are removed from the quarry bed, this water is drawn to the surface and evaporated, leaving its mineral matter to serve as a cement to bind the grains together. A superficial induration or hardening thus takes place. This phenomenon has been long since recognized by quarrymen, though the cause of the same has not been generally known.

FIG. 1.—QUARRY SHOWING SEVERAL SERIES OF JOINTS.

FIG. 2.—GLACIAL STRIPPED QUARRY.

P. 62 B

That a stone is soft when first quarried and hardens on exposure, is one of the commonest arguments used by quarriers with reference to their material, though they fail to remember that such induration may be temporary, and the rock in time crumble in spite of it. Sandstones are peculiarly liable to such induration, even in exposed outcrops in the quarry bed, so that casual inspection will give quite erroneous ideas as to the actual quality of the stone. A slight change in color, from the surface downward, is also a not infrequent occurrence, as is noted in the chapter on Weathering (p. 90).

Color of Rocks.

The subject of the color of a rock, when first quarried, after prolonged exposure, and after working is one that should be briefly considered. Among siliceous crystalline rocks the colors are due mainly to the presence of colored minerals, or to the physical condition of the feldspars. Thus the gray color of granites is due largely to an admixture of white feldspars and black mica or hornblende; the red colors to red feldspars; the dark greenish, sometimes almost black colors to clear pellucid feldspars, and the white, to white feldspars. The dark colors of the diabases and the gabbros are due to the pellucid feldspars and the dark pyroxenes they carry. Pure limestones and dolomites are white simply because that is the color of the calcite or dolomite which forms their chief constituent. The dark color common in this class of rocks is due as a rule to the presence of carbonaceous matter; the red, to iron oxides, though the pink and red colors of some of the onyx marbles seem to be due in part also to organic matter. The red, brown and yellow colors of sandstones are due to iron oxides. The changes in color which these rocks are likely to undergo, on exposure, are noted in the remarks on rock-weathering. It may not be out of place to state here, however, that nearly any feldspathic rock is likely to become lighter in color during the incipient stages of weathering owing to the opening up of the cleavage planes in the feldspars. It is for this same reason that the hammered surface of one of these rocks is of a lighter color than the natural rock face or polished surface. The impact of the hammer breaks up the granules on the immediate surface so that the light falling upon it is reflected, instead of absorbed, and the resultant effect upon the eye is that of whiteness. The darker color of a polished surface is due merely to the fact that through careful grinding all these irregularities and reflecting surfaces are removed, the light penetrating the stone is absorbed, and the effect upon the eye is that of a more or less complete absence of light or darkness. Obviously then the more transparent the feldspars and the greater the abundance of dark minerals, the greater will be the contrast between hammered and polished surfaces. This is a matter worthy of consideration in cases where it is wished, as in a monument, to have a polished die, surrounded by a margin of hammered work to give contrast. Often when a piece of work of this nature is exposed, the contrast between hammered and polished work diminishes slightly owing to the gradual weathering out of the particles splintered through hammering. The contrast is less when the stone is wet than when dry, because the water fills all the little rifts and crevices and by its refracting power tends to produce the same effect as though the stone were polished.

Geological Age.

The matter of geological age is only of very general economic interest. It is indeed true that the process of metamorphism—the change from the amorphous or fragmental condition to one more or less crystalline—has as a rule gone on more extensively among the older rocks, than among those later formed, but the rule is by no means universal, and moreover metamorphism is not always productive of such characteristics as make a stone adapted for either building, monumental or decorative work. While metamorphism may render a stone crystalline, it may also render it granular and friable; while it may develop color, it may also develop schistosity and other blemishes. So far as the United States are concerned, one can say, however, that few stones are used to any extent that are of later date than the Triassic, and that few if any of our marbles are younger than Silurian, while nearly all our granites, as now quarried, belong at least to Paleozoic or Archaean times. Stones of later than Triassic age, are, so far as relates to the Eastern United States so friable, or so poor in color, as to be of little value.

THE STRENGTH OF STONES.

Much has in times past been written on the subject of the crushing strength of building stones, and hundreds of tests have been made, the results of a few of which are given in this work. A few words only on the subject are here necessary. It is doubtful if in any but the most extreme cases it is necessary to continue this line of investigation. The results thus far obtained are sufficient for us to formulate general rules, and the average results obtained are so vastly in excess of all ordinary requirements that they may safely be ignored. A stone so weak as to be likely to crush in the walls of a building, or even in a window stool, cap or pillar, bears so visible marks of its unfitness as to deceive no one with more than an extremely rudimentary knowledge on the subject. It is rare to find a stone that will not show, under the methods of testing now in vogue, a crushing strength of at least 6000 lbs. to the square inch, while many stones, particularly those of the granite group, will range as high as 20,000 to 30,000 lbs. to the square inch. Since the first named amount is tenfold more than is likely to be required of it in any but the most extreme cases, the absurdity of making further tests is manifest. The few that have here been made, were made in recognition of the still prevailing—though mistaken—demand for tests of this nature. They show, as was to be expected, that the matter of the strength of those of the Maryland stones now on the market, may well be left out of consideration in the future, and this for the reasons above suggested.

In fact, it is the weathering quality of a stone more than its ultimate strength, that should concern us, and a careful examination of the natural outcrops, old quarry faces and buildings, will give a more correct idea to an experienced man, than will all the tests that can be made in the laboratory. This view the writer expressed some years ago,[1] and to it he still adheres with little fear of contradiction.

GEOGRAPHIC DISTRIBUTION OF STONE IN THE STATE.

By referring to the map of Maryland (Plate VI, Vol. I), it will be seen that the state is divided into three well defined topographic prov-

[1] Stones for Building and Decoration, Wiley and Sons, N. Y.

inces, which are intimately related to its geologic structure and hence have a bearing upon its mineral yielding capability. It will therefore be worth our while to devote a little space to a consideration of this branch of the subject, bearing in mind, the while, that much that is said here regarding Maryland is true to a certain extent of the entire Eastern United States.

The most easterly of these topographic provinces, known as the Coastal Plain, comprises the area between the Atlantic Ocean and a line passing N. E. to S. W. from Wilmington (Delaware) to Washington, D. C., through Baltimore. The region is about 100 miles broad in its widest part, and includes very nearly 5000 square miles of territory or about one-half the area of the entire state. It is characterized by broad level-topped stretches of country, which extend with gradually increasing elevations, from the Coastal border, where the land is scarcely at all elevated above sea-level, to its western edge, where heights of 500 feet and more are to be found. The underlying rocks are as a rule but slightly indurated, consisting mainly of clays and sands, sometimes locally cemented into ferruginous sandstones and conglomerates and never of such consistency as to be of value in their natural state for building purposes. We may therefore dismiss this portion of the state from further consideration.

The second province, known as the Piedmont Plateau, borders the Coastal Plain on the west and extends to the base of the Catoctin Mountain. It is nearly 40 miles in width in the southern portion of the region, but broadens toward the north until it reaches 65 miles in width, comprising altogether an area of approximately 2500 square miles, and including Cecil, Harford, Baltimore, Howard, Montgomery, Carroll and Frederick counties. As it is this province which furnishes by far the larger amount and greater variety of building stones and marbles, it will be worth the while to consider it in some detail. The Plateau, as a whole, is divided very nearly in its central portion by an area of high land known as Parr's Ridge, into an eastern and a western district. To the east of this ridge lie the gneisses, granites, gabbros, crystalline dolomites (marbles), serpentines, and roofing slates, the main portion of the area being occupied by the gneisses, through which have been sporadically intruded the granites and gabbros which, by erosion, are now exposed in the form of isolated patches of comparatively limited extent, as shown on the map. The building marbles of the state are limited almost wholly to this eastern division, as shown in the areas north of the city of Baltimore.

This eastern division has, on account of its crystalline rocks and their complicated structure, a diversified topography. Along the eastern margin the land attains, at several points, heights exceeding 400 feet, reaching at Catonsville 525 feet above sea-level. To the west the country gradually increases in elevation until it culminates in Parr's Ridge, which exceeds 850 feet in Carroll county.

The drainage of the eastern district is to the east and southeast. On its northern and southern boundaries it is traversed by the Susquehanna and Potomac rivers, which have their sources without the area, while the smaller streams, which lie between them either drain directly to the Chesapeake Bay or into the two main rivers. Among the larger of the intermediate streams are the Patuxent, Patapsco and Gunpowder rivers, whose headwaters are situated upon Parr's Ridge. The Patapsco especially flows in a deep rocky gorge until it reaches the Relay, where it debouches into the Coastal Plain. All these streams have rapid currents as far as the eastern border of the Piedmont Plateau, and even in the case of the largest rivers are not navigable.

This last is an important item since it precludes the possibility of shipment of quarried material by other than rail, canal or wagon routes.

The western division extends from Parr's Ridge to Catoctin Mountain. Along its western side is the broad limestone valley in which Frederick is situated, and through which flows the Monocacy River from north to south, entering the Potomac River at the boundary line between Montgomery and Frederick counties. The valley near Frederick has an elevation of 250 feet above tide, which changes slowly to the eastward toward Parr's Ridge, and very rapidly to the westward toward Catoctin Mountain. Situated on the eastern side of the valley, just above the mouth of the Monocacy River, and breaking the regularity of this surface outline, is Sugar Loaf Mountain, which rises rapidly to a height of 1250 feet.

The underlying rocks of this division are as a rule far less crystalline than those of the eastern, consisting mainly of blue gray limestone, red brown sandstones, phyllites, and other siliceous and argillaceous rocks which are largely unsuited for construction purposes and hence need no mention here. There are, however, in Carroll and Frederick counties several comparatively small included areas of highly crystalline limestones capable of furnishing in small blocks material of such color and texture as to make them of value as marbles.

The third or Appalachian region borders on the Piedmont Plateau and forms the entire western portion of the state. It includes the western portion of Frederick, and all of Allegany and Garrett counties, an area of some 2000 square miles. This is the most mountainous region of the state, consisting indeed of little more than a series of parallel mountain ranges with deep narrow intervening valleys which at the southern limit of the state are cut almost at right angles by the Potomac River. This area has as yet furnished practically nothing in the way of structural material though it does not necessarily follow that satisfactory materials do not exist. The rocks consist mainly of sandstones, shales and limestones, none of the latter being sufficiently metamorphosed to make them of value as marbles. The possible resources of this region will be discussed later.

Methods of Quarrying and Working.

In the work of extracting stone from the quarry, and reducing it to the desired shapes for use, there are two considerations of primary importance. These are, 1st, the accomplishing of the work with the least possible injury to the material, and, 2nd, the accomplishing of it cheaply. Unfortunately the two methods are almost directly opposed to each other, and equally unfortunately the cheaper methods are those, as a rule, most likely to produce injurious results. This last is only partially true, however, since where the work is carried on on a large scale, the better way proves in the end the cheapest. In many kinds of manufacture complaint is made that machine-made goods are inferior to those made by the old-time hand processes. In stone work this is certainly not correct, however. With machines it is possible to produce better results, in less time than by hand methods. This is particularly true regarding quarrying, sawing, grinding and polishing. There are of course certain kinds of work, certain forms of finish, for the satisfactory performance of which no machines have been designed.

Before considering in detail the methods employed in stone quarrying and stone working, let us first consider the conditions under which the stone exists in the quarry, what difficulties are to be overcome, what methods can be pursued with safety, and what must be avoided. All stone that is used at all extensively for structural purposes has the property of splitting, or breaking with fairly flat and even faces, along two directions at right angles to each other. The direction of greatest ease is known as the rift, that at right angles as the grain. The cause of this tendency to split along definite lines is not fully understood. It is enough for our present purposes that it exists. The rift is often very pronounced, and its direction is indicated by and some is due to a parallel arrangement of the constituent minerals as in the gneisses and schists. In other rocks, like the more massive granites, it is wholly inconspicuous and the direction can be determined only by an experienced stone-worker. Nothing is more surprising to one who has given no attention to the subject, than the ease with which a workman, with no other tool than a square-faced hammer will break out by a few well directed blows a rectangular block of the required size and shape for street pavements, while an inexperienced person, with the expenditure of twice the amount of time and triple the amount of energy will produce only a shapeless mass, with bulging faces and rounded corners, utterly worthless and unfit for use. Here then are two important factors which must be taken into consideration. Another is the jointing. To this property attention has been called on p. 55, and the matter need not be wholly repeated here. It should be stated, however, that these joints may be either a help or hindrance to quarrying according to their prominence, abundance, and the directions at which they traverse the stone. As a very general rule those massive rocks which are extensively quarried owe their availability to the presence of two series of joints which like the rift and grain cut the stone in directions practically at right angles with each other. This condition of affairs is described on p. 56, and a figure is given showing the utility of joints in quarrying. Hence nothing more need be said on the subject here.

Among sedimentary rocks—the sandstones and limestones—the better grades of stone lie in well defined beds, or layers, separated from one another by other beds of inferior or worthless material. The quarrier has to consider not only how to get out the good material, but also how to get rid of that which is worthless. One method must be resorted to for the first, and another less expensive for the second.

Another feature which must not be lost sight of, here, is the difference in degree of hardness and toughness of various classes of rocks. A method of treatment allowable in one case, as with granites, would be wholly impracticable in another, as with limestones. Fortunately those rocks which are so tender as to be likely to become injured by the more violent methods of quarrying, as by blasting, are sufficiently soft to permit of their extraction by other means. The quarrier has to remember that stones have but a comparatively small amount of elasticity, that they are brittle, and any sudden jar, like that from an explosion of powder or dynamite, is likely to develop flaws and fractures, which, while they may be quite inappreciable at first, become injuriously conspicuous by weathering.

But enough has been said to show that quarrying is not quite so simple a process as may have at first appeared. Let us now devote a few pages to a consideration of the methods in vogue.

The old time and simplest method of quarrying which needs be considered here, is that of blasting out the rock by means of powder exploded in a cavity made by hand drills. This method, aside from being too slow for modern purposes, results in the production of only irregularly shaped blocks requiring a proportionately large amount of labor to reduce them to the desired sizes and shape. Moreover, the explosion of a single, large charge of powder, is likely to produce a shattering which can be wholly done away with if the charge is distributed along a line among several holes which are exploded simultaneously. This method is rendered possible through the invention of a steam drill such as is shown in Fig. 7. As may be seen it consists of little more than a steam cylinder mounted on a tripod with

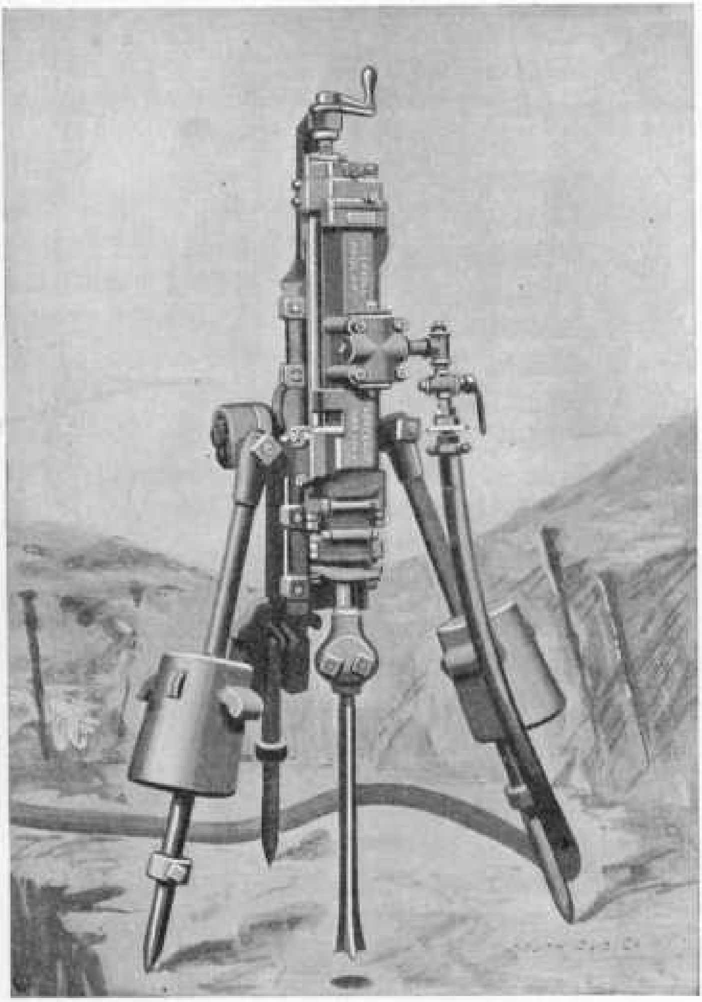


FIG. 7.—Ingersoll-Sergeant steam drill.

the drill attached to the piston. The machine is held in place by means of heavy weights on the legs of the tripod. The steam being conveyed from the boiler to the drill by means of a flexible hose, which allows the use of the drill in any part of the quarry. A different form of drill answering the same purpose is shown in Fig. 8. By means of these machines a series of two or more holes are drilled along the line where it is desired the stone shall break. These are then charged lightly with powder, and fired simultaneously by means of electricity instead of by a fuse. The result is that a large mass of rock is freed from the quarry bed, with a comparatively slight amount

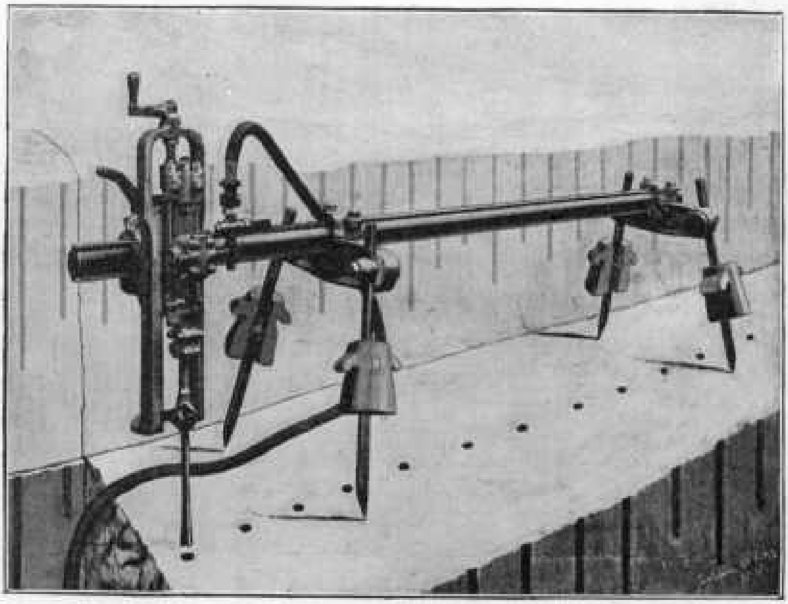


FIG. 8.—Ingersoll-Sergeant quarry bar drill.

of jar, the aim of the quarrier always being not to move the block any appreciable distance, but simply to free it, after which it is reduced to blocks of the required size by hand implements, to be noted later. Where the bottom joints in a quarry are well defined as at Vinal Haven, Maine, masses of granite some 300 feet in length and 20 feet in width have been loosened at a single blast.[1] In cases where bottom joints are not sufficiently developed, or are at too great a dis-

[1] Stones for Building and Decoration, 2nd Ed., p. 241.

tance apart, it is sometimes necessary to resort to drilling and blasting to free the rock from the quarry bed.

Once loosened from the bed, as described above, a block of granite or other hard rock, is cut up into desired sizes by means of plugs and feathers. By means of hand drills or a quarry bar drill, a series of

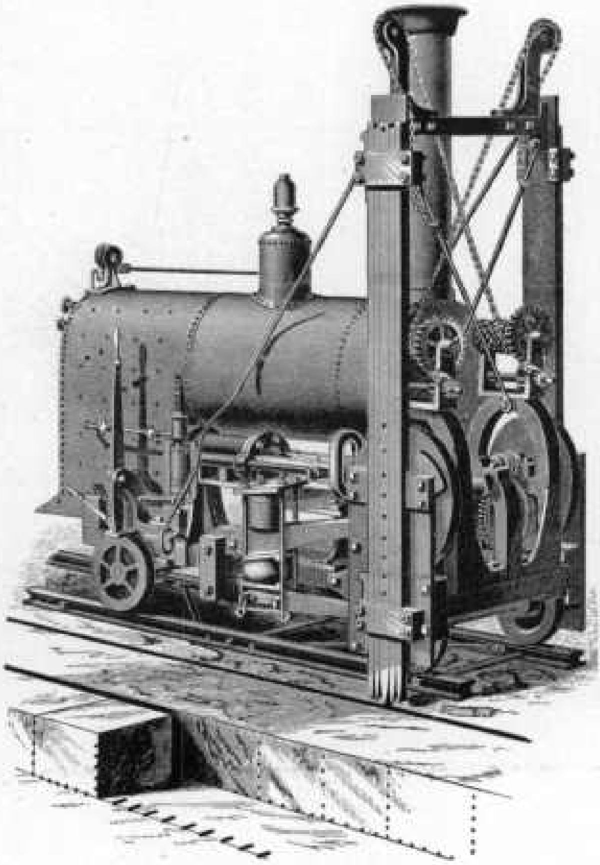


FIG. 9.—Wardwell channelling machine.

holes, not over an inch in diameter and a few inches deep, is drilled along the line where it is desired the stone shall break. Into each of these is then placed two half round wedge-shaped pieces of soft iron, the thicker ends downward, and between them is inserted a small steel wedge. When the wedges or plugs are all in place the workman strikes them one after the other with his hammer, driving them all alike, thus producing a uniform strain along the line, until the block falls apart. The method is commonly known as "plug and feather" splitting. In the softer rocks, as the sandstones, a somewhat different method is resorted to. Instead of drill holes, grooves are first cut with picks, and into the grooves large steel wedges are

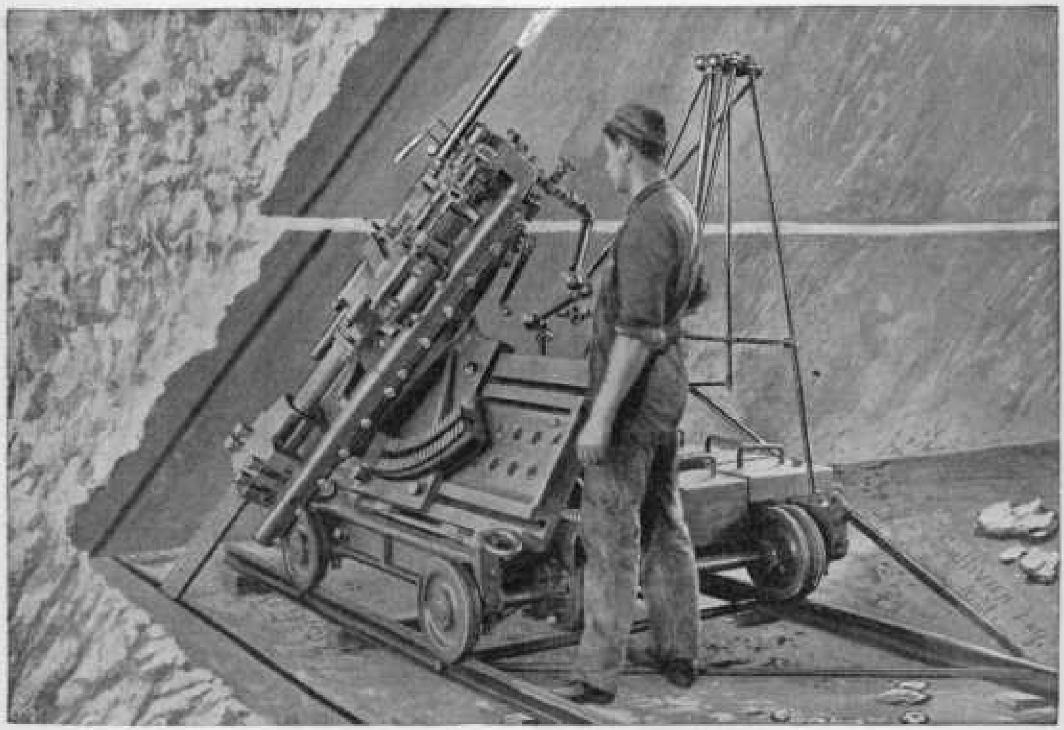


FIG. 10.—Ingersoll-Sergeant channelling machine.

inserted which are then driven with heavy striking hammers or sledges, in the same manner as before.

Blasting by means of powder furnishes the only available means for quarrying rocks of the granitic type, owing to their hardness. But the method should be used reasonably and with discretion. Material from a quarry where, as one sometimes reads, hundreds or even thousands of tons of stone have been loosened by a single blast, should always be accepted with hesitation, if at all, for building purposes, since as above noted the jar from such a concentrated explosion is likely to produce incipient fracture and injuriously develop latent joints.

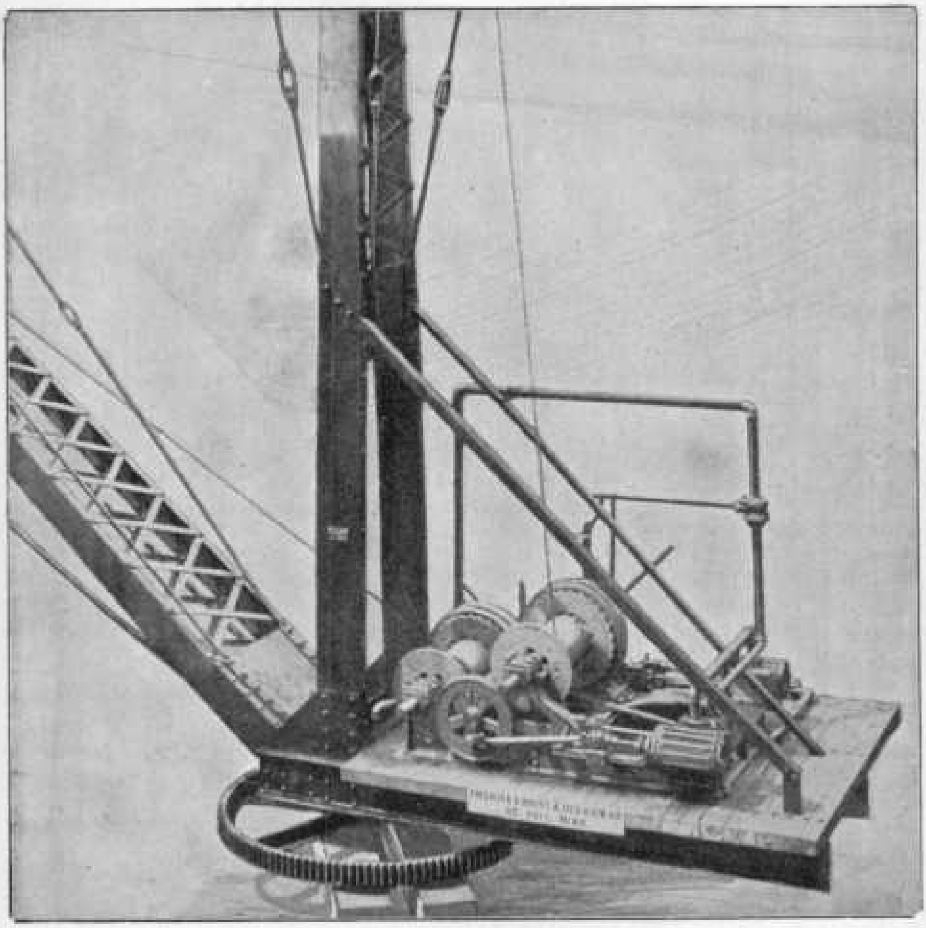


FIG. 11.—Revolving drum and hoist for derrick.
(Furnished by American Hoist and Derrick Co., St. Paul, Minn.)

In quarrying softer rocks like the sandstones, limestones and marbles, channelling machines are now used in nearly all American quarries. Two distinct types of these machines are used (Figs. 9 and 10), but with both the results are essentially the same. The machines are constructed to run forward and backward over temporary tracks laid on the quarry floor and to cut as they go straight smooth channels into the stone beneath, the channels, by repeated passage of the machine, being cut to any desired depth up to perhaps six or more feet. The rock on the floor of the quarry is thus divided up into a series of

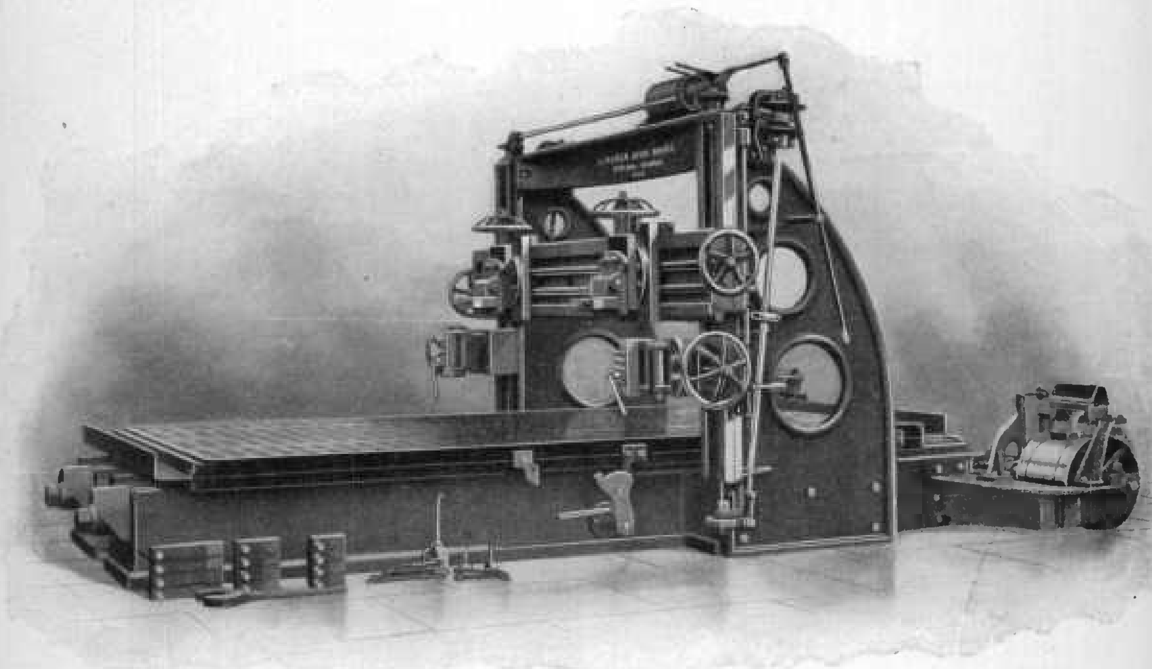


FIG. 12.—Lincoln stone planer.

blocks which need only to be freed from the quarry bed to become available. This freeing from the bed is usually done by means of machines known as undercutting or "gadding" machines. These are sometimes ordinary impact steam drills, or again diamond drills. In either case a series of holes is drilled along the desired line, and the stone then broken out by wedges, or perhaps by means of another machine which simply cuts out the partitions between the holes.

By the aid of such machines blocks of any desired size may be obtained, and what is of equal importance, selected material can be taken out with no possible danger of injury as by blasting.

The removal of blocks from the quarry to the shed is accomplished by hoists using horse, steam or electricity for power, the running-gear passing over the arm of a derrick as in Plates X and XIV, or through a truck on a cable as in Plate XXXII. The cable permits the lifting of blocks from any portion of the quarry along the line of the main cable, the derrick handling all of the material within a given distance of its base. The time and expense involved in pulling around the arm of the derrick by a rope may be lessened by the use of small drums connecting with a horizontal wheel as shown in the accompanying figure (11) or in less detail in the photograph of the Port Deposit quarries (p. 144).

Once removed from the quarries stones are cut and finished by processes, which within certain limits vary according to the hardness of the material, though the nature of the rift or bedding naturally has much to do in the matter. Granites and hard rocks of this nature are as a rule reduced to the desired size and shape by plug and feather splitting and by hand cutting with chisel and hammer. Steam saws consisting of a thin blade of soft iron fed with small globules of chilled iron or a sand composed of crushed steel are used to some extent. Monolithic columns are in some instances turned on giant lathes, the cutting tools being revolving discs of steel. A planer with cutting discs of the same nature is sometimes used (see Fig. 12). Smooth surfaces for polishing are produced by grinding, the block being placed on a horizontally revolving iron bed, the cutting material being the chilled iron, sand or emery as the case may be; or, where the block is too large there is used a movable grinder such as is shown in Fig. 13. The necessary smooth surface having been produced, the polish is imparted by means of a revolving wheel covered with felt. This is kept wet and a white powder, known to the trade as "polishing putty" is sprinkled over the surface occasionally, the friction from the revolving wheel aided by the putty shortly producing the desired results. An almost perfect surface is the first essential to the production of a good polish. Sandstones, limestones and marbles are sawn by the reciprocating blades of soft iron mentioned above, which are usually mounted several or many in a frame, an inch or more

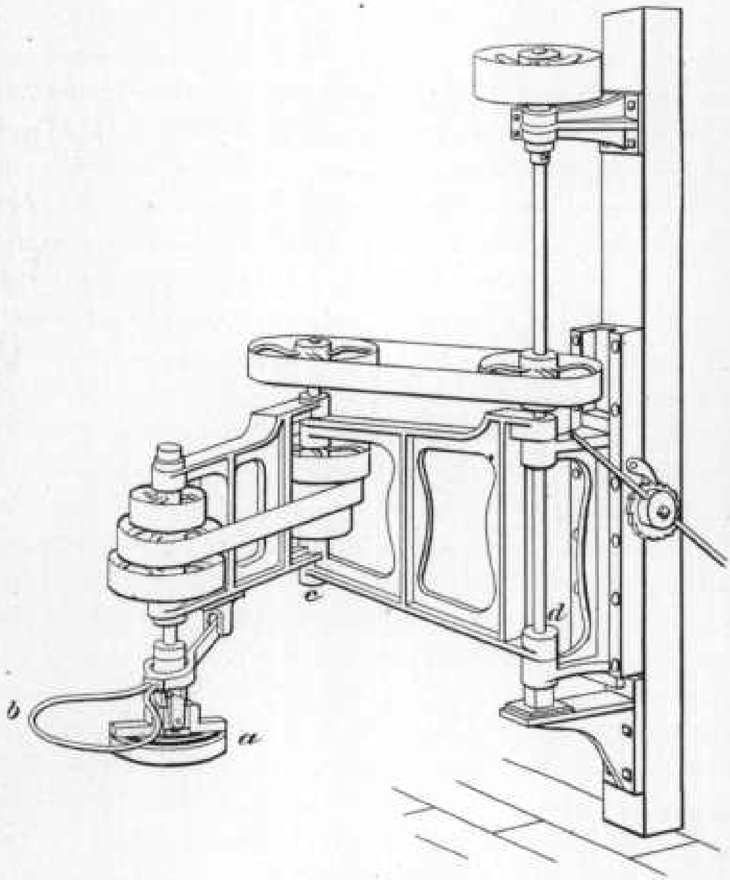


FIG 18.—Stone polisher.

apart according to the thickness of the slabs or blocks which are to be cut, the cutting material as before being sand or chilled iron. Sand is preferable when the material to be cut is not too hard, since not likely to stain the stone, through rusting. Moreover little particles of the iron or steel are likely to become imbedded in the stone during the early stages of grinding and these breaking loose during the later stages, when the surface is nearly smooth, do much damage by scratching or else remain permanently imbedded to give rise to rust spots when the stone is exposed to moisture. These softer stones are also planed by machines operating on the same principles as those used in planing metals. A modification of the same machine is used in producing mouldings. Carved surfaces are still produced mainly by hand, hammer and chisel, though machines operating like miniature stream drills have been employed for this purpose.

Various forms of finish are applied to the surfaces of stones, and are called by names as a rule indicative of the means employed. A rock face finish is the natural fracture of the rock, scarcely touched by chisel. A pointed face is a rock face the inequalities of which have been reduced by a sharp pointed implement known as a point. A surface cut into parallel shallow grooves from a quarter to a half-inch in diameter, is known as a dove-surface. A tooth-chiseled surface is produced by means of a wide chisel, the cutting edge of which is toothed like a saw. Ax or pean hammered surfaces are produced by striking upon the surface, always in one direction, with heavy hammers, the cutting faces of which are reduced to an ax-like edge, the result being that the finished surface is covered with long parallel-lying lines and ridges. A patent hammer made up of thin plates of steel so bound together as to form a compound cutting edge is also used for this work.

It is well to call attention here to the fact that in material so inelastic as stone the result of the impact of such blows, however slight, on the surface, is to produce minute fractures parallel to the surface, which result in scaling. The scales thus loosened are, it may be, but slight and at first inconspicuous. Nevertheless the tenacity of the stone for a variable distance below the surface has been weakened, and here disintegration must first make itself apparent. Beyond doubt the most durable finish is a rockface, sawn or properly prepared polished surface, since in these the natural condition of the constituent minerals or granules remains undisturbed.

It may be stated here that all stone works more easily when newly quarried than after seasoning, though this characteristic is more strongly marked in the sandstones and limestones than elsewhere.

Not only do stones harden through seasoning, but the rift and grain are often less pronounced, and dry seams and other defects become more pronounced. Hence it is always best to work up stone as soon after its removal from the quarry as possible. Indeed roofing slate, as every quarrier knows, cannot be split at all satisfactorily after the water has once dried out of it.

Relation of Maryland to other Producing Areas.

The same geological agencies which were instrumental in the forming and rendering accessible of so large a variety of stone in Maryland operated throughout almost the entire Eastern United States and were productive of very similar results. From Northern New England to Central Georgia, along the entire length and breadth of the Appalachian chain, conditions of sedimentation and uplift, of eruption and metamorphism were so similar, that a remarkable uniformity exists so far as regard to character of materials is concerned, though in quantity, accessibility and quality, there is often a very great diversity. It will be of interest as well as not unprofitable for us to devote some space to a consideration of the resources of the neighboring states, and to the conditions governing their output, since here, as in other business enterprises, competition is likely to play an important part in all other than purely local markets.

PRELIMINARY GENERALITIES.

The axis of disturbance, above repeatedly referred to, extends from Maine southeasterly, not parallel with the coast, but retreating gradually inward, until south of New York it is no longer accessible by tide-water communication. This is an important physiographic feature, since transportation by water is always cheaper than by rail. This is particularly the case with heavy and indestructible materials like stone. In Maine many of the quarries are either directly upon the coast or bordering along its numerous fiords and rivers. The quarried materials, with scarcely any preliminary handling, can be placed directly upon schooners and carried to all the leading cities of the eastern United States without transshipment. Hence Maine and Massachusetts granites and Connecticut sandstones early came into use throughout the entire coastal area of the eastern United States and in some cases were even carried around Cape Horn to cities upon the western coast (Plate V, Fig. 2). Further than this Nature has, throughout the entire New England states and large portions of New York and Pennsylvania, greatly favored quarrying operations through the medium of the glacial ice sheet. This powerful erosive agent carried off the residuary products which result from years of rock decay and left the ledges of granite, slate, marble, or whatever they may have been, fresh and hard to the very surface. Throughout the entire region to the south of the extension of this sheet, it is only here and there that there is to be found a quarry not buried by rotten matter that must be removed by stripping before quarrying can be commenced. This latter fact is well known to Maryland quarriers, and is shown in the views of quarries given on Plates XVIII and XX.

KINDS OF STONE PRODUCED BY OTHER STATES.

In *Maine* there are in operation to-day only quarries of granite, gneiss and gabbro, and of roofing slate. Very many of the granite quarries lie so near the water's edge that cost of transportation is reduced to the mininum, and hence quarriers are enabled to compete with others, even in markets at a great distance. The roofing slates lie remote from water ways and only the general excellence of the materials enables them to compete with others beyond the state limit. The output of these materials for 1889 was: of granite 6,701,346 cubic feet valued at $2,225,839.00, and of slate 41,000 squares, valued at $201,500.00.

New Hampshire has only quarries of granite and gneiss that need be here considered. These are all dependent upon railroads for transportation, but the quality of some of the granites, notably those of Concord, enables them to compete successfully with others more favorably situated. The entire output for the year 1889 was 2,822,-026 cubic feet, valued at $727,531.00.

Vermont produces a greater variety of materials than either of the above mentioned states, including granites, marbles and roofing slates, although few of the granites are of such a nature as to lead to their being transported beyond the state limits, so long as the transportation is limited wholly to railways. The marbles and roofing slates are, however, of such quality as to lead to their use, even under these adverse conditions, in nearly every state in the Union.

During 1889 the statistics of production of the three classes of stone mentioned above were as below: granite (and allied rocks) 1,073,936 cubic feet, valued at $581,870.00; marbles 1,068,305 cubic feet, valued at $2,169,560.00; roofing slates 236,350 squares, valued at $596,997.00.

The marble of Vermont, it should be stated, is, with the exception of the colored varieties of Mallett's Bay, almost wholly crystalline limestone and of such a nature as to make it better adapted for monumental and decorating work than general building, while those of Maryland are dolomites, and, so far as now developed, almost wholly building marbles.

Massachusetts. This state produces for other than local uses only granites, marbles and sandstones. With the exception of the granites which lie along the coast, as those of Gloucester, Rockport and Quincy, the transportation is wholly by rail. Nevertheless the quality of the stone, the early date at which the quarries were opened, and the energy of the operators has been such that they have been widely used, and in many cases to the entire exclusion of equally good material from close at hand. The marbles are crystalline granular dolomites and wholly of the building type, and on casual inspection are scarcely to be distinguished from those of Cockeysville, Maryland. Sandstones are produced only in the southern central part of the state, as near East Long Meadows, the stone bearing a general resemblance to that of Seneca Creek in Maryland, though perhaps of a warmer hue. Many of the granites, as those of Quincy, Dedham and Milford, are of a type quite lacking in other states. The output of the three classes during 1889 was as below, no statistics for marble being available: granite 9,587,996 cubic feet, valued at $2,503,503.00; and sandstone 1,967,179 cubic feet, valued at $649,097.00.

Rhode Island. Only the granites of this state need consideration from our present standpoint. Near Westerly are quarries of a fine, evenly textured stone of gray or sometimes pink color, that has come to be extensively utilized for monumental work in all our cities and towns. The transportation is both by rail and water, Westerly being at the extreme western border of the state, with direct rail communication to New York and Boston and but a few miles from Long Island Sound. The output of granite for the entire state for 1889 was 2,878,239 cubic feet, valued at $931,216.00.

Connecticut like Massachusetts produces granites, marbles and sandstones. The marbles like those of Massachusetts are white, crystalline granular, in part dolomites and in part limestones. The granites, with the exception of some coarsely variegated gneissoid rocks occurring at Stony Creek, are little used outside of the state. The sandstones, and especially those along the Connecticut River, as at Portland and Cromwell, are very extensively quarried and owing to the ready transportation facilities offered by the river, are extensively utilized in all the Eastern cities, and have even been sent around Cape Horn to San Francisco. These sandstones are brown Triassic stones of the same type as those of Seneca Creek and other points in Frederick county, Maryland, and it is only that they so lie as to offer exceptionally favorable facilities for quarrying and transshipment that the Maryland stone has not thus far proven a more successful competitor. The statistics for the state for 1889 so far as available are as follows: granite 3,835,704 cubic feet, valued at $1,061,202.00, and sandstone 2,821,430 cubic feet, valued at $120,061.00.

New York. This state, like Pennsylvania, yet to be noted, is so situated with reference to the Appalachian system, and comprises so large an area, that its resources are great and varied. Within its borders are to be found quarries of granite and allied rocks, marbles, sandstones, quartzites and slate. The granites, of both red and gray colors, are eminently suited for building, decorative or monumental purposes. The quarries are, however, largely in the northern central part of the state and remote from waterways, so that the stones are little used for general building outside of the state. Dolomitic marbles, coarsely or granular crystalline in structure and utilized only for general building, occur in the southeastern counties of the state. These compare closely with those of Cockeysville in Maryland, and will compete with them on about even terms. In St. Lawrence county are other coarsely crystalline, gray building marbles, which are, however, little used beyond the state limits. Black, gray and variegated marbles suitable for interior decoration occur in the northern and eastern part of the state, but being of a type wholly distinct from any known to exist within the limits of Maryland, may for the present be omitted from consideration. Sandstones and quartzites, suited for building and flagging, occur in inexhaustible quantities widely distributed throughout almost the entire length and breadth of the state, some of the better known being the Potsdam quartzites of St. Lawrence county, the Medina sandstones of Monroe, Niagara and intermediate counties and the so-called "bluestone" or "flagstone" of Albany, Green and Ulster counties. The Potsdam stones are accessible by rail, and the water routes of the Great Lakes; the Medina, also, while the flagstones last named are largely within comparatively easy reach of the Hudson River. Hence all these stones are widely and for the most part favorably known. The slate producing areas are limited wholly to the extreme eastern portion of the state, Washington county alone being a constant producer. The material is of red or green color, and on this account does not enter into direct competition with that of Maryland.

The quarry statistics of the state for 1889 are as below:

Granite	1,515,511	cu. ft. valued at	$ 222,773.00
Marble	1,171,500	cu. ft.	354,197.00
Sandstone	6,490,406	cu. ft.	1,177,822.00
Slate	16,767	squares	81,726.00

New Jersey. This state produces only brown Triassic sandstones, similar to those of Frederick and Montgomery counties in Maryland, which need consideration here. The close proximity of the state to the leading markets, as of those of New York, Philadelphia, Baltimore and Washington renders it possible to transport the quarry product at comparatively low rates, even though such transportation must be made mainly by rail. The Triassic belt extends from the New York state line southwesterly to the Delaware River. The principal quarries are in Passaic, Essex, Hunterdon and Mercer counties. The stone resembles that of Connecticut perhaps more closely than that of Maryland, but nevertheless the general resemblance is so close that as a rule the selling price of the material will be the controlling item in deciding which shall be used.

According to the returns of the 11th census, some 6,010,212 cu. ft. of sandstone were produced during the year 1889, valued at $597,-309,00.

Delaware produces little in the way of building stone except for local use. Certain gabbros and gneisses have been quarried for purposes of rough construction, but do not need consideration here.

Pennsylvania. As noted above the quarry product of this state is large and varied. Singularly enough, however, there is little in the way of granitic rocks that need consideration. Good building marbles and serpentines occur in Montgomery and Chester counties and in both instances the stone so closely resembles that of Maryland that the price at which the material can be put upon the market must be the controlling factor of commercial importance. The Maryland quarries are nearest to the markets of Baltimore and Washington, but those of Pennsylvania to those of Philadelphia and New York. Brown Triassic sandstones, similar in a general way to those of Frederick and Montgomery counties, but of a more uniform brown hue, are quarried at Hummelstown in Dauphin county, and enormous quantities of gray and blue, gray thin bedded sandstones and "bluestones," used for general building and flagging, in Pike, Carbon, Luzerne, Wyoming and Susquehanna counties. With the exception of the "Wyoming Valley" stone, as that of Wyoming county is commercially known, few of the latter find their way beyond the state limits. Blue-black roofing slates, such as must compete with those of Maryland, occur in the southwesterly part of the state, in Berks, Dauphin, Cumberland and Franklin counties, and also in enormous quantities in the northern parts of Northampton and Lehigh counties. For many years these deposits have been systematically worked, the product being used for roofing, billiard tables, sinks and school purposes all over the United States. The statistics given below will convey better than words some idea of the magnitude of the quarrying operations here carried on.

Granite 5,782,887 cubic feet, valued at $623,252.00;[1] marble, statistics not given; sandstone 19,119,357 cubic feet, valued at $1,942,-979.00; serpentine statistics not given; slate 476,038 squares, valued at $1,541,003.00.[2]

Virginia produces granites, sandstones and slates only, and as transportation of the quarry output is wholly by rail and there is little competition in the carrying trade, but little of the material finds its way into the general markets. The granites near Richmond have been used in some of the important buildings of Washington, and the red-brown Triassic sandstones from near Manassas are in demand for the construction of dwellings. The statistics of the state are given below:

Granite 1,073,936 cubic feet, valued at $581,870.00; sandstone 70,800 cubic feet, valued at $11,500.00; slate 30,457 squares, valued at $113,079.00.

North Carolina. With the possible exception of one granite and a few Triassic sandstones this state at present produces nothing finding a market beyond its limits. There are, it is true, in the western half, granites in abundance, and several promising beds of marble, but

[1] It is difficult to say what is included here under the name of granite, since there is scarcely a quarry of true granite within the state limits. Presumably it includes everything not otherwise classified.

[2] Some $370,723 worth used for other purposes, in addition.

so far they have been so little worked that nothing definite can be said regarding them. In the southern central part of the state are beds of brown sandstone, the equivalents of the Triassic beds in the states to the northeast. These have been worked spasmodically and the quarry product shipped to coastal cities including Baltimore and Washington. The total output in 1889 so far as statistics are available is as follows:

Granite 708,267 cubic feet, valued at $146,627.00; sandstone 50,000 cubic feet, valued at $12,000.00.

South Carolina. Although there is an abundance of granite in Fairfield, Richland, Newberry, Lexington, Edgefield and Aiken counties none of the material finds its way beyond the state limits. Material to the value of $55,320.00 is stated to have been quarried in 1896.

Georgia. This state has several quarries of granite, and in its northern portion extensive deposits of coarse crystalline granular building marble. This last named is coming into very general use for building, monumental and interior work, even in cities as far north as Boston. Its consideration is therefore important here. A deep dark gray, nearly black roofing slate also occurs at Rockmart in Polk county which is finding a slight market outside of the state. The statistics for 1889 as given are as below:

Granite 2,425,622 cubic feet, valued at $752,481.00; slate 3,050 square feet, valued at $14,850.00; marble 25,000 square feet, valued at $196,250.00.

The quarries, it should be noted, are all remote from waterways, and transportation is therefore limited to railroads.

Tennessee. In this state only the marbles need consideration from our present standpoint, and these only on the supposition that at some time the proposition may be entertained of opening up quarries in the colored marbles of Carroll and Frederick counties. The Tennessee stones are dark chocolate and white, fossiliferous, and gray and pink crystalline granular limestones. The latter are used both for general building and interior work and the first for interior work only.

There are in addition to the stones above mentioned, certain others from more remote sources which, owing to their peculiar lithological natures, are to be found in all the principal markets of the country. The so-called Bedford stone or Bedford Oolites and the Berea sandstones are of this type. The first mentioned of these is a very pure limestone but differs from those of the states above mentioned in that it is made up almost wholly of minute rounded or oval concretionary grains, often of almost microscopic dimensions. It is of a very light grayish color, sometimes almost buff, soft, very readily workable, and occurs in nearly horizontally lying beds covering a large extent of country. It can therefore be quarried and worked very cheaply, and as it is, on the whole, of a pleasing color and fairly durable nature, it finds a ready market in most of our larger cities.

The second stone mentioned, that of Berea, Ohio, is a fine grained sandstone belonging to the Waverly series of the carboniferous formations. This rock is an ideal " freestone " in so far as this term refers to working qualities, since its even granular structure and not too pronounced lamination permit it to be worked with the greatest facility in any direction. The prevailing colors are light gray to buff, and though from the standpoint of durability no better, nor perhaps so good as many stones nearer at hand, it too, on account of its cheapness and color, finds its way into markets at such a distance as would cause it to be excluded by cost of transportation under less favorable conditions.

Reference in passing should also be made to such stones as are brought to our markets from foreign sources. As a very general rule it may be stated that the stones thus introduced are of a different type, so far as color and texture are concerned, from those produced locally, and that they are brought in in response to the public demand for a greater variety. This is not, however, invariably the case since, as is the case with certain of the Italian marbles, easy quarrying facilities and cheapness of labor enable the producers to put the stone upon the American market at lower rates than the domestic product, notwithstanding the discrepancies of distance and consequent cost of transportation. Naturally a large proportion of the imported materials are marbles since, aside from being most expensive, such are used very largely in the form of thin slabs for veneering, rather than in solid blocks of masonry. There are, however, a few stones of the granitic type, used more particularly for monumental work, which find their way into our markets in considerable quantities. Of the marbles which come to our market we need mention more particularly the deep red and yellow often brecciated varieties from Algeria, the so-called Numidian marbles; the white, blue-gray, often veined, black and yellow mottled varieties from Northern Italy, particularly from Carrara and Sienna; and the green or so-called Verd-antique marbles (serpentines) from Genoa and near Prato. Stones very similar to these last are found in various parts of the United States, particularly in Vermont, but are excluded from competition by the high prices of labor prevalent in America. Stones of this same general nature, but of more uniform green color, occur in Maryland and adjacent portions of Pennsylvania, but though from time to time quarried, have never been worked upon a scale sufficient to exclude the imported material even were the character of the marble the same. Other marbles than those mentioned, that come to us from abroad, are the so-called Formosa and Bougard marbles of Germany and the Griottes of France.

Nearly all of the granitic rocks which reach the American markets from abroad are what are known as monumental stones. With the exception of those that are introduced from nearby sources, as New Brunswick, the cost of transportation is too great to warrant the bringing in of materials that must be sold sufficiently cheap to compete with the native product in ordinary structural work. Among the more important of the granites introduced are the red and gray so-called Scotch granites, from near Peterhead in Aberdeenshire, Scotland. A coarse, porphyritic stone, showing large pink orthoclase crystals in a gray ground mass comes from Shap in Northern England. Of greater interest on account of their beauty are a few types of granitic rocks that have of late been introduced into our markets from near Finspong in Southern Sweden. One of these is a coarse granular aggregate of deep red feldspars and opalescent quartz, forming when polished a strikingly beautiful stone for monumental work, and quite unlike anything now produced elsewhere. There have been also introduced from this region coarse feldspathic rocks belonging to the syenitic type, of a dark blue gray color, sometimes almost black, which are of particular interest on account of the iridescent character of the feldspars. They are quite similar in general appearance to the so-called labradorite rock from Labrador, and well adapted to interior decoration work.

Resumé. We have thus enumerated briefly the possible resources of the coastal states with which Maryland may be profitably compared. It is apparent that the future of the quarry industry must depend then, not so much on the kind of materials since similar kinds are to be found elsewhere, as on accessibility to certain markets, and perhaps an ability to quarry at such rates as will enable her to compete with others, more favorably situated, at a distance. Although placed at a disadvantage so far as relates to actual quarrying through the mantle of decomposition product that covers so much of the outcrops, and through a lack of water transportation, the state is favored by a climate that will permit work out of doors for a much longer period than is possible in the North. Differences in price of labor is also an item which may be taken into consideration.

WEATHERING OF BUILDING STONE.

All stones, as they lie at and near the surface of the ground, are subjected to a number of agencies, in part physical and in part chemical, which result in a more or less complete disintegration, decomposition, or it may be temporary induration of the materials acted upon. Since these changes are due to atmospheric agencies, to the expansion and contraction of ordinary temperatures and to hydration, solution and oxidation brought about through meteoric waters, they are all grouped commonly under the general name of weathering.

Rock-weathering has been going on ever since the first rocks appeared above the ocean level. To its destructive powers we are indebted for not merely the soil, but for the materials which make up the many thousands of feet of conglomerate, sandstone, shale and slate which occupy so large a part of the earth's surface.

The effects of this weathering are to-day visible and the progressive stages readily traceable in many parts of Maryland and in other of the states to the southward.

The views given in Plate XIV show the manner of weathering quite characteristic of granite rocks, particularly where such are traversed by numerous joints. The water percolating over the surface and filtering downward through the joints, brings about a disintegration and decomposition, whereby the sound rock gives way to sand, gravel and clay, all very likely discolored by iron oxides set free through decomposition from the micas and other ferruginous silicates. Since on joint-blocks this weathering, which may well be compared with the rotting of an organic body, would naturally take place most rapidly on sharp edges and corners, so these salients become gradually rounded, and an oval, bowlder-like mass of varying size results, as shown in the Plate XIV. It is thus that there have been formed from the dark colored igneous rocks the so-called "nigger-heads" so common in many parts of the state. It is not necessary to here go into a detailed discussion of the processes and resultant products of rock-weathering. Such a treatment of the matter the writer has given elsewhere.[1] It will be sufficient here to say, that the results of prolonged weathering of granitic and allied rocks is a ferruginous sand and clay; of sandstones a sand, and of argillite and limestones a ferruginous clay. In some instances weathering may be productive of a local induration causing soft and friable stones to become harder and more durable, though this is far from being a general and wide-spread phenomenon. In many instances the preliminary stages of weathering are manifested by a change of color, due to the whitening of the feldspathic constituent, or, as a rule, to the oxidation of included sulphides of iron (pyrite and marcasite) or to a like change in ferrous carbonates or iron-rich silicates. Such changes may or may not be detrimental, according to local conditions. Obviously a yellow or brown stain from oxidizing pyrite on a light surface like that of marble, is unsightly. In many lime and sandstones, however, the ferruginous constituents are so evenly disseminated that the stone,

[1] Rocks, Rock-weathering and Soils, the Macmillan Company, New York, 1897.

on exposure, assumes a uniformly buff or yellowish hue, which is known, commonly, as "mellowing," and which is not at all undesirable. Changes of this kind are limited mainly to light colored sedimentary rocks, and such as have been quarried from below the permanent water level. This for the reason that exposure in the quarry bed above the water level has already brought about the oxidation and color change, so that when quarried and placed in the walls of a building no further change takes place.

But the effects noted above are mainly the products, it may be of geological periods, of years so many as to be quite incomprehensible from a human standpoint. We need consider here only those effects which may be brought about by these same agencies operating throughout a few score or perhaps hundreds of years.

Stone taken from the ground and exposed in the walls of a building is subject to two agencies both destructive and tending toward disintegration. As already noted, the one is physical and the other chemical. During a hot summer day, stones exposed to the direct rays of the sun may become, on the immediate surface, heated to a temperature of even 150° Fahr. On the going down of the sun, a gradual cooling takes place. In the coldest weather of winter the temperature may sink as low as zero. Now, as it is well known, heat causes expansion and cold contraction. Let the reader then picture to himself what here takes place. The mass of the stone is made up of an admixture of mineral particles without definite order of arrangement and all practically in actual contact with one another. As the temperatures rise each mineral expands ever so slightly and crowds against its neighbor; but aside from the unequal expansion of minerals of different species, the process is further complicated by their tendency to expand unequally along their different crystallographic axes. So all through that portion of the stone thus warmed there arises a condition of very unequal tension, which is naturally greater the greater the amount of heat. As temperatures fall a corresponding contraction takes place; but in material so granular and inelastic as stone the particles do not again recover exactly their original relative positions. Minute rifts are opened, not merely between the granules, but also along the cleavage planes of the minerals themselves, so that in time all cohesion is lost and the stone becomes so weak as to fall away to the condition of sand, or as is more commonly the case, absorbs so large an amount of water that when freezing ensues, disintegration results. Since any stone will absorb the most water along the bedding or lamination planes, and since too the stone is weakest, the cohesion of the particles least, along these planes, so it follows that laminated stones, like sandstones, often show signs of scaling on their outer surfaces even after an exposure of but a few years in the walls of a building. It is this form of disintegration which is so conspicuous and unfortunate a feature in many buildings constructed of brown, laminated sandstone, in Baltimore and other cities. Such a tendency may be largely overcome by laying this stone on its natural bed, but any stone whatever its nature is more or less susceptible. Inasmuch as stones are but poor conductors of heat, that is, as the heat penetrates but slowly, and to but slight depths, such a form of disintegration is limited to the immediate surface. Where, however, the disintegrated material is removed so soon as formed, the process may go on indefinitely until a finely carved front or cornice may be entirely ruined.

It follows from the above that, other things being equal, a stone in which the various mineral particles are closely interknit will be more durable than one of granular structure.

One of the most serious of the destructive agencies to which stone in the walls of a building are subjected is the freezing of absorbed water. All stone as they lie in the ground contain more or less moisture or *quarry water*, as it is called, which in time dries out after the stone is quarried. More water is however likely to be absorbed on exposure to rains, and since water in freezing exerts an expansive force equal to some 150 tons to the square foot it may be readily understood that if the amount of moisture contained in the pores of a stone is at all large, serious disintegration may result. It is to this cause that is largely due, as already noted, the scaling and crumbling of the brown sandstone so commonly used in house construction throughout the Eastern United States. Other things being equal again, a stone possessing low absorptive power will be more durable in moist, temperate and frigid climates than one that will absorb a large amount. Figures showing the relative amount of water absorbed by stones of various kinds are given in the following table.

ABSORPTION TESTS I.

Kind of Stone.	Wgt. after drying 24 hours at 212 F.	Wgt. after immersion 24 hours in water. Grams.	Gain in weight. Grams.	Percentage of absorption.
Marble, Cockeysville,	367.15	367.93	0.78	0.212
" "	367.07	367.86	0.79	0.215
Sandstone, Seneca,	313.35	321.28	7.93	2.530
" "	313.75	321.18	7.43	2.368
Granite, Port Deposit,	351.33	352.22	0.89	0.253
" "	341.34	342.00	0.66	0.196
Granite, Woodstock,	340.43	341.31	0.88	0.258
" "	340.45	341.24	0.79	0.232
Gneiss, Baltimore,	354.37	355.07	0.70	0.197
" "	323.36	326.97	3.61	1.116
Sandstone, Taneytown,	320.22	324.05	3.83	1.196
Quartzite, Emmitsburg,	347.58	347.87	0.29	0.083

ABSORPTION TESTS II.

	Wgt. air dry. Grams.	Wgt. after immersion one hour. Grams.	Wgt. after immersion one day. Grams.	Wgt. after immersion one week. Grams.	Gain in wgt. Grams.	Percentage of absorption.
Marble, Cockeysville,	367.25	367.30	367.60	367.60	0.35	0.09
Sandstone, Seneca,	1002.70	1007.70	1010.80	1011.70	8.05	0.07
Granite, Woodstock,	345.00	345.50	345.50	345.55	0.05	nil
Gneiss, Baltimore,	350.70	350.65	350.70	350.67	——	nil
Sandstone, Taneytown,	329.60	330.50	330.90	331.55	1.95	0.59
Quartzite, Emmitsburg,	344.50	344.50	344.50	344.85	0.35	0.10

In the second set of experiments which were conducted by Dr. Mathews, the blocks were all of the same size (two inches cube) as those of the first set, except in the case of the Seneca sandstone, where a block four inches square and one and a half inches thick was employed. The weighings were made after the blocks had been swabbed until no glistening water remained. These tests show that little water is taken up by the specimens beyond that carried after remaining over a year in the warm air of an office. The weather during the experimenting was warm (85°-95° F.), and the humidity was approximately seventy per cent.

The water which comes to the earth in rainfalls is never absolutely pure, but contains a variety of mechanically and chemically admixed impurities. Among the chemically admixed, or dissolved impurities, which are the only ones that need here be considered, carbonic acid is the most widespread and abundant, while in smaller amounts and particularly near large cities there may be traces of hydrochloric and sulphuric acids. These all are capable of exerting a solvent action on the material composing building stone, particularly on lime carbonate. The amount of material that will be dissolved during a single shower may be infinitesimal, or during a year scarcely appreciable. Yet there are many stones, particularly those composed of pure lime carbonate (limestones), or of siliceous granules cemented by lime carbonate, which in time suffer severely. The roughened surface and loss of polish seen so frequently on marble tombstones and exterior work of any kind is usually due to this solvent action of rain water and its dissolved acids.

The adaptability of a stone for structural purposes depends then, in no small degree, upon its weathering qualities, that is to say upon its power to withstand for centuries even, exposure in the walls of a building, without serious discoloration, disintegration or solution. Let us now take into consideration these weathering qualities as displayed by the various types of rocks, although a full discussion of the subject must be left for more comprehensive treatises.[1]

Granites and gneisses possessing very low ratios of absorption (see table above) and being made up so largely of silica and silicate minerals, are very little affected by freezing and solution. The chief causes of disintegration with rocks of this class, are temperature changes, such as produce granulation. Aside from a weakening of the cohesion power between the individual constituents, the feldspars may split up along cleavage lines, and a disintegration follows which may be sufficiently evident to cause small spawls to fall along the

[1] See Rocks, Rock-weathering and Soils, the Macmillan Company, New York, and Stones for Building and Decoration, Wiley and Sons, New York.

joints between the blocks, or perhaps to ruin fine carvings. In some instances deleterious minerals like pyrite may be present in sufficient quantity to cause unsightly discoloration.

All things considered, a fine grained homogeneous rock will be found more durable than one that is of coarser grain. Also a rock in which the individual particles are closely interknit, dovetailed together, as it were, will resist disintegration longer than one that is of a granular structure at the start.

Serpentines are likewise only slightly absorptive and when homogeneous little affected by solution. Nearly all serpentines of such quality as to be used as verdantique marble contain, however, veins and spots of calcite, dolomite or magnesite, and many dry seams. Such rocks, therefore, weather unevenly, lose their polish, and may shortly crack and split along these dry seams when exposed to the weather. These marbles should then be used only where protected from the weather. Crystalline limestones and dolomites (marbles) are extremely variable in their weathering qualities, are likely to carry pyrite, and great care needs always be exercised in their selection. A limestone marble, *i. e.* one composed essentially of lime carbonate, is likely in time to suffer from solution whereby corners become rounded, surfaces roughened and perhaps inscriptions obliterated. The mechanical agencies are here also operative as in granite, so that, as a rule, a stone of this class is less durable than a good granite. The pure white stones are, as a rule, more granular and weaker than the gray and blue gray. Dolomites being less soluble than limestones might at first thought seem promising of greater durability than the limestones. Unfortunately this is not altogether the case, since such stones often possess a more granular structure than do limestones, and hence suffer more from disintegration. Indeed a dolomitic marble can, not infrequently, be distinguished from one of pure limestone, simply from the way it weathers in the natural outcrop. In the case of the dolomite, the surface of the outcrop may be found covered here and there with a sand composed of angular particles which results merely from the mechanical disaggregation of the stone, while in the second case the stone loses almost wholly by solution, and we find it passing superficially into a clay without the production of sand.

The light colors characteristic of most marbles render iron stains peculiarly objectionable, and as pyrite is a very common constituent of such rocks, much care is necessitated in its selection. The ordinary unmetamorphosed limestones, like the deep blue-gray varieties from the Trenton formation are scarcely at all absorptive, and weather fairly well, but their sombre colors are something of a drawback.

FIG. 14.—Photomicrograph of Seneca Sandstone (magnified ten diameters).

Sandstones, on account of the widely varying character of the materials of which they are made up, variation in texture, degrees of porosity, etc., are perhaps as a whole more variable in their weathering qualities than any other class of rocks. In order to fully appreciate this variability, we must remember that we have to do here with what are but beds of indurated sand; that these stones are made up of sand particles held together by simply being closely compacted by finer material, or by means of a cement composed of lime carbonate, iron oxides or silica (see Fig. 14). Where the sand is loosely compacted, or the sand granules are interspersed with much finer, clayey matter, the stone will absorb comparatively large amounts of water and is likely to become injured on freezing. Where the cementing matter is carbonate of lime, rain water trickling over the surface is likely to remove it in solution, leaving the stone to fall away, superficially, to the condition of sand once more. Ferruginous cements are likewise slightly affected, though in a much less degree. The siliceous cement is least affected of all, and provided the amount of induration be the same, a purely siliceous sandstone, cemented by a siliceous cement, is one of the most indestructible of building materials.

Many sandstones have a distinctly laminated structure; that is, their particles are laid down in parallel layers, differing somewhat in size, color and degrees of compactness. The result is that some layers will absorb more water than others and the rock will undergo a splitting up into thin flakes. When such a rock is stood on edge in the walls of a building and the water filters down along these porous layers and there freezes, serious results follow, particularly when the stone is carved. Pyrite is a common constituent of sandstones, particularly the gray varieties, and is likely to produce staining. Its presence needs to be looked for with care. A fine-grained sandstone is often fully as absorptive as one that is coarse, and fully as likely to injure from freezing. A ratio of absorption of more than 4 per cent by weight must be regarded as unfavorable.

Roofing slates or argillites represent as a rule the indurated and otherwise changed argillaceous products of the weathering, or rotting as we might say, of pre-existing rocks. They are in short made up from the most indestructible of natural materials, and on first thought might themselves seem indestructible. Unfortunately those capable of being split sufficiently thin for roofing purposes are not in all cases indestructible, nor are they equally resisting in all parts. In nearly all slates there are to be found dark colored bands or ribbons, containing deleterious minerals like pyrite or marcasite, which are less durable than are the other portions. Moreover the exposed position of slates, when on a roof, is such as to try to the utmost their lasting qualities.

It is here that the extremes of temperature are greatest and the acid action of rains most manifest. It is little to be wondered at therefore that in time the slates become brittle and break, or at least crack, a condition of affairs soon indicated by leaking. A slight fading in color is also a not uncommon feature of many slates, the exact cause of which does not seem to be yet fully apparent.

Methods of Testing Building Stone.

How to ascertain by any series of tests that can be performed in a laboratory the durability or general suitability for construction of any stone is a problem with which builders have long struggled and which is yet far from solution.

In order to appreciate the difficulty in the problem, let us briefly recapitulate.

Stone in the walls of a building is exposed to the chemical action of the atmosphere, the physical actiou of temperature changes and to the crushing and shearing forces incidental to its position in the wall. Satisfactory tests, then, must show the ability of the stone to withstand to-day any of the agencies enumerated above, and must also indicate its ability to withstand them after years of exposure.

A stone which to-day will withstand effectively any of the tests which can be applied may, through the prolonged action of external agencies, become so weakened as to be valueless or so discolored as to be unsightly.

In this chapter it is proposed to give a general summary of the tests which have thus far been applied, to show in how far they are successful, and to make such suggestions as seem pertinent to the subject. It will not be necessary to give in full all the details of these tests, as they have from time to time been made. It will be sufficient, rather, to refer only to such as are historically interesting or of value on account of the results they may have yielded.

(1) Tests to ascertain permanence of color. The change of color in a rock, on exposure in a building, is due mainly to a change in the

form of combination of the iron. Rocks taken from below the water level often carry iron in the form of protoxide carbonate ($Fe\ CO_3$) or pyrite ($Fe\ S_2$). Either on exposure to the air is likely to become oxidized as noted under the head of weathering. The tests that can be applied in the laboratory are made (1st) to ascertain the presence of sulphur, indicating pyrite, and (2nd) the effects of an artificial atmosphere in accelerating oxidation.

The following is the method for this last mentioned test as adopted by Prof. J. A. Dodge.[1]

The specimens tested were rectangular in outline, and from an inch to an inch and a half in diameter. These were dried in a water bath (temp. 212° F.) till all the absorbed moisture was expelled, cooled and weighed. They were then placed upon a set of glass shelves standing in a porcelain pan containing strong muriatic (hydrochloric) acid.

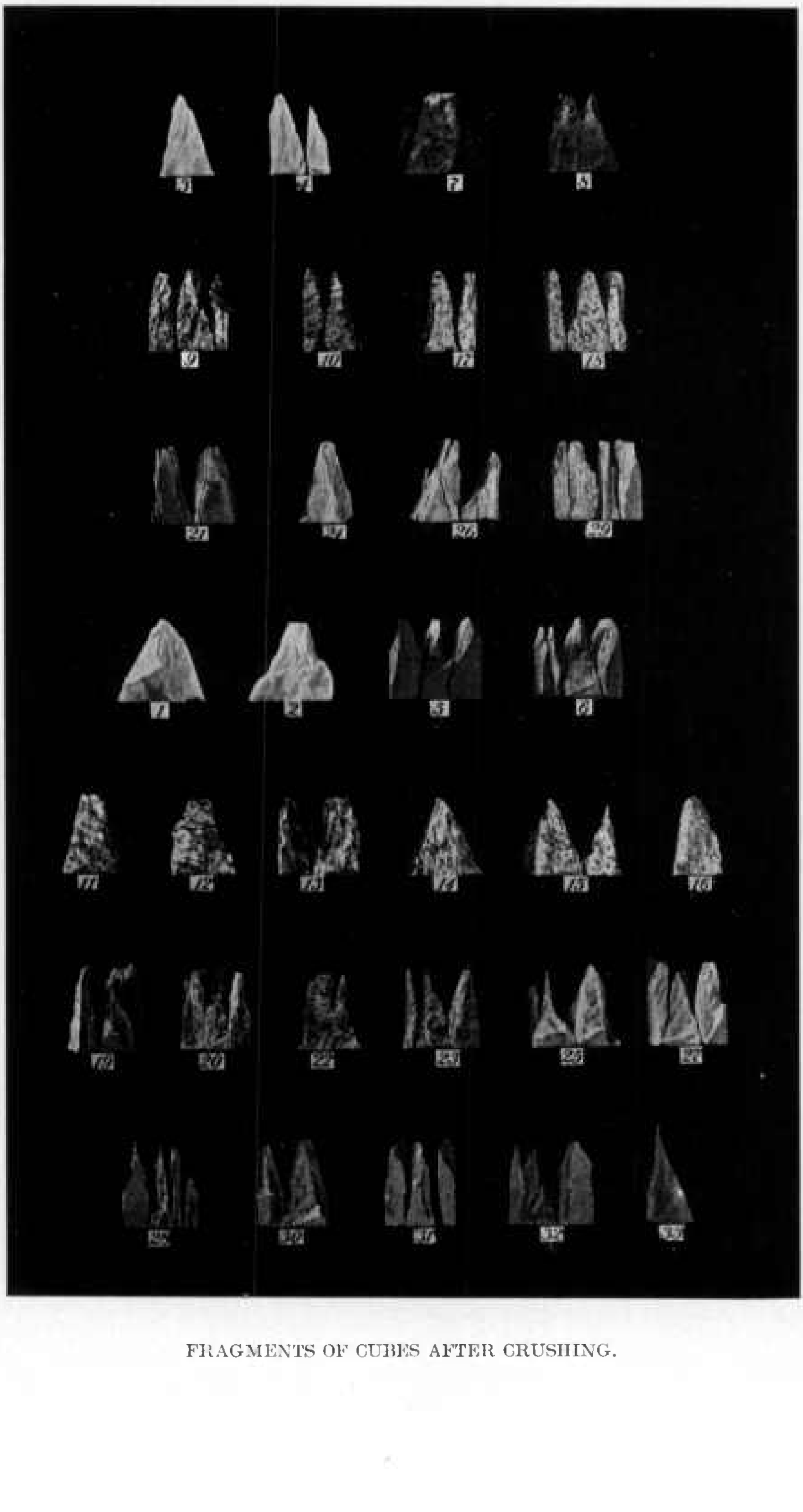
An open bottle containing nitric acid, and one containing hydrochloric acid and black oxide of manganese were placed close by, and the whole covered by a bell glass, forming an air-tight chamber. The fumes from the acids, together with the chlorine fumes from the manganese and hydrochloric acid, filled the chamber and exercised a powerful corrosive and oxidizing effect on the samples. After a period of seven weeks the stones were removed and washed, and the change in color, if any, noted. A similar series of tests was made by Prof. A. Wendell Jackson in 1887 on California building stones,[2] and the efficiency of the method seems fairly well established.

(2) Tests to ascertain resistance to corrosion. The question to be settled here is one relating chiefly to calcareous rocks, to limestones and marbles, or to sandstones containing a calcareous cement. The most satisfactory method available, is apparently that of Prof. Dodge, given in the publication above referred to, which is as follows:

A set of pieces of essentially the same size and shape as those used in the last mentioned tests were selected and dried and weighed in the same manner. These were then suspended by strings in a glass

[1] Final Report Geological and Natural History Survey of Minnesota, vol. i, 1872-82 (1884), p. 185.

[2] Seventh Ann. Report State Mineralogist of Cal., 1887 (1888), p. 205.



FRAGMENTS OF CUBES AFTER CRUSHING.

P. 100 B

vessel of water, not in contact with one another, and a stream of carbonic acid gas was run through the water for several hours at short intervals, so as to keep the water pretty well saturated. The gas was washed before entering the vessel containing the stones, and the water in the vessel was changed every few days by means of a siphon. The action was continued for a period of six weeks, when the specimens were removed, washed in pure water, dried and weighed. The difference between the first and second weighing indicated the amount of material dissolved by the carbonic acid water. In the case of some limestones this was found to be over 1 per cent, though as a rule much less, and in the case of some granites so small as to be scarcely appreciable.

(3) Tests to ascertain resistance to abrasion. Tests of this nature are necessary only in cases where, as in steps and walks, the material is subject to the friction of feet, or where as in dams and breakwaters, it is subject to the action of running water and waves. In some instances it is possible that stones may be so situated as to be subjected to the action of windblown sand. In the selection of Belgian blocks for street pavements, it is naturally an important matter.

The resistance to wear, it may be stated, depends not more, perhaps even less, upon the actual hardness of the constituent particles of a stone, than upon the firmness with which they adhere to one another. This is well illustrated in the case of many sandstones, which though made up of the hard and difficultly destructible mineral quartz, are so friable as to be practically worthless. In making a series of tests of this nature, it is well to consider the uniform as well as actual hardness of the stone. Many stones wear unevenly, owing to their unequal hardness in various parts, and are even more objectionable than though uniformly soft throughout. The serpentinous steatite used many years ago for steps and sills in Philadelphia wore very unevenly owing to the superior hardness of the serpentine over the steatite, causing the former in time to stand out like knots in decaying logs. The power of any stone to resist abrasion can in the writer's belief, and as he has elsewhere[1] stated, be ascertained by observing the manner in which it works under the chisel.

[1] Stones for Building and Decoration, 2nd Ed., p. 445.

Resistance to the action of windblown sand could readily be ascertained by subjecting prepared samples to the action of an artificial sandblast such as is used in the Tilghman process of stone carving. A fairly accurate idea of the resistance to actual wear can be obtained by the rate at which the samples can be ground down on a common grinding bed. It is difficult to perfect this method, since so much depends on the weight applied and the constancy of the supply of emery, sand or whatever may be the cutting medium.

(4) Tests to ascertain the absorptive powers. These tests have a direct bearing upon those which are to follow, since it is largely through freezing of absorbed water that cold produces disintegration. The test of the absorptive powers is therefore one of the most important, and for a single test perhaps the most conclusive of any, as the writer has also elsewhere stated.[1] For reasons noted below it cannot be relied upon altogether.

There are two absorptive tests commonly made; the one to determine the absorption of moisture from a damp atmosphere, and the other the amount of absorption of water through actual soaking. Of the two the last is by far the more important.

The method of determining the absorption from a damp atmosphere as carried out by Prof. Dodge[2] is as follows:

The samples of stone were placed in the cells of a hot-water bath for several days, to expel their hygroscopic moisture, after which they were allowed to cool in desiccators, over sulphuric acid, and weighed. They were then placed upon a set of glass shelves standing in a pan of water, and a tight cylinder was inserted over the shelves, the mouth of the cylinder being sealed by the water, after the manner of a gas holder. The apparatus remained thus in a room the temperature of which was pretty uniform (from 60° to 70° Fahrenheit) for seven weeks, the water being replenished from time to time so as to maintain a constant closure of the cylinder. The stones were then removed to bell-jars in which they were supported over water, and thus taken to the balance and weighed. The samples submitted to this test were somewhat larger than those used for making the determination of specific gravity. They had an average weight of about 70 grammes,

[1] Op. cit., p. 439.

[2] Op. cit., p. 185.

and were roughly shaped. The minimum absorption of moisture .03 per cent of the weight of the stone, is so small in amount as to be practically nothing. The maximum 3.94 per cent of the weight of the stone seems quite considerable. It seems probable that, in the atmosphere saturated with moisture in which they were kept for seven weeks, some of the stones absorbed all the moisture they were capable of taking up, while others by a longer exposure to the same conditions would have shown still higher figures.

In determining the amount of absorption by soaking it is best to have the specimens as nearly rectangular as possible, with faces ground smooth, and for purposes of comparison as well as for possible subsequent use in other tests it is well to have them approximately in the form of 2-inch. cubes. These should be thoroughly dried and weighed, as in the tests previously mentioned and placed in a porcelain dish with sufficient water to cover them and allowed to stand until fully saturated—say a period of 3 or 4 days at least. The cubes should then be carefully removed, the water absorbed from the immediate surface by means of blotting or any form of bibulous paper, and then weighed. The drying and weighing should be accomplished with as little delay as possible, to avoid loss by evaporation. The increase in weight of the cubes is of course due to the water absorbed, and the percentages can thus be readily calculated. The results of a few tests of this nature are given on p. 94. As here shown, and as an almost universal rule, the sandstones are the most absorptive. It may be said further, that the absorption takes place most rapidly and in the largest amounts along the bedding planes. While the absorption of more than 3 or 4 per cent of water is a matter that can as a rule be regarded as detrimental, still it does not necessarily follow that such a stone will suffer most on freezing. This for the reason that a coarsely porous stone will dry more quickly than one of finer grain and moreover the size and shape of the interstitial cavities is such that the expansive action of freezing water finds relief without forcing apart the granules as noted below. It is sufficient to note here that a high rate of absorption is more detrimental to a fine than a coarse grained stone, and also that experiment has indicated that such stones are weaker, will crush under less load, when saturated with water than when dry.

(5) Tests to ascertain resistance to freezing. The power of a stone to resist the action of frost is naturally largely dependent upon its absorptive qualities, as noted above, since it is the freezing of the absorbed moisture that produces disintegration. It has been shown that water passing from the liquid to the solid state, that is to the condition of ice expands in the proportion of 100 to 109. That is to say, an amount of water occupying 100 cubic inches before freezing must occupy 109 cubic inches after. The pressure exerted by this expansion is equal to 150 tons for each square inch of surface. Provided then the interstices of a stone are filled with water, which there freezes, it is easy to see that if there is no other way of relief, the stone must be sadly disrupted. Abundant evidences of this are to be found in any sandstone quarry that has been closed during the winter months without protection. That the result is not more marked than it is, is due to the fact that relief is found in the expansion outward through the pores of the stone. It is for this reason that a coarsely porous stone will often stand a freezing test better than one that is of fine grain, the expansive force finding relief outward through the larger pores.

The importance of the freezing test was early recognized, and several methods have been devised for making such in the laboratory.

Obviously, the best method to pursue is that of nature, and to actually submit the samples to repeated freezings and thawings. Unfortunately this can not at all times be readily done, and moreover nature's methods are sometimes slow, so that other schemes have been proposed with a view of showing the *relative* rather than the actual powers of resistance of different stones. Perhaps the best known method of determining the resisting power of stones is that proposed by Brard which consists in saturating the stone with a solution of sulphate of soda which on crystallizing expands as does water on passing into the condition of ice. A modification of Brard's original process was used by Mr. C. G. Page with reference to the selection of material for the Smithsonian Institution building in Washington.[1]

[1] See Hints on Public Architecture, p. 119, by R. D. Owen, also Stones for Building and Decoration, p. 439.

The process as carried on by Mr. Page consisted in boiling a carefully prepared and weighed cube, for half an hour, in a saturated solution of the sulphate, and then allowing it to dry, during which process the absorbed salt crystallized and expanded. Although the results were found to be not in all cases quite reliable, and evidence was deduced to the effect that the boiling salt solution exercised a chemical as well as mechanical action, still they are not without interest and may be given in tabular form as below.

Materials.	Specific gravity.	Loss in grains.
Marble, close-grained, Maryland	2.834	0.19
Marble, coarse "alum stone," Baltimore County, Maryland	2.857	0.50
Marble, blue, Maryland	2.613	0.34
Sandstone, coarse, Portland, Connecticut	..	14.36
Sandstone, fine, Portland, Connecticut	2.583	24.93
Sandstone, red, Seneca Creek, Maryland	2.672	0.70
Sandstone, dove-colored, Seneca Creek, Maryland	2.486	1.78
Sandstone, Little Falls, New Jersey	..	1.58
Sandstone, Little Falls, New Jersey	2.482	0.62
Sandstone, coarse, Nova Scotia	2.518	2.16
Sandstone, dark, coarse, Seneca Aqueduct, Peters's quarry	..	5.60
Sandstone, Acquia Creek, Virginia	2.230	18.60
Sandstone, 4 miles above Peters's quarry, Maryland	..	0.58
Sandstone, Beaver Dam quarry, Maryland	..	1.72
Granite, Port Deposit, Maryland	2.609	5.05
Marble, close-grained, Montgomery County, Pennsylvania	2.727	0.35
Limestone, blue, Montgomery County, Pennsylvania	2.699	0.28
Granite, Great Falls of the Potomac River, Maryland	..	0.35
Soft brick	2.211	16.46
Hard brick	2.294	1.07
Marble, coarse dolomite, Mount Pleasant, New York	2.860	0.91

The specimens operated upon, it should be stated, were cut in the form of inch cubes. Each was immersed for half an hour in the boiling solution of sulphate of soda, and then hung up to dry, this performance being repeated daily throughout the four weeks which the experiment lasted.

Although as above noted this process is practically abandoned, the series of tests given was productive of certain results which are well worth a moment's consideration. Thus the red sandstone from Seneca Creek, Maryland, with a specific gravity of 2.672, or a weight per cubic foot of 167 pounds, lost by disintegration but 0.70 grains. This was the stone ultimately selected for the Smithsonian Institution building, and the structure as a whole is to-day probably in as good a state of preservation as any of its age in the United States. The second stone, from Acquia Creek, Virginia, with a specific gravity of 2.23, or a weight per cubic foot of but 139.37 pounds, and which lost 18.6 grains is the one in the construction of the White House and the old portions of the Capitol, Interior Department and Treasury buildings. This stone has proven so poor and disintegrates so badly that the buildings are kept in a condition anywise presentable only by repeated applications of paint and putty. The results obtained with hard and soft brick are also very striking; the one weighing at the rate of 138 pounds per cubic foot, losing 16.46 grains, while the harder brick, weighing at the rate of 143 pounds, lost but 1.07 grains. If anything can be learned from the series it is that with substances having the same composition, those which are the most dense—which are the heaviest bulk for bulk—will prove the more durable. The results obtained on coarse and fine varieties of Portland sandstone suggest at least that water would freeze out of the coarser stone, and therefore create less havoc than in that of finer grain, a probability to which I have already referred.[1]

More recently this method has been reinvestigated by Dr. L. McI. Luquer[2] with a view of ascertaining what relation may exist between the sulphate of soda and the freezing methods when both are carried on under the same conditions. In these tests recognition is taken of the fact brought out a generation or more ago to the effect that a hot solution of a sulphate of soda is likely to undergo decomposition and give rise to free alkali (Na_2O) which exerts a powerful chemical effect and weakens the cohesive power of the granules. The method employed, as given in the paper above referred to, was as follows:

The specimens, which had been carefully prepared, brushed, dried and weighed, were boiled in the sulphate of soda for half an hour, in order to get complete saturation. At the end of the half hour it was noticed in every case that the solution was slightly alkaline, although at the start it had been neutral. In order to prevent any continued

[1] Stones for Building and Decoration, 2d ed., p. 438.
[2] Trans. Am. Soc. Civil Engineers, Mar. 1895, p. 235.

chemical action the beakers were emptied, the specimens rapidly washed with water, and the beakers immediately refilled with the neutral sulphate solution. After soaking for several hours the specimens were hung up by threads, and left for 12 hours (during the night) in a dark room.

In the morning all the specimens were covered with an efflorescence of the white sulphate of soda crystals; they were then allowed to soak in the solution during the day and again hung up at night. Efflorescing for about 12 hours and soaking for about the same time constituted a period. The experiments lasted for eight periods, and were conducted in this way in order to make them correspond with those made with freezing water, as in the cold-storage room the specimens could only be changed night and morning.

In two cases the specimens were allowed to effloresce for 36 instead of 12 hours, to insure thorough action of the salt. The experiments thus really lasted for 10 days. It was deemed that eight periods or days were sufficient, as de Thury states that if a specimen is acted on by this method of testing, the effect will be noticed in five days. The general opinion of others seems to be also, that a week or eight days is long enough to obtain good results. During the test the solution was renewed from time to time, and appeared to remain neutral. The temperature of the room varied from 60° to 70° Fahr. (18° to 21° Cent.). Those specimens most affected began to show the disintegrating action of the solution very early in the course of the experiments. At the end of the 10 days the specimens were sprayed with the stream from a wash bottle to remove any adhering particles, washed in water to remove the sulphate of soda, carefully dried in an air bath at about 120° Cent., and weighed again.

The difference between the weights was taken as the loss due to the action of the sulphate of soda. The results are given in tabular form below.

In the experiments of Prof. Dodge[1] carefully prepared cubes the dry weight of which had been previously ascertained were placed in a shallow iron pan, nearly covered with water and exposed to the open air, but in a sheltered place, to freezing and thawing, for a period

[1] Geol. and Nat. Hist. Survey of Minnesota. Final Reports, vol. i, p. 186.

of 8 weeks during February and March. To thaw, the specimens were occasionally brought into a warm room for a few hours. After the exposures, the pieces were carefully examined, then dried for six days and weighed, the difference between the first and second weight indicating the loss of material by the frost action. In the freezing experiments by Dr. Luquer, above referred to, the specimens were allowed to thaw and soak in water during the day, and were hung up and frozen at night. The experiments lasted the same number of periods as did the sulphate tests. The temperature of the cold room in which the freezing was carried on varied from 4° to 10° Fahr. and that of the room in which the soaking and thawing was done, 85° Fahr. After the freezing the specimens were allowed to soak in water for the same period as did those used in the sulphate of soda experiments, after which they were dried and weighed. During the progress of the experiments, it is stated the deterioration was so slight that the effect was scarcely noticeable, the sandstones only showing the effect of a slight residue in the bottom of the pails in which the experiments were performed. Below are given in tabular form the results obtained by both processes. It will be noted the action of the sulphate was by far the most energetic, but it cannot be learned that there is any definite relationship. Hence all things considered it seems best that the sulphate method be abandoned, and the actual freezing test always resorted to.

Results of Experiments with Sulphate of Soda.

No.	Specimens tested.	Original weight in grams.	Loss of weight in grams.	Loss of weight in parts in 10,000.
1	Coarse crystalline dolomitic marble	71.9020	0.0775	10.78
2	Medium crystalline dolomitic marble	93.8861	0.1597	17.01
3	Fine-grained limestone	67.0964	0.1744	25.99
4	Coarse-grained red granite	71.8648	0.1115	15.51
5	Medium-grained red granite	56.4939	0.0370	6.55
6	Fine-grained gray granite	43.5910	0.0225	5.16
7	Rather fine-grained gneiss	61.8687	0.0392	6.33
8	Norite, "Au Sable" granite	35.1173	0.0135	3.84
9	Decomposed sandstone	39.4294	1.9010	482.12
10	Very fine-grained sandstone	37.7760	0.1800	47.65
11	Sandstone	28.0325	0.4070	145.18
12	Pressed brick	37.4025	0.0930	24.86
51	Decomposed sandstone	22.9660	3.7235	1 621.31
52	Sandstone	23.9001	0.1381	57.78

Results of Experiments with Frost.

No.	Specimens tested.	Original weight in grams.	Loss of weight in grams.	Loss in weight in parts in 10,000.
1	Coarse crystalline dolomitic marble......	63.6407	0.0197	3.10
2	Medium crystalline dolomitic marble....	93.9851	0.0216	2.30
3	Fine-grained limestone.................	55.2787	0.0115	2.07
4	Coarse-grained granite..................	52.2787	0.0072	1.38
5	Medium-grained red granite.............	63.4693	0.0112	1.76
6	Fined-grained gray granite..............	58.6149	Very slight, about same as No. 5.	
7	Rather fine-grained gneiss..............	52.7260	Very slight, about same as No. 5.	
8	Norite, "Au Sable" granite............	44.4665	Very slight, less than No. 5.	
9	Decomposed sandstone..................	38.4055	0.2640	68.74
10	Very fine-grained sandstone............	39.5120	0.0420	10.63
11	Sandstone...............................	21.9437	0.0312	14.21
12	Pressed brick...........................	37.1790	0.0255	6.86
51	Decomposed sandstone..................	24.1020	0.0610	25.31
52	Sandstone	20.2285	0.0180	8.89

(6) Tests to ascertain ratio of expansion and contraction. Tests of this nature are of value for the purpose of (1st) making proper allowance for expansion in parapet walls, and similar situations, and (2nd) because through expansion the tenacity of the stone is weakened. As long ago as 1832 Col. Totten, in view of the difficulty of making permanently tight joints even with the strongest cements, instituted a series of experiments to ascertain the actual expansion and contraction of granite, sandstone and marble when subjected to ordinary temperature. He found the rate per inch for each degree of temperature for granite to be .000004825 inch; for marble .000005668 inch, and for sandstone .000009532 inch. That is to say a block of stone one foot in length raised from a temperature of freezing (32°) to that of a hot summer day, say 90°, would be expanded to the amount of .005416 inch or would be 1.005416 inches in length. The amount is apparently trifling yet it produces a weakening effect which is of both economic and geologic significance.

Within recent years some good work in this line has been done under the direction of the Ordnance Department of the U. S. Army.

The method of testing has consisted in placing carefully measured bars of stone in baths of cold water (32° F.), hot water (212° F.), and back to cold water once more. It was noted that in none of the samples tested did the stone quite regain its first dimensions on cooling but showed a slight "permanent swelling." Since this can only mean that the particles composing the stone have separated though ever so slightly, it is an important matter as it necessitates a weakening which is shown by actual pressure tests. The tables given below show the amount of permanent swelling occurring in stone bars of a gauged length of 20 inches.[1]

Granites.

Description.	Amount of permanent swelling. Inch.
From Braddock quarries near Little Rock, Ark. (Light)	.0048
From Braddock quarries near Little Rock, Ark. (Dark)	.0024
From Millbridge, Maine, White Rock Mountain	.0032
From Broad Rock quarry, Chesterfield County, Virginia	.0047
From Korah Station, Virginia	.0048
From Exeter, Tulare County, California	.0019
From Rockville, Stearns County, Minnesota	.0061
From Sioux Falls, Minnesota	.0059
From Troy, New Hampshire	.0021
From Branford, Connecticut	.0043
	.0033
From Milford, Massachusetts	.0071
Mean	.0040

Marbles.

Description.	Amount of permanent swelling. Inch.
Rutland, white, Vermont	.0135
Rutland, white, Vermont (second exposure)	.0029
Mountain Dark, Vermont	.0064
Sutherland Falls, Vermont	.0107
From St. Joe, Searcy County, Arkansas	.0196
From De Kalb, St. Lawrence County, New York	.0055
From Marble Hill, Georgia	.0077
Mean	.0090

[1] Rep. on Tests of Metals, etc., at Watertown Arsenal, U. S. War Dept., 1895, p. 322-23.

Limestones.

Description.	Amount of permanent swelling. Inch.
From Isle La Motte, Vermont	.0081
From Wasioja, Minnesota	.0024
From Fort Riley, Kansas	.0052
From Beaver, Carroll County, Arkansas	.0060
From Mount Vernon, Kentucky	.0075
From Darlington quarry, Rockwood, Illinois	.0114
From Bowling Green, Kentucky	.0077
	.0119
From Bedford, Washington County, Indiana	.0025
Mean	.0070

Sandstones.

Description.	Amount of permanent swelling. Inch.
From Cromwell, Connecticut	.0067
From Worcester quarry, East Longmeadow, Massachusetts	.0022
From Kibbe quarry, East Longmeadow, Massachusetts	.0029
	.0003
From Maynard quarry, East Longmeadow, Massachusetts	.0019
From Kettle River quarry, Pine County, Minnesota	.0018
From Cabin Creek quarry, Johnson County, Arkansas	.0018
From Sebastian County, Arkansas	.0015
From Bourbon County, Kansas, "Bandera stone"	.0017
From Piedmont quarry, Alameda County, California	.0174
From Olympia, Washington	.0035
From Chuckanut, Washington	.0052
	.0148
From Tenino, Thurston County, Washington	.0035
Mean	.0047

(7) Tests to ascertain the fireproof qualities of stone. The expansive power of natural temperatures is but slight in comparison with that induced by the heat of a burning building, which is at times so great that no natural material can be expected to remain uninjured. Several years ago H. A. Cutting[1] made a small series of experiments to ascertain the relative powers of resistance of various stones to artificial temperatures. According to his results the heat resisting capacity of the various stones tested stands in the following order, the

[1] Weekly Underwriter.

first mentioned being the least affected: (1) marble, (2) limestone, (3) sandstone, (4) granite, and (5) conglomerate. The tests were however scarcely sufficient to fully establish any such law. Prof. Dodge, to whose work on the Minnesota Survey reference has already been made, proceeded as follows:

The prepared samples were first heated to a red heat in a muffle furnace, the temperature being raised gradually. Twice each sample was removed with tongs, and carefully inspected to note the effect of heating.

After this heating test the samples, while still very hot but at a temperature below redness, were immersed in a tank of water for a few minutes. The action of the water in causing cracking or crumbling was noted. Such tests are really too severe to be used in any but the most extreme cases since no stone can be expected to pass through such an ordeal unharmed.

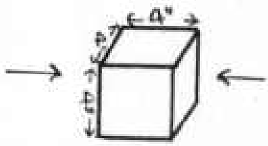


FIG. 15.—Cube for crushing tests.

(8) Tests to ascertain resistance to crushing. This is far the most common test that is applied to stone. Concerning the utility of such tests as usually applied, the writer has expressed himself elsewhere.

The first systematic and really exhaustive series of these tests made in America were those of Q. A. Gillmore, of the Engineer Department, United States Army, whose results were published in the Annual Report of the Chief of Engineers for 1875.

The size of specimens operated upon by Gillmore in the systematic part of his work was that of a two inch cube. During his preliminary experiments he found that at least within certain limits the compressive resistance of cubes, per square inch of surface under pressure increases in the ratio of the cubic roots of the sides of the respective cubes expressed in inches. Thus the actual resistance of a $\frac{1}{2}$ inch cube, expressed per square inch, was about 6,080 pounds, while that of a 4 inch cube, that is one having 8 times the length of side, was

11,720 pounds per square inch. The general conclusions arrived at was that having ascertained from an average of several careful trials the crushing resistance of a 1 inch cube, an 8 inch cube of the same nature should show twice as much resistance per square inch of crushing surface as the 1 inch. This conclusion was not fully borne out by later experiments but enough was gained to show that for purposes of fair comparison it was necessary that all tests be made on cubes of approximately the same size. Gillmore's tests showed also that much depends on the breadth when compared with the height of the specimens tested. Thus he found that while an inch cube of Berea standstone crushed under a weight of 9500 pounds, a block of the same stone 1 inch thick by two inches square, and which contained therefore only four times the amount of material sustained not merely 4 x 9500 or 38,000 pounds but 76,000 pounds. When the height or thickness of the specimen was doubled, so as to have the form of a two inch cube it sustained but 50,000 pounds, and when the height was increased to twice that of the width, or base, it sustained only 44,000 pounds.

Gillmore further found that there was a great difference in the results obtained by crushing between plates of various kinds of material as wood, leather, lead and steel, in every case the tests between steel plates yielding the highest results, a fact which was shown to be due to the lateral spreading action of the other substances mentioned. As a result of these and other trials which need not be given in detail here it seems best that pressure tests be made on two inch cubes, the faces of which have been carefully sawn or ground so that no incipient fractures are developed, and those which are to come in contact with the steel plates rubbed with a very thin coating of plaster of Paris to fill in all inequalities. In the process of testing it is customary to note (1st) the number of pounds registered by the crushing machine when the stone first begins to show signs of fracture, and (2nd) the number registered when it actually crushes. Both of these phenomena are noted in the accompanying tables (p. 145, 156, 164).

The result of many experiments has been to show that most laminated or bedded rocks will bear a greater pressure in a direction at right angles to their bedding than parallel thereto. That is, a block will stand more if laid on its natural bed than if stood on edge. This result may not always appear in a small series of tests owing to sundry imperceptible differences in the specimens tested, but it is nevertheless true in a general way.

Study of the results of large numbers of tests that have been made at periods extending over many years have shown that the results of recent tests are much higher than those several years ago, even on the same class of material. This result, which is simply due to the perfection to which the methods have been brought, is so great that very unfair deductions may be drawn regarding the relative strength of materials tested at different times under perhaps different conditions. In fact there are few things more misleading than a tabulated statement of crushing strengths, made at intervals covering many years, on cubes of varying sizes, and under conditions which are not stated.

It is interesting to note the form assumed by the fragments as a result of crushing.

As a rule, a perfectly homogeneous rock gives rise to conical or pyramidal fragments according as the stone is friable, of a pronounced granular structure like sandstone, or compact as are most granites. Stones crushed on edge naturally split up into flakes or slabs. In the plate herewith given (Plate VI) are shown the shape of the fragments formed during the tests tabulated. (See p. 113.)

In all this work of testing the strength of stone it is well to remember that stones as a rule are apparently weaker when saturated with moisture than when dry. It is true that we have not at hand to-day sufficient data for proving this conclusively, but such data as are at hand are more than merely suggestive. Thus MM. Tournaire and Michelot have shown[1] that cubes of chalk three decimeters in diameter crushed wet under a pressure of but 18.6 kilograms; but when air dried under 23.5 kilograms and when stove dried under 86.2 kilograms. Delesse's experiments on 5 centimeter cubes of chalk and the "calcaire grossier" found that the chalk when wet crushed under a pressure of 12.9 kilograms; when air dried 23.6 kilograms, and when

[1]American Journal of Science, 3rd series, vol. xvi, 1878, p. 151.

stove dried 36.4 kilograms. The limestone (calcaire grossier) crushed when wet under 24.35 kilograms, when air dried kilograms, and when stove dried under 42.7 kilograms. Inasmuch as stones in a foundation are subject to periodic or perhaps constant saturation these facts are worthy of consideration.

It is well to note here too that the effect of temperature changes upon stone is weakening. In the tests made by the Army Engineers to which we have already referred[1] it was found that samples which had been submitted to the hot and cold water tests to ascertain their coefficient of expansion and contraction had suffered to a remarkable degree. The average result showed that the stones from the water baths lost in strength on an average 34.9 per cent, the granites, after passing through both hot and cold water tests, possessing but 83.7 per cent their original strength; the marbles 46.2 per cent; the limestones 58.8 per cent, and the sandstones 66.9 per cent.

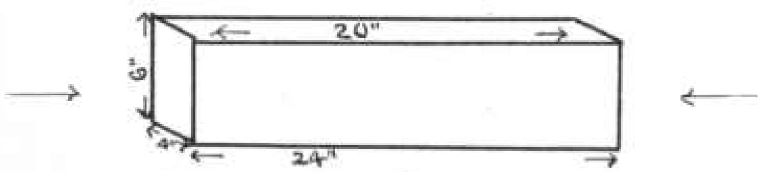


FIG 16.—Bar for expansion tests.

Tests on bricks made by the United States Army Engineers showed that the wet samples had as a rule but 85 per cent the strength of the dry ones, the greatest loss in strength occurring in medium hard and hard brick.

(9) Tests to ascertain elasticity of stone. Tests to ascertain the elasticity of stone when subjected to compressive and transverse strains, have also been made by the United States Army Engineers, and the results obtained may well be noted briefly here, though for details the reader is referred to the original publications.[2]

The tests of elastic properties under compression were made upon prisms 4-in. by 6-in. by 24-in., the loads being applied parallel to the

[1] Report on Tests of Metals, etc., 1895.

[2] Report of the Tests of Metals, etc., made at Watertown Arsenal. Years 1890, 1894 and 1895, Washington, D. C.

direction of the long sides (see Fig. 16), the compressibility being measured by means of a micrometer. It was found here, as in the tests for ascertaining expansion that the stones shortly developed a permanent "set," from which they did not recover during the period of time over which the observations were extended.

COMPRESSIVE ELASTIC TESTS.

	APPLIED LOADS.		20″ IN GAUGED LENGTHS.	
	Total pounds.	Per square inch pounds.	Compression inch.	Set inch.
Granite, Milford, Mass	215,460	9,000	0.0229	.0015
Granite, Troy, New Hampshire	243,600	10,000	.0411	..
Granite, Troy, New Hampshire	219,240	9,000	.0379	.0062
Marble, Cherokee, Georgia	144,960	6,000	.0133	..
Marble, Cherokee, Georgia	48,320	2,000	.0037	.0006
Limestone, Mount Vernon, Kentucky	59,832	2,400	.0182	...
Limestone, Mount Vernon, Kentucky	2,493	100	..	.0032
Sandstone, East Long Meadow, Mass	96,400	4,000	.0554	..
Sandstone, East Long Meadow, Mass	2,410	100	..	.0136

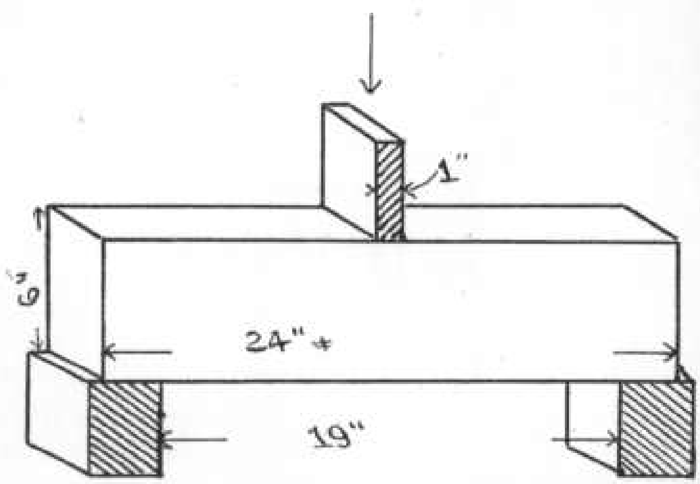


FIG. 17.—Bar for elasticity tests.

The transverse tests were made on similarly prepared prisms, supported at the ends, the load being applied at the middle as shown in Fig. 17. In the table below is given the results of a few selected tests, as determined by the authorities referred to, the term modulus of rupture signifying the weight in pounds under which the bar breaks; only the maximum results are tabulated.

TRANSVERSE TESTS.

Pink Granite from Milford Pink Granite Company, Boston, Mass.

No. of tests.	Distance between end supports.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture.
	Inches.	Inches.	Inches.	Pounds.	Pounds.
203	19	4.03	6.03	9,020	1,745

Granite from Pigeon Hill Granite Company, Rockport, Mass.

No. of tests.	Distance between end supports.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture, R.
	Inches.	Inches.	Inches.	Pounds.	Pounds.
204	19	4.03	6.02	12,320	2,404
205	19	4.01	6.06	12,450	2,416

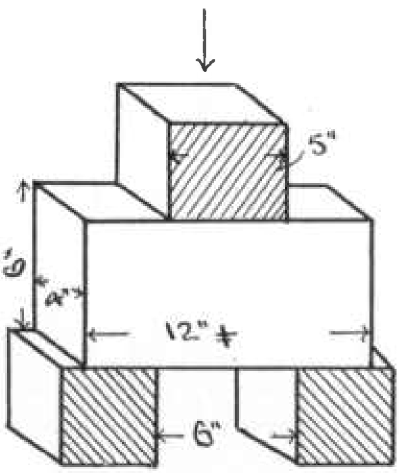


FIG. 18.—Bar for shearing tests.

(10) Tests to ascertain resistance to shearing. The term shearing as used in geology includes a strain due not merely to pressure in one direction, but also those due to pulling or thrusting in all directions up to those perpendicular to the first. It is a form of strain likely to be brought to bear on stone in many parts of a building, bridges, etc., and is by no means unimportant. As performed by the Army Engineers the test consists in subjecting prepared prisms supported at each end by blocks 6 inches apart, to pressure applied by means of a "plunger" having a face 5 inches wide, there being then a clearance space of half an inch between the sides of the plunger and the blocks on each side, below (see Fig. 18).

The results of a few experiments of this nature are given below. It is worthy of note that "before the shearing strength was reached during the tests, tension fractures were developed on the under side of the stone midway the 6-inch free span, and there were instances in which longitudinal fractures opened in the ends of the stones, corresponding to shearing along the grain in the tests of timber."

NATURAL STONES.—SHEARING TESTS.

Stones from Charles River Stone Company, Boston, Mass.

No. of tests.	Description.	Shearing dimension.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength. Total.	Shearing strength. Per square inch.	Surfaces sheared.
		Inches.	sq. in.	lbs.	lbs.	lbs.	
240	Milford granite, Milford, Mass........	4.02 x 6.03 x 2	48.48	24,800	108,400	2,236	one
241	" " " "	4.02 x 6.01 x 2	48.32	27,300	138,800	2,872	two
242	Branford granite, Branford, Conn.....	4.04 x 6.01 x 2	48.56	18,900	93,500	1,925	one
243	" " " "	4.03 x 6.01 x 2	48.44	19,600	84,400	1,742	one
244	Troy granite, Troy, New Hampshire...	4.03 x 6.00 x 2	48.36	29,900	107,900	2,231	one
245	" " " " " ...	4.06 x 6.02 x 2	48.88	34,400	107,400	2,197	one
246	Maynard stone, E. Long Meadow, Mass.	3.99 x 6.01 x 2	47.96	25,800	53,700	1,120	one
247	" " " " "	4.02 x 6.00 x 2	48.24	19,900	62,100	1,287	two
248	Worcester stone, E. Long Meadow, "	4.00 x 6.00 x 2	48.00	22,900	66,400	1,383	two
249	" " " " "	4.00 x 5.98 x 2	47.84	26,200	52,700	1,102	two
250	Kibbe stone, East Long Meadow, Mass.	4.00 x 6.00 x 2	48.00	25,100	47,600	992	two
251	" " " " "	4.00 x 6.00 x 2	48.00	29,400	62,800	1,308	one
252	Southern marble, Marble Hill, Georgia.	4.02 x 6.00 x 2	48.24	26,700	56,100	1,163	one
253	" " " " "	4.02 x 6.00 x 2	48.24	30,300	72,400	1,501	one
254	Tuckahoe marble, Tuckahoe, New York.	4.02 x 6.01 x 2	48.32	29,850	75,100	1,554	one
255	" " " " "	4.02 x 6.00 x 2	48.24	35,700	68,800	1,426	one

NATURAL STONES.—SHEARING TESTS.

Pink Granite from Milford Pink Granite Company, Boston, Mass.

No. of test.	Shearing dimensions.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength. Total.	Shearing strength. Per square inch.	Surfaces sheared.
	Inches.	sq. inch.	Pounds.	Pounds.	Pounds.	
262	6.01 x 4.02 x 2	48.32	38,300	88,200	1,825	one

Granite from Pigeon Hill Granite Company, Rockport, Mass.

No. of test.	Shearing dimensions.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength. Total.	Shearing strength. Per square inch.	Surfaces sheared.
	Inches.	sq. inch.	Pounds.	Pounds.	Pounds.	
263	6.05 × 4.00 × 2	48.40	45,400	99,100	2,047	..
264	6.01 × 4.00 × 2	48.08	38,600	50,600	1,052	..

(11) Tests to ascertain the specific gravity. The determination of the specific gravity of a stone, or its weight when compared with an equal volume of water, is of interest, and sometimes of practical importance. Of two stones of the same mineral nature, the one having the highest specific gravity, that is the greatest weight bulk for bulk, will be the least absorptive, and hence as a rule the most durable. Moreover the specific gravity determination affords an easy method of determining the weight of any stone per cubic foot. The weight of a cubic foot of distilled water, at a temperature of 4° C., is 62.5 pounds. Hence, if we find that a stone has a specific gravity of 2.65, that is to say is 2.65 times as heavy as water, we get its weight by simply multiplying 62.5 by 2.65 which gives us 165.62, which is the average weight per cubic foot of granite. Specific gravity tests are made by carefully weighing a small piece of the rock in the air, and then weighing it again in water, the weight in the last case of course being less. The figures representing the weight in air divided by those representing the loss of weight in water, give the specific gravity. It is customary in making the weighings to have the rock fragment suspended to the arm of the balance by a fine wire, or hair, so as permit of its being readily immersed in water for the second weighing. In very accurate determinations the vessel of water containing the fragment should be placed upon the bell jar of an air pump and the air exhausted in order to remove the air from and admit the water to the pores of the stone.

The Testing of Roofing Slates.

The condition of exposure under which slates on a roof are placed are such as to require a slight modification of the tests as above outlined.

Obviously the matters of toughness and permanency of color are of greatest importance. The first is readily ascertained by direct tests made on the fresh slates, and on samples which have been submitted to the corrosive action of acids. The matter of permanence of color is not however so easily solved, and indeed as yet the cause of the fading of some of our slates is not well understood.

The best series of tests that, so far as the writer is aware, have yet been inaugurated, are those of Prof. Mansfield Merriman,[1] from whose paper the facts given below are mainly derived. The tests here quoted were made wholly on Pennsylvania materials. Others made on Peach Bottom materials are quoted on pp. 228-231.

The strength and toughness of slate, writes Prof. Merriman, are important elements in preventing breakage in transportation and handling, as well as in resisting the effect of hail, or of stone maliciously thrown upon the roof. They are also brought effectively into play by the powerful stresses produced by the freezing of water around and under the edges. Porosity is not a desirable property, for the more water absorbed the greater the amount of disintegration through freezing. Density tests are of value, since the greater the specific gravity of one of several similar substances, the greater is its strength. Hardness may or may not be a desirable quality, accordingly as it is related to density or to brittleness. Lastly a test for corrodibility, or the capacity of being disintegrated by the chemical action of smoke and of fumes from manufactories, is desirable.

(1) Strength and Toughness.—The tests were made upon selected pieces 12 inches wide, 24 inches long and varying from $\frac{3}{16}$ to $\frac{1}{4}$ of an inch in thickness. The pieces were supported in a horizontal position, upon wooden knife edges 22 inches apart and the loads were applied upon another knife edge placed half way between the supports. This load being applied by means of sand running out of an orifice in a box, at the rate of 70 pounds per minute, the flow being checked by means of an electric attachment the moment rupture took place. The deflection or bending of the slate in the pieces tested was sufficiently great to permit of easy measurement, and both the amount of bending —indicating toughness—and the actual strength of the slate could

[1] Trans. Am. Soc. of Civil Engineers, vol. xxvii, 1892, pp. 331-349.

be thus ascertained by a single test. The test of specific gravity of slate and the porosity are made in the same way as with other stone.

(2) Corrosion by Acids.—In making these tests very dilute solutions were prepared, consisting of 98 parts water, 1 part of hydrochloric acid and one part of sulphuric acid. In this solution pieces of slate some 3 x 4 inches in size were immersed for 63 hours each, after careful weighing. At the expiration of this time they were removed, allowed to dry for two hours, and again weighed, the differences between the first and second weighing of course representing the amount of corrosion.

(3) Softness or Capacity to Resist Abrasion.—This was determined by simply holding a weighed block of slate some 4 x 4 inches against a grindstone under a constant pressure of 10 pounds. The table below is given to show the mean results of the tests above enumerated, on certain Pennsylvania slates, as made by the authority quoted. The general conclusions adopted as a result of these tests are also given.

MEAN RESULTS OF PHYSICAL TESTS.

Property.	Measured by	Albion slates.	Old Bangor slates.	Mean of both.
Strength	Modulus of rupture, in pounds per square inch	7,150	9,810	8,480
Toughness	Ultimate deflection, in inches, on supports 22 inches apart	0.270	0.313	0.291
Density	Specific gravity	2.775	2.780	2.777
Softness	Weight in grains, abraded on grindstone under the stated conditions	80	128	104
Porosity	Per cent of water absorbed in 24 hours, when thoroughly dried	0.238	0.145	0.191
Corrodibility	Per cent of weight lost in acid solution in 63 hours	0.547	0.446	0.496

Conclusions.—The above investigation seems to indicate the following conclusions regarding the soft roofing slates of Northampton county, Pennsylvania:

1. Slates containing soft ribbons are by common consent of an inferior quality, and should not be used in good work.

2. The soft roofing slates weigh about 173 pounds per cubic foot,

and the best qualities have a modulus of rupture of from 7000 to 10,000 pounds per square inch.

3. The stronger the slate, the greater is its toughness and softness, and the less is its porosity and corrodibility.

4. Softness, or liability to abrasion, does not indicate inferior roofing slate; but, on the contrary, it is an indication of strength and good weathering qualities.

5. The strongest slate stands highest in weathering qualities, so that a flexural test affords an excellent idea of all its properties, particularly if the ultimate deflection and the manner of rupture be noted.

6. The strongest and best slate has the highest percentage of silicates of iron and aluminum, but is not necessarily the lowest in carbonates of lime and magnesia.

7. Chemical analyses give only imperfect conclusions regarding the weathering qualities of slate, and they do not satisfactorily explain the physical properties.

8. Architects and engineers who write specifications for roofing slate will probably obtain a more satisfactory quality if they insert requirements for a flexural test to be made on several specimens picked at random out of each lot.

9. Although the field of this investigation is probably not sufficiently extended to fully warrant the recommendation, it is suggested that such specifications should require roofing slates to have a modulus of rupture, as determined by the flexural test, greater than 7000 pounds per square inch.

Probably more can be learned regarding the lasting powers of a slate by microscopic methods than in any other class of rocks. As the writer has elsewhere noted,[1] the roofing slates occupy a very interesting position in the lithologic series. Originally formed as a fine silt on a sea bottom, they owe their fissile properties not to sedimentation but to squeezing and shearing forces such as are incidental to the formation of mountain chains. But this shearing, while developing schistosity, or cleavage, has also brought about other structural modifications in the slate which, although not so manifest,

[1] Trans. Am. Soc. of Civil Engineers, vol. xxxii, 1894, p. 540.

are nevertheless of great importance. If we examine a thin section of a slate under the microscope we shall find that the individual particles of quartz and feldspar, etc., of which they are composed, are all arranged with their longer axes parallel with each other and with the direction of cleavage. In fact it is to this cause that the finely fissile nature of the slate is largely due. But this is not all. Pressure always causes heat, and since all rocks lying in the ground contain more or less moisture, the rock becomes permeated with warm or hot solutions which may be productive of partial solution and recrystallization. In fact, our roofing slates pass by insensible gradations into crystalline schists. So far as the writer's experience goes, the greater the amount of crystallization, that is the more nearly the slates approach the crystalline schists in structure and composition, the tougher and more durable they are likely to be. It is unfortunate that this crystallization interferes to some extent with the fissile property, the slates of this nature yielding thicker slabs, and with less even surfaces. Such, while more desirable, demand increased strength in roofing timbers. The point to be made here is, however, that the microscope, in showing the crystalline condition of the slate, the presence or absence of pyrite, or of free carbonates of lime, iron or magnesia, such as are likely to be corroded by rains, will enable one to draw some inference regarding its lasting power. A chemical analysis shows what the slate contains, but it does not show the form of combination of the various elements.

AN ACCOUNT OF THE CHARACTER AND DISTRIBUTION OF MARYLAND BUILDING STONES

TOGETHER WITH

A HISTORY OF THE QUARRYING INDUSTRY

BY

EDWARD B. MATHEWS.

INTRODUCTION.

The rocks of the state of Maryland present many varieties of excellent building and decorative stones. The greater amount of the product is obtained from that portion of the state north of Washington and east of Harpers Ferry, W. Va., which has been termed the Piedmont Plateau, and which includes some of the oldest rocks found in the state. The central location of this area, traversed by two main railroad lines and several more local ones, places it within convenient distance of the prominent cities and towns of the Middle Atlantic coast and renders the products both valuable and available wherever the local conditions are otherwise favorable. Counteracting the value of this central location, however, is the fact that the state of Maryland represents but a section across a series of geological formations, which are present in Pennsylvania and Virginia, where there are offered similar opportunities for quarrying building stone. In some instances operations were commenced in these areas earlier than in Maryland, with the result that trade has been diverted to neighboring states, which might be gained for Maryland by more energetic and intelligent action on the part of the local operators. At the present time the operations in the area are in no wise commensurate with the supply of material at hand, and the demand which might be developed if sufficient forethought and care were expended to make the output uniformly and economically quarried.

The rich variety in the rocks adapted to structural and decorative purposes renders a description of each variety out of the question, and it becomes necessary to treat the occurrences under the following heads: I. The Granites and Gneisses. II. The Marbles, Serpentines and Limestones. III. The Quartzites and Sandstones. IV. The Slates and Flags.

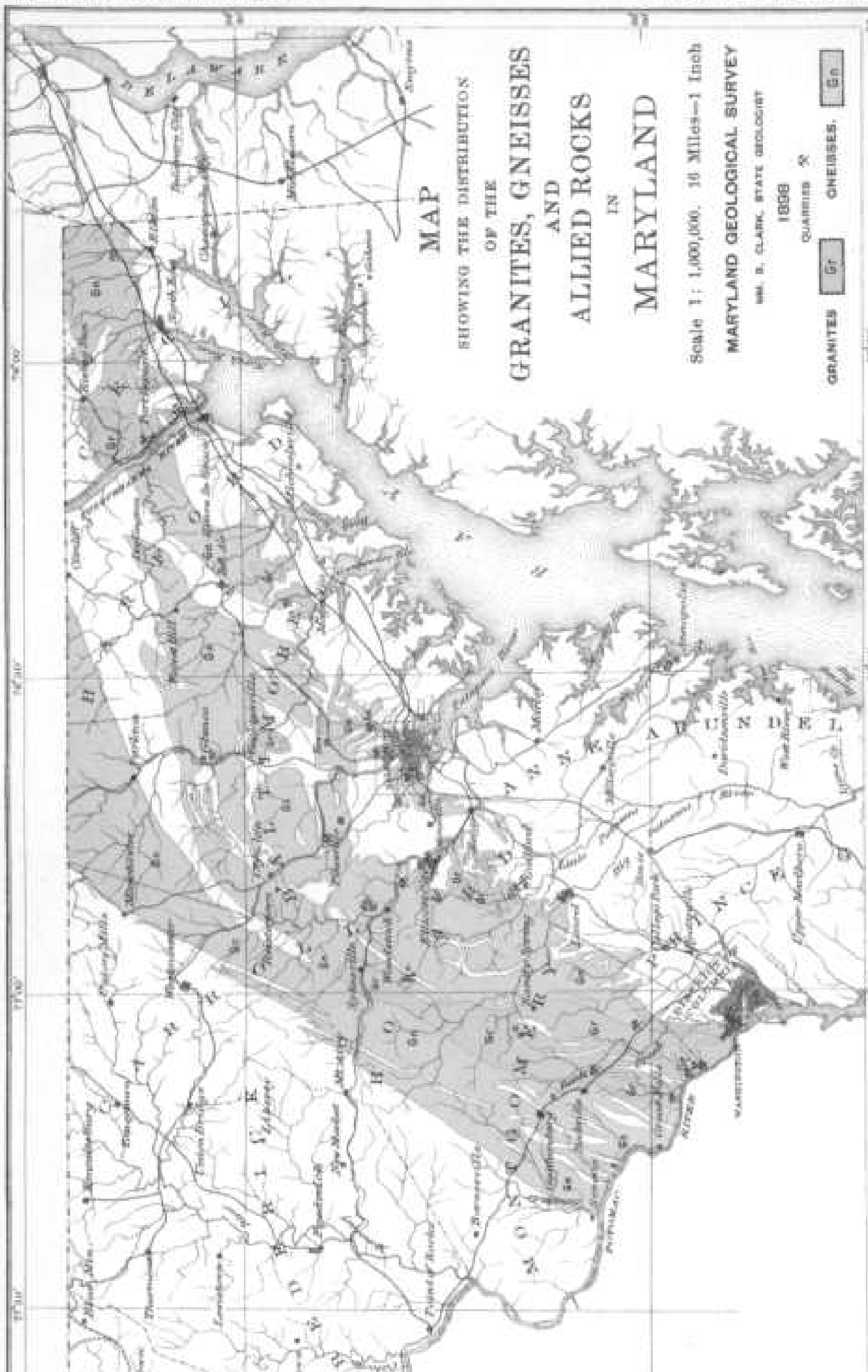
Previous Publications.

The bibliography at the end of this chapter is the somewhat dry expression of the amount of study which has been carried on regarding the building stone products of the state, their geological occurrence, properties and industries. From the books and papers therein enumerated one may glean the following resumé of the results which have been accomplished.

The earliest reference of scientific value to the quarrying of Maryland stone is found in a paper by H. H. Hayden (1), published in 1811. In this very rare and interesting report we learn, that, at the time of writing, the stone "a mile and a half from Baltimore" (location of the present quarries on Jones' Falls) was regarded as "highly valuable and useful in various branches of masonry," and that it was "quarried on both sides of Jones' Falls, to considerable advantage to the proprietors."

Eight years later the Rev. Elias Cornelius (2), after an extended trip through the southern states from Boston to New Orleans and return, gave a summary of his observations on the mineralogy and the geology of the country traversed to Professor Silliman, who published the same in the first volume of his journal. This letter gives the earliest account of the "Potomac Marble" which has been found in any scientific journal, and furnishes information concerning the cost of the original columns in the old Hall of the House of Representatives in Washington, as well as the name of the man who first brought this peculiar rock into use.

The next reference to the quarries of Maryland is found in a paper by Mr. William E. A. Aikin (3), who was at that time Professor of



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Natural Philosophy and Chemistry in the Mount Saint Mary's College in Emmitsburg. In this paper reference is made to the fact that "the granite may be well seen in the neighborhood of Ellicott's Mills, where there are extensive quarries that furnish vast quantities for the Baltimore market," and the fact is noted that "at one place [Ijamsville?] quarries have been opened and furnish a tolerable, coarse roofing slate."

Mention is also made of the quarries in the "Potomac marble" and of many others about Frederick and Hagerstown while the author notes that "a few miles east of Hagerstown, the exact spot I am not acquainted with, this stratum [Shenandoah limestone] includes a bed of white and perfectly fine grained limestone, which is quarried for white marble, and answers well for that purpose."

In Ducatel and Alexander's "Report on the projected survey of Maryland," published in 1834 (4), there is a summary of the existing industries dependent on the natural resources, and a plea for greater information concerning them. In this summary there are brief and incidental references to the granites of Port Deposit and Ellicott City; to the Seneca and Sugarloaf sandstones; to the slates of central Maryland; and to the marbles of Point of Rocks, Carroll county and Boonsborough. The total amount of information, however, would scarcely fill a page, and the references are of little more than historical value. From the date of this earliest report until 1836 the Geologist and Engineer were so busy with the survey and study of the features of eastern and southern Maryland that no reference is made to the structural materials of the northern tier of counties before the publication of the "Report on the New Map of Maryland," in 1836 (5). In this paper attention is called to the sedimentary origin of the Baltimore gneiss, the peculiar weathering of the granites at Woodstock, and the probable source of the pebbles in the "Capitol or Potomac breccia." Succeeding reports of Ducatel and Alexander give a few more details in the discussion of the resources of the different counties, which may be found as follows: Cecil and Montgomery in the report for 1837 (6); Harford and Baltimore in that for 1838 (7); Frederick and Carroll in that for 1839 (8); and western Maryland in the last for 1840 (9). The most important work on the building stones of the state published prior to the war is found in a Report of the Board of Regents of the Smithsonian, presented to the Senate in 1849. This contains, besides many letters showing the price of stone and the state of the industry at that time, the following reports: One by Dr. Charles G. Page (10) "To the Building Committee of the Smithsonian Institution on the action of frost upon certain materials for building"; another by Mr. James Renwick, Jr. (11), entitled "Report to the Building Committee of the Smithsonian Institution," which deals with the quality and quantity of serviceable stone exposed along Seneca Creek; and two by Dr. David Dale Owen, entitled a "Report on the Baltimore county quarries" (12), and a "Report on the sandstones of the Potomac" (13). These give the first accounts by geologists and architects who visited the Maryland quarries to study their ability to supply good structural materials in large quantities.

Somewhat later W. R. Johnson (15) used the facts published in the preceding reports, together with information furnished by Robert Mills and by Mr. Dougherty in his comparison of the strength and durability of foreign and domestic building materials. His summary includes practically all of the pressure test results which had been obtained up to that time. Many discrepancies appeared which the author thought conformed to the law that there is "a direct relation between the power of resistance of a cube and the product of the *area of the base multiplied into the cube root* of that area." The law has not been accepted and the paper is chiefly of historical value through reference to papers which are now unobtainable, since many of the figures therein contained are not comparable with those obtained by the testing made in recent years under better conditions.

Prof. Chas. T. Jackson (16) visited the marble quarries at Texas in 1859 at the request of one of the operators, and on his return to Boston gave a brief account of the stone of the quarry visited, and drew comparisons between it and the stone from a neighboring quarry, which had been accepted for the extension of the General Post Office Building in Washington. The report is short, but contains figures representing the specific gravity, weight per cubic foot, crushing strength and chemical composition of two dolomites and an "alum stone."

Tyson (17) was the first to give a systematic account of the materials grouped in this report as building stones or structural materials. This appeared in the appendix to his first report, entitled "Mineral resources of Maryland." The marbles are divided into three classes with the accessory "verde antique" and "Potomac marble" while numerous details are given regarding the granites, sandstones, slates, and flags, which are found in the state. Emphasis is laid on the availability of the tidewater granites and upon the slates of Harford and Frederick counties. The total discussion, however, is not more than eight pages long.

The state report of 1865 (18), prepared by a select committee of the legislature, gives a somewhat more extended account of the resources of the state, as then known. It represents a compilation of previous work rather than the results of new investigations in the area. It is based in great measure on the work of Tyson.

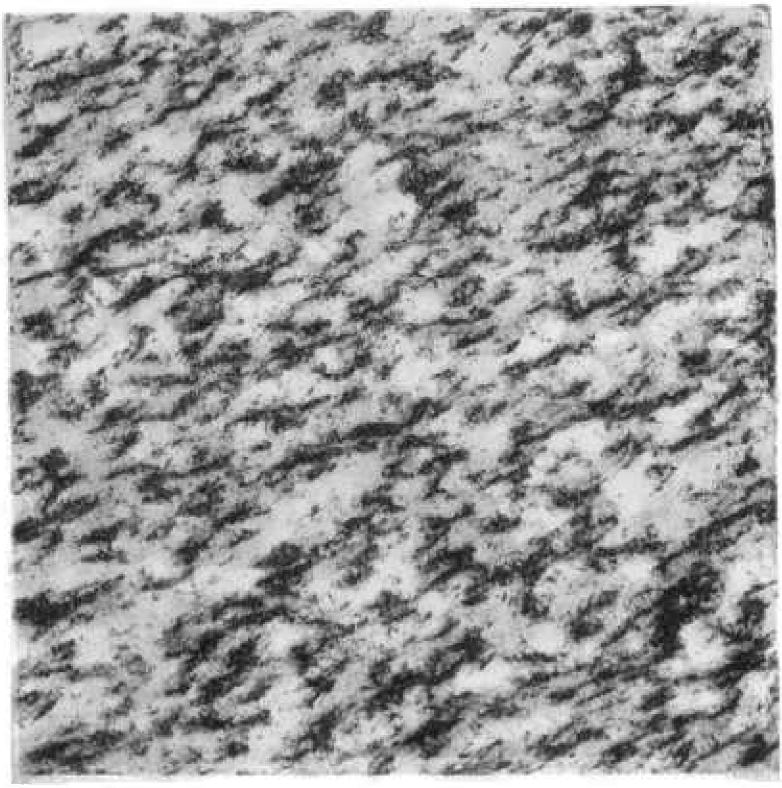
Professor Genth's (20) report on the Broad Creek (Harford county) serpentine, published in 1875, is perhaps the first special report calling attention to the availability of that stone for structural and decorative purposes. Although the geological interpretation of the area is open to question the paper remains of value from its descriptions of the stone and the chemical analyses therein presented.

The well known "Report on the Compression Strength, Specific Gravity, and ratio of Absorption of the Building Stones in the United States" by Lieut. Q. A. Gillmore (21) deals almost entirely with the material from areas outside of Maryland, but does include the results of tests on Port Deposit granite.

Since the publication of the preceding report by Gillmore, the work, which has been done on the building stones of the state, has been conducted almost entirely by the Tenth Census Commission, the U. S. Geological Survey and the Johns Hopkins University. The report by the Census Commission includes many statistics (23) indicating the state of the industry in 1880, a "Description of the Quarries and Quarry Regions compiled from notes of Messrs. Huntington, Monroe and Singleton" (24) and notes on the building stones used in Washington by Geo. P. Merrill (25). The last paper gives many dates at which Maryland material was used in the construction or extension of the Government buildings.

Somewhat later Merrill (26) published a handbook on "The Collection of building and ornamental stones in the U. S. National Museum," which had accumulated from the Centennial Exposition at Philadelphia in 1876 and from the Tenth Census collections of 1880. This book shows that about fifty specimens of the collection came from Maryland, and, that they represent many of the varieties which are described in the succeeding portion of this report. The author gives short summaries of the occurrence and character of these rocks under their proper headings. The work of the U. S. Geological Survey has been twofold, statistical and areal. The former has been conducted from Washington, and has led since 1883 to yearly statements concerning the output and state of various industries during the preceding year. This work has been carried on to a greater or less extent in co-operation with the Johns Hopkins University, and has led to a series of papers by Williams, Hobbs, Keyes, Grimsley and others, who have been occupied largely with the more purely scientific aspects of the problems. Williams' (27, 39) work deals particularly with the broader geological problems; Hobbs' published papers include detailed discussions of certain of the granites and gneisses in the vicinity of Baltimore; Keyes' shorter papers (31, 32) deal with the weathering and petrographical features of the granites, while his longer paper on the same subject gives more of economic interest. Grimsley's (35) publications on the granites of Cecil county deal particularly with the Port Deposit rock, and give many suggestions regarding the geology and economic features of the northwestern part of the county. Although all of these papers are devoted especially to the purely scientific questions, one may find many incidental references to the economic products, which have increased considerably the present stock of information.

Two works of later date deserve especial notice, viz., Keith's "Ge-



FOLIATED GRANITE.

PORT DEPOSIT, CECIL COUNTY.

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ology of the Catoctin Belt" (36) and "Maryland, its Resources, Industries and Institutions" (32, 33). The first gives the most exhaustive discussion of the formations of Frederick and Washington counties which has been published and furnishes many facts on the character and occurrence of the sandstones and breccias of the Newark formation, especially of those in the vicinity of Point of Rocks. The second, prepared by Williams and Clark and published under the direction of the World's Fair Commission, presents the facts more fully and more attractively than had been attempted previously.

Soon after the inauguration of the present organization an extensive reconnoissance was made of the resources of the entire state, and the results of this work were incorporated within an outline of our present knowledge of the physical features of Maryland, which appeared as Part III of volume one of the Survey reports. In this review are brought together concisely the more important facts regarding the building stones of the state, and an outline of the proposed investigation which has resulted in the present paper.

From the foregoing summary of the previously published literature it is evident that many men have written on those rocks of Maryland, which now serve as sources for structural materials. The amount of matter written, however, is small, and much of that extant possesses only an historical interest. Since the total volume of published information is small, and especially since many of the papers just enumerated are either out of print or generally inaccessible, it has been deemed best to incorporate the results obtained in the presentation of the new facts which have been acquired by the personal inspection of almost every quarry found within the state.

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THE QUARRIES OF MARYLAND.

Granites and Gneisses.

Granite is the broad family name that is applied to a large and common group of rocks, which are usually of a somewhat mottled light gray color, and almost always carry two minerals, quartz and feldspar, as essential constituents. Besides these, which make up the mass of the rock, there are dark colored iron-bearing minerals, such as black mica, or biotite, hornblende and occasionally pyroxene. Each of these may be evident to the eye without the aid of a lens. The microscope shows in addition many other minerals such as zircon, apatite or epidote which are of scientific interest, but of little economic importance as constituents of building stones, since they influence neither the appearance nor the wearing qualities of the material.

The foregoing minerals usually form irregular aggregates, in which the individual grains interlock in such a way that the cohesive strength of granite is relatively high. The constituent grains vary very widely in size, from individuals two or more inches in diameter to those which are scarcely separable with the unaided eye. The arrangement of the different mineral grains is irregular and without any prominent lines of distribution, when the granites are unmodified products of crystallization from a molten state. Subsequent action on the rock, however, through pressure or recrystallization, generally arranges the constituent minerals in some regular order, such as in parallel or wavy interlocking lines. It is in this way that many so-called gneisses or granite gneisses originate from granites, as at Port Deposit. True gneisses, however, usually result from the recrystallization of rocks laid down under water, and still retain their banded character. Since in the trade granites and gneisses compete for the same work, and since, when well sorted, there is little difference in their practicability for building purposes, they will be treated together in the present chapter, the differences between the two being shown in the order of grouping in the discussion of the principal quarries.

GEOLOGIC OCCURRENCE.

The granites and gneisses of Maryland are almost entirely limited to that portion of the state which has been described, in previous parts of this paper, under the title of the Piedmont Plateau, an area which consists of masses of ancient crystalline and partially crystalline rocks, which are of both igneous and sedimentary origin. These rocks since their formation have been subjected to many changes and alterations, which have produced a marked foliation or schistosity, showing a general trend from the northeast to southwest, with a moderate dip or inclination toward the northwest. The topography of this area is that of a moderately high and level plateau, which has been deeply eroded into a series of rounded hills and valleys by the streams that flow across it. The granites and gneisses of the plateau show no marked topographic features, although they are more prominent than the less resistant limestones, which occur scattered over the region. The industry based on the quarrying of the granites and gneisses is limited to a triangular area bounded on the east by the gravels and clays of the Coastal Plain and on the west by the less crystalline rocks on the western slopes of Parr's Ridge. Within this limited area there are included other crystalline rocks such as the serpentines, gabbros and peridotites, and in a few instances certain partially metamorphosed sedimentary rocks, such as the phyllites and roofing slates of Harford and Baltimore counties.

The complex geological structure of the Piedmont zone plainly shows that the rocks have been greatly disturbed at various times both prior and subsequent to the early base leveling of the region, when the crystalline rocks formed the foundations upon which the more westerly sediments were laid down. Some of the clastics became involved and infolded with the massives during the process of many foldings, and both were then subjected to the more or less intense dynamic action of the later orographic disturbances. The influence of the numerous intrusives, which are known to have broken through at various periods, operated still further to obliterate the original character of the rocks. The exact sequence of events has not been deciphered, although one speaking broadly may say that the gabbroic and dioritic types were the earliest to be extensively intruded.

These in turn were followed by the more basic non-feldspathic rocks, and then at different intervals the granite types appeared, breaking through all of the preceding series.

These granites as shown by the accompanying map (Plate VII) occupy several distinct areas along the eastern slope of the Piedmont Plateau. The largest of these is that extending from Sykesville to Washington, while the most important economically is the lenticular mass extending from Rising Sun through Port Deposit to the western side of the Susquehanna river. In all there are some fifteen areas where granite is prominently developed, and in at least five of these there are quarries of considerable economic importance.

DISCUSSION OF INDIVIDUAL QUARRY AREAS.

GRANITE.

Port Deposit.

The Maryland granite which is perhaps best known outside of the limits of the state is that quarried in the vicinity of Port Deposit. This town is situated on the Susquehanna river three miles above its mouth at Havre de Grace. It is one of the principal towns of Cecil county and has good railroad connections with Philadelphia, sixty-seven miles distant, Baltimore, forty-three miles, Washington, eighty-three miles and Harrisburg, sixty-five miles. It is possible also for light crafts to ascend the Susquehanna as far as the town and receive their loads directly from the quarry, thus furnishing water connections between the quarries and Philadelphia eighty miles, Baltimore fifty miles, Washington two hundred and twenty-five miles and Richmond three hundred miles. The gorge of the Susquehanna is emphasized by the wall-like mass of granite which skirts the river, from which it is generally separated by a narrow belt of meadow or marsh land. A mile above Port Deposit this rock wall becomes nearly perpendicular, and approaches close to the river. It was this protruding mass of the wall which first called attention to the valuable granites of the area, and it is at this point that the largest quarries are operated, the openings extending nearly to the water's edge. While some small quarrying has taken place in several spots, to gain room for buildings,

FIG. 1—PHOTOMICROGRAPH OF GRANITE, PORT DEPOSIT. (MAGNIFIED TEN DIAMETERS.)

FIG. 2.—PHOTOMICROGRAPH OF GRANITE, ELLICOTT CITY. (MAGNIFIED TEN DIAMETERS.)

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the industry at present is limited to the northern edge of the town, where the rock now stands exposed in an almost vertical wall measuring from the base to the top something over a hundred feet.

The value of the granites of this area was early recognized, and the rock was used by the settlers for the foundation of some of the oldest colonial dwellings. The industry arising from the quarrying of the rock is, however, of somewhat later origin. In the years 1816-1817 a bridge was built across the Susquehanna river at Port Deposit by the Port Deposit Bridge Company. During the process of construction the abutments for the eastern approach were made from stone quarried at the eastern end of the bridge, which is within the present corporate limits of the town of Port Deposit and not far from the site of McClanahan's quarries. For about ten years the opening so made was worked in a small way by Simon Freeze, who had supplied the materials used in the construction of the bridge. In 1829 the owners of the Maryland canal became interested in the quarry, and increased its workings. In 1830 the business passed into the hands of Samuel Megredy and Cornelius Smith, who still farther increased the scope and operations, and developed a considerable trade with Baltimore and other coastwise towns. Two years later Ebenezer D. McClanahan became interested in the granite quarrying industry through his brother-in-law Daniel Megredy, who was then a successful operator. McClanahan became the dominant factor in the local development and gradually increased the business until in 1837, from data furnished by Anthony Smith, Ducatel[1] estimated the annual output at from 12,000 to 15,000 perches. On the retirement of E. D. McClanahan the business was transferred to his sons, who are at present the principal owners in the Port Deposit company, which controls the local industry.

The quarries at Port Deposit, as shown by Grimsley in his work on the granites of Cecil county, are in rocks of igneous origin, which have been variously modified by severe dynamic action. This has produced a certain degree of schistosity which causes the Port Deposit granites to be taken at times for a gneiss rather than a granite. This foliation which is produced by the parallel arrangement of the black

[1] Ann. Rept. of the State Geologist of Maryland, 1837, p. 15.

mica flakes has a northeasterly trend nearly at right angles to the course of the river and a dip that is almost vertical. There is no marked banding in the rock, but the whole face of the quarry, which shows thousands of feet of surface, appears perfectly homogeneous, as though made up of a single rock. Through this mass there now pass several series of intersecting joints of which the most prominent approximately coincides with the northeast trend of the foliation, but which inclines somewhat to the dip of the foliation. A second set of joints runs almost normal to the first and is almost as sharp as those of the main series. A third set trending west of north is inclined 60° to the principal joints, while a fourth set, approximately horizontal, serves as bedding joints. The surface of the jointing plane is usually quite smooth and even, but the direction and distance between the parallel surfaces is not always constant. This produces a slight wedging in the blocks, which increases somewhat the cost of quarrying. On the other hand the smoothness of the joint surface frequently renders the rock ready for use in building without the intervention of the stone cutter, and allows the extraction of enormous nearly rectangular blocks. The expense of preparing the rock for use in the wall is accordingly reduced.

Although there are some half dozen series of jointing the rock a short distance below the surface is very compact, homogeneous, and strong, as is shown by the pressure tests of Gillmore, who found that the compressive strength of this rock was 13,100 pounds per square inch when tested "on edge," and still more clearly by the more recent tests just completed which show a crushing strength of over 80,000 pounds on two inch cubes. The incipient jointing planes, although so closely welded together as to show this great strength, are made use of by the quarrymen in trimming the huge monoliths and in cutting the smaller Belgian paving blocks, as the rock may be readily opened by means of wedge and "feathers."

The distance between the major joints, which varies from half an inch to several feet, is sufficiently great to allow the extraction of any sized block, which can be handled advantageously by the machinery and by the transporting agencies. It is usually considered that the rock of the Port Deposit quarries is somewhat more easily worked than that at Frenchtown, which otherwise is indistinguishable. This difference in working arises in part no doubt from the greater age, better facilities for quarrying and handling and also from the more convenient position of dominant lines of working in the Port Deposit quarries.

The *texture* of the Port Deposit granite, or granite-gneiss is highly characteristic. The rock is composed of the usual granitic constituents, quartz, potassium, and lime-soda feldspars, biotite and accessory minerals. The most noticeable feature of the rock is the secondary gneissic structure, which is brought out by the arrangement of the shreds and flakes of black mica. This arrangement, which is better shown in the ledge and the hand specimen (Plate VIII) than in a thin section, is seen on examination to be due to small disconnected groups of mica flakes, which lie in approximately parallel lines. These lines are not straight or continuous, but are wavy and the flakes are disseminated or overlapping in such a way as to produce the well-known lenticular effect of gneiss. The color of the rock is a light bluish gray, which in buildings gives a bright fresh appearance at first and then gradually becomes somewhat darker through an accumulation of the dust and dirt in the atmosphere. Such a darkening of the rock produces a mellowed pleasing effect in structures situated in most of the cities. The roughness of the surface, however, and the abundance of the black mica render the appearance of the older buildings constructed from this rock somewhat sombre, if the atmosphere is strongly charged with dust particles. This is particularly true in cities where soft coal is used extensively without smoke consumers. On the whole the appearance of this rock is unusually pleasing. The effect in a building is somewhat variable according as the rock is laid on its bed or on its edge. The color on edge seems to be slightly brighter and more pleasing than when the stone is cut to lie parallel to the lamination.

The *chemical composition* of the Port Deposit "granite," as shown in the following analysis[1] of the specimen from McClanahan's quarry, is not normal for a granite. It is high in soda and lime and too low

[1] Made by Wm. Bromwell and given by Grimsley. Op. cit. p. 312.

in potash, and the excess of soda over potash shows that the rock is really a quartz mica diorite rather than a true granite. Since the amount of potassium feldspar is greater in many of the slides from other portions of the area, and since the rock is widely known as granite, this term is used in the present discussion in the trade-sense, rather than with the stricter scientific limitation.

Analysis of Port Deposit Granite.

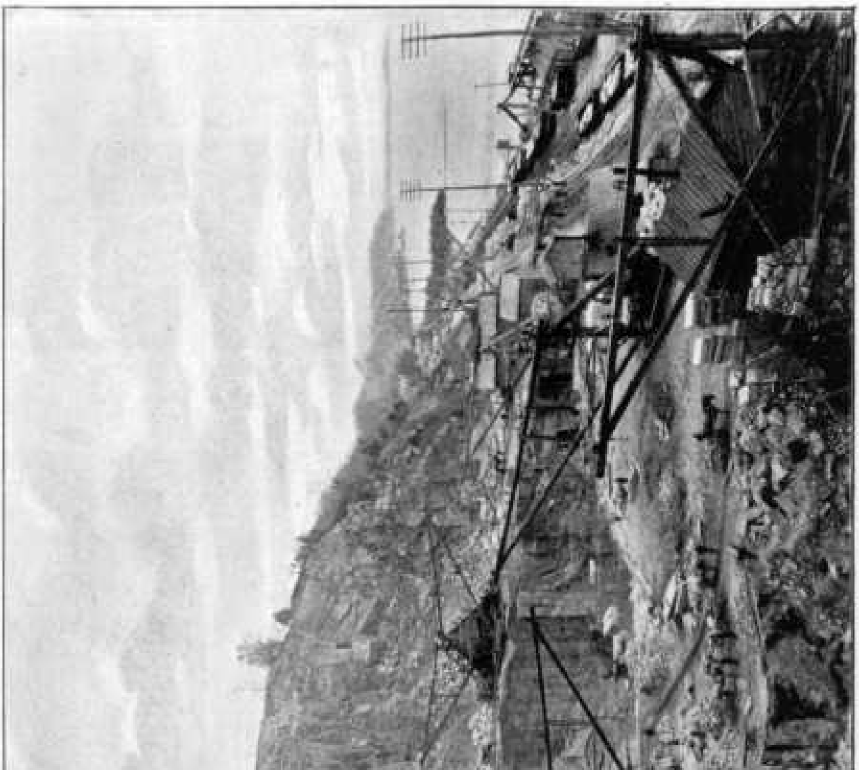
SiO_2	73.69
Al_2O_3	12.89
Fe_2O_3	1.02
FeO	2.58
CaO	3.74
MgO	.50
Na_2O	2.81
K_2O	1.48
H_2O	1.06
Total	99.74

From the above analysis, the results of mechanical separations by specific gravity, and estimates based on a study of thin slices, Grimsley has calculated the proportionate mineralogical composition of the rock. The following percentages are thought to be representative:

Calculated percentages, from chemical analyses.	
Quartz	40.0
Orthoclase	9.0
Albite molecules	25.8
Anorthite	13.6
Biotite	9.7
Epidote	3.9

Percentages obtained by specific gravity separation.		
Sp. gr.		
2.65	(Quartz)	40.0
2.55–2.64 2.67–2.8	Feldspar	45.0
Above 2.8	Biotite, Epidote,	15.0

A microscopic study of sections from the Port Deposit granite shows the presence of the usual granitic minerals, such as quartz, feldspar, dark and light micas, apatite, zircon, sphene, allanite, epidote, chlorite, hornblende, magnetite, garnets and occasionally calcite. The quartz is in relatively large sized areas, ranging from 0.5 mm. x 1.5 mm. to 3 mm. x 5 mm. With the aid of the microscope these areas are seen to be not single units, but composed of a great number of small quartz fragments, which have resulted from the crushing and recrystallization of the original granite during the period when the



McCLANAHAN GRANITE QUARRY, PORT DEPOSIT.

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rock received its present schistose structure. These smaller quartz fragments are aggregated together by intricate interlocking sutures in a way which renders the rock less rigid and at the same time capable of withstanding fully as much pressure as an individual grain. The interstitial areas between the fragments of the coarser mosaic are filled with a mosaic of still smaller grains. Occasionally the quartz shows small inclusions of iron oxide, dust-like particles and "quartz needles," although it usually appears exceptionally free from them. After a study of several sections from the McClanahan quarry the present writer is inclined to think that the estimated proportion of the alkaline and plagioclase feldspar may better represent the character of the rock of the area, and that the figures obtained from the analysis and the slides indicate a greater amount of the more soluble plagioclase feldspar than the average run of the quarry. If the inference is correct the stone is stronger in its resistance to decomposition than the above analysis would indicate. The feldspars, like the quartz, occupy well defined areas and show the shattering and recrystallization into a mosaic, as a result of the dynamic forces which have modified the rock. These mosaics are much less frequent in the feldspars than in the quartz. The biotite occurs in aggregates of fine shreds, showing varying degrees of orientation, and is frequently associated with irregular grains or small crystals of epidote, sphene and allanite. The shreds and flakes are so small and so interlocked with minute grains of quartz, that they offer little increase to the weakness due to schistosity. The other constituents are so insignificant in quantity and so stable under atmospheric conditions that they do not influence appreciably the physical or chemical stability of the rock.

In any discussion or consideration of building stones, in order to appreciate the practicability of the rocks for large and permanent structures, it is necessary to know something of their physical properties. Among these the most important, as already shown in the previous chapter, are specific gravity, the ratio of absorption, the effect of freezing and thawing, and the compression strength. The specific gravity must be known in order to compute the weight to each cubic foot of the rock, which in turn indicates the amount of pressure imposed on the lower courses of the structure. Since almost all building stones are exposed to the atmospheric agents which influence them, it is well to know also what the varying conditions of temperature have upon a given stone. For example heating, due to the rays of the sun, causes the minerals to expand. Since the rate of such expansion is different for different minerals and even for different directions in the same mineral, there is unequal enlargement of the grains, and hence a loss in the cohesive strength of the rock. Other things being equal this change is greater in aggregates composed of many and vari-colored constituents. Again, if the rock is porous, the expansion of included moisture may rend the rock in freezing weather, so that it becomes necessary to know the amount of moisture absorbed by the rock, and so liable to expansion through frost action. The values obtained by Gillmore[1] on Port Deposit granite are as follows:

Position.	Cracked.	Strength of spec.	Strength per sq. in.	Sp. gr.	Weight of 1 cubic ft.	Ratio of absorption.	Remarks.
On bed.	......	79,000	19,750	2.720	170	0	Coarse, strongly dashed with black.
On edge.	33,000	52,400	13,100	2.720	170	0	do.
On bed.	......	66,000	16,500	2.720	170	0	do.
" "	......	60,000	15,000	2.720	170	0	Burst suddenly.

In the tests made during the search for a stone suitable to be used in the building of the Smithsonian Institution at Washington several Maryland building stones were studied, among which was included the Port Deposit granite. Dr. Chas. G. Page,[2] in his report on the action of frost on certain materials for building, gives as the specific gravity for the Port Deposit the figures 2.609, and as the loss by frost in grains 5.05. The method of investigation was the so-called Brard process, which consists in substituting the crystallization of sulphate of soda for the freezing of water.

The tests made[3] for the present paper are even more creditable to

[1] Gillmore, Reports on the Compressive Strength, Specific Gravity and Ratio of Absorption of the Building Stones in the United States. Rept. of the Chief of Engineers for 1875, Appendix II, p. 847. Also Republished 8vo. 37 pp. Van Nostrand, New York, 1876.

[2] See Bibliography No. 10.

[3] The conduction of this test was confided to Mr. Louis K. Shellenberger, Engineer of Tests, for Riehlé Bros. of Philadelphia, who rank high as specialists in the construction of testing machinery.

the rock. The specimens submitted were two inch cubes, carefully prepared and subjected to tests under the most uniform conditions. The results are as follows:

Simple Crushing.		Absorption, percentage of gain.	Freezing, percentage of loss.	Crushing after freezing.	
Crack.	Break.			Crack.	Break.
....	67,100	0.253	0.000	83,000	86,000
....	79,200	0.193	0.011	78,100	90,800
....	86,200				
....	101,540				

Tests made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on a 2-inch cube gave the crushing strength as 84,730 pounds for 2-inch cubes, which is equivalent to 21,180 pounds per square inch.[1]

The results of these various investigations clearly show that the Port Deposit rock is strong enough to withstand all the demands made upon it by the pressure of superimposed stone work in structures, and to resist the various deteriorating influences of frost and atmosphere.

This view of the *durability* of the Port Deposit granite is well sustained by a study of its mineralogical and chemical composition, and the evidence of disintegration shown in the quarries and in old structures. The mineralogical composition indicates stability, as no mineral is present more liable to alteration than the lime-soda feldspar, which itself is not particularly prone to decomposition, although the first of the prominent constituents to yield to atmospheric action. Investigation at the quarries, where a considerable depth of decomposed rock is seen to overlie the more marketable material suggests the suspicion, that the Port Deposit granite will not withstand atmospheric agencies for any great period of time. This deceptive appearance arises from the fact that the crystalline rocks southward from Philadelphia have not been scoured and cleaned by the action of glacial ice as in more northern latitudes. Thus the overlying waste represents the decomposed products of several geological epochs, perhaps reaching back as far as Cretaceous time.

The number of quarries about Port Deposit has never been very large, although now and then attempts have been made to establish

[1] 18th Ann. Rept. U. S. Geol. Surv., pt. V, 1897, p. 964.

rivals to the large quarries which are at present operated by the McClanahan & Brother Granite Company.

Frenchtown.

At the eastern end of the high suspension bridge of the Baltimore and Ohio Railroad over the Susquehanna river there is a small quarry opened in a schistose granite, which is very similar to that worked at Port Deposit. This quarry was probably first opened during the construction of the railroad bridge,[1] but nothing of economic importance was done here until the firm of Wm. Gray and Sons of Philadelphia became interested in 1894. At this time the capital invested was about $8,000, a sum which represents but part of the present investments. No work of any particular moment was done by the present owners until the autumn of 1896, when the receipt of some moderate sized contracts encouraged the further opening of the quarry, which now bids fair to establish a well organized industry at Frenchtown. The only buildings of importance which have been built from the Frenchtown rock are the Cold Storage Warehouse and and an extension of the Baldwin Locomotive Works in Philadelphia.

The location of the quarry topographically and geologically is similar to that of the quarries at Port Deposit. The ground is stripped upon the side of a hill and the quarry has worked down to the level of the low bench, along which runs the Port Deposit and Columbia Railroad. The jointing of the rock is similar to that at Port Deposit, and there are here three prominent sets of joints intersecting approximately at right angles. Members of the same series are so placed as to facilitate working of the quarries and blocks containing 3,000 to 4,000 cubic feet might easily be obtained.

The texture of the rock like that at Port Deposit is coarsely granular, with a secondary lamination, and is adapted to all ordinary uses in general building, exterior ornamentation, curbing, paving, etc. It is possible, however, that this rock may be a little more "plucky" in working than the larger deposit farther north. This difference in the ease with which the stone is worked seems to be a temporary

[1] The main piers of the bridge are built of Port Deposit granite.

GRANITE-PORPHYRY.

ELLICOTT CITY, HOWARD COUNTY.

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feature which may have disappeared before the publication of this report. Like the rock quarried at Port Deposit, that at Frenchtown frequently appears somewhat disfigured by small black patches or basic segregations of biotite, which often render the stone unavailable for the highest grades of ornamental work. The microscopical characteristics of this rock as well as the color and texture are the same as those of the Port Deposit rock already described. The quarries have not been worked long enough to indicate by the product the durability of the rock or to call for discussions of its specific gravity, crushing strength and other physical features. There is no doubt, however, that the rock will respond readily to all the demands made upon it for ordinary building purposes, and that it will resist any pressure or atmospheric influences which it would normally encounter. It weighs about 170 pounds to the cubic foot.

The quarry as yet is small. At the time it was visited in 1896 the total space excavated was scarcely more than 5,000 square yards. In 1897 the opening was fully twice that size. The transportation facilities are very good, the same as those at Port Deposit. The stone may be loaded directly on the cars for Philadelphia and Baltimore or on barges for these and other coastwise points.

Ellicott City.

The Ellicott City granite area consists of an irregular L-shaped mass, which has an extreme length of about five miles in an east and west direction and a breadth varying from one-half to two miles. On the north, west, and south it is bordered by a large gabbro area; on the east by gneiss. A considerable portion of the granitic area of this district is overlain by Neocene gravels (Lafayette Formation) and Cretaceous clays (Potomac Formation), thus concealing from direct observation much of the rock in question. The clastics, however, are quite thin, and consequently all the rivers and even the minor water-courses have cut their channels down to the more resistant crystalline rocks. The boundaries of the granites, gabbros, and other massive rocks are thus capable of being determined with nearly as much accuracy as if the sedimentary deposits were not present.

The quarries of Ellicott City are situated nine miles by road from

Baltimore and fifteen miles by railroad. They are located on either side of the Patapsco river in Baltimore and Howard counties, and the rock in which they occur extends on the eastern side of the Patapsco as far east as Ilchester, but on the western side only as far as Grays. The material on the Baltimore county or eastern side is a fine grained mass, with a decided foliation or gneissic structure. On the opposite side of the river in Ellicott City itself it is more uniform and granitic. Here it also has a porphyritic structure in consequence of the development of large flesh-colored crystals of feldspar which are disseminated somewhat irregularly through the rock, as shown in Plate XI.

The time of opening these quarries dates back probably into the last of the 18th century, but the details are entirely wanting. The beautiful appearance of some of the more uniformly porphyritic specimens early attracted attention, and in the earliest works which we have on this area, that by Dr. Hayden,[1] published in 1811, mention is made of these quarries. It is not certain whether the quarry on the Baltimore county side or the quarries of the Howard county side furnished the first material for Baltimore, but it is clearly evident from the character of the rock furnished for the Catholic Cathedral, that the gneiss was the more important rock at that time. Local tradition assigns the source of the stone sometimes to the Baltimore county side and sometimes to the Howard county side and the published information is equally conflicting and indefinite. When the Cathedral was constructed during the years 1806 to 1812 and subsequently from 1815 to 1821, the material was hauled from Ellicott City to Baltimore along the old Frederick road in huge wagons drawn by nine yoke of oxen. After furnishing the rock for this building, which must have been one of the most important stone structures in the United States at the time of its construction, the quarries evidently were worked only to meet local demands. In fact they have never since been of such relatively great importance. Dr. David Dale Owen, indeed, while studying the various building stones of Maryland at Cockeysville, Woodstock and Port Deposit, with the view of

[1] Geological Sketch of Baltimore, see Bruce's Amer. Min. Jour., vol. I. New York, 1814, pp. 243-248.

FIG. 1.—GAITHER'S QUARRY, ELLICOTT CITY.

FIG. 2.—WEBER'S QUARRY, ELLICOTT CITY.

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gaining all the information for the Smithsonian building, twice passed by these quarries and yet makes no mention of them. At the time of the Tenth Census the agent remarks that he "knows of no other place in the country where there are so many stone buildings in an area of the same size."

Of the quarries in operation at the present day those of Werner Bros. were opened as early as the beginning of the century. In 1872 Charles J. Werner reopened a quarry, which since his death in 1888 has been operated by his sons, who purchased in 1890 a second quarry, which had previously been opened by Robert Wilson. These quarries became of some importance in 1893, when one of them is spoken of as the principal Ellicott City quarry, although it is now producing little or no building stone except during the fall of the year when random rubble is quarried for local use. The output for the year 1896 did not aggregate over 200 perches. The most active quarry at the present is that operated by A. Weber (see Plate XII, Fig. 2). This quarry is situated on the Howard county side some distance below the station. The material has been furnished in recent years for some important buildings, as those of the Woman's College of Baltimore, but most of the material seems to be used for Belgian blocks, curbing and macadam.

The system of joints in the region under discussion are not regular, but intersect at varying angles and at different distances. In the Weber quarry there is one prominent series of bedding joints, which strikes in a southeasterly direction and dips at a low angle into the hill. Besides this principal series there are four or five others with more vertical dips and varying strikes, which free the rock in huge irregular blocks. The jointing is so prominent and so irregular that it modifies the manner of quarrying quite perceptibly, as the stone is first obtained in irregular masses and then worked into desired form by hand. Such a process increases the cost of operation, but at the same time furnishes considerable random rubble of a size suitable for ballast and rough road material. Across the river from the Weber quarry, in the opening worked by Gaither, the jointing is more regular and the face of the quarry is seamed into innumerable rhomboids several feet in diameter (Plate XII, Fig. 1).

The opportunities for shipment and drainage are good. Those of the Weber quarry are seldom excelled, as the opening is in the side of a hill so close to the tracks of the Baltimore and Ohio Railroad (main stem) that cars may be loaded simply by turning the derrick boom.

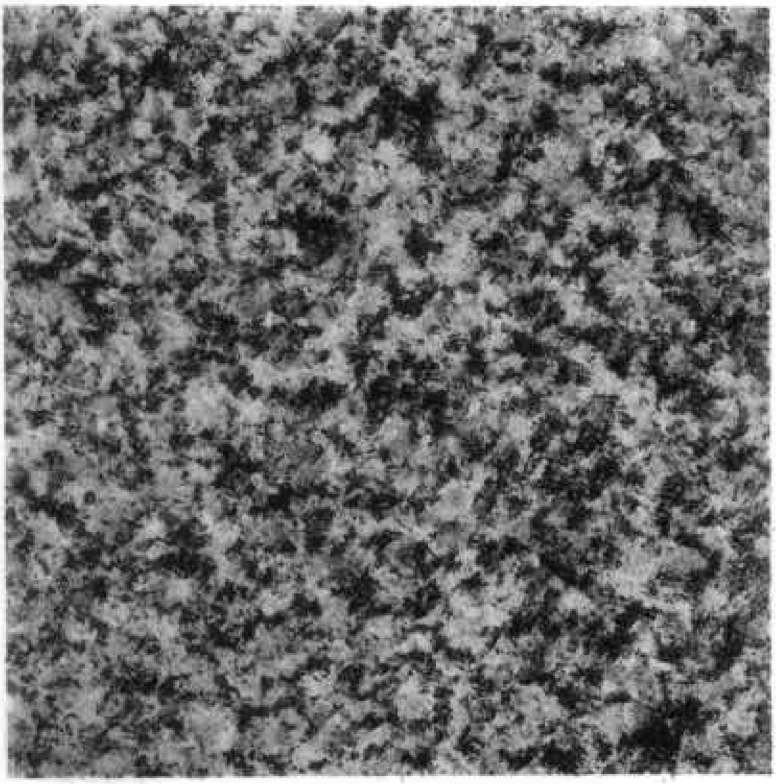
Probably no area of granite within the state shows as great variation in the texture and the character of the rock as that about Ellicott City. In the quarries on the eastern side of the river the rock appears quite schistose and homogeneous, and practically lacking in porphyritic crystals. Through it are scattered large patches or segregations of the darker minerals, which give to the rock the somewhat sombre effect displayed by the Baltimore Cathedral. These patches do not weaken the rock, though they render the stone less attractive. On the other side of the river, as has been mentioned already, the stone has a distinctly porphyritic character, which gives to it a mottled effect, well shown in Plate XI. The increased amount of feldspar brightens the rock and the distribution of the crystals adds detailed variety to the structures in which it is used.

The microscopic texture of the porphyritic type is shown in the reproduced photomicrograph (Plate IX, Fig. 2) where the grains are represented ten times their natural size. There is nothing particularly noticeable in the arrangement of the constituent since they unite with interlocking sutures, as already described in the discussion of the Port Deposit granites.

Woodstock.

Perhaps the best granite in Maryland for general building purposes is that which is found in the small area in the southwestern corner of Baltimore county near the railroad station of Woodstock, Howard county. Woodstock is situated on the main branch of the Baltimore and Ohio Railroad in the valley of the Patapsco twenty-five miles from Baltimore. It is a small country hamlet, but serves as the shipping point for the granites, which are quarried about one and one-half miles to the northeast. Within the area of the quarries is the small town of Granite, which was formerly known as Waltersville. According to the account of Mr. Arnold Blunt,[1] " boulders first attracted

[1] Maryland, its Resources, Industries and Institutions, Balto., 1893, p. 126.



GRANITE

WALTERSVILLE, BALTIMORE COUNTY.

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attention and were worked by several enterprising men from New Hampshire, who commenced their operations here about the years 1832-33. Among them were the names Sweatt, Riddle, Putney, Holbrook, followed by many others, among whom were the Emorys, Gaults and Eatons. The principal demand was at first by the Baltimore and Ohio Railroad for stone stringers, dressed to correspond to the flange and tread of the car wheels, and also ashlar, &c., for their bridge and culvert work."

Although prospecting has been carried on ever since, only two ledge quarries have been discovered, viz.: the "Waltersville" and "Fox Rock." The former is the principal one, and was at first called the "Branch." This rock developed into a fine ledge, surpassing all the granite around in quantity, quality and easy access, so that all the boulders in which Sweatt, Putney and Riddle were interested were at once abandoned. After working it for a year or two Putney and Riddle obtained a lease of this quarry for twenty years in August, 1835, from the owner, Captain Alexander Walters, to whose family this quarry has belonged for more than a century. It is called in the lease and is still known as the Waltersville quarry, although the name of the village of Waltersville was changed to Granite about 1873-74, when the first post-office at the place was established. The lessees went to work vigorously, and besides many other improvements, built a railroad two miles long to connect with the Baltimore and Ohio at Putney and Riddle's bridge, about one mile east of Woodstock. Their first contract of importance was furnishing stone for the Baltimore Custom House. They, however, continued the business only a few years. Extravagance and mismanagement caused the failure, and they were succeeded by Edward Green and Joshua B. Sumwalt, under the firm-name of Green & Sumwalt. The senior partner dying about 1849, he was succeeded by his son Frederick, and the firm became Sumwalt & Green, who conducted the business until 1865, when Attwood Blunt, whose wife owned the property, took charge and continued the business until 1871, when the quarry was leased to Ansley Gill and James McMahon. After a lapse of about sixteen years, the firm was dissolved by the death of

McMahon. Mr. Gill continued the business alone for a short while, when he associated with him Wm. H. Johnson, of Baltimore, and they soon after formed with George Mann, Hugh Hanna, Messrs. Grey & Sons, of Philadelphia, and Mr. Hamilton of Baltimore, a joint stock company, calling it the Guilford and Waltersville Granite Co. This company is now conducting the business.

The rock from the Woodstock area was early used, as indicated in the preceding sketch, but the first published account of it which attracted attention was that by Dr. David Dale Owen.[1] In his report to the Building Committee of the Smithsonian Institution he says: "During the examination of structures and monuments of Baltimore marble, both in Greenmount cemetery and in the city of Baltimore, with a view to ascertain the durability and facility of working this material, I was so much struck with the beauty of some of the granite vaults and fronts of buildings that I determined to visit the quarries from whence this material was procured. . . . Accordingly I stopped at Woodstock, 16 miles beyond the Relay House, and inspected carefully the Waltersville branch and the Fox Rock quarries in this vicinity; both of which are well opened, and afford a good opportunity of judging the quality and extent of this formation.

"For about a mile square at this locality is an outburst of quartzose granite of magnificent quality, both as regards beauty of appearance, compactness of structure, and uniformity of color, texture, and composition. I have never seen anything superior in this country; indeed, I doubt whether it can be excelled in any country. . . . .

"Fully to appreciate the quality of this granite, the quarries themselves must be visited, and the huge blocks in mass inspected as they are removed from their original bed. There, one may see a perpendicular face of nineteen feet presented to view, extending twenty, thirty, and even forty or fifty feet, without a seam or flaw, or the slightest variation in hue. A mass of forty or fifty tons weight may often be seen severed from the parent rock, by the simple but effective means of small iron wedges. . . . The Fox Rock quarry is thirty-six feet from top to bottom, where now excavated. It might be worked

[1] Report of the Board of Regents of the Smithsonian Institution, Jan. 6, 1848. Senate Doc. 30th Congress, 1st Session. Miscl. No. 23, pp. 31-32.

FIG. 1.—WELLER'S QUARRY, GRANITE, BALTIMORE COUNTY.

FIG. 2.—GUILFORD AND WALTERSVILLE QUARRY, GRANITE, BALTIMORE COUNTY.

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some fifteen or twenty feet lower before being incommoded by water. Mortar adheres with such force to this granite, that, when fairly set, it requires as much force to separate the substance of the granite as to detach the mortar from the face.

"On the whole, the inspection of these granite quarries has impressed me with the belief that no locality can furnish a superior quality of granite, and that it cannot be surpassed for strength and durability by any building-material in the world."

The letters which accompany this report show that in 1847 the firm of Sumwalt, Green & Co., evidently composed of Edward Green and Joshua B. Sumwalt and his son Frederick, carried on the business, and the size of the quarries, as indicated in the remarks of Dr. Owen, shows that the business had already reached a considerable importance. Perhaps as the result of this report by Dr. Owen, the contract was granted for furnishing the foundation stone, which was used in an extension of the Patent Office Building constructed in 1849, and the Postoffice Building, in 1855, although some of the Woodstock granite had been used in the general Postoffice before 1847.[1]

The granite mass as indicated by the map forms a more or less oval, isolated area of granite extending scarcely two miles northeast and southwest and a mile northwest and southeast. Although so small, it is one of the most important economic areas within the state. This mass of granite, which is evidently intruded into the gneisses, is entirely enveloped by them and sends no dikes or apophyses into the surrounding rock. That the gneiss is really older than the granite is shown by the great number of inclusions found within the latter. These are chiefly of gneiss, and they occur often in huge irregular blocks six to eight or even ten feet in size, showing narrow rims due to contact metamorphism. They are beautifully puckered and wrinkled and being much richer in ferro-magnesian silicates than the granite itself, their irregular outlines contrast sharply with the lighter background. (The darker portion of the large block in the center of Plate XIV, Fig. 2, is included gneiss.)

The most marked feature of these quarries, especially in the Waltersville quarry (Plate XIV, Fig. 2), is the sharp definition of the

[1] Loc cit. p. 41.

systems of vertical and horizontal joints which are so prominent and so persistent in their horizontal extent, that they at first glance give the impression of stratification. They strike approximately north 60° east and dip at an angle of 10°-15° to the northwest. The joint faces are not planes, but are curved more or less irregularly. The figures given represent the general strike and dip as seen in the Waltersville quarry, but even these somewhat generalized values are not persistent over the entire area, for in the center of the Weller quarry, which abuts upon the Waltersville quarry on the west, the strike and dip changes completely within the distance of a few feet. This irregularity in the joints has caused considerable trouble in the quarrying, although when visited the ledge worked was well exposed, and the blocks were large and easily obtained. The accompanying figure (Plate XIV) shows how large slabs and blocks may be freed at little expense. The piece in the center of the picture has been separated from the ledge at the back by a series of wedges, while it was only necessary to use a bar to pry the mass from the ledge beneath. There are fully five or six series of joints which are distributed without any marked uniformity through the mass. Besides the main horizontal joints there are others at a slight inclination, which continue for a short distance and then die out. The vertical joints show several planes oriented in different positions and showing variable dips and uneven surfaces.

This jointing is sharply brought out by the weathering of the rock. "The quarry ledge has the appearance of a great wall of cyclopean masonry, layer upon layer of huge blocks rising one upon another with the regularity and precision of human workmanship. The separate blocks are more or less oblong in shape, and often measure 15 to 20 feet in length and from 2 to 8 feet in height. They are all more or less rounded, the spaces between the different boulders being filled with incoherent granitic sand, derived from the decomposed edges and the sides of the blocks. It is quite evident that the granitic mass was originally everywhere jointed, and that atmospheric decay took place much faster on the edges and corners than on the flat sides of the great fragments, thus quickly rounding and forming them into boulders like those found throughout drift areas. The sandy matrix is

DETAILED VIEW, WELLER'S QUARRY, GRANITE.

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usually from 5 to 10 inches in thickness. The interior of the boulders is perfectly fresh, and affords the best of rock for building purposes. As decomposition progresses the amount of interstratified sand greatly increases, and the blocks become proportionately smaller."

This method of weathering facilitates the early workings in a quarry and so brings the rock into notice, but there is necessarily a great deal of waste and considerable expense in bringing these boulders into rectangular form unless there are well defined seams or a " grain " running through the rock, as is the case at these quarries. The grain of the rock is so marked that it cannot fail to impress any thoughtful observer who visits the quarries.[1]

The jointings in the Fox quarries are not as strongly brought out by weathering as they are in the Weller and Guilford and Waltersville quarries although the different series are distributed in about the same manner. At the time of inspection, these quarries, which are operated by the Gaults, were not in active operation, although considerable material suitable for furnishing Belgian blocks and random rubble was scattered about the pits.

The appearance of the Woodstock granite is well represented in Plate XIII which reproduces the polished surface in natural size. The color of the rock is bright gray, with something of a luster imparted by the quartz and the unaltered feldspars, the latter often giving an additional faint pink tone. The mica occurs in evenly disseminated fine black flakes which emphasize the grain of the rock and only slightly subdue the bright fresh aspect of the stone. The size of the constituent grains which varies from 0.05-0.2 inches in length, and from 0.01-0.10 inches in breadth, for quartz and feldspar, is little marred by the less resistent mica wearing away and leaving small depressions, that are scarcely discernible to the naked eye. The polished surfaces, such as are represented in the plate, are darker than the rough or ashlar finished stone.

The chemical composition of the rock, as indicated in the following analysis by Mr. Hillebrand,[2] shows the rock to be somewhat siliceous

[1] See ante p. 152 and Plate XIV, Fig. 1.

[2] Report of Work done in the Div. of Chemistry and Physics. Bull. No. 90, U. S. Geol. Survey. (1890-91) Washington, 1892. p. 67. E.

and yet particularly rich in lime. This marked increase in the percentage of CaO is explained by the presence of considerable allanite and epidote in the rock. It is therefore not a source of contamination, for the epidote is particularly stable under atmospheric conditions. The percentage of the alkalies is moderately high, while the iron and magnesium content is very low. The rock, accordingly, possesses great durability and power of resistance toward atmospheric decomposition.

SiO_2	71.79
Al_2O_3	15.00
Fe_2O_3	0.77
FeO	1.12
CaO	2.50
MgO	0.51
K_2O	4.75
Na_2O	3.09
H_2O	0.64
	100.17

The tests to which specimens from the Waltersville quarries have been subjected show the rock to be all that could be desired for strength and durability. The strength of the stone is several times that of brick, and the percentage of absorption is very low, showing that the stone can withstand both pressure and the deteriorating action of frost. The figures obtained are as follows:

Simple crushing.		Absorption.	Freezing.	Crushing after freezing.	
Crack.	Break.	Percentage of gain.	Percentage of loss.	Crack.	Break.
79,700	85,700	0.258	0.011	79,400	102,200
79,200	83,420	0.232	0.029	86,800	90,300

Guilford.

Perhaps the most attractive stone found within the state is that which is quarried at Guilford in Howard county, about five miles northwest of Annapolis Junction, on the Little Patuxent river. This granite early attracted attention because of the uniformity and fineness of its grain, its light color and pleasing effect. Although the area furnishes excellent monumental and building material it is unfortunately situated some miles north of the Baltimore and Ohio Railroad, a circumstance which has delayed such a development and recognition of the rock as the material deserves. At present there is a sidetrack which runs from the Baltimore and Ohio Railroad to Savage Factory only two miles distant. This distance, however, with the necessary hauling, is sufficient to render successful competition with more favorably deposits somewhat doubtful.

The quarries at Guilford were originally opened about 1834, and were worked almost continuously from that date until the outbreak of the civil war in 1860. During the succeeding twenty-five years the operations were of little account, and little work was done until the Guilford and Waltersville Granite Company attempted to develop the industry in 1887. This effort lasted but a short time as all of the machinery was removed from the quarries in 1889. The industrial life of the district has been revived somewhat in recent years by the operations of Messrs. Matthew Gault and Sons, who commenced work in 1893, and by Messrs. Brunner and White, who opened a quarry of superior quality in March, 1895.

The Guilford granite is bordered on the north and west by the Piedmont gneiss and on the east by the gabbro. It is also in part covered by the gravels and clays of the Potomac. The jointing of the rock is sharp and usually regular, the individual planes being sufficiently far apart to allow the quarrying of blocks of any reasonable size; at the same time they aid materially in the freeing of the stone.

The rock of this area differs from all of the other granites of the state in the persistent presence of both light and dark colored micas. Thus, according to the German classification, it is the only "true granite"[1] in the state. Other granites may have muscovite as a constituent, but it is not so abundant or typical as in the present instance. Both of the micas are products of the original crystallization of the molten rock magma, and they are frequently in parallel growths. The biotite, which is especially rich in iron, possesses a very dark color, but shows no evident disintegration or decomposition. The feldspar

[1] The use of this term in previous papers on the granites of Maryland has led to some misunderstanding on the part of quarrymen. In this petrographical sense as applied to granites "true" has not meant that all of the granites of Maryland with this exception are "bastard" granites, but it has only meant that this granite corresponds to the "zwei-glimmer" or "echte granit" of the German classification.

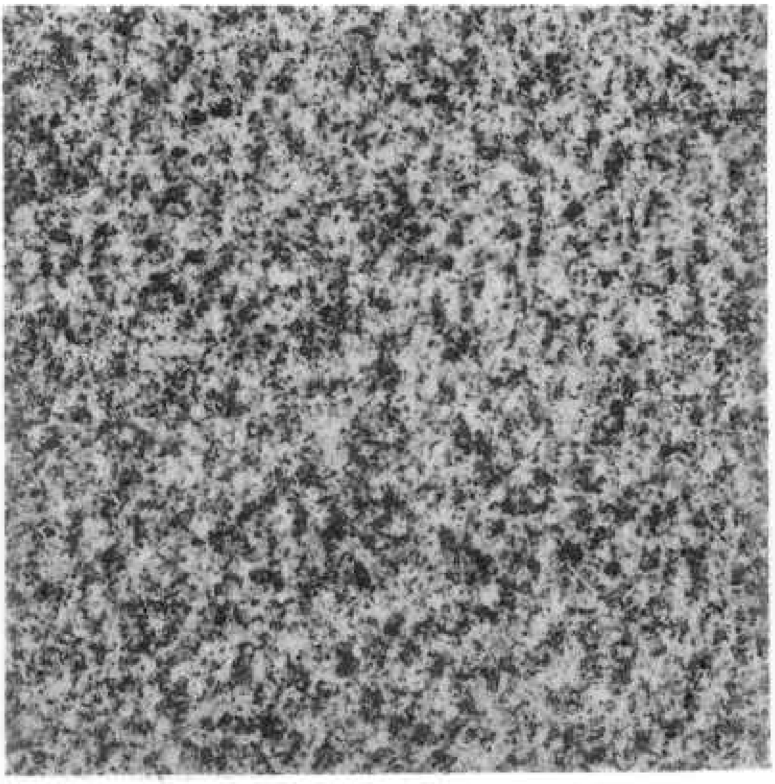
is almost entirely microcline, which shows the cross-twinning very clearly, and appears clear and fresh with very few included flakes or small cystals. These microclines form the largest individual areas in the rock mass, sometimes reaching 0.15-0.2 of an inch (4-5 mm.) in diameter, while the clear transparent grains of quartz average less than 0.01 of an inch (.03 mm.). The individuals are interlocked in a mosaic, which indicates that the rock can well withstand any pressure to which it may normally be subjected. The mica flakes are small and evenly disseminated, so that they do not injure the polish which may be given to the rock in preparing it for monumental purposes.

Minor Areas.

Besides the five areas already described there are several other granite masses within the state, as indicated by the map, which have been worked from time to time to supply the local demands, and occasionally with the hope of bringing the stone into commercial importance. Of these smaller masses which have been quarried spasmodically the most important is that of *Dorsey's Run* on the Baltimore and Ohio Railroad between Ellicott City and Woodstock. The stone of this area was first quarried for use on the Baltimore and Ohio Railroad to protect the roadway from the encroachments of the Patapsco. These and subsequent operations have developed two or three quarries which have furnished about 10,000 cubic feet each, since they were first opened. The proximity to the railroad has been of advantage and efforts were made in 1893 by Mr. W. B. Gray of Baltimore and Messrs. Peach and Feenay of Woodstock to develop a trade in curbing and paving blocks. The quarries at the time of writing, however, have suspended operations. The ledges furnish blocks of 40 or 50 cubic feet, but the product seems to be overshadowed by that of the neighboring quarries in Ellicott City and Woodstock.

In 1888 Mr. W. F. Weller of Granite leased a quarry near *Sykesville,* and began somewhat later the quarrying of Belgian paving blocks, which was continued for some year and a half. At the present time this quarry is not in operation, and no others are at present worked in the vicinity.

On the southern prolongation of the Sykesville mass near Garrett



FINE-GRAINED GRANITE.

GUILFORD, HOWARD COUNTY.

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Park and Brookville is a quarry operated by John A. Riggs, which was probably first opened about the beginning of the century, from which time it was occasionally operated in a small way up to 1881. The total amount of stone extracted, however, does not exceed 1000 perches. No large stone can be obtained from the present opening, as the rock is much broken into blocks, which contain scarcely 20 cubic feet. This opening, however, is in a poor place and the best stone has apparently not yet been reached. Since the distance from the railroad renders this rock unavailable for city demands it will probably never be of more than local importance. Some twenty-five years ago a second quarry was worked at Brookville in rock which was good for local requirements. This was opened in 1850 and some 1000 perches of rock were obtained between 1850 and 1870. The granite exposures at Garrett Park embrace several small outcrops of which the best are those along Rock Creek. At several of these small exposures, quarries have been opened and worked from time to time to supply the local demand.

Probably the most extensive operations carried on in Montgomery county are those near Cabin John, in a quarry operated by Mr. Gilbert. This quarry was opened about 1850 and there have been excavated probably 1,500,000 cubic feet. The rock is a schistose granite rather dark gray in color, and suitable for general building and road metal. In the quarry there are three prominent sets of joints, which, however, are so placed as to permit the quarrying of large blocks. Already pieces containing 1000 square feet have been obtained. The mode of transportation from the quarry to Washington, a distance of six and one-half miles, is the Chesapeake and Ohio Canal, which has rendered the location so available that the rock has supplied some of the demand for foundation stone. At the time when the quarry was visited operations had been suspended and the machinery on the ground was unused and going to ruin.

At Franklinville on the Little Gunpowder, three miles north of Bradshaw's Station, are exposures of a schistose granite resembling that quarried at Port Deposit although somewhat darker and even more schistose. This rock has not been quarried as much as its position and character might warrant. It is owned and worked by the

Cotton Duck Factory Co. It has supplied the local demands and there have been quarried about 1000 perches a year for the last seven or eight years. Large curbing blocks might be obtained easily, as blocks 11′ x 2′ x 1′ have been quarried. The opportunities for operating are good, as freedom from water and large dumping grounds are features of the location. The distance, however, from the railroad might be a serious drawback.

In the town of Benson, Harford county, there is a small opening for granite, where quarrying was first carried on in 1885. The output is small, not reaching 1000 perches a year, and yet from this locality was furnished the material for one of the churches in Bel Air. The quarry, which is owned by Mr. L. Amoss, is situated near Winter's Run on the Harford pike and was never opened with the intention of operating it extensively. The stone is in boulders and is easily worked by hand. On exposure it becomes lighter and more pleasing in color.

Near Baldwin's Station, Cecil county, is a small quarry of schistose granite, which supplies some of the local demands of Elkton, Maryland, and Newark, Delaware. This quarry is on the farm of Levi L. Hammond and was opened in the year 1842. The operations are small, the average yearly output reaching perhaps 2000 cubic feet. Blocks containing 1200 feet have been obtained, and even larger might be quarried, if the facilities for handling were at hand. The quarry is only worked occasionally for building stone, which is sold by the perch.

GNEISSES.

Certain of the more uniform and compact gneisses furnish first-class building material and many quarries have been opened in the areas where the demand is great and the expense of handling and transportation is fairly low. These quarries are especially noticeable in the vicinity of Baltimore where all of the conditions are fulfilled. The gneisses of the area, represented on the map, show great constancy in their mineralogical and textural composition. They are composed of alternating bands of fibrous to micaceous hornblende, biotite and chlorite schist between lighter colored more or less feldspathic quartz-schist. The dark ferruginous bands break down readily and are not used at all as structural material, but are discarded as waste. The best material comes from those portions of the lighter bands which are composed almost wholly of quartz, the prepared blocks differing but little from those made of a well characterized quartzite. The rocks are rather strongly bedded in slabs from one quarter to three feet in thickness, and are thus more easily worked than the hardness of the rock might at first suggest. The areal distribution of the gneisses, as represented by the accompanying map, clearly shows that the structure of the area is intricate and complex.. The general trend of the formation is north-northeast and south-southwest, with a similar strike for the foliation, which usually dips to the northwest at a high angle. In the region adjoining Baltimore the structure, as indicated by the contacts and the position of the foliation, is still more complicated by sharp folds, faults and intrusive masses. Beginning east of Catonsville the strike of the foliation (probably nearly the same as the original bedding) becomes more and more northerly, until at Woodberry it turns quite rapidly to the east and southeast crossing Jones' Falls south of Hampden with a trend somewhat north of east. The strike about Lake Montebello (Baltimore city) seems to radiate in a fanlike manner to the northwest, north and northeast. About Lake Roland and the Bare Hills this structure becomes even more confused, and yet preserves a general parallelism with the gabbro-gneiss boundary.

The quarries about Baltimore are grouped around two centers, Jones' Falls and Gwynn's Falls, on the northern and western sides of the city, the location being determined by the facilities afforded by the shape of the country for opening and working the quarries on a horizontal plane. This method of working decreases the cost of handling the stone, avoids any expense or difficulties because of water and often furnishes a convenient and cheap dumping ground away from the rock bed which may be worked in the future.

Jones' Falls.

The quarries on Jones' Falls were originally opened at some distance from the city, as they were in operation probably before the beginning of the present century. The first mention of them is found in a rare journal[1] published in Baltimore in 1811, where the following words occur in a description of the geology of Jones' Falls: "Immediately above this [a pegmatite dike] it [the gneiss] assumes nearly the texture of the first mentioned, being fine, hard and compact, and gradually passing through the above transitions, until, at one mile and a half from Baltimore, it acquires a texture, such as to render it highly valuable and useful in various branches of masonry, and as such, is here quarried on both sides of Jones' Falls, to considerable advantage to the proprietors."

The first quarries opened were probably situated on the *right* bank of the Falls about where the Mount Vernon shops now stand, and were operated more or less continuously until the building of the Northern Central Railroad, about 1830. The quarries on the left bank of the stream have been in almost continuous operation from the time of their opening until now. It has been difficult, however, to gather any information regarding the various operators who have been interested here.

The occurrence of the quarries is all that could be desired. The rock is clearly bedded in sheets, ranging in thickness from four or five inches to five or six feet. These sheets extend with almost no break for considerable distances, as is shown in the accompanying view of the quarries leased by Messrs. John F. Curley and John G. Schwind. The sharp light lines extending diagonally across the main sheet from left to right are small faults with a throw of a few inches. These sheets are rendered workable by two series of joints at right angles to each other, situated at favorable intervals. These are also supplemented by a "grain" in the rock, which is at right angles to the bedding and nearly parallel to one of the planes of jointing. From this distribution of the lines of weakness, it is possible to free large blocks from the bed and then, if desired, the slabs may be separated readily into smaller blocks. The angles of inclination between the planes of jointing, bedding and grain do not vary widely (usually 10°-15°) from 90°, so that the stone may be squared without great cost. No dynamite is used in the quarrying, but occasionally charges

[1] Loc. cit. pp. 255-271.

FIG. 1.—PHOTOMICROGRAPH OF GRANITE, GRANITE. (MAGNIFIED TEN DIAMETERS.)

FIG. 2.—PHOTOMICROGRAPH OF GNEISS, BALTIMORE. (MAGNIFIED TEN DIAMETERS.)

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of powder are employed to loosen the rock and thus render it easily separable along its joints and grain with the "plug and feather" wedges.

The inclination or dip of the beds also facilitates the quarrying. It is usually about 45° to the northwest, so that the freed blocks may be easily handled. There are two methods of utilizing this dip. In the Peddicord quarry on the Falls road the operations are carried in horizontally *along* the strike, and then the various beds are worked from the top and side. In the Curley-Schwind quarry, where the same beds are exposed, the "head" is first driven in *across* the strike, and then the beds are worked along the strike.

The *texture* of the different sheets varies considerably, but the first quality rock runs quite uniformly. It always shows a lamination parallel to the original sheeting and should therefore be laid on its bed in structures. The quartz and feldspar grains are of approximately the same size and unite with the small mica plates to form a uniformly textured rock of dark gray color. The different beds vary somewhat among themselves in the size of the grain, in the relative amount of quartz and feldspar and in the amount of lamination. As is true of many sedimentary gneisses, this difference in the dark and light bands is so well defined that the quarrymen by a little sorting may furnish material which will run uniformly for individual shipments. There will, however, be some difference between different shipments, unless considerable care is exercised by the quarry master.

The *color* of the rock has been given already as dark gray, but from this there are many variations, with a range from very light gray to a dark sombre, vitreous blue-black. The variation depends upon the amount of feldspar and mica present. If the rock is composed almost entirely of clear, vitreous and pellucid quartz grains the rock is usually dark and cold whether there is much mica present or not. When feldspar is present or the grain of the rock becomes fine or saccharoidal the color of the rock is brighter and more pleasing. The amount of mica present in the feldspathic fine grained rock seems to have a greater effect on the color than is the case in the more quartzose varieties. This constant blue-gray tone in the color of the rock has led to the application of the local term "blue stone," which is current among the quarrymen and is often introduced into contracts.[1]

The chemical composition of the gneiss is so variable that single analyses cannot represent the character of the whole mass. A fair representation of the composition of the lighter colored gneiss would show the silica rather higher than the average. A microscopical study of these same lighter bands, which are used the more extensively, show that the constituents do not always interlock, although there has been considerable growth of the quartz grains since the rock was formed. These are indicated by the light veins about many of the grains in Plate XVII, Fig. 2. Most of the grains are somewhat rounded, suggesting that the gneiss is of sedimentary origin, and the interstitial spaces are filled with more finely comminuted fragments of quartz, feldspar and secondary minerals. Among the last are epidote, garnets and occasionally fibrolite, cyanite and staurolite.[2]

The chemical and mineralogical composition of the Jones' Falls rock show that the individual constituents are not liable to decompose readily and that there are few minerals occurring as accessory constituents which really vitiate the rock. On the other hand, the crushing tests show that there is a much more marked tendency to physical disintegration in certain directions. The rock to be serviceable must, therefore, be placed in the wall in certain positions only. The results of the tests are as follows:

	Crushing.		Absorption. Percentage of gain.	Freezing. Percentage of loss.	Crushing after freezing.	
	Crack	Break.				
Quartzose layers ("Blue Stone.")	66,700	70,140	0.197	0.028	80,118	118,000
	85,940	96,300	......	......	......	......
Feldspathic layer ("B. granite.")		94,200	1.116	0.052	63,060	84,220
	78,600	103,500				

[1] This term "blue stone" is a popular one which is applied to different rocks in different localities; e. g. in the District of Columbia it signifies a mica schist; in Pennsylvania and New York a blue-gray sandstone; in Ohio a gray sandstone. This last usage has become so common in the trade that it is hardly proper to call the Baltimore gneiss a "blue stone."

[2] On the faces of the joints where there has been a little space after the movement of the rock there are often found haydenite (chabazite), laumonite, harmotome (or phillipsite?), stilbite, beaumontite (heulandite), siderite, pyrite, barite, haloysite, epidote, garnet, and tourmaline. See Notes on the Minerals occurring in the neighborhood of Baltimore by George H. Williams. 17 pp. Baltimore, 1887.

The quarries show that the rate of decomposition and disintegration is really very slight for gneisses standing at so steep an angle that the surface waters may saturate the rock with great freedom. There is, of course, considerable stripping required in some places, but when it is remembered that these rocks, unlike the rocks farther north, retain the evidences of exposure to the destruetive agents of the soil and atmosphere since Cretaceous time, certainly several million years, the amount of weathering seems insignificant.

The most serious drawback is not in any possible line of weakness, but in the color. When pieces of gneiss from different layers are intermingled without any care or arrangement, the effect is not pleasing, but quite the reverse. There is current an impression that the material for the Cathedral in Baltimore came from the Jones' Falls quarries, a view which is scarcely in harmony with the statement of Mr. Robert Gilmor, Jr.,[1] in which he describes how the material was brought from the Falls of the Patapsco about ten miles out on the Frederick pike. Part of the material may have been furnished from the nearer source, but under these circumstances it would probably have been from the quarry on the right bank and not from any of those on the left bank, since the former was then the more important source of material. Moreover, certain buildings such as the old Court House, portions of the Jail and some of the buildings at the Woman's College show that the rock may give a pleasing effect in structures. The demands at the present time are satisfied by higher grade material, such as the Port Deposit or Woodstock granite, and a large part of the gneiss quarried is employed either for foundations and paving or as a backing for the more pleasing stone.

The quarries in operation at the time of inspection by the writer were the Peddicord, the Curley-Schwind, and the Atkinson.[2] Of these the Peddicord is the largest, showing an excavation of over seventeen million cubic feet; the Curley-Schwind shows about three million, and the Atkinson something over a million cubic feet.

[1] Bruce's Amer. Min. Jour., vol. i, New York, 1814, p. 232. See p. 126.

[2] The "Atkinson" of the topographic map is now the Peddicord and Atkinson is working a smaller quarry a little farther northeast beyond the Curley-Schwind quarry.

Gwynn's Falls.

The work in the area west of Baltimore along the Gwynn's Falls and Gwynn's Run did not begin for some fifty years after that along the Jones' Falls, since the product lay to the west of the growing town and was separated from it by a series of ridges which increased the cost of transportation. As the city extended westward, the supply from Jones' Falls became more expensive, and that from the small openings along Gwynn's Falls cheaper. The real work of the area began about 1850 and has continued without any marked abatement to the present time. The largest quarries in this part of Baltimore are operated by John G. Schwind, lessee and part owner of the large quarries on Edmondson Avenue, which are perhaps the largest and best equipped of any of the openings about the city.

As shown upon Plate XVIII, Fig. 2, the rock of this quarry is a gneiss, inclined at an angle of 30° and dipping to the northwestward. The general strike of the beds conforms to that of the area, which is north 45° east. As is the case of the Jones' Falls quarries, the rock exposed in the quarries varies considerably, and furnishes two marked grades of material, one which is almost pure quartz resembling a quartzite and the other a much more feldspathic and micaceous aggregate very similar to the granite, but showing a greater or less perfection in its bedding.

In the quarry face the individual beds range in thickness from two to four feet, each showing great uniformity. The workable ones are clearly separated from each other, either by well defined bedding joints or by beds of inferior quality. Across each sheet are at least three sets of joints nearly at right angles to each other, which greatly increase the ease with which the material is extracted. The joints are separated from each other by distances ranging from a few inches to several feet, so that while facilitating the work they do not render the rock inferior, because of too great frequency. It is possible to obtain blocks of any size within the range of economical handling. This limit seems to be reached in blocks of seven or eight tons. The hoist in use, however, is capable of handling ten ton blocks. The product of these quarries is scarcely distinguishable from that already described as characteristic for those of Jones' Falls. Like the latter the

FIG. 1.—GURLEY-SCHWIND QUARRY, BALTIMORE.

FIG. 2.—"EDMONDSON AVENUE" QUARRY, BALTIMORE.

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range in material is very wide. All of the product furnished is unaffected by any considerable amount of deleterious minerals. The worst blemish arises from an occasional concentration of the feldspar individuals and occasionally disseminated bright pyrite crystals. The minerals, such as laumontite, stilbite, etc., for which the quarry is well known, do not occur within the body of the rock, but are secondary products distributed along the jointing planes. They accordingly are not injurious to its strength or weathering properties. Material has been furnished from these quarries for a good many well known buildings, especially in the city of Baltimore. Some material has also been shipped to Virginia. Perhaps the most prominent structures which have used this stone are the Traction Power House, a portion of the new Penitentiary and the Bolton Synagogue. In these buildings the stone is used chiefly as a foundation stone, the superstructure being constructed in part of Port Deposit granite and in part of other domestic stone. Besides furnishing first-class foundation material the quarries utilize their waste by means of crushers in the preparation of crushed stone suitable for the construction of roads and gravel walks.

The openings somewhat farther west, owned and operated by David Leonard, produce some of the best stone from this region. They were opened sometime prior to 1850 and have been worked more or less continuously ever since. The stone is very similar to that of the Edmondson Avenue quarry possessing the same marked bedding and several sets of joints, which allow the extraction of the stones in rectangular blocks of convenient size. It is probable that in this quarry the jointing is a little more irregular and the material furnished a little less satisfactory for the production of large blocks of foundation stone. This slight difference in the character of the material extracted has led the present owner to work a considerable portion of his stock into paving blocks. The distance of the haul and the sharp hill, which limits somewhat the load, increases a little the expense of furnishing the stone in the center of the city. The quality of the stone, however, which when cut is fully equal to that of any of the quarries about Baltimore, together with the uniform faithfulness in fulfilling contracts causes a steady demand for the product of the quarry.

In addition to these two quarries, there are others in the immediate vicinity, which are worked in a small way, furnishing a little material now and then for various local demands. These, however, change hands so frequently and are worked so irregularly that they do not seriously affect the market for stone of this general character.

Besides the larger quarries of the area just considered there are scattered in various directions about Baltimore, especially to the east and north of the city, several others which have been worked to some extent to supply the local demand for building stone. Such openings are worked occasionally along various portions of Herring Run, near Hall Spring, and Ivy, and along the upper course of Gwynn's Falls. near McDonogh. These quarries furnish material similar to that obtained from those on Jones' Falls and Gwynn's Falls and help to supply the demand for paving blocks, sills, steps and curbings in their local areas. The chief sale for this product, however, arises from its use as a road ballast in the construction of many of the pikes which radiate from Baltimore. The material is crushed and furnishes a very fair road metal.

GABBRO.

Although the gabbro or "niggerhead rock" of Harford, Baltimore, and Howard counties is sharply separated from the granites and gneisses scientifically, when used as a foundation and building stone it competes with the granites and gneisses, so that it is proper to consider this material under the general title of the present division. The stone is so hard to work and so sombre in its effect, that little or no demand has ever been developed for it. There are, however, a few buildings such as the railroad station at Arlington, a church and some of the mills at Woodberry and a few scattered structures in the valley of the Patapsco which have been made of it. The stone is generally used in natural boulders, as the drift materials of the New England states is used in the construction of higher grade of Queen Anne houses. The slight demand for dressed gabbro, the use of boulders and its plucky character have practically precluded the successful exploiting of this rock for building-stone purposes. There is, however, a strong and ever increasing demand for materials of this character in the construction of macadamized roads, since as a road metal there is no substance in the state better adapted for this purpose.

AMPHIBOLE SCHIST.

Carroll county, about Westminster, and Montgomery county, northwest of Washington, possess a finely crinkled, compact rock which has been used in a few instances as a building stone with good effect. The material quite probably is a metamorphosed amygdaloid, in which most of the minerals have been changed to very stable forms. It is of a pleasing grayish green color and even texture, and when freshly furnished it is very easily worked, being carved in almost any form with ordinary tools. On exposure it hardens through a secondary deposit of silica, and becomes a very serviceable stone. It has been used in the Keyser Memorial Church at Reisterstown, in the residence of the president of the Western Maryland College, and in the foundations of many of the more prominent buildings in Westminster. Some of the stone, which was used as a base of the buildings constructed there at the beginning of the century, shows that it suffers little or no disintegration from exposure to the atmosphere. This material will never be used extensively as a building stone, since it is very uneven in its appearance and limited in its local occurrence. The porosity of its texture causes it to collect dirt rapidly and so it becomes unsightly if used in the large cities.

MARBLES AND LIMESTONES.

The marbles and limestones of Maryland are the most uniformly distributed of all the building stones in the state, for larger or smaller areas may be found in Baltimore, Carroll, Howard, Frederick, Montgomery, Washington, Allegany and Garrett counties. These differ widely however, in character, mode of occurrence and geological age. Unlike the granites, gneisses and serpentines, they are not confined to the central portion of the state, called the Piedmont Plateau, since they are found well developed in the broad Hagerstown and Frederick valleys and in the more mountainous areas of the Alleghanies. The exposures are almost always poor on account of the relative readiness with which these rocks break down under atmospheric agencies, and from the same cause they always occur in valleys and never along ridges or the crests of mountains, as the sandstones do. Moreover, whenever there occur sufficient bodies the valleys are characteristically broad, flat and very fertile.

According to their geological age the marbles and limestones have undergone various degrees of change, since the time of their formation. There is a progressive increase in their crystalline character and freedom from fossils, from the little changed fossiliferous Greenbrier limestones of Garrett county to the crystalline, non-fossiliferous marbles of Baltimore county. This increased alteration, which they have undergone, is accompanied by a change in color from the dark limestones of the Carboniferous and Lewistown formations through the lighter Shenandoah limestones to the variegated marbles of the Phyllite formation and the clear white or blue marbles of unknown age which are so extensively worked in Baltimore county.

The geological formations which furnish either limestones or marbles are the

Triassic (Newark), running as a narrow belt across Montgomery, Frederick and Carroll counties;

Permian (Frostburg), occurring in a few hills about Frostburg;

Carboniferous (Bayard and Greenbrier), forming several bands of limestone in Garrett and Allegany counties;

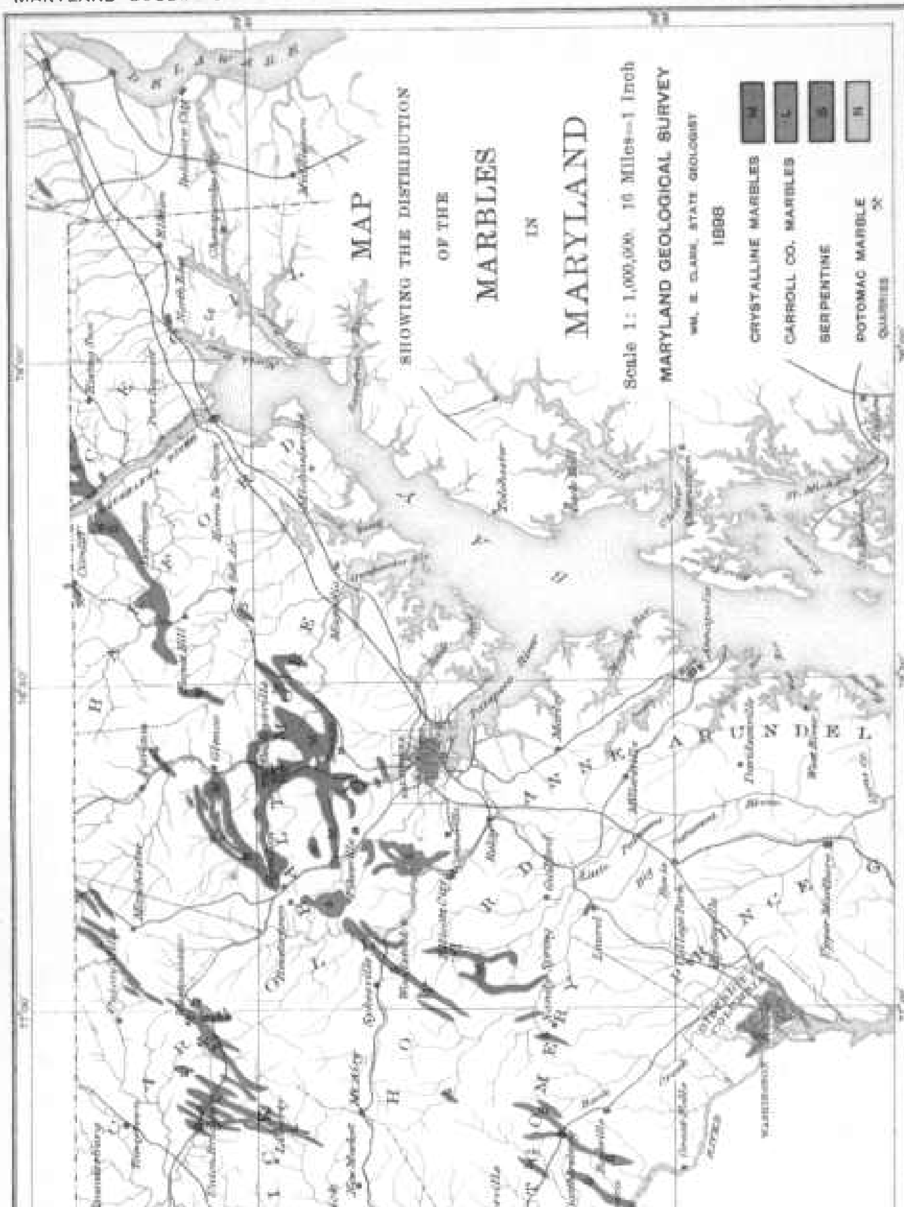
Silurian (Lewistown), with its heavy beds of limestone in several belts confined to the western and eastern portions of the Central Appalachian district, in Allegany and Washington counties;

Cambro-Silurian (Shenandoah), blue and gray limestones, dolomites and marbles, forming the broad and fertile Hagerstown and Frederick valleys in Washington and Frederick counties;

Undetermined, interlocated in the phyllites of Frederick and Carroll counties, and the

Archean (Algonkian ?) marbles of Baltimore and Howard counties.

According to their character, their occurrence and the uses to


MAP
SHOWING THE DISTRIBUTION
OF THE
MARBLES
IN
MARYLAND
Scale 1: 1,000,000. 16 Miles=1 Inch
MARYLAND GEOLOGICAL SURVEY
WM. B. CLARK, STATE GEOLOGIST
1898
CRYSTALLINE MARBLES
CARROLL CO. MARBLES
SERPENTINE
POTOMAC MARBLE
QUARRIES
A R U N D E L

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which these various stones are put they may be grouped for discussion in the following subdivisions:

The Marbles, including the highly crystalline dolomites and marbles of Baltimore, Howard and Carroll counties.

"*Potomac Marble*" or breccia which is found locally in the "Red beds" of the Newark Formation (Triassic) in Montgomery, Frederick and Carroll counties.

Serpentines or "Verde Antique," of Harford, Baltimore and Montgomery counties.

The Limestones, including the crystalline blue and gray limestones, magnesian limestones and "dolomites" of Frederick, Washington, Allegany and Garrett counties.

MARBLES.

The marbles of Maryland have been known for their excellent effect in building and monumental work since the beginning of the century. They are all confined to that portion of Maryland composed of the highly crystalline rocks of the Piedmont Plateau, while those of economic importance at the present time are confined to a small valley known as the Green Spring Valley extending east and west at a distance of 12 to 20 miles north of Baltimore.

This broad and beautiful valley sends off several large arms into the surrounding hills of gneiss and granite in such a way that the areal distribution is so anomalous and irregular as to render any explanation of the structure unsatisfactory. The same irregularity in distribution is noticeable in the marble areas between Glyndon and Glencoe and west of Ellicott City. This complexity of structure has led to various views regarding the age of these deposits. Ducatel[1] and Alexander from their study of the formation in 1833 regard them as "primitive." Tyson[2] in his first report classes them with the "metamorphic rocks" and evidently regards them as Silurian since they are placed on his map and in his list of "Geological Formations"[3] between the Chazy-Black River and Trenton. In the

[1] Report on the Projected Survey of the State of Maryland, Annapolis, 1834, p. 21.

[2] First Report of Philip T. Tyson, State Agricultural Chemist [1860], p. 30.

[3] Same, pp. 30, 35-36.

"Report on the Building Stones" of the Tenth Census Mr. Huntington[1] describes the area as "a small isolated area of Lower Silurian limestone bounded by rocks of Archean Age," and calls attention to the fact "that almost all of the marbles of commerce so extensively quarried east of the Alleghanies are from strata of Lower Silurian Age." Somewhat later Dr. G. H. Williams who made a detailed study of the area expressed the conclusion that[2] "The position to be assigned to this complex [gneiss, marble, quartz-schist] in the geological column is a matter deserving careful consideration, although data for a perfectly satisfactory conclusion are not at hand. It is believed that these rocks are demonstrably older than the altered lower Paleozoics of the western Piedmont region; and yet that they themselves contain in their chemical composition, stratigraphy and the presence of certain obscure conglomeratic beds near Washington, evidence of a clastic origin. For these reasons, as an expression of our present knowledge, the complex is provisionally assigned . . . to the Algonkian horizon." This view was subsequently restated[3] and held by the author until his death.

The marbles of this eastern area are throughout much coarser than the lenses of fine compact crystalline marble found intercalated in the phyllites of Carroll and Frederick counties. "Another striking contrast between the marbles of these two regions is, that, while the latter contain their impurities in the form of thin argillaceous bands, the former have theirs represented by layers of perfectly crystallized silicates." The western marbles also seem to be much more shattered and more difficult to work than the somewhat uniformly jointed marbles of the Cockeysville area.

Cockeysville and Texas.

These two towns are located on the Northern Central Railway about fifteen miles north of Baltimore, and are separated from each other by a distance of a mile and a half. Although situated so close together, and representing but parts of a single formation in a common

[1] Building Stones and the Quarry Industry. Tenth Census, p. 177.
[2] Guide to Baltimore, p. 89.
[3] Maryland, its Resources, Industries and Institutions, Baltimore, 1893.

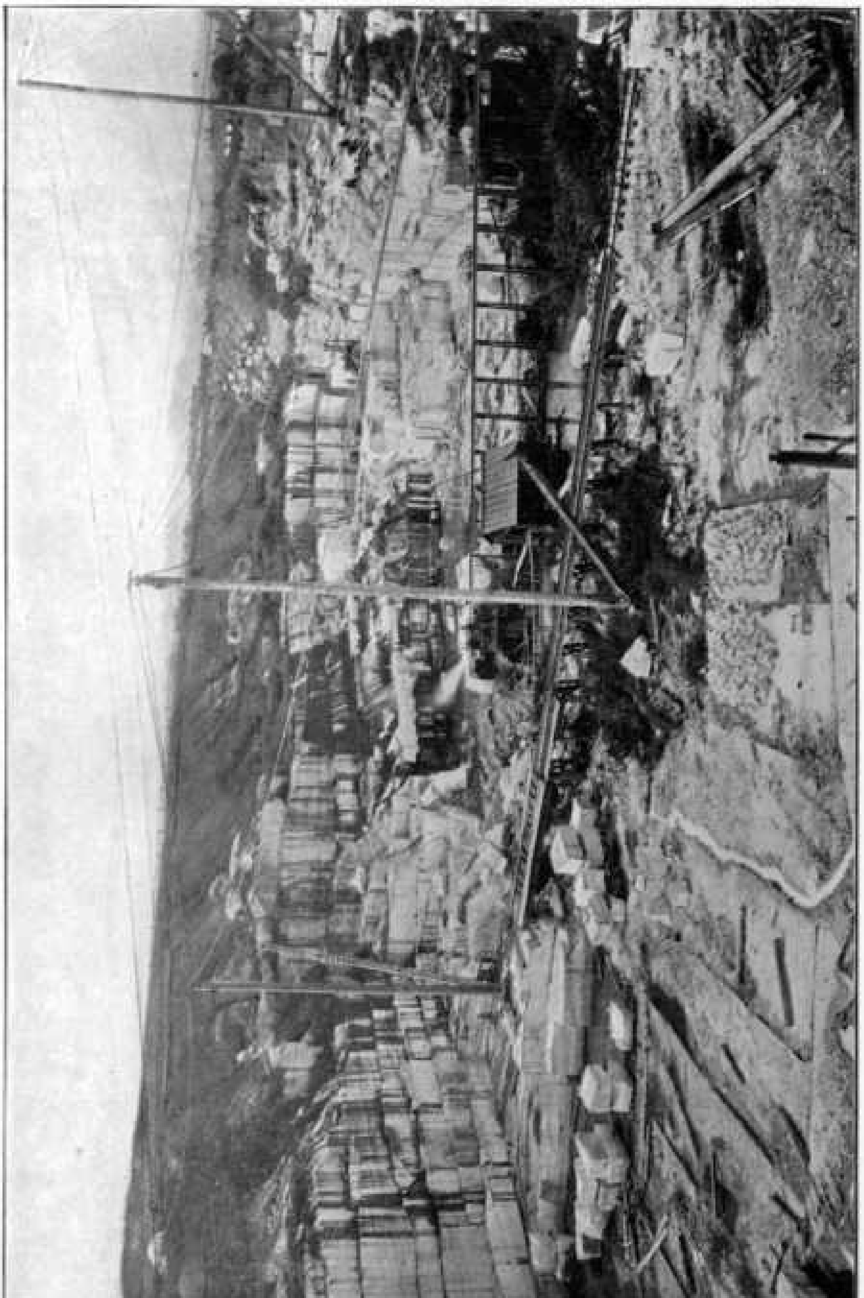
valley, the quarries expose rocks showing many differences in composition, purity, coarseness of grain and texture, which have developed different industries in the two places. The rock at Texas is a coarse-grained marble of nearly pure carbonate of lime suitable for use as a flux or fertilizer, while that at Cockeysville is a finer-grained dolomitic marble, rich in magnesium and well adapted to building and decorative purposes.

It is not known when the stone of this area was first used or first recognized as of economic importance. The first recorded description is that in a letter by Dr. H. H. Hayden[1] to Dr. Nathaniel Potter in which he writes: "Immediately to the northward, as well as to the eastward of the Bare Hills the limestone commences. This, I believe, is its first appearance in the vicinity of Baltimore, which is distant six miles. From this to the distance of twenty miles to the northward, and how much farther I am unacquainted, the limestone tracts discover a variety of transitions. In many places it approaches so near to a marble, as to render it not only useful, but highly valuable in almost every branch of civil architecture; and the prospect is favorable to a supply of such as will answer every purpose of statuary and sculpture in all their variety."

That Dr. Hayden's view of the adaptability was correct was soon shown by Mr. Mills in the construction of the Washington Monument in Baltimore, the cornerstone of which was laid on the Fourth of July, 1815. A lack of funds delayed the completion of the monument for nearly fifteen years, and it was not until the 25th of November, 1829, that the last piece of the statue, comprising the bust, etc., was raised to the summit.

The three blocks constituting the figure of Washington were originally quarried as a single piece over seventeen feet long at the Taylor quarry, about a quarter of a mile west of the railroad at Cockeysville, and presented by F. T. D. Taylor of Baltimore county. The marble used in the monument, which came in part from the Taylor quarry and in part from the Scott quarries five miles farther north, was

[1] Hayden's Geological Sketch of Baltimore. Jour. Balto. Med. & Phil. Lyc. vol. i, 1811, pp. 255-271. Repub. Bruce's Amer. Min. Jour., vol. i, New York, 1814, pp. 243-248.



BEAVER DAM QUARRY, COCKEYSVILLE, BALTIMORE COUNTY.

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perch of 3000 pounds for rubble delivered free on board the cars at Cockeysville.

Of the quarries inspected by Dr. Owen only a few are still (1898) in operation, most of them having become exhausted.

Scott's quarry, which is located about five miles north of Cockeysville, has not been worked during the last forty years, as the opening was abandoned as soon as the good stock was exhausted. It was from this quarry that part of the marble for the Washington monument was obtained.

An old quarry formerly on the property of Mrs. Chisilla Owings, about 200 yards from the present Beaver Dam quarries, was opened in 1840 and worked till 1873. It was then abandoned on account of the poor quality of the stone, and is now filled with water. This quarry was operated for a time by the Sherwood Marble Co.

The old quarry of Thos. Worthington from which the stone was obtained for the City Hall in Baltimore is situated about a mile west of the railroad at Cockeysville Station. It was opened some years prior to 1845 and was abandoned in 1873, when the white stone was exhausted. It is now the property of Mr. William Wight.

Samuel Worthington's old quarry is located about half a mile southwest of the one just mentioned, and is now owned by Mr. E. Gittings Merryman. It was abandoned in 1873 on account of the poor quality of the stone. While in operation the stone was quarried only when orders were received for it.

A quarry now owned by Mr. Lenwood Parks is situated about a quarter of a mile west of the last mentioned quarry. It was opened originally by Charlotte Owings and has not been operated since 1855. It was worked only according to orders and the good stone was soon exhausted.

Another old quarry about a quarter of a mile north of Cockeysville on the property of Mr. Geo. Jessups was formerly operated by a Mr. Cockey. It was shut down about 1879, since it was impossible to get out stone of sufficiently high grade to compete with the product of the other quarries.

From the foregoing it is seen that the present quarries, operated by the Beaver Dam Marble Co., have surpassed and outlived the competing quarries by the greater abundance and higher quality of the marketable stone. This company owns and operates the old Baker and Connelly quarry, which on the death of the senior partner was operated by Mr. Jas. B. Connelly, who left it to his sons Messrs. J. B. and T. F. Connelly. It was during the years 1859-61 that the huge blocks, each 26 feet in length, were furnished for the 108 columns in the National Capitol. These quarries were finally purchased by the present Beaver Dam Marble Co., capitalized at $100,-000. It began operations in 1879 with Mr. Hugh Sisson as president. To-day this is the only large operator at Cockeysville and at the time of writing it is busy furnishing material for the new Court House in Baltimore. It has already commenced the shipment of 38 ton monoliths which are to be used as columns. (See Plate XXII, Fig. 1.)

There are more of the old quarries still active in Texas than in Cockeysville, although little or nothing is done in quarrying stone for building purposes.

The Fell and Robinson quarry which was opened early in the century is situated a short distance west of the railroad. It passed from the hands of the original owners to a Mr. Miller, and from him to Mr. V. T. Shipley, whose heirs are now operating it. All the stone quarried is burnt in a single kiln which uses about 10 tons of stone daily.

Griscom's old quarry is on the east side of the railroad about 400 yards from the preceding. It is owned and operated by Mr. Wm. P. Lindsay, who employs about 30 men. Work is carried on all the year round, six kilns burning each day a load of about fifteen tons of stone apiece.

Burroughs' quarry is on the west side of the track and is now owned and operated by Yellott and Kidd, who burn about ten tons of stone each day.

Mr. William C. Dittmann operates the following old quarries: Mrs. Chisella Owings', situated on the property of Miss M. B. Price about a mile northeast of Texas and half a mile east of the railroad;

Cooper's quarry on the same property immediately on the railroad; the old John C. Bosley quarry at Texas and the Parks quarry, once operated by the Ideal Lime Co. Ten kilns are kept going throughout the year, consuming in all about 120 tons a day. It was from the old Bosley quarry that the stone in the North Avenue viaduct at Baltimore was obtained.

The Texas Lime Co. has a quarry at Texas which produces about 10 tons of stone daily.

Mr. Frank Lee has a quarry on his property about half a mile northeast of Texas which is worked throughout the year, producing about 10 tons of stone each day. The entire product is burnt and sent to the Baltimore chrome works, where it is used as a flux.

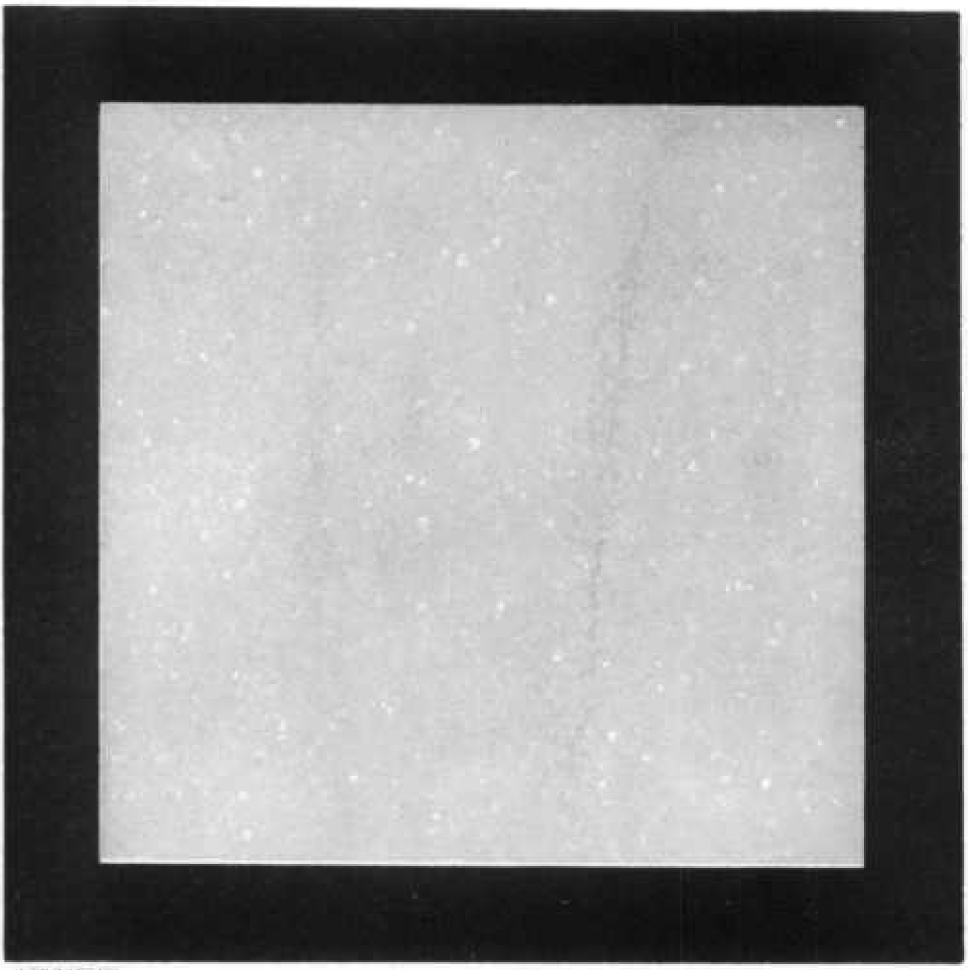
The *texture* of the eastern marble varies widely. The rock from Texas is a very coarsely crystalline marble or "alum stone" in which the individual grains are sometimes $\frac{1}{2}$ or $\frac{3}{4}$ of an inch in diameter. The constituents are weak in themselves and they are weakly held together. The single grains show twinning striae parallel to the crystal $-\frac{1}{2}$ R that have been produced by a pressure, causing a gliding of the molecules over one another which has weakened the strength of the grain. Such a texture as is here shown renders the rock nearly worthless as a building stone where small blocks must be used and great weights sustained. This is emphasized by the determination of the crushing strength, which is very low. The grain of the Cockeysville or Beaver Dam rock is fine, the individuals seldom exceeding $\frac{1}{16}$ of an inch in diameter, the component particles forming a closely interlocking aggregate. This interlocking of the grains tends to produce a more compact and harder rock whose crushing strength is high (67,000 lbs.) and absorption ratio low (0.213%). This difference in closeness of grain is not strictly a geographical one, since fine-grained marbles, similar to those at Cockeysville, may be found at Texas. There is at the latter point, however, little evidence of the occurrence of rock which will combine such fineness and closeness of grain, freedom from mica and pyrite, and abundance as is shown in the rock worked by the Beaver Dam Company at Cockeysville.

The uniformity in color is more marked at Texas than at Cockeysville, where there are frequent zones or horizontal bands of crystallized silicates, which represent old impurities and possibly the original bedding of the rock. These darker bands which are composed of copper-colored mica (phlogopite), colorless, radiating tremolite, pyrite and quartz, sometimes obstruct the working of the quarries when the stone required must be large and cannot be stood "on edge." In the smaller blocks these bands are avoided by "facing" parallel to them and setting the blocks perpendicular to their natural bedding. Uniformity in the size of the grains and in the texture, on the other hand, are more prominent at Cockeysville than at Texas. This uniformity in texture distributes the strain more evenly, making the position "on bed" and "on edge" less essential.[1]

The color of the marketable Cockeysville rock is clear white,[2] with now and then a few streaks or bands of pale blue which give to the rock face a faint gray color. In the poorer grades of stone which are sometimes shipped as far as Baltimore for use as door steps, sills, etc., there are occasional brown bands where the mica has been more abundantly developed. When polished and kept clean the rock is of a dazzling whiteness, often noticed by visitors walking through the residence portion of Baltimore. If the rock is laid in ashlar the little interstices between the grains soon gather dust, and the bright effect of the white rock is softened to a dove-colored gray. This same toning effect may be noticed in buildings, like the Peabody Institute, Baltimore, which have been built of smoothed stone, that has not been scraped or repolished. The Cockeysville stone is thought by some to stain easily, but this fault may be avoided by carefully selecting for first-class work those pieces which are free from the pyrite that sometimes is present in little pockets or stringers. Few instances,

[1] After examining a large number of buildings where this stone has been used as a trimming and set "on edge," the writer is inclined to believe that the texture is sufficiently massive and granular to warrant such a setting, where the weight and exposure are not exceptionally large. This view seems to be borne out by the various results of pressure tests to which the rock has been subjected.

[2] The accompanying illustration (Plate XXI) hardly does the stone full justice since it fails to give the clear white color that is so characteristic for the stone.



MARBLE.

COCKEYSVILLE, BALTIMORE COUNTY.

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in the buildings examined, have shown any indication of staining from inherent impurities.

The Texas and Cockeysville stones differ in their chemical composition as well as in their texture and color. Although before 1850 there was some dispute as to which of the two rocks was richer in magnesium the question is now clearly decided. According to Williams "the long series of analyses which are constantly being made of the Texas rock by the Maryland Steel Company, where it is used as a flux, show that it does not average over five per cent. of carbonate of magnesia; a number of analyses of the Beaver Dam product, on the other hand, give the average amount of this substance as high as forty per cent."[1]

Analyses of Marble.

	I.	II.	III.	IV.
Insol.	5.57	.....	2.33	2.00
SiO_2	......	0.44	......	......
Al_2O_3 Fe_2O_3	.40	......	......	......
FeO	......	tr.	....	......
CaO	29.08	30.73	29.30	52.08
MgO	20.30	20.87	20.81	2.38
HO	......	1.22	0.08	......
CO_2	44.26	45.85	45.31	43.54
	99.61	100.33	99.38	100.00

	Specimen.	Analyst.	References.
I.	Cockeysville.	Schneider.	Bull., 148, p. 255.
II.	"	Whitfield.	" " p. 255.
	"	"	" 60, p. 159.
	"	"	Guide to Baltimore, p. 98.
III.	"	Higgins. (?)	(recalculated.)
IV.	Texas.	estimated average.	

The exact limits of the areal distribution of the marble and the dolomite have never been determined because of the lack of exposures and the high state of cultivation throughout the area underlain by the two rocks. It seems probable, from the data at hand that the distribution presents an intricate interweaving of the two types which may yield much information on the subject of dolomitization if the workings ever present sufficiently continuous exposures of the rock surface.

[1] Maryland, its Resources, Industries, and Institutions, p. 135.

The microscopical texture of the Cockeysville and Texas rocks differs but slightly from that presented to the unaided eye. The grains interlock in about the same way and the interstitial areas left between them seem very small. The two rocks differ from each other, when seen with polarized light, since sections of the Cockeysville rock show fewer vari-colored bands than that from Texas, due to the secondary twinning of the small individuals of the carbonate of lime which is more susceptible to twinning through pressure than the magnesian carbonate. The two minerals are intimately mixed in their distribution, and only occasionally show any marked variation in the size of the grains. Accessory minerals are present, but they show no differences in texture beyond those evident to the naked eye.

Few American building stones have been as thoroughly investigated with reference to their crushing strength as the marbles of Baltimore county. From the time that Mr. Robt. Mills became interested in the properties of the Baltimore marbles, which he used in the construction of the Washington monument in Baltimore, the engineers and architects charged with the construction of the Public Buildings in Washington have watched with interest the behavior of this stone in structures. The use of these marbles in public buildings has also led to extended experiments on the part of government officials. Prior to 1837 all of the important public buildings at Washington were constructed of Aquia Creek (Va.) sandstone, which was so treacherous and unsightly after exposure that as early as 1839 an inquiry was instituted by Congress as to the availability and cost of marble and granite. At this time Mr. Gilmore offered to furnish marble from the Baltimore county quarries at 90 cents a cubic foot, and Mr. Mills, the government architect, highly endorsed the rock.

The first published results of crushing strength tests on Maryland marbles were obtained before 1851, as stated in Professor W. R. Johnson's paper on American and Foreign Building Stones (pp. 6, 7),[1] by Mr. Robert Mills and Dr. Charles G. Page. These tests were made on two-inch cubes of coarse "alum stone" from Texas and

[1] Comparison of Experiments on American and Foreign Building Stones to determine their relative strength and durability; by Professor Walter R. Johnson, Amer. Jour. Sci., 2 ser., vol. xi, 1851, pp. 6-7.

showed considerable range in values. Similar tests were also made on two-inch cubes of fine grained marble from Symington's quarry (now abandoned), which show much greater uniformity. Other experiments on Maryland marbles were made by Mr. Dougherty, Superintendent of the Washington monument in Washington, which gave still other results. Prof. Johnson noted the wide discrepancies in the figures obtained from these different experiments on material from the same localities, and concluded that the variations must be explained either on one or the other of three suppositions; 1st, that the strength of the different specimens of the rock is thus variable, and that consequently no certain reliance can be placed on its powers of resistance; 2nd, that the experimenting or the machines with which the testings were conducted were faulty; or 3rd, that the resistance to crushing for a unit of area at the base, increases in some ratio with the number of units composing that area, that is, with the actual area of the base.[1] Johnson favored the third explanation, but the second seems to be as much in accord with later results. Since these early experiments were conducted, great advances have been made in the manner, uniformity and accuracy of the testings, so that results obtained now are not to be compared or averaged with those of earlier workers. The conditions under which the testings are carried on cause the results to vary within wide limits.

The experiments conducted in the preparation of the present report were made with the greatest care and under the same conditions. All of the specimens were two inch cubes, placed between two quarter-inch thick soft pine blocks in exactly the same position, and the testing machine was run at the same speed in each case. Almost all of the blocks were cut from the average stock of a well-known stone-yard. Some were crushed just as they were received from the stone cutter, while others were crushed after they had been submitted to absorption, freezing and thawing tests.

The results are as follows:

						Crack.	Break.
1.	Cockeysville marble,	unoriented	without	immersion		......	57,740
2.	"	"	"	"	"	......	81,580
3.	"	"	"	after absorption and freezing.		......	60,240
4.	"	"	"	"	"	47,560	69,800

[1] Loc. cit., p. 17.

Somewhat higher figures have been obtained at other times, as is shown by the accompanying letter, but the conditions of the testing are not known.

[HUGH SISSON, ESQ.,
Baltimore, Md.,
Sir:—] Washington, D. C. [ ]

The compressive strength of the six 2″ cubes of Beaver Dam Marble, which you furnished, was as follows:

No. 1.	84,000 lbs.
2.	90,000
3.	90,000
4.	84,000
5.	95,000
6.	94,000
	89,066 Average.

Strength per square inch, 22,416 lbs. The strength of the large crystal marble is about 12,600 lbs. per sq. inch. The 1″ cubes have not yet been crushed, but I feel satisfied the result will not show a greater strength per square inch than those obtained in crushing 2″ cubes.

Very respectfully,
Your Obt. Servt.,
GEO. W. DAVIES,
By direction of Col. Casey. *Capt. Assist. Engineer.*

It is therefore clearly shown that the rock from the Beaver Dam quarries at Cockeysville, *as usually furnished*, can well sustain any weight which the exigencies of structures may demand.

Many crushing tests were made on the coarse-grained " alum stone " from Texas in earlier years and the results have been brought together by Johnson. The most satisfactory test, however, is furnished by the Washington National Monument itself, which shows the Texas rock (Griscom's lime quarries) subjected to increasing pressure from top to bottom as given in the following table from the report made by Col. Thomas L. Casey, Corps of Engineers, United States Army, engineer in charge of the construction of the monument, to W. W. Corcoran, Esq., chairman of the joint commission for the completion of this structure dated July 27, 1878.[1]

[1] Quoted in Tenth Census, vol. x, Report on Building Stones, p. 359.

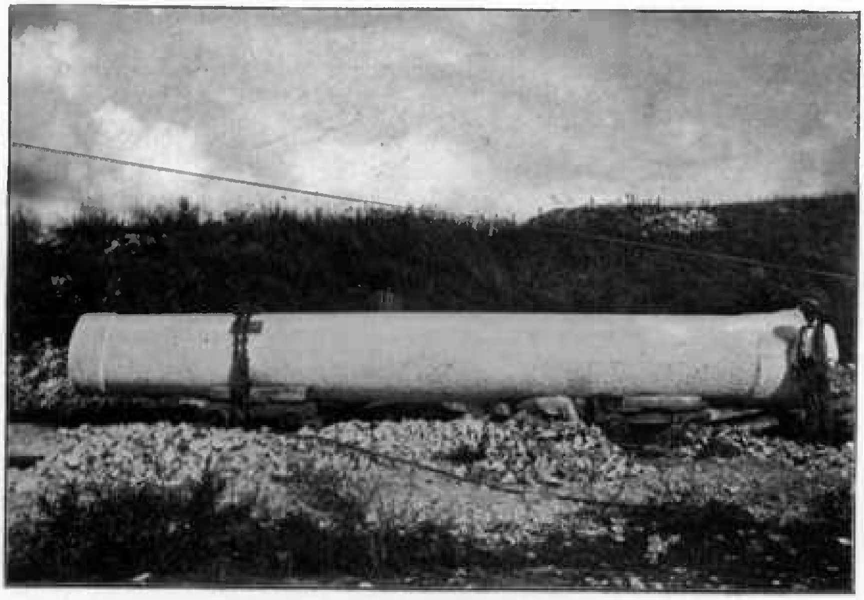

FIG. 1.—THIRTY-EIGHT TON MONOLITH, COCKEYSVILLE.

FIG. 2.—POTOMAC MARBLE QUARRY, POINT OF ROCKS.

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Distance of joint from top, in feet.	Contents in cubic feet.	Average weight per cubic foot of masonry in several divisions.
25	....	First Division, 169.5 pounds.
50	13,555	
100	34,719	
150	63,957	
171.66	79,239	
200	101,674	Second division, 167.8 pounds.
250	148,298	
300	204,273	
343.66	261,291	
350	272,369	Third division, 165.8 pounds.
400	366,268	
450	470,495	
500	585,476	

Weight in pounds.	Pressure in tons (2240 lbs.) per square foot.			Distance of line of resistance from axis in feet.	Stability under action of the wind.
	Least.	Mean.	Greatest.		
....	....	....	....	0.603	29.454
2,297,630	2.67	2.96	3.26	1.052	17.378
5,884,973	4.41	5.23	6.04	1.676	11.529
10,840,728	5.85	7.24	8.64	2.087	9.758
13,431,081	6.44	8.08	9.72	2.224	9.360
17,195,713	7.14	9.12	11.09	2.383	8.983
25,019,140	8.35	10.90	13.44	2.607	8.610
34,411,997	9.54	12.63	15.73	2.779	8.452
43,963,655	10.56	14.11	17.66	2.899	8.417
45,816,912	8.28	11.51	14.73	2.892	8.481
61,385,397	10.09	13.84	17.60	2.869	8.902
78,666,278	11.76	16.03	20.30	2.889	9.190
97,264,244	13.38	18.02	22.658	2.928	9.413

The fact that the coarse-grained marble without crushing actually withstands a pressure of 28,796 [1] pounds to the square inch when this pressure is applied evenly and slowly would seem to indicate that stone like that from Cockeysville might withstand under similar circumstances a pressure of fully twice as much as the figures given, since the earlier tests by Mills and by Dougherty place the strength of the "Symington" stone at twice that of the Texas rock.

The freezing tests which were conducted by Dr. Charles G. Page according to the Brard method described on page 104 gave the following results: [2]

[1] Computed on the assumption that the value of the crushing weight varies as the third power of the side of the areas compared.

[2] Report of the Board of Regents of the Smithsonian Institution. Sen. Doc. No. 23, 30th Congress, 1st Session, p. 21.

Spec. marked.	S. G.	Weight per cubic ft.	Loss by frost in grains.	Per-cent. of loss.
2. Symington's close-grained marble (similar to Worthington's.)	2.834	177.1	0.29	0.026
4. " large crystal marble,	2.857	178.5	0.50	0.069
5. " blue limestone,	2.613	163.3	0.34	
8. Port Deposit granite,	2.609	163.0	5.05	

Since the cubes used were but one inch in diameter they did not weigh over 720 grains and the percentage approximates the values given in the fourth column.

During the preparation of the present report Mr. Shellenberger tested the rock by depositing two-inch cubes in a freezing chamber for forty-eight hours and subsequently drying them at 212° F. The percentage loss from freezing and thawing, calculated on the difference between the original weights before immersion and after drying, was obtained as follows:

Mark on cube.	Kind of stone.	Weight after drying 24 hours at 212° F. Grams.	Weight before freezing 48 hours at 2° F. Grams.	Weight after freezing 48 hours at 2° F. and then dried at 212° F. for 24 hours. Grams.	Loss in weight. Grs.	Per cent of loss by freezing and thawing.
3.	Marble	367.15	367.93	367.13	0.02	0.005
4.	"	367.07	367.86	367.03	0.04	0.11

These figures and practical experiments show that a cubic foot of the Cockeysville rock weighs about 175 pounds per cubic foot or 4,375 pounds per perch of twenty-five cubic feet.[1] They also indicate that the close-grained marble (now the only one in general use for buildings) is exceptionally non-absorbent and resistant to the disintegrating effect of frost. This is well borne out by a study of the oldest structures standing, which show little or no "spalling" as the result of frost action, and the character of the weathering shown in the quarries.

The "dry seams" which have caused occasional loss, as in the case of the Baltimore Court House monoliths, seldom prove troublesome in the material furnished for ordinary buildings, since they may

[1] When sold by weight it has been customary to figure 3,000 lbs. to a perch.

usually be avoided in the smaller blocks. The strain which cause them to open after dressing is also more evenly distributed in structures using smaller pieces of stone.

The mineralogical and chemical composition of carefully selected blocks of marble from Cockeysville show that little more can be desired to assure the stability and consequent durability of the stone. When care is taken to avoid the few bands and pockets of pyrite and mica there is nothing in this rock which will render its decomposition rapid, as all the accidental or accessory constituents are in the form of stable compounds such as tremolite, tourmaline, or quartz. These in the first-class stock are seldom in any abundance, with occasional exception of finely fibrous and disseminated colorless tremolite. The outcrops, though decayed from ten to twenty feet below the surface, show the rock to be very durable for a carbonate, especially as the entire area of its occurrence has been exposed more or less continuously to disintegrating influences since at least late Tertiary time without any period of scouring by glaciers. Old tombstones, said to have been cut as early as 1829, show their lines as sharp and their surface as smooth as pieces which have been exposed to the atmosphere for only a few years. Little discoloration has developed beyond the darkening due to dust or nearby brick or iron.

The other areas of marble, similar to that of the Green Spring Valley, are not worked for building stone, but the whole product is burnt for lime, which is generally applied to the land of the immediately adjacent country. The centers of distribution are Butler in Baltimore county; Marriottsville and Highland in Howard county. Both Butler and Highland are so far from railroads and so lacking in transportation facilities, that they will never compete with the Cockeysville product so long as conditions remain as at present.

Marbles of Carroll County.

Intermediate between the clear white, fine grained saccharoidal marbles of Baltimore and Howard counties and the crystalline dark blue and gray limestones of the Hagerstown and Frederick valleys are the variegated marbles of Carroll county, which have furnished samples unsurpassed in beauty and variety by those of other states.

At the Centennial Exposition in Philadelphia in 1876 there were exhibited specimens of "deep red," "dark red veined with white," "salmon colored," "lavender veined," "undulate pink and white" and "ruby" marbles which came from Carroll and Frederick counties. Besides these many others might have been supplied. Some samples of the stone resemble the deeper colored Tennessee marbles, while others suggest the yellow Sienna, but lack its bright, clear tone.

All of these varieties occur in lenses in the phyllites which in certain localities have been shown by Mr. Keith to be of Cambrian age. The lenses do not occupy any considerable extent or present large exposures, but instead are confined to valleys which are long and narrow and are the direct result of the readier removal of the calcareous rocks than of the adjacent shales and sandstones. The marbles thus occupy the bottom lands and seldom outcrop high above the level of the streams. All of the valleys formed in this way trend parallel to the longer axes of the lenses in a N. E.-S. W. direction, as is well represented in the valley east of the road from New Windsor to Unionville and in the smaller valleys at the south of Spring Mills P. O.

Up to the present time the method of extracting the stone has been very crude, since the only desire has been to obtain the rock in pieces small enough for foundations and ordinary buildings. According to information furnished by Prof. Uhler, there has been a marked deterioration in the method of quarrying these marbles since he first began to study these rocks. Formerly considerable attention was paid to the extraction of the stone without explosives, while at the present almost all of the quarries use powder or dynamite to loosen the rock and render its extraction easy. During the earlier workings beautiful slabs were taken out for altar fronts and interior decorations. From a study of the walls of the small quarries it seems probable that no blocks can now be obtained in size, shape and quantity for first-class building purposes. The jointing is not trustworthy and the rock tends to break down into thick angular blocks varying in size from eight cubic feet to small fragments. Careful work with channelling-machines or diamond drills and a discontinuance of explosives might allow the quarrying of blocks which would be valuable for interior decoration in the form of mosaics and mantels.

Another serious drawback in working these rocks, which appear so beautiful in samples, is the irregular distribution of the colors, which seem to obey no rule and to follow no definite course. The white may be replaced by red or the red may be replaced by blue and so on. There seems, however, to be a greater amount of red and white or clear white than anything else. The variations in color are so frequent and uncertain, that it seems doubtful, if any quarry now opened could fulfill any moderately large order with material like a given sample. That there are beautiful marbles within these lenses is beyond doubt, but a suitable place for the development of a profitable industry in them has yet to be found.

Among the openings in these marbles in Carroll county, which are used quite generally for lime, are the following:

Jonas Bachman, Bachman's Mills; Wm. H. Eberhart, Bachman's Mills; Jeremiah Brown, New Windsor; Samuel Harris, Lessee, New Windsor; Eph. Stouffer, New Windsor; John T. Dutterer, Silver Run; Wm. A. Leppo, Silver Run; J. C. Robertson, Warfieldsburg P. O.; E. J. Gorsuch, Westminster; Wm. A. Roop, Westminster; Henry B. Rigle, Westminster.

At various points around the northern end of the Blue Ridge and occasionally along the course of the Shenandoah river Mr. Keith has found a local development of white marble, which is often pure white, with an exceptionally even grain, resembling a high grade statuary marble. Mention of such material may be found in the reports of the earlier state geologists, and the exposures have been met with in several places, but in no instance have they been free from stain or jointing in masses which offer a reasonable return for investment. Such, however, may sometime be found, although Keith considers that this marble is not of sufficient body to be valuable. Small quarries have been opened near Keedysville and just below the station at Edgemont, but these have not been adequately developed.

POTOMAC MARBLE.

The most interesting building material in the entire state of Maryland is the "Potomac marble," "calico rock" or "Potomac breccia," which has been used occasionally for the greater portion of the century. The chief interest in this rock arises from the fact that it is "the only true conglomerate or breccia marble that has ever been utilized to any extent in the United States."[1]

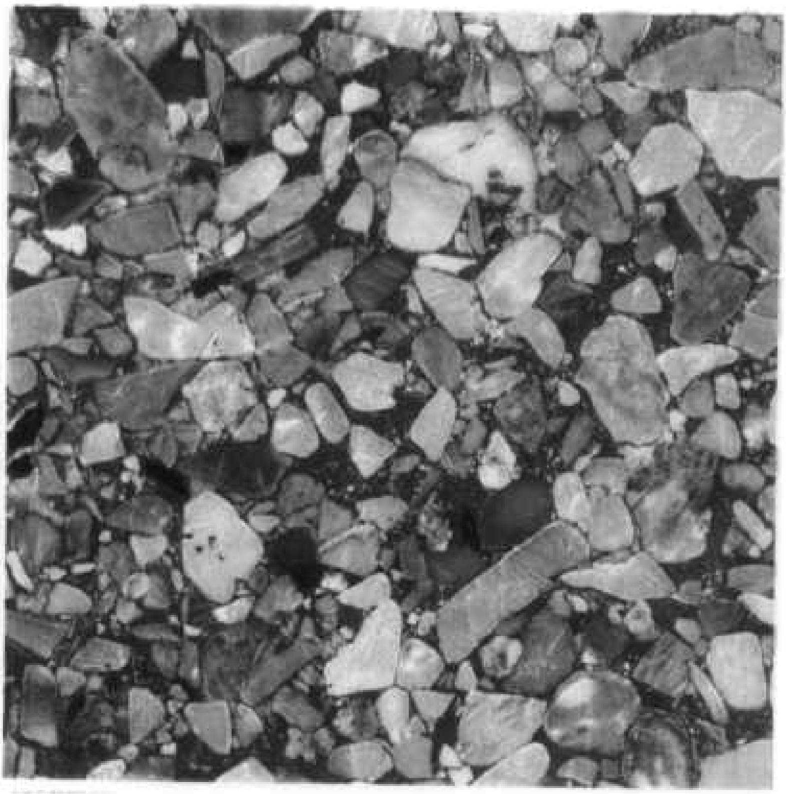
This conglomerate is found in several places along the eastern slope of the Blue Ridge and is most extensively quarried in the vicinity of Point of Rocks, Frederick county near Washington Junction on the Baltimore and Ohio Railroad. The quarries are small affairs, which have been operated spasmodically. The one in operation at the present time is located about a mile east of the Washington Junction station on a spur which runs northeasterly from the Metropolitan Branch.

This rock was first brought into notice by Mr. B. H. Latrobe, Superintending Architect in the construction and repair of the Capitol and White House before and after the war of 1812. In his report on the public buildings, read February 14, 1817,[2] Mr. Latrobe gives the first account of the use of this marble as a building stone, as follows: "For the columns, and for various other parts of the House of Representatives, no free-stone that could be at all admitted has been discovered. Other resources, therefore, were sought after. A stone hitherto considered only as an encumberance to agriculture, which exists in inexhaustible quantity at the foot of the most southeasterly range of our Atlantic mountains—probably along the greatest part of their extent, but certainly from the Roanoke to the Schuylkill, and which the present surveyor of the capitol, and probably others, had many years ago discovered to be a very hard, but beautiful marble—this stone was examined, and, after much labor and perseverance, has been proved to answer every expectation that was formed, not only of its beauty, but of its capacity to furnish columns of any length, and to be applicable to every purpose to which colored marble can be applied.

"The present commissioner of public buildings has, therefore, entered into a contract for all the columns, and progress has been made in quarrying them. They may be procured each in a single block should the transportation be found convenient.

[1] Merrill, "Stones for Building and Decoration," New York, John Wiley and Sons, 1891, p. 92.

[2] Senate Documents, 14th Congress, 2nd Session, No. 101, pp. 3 and 6.



POTOMAC MARBLE.

POINT OF ROCKS, FREDERICK COUNTY.

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"A block of one of the pilasters lies ready to be brought down to Washington, and will, probably, arrive in a few days. The quarries are situated in Loudoun county, Virginia, and Montgomery county, Maryland."

The columns which were then procured are still standing in the old House of Representatives, now used for the sittings of the Supreme Court. The quarries whence they were obtained have never been fully developed, although Mr. Latrobe thought that he had found in the newly discovered marble of the Potomac an inexhaustible resource of the most beautiful building materials situated easily accessible by water. There is some doubt as to the exact location of the particular source of these blocks used in the capitol, although they were monoliths of considerable size for the time and the primitive means of transportation.

Plate XXII, Fig. 2, represents the opening reported to be the source. It is situated in the woods north of the Metropolitan Branch of the Baltimore and Ohio Railroad about half way from Washington Junction to the quarries now in active operation.

A few years later in his paper on the geology of the Southern States the Rev. Elias Cornelius[1] gives the following account of this brecciated limestone:

"It is also in the valley of this river [Potomac], and not far from its famous passage through the Blue Ridge, that immense quarries of beautiful breccia have been opened. This rock was first brought into use by Mr. Latrobe, for some years employed by the government as principal architect. It is composed of pebbles, and fragments of siliceous and calcareous stones of almost every size, from a grain, to several inches in diameter, strongly and perfectly cemented. Some are angular, others rounded. Their colors are very various, and often bright. Red, white, brown, gray, and green, are alternately conspicuous with every intermediate shade. Owing to the silicious stones which are frequently imbedded through the mass, it is wrought with

[1] On the Geology, Mineralogy, Scenery, and Curiosities of Parts of Virginia, Tennessee, and the Alabama and Mississippi Territories, &c., with Miscellaneous Remarks, in a letter to the Editor, vol. i, Amer. Jour. Sci., New Haven, 1819, p. 216.

much difficulty; but when finished, shows a fine polish, and is unquestionably one of the most beautifully variegated marbles, that ever ornamented any place. It would be difficult to conceive of anything more grand than the Hall of the Representatives, in the Capitol, supported as it is by twenty or thirty pillars formed of the solid rock, and placed in an amphitheatrical range; each pillar about three feet in diameter, and twenty in height. Some idea of the labor which is employed in working the marble may be formed from the fact, that the expense of each pillar is estimated at five thousand dollars. The specimens in your possession, are good examples of its general structure, but convey no adequate idea of its beauty."

The words of commendation and the beauty of the columns of the Capitol led the regents of the Smithsonian Institution to investigate the locality and to consider the availability of this rock for the building of the Smithsonian Institution. Accordingly in the spring of 1847 Dr. David Dale Owen visited these quarries which, on the whole, he found were worthless for the purpose in hand.

At the present time the work in the Potomac marbles is carried on almost exclusively by the Washington Junction Stone Co., which quarries both sandstone and Potomac marble. The former is obtained in good sized blocks but the latter is wrought almost entirely in small slabs. The marble is taken from a small opening about half a mile southwest of the quarry buildings. The conglomerates under discussion belong in the Newark formation, which extends along the western border of the Piedmont Plateau from Connecticut and New York southward. The development of the Potomac marble within the Newark is not great and there are but few exposures within the state. It is sparingly developed north of Frederick, a mile south of Thurmont and only barely represented at Point of Rocks on the eastern slopes of the Catoctin Mountain. According to Mr. Keith[1] this limestone conglomerate occurs in lenses or wedges in the sandstone ranging from 1 foot to 500 feet in thickness, or possibly even greater. They disappear through complete replacement by sandstone at the same horizon. The wedge may thin out to a feather edge or may be bodily

[1] Keith, Geology of the Catoctin Belt, 14th Ann. Rept. U. S. Geol. Surv., Washington, 1894, part ii, p. 346.

replaced upon its strike by sandstone; one method is perhaps as common as the other.

The conglomerate is made up of pebbles of limestone of varying size which sometimes reach a foot in diameter, although usually averaging about two or three inches. The fragments, which are both well rounded and angular, range in color from gray to blue and dark blue, and occasionally pebbles of quartz, chloritic schists and white crystalline marble occur. All are embedded in a red calcareous matrix mixed with a greater or less amount of sand. The pebbles are very similar to the magnesian limestones of the Shenandoah formation, developed in the Frederick and Hagerstown valleys and to the rocks of the complex which forms the Catoctin Mountain. Occasionally pebbles show evidences of having been decayed even before they became a part of the conglomeritic mass, but this may be due to their greater solubility, since the matrix does not show a corresponding degree of decomposition.

The bedding so far as it has been observed is irregular and of little importance in the quarrying of the rock, the lenticular character of the beds having far more importance than the position of the individual pebbles within the mass. In the same way the jointing is also a relatively subordinate feature since the different degrees of cohesion between the parts of the pebbles and that between the pebbles and the matrix play an important part in determining along what planes a rupture will take place. The texture shows a wide variation in the size of the grains, in the character of the material composing them, and in the relative amount of matrix between the grains and pebbles. This wide range in the size of the particles and in their abundance leads to many difficulties in polishing the rocks, but the difference between the hardness of the limestone and that of the quartz pebbles is particularly a source of expense and annoyance, since the hard quartz pebbles break away from the softer parts in which they lie, leaving numerous cavities to be filled with colored wax or shellac. This difference in the hardness and material of the pebbles, together with the conglomeritic character of the mass excludes the use of hammers and chisels. Any satisfactory quarrying of the blocks must be done with saw and abrasive materials. It is this difficulty in the working, together with the fragile nature of the stone itself, which has kept it from the conspicuous place in the market, which its oddity and beauty deserve.

The chemical composition of breccia can scarcely be determined from a single analysis, and the figures obtained from an average of several analyses may be of little account. The values obtained depend very largely on the accuracy of the analyst, the fineness of the grain, the homogeneity of the specimens and the number of samples taken to make an average test. Higgins[1] gives the following as "the average of various analyses made of the Breccia marble, or Calico limestone, found in Montgomery, from which the pillars in the House of Representatives at Washington are made:"

Sand	12.25 per cent.
Iron and clay	1.00
Lime, as carbonate	70.50
Magnesia	15.00
Other constituents not worthy of estimation	0.25
Total	99.00

This is probably of little value in itself and should have no weight in estimating the value of the marble. The stone is particularly suited to mosaic work and interior decorations, and should not attempt any competition as a structural material with the stones now in common use.

The influence of microscopic structures in a stone like this breccia is more than over-balanced by the variations in the larger structural features of the rock. If the microscope or hand lens shows that the stone is sufficiently fine and homogeneous to take a good polish with few minute irregularities on the surface that is sufficient, still experience clearly shows that this rock will take a good polish and that it will withstand any pressure to which it may be subjected as an ornamental or decorative stone.

This unique material deserves to be fully exploited and pushed as a novelty in the highest class of interior furnishings. It is believed that a demand might be created for this stone in some of the best

[1] Second Rept. Jas. Higgins, State Agr. Chemist, Annapolis, 1852, p. 39.

FIG. 1.—WHITEFORD QUARRY, CAMBRIA, HARFORD COUNTY.

FIG. 2.—SLATE QUARRY, IJAMSVILLE, FREDERICK COUNTY.

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work which is done in New York, Philadelphia, Washington and other large cities, where there is a call for materials which are suitable for floors and other interior decorations, striking in color and texture and of pleasing contrasts.

SERPENTINE.

Serpentine or "Verde Antique" has been quarried in Maryland for many years, but the annual production has always remained small. As this rock enters into competition with some of the marble for interior decoration it has frequently been classed as a marble, although so far as the Maryland deposits are concerned it is in no wise related to the marble, however intimately interwoven with calcite veins it may be. The deposits of the state are found in Cecil, Harford, Baltimore, Howard and Montgomery counties, where they have been worked to a greater or less extent in the hope of obtaining good material for general building or interior decoration. The most thoroughly exploited are those about Baltimore, at the Bare Hills, those on the banks of Broad Creek in the eastern part of Harford county, and a small area near Cambria in the northern part of the same county. That the stone is capable of furnishing beautiful slabs for decorative purposes is readily seen from the accompanying illustration (Plate XXV). The deposits on Broad Creek are situated in the midst of a large serpentine area, which extends from the Susquehanna southwesterly into Baltimore county. The nearest town is the small village of Dublin some three miles to the south, which is lacking in both railroad and canal communication. In the shipping of orders it is necessary to have all of the stone hauled to Conowingo on the Perryville and Columbia Railroad, a distance of three or four miles.

It is not known when the quarries on Broad Creek were first opened. Local tradition asserts that they were operated some years before the civil war. It at least seems probable that they were opened as early as 1870, since at the time Professor Genth made his report (1875), some of the shafts had been worked to a depth of 57 feet. The area was still earlier the scene of mining operations for iron, and it probably was prospected for chrome deposits about the beginning of the century. In 1875 the Havre Iron Co. of Wilmington, Delaware, asked Professor F. A. Genth of the University of Pennsylvania to visit the area for the purpose of "examining into the nature and extent of the deposit of Green Ornamental Stone" occurring on their property. The results of this visit were published in a small pamphlet entitled "The Geological Report of the Maryland Verde Antique Marble."[1] How long this company operated for serpentine could not be ascertained, but evidently the quarries were not worked in the period just prior to 1880, when the Serpentine Marble Co. began operations in this district. This company operated the quarries in a more business-like way, constructing sawing sheds and polishing tables as well as a short railroad across Broad Creek on which they removed the refuse. The quarries when visited by the writer were not in operation on account of the lack of success, extravagant management and litigation arising from the death of the mortgagee, who held a mortgage on the property for $40,000. During the activity of this latter company considerable material was furnished for building purposes and for interior decoration, the principal market being New York, where the material was used entirely for decoration. The largest building constructed of this material is the Protestant Episcopal Grace Memorial Church of Darlington, Md.

The geological occurrence and the mineralogical character are similar to those of the serpentine deposits all along the eastern border of the continent, which occur as alteration products of basic magnesian rocks like peridotite. The changes which have taken place show all of the features of serpentinization with the development of accessory deposits of calcite, quartz, opal, gibbsite, deweylite, etc. The rock face of the quarries rises quite sharply from the bed of Broad Creek and offers every facility for operating above water level, and for the handling of the stone at little expense. There does not appear to be any marked bedding in the rock, although Genth seems to have regarded the mass as possibly of sedimentary origin. The ledge which has been worked seems to form a lens of more massive rock between more micaceous and schistose layers, the long direction of the layers having a strike of N. 69° E. The seaming of the rock is its least

[1] The Geological Report of the Maryland Verde Antique Marble and other Minerals on the lands of the Havre Iron Co. in Harford County, Maryland, by Prof. F. A. Genth, University of Pennsylvania, 1875, 9 pp., map.

favorable feature, since the seams run irregularly both in direction and and in distance, causing the stone to break up into irregular masses, which require considerable handling before they can be reduced to good form. The rock also gives evidence of having undergone considerable disturbance, as shown by the bands of fibrous serpentine which are often faulted to the distance of $\frac{1}{2}$ or $\frac{3}{4}$ of an inch (Plate XXV). This seaming and faulting cause considerable waste and render the stone tender, so that it must be shipped with care and used where it is not subject to great pressure.

The texture of the stone does not vary very widely, and the impression is left that the stone works readily. If due care is used to avoid the use of explosives and the working of the stone after it has lost the so-called quarry water much of the waste may be avoided. The use of diamond drills or channelling machines offers the only method which will justify the expectation of profitable work. The stone as described by Genth[1] "is a variety of massive serpentine, somewhat resembling williamsite, and shows sometimes a slightly slaty structure. It occurs in various shades of green, from a pale leek-green to a deep blackish-green, and from a small admixture of magnetic iron, more or less clouded; rarely with thin veins of dolomite passing through the mass. It is translucent to semi-transparent; it is exceedingly tough, and its hardness is considerably greater than that of marble, scratching the latter with great ease."

The analyses of the deep green translucent and black mottled varieties gave the following results:

Silicic acid	40.06	40.39
Alumina	1.37	1.01
Chromic oxide	0.20	trace.
Niccolous oxide	0.71	0.23
Ferrous "	3.43	0.97
Manganous "	0.09	trace.
Magnesia	39.02	38.32
Water	12.10	12.86
Magnetic iron	3.02	6.22
	100.00	100.00
Hardness	4.00	4.00
Specific gravity	2.668	2.669

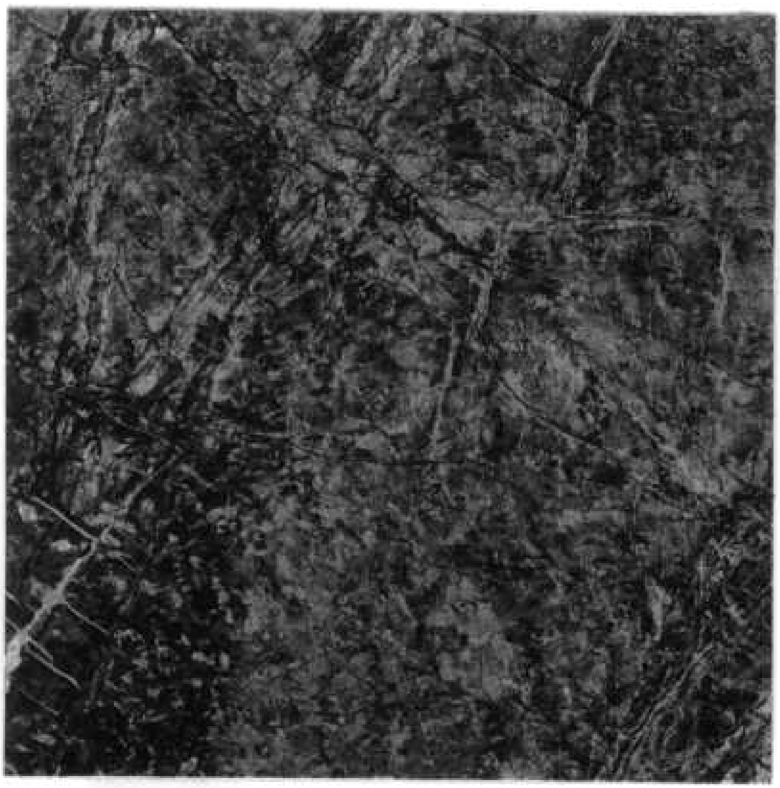
[1] Loc. cit. p. 7.

Merrill states in his "Stones for Building and Decoration" that the "specific gravity is 2.668, which denotes a weight of 166¾ pounds per cubic foot, or practically the same as granite. Specimens of this stone received at the National Museum admitted of a very high lustrous polish, the colors being quite uniformly green, slightly mottled with lighter and darker shades. It is not a true verde antique in the sense in which this name was originally employed. So far as can be judged from appearances, this is a most excellent stone, and admirably suited for interior decorative work."

Since the rock has been formed under conditions not far different from those existing at the surface, it is probable that no considerable degree of chemical decomposition will take place; the source of danger, however, lies in the tendency toward physical disintegration, brought about by pressure and frost action. The beauty of the rock, when polished, fits it pre-eminently for service as an ornamental stone, and, when used in the interior for ornamental veneering, the rock is not subjected either to harsh atmospheric action or to any detrimental amount of pressure.

What has been said of the Broad Creek quarries may equally well be said of the smaller opening operated by W. Scott Whiteford about three quarters of a mile southwest of Cambria, a small station on the Baltimore and Lehigh Railroad not far from Cardiff. This is the only quarry which has made any shipments during the last year. The opening whence the material is obtained is now filled with water and does not appear at first sight very favorable. As represented in the accompanying figure (Plate XXIV, Fig. 1), it is still small and there is considerable opportunity for expansion. The transportation facilities are good and the supply of material is sufficient to permit successful competition with other serpentine areas.

The rock worked seems more suitable than in many of the abandoned openings of serpentine, since it is firmer and somewhat more schistose. If the sawing is done parallel to the schistosity the expense is less and the slabs are relatively stronger. Cutting in this direction does not give quite as pleasing a texture to the surface, but the general effect is good. The stone from the Whiteford quarry is



SERPENTINE.

BROAD CREEK, HARFORD COUNTY.

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lighter and more mottled than that from Broad Creek. In its mottling it resembles the product from abandoned openings near White Hall, Baltimore county.

The plant includes machinery for sawing, grinding and polishing the rock by steam power and the operators have shown that in spite of the difficulties to be overcome beautiful slabs of polished stock 8′ x 4′ x 2″ may be obtained.

LIMESTONES.

The blue and gray limestones of Paleozoic age have never been quarried in Maryland as building stones except for local use. The most important and in fact the only one which has been used in prominent buildings is that from the Shenandoah formation of the Hagerstown and Frederick valleys. According to the Report of the 10th Census this rock is a magnesian limestone containing alumina and graphite, while earlier analyses made by Dr. James Higgins[1] show a wide range in the composition of specimens from different portions of the Hagerstown valley.

Analyses of Limestone.

SiO_2	5.80	0.25	2.40	3.00	0.70	2.00	0.60	6.00	0.20	2.00
Al_2O_3 Fe_2O_3	0.10	......	0.60	0.27	......	0.64	0.00	.20	0.10	0.30
CaO*	50.70	56.18	53.07	30.21	30.76	31.64	55.18	50.70	54.32	53.20
MgO*	1.57	1.31	1.07	20.37	21.12	14.69	0.41	1.43	1.19	1.24
CO_2	41.58	44.01	42.87	46.06	47.40	41.03	43.81	41.48	43.99	43.16
Undt.	0.12	.25	tr.	tr.	tr.	0.00	0.00	0.00	0.30	0.10

* Computed from $CaCO_3$ and $MgCO_3$.

The quarries, according to Prof. Chas. E. Monroe, are on a belt locally called Cedar stone, a few hundred feet in width extending for a distance of several miles, and believed to be peculiar in the fact that the upper layers furnish the most desirable stone.

This stone is of a deep blue color when freshly quarried, but upon exposure there is slowly formed a thin white coating over the face of the rock, which brightens the color to a dove-gray, thereby greatly improving the appearance of the buildings. This change goes on uniformly and accordingly does not pass through the unsightly mottled stage.

[1] 3rd Report, p. 135.

There is no doubt that this rock might become of considerable importance economically as a building stone. At present, however, the residual soil, with which it is covered, lends itself so readily to brick making that there is little demand for stone except in heavy structures or for foundations.

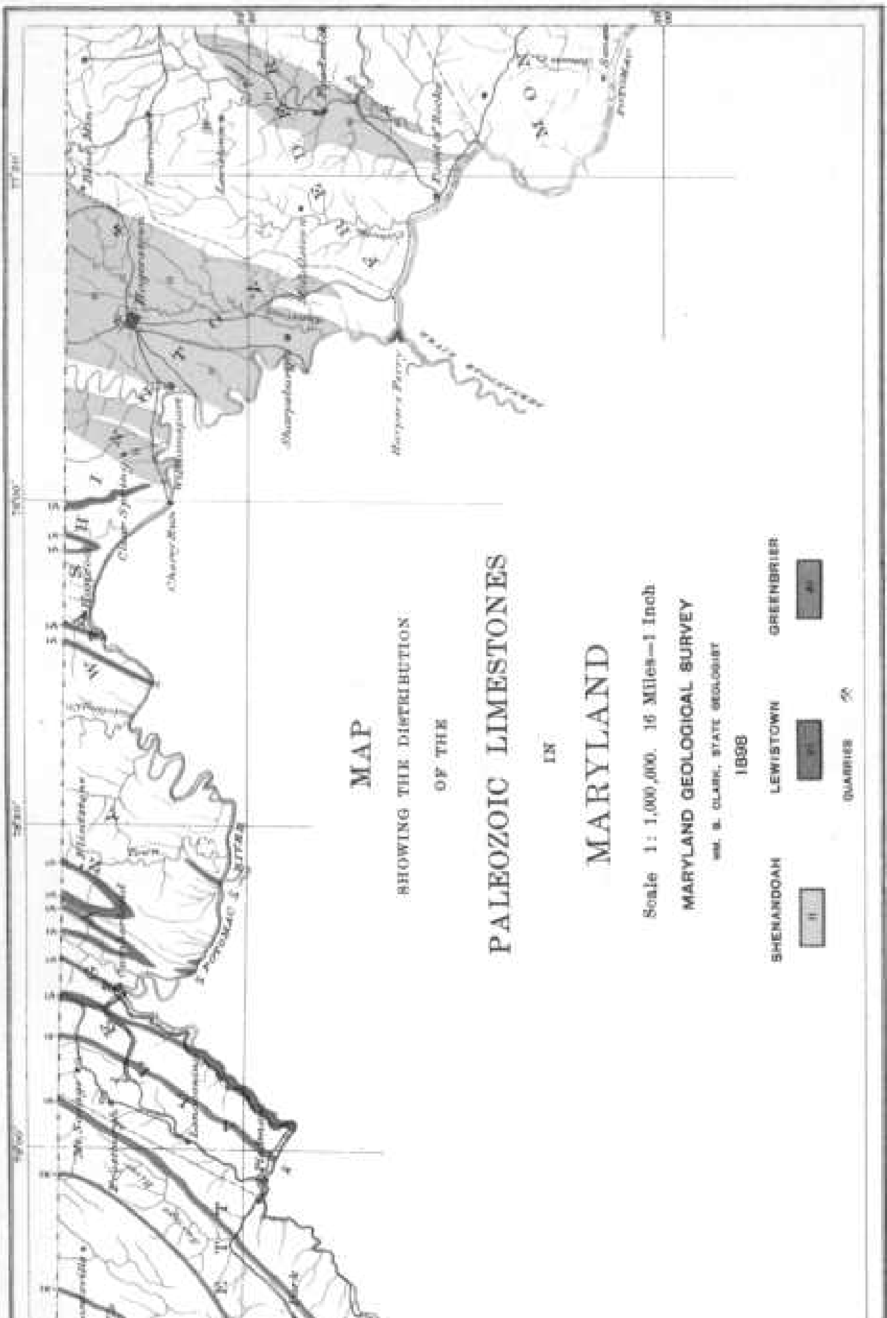
Many other areas in the Hagerstown valley offer limestones which may ultimately prove of importance as building stones. Openings in the rock are made only for lime at the present time, and the methods of quarrying, which shatter the rock by heavy charges, make the exposures look less favorable for the production of building stone than is actually the case. If proper care in extraction were exercised, there is no doubt but that large blocks of limestone could be quarried in many places throughout the entire valley, which would in some instances work into a good grade of "black marble."

In the Frederick valley little has ever been done towards quarrying the blue limestone for building purposes, as almost all of the stone which has been taken out has been burned for lime which finds a ready market. The buildings in Frederick show that there has been some quarrying for building material, since several of them are built of limestone and almost all of them have limestone foundations or sills.

West of the Hagerstown valley in Washington, Allegany and Garrett counties there are three Paleozoic limestones, namely the Lewistown, Rockwood and Greenbrier. Of these the first is the only one which offers reasonable grounds for expecting good building material within its limits. The upper massive beds of the Lewistown which outcrop in five or six small bodies along the Potomac from Hancock to Cumberland, and form a continuous belt from the latter point to Keyser, West Virginia, afford every indication that satisfactory building material may be obtained. Little if any work has been done in this formation because there have been no local demands.[1]

Of the two remaining formations the Rockwood is of such a nature that it cannot be used at all, and the Greenbrier is scarcely any better adapted to building purposes. Both formations occur in valleys with

[1] It is a matter of interest in this connection to note that outside of Cumberland and Frostburg there is scarcely a stone building in either Allegany or Garrett counties.


MAP
SHOWING THE DISTRIBUTION
OF THE
PALEOZOIC LIMESTONES
IN
MARYLAND
Scale 1: 1,000,000. 16 Miles—1 Inch
MARYLAND GEOLOGICAL SURVEY
WM. B. CLARK, STATE GEOLOGIST
1898
SHENANDOAH
LEWISTOWN
GREENBRIER
QUARRIES
POTOMAC RIVER
Hagerstown
Williamsport
Harpers Ferry
Cumberland
LITH. BY A. HOEN & CO. BALTO.

very few outcrops. The latter division has a single exposure on the Potomac between Keyser and Piedmont, West Virginia, and is imperfectly shown on Jennings Run and Braddock's Run. It is also injured for structural purposes by the pyrite which occurs scattered through it.

Sandstones.

Although there is but one sandstone within the state which has attained any considerable reputation as a building stone, there are many formations in different parts of the area which furnish suitable sandstones for local construction. As is the case with all building stones the factor of transportation facilities is so important that only those deposits can come into general use which are situated adjacent to prominent lines of travel either by railroad or boat. The sandstones of the state range in geological age from those which are supposed to be Archean to those which belong to the Triassic period. According to their age and importance they may be considered under the following heads: the *Triassic sandstones*, the *Paleozoic sandstones* of the Pocono, Monterey and Tuscarora formations, the *Cambrian* or *Mountain sandstones*, and the *Micaceous sandstones* of the eastern Piedmont area. Their distribution is shown on Plate XXX.

THE TRIASSIC SANDSTONES.

The Triassic or "Seneca Red" sandstones are the only ones quarried in Maryland which possess a recognized reputation in the market, or which furnish materials for more than local work. The formation in which they occur is extensively developed along the eastern edge of the United States from Connecticut southward through New York, New Jersey, Pennsylvania, and Virginia, and in scattered areas into North and South Carolina. It is from rocks of the same age that the well-known building stones from Portland, Connecticut; Prallsville, New Jersey, and Hummelstown, Pennsylvania, are quarried. This formation enters Maryland from the north near Emmitsburg, and continues with varying width through Carroll, Frederick and Montgomery counties to the Potomac river. Between these limits there is an almost continuous belt locally known as the "red lands," which is divided into two areas by a small exposure of the underlying Shenandoah limestone a few miles west of Frederick, where the whole of the Triassic has been removed by stream erosion.

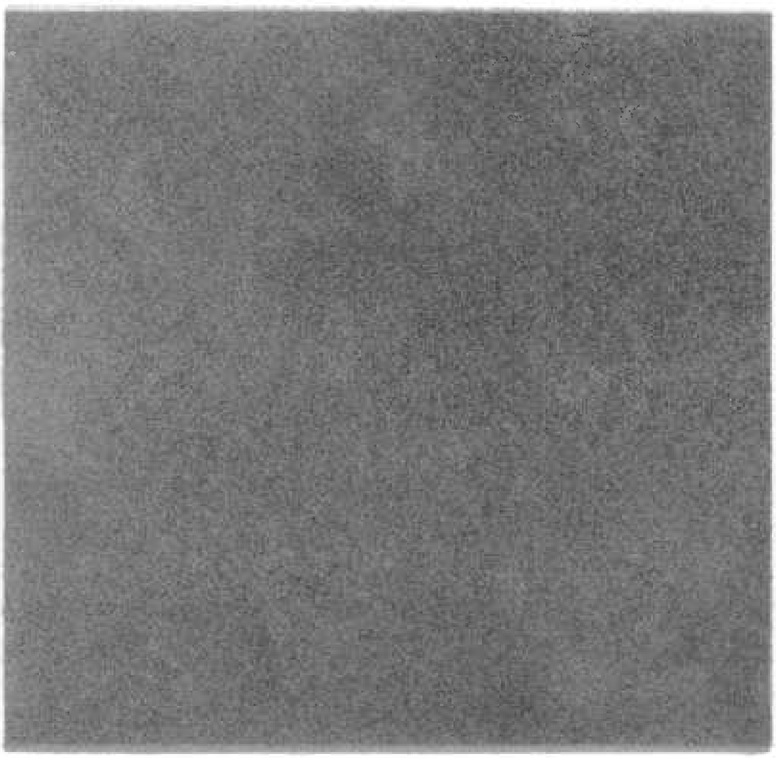
In either direction from this point the formation widens to about 16 miles at the Mason and Dixon line and 4 miles where it crosses the Potomac. East of this belt in the southwestern corner of Montgomery county there is also a broad area of the same formation which is continued southward into Virginia. It is to this southern area that the quarrying of sandstone is almost entirely confined. The prominent quarries are situated near the mouth of Seneca Creek, Montgomery county, on the Chesapeake and Ohio Canal about 23-25 miles northwest of Washington.

Seneca Creek.

The first use of this stone is not known, although it is evident that blocks of this material were utilized in the construction of the old Potomac canal built around the Great Falls of the Potomac in the year 1774. From that time until the present these quarries have been worked more or less systematically to supply the demands for local buildings and for shipment. During the extension of the Chesapeake and Ohio Canal from 1827 to 1833 considerable material was quarried for the construction of aqueducts and embankments, which is still in a state of good preservation. About this time, or soon after, some of the quarries of this area came into the possession of Mr. John P. C. Peter of Montevideo, near Darneystown, Montgomery county, Maryland, who was the owner of the quarries at the time when the stone was obtained for the Smithsonian Institution in 1847. Before the rock for the above building was quarried the area about Seneca Creek was visited and the quarries then opened were carefully examined by Dr. David D. Owen.[1] Somewhat later, after the stone had been adopted and the quarries practically selected, James Renwick, Jr.,[2] architect for the Institution, visited the quarries with a view of ascertaining their capability of affording a sufficient quantity of build-

[1] Report of Board of Regents Smithsonian Institution, Jan. 6, 1848, Sen. Doc. 30th Congress, 1st Session, No. 23, pp. 36-39.

[2] Same pp. 105-107.



RED SANDSTONE.

SENECA, MONTGOMERY COUNTY.

P.200 B

ing material of uniformly good quality and color. From the reports of these gentlemen we learn that at that date there were several quarries which had been opened and worked usually on a royalty of 25 cents per perch for all stone quarried.

The quarry most extensively operated at that time was the so-called "College quarry," which lay about a quarter of a mile farther west than the quarries owned by Mr. Peter on Bull Run, from which the stone for the Smithsonian was obtained. Messrs. Peter, Lee and Vincent seem to have been the most prominent operators in the area. In 1867 Mr. Peter sold his quarry to Mr. H. H. Dodge, who organized the original Potomac Red Sandstone Company, a company which greatly developed the quarries and marketed a large amount of the stone, principally in Washington. In 1874 the company became involved in litigation, and the quarries were closed for nine years. In 1883, the company was reorganized, and the work pushed rapidly forward until June, 1889, when the canal, upon which the company depended for transportation, was washed out and the quarries lay idle for a period of two years. In 1891 Mr. George Mann, of Baltimore, purchased the property and founded the present organization, "The Seneca Stone Company," which has worked the quarries during the last seven years.

The beds from which the building stones are now obtained lie west of Seneca Creek, on the left bank of the Potomac river, where the dip is some 15 to 20 degrees to the southwest. This inclination of the beds allows the quarrying to be carried on from the south and southwest without very much stripping and little or no binding from overlying strata. The openings show that the available material is distributed in workable beds, varying in thickness from eighteen inches to six or seven feet. These are separated from each other by bands of inferior material of different color and texture. The sandstone beds themselves differ very much, not only in color but also in hardness and texture. Some are fine-grained and can be wrought to a sharp arris; others are coarse-grained and may assume the character of a conglomerate. Interstratified with these grits are argillaceous shaly beds, which, together with some of the conglomeritic beds, are entirely unfit for the better grades of work, and cannot compete with local stone for rough foundation work on account of the cost of transportation. In strata showing as wide variation as these do it is natural that only a portion of the material excavated is available, and there must necessarily be a considerable waste. Occasional clay holes in the lower grades, which produce unsightly holes on exposure, increase the waste, but these do not affect the character of the better grade of stone, since they may be avoided by a careful selection of the material. The bedding of the rock determines the direction and manner of operating the quarry, while the presence of two series of joints greatly facilitates the extraction of the material. These joints run normal and parallel to the strike of the bedding. The first stands perpendicular to the dip and the second is practically vertical, so that the blocks obtained are more or less rectangular. The distance between the joints varies from a few inches to several feet, but average satisfactorily for economical quarrying.

The texture of the stone which is placed upon the market is exceptionally good. It is very fine-grained and uniform and is not at all shaly, and shows little or no disposition to scale when exposed to the weather. The particles of quartz are evidently distributed through a fine, scarcely perceptible cement, and over the entire face there are very minute flakes of muscovite which brighten the general appearance of the rock. Occasionally in larger blocks there are seen small bands of coarser grain which indicate the bedding, and in a few instances this alternation in texture is emphasized by variations in the color of the cement.

One of the most valuable features of the Seneca sandstone is the extreme readiness with which the stone may be carved and chiseled when it is first quarried. It is then soft enough to be easily cut and the texture is sufficiently uniform to render the stone satisfactory for delicate carving. As is frequently the case with all building stones the rock after exposure loses the readiness with which it may be worked and becomes hard enough to turn the edge of well tempered tools. It is this hardening on exposure which protects and preserves the delicate tracery sometimes seen in the finer examples of dressing in blocks from these quarries.

The color of the Seneca Creek sandstone as furnished by the Seneca Stone Company varies from a homogeneous light reddish brown or cinnamon to a chocolate or deep purple-brown. When freshly quarried the colors are even brighter than after the rock has been exposed some time, the rock presenting tones of a light reddish fawn color. The color changes with the composition. With an increase in quartz the lustre of the rock becomes brighter and with an increase in feldspar the tone of the rock becomes grayer, while an increase in the amount of cement deepens the color.

The rock under discussion when studied microscopically is found to be composed of angular grains of quartz, microcline, plagioclase and muscovite. The first three of these minerals occur in more or less clearly defined polygons, which abut each other without interlocking. They show no uniform direction in the position of their longer axes. The same is true of the muscovite which occurs in long narrow shreds. This lack of interlocking between the grains causes large interstitial spaces which render the rock friable, porous and absorbent unless they are filled with some cement. In the Seneca stone the spaces are almost entirely occupied by a natural ferruginous cement which increases the strength of the rock. The relations between color, cement and porosity are indicated in the first two determinations by Page, given below. The individual grains are covered with films of iron oxide and there seems to be no evidence of enlargements due to the secondary deposition of silica. The plagioclase grains show some alteration, but those of the microcline are usually fresh and unclouded by decomposition products. Since the plagioclase is present in very subordinate amounts its alteration does not materially decrease the strength of the rock.

A cursory examination of some of the old buildings made of stone from Seneca Creek leaves the impression that at least part of the rock from this locality is unsuitable for fine buildings because of its low crushing strength and its tendency to scale. This apparent defect in the rock arises from two causes, the lack of care in the selection of material, and in the cutting of the blocks so that they will rest parallel to their bedding when set in the buildings. Material where such scaling appears does not represent the better grade of Seneca stone but is coarser, showing more evidences of cross-bedding, and it is also much richer in mica and poorer in cement. There seems to have been a constant tendency among the earlier builders and stone cutters to place the rock, not on " bed," but on " edge." Many of the prominent structures which now give evidences of flaking or spalling clearly show all of the defective blocks to be on " edge." In all rock like the poorer grades of sandstone, such a position speedily brings out the inherent weakness of the rock. The only determinations of crushing strength available, prior to the present study, were made many years ago by Dr. Chas. G. Page and published by Walter R. Johnson[1] in the American Journal of Science. These give the average crushing weight per square inch as 2691 pounds. This value was obtained on two separate specimens, one of which was from the Smithsonian Institution. The fact that both rocks give the same values indicates a marked uniformity in the strength of the better grades of rock. The tests recently made show the strength per inch as high as 18,625 pounds per square inch (see below).

The weight and disintegrating effects of frost upon the Seneca sandstone were carefully studied by the Brard method before the stone was accepted for the Smithsonian Institution, and we have as a result of Dr. Page's[2] investigation the following determinations:

	Specific gravity.	Lost by frost in grains.
Dark red Seneca sandstone (similar to Peter's)	2.672	0.70
Light Seneca sandstone, dove-colored	2.486	1.78
Dark coarse sandstone, of Seneca aqueduct, Peter's quarry	not ascertained.	5.60
Sandstone four miles above No. 2 D, Peter's next west Beaver Dam quarry	not ascertained.	1.58
Dark sandstone, from quarry near Woods' residence	not ascertained.	3.94

The specific gravity of these rocks indicates that the weight per cubic foot of the stone is 154 to 165 pounds. These figures seem to

[1] Comparison of Experiments on American and Foreign Building Stones to Determine their Relative Strength and Durability. Amer. Jour. Sci., 2 ser., vol. xi, 1851, p. 7.

[2] Report of the Board of Regents Smithsonian Institution, Senate Doc., 30th Congress, 1st Session, No. 23, pp. 21-22.

FIG. 1.—SANDSTONE QUARRY, EMMITSBURG, FREDERICK COUNTY.

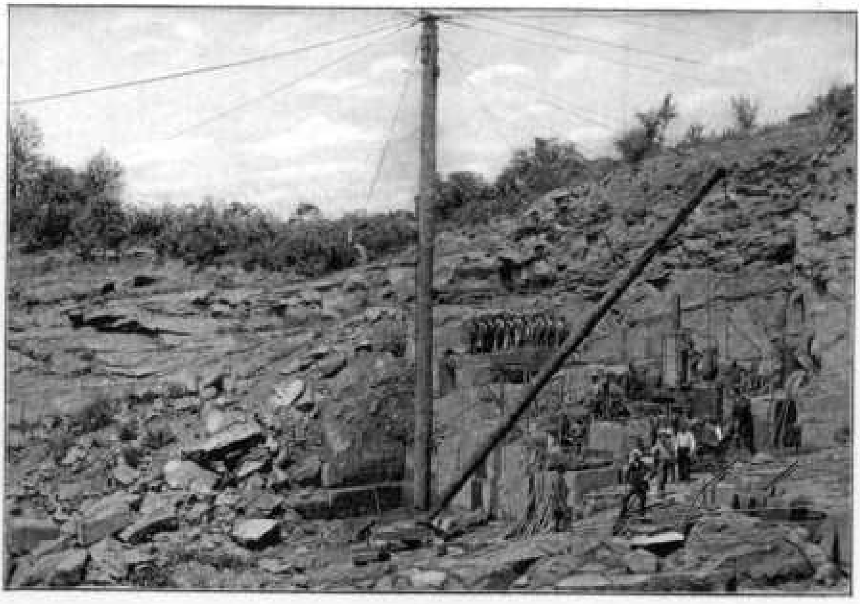


FIG. 2.—SANDSTONE QUARRY, SENECA, MONTGOMERY COUNTY.

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indicate that the Seneca rock is slightly heavier than the usual run of brownstones, which, according to the table given by Hopkins,[1] range from 127.5 to 166.1, with an average of 161.4 pounds. In structures the Maryland and Pennsylvania stones will range between approximately the same limits.

The various tests recently conducted by the Survey are very favorable to the Seneca rock. The specimens examined were in two-inch cubes cut from stock furnished to one of the stone yards of Baltimore. The figures below thus represent the average run of the quarry and not especially selected stock.

Simple crushing.	Absorption.	Freezing.	Crushing after freezing.	
			Crack.	Break.
......	2,368	0.006	73,700	74,500
72,280	....	....	......	......
......	2,530	0.012	65,840	69,500
69,000	....	....	......	......
67,560				
65,240				

The mineralogical and chemical composition leave nothing lacking as to the promise of permanency in the Seneca sandstone under the action of atmospheric agents. There are no deleterious minerals in the carefully selected stone which may injure its wearing power, and the chemical analyses show that the constituents are in stable combinations. The microscopical examinations also show (Fig. 14, p. 97) that the cement firmly binds the interlocking grains without leaving any considerable interstitial spaces in which moisture may lodge to destroy the integrity of the rock. This lack of porosity is shown also in the slight loss by freezing, as given in the above tables.

The best evidence of durability is found in the structures which have been made of this material. Owen reports (1847) that "by close inspection of slabs exposed now 20 years to atmospheric agencies and severe mechanical friction, the mark of the dressing-chisel is still sharply imprinted in the surface. On the perpendicular wall of the aqueduct, where the water has been oozing through the joints and trickling down its face, forming an incrustation of carbonate of lime,

[1] The Building Materials of Pennsylvania, No. 1 Brownstone. Appendix to the Ann. Rept. of Penn. State College, Official Document No. 22 for 1896, pp. 30-31.

one may observe, where this calcareous crust has sealed off, the grooves and ridges of the surface still nearly as distinct as when the block first came from the hand of the stonecutter.

"The angles and edges of the keystones of the arch, placed under these most unfavorable circumstances, are sharp and entire. Only one or two blocks of this work of 20 years' standing show sign of decay; but these seem to be such as either have not been well selected, or have been placed on the edge in the wall.

"Even the tow-path of this aqueduct, over which the horses pull and mules have been traveling 20 years, is still unimpaired. Even the corners around which the heavy lock-gates swing, show no signs of chipping."

Merrill later (1891) corroborates these observations and says: "On blocks of the stone in the aqueduct of the Chesapeake and Ohio Canal which have been constantly permeated by water every season for fifty years, the tool-marks are still fresh and no signs of scaling are visible other than are produced by too close contact at the joints. . . . The Smithsonian Institution erected in 1848 to 1854 from this stone, shows few defects from weathering alone, and these only in those cases where they might have been avoided by judicious selection."

No discoloration has been noticed in the rock beyond the darkening which gradually and uniformly takes place on exposure.

Minor Areas.

Throughout the entire extent of the Triassic as exposed in Maryland there are small local quarries developed to supply the demands for foundations and occasionally for more pretentious building. The general demand, however, is more than overcome by the cost of transportation in all but the most favorably situated localities. There are many occurrences which will prove of value as the country becomes developed and improves its facilities for distributing its resources. Among the most promising of these smaller openings is one located near Taneytown and owned by John Yingling. This quarry is situated on the western side of a little hill on the road leading from the Emmitsburg pike to Harney, not far from the former. The rock exposed is more feldspathic than any of the Triassic sandstones now worked in the state. It is bright gray and gives a pleasing impression, which is in accord with the present demands for light and cheerful trimmings. The stone has been tested and the crushing strength and absorption for two-inch cubes is as below.

	I.	II.	Absorption.
Crack........	67,900 pounds.	94,000 pounds.	0.004
Break........	94,000 "	109,400 "	

The rock is, therefore, strong and when manipulated properly may be extracted in blocks of sufficient size to meet ordinary demands. The means of drainage and the opportunity for dumping waste are favorable, while the distance from the quarry to the railroad is not far enough to render competition unsuccessful. The smaller quarries which have been worked spasmodically include the quarries just north of Emmitsburg, and several openings about Taneytown, Thurmont and Union Mills.

It is not improbable that suitable rock might be found in the vicinity of Bruceville, where the railroad facilities are especially favorable.

Washington Junction.—The only other source of red and brown sandstone from the Triassic formation of Maryland, which enters into competition with the Seneca stone, is near Washington Junction in Frederick county. Here the Washington Junction Stone Company, capitalized at $30,000, carries on considerable work in extracting and dressing the red, brown and variegated sandstones. The present operators began work in 1892, and have continued quarrying almost continuously ever since, furnishing much stone for such buildings as the Fort McHenry Hospital, Baltimore, churches at Forest Glen, Maryland, and Winchester, Virginia, and many houses in the better part of Washington.

The beds from which this sandstone is obtained dip gently to the west, and thus afford opportunity for the economical extraction of the stone. Blocks 20 x 6 x 4 feet may be obtained if the demand and the machinery warrant. The stone does not differ noticeably from that furnished at Seneca but shows the same pleasing color and texture already noticed in the latter place. The quarries are well equipped with saws, rubbing beds, polishing machines, etc. The chief drawback in the location of this opening, which is a mile and a half from the railway station, is removed by a small spur track which extends from the quarry to the station and to the wharf on the Chesapeake and Ohio Canal.

The general mode of working the quarry is shown in the accompanying figure (Plate XXIX, Fig. 2), which inadequately represents the ledge whence the material is obtained.

PALEOZOIC SANDSTONE.

Among the various later Paleozoic formations there are four which develop well marked sandstone series. These are the Pottsville, the Pocono, the Monterey and the Tuscarora. None of these have been worked to any considerable extent as building stones, because of the lack of demand and transportation facilities.

The Pottsville Formation.—The Pottsville is the lowest division of the coal measures and forms the mountain ridges which border the coal basins. It consists of sandstone and conglomerates interstratified with sandy shales in which thin beds of coal are locally developed. The sandstones are usually coarse-grained and conglomeritic, with marked evidences of cross-bedding which are irregular in extent and distribution. The individual pebbles, frequently very small, are held together by a siliceous cement, which indicates great durability for the rock. Unfortunately such a cement renders the working of the stone both difficult and expensive. It is probable that this material will never become of economic importance except in the supply of local demands for foundations, steps and occasional door sills.

The Pocono Formation.—The Pocono formation is very similar to the Pottsville and consists mainly of hard, thin-bedded flaggy sandstones which occasionally become sufficiently conglomeritic to produce confusion between the two formations. The sandstones of the former have received but little attention and have been used only occasionally as a supply for flagging. It seems quite probable that as the demand for building stones increases the flags, which are well developed in places, may come to be of some importance.

The Monterey and Tuscarora Formations.—These two formations have a considerable development in Allegany and Washington

FIG. 1.—MONOCACY AQUEDUCT, WHITE QUARTZITE FROM BELT'S QUARRY.

FIG. 2.—SANDSTONE QUARRY, POINT OF ROCKS, FREDERICK COUNTY.

counties, where the stone has been used to supply the local demands. This is especially true of the area about Cumberland. Here the Monterey sandstone, which is of a buff-brown to yellow color, was the first to be introduced. It is the source of all of the sills, foundations and lintels for the older buildings. The most important structure in which it is exclusively employed is the Episcopal church. Time has shown that the very property for which the stone was first chosen, viz., the ease with which it is cut, is detrimental and that it, together with the clay holes which seem to be developed frequently, leads to the ready disintegration of the rock, so that many of the steps, sills and foundations of the older buildings are in quite a dilapidated state. Where this stone was used in curbing the blocks have become rounded, or broken or deeply worn. The stone itself when dressed presents a very pleasing appearance, especially in trimmings, where it coincides with the present tastes in architectural work. It is quite possible that by careful selection good material might be obtained from one of the several quarries in Cumberland to supply the demands for a light gray or yellow trimming stone. As a clew in the choice of material it may be stated that as the number of fossils decreases the rock becomes harder.

Although the Monterey has not proved altogether satisfactory about Cumberland there are other points in the distribution of this formation where it seems probable that good material may be obtained. The best of these is the quarry owned by Mr. B. S. Randolph of Frostburg, which is located in Washington county near Dam No. 6 of the Chesapeake and Ohio Canal. The opening, which was made for glass sand and not for building stone, is in the form of a tunnel from thirty to forty feet deep, and is situated about 800 yards back from the canal and from 400 to 500 feet above it. The stone is of clear creamy-white color and would make a bright trimming or structural material. At first sight the rock looks as though it is too friable and not strong enough to endure pressure, but the experiments show that in two-inch cubes it has a crushing strength of 73,780 pounds on edge and 75,600 normal. This indicates that the first impressions are incorrect and that the rock is capable of withstanding any ordinary pressure. The purity of the rock is attested by the following analyses made by O. Creath of Pottsville, Pa.:

	1.	2.	3.	4.
SiO_2........	99.255	99.558	99.398	97.55
Al_2O_3........	.610	.341	.473	2.44
CaO.........	.110	0.81	.102	.01
MgO........	tr.	tr.	tr.	
FeO........	......	......	.027	tr.
FeO.........	.025	0.20	......	......
	100.000	100.000	100.000	100.00

When it was found that the Monterey sandstones were not as durable as expected and that they soon became disfigured by exposure, attention was directed to the harder white sandstones of the Tuscarora which are exposed in Wills Mountain just west of Cumberland. The ledge here exposed has a thickness of some 300 feet, but the solid rock has not yet been quarried, since the demand is more readily supplied by utilizing the many detached blocks which cover the slopes of the mountain. At the present time this stone is used for foundations and trimmings in all of the better class of buildings in Cumberland, and its character is well shown in the Presbyterian church. The rock varies somewhat in texture and firmness according to the different beds, but on the whole shows unusual uniformity. It is bright gray in color and is composed entirely of fragments of quartz, which are themselves cemented by a siliceous cement, causing the rock to be in reality a quartzite rather than a sandstone. Feldspar and mica are also found in the rock. Few imperfections were noticed and for one of such siliceous character the rock seems to be very free working.

The chemical composition, as might be inferred from the mineral contents, is largely silica. Professor C. F. Chandler[1] in his report on the mineral resources of Cumberland gives the following analysis:

Silica..	98.35
Sesquioxide of iron..............................	0.42
	98.77

[1] See Tenth Census, vol. x, Report on Building Stones, p. 178.

while a more complete one furnished by the present operators is as follows:

Silica	98.00
Al_2O_3	.65
Fe_2O_3	.15
CaO	.40
MgO	.21
Alkali	tr.
Water and organic	.50
	99.91

The Tuscarora sandstone unlike that of the Monterey shows great durability in whatever position it may be placed, and it is accordingly used in almost all of the local work on the embankments of the Chesapeake and Ohio Canal and in foundations wherever there is a considerable superstructure. It is also used to great advantage for paving, curb-stones, steps and trimmings.

Besides the prominent sandstone formations of the Paleozoic already mentioned and that of the Cambrian considered below, there are scattered throughout the series numerous small beds of sandstone which are sometimes utilized to supply local requirements. The quarries which have been opened are scarcely worthy of the name and the product from all of them is insignificant.

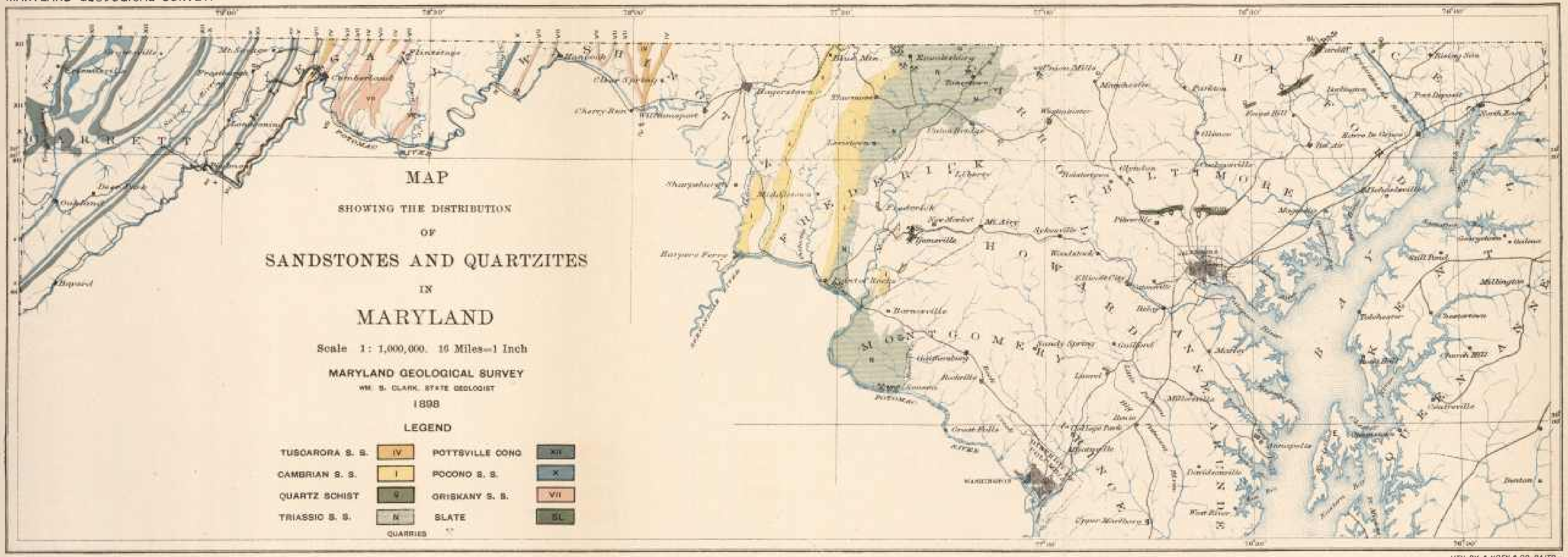
Cambrian or Mountain Sandstone.—There extend across the state two parallel bands of dense quartzites which form the Blue Ridge and Catoctin mountains. These quartzites were originally porous sandstones, which have subsequently been thoroughly consolidated by a dense siliceous cement. Similar rocks also occur in the small detached area of Cambrian sandstones which forms Sugar Loaf Mountain. The rock has never been brought prominently into the market, although it has been used quite extensively for railroads, canals, roads and a few individual buildings. It is not known when the first work was done here, but according to Scharf the quarries at Sugar Loaf were operated quite extensively prior to 1830 to furnish stone for the old canal. At this time there was a tramroad several miles long extending from the quarries to the canal. The rails were striplings and the tram cars were hauled by horses. This little railroad antedated the Baltimore and Ohio and has practically disappeared, road bed and all. During the succeeding decade the Sugar Loaf stone was used in the Baltimore and Ohio Railroad, which has continued its use occasionally ever since.

Other quarries have been opened in a small way along the Western Maryland Railroad to supply the demands for good road metal and small quarries have been operated by the Mount St. Mary's authorities at Emmitsburg. The latter furnish a stone of dense, even texture in which there can be little absorption and little consequent loss by the action of frost. The crushing tests show that its strength is exceptionally great as a two-inch cube sustained a weight of 93,900 pounds before cracking and 104,200 pounds before breaking. In buildings the rock appears of a bright fresh gray color which darkens but little on exposure. Its general appearance is well shown in the recent additions to the buildings at Mount St. Mary's. The siliceous character of the rock renders it difficult to work in other than the natural face, but its durability, strength and compactness render it unsurpassed where great permanence is desired.

There are within the area of Cambrian sandstone above enumerated many exposures of rock which deserve more careful investigation and which no doubt would prove of service if the transportation facilities were at hand. At present the demand is not enough to warrant any workings beyond the occasional operations carried on at the McGill Belt Quarry at the base of Sugar Loaf Mountain and the incidental quarrying at Mount St. Mary's, near Emmitsburg.

MICACEOUS SANDSTONES OF EASTERN MARYLAND.

Scattered over the northeastern portion of Maryland in Baltimore and Harford counties are several exposures of highly micaceous quartzose rocks, which were originally sandstones, but which have now undergone considerable change through dynamic metamorphism. These are most characteristically developed in Setter's Ridge along the Green Spring Valley, ten miles north of Baltimore, and on the Baltimore and Lehigh Railroad near Pylesville, and eight or ten miles south of the Mason and Dixon line where the railroad crosses Deer Creek.



LITH. BY A. HOEN & CO. BALTO.

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Deer Creek Sandstones.

At the station known as "The Rocks," the Baltimore and Lehigh Railroad and the Deer Creek pass through a ridge of highly metamorphosed hard micaceous sandstones in a gorge 350 feet below the summit. This ridge extends in a northeasterly and southwesterly direction for a distance of ten to twelve miles and forms a part of the folded phyllite series which are probably of Cambrian age. The sandstone of which it is composed lies geologically some distance above the base of the series and below the bottom of the Peach Bottom slates.

The stone is a micaceous sandstone rich in quartz which locally becomes clearly conglomeritic. It contains more or less white mica, chlorite and bluish kyanite which are the product of secondary crystallization due to the metamorphism. The schistosity is well marked and in many instances minute flutings and crinklings are noticeable, producing in a cross section of the rock a somewhat pleasing figure and lustre. This stone has long been used in the surrounding country for foundations, sills, steps, and hearthstones, and its fire-proof character was early appreciated by Dr. Thomas Johnson of the U. S. Army. In 1891 a company known as the "Maryland Granite Company" was organized to develop the material as a building stone. Cables were strung to deliver the stone on board the cars and considerable work was accomplished in preparing for quarrying. The company soon ceased operations, either because satisfactory rates were not made with the railroads or because there was no demand for the stone, which was not a granite either in character, origin or even in appearance.

In the northern extension of this ridge, about Pylesville, the rock becomes less conglomeritic and micaceous. It has never been worked for any purpose in this vicinity, but if the demand should arise it is highly probable that the area will offer suitable material for a medium grade building stone.

Setter's Ridge Quartzite.

Setter's Ridge is a prominent topographical feature along the south bank of the Green Spring and Mine Bank valleys from Green Spring Junction on the Northern Central Railroad to Summerfield on the

Baltimore and Lehigh Railroad. It is composed of a thin series of highly micaceous beds of quartz-schist which are sharply separated from the overlying limestones on the north and merge more or less gradually into the gneisses on the south. "Whatever the origin of the quartz-schist may have been it is closely allied to the gneiss into which it grades. . . . It is not improbable that this peculiar rock represents a facies of the gneiss produced by some dynamic agency, for it always shows the effects of intense mechanical action and motion." This formation never attains any considerable thickness and it always occurs as a series of beds of quartzite of varying thickness, separated by parallel layers of muscovite, in which are emplanted numerous shattered tourmaline crystals which appear stretched and drawn out in the manner described and figured by Williams.[1] The readiness with which the quartz-schist cleaves into broad slabs well fits it for flagging. It is quarried at a number of points in the Green Spring valley, but it is most extensively worked at the Shoemaker quarries about one-half mile west of Stevenson Station. From here it is transported for considerable distances and may often be seen in foundations and bridge abutments. It is a rock of low quality, and quarried in a careless way and at present is of little economic importance.

Slate.

GENERAL DISTRIBUTION.

When Tyson made his first reconnaissance of the state as Agricultural Chemist in 1859 few industries appealed to him more strongly or seemed to promise greater returns than the quarrying of slate. That his view, which was based on the fire-proof quality of slate roofs alone and did not take into account their durability or pleasing appearance, has not been fully realized, is due to factors beyond his control. Other states have gained the advantage by superior mercantile energy. At the time of his visit three quarries were in operation in Harford county, while smaller openings had been made for slate at Hyattstown, Ijamsville and Linganore. None of the latter are now in active operation, but the Ijamsville area will be treated briefly after a discussion of the Peach Bottom region.

[1] Guide to Baltimore, p. 104.

THE PEACH BOTTOM AREA.

The slate produced in the quarries of the Peach Bottom district of Maryland and Pennsylvania is the most widely known structural material manufactured within the limits of the state. Unfortunately Maryland has received little credit for its share in the industry although almost all of the productive quarries are situated within its limits. This apparent injustice has arisen from the fact that the shipping point for most of the quarries and the residence of many of the operators is Delta, Pennsylvania, a town lying at the foot of the ridge which supplies the stock for the manufacture of slate. Delta is so much better known than its Maryland associate, Cardiff, that mail is received through the Delta postoffice by inhabitants living scarcely one hundred yards from the Cardiff office.

The topographic relations between the town and the quarries are particularly favorable for the shipment of slates and the establishment of a prosperous community. The town is connected with the principal cities of the Atlantic seaboard by the York and Peach Bottom Railroad (broad gauge) which forms a portion of the Pennsylvania system, and the Baltimore and Lehigh Railroad (narrow gauge) which runs from Cardiff to Baltimore. The latter railroad, because of its small cars and narrow gauge, permits shipment of slates no farther than Baltimore, where trans-shipping to broad gauge cars is necessary. When it is broadened, as is now contemplated, the shipments from Cardiff will no doubt increase and Maryland will receive a more just proportion of the credit for the manufacture of one of the most perfect slates produced in the world.

The quarrying of slate in the Peach Bottom area is divided chronologically, according to the nationalities of the quarrymen and the methods of quarrying, into two well defined epochs, the first ending with the arrival of the Welsh immigrants during the years 1845 to 1860. During the first period the workers were not professional quarrymen, skilled in the manufacture of slate. The Welsh, on the other hand, were trained in the art from their childhood, and many of them are known to have been employed in the Festiniog quarries of northern Wales. There is no information at hand from which we may learn when the presence of valuable roofing slates was first recognized in this area or when the first material was taken out for roofing purposes. According to the local tradition, which is subject to some doubt, the slates were quarried as early as 1750. The building on which these slates were laid was destroyed a few years ago and the inferences concerning its age are based on a series of deeds and family papers which seem to indicate the date of construction as 1749 or 1750 and the source of the material as some point on the ridge not far to the north of the Mason and Dixon line. The first authentic evidence of quarrying is the slate recently removed from the roof of the old Slate Ridge Church, known to have been built in 1805, which was torn down in 1893. The slates from this old roof which had been exposed to the atmospheric agents of degeneration for eighty-eight years show no change in color or firmness, although some of them were covered by lichens and other vegetable growths. The slabs of slate used ranged in size from large pieces three feet square in the lower courses, to small ones three by seven or eight inches near the ridge pole. Some of the larger slabs have been preserved by the quarry superintendent to show the great stability of their stone, even when poorly prepared and poorly laid. These pieces are irregularly cut and more or less unevenly split. The stock used is not equal to the first or even the second quality of slates furnished at present. Prior to the coming of the Welshmen with their improved methods of working, the limit of the quarrying was the "Big Red" clay[1] which is the limit of weathering and the point to which the ledges are now stripped. When the hard rock was reached in earlier times, work ceased, since explosives were not used to cut a "head" or to loosen the rock. The earlier workers also had no adequate methods of trimming their slates and tradition says that their splitting chisels were mattocks.

During this period of early work the most prominent operators were Messrs. Carmen and Docker, two Englishmen who obtained a lease of the land, including the quarry now operated by R. L. Jones, a short distance north of the state line. These gentlemen, with Peter Williamson as foreman, opened and operated a quarry from 1812 to 1817,

[1]Shown at the point of stripping reached by the men in Plate XXXI, Fig. 1.

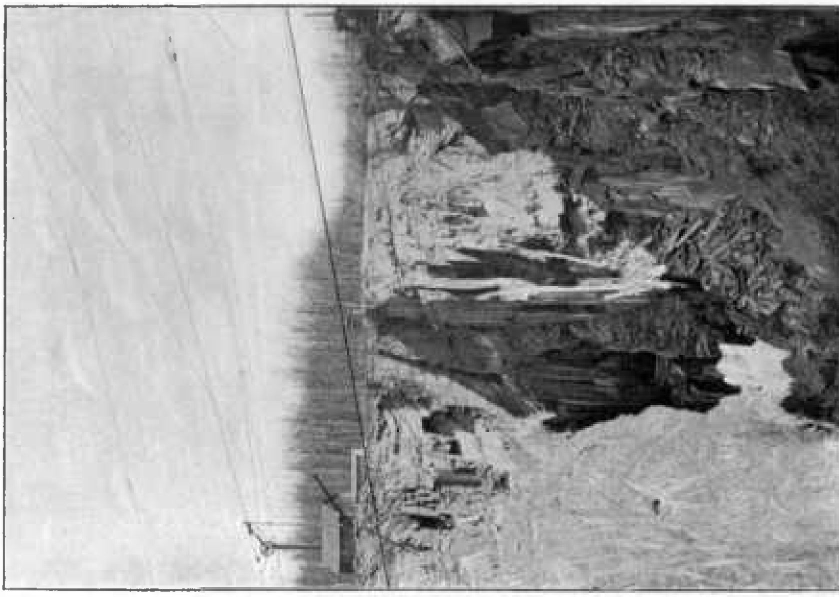

Fig. 2.—PEACHBOTTOM-EXCELSIOR-PEERLESS QUARRY,
CAMBRIA, HARFORD COUNTY.

Fig. 1.—PROCTOR BROTHERS' QUARRY,
CAMBRIA, HARFORD COUNTY.

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when it was abandoned because competition with the Welsh product was unremunerative. The Welsh slate at this time was shipped to America as ballast and admitted free of duty.

About the same time (1812) Mr. Sinclair made an abortive attempt to produce slates successfully on the "A. B. Miles property." The location of his opening was between two quarries which have subsequently been worked with greater or less profit. Nothing is known of this operator beyond the facts enumerated, except that he seems to have left the country about 1817 at the time when Carmen gave up his work. During the seventeen years from 1817 to 1834 no work was done along that portion of the Peach Bottom district which lies west of the Susquehanna. Mr. Williamson, however, seems to have removed to Lancaster county and to have carried on the manufacture of slates in a small way during the interval. The property whence he obtained his material belonged to a Jeremiah Brown.

In the fall of 1834 Carmen returned to Delta and wished to sell his lease as the quarry had been so unremunerative that he had changed his business. His former foreman, Mr. Peter Williamson, finally bought the lease and began operations which have continued in this locality up to the present. The rental paid by Mr. Carmen to Mr. McCandless for the entire tract was $36 a year and the price paid by Mr. Williamson for the land in fee simple was $12,000. Slate at this time, whether from Welsh or American quarries, sold at about $20 a ton, or approximately $5 a square, as slate is now figured. The first lease to Welsh immigrants was granted by Williamson about 1845, when two families by the name of Davis (an uncle and nephew) began operations after the improved methods with which they were familiar in the old country. The Davises took a lease of a portion of the ridge just north of the Mason and Dixon line and worked a quarry for two years, when the same was leased to Roland Perry, a recent arrival from Wales. Mr. Perry greatly developed the industry, and soon had in his employ a force of sixty to seventy-five men, who turned out a highly improved grade of slate. About the same time John Humphrey, another prominent operator of the area, with others worked a quarry near West Bangor and became very successful. Both Perry and Humphrey cleared about $50,000 or $60,000 each, during their operations. Their method of working the quarries seems, however, to have been somewhat faulty as they were inclined to follow down a "vein" without sufficient breadth, until at a depth of 160 to 176 feet the loosened and insufficiently supported top rock either caved in or rendered the working of the quarries exceedingly dangerous.

The first quarry south of the state line operated by the Welsh methods was opened by Mr. Robert Griffith some time in 1847 at the location of the present York and Peach Bottom quarries. This was the only firm working south of the Mason and Dixon line during the succeeding decade. The power until 1855 was supplied by horse windlass, when a steam engine was added to the equipment in order to pump the water from the pit. Griffith successfully operated the quarry for several years. At his death the work was continued by Samuel M. and Hugh C. Whiteford, his administrators, who made and sold a large amount of slate. The quarry leased was then sold to Isaac Parker of New York for $18,000. This property, together with that operated by Proctor Bros., and all the slate lands extending and bounding on the Mason and Dixon line on the east, belonged to Thomas Hawkins, who entered it previous to 1776.

Thomas Proctor came to this country about the same time with Carmen, Docker and Sinclair. As general managers, Sinclair and Proctor opened a quarry on the Hawkins property, on the north side of the road 200 or 300 yards northeast of the now York and Peach Bottom quarry. In the meantime Thomas Proctor married Elizabeth, only daughter of Thomas Hawkins, and became possessed of part of Thomas Hawkins' estate and built on it, amongst other structures, a stone springhouse, which is still standing covered with slate from this quarry. This, according to one tradition, was the first slate roof put on, and antedates that of Slate Ridge church which was taken from the same quarry in 1805. This quarry was operated by a few hands in 1812, as the father of Mr. Wm. G. Coulston brought from them a flag for a doorstep, dressed about 5 feet long, 2½ feet wide and 3 inches thick. The hands put it down for him and it remains the same to-day. The vein was narrow and did not work to profit and was abandoned. Mr. Proctor tried other places without success, and it was left to his grandsons to profit by his oversight.

During the year 1858 Richard Griffith, of Philadelphia, no connection of the above named Robert Griffith, opened a quarry in the lower portion of the northwest side of the ridge, not far from the present town of Cambria. This prospecting opening was sold to a syndicate composed of Samuel Bottime (President), W. P. Bolton (Superintendent and Local Manager), and others, who attempted to operate the quarry. The whole project was abandoned the following year. The failure was due to the selection of a place of opening on the very edge of the slate formation instead of at some point on the top of the ridge nearer the center, where the stock is much better. This syndicate at that time held land which carried the best beds of slate known at present, since some ten years later, April 8, 1868, the present "Peach Bottom Slate Company of Harford county, Maryland," rented their site from this company on a thirty year lease. The Peach Bottom Slate Company worked on the lease for a few years when at the death of one of the owners, according to the laws of the state then in force, the entire property was offered for sale. Following the advice of Col. Webster of Bel Air, who was interested in the company, the lessees bought that portion of the estate which they had held by lease and in 1878 were incorporated as a company with the above title.[1]

[1] The history of this property, which contains the most active quarries, is quite involved. After the property which Richard Griffith bought of the Whiteford estate proved worthless, the 25 acres adjoining, which includes the Peach Bottom, Peerless, and Excelsior quarries, were sold by Michael Whiteford to John Morrison for $500. (His eldest son says that his father Michael received no money, but took it out in shoemaking and mending for his family and bond servants). Morrison willed the land to his daughter, who married Thomas Wright. Mrs. Wright offering the land by an agent, Joseph D. Wiley, found no bidders, and subsequently bequeathed it to her five daughters, one of whom sold her lots to a company composed of John Humphrey, Richard Rees, Owen Owens, Benjamin Williams and ——— Jones. One other daughter sold her portion to a company—Thomas W. Jones, John Parry, William Thomas and William Parry. This lot was sold by the minor heir; in consequence the purchasers afterward had trouble in perfecting their title. The price of each of these lots or portions was $1200.

In the fall of 1870 John Parry, William W. Thomas, Thomas W. Jones, William Parry, Catherine Jones, and others formed the Welsh Slate Company which leased four acres adjacent to that of the Peach Bottom and opened the "Hickory Hill Quarry," subsequently worked by the Peerless Slate Company of Pittsburg for a term of ten years ending in July, 1898.

In 1873 or 1874 the Welsh Slate Company through Mr. Parry bought the land for $12,000 and other considerations, a figure which shows a marked increase in the valuation of the property since 1850, when 25 acres, including all of the quarries now operated was offered for sale for $1,200 and found no takers. Since the property bought by Mr. Parry was deeded by a minor there developed a great lawsuit concerning the ownership of the property and it was only after considerable expense that the company cleared its title to the land.

The Excelsior Quarry was first operated by a small company, who bought a little land in 1860 and operated until the spring of 1861, when the work was stopped by the enlistment of most of the owners, who themselves worked in the quarries. This land was sold to Isaac Parker after the war and later come into the possession of William E. Williams & Co., who leased it to two parties soon after on short leases. The quarries have been operated under leases ever since the land became the possession of the present owners. The quarries operated at present by Proctor Brothers, who started work in 1893, was first operated about 1868 but was not worked very much until under the present regime.

In 1880 Persifor Frazer[1] in his report on the Peach Bottom slates in York County and Maryland says that the following quarries succeeded each other beginning at the state line and proceeding southward into Maryland at the time they were visited in 1877:

Kilgore & Co.'s, James Perry & Co. (has been idle several years); Wm. E. Williams & Co. (leased and operated by the York & Peach Bottom Co.); Wm. C. Roberts (owned and operated by Proctor Bros.); John Humphrey & Co. (Peach Bottom Slate Co.); Thos. W. Jones & Co. (idle for several years, now owned by Peerless Slate Co. who

[1] Geology of Lancaster county, Second Geological Survey of Pennsylvania, CCC., Harrisburg, 1880, pp. 182-190.

have made a new opening recently); John W. Jones & Co. (8 miles south of state line along the ridge); Hugh E. Hughes & Co. (idle about ten years).

The accompanying sketch shows the location of the abandoned and active quarries within the State of Maryland at the time of their study for the present report in 1896.

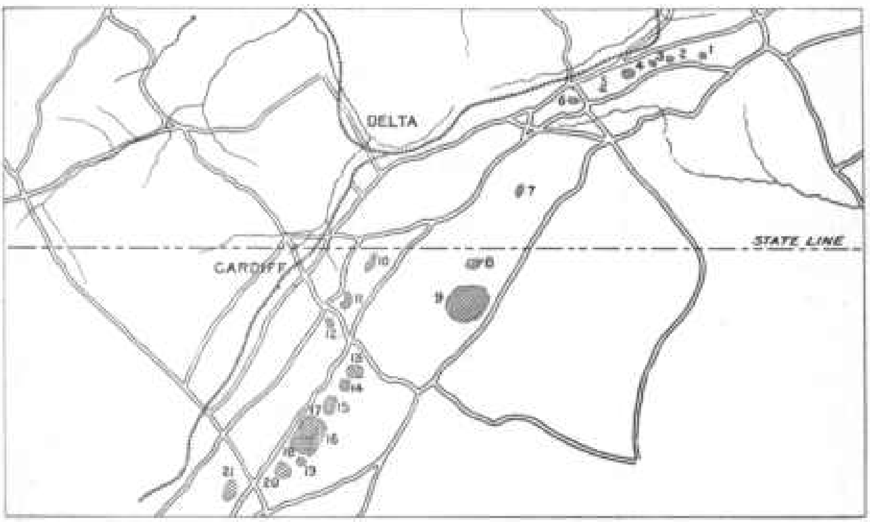

Fig. 19.—Sketch map of Peach Bottom Slate area.

Slate Quarries at Delta, Pa.

1.	Faulk Jones & Son,	(w)	11.	Scarborough's Quarry,	(a)
2.		(a)	12.	Baltimore & Peach Bottom,	(a)
3.		(w)	13.	Henry's Quarry,	(a)
4.	R. D. Jones & Co., Tunnel,	(w)	14.	York & Peach Bottom,	(w)
5.	E. W. Evans & Co.,	(w)	15.	Proctor Bros.,	(w)
6.	R. L. Jones,	(a)	16.	Peach Bottom,	(w)
7.		(a)	17.	Excelsior,	(w)
————	————————	State line.	18.	Peerless,	(w)
8.	Slate Springs,	(a)	19.	Aiken & Co.'s.	(w)
9.	Delta & Peach Bottom.	(w)	20.	Stubbs or Cambria,	(w)
10.	Schwab's Quarry,	(a)	21.	Baltimore & Peach Bottom.	(a)

(a) Abandoned. (w) Working.

The geological position of the beds, which furnish the slates of the Peach Bottom district, is in either the Hudson River or Quebec series, probably the latter as determined by Professor James Hall in 1883 from fossils submitted to him by Dr. Persifor Frazer.[1]

The productive beds are thought to be the axis of a narrow overturned synclinal fold which is included within the phyllite formation, extending in a northeast-southwest direction across eastern Maryland. The stratigraphic position of the band is still in some doubt, since no detailed mapping of the area has ever been completed. Just below the slates, which form the top of the well-defined topographic features called the "Slate Ridge," is a band of talcose chlorite slate which runs parallel to the roofing slates on either side of the ridge. These talcose slates are in turn underlain by a metamorphosed quartz conglomerate which resembles that of the exposures at the Rocks of Deer Creek. This quartzitic conglomerate wraps about the end of the slate formation some fifty feet below the exposure of the slate. To the southward the bands of conglomerate from either side coalesce and form a continuation of the slate ridge, which extends outhwesterly across the Broad Creek at Pylesville, where Broad Creek has cut a well-defined gorge. While few, if any, observations have been made upon the true bedding of the slates and while no satsifactory contacts have been found in recent studies in the area, the workings along the ridge seem to point conclusively to the fact that this syncline is somewhat overturned to the east, so that the dip of the westerly side is practically coincident with the cleavage, as is claimed by the quarrymen. The slate belt itself forms a narrow zone beginning a short distance southwest of the road running from Cambria to Prospect and extends in a northerly direction more or less parallel to the "Slate Ridge" through Maryland and York county, Pennsylvania, to the Susquehanna river, which it crosses. There is a short extension of the formation east of the Susquehanna in Lancaster county, which at times has been the most productive portion of the belt.

Throughout all of that part of the area which has furnished good slates the bedding is not clearly defined and the ledges of first-class material do not seem to present any continuous arrangement, suggesting valuable beds separated by non-productive ones. This lack of definition in the bedding of the stone renders it impossible to com-

[1] Trans. Amer. Inst. Min. Eng., vol. xii, 1884, p. 358.

pute with any degree of accuracy the thickness of beds or "veins." Some of the quarries produce good slate over a distance of a least 150 feet across the strike and their operations are limited not by the quality of the stone but by a short-sightedness during early operations which allowed the rubbish to be dumped upon the workable beds.

All of the quarries along the line show a great many series of joints which both aid and hinder the working of the quarries. The principal or bedding joints, as observed in the Proctor Brothers' opening (shown in Plate XXXI, Fig. 1) strike cross the cleavage and dip at an angle of 42° to the southwest. Similar bedding joints were observed in the Peach Bottom and York and Peach Bottom quarries (Plate XXXII). In addition to this most clearly marked jointing, there is a second series of joints dipping at an angle of 26° with the same strike and another set of joints which dip at about 80° to the northeast with their strike normal to the cleavage. These three systems free the rock in large rhomboidal slabs and they, if they existed alone, would be very valuable aids in quarrying the rock. Unfortunately besides these somewhat uniformly inclined joints there are a great many other jointing planes developed through the beds which do not seem to be conformable to any system of arrangement. They cut each other at all angles and intersect the plane of cleavage either acutely or with considerable obtuseness. In the York and Peach Bottom quarries there are sharply defined uneven jointing planes which leave the rock protruding like a series of folds whose axes lie parallel and separate from each other at a distance of one to three feet. The material on each side of the curved jointing planes (see Plate XXXII, Fig. 1) is of the same character and there is no evidence to warrant the assumption that there has been a direct bending into small folds either prior or subsequent to the development of the cleavage and the other jointing planes. The great number of joints and their intersection with each other at varying angles renders much of the material extracted unavailable for the manufacture of roofing slates or mill stock. While this is so and the amount of rubbish about the quarries is very great it is doubtful if there has been a greater portion of waste material than is common in slate quarries the world over. Another factor which must be regarded by practical operators working in the Peach Bottom area, is the presence of "flint seams" and "blue joints" which modify the manner of working the stone and frequently render much of the material worthless. The "flint seams" are of at least two classes; those of the first occur in long thin layers along the jointing planes where the two sides of the joint have been separated sufficiently to allow the deposition of quartz. The second class includes much more irregular deposits which occur in irregular masses varying from a fraction of an inch to several feet in diameter. These apparently represent zones of more intense crushing and subsequent deposition of quartz since it is a common saying among the quarrymen that the seams cleanse the rock and make the cleavage finer and truer. The "blue joints" referred to are really closed jointing planes in which chlorite has been deposited in more or less complete orientation with the chlorite of the body of the slates. The seams are not evident at first, but during the splitting and trimming of the slates develop as lines of weakness which render the pieces obtained of no value.

The most prominent feature in the texture of the Peach Bottom slates is the coarse fibrous arrangement of the particles which give to the stone an appearance somewhat suggestive of the fibre of petrified wood. This texture renders the slates much stronger in certain directions than they might otherwise be, but precludes the method of breaking the slates by sharp blows applied normal to the cleavage and makes the stock unavailable for milling purposes. The peculiar "fibrous" texture of the slate is indistinctly shown in Plate XXXI, Fig. 1, which represents the combined opening of the Peerless, Peach Bottom and Excelsior quarries. This also renders the use of the "plugging machines" and similar instruments of doubtful value. It has also been found more economical and feasible to saw the slates across their grain. The material prepared for market shows little or no variation in the nature of the stone employed, but the character of the finished product seems to vary somewhat in different quarries. Not only is there a difference in the skill with which the work is done, but the quarrymen seem to differ in the amount of care which they exercise in sorting the first and second qualities. While different beds and different portions of the quarry furnish stock that differs in the ease with which it is worked and in the character of the finished product, the quarrymen say that good material may be obtained from all portions of the opening and at all depths below the zone of superficial weathering. In company with quarrymen from all regions the men hold to the belief that the rock improves indefinitely with the depth.

The color of the Peach Bottom slates is a deep blue-black which is absolutely unfading, as is shown by the color of slates which have been exposed since the beginning of the century. This fact alone places the product of the area among the best slates of the world. From this color there seems to be no variation in any of the well prepared material. It should be borne in mind, however, that slates, like broadcloths, when placed side by side with their texture in different positions show differences in their sheen and that these differences may become so marked that an impression of a variation in color is often given. Care must be exercised accordingly not only in the selection but also in the laying of the slates if the most desirable effect is to be obtained. The unfading quality of the Peach Bottom slates allies them with the products of the Maine and certain of the Vermont quarries and separates them from the less uniformly colored slates of the Lehigh and Slatington districts which are not always able to retain their color unmodified by exposure. The only influence of exposure in the Peach Bottom slates which has been noticed, is a slight increase in the gloss or sheen in those pieces which have been longest exposed to the sun and atmosphere.

The bulk composition of any building stone may be very misleading, since it does not show in what state the chemical constituents are combined. This is especially true with slates. It, however, is of considerable advantage in showing the lack of injurious elements and the presence of advantageous components. The valuable constituents in the slates are the silicates of iron and alumina, while the injurious constituents are sulphur and the carbonates of lime and magnesia. Three analyses of the Peach Bottom slates are given below, one by the Pennsylvania Geological Survey made in 1877,[1] one by Booth, Garrett

[1] Second Report Laboratory of the Survey, by Andrew S. McCreath, Harrisburg, 1879, p. 370.

and Blair of Philadelphia in 1885, and one by George P. Merrill.[1] They are as follows:

Analyses of Slates.

	Pa. Geol. Sur.	B. G. & B.	Merrill.
SiO_2	55.880	58.370	44.15
TiO_2	1.270	tr.	tr.
Al_2O_3	21.849	21.985	30.84
FeO } Fe_2O_3	9.034	10.661	14.87
MnO	0.586	tr.	tr.
CaO	0.155	0.300	0.48
MgO	1.495	1.203	0.27
CoO	tr.	....	....
K_2O } Na_2O	4.100	1.933	4.36
H_2O	3.385	4.030 }	0.51
CO_2	....	0.390 }	4.49
C	1.974	0.930 }	....
S	....	0.107	wanting.
SO_3	0.22	....	"
FeS_2	0.051	....	"
	99.801	99.909	99.97

These analyses show the percentage of deleterious and advantageous minerals as follows:

	Geol. Surv.	B. G. & B.	Merrill.
Silicates of iron and alumina	86.763	91.016	89.86
Sulphur	0.039	0.107	wanting.
Carbonates of lime and magnesia	3.319	3.066	1.435

The source of the material for the first analysis was the "J. Humphrey & Co.'s quarry," now the Peach Bottom, and the second was also from the same opening. The material for the third analysis was taken from the opening of the Peerless quarry about one hundred feet west of the limits of the pit of the Peach Bottom. In describing the source of the materials Merrill gives the following description of the mode of weathering of the slates: "In the fresh cuts made during the work of stripping, to open new quarries, the sound rock is overlain by a variable thickness of ferruginous residual clay. Joint blocks and splinters of the slate scattered through this clay, in all stages of decomposition leave no doubt as to its origin. Blocks, deep velvety black on the interior, are surrounded by a crust of ocherous

[1] Rock, Rock Weathering and Soils, 1897, p. 229.

FIG. 1.—YORK AND PEACHBOTTOM QUARRY, CAMBRIA.

FIG. 2.—YORK AND PEACHBOTTOM QUARRY, CAMBRIA.

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brown-red decomposition product, the decay penetrating irregularly like the processes of oxidation into a piece of metal. The first physical indication of decay is shown by a softening of the slate, so that it may be readily scratched by the thumb nail, and an assumption of a soapy or greasy feeling, the entire mass finally passing over to the deep red-brown unctuous clay, sufficiently rich in iron to serve as a low-grade ochre, for paints. The incidental chemical changes are surprisingly large, as shown by the analysis below, column I being an average of two analyses of one of the blocks, and II that of the residual clay. In III, IV, and V are given the calculated losses of constituents."

	I.	II.	III.	IV.	V.
Constituents.	Fresh Argillite.	Residual Clay	Percentage of loss for entire block.	Percentage of each constituent saved.	Percentage of each constituent lost.
SiO_2	44.15%	24.17%	25.34%	42.43%	57.57
Al_2O_3	30.84	39.90	0.00	100.00	0.00
FeO } Fe_2O_3	14.87	17.61	1.23	91.22	8.78
CaO	0.48	None.	0.48	0.00	100.00
MgO	0.27	0.25	0.08	71.84	28.16
K_2O	4.36	1.24	3.39	22.04	77.95
Na_2O	0.51	0.23	0.33	0.36	99.64
C	......	......	......	......	......
H_2O	4.49	16.62	0.00	187.37	None.
	99.97%	100.02%	40.83%	......	.....

Microscopical and physical examinations are even more important than chemical analyses in determining the stability of roofing slates which expose such a relatively large surface to the action of frost and solution. Merrill has based his discussion of the stability of slates upon the amount of crystallization as shown by the microscope and the presence or absence of free carbonates of lime and magnesia, sulphides of iron or of carbonaceous material. The most characteristic features of the microscopic structure of the Peach Bottom slates are as follows:

The most evident constituents are quartz, feldspar and chlorite. These are very small and indistinctly outlined against each other, as is usual in fine-grained slates. In the preparation of the slide the fibrous character of the stone which is evident upon larger pieces is especially prominent, and this is not wholly lost in even the thinnest parts of the slide. The material seems to be completely recrystallized and no constituent is present in large areas which is at all untrustworthy. As the color seems to come from the chlorite and not from the finely comminuted particles of non-crystalline material, it should be permanent and unfading.

Professor Mansfield Merriman,[1] who has made a long series of experiments on the best methods of determining the durability of slates, regards physical and impact tests as most expressive of their permanency. An account of his experiments on the Peach Bottom slates is as follows: "During the present year the writer has made tests for strength, toughness, density, softness, porosity and corrodibility on twelve specimens of Peach Bottom slate, following the same methods as described in the former paper for the old Bangor and Albion slates. The specimens were 12 x 24 ins. in size, varying in thickness from 0.21 to 0.29 in. For the test of strength they were laid on supports 22 ins. apart and broken by a load slowly applied at the middle. The modulus of rupture for each case was then computed from the formula:

$$\text{Modulus} = \frac{3 \text{ x breaking load x length}}{2 \text{ x width x square of thickness}}.$$

"For instance, the specimen marked Q_1 was 12.04 ins. wide, 22 ins. between supports, 0.26 in. thick, and it broke under a load of 283½ lbs.; hence its modulus of rupture is 11,490 lbs. per square inch. The deflection, measured at the moment of rupture, was also noted as an index of toughness.

"The density of the specimens was determined by finding the specific gravity of each. The degree of softness was found by the weight abraded by 50 turns of a small grindstone under a constant pressure of 10 lbs. The porosity was determined by finding the percentage of water absorbed in 24 hours, after being dried for the same length of time at a temperature of 135° Fahr. The test for corrodibility was the percentage of loss in weight after immersion for 63 hours in a solution consisting of 98 parts by weight of water, 1 part of hydrochloric, and 1 part of sulphuric acid.

"The color of the slate was a dark bluish gray, or bluish black, and the texture of the surface was slightly scaly and soapy, being less

[1]Trans. Amer. Soc. Civil Eng., vol. xxvii, 1892, pp. 331-349; vol. xxxii, 1894, pp. 529-539.

smooth than the Northampton varieties. When ruptured by flexure, the specimens broke square across the grain without splitting or lamination. The tests for density, softness, porosity and corrodibility were made on pieces of the ruptured specimens.

"The table below gives the results of all the tests for each of the 12 specimens and also the mean values.

"An examination of these results tends to confirm the conclusions announced in the previous paper that in general the strongest specimens are the heaviest and softest, as also the least porous and corrodible, although exceptions occur in the case of Q_7 and P_2, and the Q specimens seem more corrodible than the P's, although greater in strength. The tests for strength and corrodibility are probably those of greatest importance in forming an opinion regarding the value of the slate under actual conditions of service. The test for softness, although a good one for a single lot of specimens, may not serve to fairly compare lots tested at different times on account of the varying conditions of the grindstone.

Mark of specimen.	Modulus of rupture in lbs. per sq. in.	Ultimate deflection in inches on supports 22 ins. apart.	Specific Gravity.	Grains abraded by 50 turns of small grindstone.	Percent. of water absorbed in 24 hours.	Percent. of weight lost 68 hours in acid solution.
Q_1	11,590	0.32	2.886	69	0.265	0.247
Q_2	12,585	0.30	2.907	115	0.197	0.197
Q_3	8,400	0.30	2.900	110	0.304	0.291
Q_4	13,430	0.32	2.893	177	0.228	0.194
Q_5	8,320	0.28	2.900	75	0.264	0.237
Q_6	12,010	0.32	2.918	67	0.209	0.200
Q_7	14,210	....	2.890	111	0.278	0.341
Q_8	13,060	0.34	2.902	67	0.261	0.240
P_1	10,520	0.24	2.912	69	0.171	0.150
P_2	9,360	0.20	2.885	53	0.143	0.226
P_3	10,470	0.34	2.858	87	0.216	0.161
P_4	11,255	0.26	2.873	80	0.155	....
Means.	11,260	0.293	2.894	90	0.224	0.226

. . . . While the preceding methods of testing are readily carried on in the laboratory, they are not easily made under conditions of actual practice on account of the absence of precise weighing apparatus, and the lack of time and skill. It seems desirable that a test for slate should be devised which can be quickly applied by an architect or builder, and be used with confidence. An impact test, made by simply dropping a ball, appeared one likely to yield good results, and accordingly a series of experiments has been carried on to determine what can be done in this direction. In connection with these, a series of severe acid tests has been made on the same specimens. . . . . The pieces of slate used in the impact test were 6 x 7¾ ins. Each piece was placed with the ends loosely clamped in grooved supports, so that it was approximately in the condition of a beam with fixed ends, the length between edges of supports being about 7¼ ins. and the width 6 ins. A wooden ball weighing 15.7 oz. was dropped upon the middle of the slate from a height of 9 ins., and the number of blows required to produce rupture was noted. The number of foot-pounds of work per pound of slate, expended in causing rupture, is a measure of the ultimate resilience of the material or of its capacity to resist shock, and thus is an index, both of its strength and toughness. Five specimens of each kind of slate were thus tested, and the table below gives the individual results and means. . . . As the result of the investi-

Specimen.	Thickness inches.	Weight ounces.	No. of b ows.	Foot-pounds of work per pound of slate.
P_1	0.26	17.3	9	6.13
P_2	0.26	17.2	15	10.29
P_3	0.31	20.4	55	31.74
P_4	0.28	18.4	52	33.35
PP_4	0.29	20.4	68	39.33
Means	0.28	18.7	39.8	24.17
Q_1	0.26	17.2	11	7.54
Q_2	0.27	17.8	20	13.25
Q_3	0.29	19.3	17	10.39
Q_4	0.28	18.2	6	3.89
QQ_7	0.27	17.6	11	7.37
Means	0.27	18.0	13.0	8.49

Spec.	Percentages of loss of weight. After 120 hours.	After 240 hours.	After 360 hours.	Foot-pounds of work per pound of slate.	Specific gravity.
Q_3	0.45	0.90	1.27	....	....
Q_5	0.40	0.99	1.32	...	....
Mean	0.42	0.94	1.29	8.5	2.90
P_3	0.32	0.81	1.12	....	....
P_5	0.28	0.93	1.10	....	....
Mean	0.30	0.87	1.11	24.2	2.89

gations thus far made, it may be concluded that the tests for density and softness, although of importance for slates of the same locality, are not good indications of the strength and weathering qualities of those of different regions; that the tests for porosity, corrodibility and flexural strength give good indications of these properties; that the results found for strength and corrodibility when mentally combined give on the whole an excellent idea of the value of the slate; and that an impact test with a wooden ball shows both strength and toughness, while it at the same time indicates the capacity for resistance to corrosion."

IJAMSVILLE.

At the present time no slate is quarried at Ijamsville, although this locality has been known as a source of slate for nearly, if not quite, a hundred years. Parrish in his brief history of the slate trade in America states[1] that quarries "near Frederick" were opened about 1812. This may be a reference to the small openings at Linganore, but it seems more in harmony with local traditions to infer that the quarries about Ijamsville were in mind.

When Tyson prepared his report there were two slate quarries in operation. One was situated just west of the railroad station, beside the tracks, and the other was about a half mile south of the town. They were evidently quite small, for they had not reached the best material. Little work was done during the time of the Civil War, and the more prominent quarry, shown in Plate XXIV, Fig. 2, was permanently abandoned about 1870, when the "pit" commenced to undermine the roadbed of the Baltimore and Ohio Railroad. The smaller opening, lying south of the town, never attained any considerable importance, although efforts were made as late as 1892 to bring the product of this quarry into the market. The method of working followed was that of the Germans, who mine rather than quarry their slate. A shaft was sunk to a depth of about sixty feet, but the enterprise was not successful.

The slates from Ijamsville formerly brought nearly as good prices

[1]Amer. Jour. Mining, ii, 1866-7.

as those from Harford county,[1] but at the present time they are almost unsaleable. This is not due to the poor or unstable character of the stone so much as it is to the relatively poor workmanship displayed in recent years and the popular demand for a slate which will *ring* when tapped with a finger or pencil. Because of the hard and compact character of the better siliceous slates from Pennsylvania and the northern states, it has become customary to regard all dull or soft slates as untrustworthy. In many instances this view is correct, but in the case of the Ijamsville slates it is not warranted by the facts. The slates from this locality show microscopically that they are well crystallized, and that they do not owe their softness to a partial change from a shale to a slate, but to an admixture of the relatively stable and soft mineral talc, which is usually wanting in the better known slates. If the stone were unstable the blue-black color would change upon exposure. This it does not do, since roofs on which the slates have been exposed to the atmosphere for fully fifty years do not indicate any change in color as a result of this exposure. In spite of their permanency in color and their strength the slates have yet to prove themselves a basis for a profitable industry.

[1] The price per ton for the Harford county slates, as given by Tyson, ranged in 1860 from $12 to $22, which would be approximately from $4 to $6.50 per square. The prices for the Ijamsville slates were: "First quality, $5 for 560 lbs., which cover 100 square feet; second quality, $4 for 620 lbs., which cover 100 feet." The quality of the slates furnished was probably about equal to that of the Lehigh slates of to-day.

THE BUILDING-STONE TRADE.

Collection of Statistics.

Any discussion of the statistics concerning the building-stone industry in Maryland or any other state must be limited to conditions obtaining during the last ten or fifteen years, and even within these limits the figures obtained are far from satisfactory. There is probably no line of statistical work which offers a greater number of discouraging features in proportion to the problems involved than that connected with the quarrying industries. These difficulties arise from several causes. Prior to the inauguration of statistical work by the U. S. Geological Survey there seems to have been no attempt at the uniform collection of annual figures regarding the output of building stone within the limits of the United States. The only exceptions to this statement are found in the tables presented in the Eighth, Ninth and Tenth Census Reports made in the years 1860, '70 and '80 respectively. Earlier reports of this nature either made no enumeration of the industry based on actually gathered statistics, or their classification is such as to render comparison with later data of little value.

The work of the U. S. Geological Survey in the collection of statistics has been noteworthy, and a marked increase in the amount of information concerning the building-stone industry is evident from year to year. The first reports of this organization were based upon the Tenth Census, and it was not until the year 1884 that any considerable amount of material was collected concerning the granite industry of the different states. At the beginning of their work the agents of the Federal Survey met with many discouragements which have been encountered anew in the prosecution of the present work. The greatest source of delay and lack of details arises from the attitude of the quarrymen themselves, who disregard written communications and even refuse to impart information to members of the Survey. The grounds for this attitude among the quarrymen are due to various reasons. Sometimes no record has been kept of the amount of the product which has been shipped, and in other instances the record preserved is in such shape that little of a statistical nature can be gathered. Among those operators who preserve a careful record of their output, expenses and wage list, there are many who refuse to give information because they have been so annoyed by the importunities of unauthorized gatherers of statistics, who make unwarranted requests on the time and information of the quarrymen, that they fail to make a discrimination between demands which are legitimate and those beyond all reasonable bounds. Many of the trade journals and similar organs have gathered statistics from year to year and published them in such a way that trouble has arisen between the employers and the employees, until the operators are almost afraid to give even the most commonplace information. Other statistics gathered from various sources have been utilized by the tax collectors and other petty officials as a basis for exorbitant demands, until the quarrymen feel that information may be used against them in almost any conceivable way. Before satisfactory statistics can be gathered concerning the various phases of the quarrying and marketing of stone, it will be necessary to overcome all of these misunderstandings and prejudicial notions held by the quarrymen.

Annual Production in Maryland.

Considering all of the available sources of information, of which the most trustworthy are the reports of the U. S. Geological Survey, it has been possible to construct the following table which approximately represents the annual output of the quarries within the state during the years 1860 to 1897 inclusive.

A study of these columns gives only an inadequate conception concerning the fluctuations of trade which have occurred during the last half century. So much depends upon the conditions under which the statistics were gathered and the minimum limit of output recorded that it is of little use to make a detailed study of the individual industries. There are, however, a few facts concerning the statistics obtained in different years as recorded by the various statistical bureaus which are of interest.

VALUE OF ANNUAL PRODUCTION IN MARYLAND.

	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
1860	46,900	......	26,000	30,000	224,630	......
1870	83,229	......	80,853	275,000	234,199	......
1880	224,000	......	56,700	65,929	......	......
1881	......	......	......	......	......	......
1882	......	......	......	......	......	......
1883	......	......	......	......	......	......
1884	......	......	45,000	......	......	......
1885	......	......	65,250	......	......	......
1886	......	......	54,000	.....	......	......
1887	. ...	......	90,000	160,000	429,000	......
1888	263,952	[15,000]	85,500	175,000	[175,000]	......
1889	447,489	10,605	110,008	119,675	164,860	872,778
1890	447,489	10,605	110,008	139,816	164,860	872,778
1891	450,000	10,000	125,425	100,000	150,000	835,425
1892	450,000	5,000	116,500	105,000	200,000	867,500
1893	260,855	360	37,884	130,000	......	......
1894	308,966	3,450	153,068	175,000	350,000	990,484
1895	276,020	16,836	60,357	145,000	200,000	698,214
1896[1]	251,108	10,713	72,142	110,000	264,278	708,241
1897	188,335	[10,000]	53,939	106,000	249,809	608,083

Granite.—Since the war the granite industry has shown a slight but steady increase in the amount of its output, which is not fully brought out by the increasing values of the annual product. The reason for such an increase in volume seems to lie in the growing demand for granite in all sorts of structures and in the slight cheapening in the cost of extraction and dressing. These conditions are accentuated by the gradual change in public taste respecting the use of trimming stones, which demands gray sandstones and granites in place of the brownstones. The latter now hold a far less important position in the market than in the years immediately succeeding the Civil War. During these years there has also developed a considerable trade in paving stones and road metals which has allowed the utilization of the angular blocks and waste of the quarries, thereby decreasing largely the expense of operation. The trade seems to be moderately uniform and somewhat similar to the oscillations in the general demand, as, for example, in June, 1893, there was a marked falling off in the output, the only shipments being in fulfillment of

[1] See note p. 241.

orders already presented. The trade recovered temporarily in 1894, but has since then been in even a more discouraging condition than at any time during the last decade.

Sandstone.—The sandstone industry is the most variable among all of the quarrying industries carried on in the state. During the years 1875 to 1884, no work was carried on at the Seneca. This stagnation in business was due to the strong reaction against brownstone and other sandstones which swept over the country about 15 or 20 years ago. During the years 1888 to 1891 there was considerable activity, but the sandstone industry felt the general depression of '93 so strongly that the reports indicate almost no output. Later, as the companies became active, the product increased somewhat and is at the present time about normal. In fact, there seems to be a slightly growing demand for high grade brownstone which may in time supersede the lighter colored stone as trimming.

Marble.—The marble industry has been almost constant throughout the last ten years, showing only slight relative changes in the value of the product, which averages about $140,000 annually. This is the only industry which did not seem to feel the depression of '93, a fact which is due no doubt to the uniform product and uniform demand for the Cockeysville marble, which furnishes most of the material within the state. Some of the fluctuations between the different years may be accounted for by the oscillations in the serpentine output, since this is included among the marbles.

Slate.—The nearest complete details concerning the actual output of the quarries are available respecting the slates. This no doubt arises from the peculiar nature of the manufacture and the high skill and intelligence required in the preparation of slate stock for the market. Unlike that of the other building stones, the manufacture of slate requires a special skill which is usually acquired by practice from childhood. This fact influences greatly the product of the various quarries, for it is regarded by the operator as more disastrous to discontinue operations than to be left with a surplus of stock. The labor, because of its peculiar skill, cannot be replaced at will, and the quarrymen thrown out of their customary employment are unfitted to engage in other lines of industry. This method of procedure requires an increased capital, which in turn has rendered the profits much less during periods of depression, since there is no compensating reduction in the wages of the quarrymen.

Prices, Wages, etc.

The facts which have been gathered from personal conversation with quarrymen and contractors over the entire state are so at variance with one another, especially concerning the price, that it has been impossible to obtain any mean values which satisfactorily represent the average price per foot for the different products throughout the state. With the exception of the highest grade work, and the product of one or two of the larger operators, there is no systematic regularity in the price charged for products of the same kind and quality, the prices even varying 20 to 40 per cent on opposite sides of a hill connected by a deeply cut valley which eliminates variations due to differences in the price of hauling. The same fact is true concerning the gneisses quarried about the city of Baltimore, where the figures given for different quarries show a variation in the price of random rubble, for example, of fully 150 to 200 per cent. The prices for the different products are given in subjoined tables, from which it may be seen that the same material when sold by different standards is really sold at quite different prices, as, for example, when rubble-gneiss is sold at the rate of $2 a cubic yard ($1.38 per perch), $1 per long ton ($.74 per perch) and $1 per perch. The figures gathered likewise do not show a uniform difference in price between the labor and the product in the counties and those in the vicinity of Baltimore, although the price is usually lower in the country districts for both, except among the skilled laborers belonging to unions which regulate the wages. Even here at times there seems to be an unfairness toward the city artisan, since he is compelled to pay somewhat more for living expenses than his competitor outside of urban influences.

The actual information in these tables is limited by the confidential nature of the facts given and the unwillingness in certain instances to impart any sort of statistics because of previous breaches in confidence by unofficial agencies. The wages are generally fixed by the unions to which most of the skilled workmen belong. Considering the capital invested, the wear of machinery and the value of the stone in the ledge, the margin between the cost of extraction and the price of the finished product is not excessive.

GRANITE AND GNEISS.

	Undressed Stone.		Cost of Dressing.	Wages.		Prices at Quarry.			
	Per foot.	Royalty per perch.		S.	L.	Per perch.	Per yd.	Per cu. ft.	Per ton M
Rubble	......	......	....	$3.50	$1.00	...	$1.00	...	....
	......	......	....	1.80	...	...	...	...	....
Flagging	......	......	....	...	...	...	...	.30	....
	......	......	....	...	...	...	...	.35	....
Curbing	......	......	....	...	...	...	...	.30	....
	......	......	....	...	...	...	...	.35	....
Paving	......	......	....	...	...	...	...	.25	....
	......	......	....	...	...	...	...	.30	....
Belgian blocks	......	$10 per M.	....	...	...	...	...	...	....
Dimension	.60–1.25	......	....	...	...	...	...	...	....
Monumental	.70–1.25	......	....	...	...	...	...	...	....
Rubble	......	.05	....	3.00	1.00	.80	2.00	...	....
	......	......	....	...	1.25	1.50	...	...	....
Flagging	.21	......	....	...	...	...	...	.28	....
	......	......	....	...	...	...	...	.56	....
Curbing	......	......	6–10	...	...	...	...	.35	....
	......	......	....	...	...	...	...	.60	....
Coping	......	......	8	...	...	...	...	.45	....
	......	......	....	...	...	...	...	2.00	....
Dimension	......	......	....	3.50	1.50	...	...	...	....
Pointed	......	......	....	3.00	1.25	...	...	.65	....
	......	......	....	...	...	...	...	.75	....
Ax hammered	......	......	12–15	...	...	...	...	.65	....
	......	......	....	...	...	...	...	1.50	....
Bush hammered	......	......	32–33	...	...	...	...	1.02	....
Belgian blocks	......	$10 per M.	....	...	...	...	1.80	20	$45
	......	......	....	...	...	...	...	...	59

TRIASSIC SANDSTONE.

	Cost of Undressed Stone.		Wages.	
	Cu. ft.	Royalty per perch.	S.	L.
Rubble	.60—$1.50	.25	$3.50	$1.25
	....	....	3.00	1.25

PALEOZOIC SANDSTONE.

	Cost of Undressed Stone.	Wages. S.	Wages. L.
Rubble	\$1.00—\$3.00 per cu. yd.	\$1.35—\$1.45	\$1.25
Flagging	1.45 per sq. yd.	......	....
Macadam	.70 per perch.	......	....

The wages in Allegany and Garrett counties are lower than in Montgomery and Frederick since the industry in the latter localities is more firmly established and the product of a higher grade. The variations in price for the same material according to the units of measurement are noticeable in the sandstone reports, but they are not so extreme as in the gneiss and granites.

All of the product of the Peach Bottom area is used for roofing slates, since the grain of the rock is rather against its being used for milling purposes. Thus the above prices represent the figures for almost the entire output of the region. The slate trade maintains the price of stock more uniformly than almost any other of the stone quarrying industries, for the prices obtained to-day are nearly the same as those obtained seventy-five or eighty years ago. The method of reckoning has changed from weight to area of roof, and the "lap" of the upper courses of the latter has during the years increased from two to three inches in the higher grade materials. The manner of estimating the number of pieces per square is based on the practice in laying slates. The slates are laid so that the first course is overlain by the second course and by two or three inches of the third. The overlapping of the first third courses is known as the "lap," and it is not unusual for the roofer to buy his stock with a "three-inch lap" and lay it with only a "two-inch lap," thereby saving for himself a small margin which does not appear to the consumer. Moreover, the workmanship and uniformity in the product has greatly improved so that, although the apparent price remains the same, there has been a steady improvement in the material furnished to the consumer.

The following list of prices does not represent any except the standard thickness of three-sixteenths inches. That is, the stock runs about four pieces to the inch "in the rick." When the speci-

SLATES.

		Md. & Pa. Slates.		Pa. Slates.				Maine Slates.		Vermont Slates.		
Size.	No. Pieces 3 lap.	Peach Bottom 98.	Peach Bottom 95.	Northampton Co.	Washington.	Franklin Tunnel.	Lehigh, No. 1.	Maine, No. 1.	Maine, No. 2.	Unfading Green.	Bright-red.	Buckingham Co., Va.
9x7	686							3.50	2.50			
10x5	823	3.05	3.25									
10x6	686	3.50	3.50								7.00	
10x7	596	3.50	3.50								7.00	
10x8	514	3.50	3.50					4.00	3.00		7.00	
11x5	720	3.35	3.50									
11x6	600	3.65	3.75									
11x7	514	3.65	3.75									
11x8	450	3.65	3.75					4.50	3.50			
12x6	534	4.50	4.75	3.20	3.10	3.55		4.80	3.80	4.00	9.00	
12x7	458	4.60	4.75	3.25	3.20	3.55		5.00	4.00	4.00	9.50	
12x8	400	4.60	4.75	3.25	3.25	3.55		5.50	4.50	4.00	9.50	
12x9	356	4.60	4.75					5.60	4.60	4.00	9.50	
12x10	320	4.60	4.75					5.80	4.80	4.00		
14x7	374	4.85	5.25	3.50	3.40	3.95		6.40	5.40	4.50	11.	3.60
14x8	328	4.85	5.25	3.75	3.40	3.95		6.60	5.50	4.50	11.	3.60
14x9	291	4.85	5.25	3.75				6.50	5.50	4.25	11.	3.60
14x10	262	5.00	5.25					6.60	5.60	4.25	11.	3.60
14x12	219							6.50	5.50			
14x14	187							7.00	6.00			
16x8	277	5.10	5.60	4.40	3.75	4.25	3.00	7.20	6.20	4.50	11.	4.00
16x9	247	5.10	5.60	4.40	3.75	4.25		7.00	6.00	4.50	11.	4.00
16x10	222	5.00	5.50	4.40	3.75	4.25		7.10	6.10	4.50	11.	4.00
16x11	202	5.00	5.50					6.90	5.90	4.25		
16x12	185							6.80	5.80	4.00		
16x16	139							7.00	6.00			
18x9	214	5.10	5.60	4.30	3.75	4.25	3.00	7.10	6.10	4.50	11.	4.00
18x10	192	5.10	5.60	4.30	3.75	4.25		7.20	6.20	4.50	11.	4.00
18x11	175	5.00	5.50					7.00	6.00	4.25		
18x12	160	5.00	5.50					6.80	5.80	4.00		3.60
18x14	137							6.50	5.50			
20x10	170	5.10	5.60	4.20	3.75	4.25	3.00	6.80	5.80	4.50	11.	4.00
20x11	154	5.00	5.50	4.20				6.80	5.80	4.25		
20x12	142	5.00	5.50	4.20	3.50	4.25		6.90	5.90	4.25		3.60
20x13	130	5.00	5.50									
20x14	121									4.00		
22x11	138	5.00	5.50	4.00	3.35	3.80	3.00	6.50	5.50	4.25		3.60
22x12	127		5.50	4.00	3.35	3.80		6.60	5.60	4.00		3.60
22x13	116		5.50									
22x14	108		5.50							4.00		
24x12	115	5.00	5.50	3.80	3.25	3.50	3.00	6.60	5.60	4.00		3.60
24x13	105	4.85	5.35	3.80								
24x14	98	4.85	5.35	3.80		3.45		6.10	5.10	4.00		3.60
24x15	91	4.75	5.15									
24x16	85	4.75	5.15									

fications call for one-quarter inch stock, sawed edges, polished surfaces or boring and countersinking, the price increases somewhat per square according to the character of the work required. The Peach Bottom slates do not need to be drilled and countersunk as much as some of the more brittle slates from the northern states, since when punched, the hammer goes through, making a clean hole without any injurious flaking or spalling on the underside.

The figures in the foregoing table show that there has been a decrease in the prices obtained for the Maryland slates since 1895, and that the material from the New England quarries demand higher prices than that for Maryland, while the prices of the Virginia and Lehigh slates are lower.

NOTE.—The figures indicating the annual product for 1896 are those published by the U. S. Geological Survey. Although they are different from the results obtained in the exhaustive investigations carried on by the State Geological Survey, they are more valuable for a comparative study, since the conditions governing their collection and tabulation are more in accord with those existing in previous years.

PART III

REPORT ON THE

CARTOGRAPHY

OF

MARYLAND

BY

HENRY GANNETT AND EDWARD B. MATHEWS

THE AIMS AND METHODS OF CARTOGRAPHY

WITH ESPECIAL REFERENCE TO THE

TOPOGRAPHIC MAPS

NOW UNDER CONSTRUCTION IN MARYLAND

BY THE

UNITED STATES GEOLOGICAL SURVEY

IN CO-OPERATION WITH THE

MARYLAND GEOLOGICAL SURVEY.

BY

HENRY GANNETT.

INTRODUCTION.

Surveying is carried on for two widely different purposes. One consists in laying down upon the ground certain geometric figures, such as a town plat or the alignment of a railroad or an aqueduct. The other purpose is the making of maps, that is, of miniature representations of the country. While the instruments and operations are to a considerable extent the same in both these operations, the purposes and the results are very different.

Most books on surveying relate mainly, if not entirely, to the first of these, and the treatment of operations incident to making topographic maps is more or less slighted. The present article will attempt to describe the most approved methods of surveying as applied to the production of topographic maps, including those on large and small scales, and of a greater or less degree of accuracy, and also the methods used in rough reconnaissance as well as in accurate and detailed surveys.

General Considerations.

A map is a representation, in plan, of a part of the earth's surface. The variety of maps is legion, depending upon the class of features or phenomena which they represent or which is made prominent upon them. Thus there are geologic maps, zoologic maps, botanic maps, cadastral maps (which represent, primarily, property lines), political maps, etc. For all these it is essential that there be a base upon which the specific phenomena are represented. This base should show certain topographic features, streams, and other bodies of water; railroads, towns and cities; while the addition of some sort of convention to represent the relief of the ground is commonly a valuable adjunct to such base maps.

From the point of view of scale, those maps which show only topographic features may be grouped in two classes; first, those upon small scales, say ten or more miles to an inch, which may be properly called geographic maps, and which are usually compiled from other maps upon larger scales; and, second, those upon large scales, which may properly be called topographic maps. These are often made directly from surveys, and, being the first product of these surveys, are known as mother maps because they constitute the source from which other maps are compiled.

It is first in order to describe the methods of surveying and the preparation of maps upon large scales—maps which can be conveniently made directly from surveys.

Topographic Maps.

A topographic map should represent rivers, creeks, lakes, ponds and all other bodies of water, together with coast lines; it should show all artificial features which are of sufficient prominence to be represented upon the scale, such as roads, boundary lines, cities, towns, villages, houses, and in case of large scale maps, fences and other such objects, bridges, fords, dams, canals, aqueducts, etc.; it should show the relief of the ground, its hills and valleys, mountains, canyons, etc.

There are different methods of showing the relief features, which may be classed as qualitative and quantitative. The qualitative methods are those which show the relief by shading, either by means of crayon or color, or by hachure lines, which are lines drawn in the direction of the slope and which by their relative heaviness and closeness produce the effect of shading. These methods merely show the degree of slope, they give no information regarding the absolute amount of relief or the elevation above sea level. They have been in extensive use throughout the world, but their use is now diminishing rapidly.

Contours.

The method of expressing relief which is now commonly in use, and which has to a great extent taken the place of those described above, is that known as the contour method. Contours are lines drawn at equal elevations above sea level, every point upon a contour is or is supposed to be at the elevation indicated by that line. It is as if the level of the sea were raised successively to the different heights indicated by the contours, when these contours would become shore lines. This method is confessedly not as graphic as the others, but it has this great advantage, that it measures the elevations, and the height of any portion of the area represented can be read directly from it. Moreover, it expresses the slopes, since where they are steep the contours must necessarily be close together, and where they are gentle, the contours are far apart. Modern maps are as a rule contour maps.

Scales of Maps.

The scale of a map is the proportion which exists between the dimensions as measured upon the map and the dimensions upon the area which it represents. It is designated in many different ways; one, the number of miles or of feet represented by each inch upon the map; two, by what is called a decimal scale, the numerator representing a unit of the map, while the denominator represents the number of the same units corresponding to it upon the ground, as $\frac{1}{10000}$; three, by a bar scale, wherein a measure upon the map is marked with its corresponding measure upon the ground. Upon many maps all these forms of designating the scale are given.

The scale of a map should be chosen so as to represent as much detail and as great accuracy as is needed for the purpose for which the map is made. It should be neither larger nor smaller than is required to suit this purpose. For a small amount of detail a large scale is simply unnecessary, while too small a scale does not allow the representation of the detail required, or if it is crowded in, the map becomes more or less illegible. Thus the statement of the scale of a map should afford a measure of its accuracy and detail.

Contour Interval.

The contour interval is the vertical scale of the map. This should be proportioned to the horizontal scale and to the degree of relief of the country. With the same horizontal scale, the contour interval would naturally be large in a country of bold relief and small in one of slight relief, since in the former case the same difference of altitude is of much less importance than in the latter case.

Cultural Features.

The list of cultural features or works of man which should be represented upon a map should depend upon the scale of the map, and the purposes for which it is made. A general topographic map, which is designed for continuous use for many years, should contain comparatively few of these features, and only those which are likely to be permanent. They should be confined, also, pretty closely to those which are of importance to the community rather than to individuals. These features change with greater or less rapidity and in order to keep the map revised involves, in case there are many such features represented, a great deal of labor and money. For these reasons their introduction should be restricted as far as is compatible with the usefulness of the map. Upon maps on large scales, and for temporary purposes, the list may be enlarged to any extent, and in any desired direction, but the matter of inclusion and exclusion of these features should be considered carefully in view of all attendant circumstances, and no such rule as putting *everything* on the map should be entertained. It is very easy to so clutter up a map with useless information as to obscure its really valuable features.

DIAGRAM OF CONTROL

TOPOGRAPHIC SHEET

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT DIRECTOR

MARYLAND-WEST VIRGINIA-PENNSYLVANIA
FROSTBURG QUADRANGLE

CONVENTIONAL SIGNS

CULTURE
(printed in black)

- Roads and buildings
- Private and secondary roads
- Trails
- Railroads
- Street railroads
- Tunnels
- Bridges
- Ferries
- Fords
- Dams
- Locks
- U.S. township and section lines
- Located township and section corners
- Township and section corners not found
- Triangulation stations
- Bench marks
- Mines and quarries
- Prospects
- Shafts
- Mine tunnels *(showing direction)*
- Mine tunnels *(direction unknown)*

Piedmont
H.M. Wilson, Geographer in charge.
Triangulation by Geo. T. Hawkins.
Topography by J.H. Wheat and W. Carvel Hall.
Surveyed in 1897.

Wheat
Hall

Romney

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of Sept. 1898.

Romney

LEGEND

Elevations of all control points and lines are determined
- Primary triangulation stations
- Secondary triangulation stations
- Secondary triangulation locations
- Traverse locations
- Traverse lines
- Spirit level and traverse

CONVENTIONAL SIGNS

RELIEF
(printed in brown)

- 5463 Figures *(showing heights above mean sea level instrumentally determined)*
- Contours *(showing height above sea, horizontal form and steepness of slope of the surface)*
- Depression contours
- Levees
- Cliffs
- Mine dumps

DRAINAGE
(printed in blue)

- Streams
- Falls and rapids
- Intermittent streams
- Canals and ditches
- Lakes and ponds
- Intermittent lakes
- Glaciers
- Springs
- Salt marshes
- Fresh marshes
- Tidal flats

The above signs are in current use on the topographic maps. Variations from this usage appear in some maps of earlier dates.

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General Methods.

Every map is essentially a sketch, corrected by locations. This is a sweeping definition covering all maps, of all sorts, scales, kinds and qualities. It follows from this that the work of making a map consists of two parts; that of making these locations, which is done by means of surveying instruments and is geometrical; and that of sketching, which is done by the eye and hand, and is artistic. This general description applies to the making of all maps, whatever their scales, their accuracy, their degree of detail, and the character of the organization making them. The methods and instruments employed in making the locations differ with different scales, different kinds of country and the ideas of the organizations which are engaged in making them.

Although the work of sketching really furnishes all that appears upon the finished map, while none of the work of location appears thereon, still, a description of the methods of making these locations must of necessity form the bulk of a volume descriptive of surveying methods as it is an essential part of the work. It is proposed in this volume to treat only of the most approved methods and instruments in use in topographic surveying, and not to waste time and space upon methods or instruments which have been tried and discarded.

Correctness of Maps.

The correctness of a map depends upon four elements: first, the accuracy of location; second, the number of locations per square inch of the map; third, their distribution; and, fourth, the quality of the sketching. It is in connection with the first of these elements that it seems desirable to define what constitutes accuracy. The greatest accuracy attainable is not always desirable, because it is not economic. The highest economy is in properly subordinating means to ends, and it is not economic to do work of greater accuracy than is needed; for instance, to execute triangulation of geodetic refinement for the control of maps upon small scales. The quality of the work should be such as to insure against errors of sufficient magnitude to be appreciable upon paper. While the tendency of errors in triangulation is to balance one another, still they are liable to accumulate and this liability must be guarded against by maintaining a somewhat higher degree of accuracy than would be required for the location of any one point. It is not difficult to meet this first condition of accuracy of the maps. The maximum allowable error of location may be set at one-hundredth of an inch upon the scale of publication. This admits of an error upon the ground not greater, on a scale of 1:62500, than 50 feet, and proportionally upon other scales.

The second condition of correctness, that is, the number of locations necessary for the proper control of the work, is not easily defined. The requirements differ with the character of the country. A region of great detail and of abrupt features requires more control than one of great uniformity, of gentle slopes or of large features, so that no general rule can be laid down. Furthermore, it depends upon the quality of the sketching; with indifferent sketching a greater number of locations is required in order to bring the map up to the requisite quality. Examples of the amount of control upon maps are scarce, since little has been published upon this subject.

The following table represents a summary of the amount of control in certain maps prepared by the U. S. Geological Survey. It is presented not as a type of what should be, but to show what has been done and also to illustrate the wide range in the amount of control brought about by the differences in the character of the country and methods of work.

Statistics of Control.

	New England, New York and Pennsylvania.	Appalachian region and Atlantic Plain.	Arkansas.
Area surveyed, square miles	3,150	8,090	1,480
Triangulation stations	650	108	8
Number of square inches per station	4.7	18.7	46.3
Points located by triangulation	3,330	1,427	......
Triangulation stations and located points	3,980	1,530	......
Number of above locations per square inch	1.3	0.7	......
Number of miles traversed	4,460	12,269	2,360
Inches traversed per square inch	1.4	1.5	1.5
Number of traverse stations	29,150	113,500	20,760
Traverse stations per square inch	9.3	56.1	56.1
Total number of locations per square inch	10.6	56.8	56.1
Traverse stations per linear mile	6.5	9.2	8.8
Heights measured instrumentally	5,700	7,800	130
Heights measured by aneroid	23,886	48,880	9,690
Total number of measured heights	29,586	56,680	9,820
Heights per square inch	9.4	28.0	26.5

As the reader will observe, the amount of control of various sorts is given in the above table with reference to areas in square inches upon the map as published. It is given in these terms in order to eliminate from it the question of scale.

There are two general methods of location of stations and of minor points for the correction of the sketch, the one by angular measurements (triangulation), the other by measurement of direction and distance, or what is known popularly as the traverse or meander method. In ordinary practice, work may be done by either of these two methods, or they may be used in conjunction. The former of the two methods may be carried on with the plane table, various forms of the theodolite, with a compass, or, indeed, with any angle-reading instrument. The latter method may be carried on with the same instruments, supplemented by various forms of odometers, chain, steel tape, stadia, etc., for the measurement of distance. The first method, whenever it can be used economically, is the most accurate, and is, as a rule, the most rapid, and the locations are likely to be of the greater service and distributed most uniformly. It can be used economically where the country presents more or less relief, and where points for location, either natural or artificial, exist in sufficient numbers and are well distributed. These conditions are satisfied almost everywhere in the western mountain regions, where mountain peaks, summits of hills, plateau points, buttes, etc., furnish an abundance of natural points for stations and locations. It can be used, to a considerable extent, though not with the same ease or economy, in the Appalachian mountains; but in this region it is necessary to supplement it extensively by traverse lines, especially in tracing the courses of streams in the valleys. It can be used, too, in the hill country of New England, where objects of culture, such as churches, houses, etc., furnish an abundance of signals. On the other hand, throughout the whole extent of the Atlantic and Gulf plains, where the country is level or nearly so, and is covered with forests, the traverse method of surveying must be resorted to; this is a country devoid of sharp natural objects, a country in which extended views cannot be obtained. For many reasons, this method of obtaining locations is inferior to the former. It is inferior not only in accuracy, but in the facilities which, as carried out, it affords for sketching the country, and it should be so regarded, and should be adopted only when it becomes necessary, or when the former method cannot be applied economically.

For convenience, traverse lines are generally run along the roads or trails, and thus the best points for commanding views of the country are avoided rather than sought. Being practically confined to the roads, there is danger lest the topographer neglect, in greater or less measure, the areas lying between them. On account of the errors incident to running a traverse it is necessary that, in this class of work, frequent locations be made by triangulation for checking and thereby eliminating its errors.

All locations fall into one or the other of these two classes. Locations by triangulation are of much greater value than those by traverse. As a rule, they are selected points chosen because each controls positions in a certain area. On the other hand, traverse locations are not, as a rule, chosen for their control value, but only for intervisibility on roads. Furthermore, the great majority of traverse stations are of no service whatever beyond carrying the line forward, so that in estimating the total amount of control in a certain area where the control is made up in whole or in part of traverse lines, less weight should be given to them than to locations by triangulation.

The third element of accuracy, the distribution of locations, is a point concerning which it is equally difficult to speak definitely. Other things being equal, the distribution should be uniform over the area, but it will necessarily vary with the character of the surface. The accompanying diagram shows the amount and distribution of control in a typical piece of work. In general, in the mountain regions, locations by angular measurements are frequent and accompany the ranges or ridges, and such locations are few in number in the valleys, being supplemented there by traverses.

The matter of locations may be treated from another point of view, that of the features to be represented. All points selected for location should be chosen for the purpose of locating the sketch of cer-

DIAGRAM OF TRIANGULATION

TOPOGRAPHIC SHEET

VOLUME II. PLATE XXXIV

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STATE OF MARYLAND
WILLIAM BULLOCK CLARK
STATE GEOLOGIST

MARYLAND–WEST VIRGINIA–PENNSYLVANIA
FROSTBURG QUADRANGLE

H. M. Wilson, Geographer in charge.
Triangulation by Geo. T. Hawkins.
Topography by J. H. Wheat and W. Carvel Hall.
Surveyed in 1897.

Edition of Sept. 1898

tain features. Streams, roads and other linear features can ordinarily be best and most economically located by means of traverse lines, *i. e.* by establishing by traverse a series of points along their courses. Houses can commonly be best located by intersection, either in connection with the secondary triangulation or from a traverse.

The location of contour lines requires more than a passing mention. At the outset a very common mistake must be corrected. It is generally supposed by those unacquainted with the subject, that contours are located by finding and fixing points directly on these contours, and sketching the contours between these points. This method is, however, employed but very rarely and that only in the most detailed surveys. In the topographic surveys of all nations, excepting the English Ordnance Survey, a different method is employed or rather a different selection of points is made. Salient points are selected for location and height measurement, such as the summit of hills, shoulders of spurs, the feet of slopes, the beds of valleys. The contours are then sketched with reference to them. By judicious selection of such points, comparatively few locations and height measurements serve to locate the intervening contours with sensible accuracy. The results are, on the whole, quite as good as if points had been located immediately on the contours, and the work of location is vastly reduced.

The fourth of the elements of the correctness of the map depends upon the artistic sense of the topographer, upon his ability to see things in their proper relation, and his facility in transferring his impressions to paper. This is by far the most important and the most difficult to meet.

In this connection it is advisable to correct a widespread misapprehension regarding the possible accuracy of maps. We hear of "perfect maps," as if such things could exist. We read of maximum allowable errors of maps and especially of the contours upon them. Every map, whatever its scale, is a reduction from nature, and is, therefore, in greater or less degree generalized and therefore departs from the original in greater or less degree. The smaller the scale, the higher the degree of generalization, and the farther must the map depart from nature the less can it resemble the ground which it represents. Bends in the streams, petty gulches, canyons and hills must be omitted. Contours must cross such omitted gulches, instead of turning up and down them. A searching examination of the map would therefore show countless places where, owing simply to this generalization, the contours are widely out of place. To specify, therefore, that the contours of a map must nowhere be in error more than a contour interval for instance, is to require an impossibility.

The education of the topographer, therefore, consists of two parts: the mathematical and the artistic. The first may be acquired largely from books, and this book knowledge must be supplemented by practice in the field. The second, if not inherited, can be acquired only by long experience in the field, and by many can be acquired only imperfectly. In fact, the sketching makes the map, and therefore the sketching should be executed by the best topographer in the party, usually its chief, whenever it is practicable to do so.

THE MAKING OF TOPOGRAPHIC MAPS.

Classification of Work.

The work involved in making a map whatever be its scale, usually comprises several operations, which may in practice be more or less distinct from one another. They are enumerated as follows:

First.—The location of the map upon the earth's surface, by means of astronomic observations.

Second.—The horizontal location of points.

This is usually of three grades of accuracy, primary triangulation, or primary traverse, in cases where triangulation is not feasible; secondary triangulation for the location of numerous points within the primary triangulation; and ordinary traverse, for the location of details.

Third.—The measurement of heights, which usually accompanies the horizontal location, and which may, similarly, be divided into three classes, in accordance with the degree of accuracy.

Fourth.—The sketching of the map.

Nearly all of the geometric work, *i. e.* the work of location, may be executed by five instruments:

Theodolites, of a powerful and compact form, used in the primary control.

Plane tables, with telescopic alidades of the best type, used for secondary triangulation and height measurements.

Plane tables, of crude, simple form, with ruler alidades, used for traversing and minor triangulation.

Odometers, stadia instruments and rods, chains and steel tapes, for measuring distance.

Aneroids, for the measurement of details of heights.

With these instruments nine-tenths of the work is done, and these instruments will be described in the proper places with such fullness of detail as seems necessary.

Other instruments, such as transits, surveyors' theodolites, compasses, wye levels, hand and Abney levels and mercurial barometers, are occasionally used. Most of these instruments, which are commonly figured and described in all works on surveying, are assumed to be well known to the readers of this work and will therefore receive no special attention.

Astronomic Determinations of Position.

The object of astronomic determinations of position is to locate the map upon the earth's surface. They are made also for the purpose of checking and correcting positions determined by primary triangulation and primary traverse.

With regard to the checking of the primary triangulation by astronomic determinations, it should be understood that in the case of a single determination the work by triangulation is far more accurate than by astronomic determinations, even when made under the best of circumstances. It is therefore desirable to introduce a check of this kind upon primary triangulation only when the latter has been carried for a long distance, 200 or 300 miles, for instance, in the course of which it may have accumulated errors greater than those incident to astronomic work.

The case is different with primary traverse. The great number of courses required in this work affords an opportunity for the accumulation of error much greater than is the case with triangulation, and consequently it is desirable to introduce more frequent checks in this work. It may be said that, in general, such work should be checked at every 100 miles.

As was suggested above, the best astronomic determinations are none too good for the control of maps. Indeed, certain errors incident to this work, some of which as yet cannot be corrected, may be of magnitude sufficient to show upon the scale of the map. It is necessary, therefore, in these determinations to use the best instruments and the most refined methods known to modern science, in order to reduce all avoidable errors to a minimum.

DEFINITIONS.

Sidereal time is the time indicated by the stars, a sidereal day being the time which elapses between two passages of the vernal equinox across the meridian. Solar or apparent time is the time measured by the sun's apparent movement or the revolution of the earth with reference to the sun, and since the earth revolves at a differing rate in different portions of its orbit, the solar days are not of equal length. A mean day is the average solar day; mean time differs from solar time by an amount which varies with the time of year, and which, under the name of "equation of time," is given in the Nautical Almanac. Mean time differs from sidereal time by about a day in the course of a year, or about four minutes in each day; the mean day being longer than the sidereal day. To convert a given date of mean time into sidereal time it is necessary to obtain, from the Nautical Almanac, the sidereal time at noon immediately preceding the date in question. Then the interval after noon, expressed in mean time, is converted into sidereal time, and the result added to the sidereal time of mean noon. Local time, whether sidereal, solar, or mean, is the time of the locality as distinguished from the time of any other locality. It must be distinguished from railroad time, which is the local time only of certain meridians.

The right ascension of the sun or a star is the sidereal time which has elapsed between the passage of the vernal equinox and the star across the meridian. It is commonly expressed in hours, minutes, and seconds.

Declination is the angular distance of a heavenly body north or south of the equator. It is plus when north and minus when south of the equator.

The zenith distance of a heavenly body equals its declination, minus the latitude of the place of observation.

Latitude is determined by what is known as Talcott's method, by measuring the differences of zenith distance at culmination of two stars which culminate on opposite sides of the zenith.

Longitude is determined by telegraphic comparison of local time at two stations, the longitude of one of which is known. This involves the determination of the errors of the clocks or chronometers used, which is done by observation of transits of stars across the meridians of the places of observation.

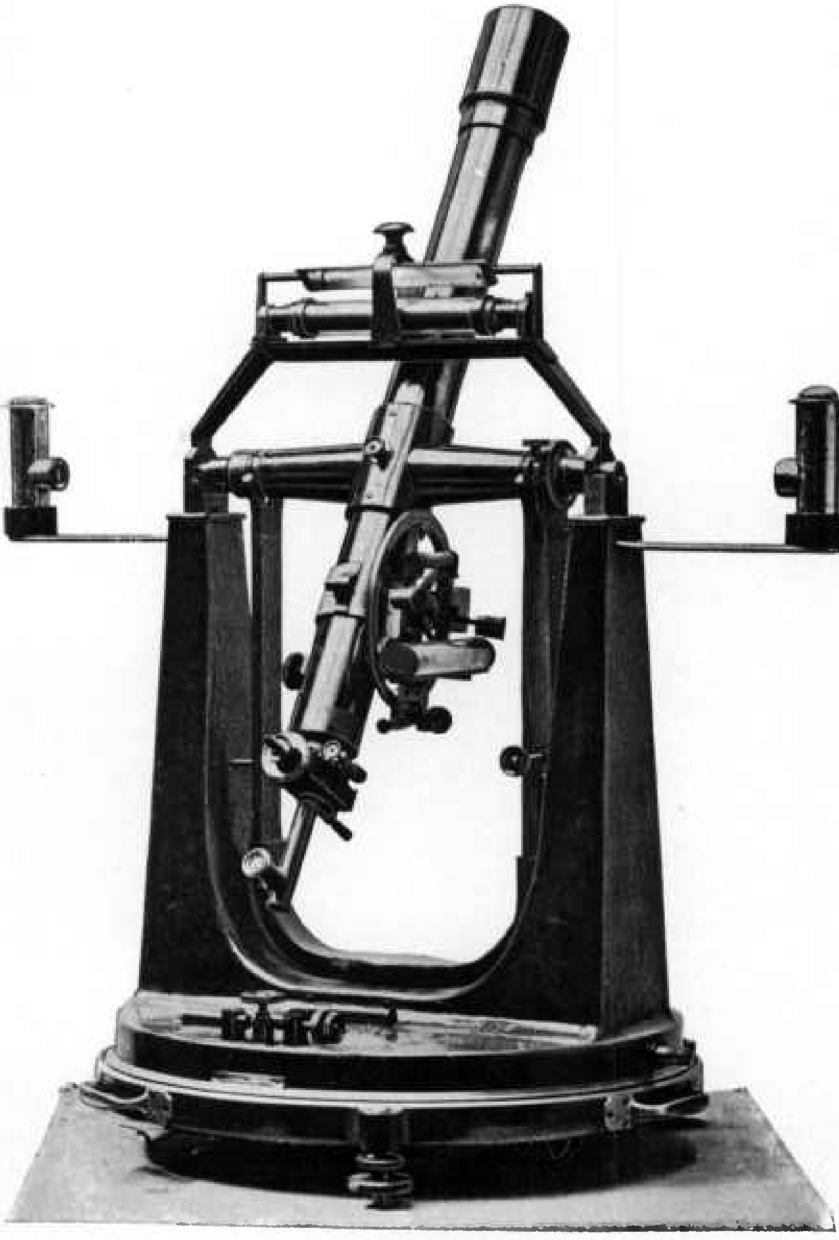
ASTRONOMICAL TRANSIT AND ZENITH TELESCOPE.

A single instrument is often used for the determination both of latitude and time. This is a combination of the transit and zenith telescope. The instruments in use upon the Geological Survey were made by Saegmuller and embody the latest improvements in these combined instruments. One of them is figured herewith. The circular base rests upon three leveling screws. Upon this circular base the whole instrument can be made to revolve when using it as a zenith telescope. A circle is graduated around the base, having a micrometer screw for slow motion, for making settings and adjusting the instrument in azimuth. The frame of the instrument is cast in one piece, and the standards are hollow in order to reduce the weight of the upper part of the instrument. The telescope has a focal distance of 27 inches and a clear aperture of 2.5 inches. Its magnifying power with diagonal eyepiece is 74 diameters. The length of the axis of the telescope is 16 inches. For use as a zenith telescope, the instrument is equipped with a vertical circle reading by vernier to 20 seconds, attached to which is a delicate level. In the focus of the object-glass there is, besides the ordinary reticule for use in transit work, a movable thread, which is moved by means of a micrometer screw, by which measurements of differences of zenith distances are made. It is furnished with direct diagonal eyepieces, the latter of which is commonly used in astronomical work.

For use as a transit instrument, the telescope is equipped with a delicate striding level for measuring the inclination of the pivots, and a reversing apparatus for turning the telescope in the wyes. The reticule, as the stationary threads in the focus of the instrument are called, consists of five threads for observing the transits of stars. The reticule is illuminated by means of bull's-eye lamps, the light from which comes through the hollow axis of the telescope and is reflected by a mirror placed at the intersection of the telescope with its axis.

CHRONOGRAPH.

The chronograph is used for the purpose of recording the time of transits of stars as observed with the transit instrument. It may be popularly characterized as an instrument for measuring time by the yard. It consists essentially of a drum, upon which is wound a strip of paper, and which is kept in revolution by a train of clockwork controlled by an escapement. A pen carried upon a small car, which is moved very slowly in a direction parallel to the axis of the cylinder, traces a spiral line upon the paper on the drum. This pen is held in place by a magnet, which is carried upon the car, and as long as the current from the battery passes through the coil and thus holds the armature the pen traces an unbroken spiral line. If the current is suddenly broken and restored, the armature is set free for an instant and a jog is made in the line traced. The battery commonly used in connection with this outfit is the ordinary zinc, copper, and sulphate of copper battery, of which four cells are usually required. The ordinary dry battery can also be used and is much more convenient. With this apparatus break-circuit chronometers are used. These differ from ordinary chronometers in the fact that they are arranged to break an electric circuit automatically at regular intervals, commonly breaking the circuit every two seconds, and the end of the minute is indicated by breaking at the fifty-ninth as well as the fifty-eighth and sixtieth seconds. When one of these chronometers is connected with a battery and a chronograph is put in the same circuit, the beginning of every even second is recorded upon the chronograph by a jog on the paper, and the distance between the jogs in each case represents, therefore, two seconds. The observer at the instrument is provided with a telegraph key, which may also be put in the circuit with the



ASTRONOMICAL TRANSIT AND ZENITH TELESCOPE.

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chronometer and chronograph, and as a star near the meridian crosses a thread in the telescope he records that fact by pressing on the key, which makes a record upon the chronograph along with the record of the chronometer.

FIELD WORK.

Since the observations for latitude and longitude, though different, are made with the same instrument, at the same time, and by the same party, certain parts of the work apply equally to both determinations and may be described once for all.

In the selection of a station, care must be taken to avoid a locality where, for any cause, the ground is liable to be seriously jarred, as, for instance, proximity to a railroad track or to a street over which heavy wagons pass. It should have a clear view from the southern horizon through the zenith to the northern horizon. It is desirable to locate at a convenient distance from a telegraph station, as it is necessary to bring a wire in from such station for the purpose of comparing chronometers. If possible, the station should be selected upon a public reservation, in order that the permanence of the monument marking the spot, which is to be erected, may be assured. But, in any event, one should avoid a locality in which such a monument is likely to be disturbed.

The support of the instrument should consist of a brick pier sunken fully three feet in the ground and rising above it to the requisite height. Upon this should be placed for the immediate support of the instrument, a block of stone well set in mortar. The chronograph may be set up on an ordinary table. Over all should be erected a wall tent with a slit closed by flaps in the roof, which can be opened when observing. The instrument is set up upon the pier, collimated, leveled, and the verticality of the threads tested as accurately as possible, and is then pointed upon the pole star. This places it somewhere near the meridian. Then taking the time of transit of a star which culminates close to the zenith, and comparing this time with the right ascension of the star, a sufficiently close approximation to the clock error is obtained for use in placing the instrument in the meridian. The instrument is then turned in azimuth to point upon some close circumpolar star approaching upper or lower culmination, moving the instrument in azimuth with the tangent screw so as to keep the star under the middle wire up to the instant of culmination. If this is done accurately at the first attempt, the instrument is placed nearly in the meridian and is ready for work, but it commonly happens that more than one trial is required before the meridian is reached. In any case, the result should be verified by a second star, before proceeding with the observations.

OBSERVATIONS FOR LATITUDE.

As preliminary to this work it is necessary to prepare a list of pairs of stars, the two stars of each pair having such zenith distances that they will culminate at nearly equal distances from the zenith, one to the north and the other to the south of it. Such a list can be prepared from the Safford Catalogue of the Wheeler Survey. For this it is necessary to know the approximate latitude of the station, the right ascensions and the declinations of the stars. The zenith distance of a star is equal to its declination, minus the latitude of the place. The stars of each pair should culminate within a few minutes of one another. They must be observed consecutively, and, therefore, those stars should be selected which culminate as nearly as possible together, leaving only a sufficient interval of time between them for setting the instrument.

Before beginning to observe, the instrument should be closely collimated and drawn into the meridian.

Upon the approach of the first star of the pair to the meridian, the instrument should be set for it, using the vertical circle for that purpose, and setting the spirit level upon the vertical circle as nearly level as possible. Then, as the star traverses the field of the telescope, keep the movable thread in the reticule upon it by means of the micrometer screw until it crosses the middle verticle thread. Then read and record the micrometer and the two ends of the level bubble. Without disturbing in the slightest degree the setting of the telescope, turn the entire instrument 180° upon its bed plate, when it will point north of the zenith, at the same angle that it formerly pointed south, or vice versa, as the case may be, and will be set for the other star upon the opposite side of the zenith. As this approaches culmination, follow it with the micrometer as before, until it reaches the middle thread;

then record as before the readings of the micrometer and of the level, whether it has changed or not.

This constitutes the observations upon a single pair of stars. For the determination of latitude twenty such pairs of stars should be observed each evening, if possible, and the same pairs of stars should, also assuming it to be possible, be observed upon other evenings. The following example, taken from observations at Rapid, South Dakota, shows a portion of the star list and the form of record:

LATITUDE DETERMINATION.

List of Stars, for Observation with Zenith Telescope.

[Station: Rapid, South Dakota. Approximate Latitude: 44° 05′.]

Name or number. Safford's Catalogue.	Mag.	Class.	R. A.	Dec.	Zen. dist.	Setting.
			h. m.			° ′
7 Lacertæ.....	4. 0	A A	22 27	49° 43′	5° 38′ N.	5 37 N.
10 Lacertæ....	5. 0	A A	22 34	38 29	5 36 S.	
1539............	6. 5	B	22 41	45 37	1 32 N.	1 27 N.
1551............	6. 5	A	22 47	42 42	1 23 S.	
1565............	6. 5	C	22 52	38 42	5 23 S.	5 22 S.
1579............	5. 0	A	22 59	49 26	5 21 N.	
1600............	6. 0	A	23 08	56 34	12 29 N.	12 19 N.
1633............	6. 7	B	23 18	31 56	12 09 S.	
1676............	5. 6	A	23 42	67 12	23 07 N.	23 05 N.
1686............	6. 5	A	23 47	21 03	23 02 S.	
1702............	4. 5	A	23 52	24 32	19 33 S.	19 31 S.
1722............	6. 5	B	24 00	63 35	19 30 N.	

Example of Record.

[Station: Rapid, South Dakota. Date: November 9, 1890. Instrument: Fauth combined transit and zenith telescope No. 534. Observer: S. S. G. Recorder: A. F. D.]

Star name or number.	N. or S.	Micrometer reading.	Diff.	Level. N.	Level. S.	(N+S) —(N′+S′)	Remarks.
		Rev.	*Rev.*	*Div.*	*Div.*	*Div.*	
7 Lacertæ.....	N.	26. 256		39. 9	16. 7	+56. 6	
10 Lacertæ....	S.	24. 052	—2. 204	26. 5	49. 7	—76. 2	
						—19. 6	
1539............	N.	30. 432		42. 0	18. 7	+60. 7	
1551............	S.	20. 095	—10. 337	21. 9	45. 0	—66. 9	
						— 6. 2	
1565............	S.	25. 164		14. 1	37. 6	—51. 7	Faint.
1579............	N.	26. 703	+1. 539	38. 1	15. 0	+53. 1	Distinct.
						+ 1. 4	
1600............	N.	32. 214		37. 5	14. 1	+51. 6	
1633............	S.	16. 033	—16. 181	19. 9	43. 1	—63. 0	Faint.
						—11. 4	
1676............	N.	26. 656		51. 0	28. 0	+79. 0	
1686............	S.	17. 684	—8. 972	17. 0	39. 6	—56. 6	
						—22. 4	
1702............	S.	25. 345		18. 0	40. 9	—58. 9	
1722............	N.	23. 722	+1. 623	36. 0	13. 2	+49. 2	
						— 9. 7	

REDUCTION OF LATITUDE OBSERVATIONS.

Before proceeding with the reduction of latitude observations, it is necessary to investigate the constants of the instrument, to ascertain the value of a division of the latitude level, and of a division of the head of the micrometer screw.

The value of a division of the head of the micrometer screw is measured by observing the transits of some close circumpolar star, when near elongation, across the movable thread, setting the thread repeatedly at regular intervals in advance of the star, and taking the time of its passage, with the reading of the micrometer. The precaution should be taken to read the latitude level occasionally and correct for it if necessary. This correction, which is to be applied to the observed time, is equal to one division of the level, in seconds of time, divided by the cosine of the declination of the star and multiplied by the level error, the average level reading being taken as the standard.

The time from elongation of the star requires a correction in order to reduce the curve in which the star apparently travels to a vertical line. The hour angle of the star is first obtained from the equation,

$$\cos t_0 = \cot \delta \tan \varphi ,$$

δ being the star's declination and φ the latitude.

The chronometer time of elongation, $T_0 = \alpha - t_0 - \delta t$, α being the right ascension of the star obtained from the Nautical Almanac, δt the error of the chronometer.

Having thus obtained the chronometric time of elongation, the correction in question is obtained from the observed interval of time of each observation before or after elongation, from tables in Appendix No. 14, U. S. Coast and Geodetic Survey Report for 1880, pp. 58 and 59. A discussion of this subject will be found in the appendix above referred to, and in Chauvenet's Practical Astronomy, vol. II, pp. 360 to 364.

The times of observation thus corrected for level, and distance from elongation, are then grouped in pairs, selected as being a certain number of revolutions of the micrometer apart, and the time intervals between the members of each pair obtained. The mean of these, divided by the sum of revolutions which separate the members of each pair, is yet to be corrected for differential refraction, which is derived from the following equation:

$$\text{Ref.} = 57''.7 \sin R \sec^2 Z.$$

R being the value of a division of the micrometer and Z the zenith distance of the star. Four-place logarithms are sufficient for computing this correction, as it is small. Below is given an example of record and computation of the value of a revolution of the micrometer.

Determination of value of one revolution of micrometer belonging to Z. T. No. 534, by observations on 51 Cephei near eastern elongation, November 15, 1890, Rapid City, South Dakota.

log. cot. δ....87° 12′ 50′′.8 = 8.6871826
log. tan Φ....44 04 45 = 9.9860380

log. cos. t_o...87 17 57 = 8.6732206

log. 1 div..............= 1.33 = 0.12385
A. C. log. cos. δ.............= 1.31334
A. C. log. 15..................= 8.82391

log. 1.82 s.....................= 0.26110

	h	m	s
t_o =	5	49	11.8
α =	6	49	20.4
T_o =	1	00	08.6
Δt =			−8.0
chron. time elong. =	1	00	00.6

Time of observation (recorded on chronograph sheet).	Micrometer revolutions.	Level. N.	Level. S.	Level. N + S.	Reduction to mean level.	Correction for change of level.	Time from elongation. = t.	Correction for t.	Reduced time.	Revolutions.	Time for nine revolutions.
h. m. s.		*Div.*	*Div.*	*Div.*	*Div. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*		*m. s.*
00 40 19.7	31.0	37.0	16.0	53.0	+ 0.8 × 1.82 =	+ 1.5	−19 40.9	+1.4	00 40 22.6	31.0 and 22.0	15 37.7
41 12.3	30.5					+ 1.3	18 48.3	+1.3	41 14.9	30.5 21.5	36.6
(lost on chronograph sheet.)	30.0	37.1	16.1	53.2	+0.6	+1.1				29.5 20.5	34.4
42 53.7	29.5					+0.8	17 06.9	+0.9	42 55.4	29.0 20.0	39.2
43 44.6	29.0					+0.5	16 16.0	+0.8	43 45.9	28.5 19.5	40.2
44 35.9	28.5					+0.3	15 24.7	+0.7	44 36.9	28.0 19.0	36.9
45 31.9	28.0					+0.0	14 28.7	+0.5	45 32.4	26.5 17.5	36.8
(missed)	27.5					−0.3				26.0 17.0	37.5
(missed)	27.0					−0.5				25.5 16.5	36.2
48 08.0	26.5					−0.8	11 52.6	+0.3	48 07.5	25.0 16.0	29.6
48 57.1	26.0	38.3	17.5	55.8	−0.6	−1.1	11 03.5	+0.2	48 56.2	24.5 15.5	33.1
49 50.2	25.5					−1.1	10 10.4	+0.2	49 49.3	23.5 14.5	36.5
50 47.0	25.0					−1.0	9 13.6	+0.1	50 46.1	23.0 14.0	31.3
51 42.3	24.5					−1.0	8 18.3	+0.1	51 41.4	22.5 13.5	35.2
(missed)	24.0					−0.9					15 35.80 = mean.
53 22.4	23.5	38.3	17.3	55.6	−0.5	−0.9	6 38.2	+0.1	53 21.6		
54 18.8	23.0					−0.9	5 41.8	+0.0	54 17.9		
55 07.1	22.5					−0.9	4 53.5	0.0	55 06.2		
56 01.2	22.0					−0.9	3 59.4	0.0	56 00.3		
56 52.4	21.5	38.3	17.3	55.6	−0.5	−0.9	3 08.5	0.0	56 51.5		
57 41.2	21.0					−0.9	2 19.4	0.0	57 40.3		
58 30.7	20.5					−0.9	1 29.9	0.0	58 29.8		
59 25.9	20.0					−0.8	−0 34.7	+0.0	59 25.1		
1 00 17.9	19.5					−0.8	+0 17.3	−0.0	1 00 17.1		
01 10.0	19.0					−0.7	1 09.4	0.0	01 09.3		
(missed)	18.5					−0.6		0.0			
02 52.8	18.0					−0.6	2 52.2	0.0	02 52.2		
03 44.8	17.5	38.0	17.0	55.0	− 0.3	− 0.5	3 44.2	0.0	03 44.3		
04 34.2	17.0					−0.5	4 33.6	0.0	04 33.7		
05 25.9	16.5					−0.4	5 25.3	0.0	05 25.5		
06 16.0	16.0					−0.3	6 15.4	0.0	06 15.7		
07 14.8	15.5					−0.2	7 14.2	−0.1	07 14.5		
08 05.1	15.0					−0.1	8 04.5	−0.1	08 04.9		
08 58.2	14.5	37.8	16.8	54.6	−0.0	−0.0	8 57.6	−0.1	08 58.1		
09 49.1	14.0					+0.3	9 48.5	−0.2	09 49.2		
10 41.0	13.5					+0.6	10 40.4	−0.2	10 41.4		
11 35.0	13.0	37.2	16.2	53.4	+ 0.5	+0.9	11 34.4	−0.3	11 35.6		
Mean level ...				=54.5							

log ....935.80 s. = 2.97118
log. cos. δ.......... 8.68666
log. 15.............. 1.17659
A. C. log. 9.... ... 9.04576

log. *R*......75′′.804 = 1.87969
Refraction.− .044

1 revolut'n. = 75.760

DIFF. REFRACTION.

log...................57′′.7 = 1.7612
log. sin..............75 .8 = 6.5652
log. sec. z........... 0.1568
log. sec. z........... 0.1568

Diff. refr.....= ′′.044 log. = 8.6400

The value of a division of the level is commonly measured with a level trier. The latitude level may, however, be easily measured by means of the micrometer, the value of a revolution of that being obtained by the following method:

Point the telescope upon some well-defined terrestrial mark and set the level at an extreme reading near one end of the tube. Set the movable thread upon the object and read the micrometer and the level.

Now move the telescope and level, until the bubble is near the other end of the tube. Again set the movable thread upon the object and again read both micrometer and level. It is evident that the micrometer and the level have measured the same angle, and that the ratio between these readings equals that between a revolution of the micrometer and a level division.

An example illustrative of this is appended.

Determination of value of 1 *division of latitude level No.* 534.

[By comparison with micrometer screw 534.]

Micrometer.	Level.		Difference.		aa.	ab.
	N.	S.	Microm.	Level.		
r.	*d.*	*d.*	*b.*	*a.*		
8. 025	47. 3	29. 2	*d.*	*d.*		
8. 508	20. 7	02. 7	48. 3	26. 55	704. 9	1283.
8. 509	18. 9	01. 0				
7. 984	49. 8	31. 0	52. 5	30. 45	927. 2	1599.
8. 511	18. 5	00. 6				
8. 045	47. 2	29. 1	46. 6	28. 60	818. 0	1333.
9. 076	18. 7	00. 8				
8. 604	46. 0	28. 0	47. 2	27. 25	742. 6	1286.
9. 442	23. 7	06. 0				
9. 009	48. 0	30. 0	43. 3	24. 15	583. 2	1046.
10. 055	21. 8	04. 0				
9. 574	48. 0	30. 1	48. 1	26. 15	683. 8	1258.
10. 661	24. 0	06. 1				
10. 212	50. 7	33. 0	44. 9	26. 80	718. 2	1203.
11. 771	18. 3	00. 7				
11. 252	48. 3	31. 9	51. 9	30. 60	936. 4	1588.
12. 328	20. 0	02. 3				
11. 872	46. 1	28. 5	45. 6	26. 15	683. 8	1192.
12. 869	22. 2	04. 6				
12. 438	47. 7	30. 0	43. 1	25. 45	647. 7	1097.
13. 468	23. 0	05. 3				
13. 080	44. 5	26. 9	38. 8	21. 55	464. 4	836.
14. 146	20. 1	02. 4				
13. 702	45. 4	27. 8	44. 4	25. 35	642. 6	1125.
14. 758	22. 3	04. 8				
14. 282	48. 6	31. 0	47. 6	26. 25	689. 1	1249.
Sum.	......	......	......	......	9241. 9	16095.

log............................16095. = 4.20669.
A. C. log......................9241.9 = 6.03424.
log 1 Div. Micrometer............ = 9.87966.
1 Div. level............=1″.320 log. = 0.12059.

Following the determination of the constants of the instrument used, the next step is to obtain the apparent declinations of the stars used. Whenever possible, these should be taken from the Nautical Almanac or the Berliner Jahrbuch. In other cases they must be computed. The positions of stars are given in Safford's Catalogue, for the epoch 1875.0, together with the annual precession and proper motion. The declinations there given should be revised by the aid of more recent catalogues, particularly with reference to stars of class C. The annual precession and proper motion multiplied by the number of years which have elapsed and applied, together with the effect of secular variation in precession, give the declination at the beginning of the year. Further corrections to bring the positions down to the date of observation are expressed by the symbols A*a′*, B*b′*, C*c′*, D*d′*. Logarithms of *a′*, *b′*, *c′*, *d′* are given in Safford's Catalogue, and A, B, C, and D are given in the Nautical Almanac. A slight additional correction, also, is to be made for proper motion, for the elapsed portion of the year. This reduction is illustrated below.

LATITUDE DETERMINATION.

Example of reduction. Computation of apparent declination of star 1539.

[From Safford's Catalogue, p. 40.]

Star No. 1539	Declination 1875.0 ° ′ ″	Annual precession. ″	Proper motion. ″
	45 33 29.20	+ 18.87	—.03

	°	′	″	
Yr. (1890–1875). × 18.87″ =		+ 4	43.05	= Precession for 15 years.
15 × —.03″ =		— 0	00.45	= Proper motion for 15 years.
		+ 0	00.07	= Secular variation in precession.
=	45	38	11.87	= Declination 1890.
			+ 9.38	= Aa′
			— 0.78	= Bb′
			+ 6.88	= Cc′
			+10.16	= Dd′
			— 0.03	= Proper motion, Jan. 1—Nov. 9, 1890.
	45	38	37.48	= Declination Nov. 9, 1890.

	log a′ = 1.2757	log b′ = 9.5294	log c′ = 9.7367	log d′ = 9.8273.
Nov. 9.	log A = 9.6966	log B = 0.3649$_n$	log C = 1.1006	log D = 1.1796.
	0.9723	9.8943$_n$	0.8373	1.0068.
	Aa′ = + 9.38″	Bb = — 0.78″	Cc′ = + 6.88″	Dd′ = + 10.16″.

With all this preliminary work done, the reduction proper of latitude observations is comparatively a simple matter. Grouping the observations by pairs, the mean declination of each pair is obtained, the corrections for difference of micrometer readings and levels are applied, with a small correction for differential refraction, and the result is the desired latitude.

Following is an example of the reduction of six pairs of stars observed for latitude at Rapid, South Dakota:

LATITUDE DETERMINATION.

Example of Reduction:

[Station: Rapid, South Dakota. November 9, 1890. Half Rev. Micrometer=37.900.″

[One Div. Level=1.83.″]

Date.	Star numbers.	δ_1	δ_2	½($\delta_1+\delta_2$.)	Corrections.			Latitude n.	Weight p.	p. n.
					Microm.	Level.	Refr.			
		° ′ ″	° ′ ″	° ′ ″	′ ″	″	″	° ′ ″		″
Nov. 9.	7 Lacert and 10 Lacert.	49 42 87.33	38 29 04.60	44 06 15.97	− 1 23.53	−6.51	−.03	44 04 45.90	.98	5.78
	1539 1551	45 38 37 48	42 44 04.63	11 21.06	− 6 31.77	−2.06	−.11	47.12	.90	6.41
	1565 1579	38 43 39.78	49 27 41.04	05 40.41	− 0 58 33	+0.46	−.03	42.51	.79	1.98
	1600 1633	56 34 06.66	31 55 56 91	15 01.78	−10 13.25	−3.78	−.19	44.56	.90	4.10
	1676 1686	67 12 10.93	21 03 54 02	08 02.48	− 3 08.43	−7.44	−.07	46.54	.93	6.08
	1702 1722	24 32 09.04	63 35 27 34	03 48 19	+ 1 01.51	−3.22	+.02	46.50	.90	5.85
									5.40	30.20

November 9. Weighted mean=44° 04′ 45.59″

OBSERVATIONS FOR TIME.

With the transit mounted, leveled, and adjusted in the meridian, the chronograph set up and running and connected in a circuit with the battery, and the chronometer and observing key connected in the same circuit the observer is prepared to begin time observations.

The list of stars which should be used is that given in the Berliner Jahrbuch as the list is fuller and more accurate than that in any other catalogue which gives day places. Stars should be so selected north and south of the zenith that the azimuth errors will balance one another as nearly as possible, as is explained hereafter. On the approach of the selected star to the meridian, the telescope is set by means of the vertical circle upon the altitude of the star above the horizon, deduced from the declination and the latitude. As the star crosses each thread in the reticule, the fact is recorded by pressing the observing key, which produces, as described above, a record upon the chronograph sheet. In this way four time stars, as stars between the equator and zenith are designated, and one circumpolar star, or a star so near the pole that it is constantly in sight, should be observed. Then the telescope should be reversed in the wyes and a similar set of stars observed. Between observations upon any two stars the striding level should be placed upon the pivots of the instrument and readings taken to ascertain the departure of the axis from a horizontal position.

In order to avoid unequal expansion of the pivots from unequal heating, both bull's-eye lamps must be lighted and placed in their stands, in order that both pivots may be equally heated.

After the comparison of chronometers at the two stations, to be hereafter described, a similar set of stars should be observed, if possible.

REDUCTION OF TIME OBSERVATIONS.

Certain constants of the transits should be measured before proceeding with the reduction of time observations. The value of a division of the striding level should be measured by means of a level trier. The equatorial interval of time between each of the threads and the mean of all the threads should be obtained, as it is not infrequently needed in utilizing broken or imperfect observations. These can best be obtained from observations on slow moving stars, but any stars may be used for the purpose. The intervals as observed, are reduced to the equator by multiplying them by the cosine of the declination of the star observed.

The object of these observations is specifically the determination of the error of the chronometer. This error equals the right ascension of a star minus its observed time of transit, corrected for certain instrumental errors. These errors are as follows:

CORRECTION FOR ERROR OF LEVEL.

The level error, designated by b, is ascertained from the readings of the striding level. The value of a division of the level in seconds of time must have been previously ascertained by means of a level trier. The effect of the level error is greatest at the zenith and diminishes to zero at the horizon. The correction in seconds is given by the following equation:

$$\text{Cor.} = b \cos(\varphi - \delta) \sec \delta = b\text{B}.$$

When the declination is north, it is to be regarded as having a plus sign for upper and a minus sign for lower culmination. When south it is negative.

CORRECTION FOR INEQUALITY OF PIVOTS.

This correction can be made a part of the level correction.

Let p = the inequality of pivots.
B = inclination of axis given by level for clamp west.
B′ = inclination of axis given by level for clamp east.
b = true inclination of axis for clamp west.
b' = true inclination of axis for clamp east.

then $p = \dfrac{\text{B}' - \text{B}}{4}$

$b = \text{B} + p$ for clamp west.
$b' = \text{B}' - p$ for clamp east.

(Chauvenet, Vol II, p. 155.)

CORRECTION FOR ERROR OF COLLIMATION.

This correction, designated by c, is the departure of the mean of the threads from the optical axis of the telescope. For stars at upper culmination with clamp west it is plus when the mean of the threads is east of the axis, and minus when it is west of it. For stars at lower culmination the reverse is the case. The value of c is one-half the difference between the clock error indicated by stars observed before and after reversal of the instrument, divided by the mean secant of the declinations of the stars. This is slightly complicated with the azimuth, although the effect of that is largely eliminated by the proper selection of stars. Consequently it is to be obtained by approximations, in conjunction with the azimuth errors. The correction to be applied to each star equals $c \sec \delta = c\text{C}$, which is plus for a star at upper culmination and minus for a star at lower culmination. It is least for equatorial stars and increases with the secant of the declination.

Y-LEVEL.

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CORRECTION FOR DEVIATION IN AZIMUTH.

This correction, designated by a, represents the error in the setting of the instrument in the meridian. Its effect is zero at the zenith and increases toward the horizon. Since the instrument is liable to be disturbed during the operation of reversal, it is necessary to determine the azimuth error, both before and after reversal, separately. A comparison of the clock error, determined from observations upon north and south stars, will furnish the data necessary for the determination of azimuth. Practically, it is determined by elimination from equations involving the mean of all these stars observed in each of the two positions of the instrument, after correcting for level, and as it is slightly complicated with collimation it must be reached by two or more approximations. The error is essentially positive when the telescope points east of south, and negative when west of south. The correction applicable to any star is expressed in the following equation:

$$\text{Cor.} = a \sin (\varphi - \delta) \sec \delta = aA \,.$$

It must be understood that the declination when north is positive for upper and negative for lower culmination, and that with south declination it is negative.

CORRECTION FOR DIURNAL ABERRATION.

The right ascension of stars, as taken from the Berliner Jahrbuch, must be corrected for diurnal aberration, which equals $0^s.021 \cos \varphi \sec \delta$. This correction is positive for upper and negative for lower culmination.

These corrections are summarized in the following equation:

$$\Delta t = \alpha - (t + aA + bB + cC).$$

A, B, C, as seen above, are constants, depending upon the latitude of the place of observation and the declination of the star. Tables for these quantities will be found in an appendix to Annual Report U. S. Coast and Geodetic Survey for 1874.

The following is an example of the form for record of observation and reduction of time observations, taken from a campaign for the determination of position of Rapid, South Dakota.

LONGITUDE DETERMINATION.

Example of Reduction.

[Rapid, South Dakota, November 20, 1890. After exchange of clock signals.]

Clamp.	1.	2. Star.	3. A.	4. C.	5. α—t	6. Cc.	7. α—t Corrected for Cc.	8. Aaw.	9. Corrected for Aaw.	10. Cc′.	11.	12. Aa′w.	13.	V.	t.
	Wt Δt				s.	s. c=−.019 s.	s.	s.	s.	s. C′+.015 s.	s.		s.	s.	h.
W.	1	γ Cephei........	−2.42	+4.45	− 35.70	−.08	−35.78	−1.00	−36.78	+.07	−36.71	−.05	−36.76	.00	23.58
	1	φ Pegasi........	+0.45	1.05	36.90	−.02	36.92	+0.19	.73	.01	.73	+.01	.71	−.05	.78
	1	ω Piscium......	+0.62	1.01	37.03	−.02	37.05	+0.26	.79	.02	.77	+.01	.76	.00	.89
	1	33 Piscium......	+0.77	1.01	37.13	−.02	37.15	+0.32	.83	.01	.82	+.02	.80	+.04	.99
	1	α Androm.......	+0.30	+1.14	− 36.90	− .02	−36.92	+0.12	−36.80	+.02	.78	+.01	.77	+.01	24.01
		Sum.....=	+2.14	....	....	....	....	....	....	....	....	....	3.80		
		Sum.....=	−2.42	+8.66	−183.66	....	....	....	3.93						
	(1)	Mean....=	−0 06 Aw	+1.73c	− 36.732	....	....	....	−36.786	....	....	....	−36.760		
								Aa.				Aa′w.			
E.	1	γ Pegasi.........	+0.51	−1.03	− 36.90	+.02	−36.88	+0.15	−36.73	−.01	−36.74	−.01	−36.75	−.01	24.13
	1	Bradley 6........	−2.26	4.23	36.17	.08	36.09	− .64	.73	.06	.79	+.03	.76	.00	.17
	1	ι Ceti............	+0.81	1.01	36.99	.02	36.97	+ .23	.74	.02	.76	−.01	.77	+.01	.23
	1	44 Piscium......	+0.68	1.00	36.89	.02	36.87	+ .19	.68	.01	.69	−.01	.70	−.06	.33
	1	12 Ceti	+0.75	−1.00	− 37.03	+.02	−37.01	+ .21	−36.80	−.02	.82	−.01	.83	+.07	.41
		Sum.....=	+2.75	....	....	....	....	....	....	....	....	....	03.81		
		Sum.....=	−2.26	−8.27	−183.98	....	....	....	3.68	....	....	....	....	Mean	=24.05
	(2)	Mean....=	+0.10 Ae	−1.65c	− 36.796	....	....	....	−36.736	....	....	....	−36.72		

Subtracting (2) from (1), ignoring azimuth terms which are small, we have:

$$+3.38c + \overset{s.}{.064} = 0$$

Approx......$c = \overset{s.}{-.019}$

From below $c' = +.015$ Adopted..$c = \overset{s.}{-.004}$

$$-2.42\ Aw - \overset{s.}{35.78} = 0 \qquad -2.26\ Ae - \overset{s.}{36.09} = 0$$
$$+0.54 \qquad -37.01 = 0 \qquad +0.69 \qquad -36.93 = 0$$

$$+296\ Aw - \overset{s.}{1.23} = 0 \qquad +2.95\ Ae - \overset{s.}{0.84} = 0$$

$$Aw = \overset{s.}{+.415} \qquad Ae = \overset{s.}{+.285}$$

Forming equations to determine c′ from columns 4 and 9:

$$+1.73c' - \overset{s.}{36.786} = 0$$
$$-1.65 \quad -36.736 = 0$$

$$+3.38c' - \overset{s.}{0.050} = 0$$

$$c' = \overset{s.}{+.015}$$

Forming equations from columns 3 and 11

$$-2.42\ A'w - \overset{s.}{36.710} = 0 \qquad -2.26\ A'e - \overset{s.}{36.790} = 0$$
$$+0.54\ A'w - 36.772 = 0 \qquad +0.69 \quad -36.752 = 0$$

$$+2.96\ A'w - \overset{s.}{0.062} = 0 \qquad +2.95\ A'e + \overset{s.}{0.038} = 0$$

$$A'w = \overset{s.}{+.021} \qquad A'e = \overset{s.}{-.013}$$
$$Aw = +.415 \qquad Ae = +.285$$

Adopted. $Aw = \overset{s.}{+.436}$ Adopted. $Ae = \overset{s.}{+.272}$
Adopted...$C = -.004$

Normal equation, formed from columns 1, 3, 4, and 5

$$10\Delta t - .28Aw + .49Ac + 39c + \overset{s.}{367.64} = 0$$

$$\Delta t - .028Aw + .049Ae + .039c + \overset{s.}{36.764} = 0$$

$$\Delta t = \overset{s.}{-36.76} \text{ at } \overset{h.}{24.05}$$

$$\alpha - t = \overset{s}{-36.764}$$
$$-.028 \times \overset{s.}{+.436} = -.012$$
$$+.049 \times \overset{s.}{+.272} = +.013$$
$$+.039 \times \overset{s.}{-.004} = -.000$$
$$\Delta t = -36.763$$

Time Determination: Example of Record.

[Rapid, South Dakota, November 20, 1890. Fauth transit, No. 584. Sidereal chronometer: Bond & Sons, No. 187 1 division of level = $0^s.118$. Hourly rate of chronometer = $0^s.133$.]

Star	γ Cephei.	φ Pegasi.	ω Piscium.	33 Piscium.	α Androm.	
Clamp	W.	W.	W.	W.	W.	W.
Level	telescope north *W.* *Sum.* *E.* *d* *d* *d* 19.8 −88.1 68.3 68.2 +87.6 19.4	telescope south. *W.* *Sum.* *E.* *d* *d* *d* 68.0 +87.1 19.1 20.2 −89.2 69.0	telescope south. *W.* *Sum.* *E.* *d* *d* *d* 20.0 −89.5 69.5 68.8 +87.2 18.4	telescope south. *W.* *Sum.* *E.* *d* *d* *d* 68.2 +86.9 18.7 19.9 −89.4 69.5	telescope south. *W.* *Sum.* *E.* *d* *d* *d* 19.8 −89.3 69.5 68.3 +86.8 18.5	telescope north. *W.* *Sum.* *E.* *d* *d* *d* 19.7 −89.5 69.8 68.8 +87.3 18.5
Difference =	− 0.5	−2.1	−2.3	−2.5	−2.5	−2.2
	h. *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*	
Thread I	23 34 52.25	23 47 24.00	23 54 10.89	00 00 13.33	00 03 12.00	
II	35 11.40	28.55	14.88	17.96	16.83	
III	29.41	32.72	19.22	21.94	21.32	
IV	46.78	36.75	23.14	25.95	26.00	
V	36 05.00	41.09	27.20	29.83	30.85	
Sum	= 4.84	3.11	5.33	9.01	7.00	
Mean	23 35 28.97	23 47 32.62	23 54 19.07	00 00 21.80	00 03 21.40	
Aberration	−.07	−.02	−.02	−.02	−.02	
Correction for level	*b B* −.22	−.06	−.05	−.04	−.06	
Correction for rate	+.05	+.03	+.01	+.00	+.00	
Reduced transit	23 35 28.83	23 47 32.57	23 54 19.01	00 00 21.74	00 03 21.32	
Tabular R. A	23 34 53.13	46 55.67	53 41.98	23 59 44.61	00 02 44.42	
$a - t$ =	−35.70	−36.90	−37.03	−37.13	−36.90	

Mean of levels = $-\frac{2.02^{div.}}{4} \times .118^{s.} = -.0596^{s.} = b$. Inequality of pivots.. = $.00^{s.}$.

Star	γ Pegasi.	Br. 6.	ι Ceti.	44 Piscium.	12 Ceti.
Clamp	E.	E.	E.	E.	E.
Level	Telescope south. *W.* *Sum.* *E.* 19.2 −88.3 69.1 68.9 +87.8 18.9 *d* ...... −0.5	Telescope south. *W.* *Sum.* *E.* 68.7 +87.3 18.6 19.4 −88.7 69.3 *d* ...... −1.4	Telescope south. *W.* *Sum.* *E.* 19.2 −88.4 69.2 68.5 +86.7 18.2 *d* ...... − 1.7 ——	Telescope north. *W.* *Sum.* *E.* 68.9 +87.8 18.9 18.9 −87.9 69.0 *d* ...... − 0.1......	
	h. *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*	*h.* *m.* *s.*
Thread V	00 08 05.25	00 10 05.00	00 14 20.70	00 20 17.35	00 24 56.85
IV	09.30	22.81	24.68	20.84	25 00.73
III	13.54	39.30	28.52	24.93	05.37
II	17.65	56.90	32.90	29.16	09.15
I	22.00	11 15.49	37.23	33.42	13.07
Sum.=	7.74	.. 9.50	4.03	5.70	5.17
Mean	00 08 13.55	39.90	28.81	25.14	05.03
Correction for aberration	−.02	−.06	−.02	−.02	−.02
Correction for level....*b B* =	−.02	−.09	−.02	−.02	−.02
Correction for rate	−.02	−.02	−.03	−.04	−.05
Reduced transit..........*t* =	00 08 13.49	00 10 39.73	00 14 28.74	00 20 25.06	00 25 04.94
Tabular *R. A*..........*a* =	00 07 36.59	10 03.56	00 13 51.75	00 19 48.17	00 24 27.91
$a - t$ =	−36.90	−36.17	−36.99	−36.89	−37.03

Mean of levels = $-\frac{.925^{Div.}}{4} \times .181^{s.} = -.027^{s.} = b$. Inequality of pivots = $.00^{s.}$

COMPARISON OF TIME.

After time has been thus observed the chronometers at the two stations should be compared by telegraph.

Chronometers are compared in the following manner: The chronometer at one station being in circuit with the chronograph and recording upon it, the chronometer at the other station is switched into the general telegraphic circuit, by which it is brought to the first station and switched into the local circuit there, so that the two chronometers register upon the same chronograph, their beats being marked side by side by the same pen. After this has gone on for a minute or more the operation is reversed, the chronometer at the first station is switched into the telegraphic circuit and made to record upon the chronograph with the chronometer at the second station. Of course the observers are informed of the hour and minute at which the joint record upon the several chronographs begins.

This method constitutes what is known as the automatic exchange of signals.

The *arbitrary* exchange of signals is made as follows:

Each chronometer recording on its own chronograph as usual, and each local circuit being connected with the main-line circuit, the observer at one station breaks the circuit by means of the main-line talking-key, which break is recorded on the chronograph sheets at both stations. The breaks are repeated at every two seconds for at least one full minute. The operation is then reversed by the observer at the second station making the breaks which are recorded at both stations as before.

The differences of time between the chronometers at the two stations are read from the chronograph sheets at each station and corrected for error of the chronometers. The results from the two chronograph sheets will differ by an amount equal to twice the time occupied in transmission of signals. The mean of the two is therefore the approximate difference of longitude.

This result is yet to be corrected for personal equation, or the difference between the errors of observing of the two observers. Every observer has the habit of recording a transit a little too early or too late, the difference between two observers not infrequently being as great as a fourth of a second. To measure this difference, the observers usually meet, preferably at the known station, both before and after the campaign, and observe for time each with his own instrument, or with one similar in all respects to that used in the campaign. A comparison of the time determinations made by the two observers gives an approximation to the personal equation.

A better method, but one not always practicable, is for the observers, having completed half of the observations for time and longitude, to exchange stations for the remainder of the work. The mean of the results before and after exchange of stations will eliminate personal equation.

There is one error incident to this work which cannot be eliminated. This is the unequal attraction of gravity, or local attraction, or, as it is sometimes called, station error. The neighborhood of a mountain mass will attract the plumb line and deflect the spirit level to such an extent as to cause serious errors in astronomical determinations of latitude and time. The same result is frequently produced by a difference in density of the underlying strata of rock, so that station errors of magnitude often appear where they are not expected. Indeed, the station error cannot be predicted with any certainty, either as to amount or even direction.

The only practical method of even partially eliminating this error is to select a number of stations for astronomical location, under conditions as widely diverse as possible, connect them by triangulation, and by this means reduce all these astronomical determinations to one point, thus obtaining for this point a number of astronomical determinations each having a different station error. The mean of these gives for this point a position from which—in part, at least—station error has been eliminated, and this mean position can be transferred back by means of the triangulation to the several astronomical stations, thus giving each of them a position similarly comparatively free from station error.

OBSERVATIONS FOR AZIMUTH.

The initial direction from which the directions of other lines in primary triangulation and in primary traversing are computed is obtained by means of astronomic observations. Such observations should be taken not only upon the initial line, but at intervals throughout the work for its verification. Such intervals should not exceed in the primary triangulation 100 miles, and in primary traversing 10 to 20 miles.

Azimuth observations are made with the theodolite used in primary triangulation or traverse. The observations consist in the measurement of the horizontal angle between some close circumpolar star, usually Polaris, and a terrestrial mark, generally a bull's-eye lantern set at a distance of half a mile to a mile from the observing station. The time of observation on the star should be noted by a chronometer or a good watch. As the star is at a much higher angle of elevation than the lamp it is necessary not only to level the instrument carefully but to measure the error of level and to correct for it. It is therefore essential that the value of a division of the level bulb be known. These observations for azimuth may be made at any time of the night, but preferably they should be made at or near the time of elongation of the star, as it is then moving most slowly in azimuth, and any error in the time of observation has the least effect upon the resulting azimuth. If such observations be taken at elongation, no record of time need be made, and the reduction of the observations is simplified. When such observations are made at any other time than at elongation, the time must be noted, as it forms an element in the reduction. The error of the clock or watch used may be obtained by comparison with railroad time, and corrected for the difference in longitude between the station and the meridian of the railroad time. A form of observation and record is appended.

AZIMUTH OBSERVATIONS.

Example of Record.

[Station: West base, near Little Rock, Ark. Fauth 8″. theod. No. 300. December 27, 1888. 1 div. micr. = 2″. 1 div. level = 3″.]

Object.	Time P. M.	Level. West end.	Level. East end.	Micrometer. A.	Micrometer. B.	Mean.	Angle.
				Telescope direct.			
	h. m. s.	*Div.*	*Div.*	° ′ *Div.*	° ′ *Div.*	° ′ ″	
Polaris............	11 00 18	13.9	47.1	346 00 14.8	165 58 25.1	345 59 39.9	
		50.5	10.2				° ′ ″
		64.4	57.3				115 32 30.0
		+7.1					
East base (mark)..	....	....		101 32 18.1	281 31 21.8	101 32 09.9	
East base (mark) .	....	....		101 32 19.8	281 31 19.7	101 32 09.5	115 34 16.1
Polaris............	11 09 20	50.4	10.3	345 58 22.0	165 57 01.4	345 57 53.4	
		13.8	46.5				
		64.2	56.8				
		+7.4					
				Telescope reverse.			
Polaris............	11 17 14	50.5	10.1	211 28 29.0	31 27 23.4	211 28 22.4	
		12.9	46.6				
		63.4	56.7				115 35 53.8
		+6.7					
East base (mark) .	....	....		327 05 06.7	147 03 09.5	327 04 16.2	
East base (mark).	....	....		327 04 26.3	147 03 00.6	327 03 56.9	115 37 08.0
Polaris............	11 26 22	14.3	46.3	211 27 10.7	31 26 07.4	211 26 48.1	
		50.1	10.5				
		64.4	56.8				
		+7.6					

AZIMUTH OBSERVATIONS.

Summary of Results.

[Station: West base, Arkansas. December 27, 1888.]

	Individual results.		Combined results.
	° ′ ″	″	° ′ ″
First set	294 10 34.2	35.25 D.	
	36.3		38.80
	49.9	42.35 R.	
	34.8		
	35.9	41.10 R.	
	46.3		39.38
	41.8	37.65 D.	
	33.5		
Second set........	42.4	43.90 D.	
	45.4		38.75
	26.4	33.60 R.	
	40.8		
	49.1	47.05 R.	
	45.0		40.10
	40.3	33.15 D.	
	26.0		
Grand mean........................			294 10 39.26

REDUCTION OF AZIMUTH OBSERVATIONS.

The time of observation of a star is first to be corrected for the difference in longitude, assuming that railroad time has been used, and for the error of the watch. It is then reduced from mean to sidereal time. From the sidereal time of observation is to be subtracted the right ascension of Polaris, if that star is used, which is given in the Nautical Almanac, the result being the hour angle or the sidereal time which has elapsed since it passed the meridian of the place of observation, given in hours, minutes, and seconds. This result is to be converted into degrees, minutes, and seconds.

$$\text{Then } \tan A = -\frac{a \sin t}{1 - b \cos t}$$

where $a = \sec \varphi \cot \delta$, $\varphi =$ the latitude.

$b = \frac{\tan \varphi}{\tan \delta}$ $\delta =$ The declination of star.

$t =$ hour angle.

$A =$ angle between north pole and the mark.

This angle is to be corrected for level as follows:

$$\text{lever corr.} = -\frac{d}{4} \left\{ (w + w') - (e + e') \right\} \tan h.$$

d being the value of a division of the level.

$w + w'$, readings of west end of level bubble.

$e + e'$, readings of east end of level bubble.

h, the angular elevation of pole star.

An example of reduction is as follows:

AZIMUTH OBSERVATIONS.

Example of Reduction.

[Station: West base; December 27, 1888. Observer S. S. G. Latitude = 34° 45′ 26.8″.

Longitude 92° 13′ 31.5″.]

			h.	m.	s.
Time of observation = Tw		=	11	00	18
Correction; ninetieth meridian time to 92°.215		=	—	8	54
Watch slow; ninetieth meridian time			+		02
local mean time	Tm	=	10	51	26
Correction; mean to sidereal time		=		+1	47
Right ascension mean sun			18	26	36
Sidereal time of observation		=	29	19	49
R. A. Polaris		—	1	18	25
Hour angle	t	=	28	01	24
		—	24		
			h.	m.	s.
	t (time)	=	4	01	24
			°	′	″
	t (arc)	=	60	21	00

$$\tan A = -\frac{a \sin t}{1 - b \cos t} \quad \text{where } a = \sec \phi \cot \delta \quad b = \frac{\tan \phi}{\tan \delta}$$

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PIEDMONT PLATEAU, LOOKING EAST FROM ROCKY RIDGE.

P.276 B

$\phi = 34° \ 45' \ 26.8''$	log sec = 0.0853539	log tan $34° \ 45' \ 26.8''$	= 9.8413076
$\delta = 88° \ 43' \ 11.9''$	log cot = 8.3491690	log tan $88° \ 43' \ 11.9''$	= 1.6508810
log a	= 8.4345229	log b	= 8.1904766
log sin t $\quad 60° \ 21' \ 00.''$	= 0.9390515	log cos t	= 9.6943423
log a sin t	= 8.3735744	log −.0076704	= 7.8848189
log (1 − b cos t)	= 9.9966559	+ 1.0000000	
log tan A $\quad 178° \ 38' \ 08.0''$	= 8.3769185	0.9923296	$= 1 - b \cos t$
angle to mark $\quad +115° \ 32' \ 30.0''$			
Level corr. $\quad -3.8$			
Az. of mark $= 294° \ 10' \ 34.2''$			

$$\text{level corr.} = -\frac{d}{4}\left\{(w + w') - (c - c')\right\} \tan h.$$

$$= \frac{3.1''}{4} \times 7.1 \text{ Div.} \times .694 = -3.8''$$

When observations for azimuth are to be made at elongation, it is necessary to know the mean time of elongation. This is computed by the following method: the hour angle at elongation is obtained from the following equation:

$$\cos t_e = \tan \varphi \cot \delta.$$

The hour angle plus the right ascension of the star gives the sidereal time of its western elongation, which, reduced to mean time, gives the local mean time in question.

The azimuth of a pole star at elongation is determined by the use of the following equation:

$$\sin A = \sec \varphi \cos \delta.$$

The following is an example of these computations:

Example of the computation of the azimuth at elongation, and the local mean times of both elongations of Polaris.

[Latitude = ϕ = 40°. Meridian of Washington. November 28, 1891.]

Sine Azimuth at elongation = sec ϕ cos δ.

log. sec. 40°		= 0.1157460
log. cos δ	$88° \ 44' \ 05.5''$	= 8.3439803
log. sine A	$1° \ 39' \ 05.8''$	= 8.4597263

Cos. hour angle at elongation, t_e. = tan ϕ cot δ.

log. tan 40°		= 9.9238135
log. cot δ	$88° \ 44' \ 05.5''$	= 8.3440862
log. cos t_e	$89° \ 56' \ 17.5''$	= 8.2678997

$t_e = 5^h \ 55^m \ 45.2^s$

Sidereal time western elongation, T_s = R. A. Polaris + t_e.

		h.	m.	s.	
R. A. Polaris	=	1	19	35.2	
t_e	=	5	55	45.2	
Sidereal Time western elongation	T_s =	7	15	20.4	
R. A. mean suu =	a_s=	16	29	14.4	
Sidereal interval before noon, 1	=	9	13	54.0	
Correction sidereal to mean interval			1	30.7	
Mean interval before noon		9	12	23.3	Nov. 28.
Local mean time, western elongation	=	2	47	36.7	A. M., Nov. 28.

		h.	m.	s.	
Sidereal time eastern elongation $24^h + \alpha - t_e$	=	19	23	50.0	
	a_s =	16	29	14.0	
Sidereal interval after noon, I	=	2	54	35.6	
Correction sidereal to mean interval	=		0	28.6	
Local mean time eastern elongation	=	2	54	07.0	P. M., Nov. 28.
Local mean time western elongation	=	2	47	36.7	A. M., Nov. 28.

For longitudes west of Washington decrease times of elongation 0.66^s for each degree.

Horizontal Location.

The primary control or geometric work is, in the ordinary case, effected by triangulation. Wherever this is not practicable or not economic, resort is had to what is known as primary traversing, but wherever the country presents sufficient relief for the purpose, triangulation is employed, as it is more accurate and cheaper.

Party Organization.

The primary triangulation is generally carried on by a special party. It is, however, on some accounts and under certain circumstances, economical and advisable that all the work be done by one and the same party. The disadvantage is that it divides the time and attention of the topographer, requiring him to turn his attention from one thing to another; the advantage, that it insures the selection of such points as are needed by the topographer for carrying forward the work. If the work is done by a special party, the points selected are more likely to be chosen on account of their forming good figures in the triangulation, than on account of their convenience and usefulness to the topographer. The secondary triangulation, the traversing, and the sketching are best carried on by different men, but under a single party organization. The sketching should be done by the chief of party, the secondary triangulation and height measurement by his most experienced assistant, while the traversing, with height measurement, should be done by the other assistants.

Base-Line Measurement.

This is, ordinarily, the first of the preparatory steps toward map making. Upon the proper selection of the site of the base line and its correct measurement depends all the subsequent work of triangulation. The site must be reasonably level. It is not essential that it be absolutely so, but the more closely it approaches a plane the less difficulty will be experienced in making an accurate measurement. The site should afford sufficient room for the measurement of a base from 5 to 10 miles in length. A base less than 5 miles in length is not an economical one, inasmuch as it is less costly to extend the base than to complicate the expansion. A greater length than 10 miles is unnecessary, because this length permits of easy expansion, and, if the length be greater than this, it may be difficult to construct signals at the two ends of the base, which will be intervisible.

The ends of the base must be intervisible, and they must be so situated with regard to suitable points for expansion and triangulation as to form well proportioned figures. Whenever possible, the base line should form a side or diagonal of a closed quadrilateral or pentagonal figure.

While it is unnecessary to devote time to obtaining the extreme of accuracy in the measurement of a base, this measurement should be so accurate that its errors cannot affect the map, although multiplied many times in the associated triangulation. All necessary precaution should be taken to secure this result.

Various methods and instruments have been employed in the measurement of base lines. Wooden rods have been employed, varnished and tipped with metal. When used in measuring, these were supported upon trestles and contacts made between them, with considerable refinement. The advantage of using these rods consisted in the fact that their length is but slightly affected by temperature, which is the main source of error in base-line measurement, and being thoroughly varnished they were not greatly affected by moisture.

Apparatus made of bars of different metals, so attached that the difference in the rate of expansion of the different metals will produce a uniform length of bar, and so compensate for temperature, have been and are still in use, but, although theoretically the compensation is perfect, in practice this result is not attained. Bars of metal are employed of the pattern known as the Coast Survey secondary bars. These consist each of a steel rod between two zinc tubes. As the two metals expand at different rates under changes of temperature, their relative lengths at any temperature as compared to the relative lengths at a normal temperature is, theoretically, an indication of the temperature of the bars at any time. The arrangement for indicating their relative lengths forms a part of the apparatus, and is intended to indicate the temperature of the bars, and thus to afford means of reducing the lengths of the bars to a normal temperature. It has not been found, however, to work well in practice. Besides this, there are other objections to the use of bars of any kind, which may be summarized as follows: First, their use is expensive. A considerable number of men are needed, and as the measurement proceeds slowly it often requires from a month to six weeks to measure and remeasure a base five miles in length. Again, since these bars are but four to six meters in length, there are many contacts to be made in each mile of measurement, and each contact affords the possibility of a trifling error.

In view of these objections and of certain positive advantages in the use of tape or wire the use of bars in the measurement of base lines, is being abandoned, and in their place long steel tapes or wire are coming into use. By their use it has been found easy to attain the required degree of accuracy in measurement, inasmuch as the number of contacts is reduced to a small fraction of the number necessary in the use of bars, while the uncertainty in regard to the temperature of the measuring apparatus is reduced to a minimum by carrying on the measurement at night or in cloudy weather. The expense of the measurement is greatly reduced since fewer men are required, the work of preparing the ground and the work of measuring are much lessened, and the rapidity of measuring is increased manyfold. The diminished cost makes it practicable to measure much longer bases, thus diminishing the number of stations required in the expansion. It allows, also, a measurement of base lines at shorter intervals in the triangulation.

The tape should be long, 100 to 500 feet. It should be carefully compared, at an observed temperature, with a standard both before and after its use in base measurement. Preferably, the site for the base line should be selected along a railway tangent, as such a location is approximately level, and the railway ties afford an excellent support for the tape. If such a location cannot be obtained, it should be selected so as to fill the requirements above mentioned, cleared of brush and undergrowth, and, if necessary, its sharp inequalities should be leveled. The tape should be supported by a series of low stools, whose legs are pressed into the ground at intervals of not more than 25 feet, while similar stools should sustain each end of the tape.

The personnel required in the measurement of a base line is, in an ordinary case, as follows:

First. The chief of the party, who exercises a general supervision over the work, marks the extremities of the tape and provides the necessary precautions against errors in the measurement, as hereafter stated.

Second. The rear chainman, who adjusts the rear end of the tape to the contact marks and who carries and reads one of the thermometers.

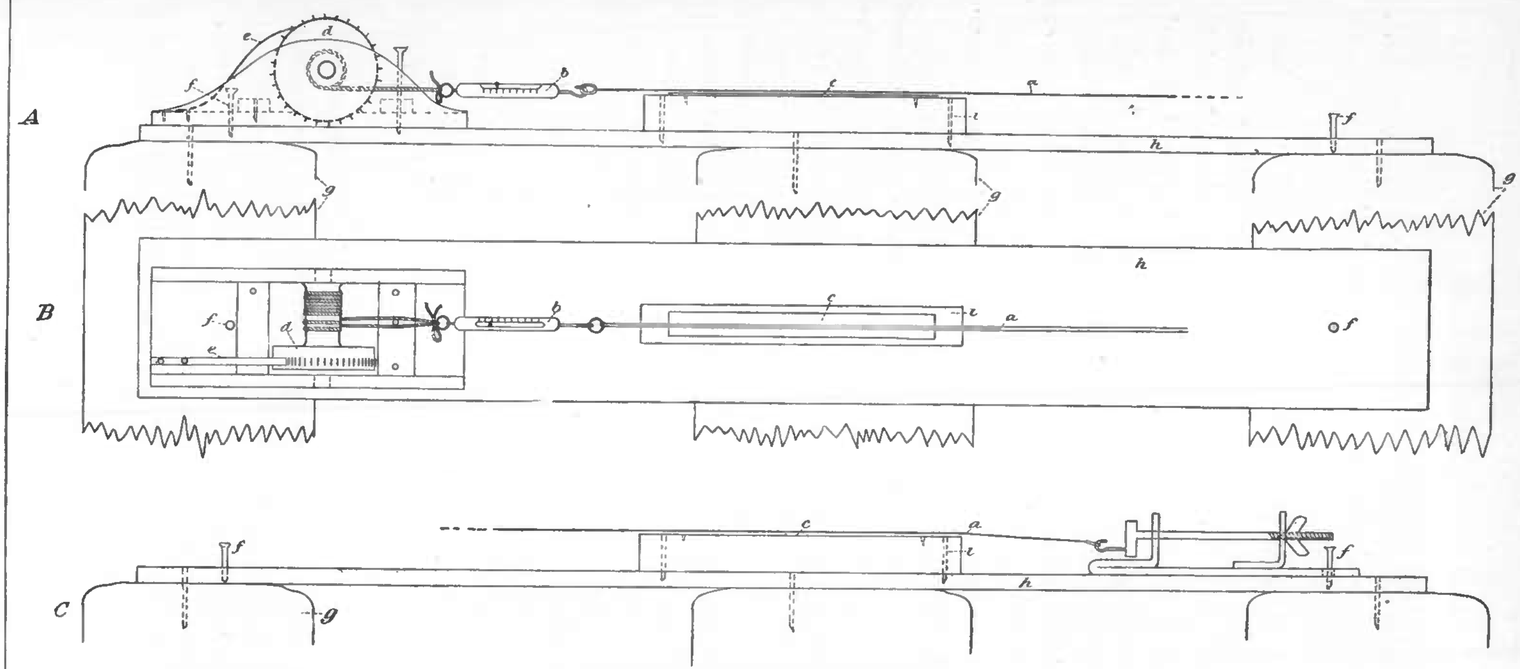
Third. The head chainman, who adjusts the forward end of the tape, exerts the requisite tension upon it, and carries and reads a second thermometer.

Fourth. A recorder.

The measurment of a base with the steel tape is a simple matter. Provision must, however, be made, first, for the proper alignment of the base; second, for the proper tension of the tape; and, third, for the measurement of temperature.

The alignment is a simple matter, and is generally marked out upon the ground in advance of the work of measurement. In cases where a railway tangent furnishes the site for the base line, no alignment is needed beyond the provision for keeping the tape always at a uniform distance from one of the rails.

For insuring a uniform tension of the tape, an ordinary spring balance is used, which is attached to the forward end of the tape,



A. Forward end, profile
B " " plan
C Rear " profile

a. Tape b. Spring balance c Zinc strips d. Cog wheel for straining tape e. Ratchet f. Nail for holding gear in place g. Railroad tie h. Pine strip i Block support for zinc strip

DEVICE FOR STRETCHING TAPE IN BASE MEASUREMENT. DESIGNED AND USED BY H. L. BALDWIN JR.

FIG. 20.

where a tension of twenty pounds is applied. In order to apply this uniformly, and to insure against slip of the tape, an apparatus devised by Mr. H. L. Baldwin, Jr., of the Geological Survey, is in use.

For its use, it is necessary to obtain strips of board about five feet long and four inches in width, in number equal to the number of lengths of tape of which the base line consists. Numbered strips of zinc of equal number, each about eight inches long and an inch in width, are tacked to blocks of wood, and these blocks of wood in turn nailed down upon the boards above mentioned, while the boards are, in case measurement is made along the railway tangent, nailed down to the railway ties. These boards are designed to support the devices for maintaining the tension, and the contacts are marked upon the strips of zinc. Mr. Baldwin's apparatus consists essentially of a wheel worked by a lever and held by ratchets in any desired position. This wheel is attached to the spring balance in such a way that by turning it the strain is put upon the spring balance, which is held at the desired tension by the ratchets. A small mechanism at the rear end of the tape is employed to hold the zero of the tape at the opposite mark. The great length of the tape, 300 feet, allows considerable friction or drag when the supports are frequent, and in order to insure a reasonably uniform distribution of the strain upon the tape, it should be raised and allowed to fall with the strain on.

The measurements should be made at night, or during cloudy days, in order that the temperature of the air, which is that indicated by the thermometers, and that of the tape be as nearly as possible the same. The temperature must be carefully observed by at least two thermometers at each tape length, in order that the best possible data for temperature correction may be obtained.

The base should be measured at least twice, and the two results compared by sections. The ends of the base must, if possible, be permanently marked by means of stone monuments set into the ground so that their surfaces are but a few inches above its level and the exact position of the ends should be indicated by a cross cut in a copper bolt embedded in the head of a stone, in order that the base may be preserved for future references.

A line of levels must be run over the site or over the stools which support the tape for the purpose of obtaining its profile and thereby the means for deducing its horizontal length.

REDUCTION OF BASE LINE MEASUREMENT.

The first correction to be applied is that of reduction to a standard. The correction for this is obtained by comparison with a standard. The correction for the entire line is in proportion to the correction as obtained by comparison with the standard. If the tape be longer than the standard, the correction will be positive, if shorter, negative.

Second. The correction for inclination, the data for which are obtained by running a line of levels over the base line. This line of levels gives the rise or fall, in feet and decimals of a foot, between the points of change in inclination. From this and the measured distance the angle of inclination is computed from the formula, $\sin\ \theta = \frac{h}{R}$ R being the distance and h the difference in height, both given in feet. The correction in feet to the distance is then computed by the equation, $\text{Corr.} = \frac{\sin^2 1'}{2} \theta^2 R$ or $0.00000004231\ \theta^2 R$, θ being expressed in minutes. (See Lee's Tables, p. 83.)

Third. The correction for temperature. Steel expands for each degree of temperature .0000063596 of its length. This fraction multiplied by the average number of degrees of temperature at the time the base line was measured above or below sixty-two degrees, which is taken as the normal temperature, gives the proportion in which the base line is to be diminished or extended on account of this factor. Care must be taken to obtain correctly this average temperature. It must be the mean of all the thermometric readings, taken at uniform intervals of distance during the measurement. If the temperature be above the normal, the correction is positive, and vice versa.

Fourth. The reduction to sea level. The base line is measured on a circle parallel to the sea surface and raised above it, at an elevation which is known at least approximately. This circle with radii drawn therefrom to the center of the earth forms approximately a triangle similar to that formed by the radii of the earth with the sea surface. The length at sea level is derived with a sufficient approximation to correctness by the proportion:

$$R : h :: K : \text{correction.}$$

R being the radius of the earth, h the mean height of the base line above sea level, and K its measured length. (See Report U. S. Coast and Geodetic Survey, 1882, Appendix 9, p. 19*b*.)

The following is an example taken from the records of measurement of a base near Spearville, Kansas, together with the reduction of this base for inclination, temperature, and elevation above sea level:

Record of measurement and reduction of Spearville base, Kansas.

[Section 1. Stations 0-10. October 16, 1889. Light rain falling]

No. of Tape.	Time, a. m.	Tension.	Thermometers. A.	Thermometers. B.	Temperature correction.	Total length of section.
	h. m.	*Pounds.*	°	°		
1......	10 13	19. 75	50. 5	50. 0		
2......	20	20. 00	50. 5	50. 0	Mean temp. = 50.51°	
3......	26	20. 00	50. 5	50. 0		
4......	31	20. 25	50. 5	50. 0		
5......	37	20. 00	50. 7	50. 5	62° − 50. 51° = 11. 49°	
6......	42	20. 125	51. 5	50. 6		
7......	47	20. 25	51. 0	50. 8	−11. 49 × 3000,	1 tape length.................. = 300. 0617
8......	51	20. 00	50. 8	50. 2	× .000006	
9......	55	20. 125	50. 8	50. 0		10 × 300. 0617.................. = 3,000. 617
10......	58	20. 00	50. 7	50. 5	= −.207	Temperature corr............ −. 207
						Result first measurement... = 3,000. 41

[*Second Measurement, October* 17, 1889.]

No. of Tape.	Time, a. m.	Tension.	Thermometers. A.	Thermometers. B.	Temperature Correction.	Total Length of section.
	h. m.	*Pounds.*	°	°		
1......	12 13	20. 00	52. 3	52. 4		
2......	21	20. 25	53. 3	52. 9		Tape set back from sta. 0 . 85 inch.
3......	25	20. 00	53. 8	54. 0	Mean = 53. 96°	= . 071 foot.
4......	29	19. 75	55. 0	54 8		
5......	33	20. 00	55. 0	53. 2	62° − 53. 96° = 8. 04°	
6......	36	20 00	53. 8	54. 0		
7......	38	20. 00	54. 0	54. 0	− 8. 04 × 3000.	
8......	41	20. 12	54. 5	54. 0	× 0. 000006	10 × 300. 0617.................. = 3, 000. 617
9......	45	19. 75	55. 1	54. 4	= −. 145	Set back...................... −. 071
0......	50	20. 13	54. 5	54. 1		Temperature corr............ −. 145
						Result second measurement = 3, 000. 401

Correction for inclination Spearville base, Kansas.

$$\text{Correction} = \frac{\sin^2 1'.\theta^2}{2} \times \text{Distance.}$$

Approximate distance.	Difference of elevation.	Angle θ.		log θ.	2 log θ.	log $\frac{\sin^2 1'}{2}$	log dist.	log correction.	Correction.
Feet.	*Feet.*	′	″						
200	0.8	13	34	1.1326	2.2652	2.6264	2.3010	7.1926	.0015
4,200	4.2	2	22	0.3674	0.7348		3.6232	6.9844	.0010
4,000	12.0	10	08	1.0052	2.0104		3.6021	8.2389	.0173
1,000	1.0	3	23	0.5250	1.0501		3.0000	6.6765	.0005
2,000	3.0	5	04	0.7024	1.4049		3.3010	7.3323	.0021
4,200	22.0	12	23	1.0917	2.1834		3.6232	8.4330	.0271
2,800	7.0	8	27	0.9263	1.8527		3.4472	7.9263	.0084
1,000	0.0	0	00	0.0000	0.0000		3.0000	0.0000	.0000
1,000	1.0	3	23	0.5250	1.0500	Constant.	3.0000	6.6764	.0005
4,200	20.0	11	16	1.0504	2.1008		3.6232	8.3504	.0224
3,800	6.0	5	20	0.7267	1.4535		3.5798	7.6597	.0046
2,000	4.0	6	45	0.8293	1.6586		3.3010	7.5860	.0038
5,400	31.4	19	39	1.2934	2.5867		3.7324	8.9455	.0882
2,000	2.6	4	24	0.6437	1.2874		3.3010	7.2148	.0016
135	0.05	1	18	0.1072	0.2144		2.1303	4.9712	.0000
									.1790

Reduction to sea level.

Correction	$= \frac{K\,h}{R}$
log K (metres)..	= 4.05956
log h (metres)..	= 2.87599
Co log R..	3.19660
log 1.356 metres..	= 0.13215
log metres to feet..	= 0.51599
4.448 feet..	0.64814

Spearville base: Summary by sections.

(Corrected for temperature.)

Stations.		First measure.	Second measure.	Difference. First—Second.
		′	′	′
1 to	10	3,000.410	3,000.401	+ .009
10	20	.418	.393	+ .025
20	30	.431	.431	+ .000
30	40	.426	.446	— .020
40	50	.437	.478	— .041
50	60	.417	.455	— .038
60	70	.369	.392	— .023
70	80	.366	.356	+ .010
80	90	.955	.938	+ .017
90	100	.676	.667	+ .009
100	110	3,000.899	3,000.898	+ .001
110	119	2,700.581	2,700.571	+ .010
119	126	2,100.244	2,100.234	+ .010
		37,806.629	37,806.660	— .031′ = .372″

Mean of 2 measurements........	= *37,806.645′
Reduction from S.W. base to △	— 168.235
Reduction from N. E. base to △	— 2.864
Correction for inclination......	— 0.179
Reduction to sea level.........	— 4.448
Corrected length	= 37,630.919

* Corrected for temperature.

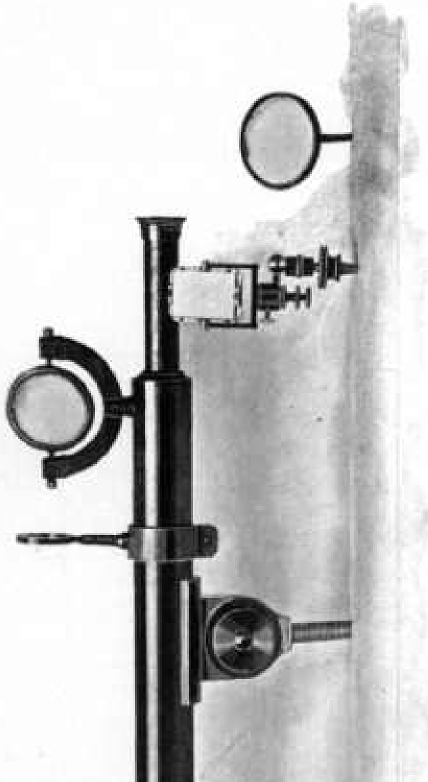


FIG. 1.—HELIOTROPE.

FIG. 2.—TRAVERSE PLANE-TABLE ALIDADES.

Primary Triangulation.

The base line having been measured, the next step is the expansion. This work, as well as the body of the triangulation, consists in the selection of stations, the erection of signals, and the measurement of angles. Each triangle proceeding from the base line outward will, when the angular measurement is completed, have one side and the three angles known, from which the other two sides can be computed by means of a simple trigonometric formula.

The expansion differs from the body of the triangulation only in the fact that the average length of the sides of the triangles is less. As the expansion progresses away from the base line, the sides of successive triangles become gradually longer, until the average length of side of the triangulation is reached. Since the sides are increasing in length, and hence since any inaccuracy in the measurement of the base is multiplied, this work must be planned and executed with greater care than the body of the triangulation requires.

A base line measured as above prescribed requires little expansion, since from the extremities of an 8 or 10 mile base one can observe directly on points 12 to 15 miles away, a distance as great as the average side of a triangle. Ordinarily, from the ends of the base, the surveyor can observe directly upon stations in his scheme of triangulation, but where the sides of triangles may be 20 to 50 miles in length, an expansion is required.

SELECTION OF STATIONS.

In the selection of triangulation stations two different sets of requirements must be served.

First. They must be so selected as to afford what is known as strong figures, in order to reduce to a minimum the errors which will creep into an extended system. In order to insure intervisibility, they should, if possible, be located upon hill or mountain summits, the most commanding in the neighborhood. No triangle upon which dependence is placed for the location of a station should have at that station an angle of less than 30° or more than 150°.

The stations should, if practicable, be grouped into simple figures, as quadrilaterals, or pentagons with an interior station, etc. In cases where an area is being covered with triangulation, such groupings naturally occur, but in certain cases the triangulation takes the form of narrow belts of figures, and then the belt may consist of simple triangles or quadrilaterals, as more complex figures are rarely desirable.

Second. Since the sole object of triangulation is the control of the topographic map, the location of stations must, as far as is consistent with accuracy, be adjusted to the needs of the topographers. This requirement affects most seriously the distance between stations. Every plane-table sheet must contain at least two primary stations, and a third is desirable. Thus, for controlling a sheet on the scale 1:62500, the stations should not be more than 10 or 12 miles apart, and should be located with direct reference to the control of the sheets. Again, since the primary stations must be occupied by topographers for intersecting on numerous points, they must be selected with reference to this requirement. They should command an extended view, especially of points suitable for cutting in, such as hill and mountain summits, houses, churches, etc.

The instrument should, wherever possible, be accurately centered under the signal. Whenever it is necessary to set up off center, the direction and distance to the signal should be carefully measured and recorded.

SIGNALS.

While signals should be of the simplest and least expensive form which will serve the purpose, their form and material must depend upon the requirements and the materials at hand. In a mountainous country, where the summits are treeless, simple cairns of stone, 7 to 10 feet in height, are employed. Where the summits are wooded, it is frequently convenient to clear them, leaving a single tree to serve as a signal. In such cases it is advisable to trim the tree of branches, with the exception of a tuft at the top. Where the station is clear, but with green timber easily accessible, it is advisable to make a tripod of small trees, each with a tuft at its top. In undulating and hill country it is often necessary to erect scaffolds. These should be built of sawed lumber and framed in simple fashion. If the lines are short, a pole with a flag may be set in the top. If the lines are long, the tower itself may serve as a signal, in which case its upper part should be clothed in black and white cotton.

The annexed cut shows a form of framed signals adapted for use on the treeless plains of Kansas and the rolling open hills of New England, and elsewhere, where observing towers are not necessary.

Fig. 21.—Signal.

It is frequently necessary to raise the instrument to a considerable elevation above the ground, in order to overlook surrounding obstacles. In such cases the structures for supporting the instrument should be combined with the signals, and hence they may properly be described and figured here. These observing towers should be in two parts. An interior structure, solidly built of sawed lumber, if available, for the immediate support of the instrument, and a framework surrounding it, supporting a platform just below the stand for the instrument, for the observer. The two should be separate, in order that the jarring incident to moving about on the platform be not communicated to the instrument.

Where sawed lumber is not obtainable, other material must be used. In the Sierra Nevada of California, among the sugar-pine forests, a support for the instrument is not infrequently obtained by sawing off the top of a high tree, and setting the instrument upon the stump, 50 or 75 feet above the ground, the tree being guyed out by wire cables to prevent swaying in the wind. The platform for the observer is supported by neighboring trees, similarly sawed off and supported for the purpose. Similar devices are resorted to also in the forests of West Virginia, Kentucky, and Tennessee. In the secondary triangulation in these regions, the instrument support is, in many cases, provided as above described, while the observer's platform, instead of having an independent support, is attached to the same tree. This is objectionable, but is often the best that can be done.

In other cases it is more economical to support the instrument upon the ground, and to have openings made through the forest upon the station hill, in the directions of the sight lines, or even to have the whole summit cleared.

It is not infrequently necessary to use more elaborate forms of signals, especially when the point observed upon is below the horizon line, so that the background, instead of being the sky, consists of forests or brown plains. In such cases resort is had to heliotropes. These are simply instruments for reflecting the sunlight to the observer at the instrument. The simplest form is a circular mirror with a screw hinged at the back, giving a universal motion. This is screwed into a stake or tripod over the center of the station to be observed upon, and a ray of sunlight is thrown through a small hole in a board nailed to a stake 10 or 15 feet away, and in the direction of the observer at the distant station. This form has the advantage of simplicity, as the simplest backwoodsman can manage it; and the triangulator can firmly fix all range stakes upon one visit to the station, and be sure of seeing the flash as he observes from each of the surrounding stations in turn.

Two other forms are in use, the Coast Survey type and the Steinheil. The former consists of a telescope which is provided with a screw for fastening it into any convenient support or upon the theodolite. Upon the telescope is a mirror and two rings, the axis of the rings as well as the center of support of the mirror being parallel to the line of sight of the telescope. The telescope being directed upon the observing station, the mirror is so turned as to reflect the sunlight through the rings and necessarily to the observing station. In many cases the use of a second mirror is necessary, owing to the relative position of the two stations and the sun, and such a mirror forms a part of the outfit. This form is little used, on account of its liability to get out of adjustment. The Steinheil heliotrope is a compact little instrument, which can be carried in a case like a pair of field glasses. It consists of a small sextant mirror, the two surfaces of which are as nearly absolutely parallel as possible. This mirror has a small hole in the center of the reflecting surface. Below this central hole is a small lens in the shaft carrying the mirror, and below the lens is some white reflecting material, as plaster of Paris. The mirror is so mounted that it has four different motions, two about its horizontal axis and two about its vertical axis, each of which can be separately bound or controlled by clamps or friction movements. To use the Steinheil, it is screwed into some wooden upright, as the side of a tree, in such a position that the main axis carrying the lens and plaster of Paris reflector shall be parallel to the sun's rays. The observer standing behind the mirror receives from the rear surface of the glass a reflection of the sun, producing an imaginary sun. The mirror should not be moved until this imaginary sun, moving with it, appears to rest on the object to which the flash is to be cast, as the hill on which the triangulator is standing. As both surfaces of the mirror are parallel, the true reflected rays of the sun from the surface of the mirror will also be cast on the object sighted to.

This instrument is in great favor because it is light and convenient to carry and use, and because there are no movable parts to get out of adjustment by jarring. This latter is a serious defect in the Coast Survey instrument, since unless frequently tested the two rings may have moved, thus causing the reflection to be cast out of parallelism with the line of sight of the telescope.

The use of heliotropes presupposes the employment of men to operate them, thus increasing materially the expense of the work. Misunderstandings continually arise between the heliotropers and the observer, causing vexatious delays, and therefore their employment should be avoided whenever possible.

THEODOLITES FOR TRIANGULATION.

Instruments differing widely in power and degree of accuracy are in use for the measurement of angles in primary triangulation, depending upon the extent of the work and the degree of accuracy required. For work of small extent, theodolites having circles 6, 7, 8, 10, and 11 inches in diameter and reading by vernier to 10 seconds may be employed. For extended operations, where greater accuracy is required, it is desirable to employ a higher class of instruments and thus obtain more accurate results, and theodolites having 8-inch circles, reading by micrometer microscopes, will be found suitable.

One of these theodolites is represented in Plate XXXIX.

The circle, as was above stated, has a diameter of 8 inches, and is subdivided into 10 minutes. The object glass is 2 inches in diameter and its focal distance is 16½ inches. The telescope with the eyepiece commonly used has a power of about 30 diameters.

The circle is read by means of two microscopes, placed opposite one another. Within the field of the microscope is a comb stretching over the space of 20 minutes. This comb has ten teeth, divided into two parts by a depression, each corresponding to 2 minutes. Parts of a minute down to 2 seconds are read by means of a micrometer screw moving a pair of fine threads in the field of the microscope.

INSTRUCTIONS FOR THE MEASUREMENT OF HORIZONTAL ANGLES.

The following general precautions should be observed in the measurement of all horizontal angles in the primary triangulation.

EIGHT-INCH THEODOLITE.

P. 292 B

The instrument should have a stable support, which may be a stone pier, a wooden post, or a good tripod. If a portable tripod is used, its legs should be set firmly in the ground.

The instrument should be protected from the direct rays of the sun by means of an umbrella, or a piece of canvas like a tent fly. It should also be shielded from winds which may jar or twist either it or its support.

The foot screws of the instrument after it is leveled for work should be tightly clamped. Looseness of the foot screws and tripod is a common source of error, especially with small instruments.

The alidade, or part of the instrument carrying the telescope and verniers or microscopes, should move freely on the vertical axis. Clamps should likewise move freely when loosened. Whenever either of these moves tightly, the instrument needs cleaning, oiling, or adjusting.

The observer should always have a definite preliminary knowledge of the objects or signals observed. The lack of it may lead to serious error and entail cost much in excess of that involved in getting such knowledge.

Great care should be taken to insure correctness in the degrees and minutes of an observed angle. The removal of an ambiguity in them is sometimes a troublesome or expensive task.

The errors to which measured angles are subject may be divided into two classes—viz., first, those dependent on the instrument used, or instrumental errors; and second, those arising from all other sources, which, for the sake of distinction, may be called extra-instrumental errors.

The best instruments are more or less defective, and all adjustments on which precision depends are liable to derangement. Hence the general practice of arranging observations in such a manner that the errors due to instrumental defects will be eliminated in the end results. The principal errors of this kind and the methods of avoiding their effects are enumerated below.

Measurements made with a graduated circle are subject to certain systematic errors commonly called periodic. Certain of these errors are always eliminated in the mean (or sum) of the readings of the equidistant verniers or microscopes, and both of the latter should be read with equal care in precise work. Certain other errors of this class are not eliminated in the mean of the microscope readings, and these only need consideration. Their effect on the mean of all the measures of an angle may be rendered insignificant by making the number of individual measures with the circles in each of n equidistant positions separated by an interval equal to $\frac{360^\circ}{mn}$ where m is the number of equidistant verniers or microscopes. Thus, if $m = 2$, the circle should be shifted after each measure by an amount equal to $\frac{180^\circ}{n}$, which, for example, is 45° for $n = 4$ and 30° if $n = 6$. The degree of approximation of this elimination increases rapidly with n. (For specifications as to particular instruments see "Number of sets required and astronomical azimuths" below.) The effect of this class of errors is always *nil* on an angle equal to the angular distance between consecutive microscopes or a multiple thereof. Other things equal, therefore, we would expect the measures of such special angles to show less range than the measures of other angles.

Besides the instrumental errors of the periodic class, there are also accidental errors of graduation. These are in general small, however, in the best modern circles and their effect is sufficiently eliminated by shifting the circle in the manner explained under "periodic errors" above.

The effect of an error of collimation on the circle reading for any direction varies as the secant of the altitude of the object observed. The effect on an angle between two objects varies as the difference between the secants of their altitudes. This effect is eliminated either by reversing the telescope in its Ys, or by transmitting it without changing the pivots in the Ys, the same number of measures being obtained in each of the two positions of the telescope. The latter method is the better one, especially in determining azimuth, since it eliminates at the same time errors due to inequality of pivots and inequality in height of the Ys.

The effect of the error of inclination on the circle reading for any direction varies as the tangent of the altitude of the object observed.

If the inclination is small, as it may always be by proper adjustment, its effect will be negligible in most cases. But if the objects differ much in altitude, as in azimuth work, the inclination of the axis must be carefully measured with the striding level, so that the proper correction can be applied. The following formula includes the corrections to the circle reading on any object for collimation and inclination of telescope axis:

$$c \sec h + b \tan h;$$

$c =$ collimation in seconds of arc,
$b =$ inclination of axis in seconds of arc,
$h =$ altitude of object observed.

Parallax of wires occurs when they are not in the common focal plane of the eyepiece and objective. It is detected by moving the eye to and fro sidewise while looking at the wires and image of the object observed. If the wires appear to move in the least, an adjustment is necessary. The eyepiece should always be first adjusted to give distinct vision of the cross wires. This adjustment is entirely independent of all others and requires only that light enough to illuminate the wires enter the telescope or microscope tube. This adjustment is dependent on the eye and is in general different for different persons. Hence maladjustment of the eyepiece cannot be corrected by moving the cross wires with reference to the objective. Having adjusted the eyepiece, the image of the object observed may be brought into the plane of the cross wires by means of the rack-and-pinion movement of the telescope. A few trials will make the parallax disappear.

When circles are read by micrometer microscopes it is customary to have them so adjusted that an even number of revolutions of the screw will carry the wires over the image of a graduation space. If the adjustment is not perfect, an error of run will be introduced. This may in all cases be made small or negligible, since by means of the independent movements of the whole microscope and the objective with respect to the circle, the image may be given any required size. In making this adjustment some standard space, or space whose error is known, should be used. At least once at each station where angles are read, observations should be made for run of micrometers. An example of such readings is given under sample of field notes below.

Tangent and micrometer screws should move freely, but never loosely. In making a pointing with the telescope the tangent screw should always move against or push the opposing spring. Likewise, bisections with the micrometer wires should be made always by making the screw pull the micrometer frame against the opposing spring or springs.

Extra instrumental errors may be divided into four classes—namely errors of observation, errors from twist of tripod or other support, errors from centering and errors from unsteadiness of the atmosphere.

Barring blunders or mistakes, the errors of observation are in general relatively small or unimportant. With practiced observers in angular measurements, such errors are the least formidable of all the unavoidable errors, and their elimination in the end results is usually well nigh perfect. The recognition of this fact is very important, for observers are prone to attribute unexpected discrepancies to bad observation rather than to their much more probable cause. After learning how to make good observations the observer should place the utmost confidence in them, and never yield to the temptation of changing them because they disagree with some preceding observations. Such discrepancies are in general an indication of good, rather than poor, work.

Stations or tripods which have been unequally heated by the sun or other source of heat usually twist more or less in azimuth. The rate of this twist is often as great as a second of arc per minute of time, and it is generally nearly uniform for intervals of ten to twenty minutes. The effect of twist is to make measured angles too great or too small according as they are observed by turning the microscopes in the direction of increasing graduation or in the opposite direction. This effect is well eliminated, in general, in the mean of two measures, one made by turning the microscopes in the direction of increasing graduation and followed immediately by turning the microscopes in the opposite direction. Such means are called combined measures or combined results, and all results used should be of this kind. As the uniformity in rate of twist cannot be depended on for any considerable interval, the more rapidly the observations on an angle can be made the better will be the elimination of the twist. The observer should not wait more than two or three minutes after pointing on one signal before pointing on the next. If for any reason it should be necessary to wait longer, it will be best to make a new reading on the first signal.

The precision of centering an instrument or signal over the reference or geodetic point increases in importance inversely as the length of the triangulation lines. Thus, if it is desired to exclude errors from this source as small as a second, one must know the position of the instrument within one third of an inch for lines a mile long, or within 6 inches for lines 20 miles long. The following easily remembered relations will serve as a guide to the required precision in any case:

1 second is equivalent to 0.3 inch at the distance of 1 mile.

1 second is equivalent to 3.0 inches at the distance of 10 miles.

1 second is equivalent to 6.0 inches at the distance of 20 miles.

1 minute is equivalent to 1.5 feet at the distance of 1 mile.

The notes should always state explicitly where the instrument and signals are and give their co-ordinates (preferably polar co-ordinates) if they are not centered.

Objects seen through the atmosphere appear almost always unsteady, and sometimes this unsteadiness is so great as to render the identity of the object doubtful. The unsteadiness is usually greatest during the middle of the day. It generally subsides or ceases for a considerable period between 2 p. m. and sundown. There is also frequently a short interval of quietude about sunrise, and on cloudy days many consecutive hours of steady atmosphere may occur. For the best work, observations should be made only when the air causes small or imperceptible displacements of signals. In applying this rule, however, the observer must use his discretion. Errors of pointing increase rapidly with increase of unsteadiness, but it will frequently happen that time may be saved by counterbalancing errors from this source by making a greater number of observations. Thus, if signals are fairly steady it may be economical to make double the number of observations rather than wait for better conditions.

The best results in a triangulation are to be obtained by measuring the angles separately and independently. Thus, if the signals in sight around the horizon are in order A, B, C, etc., the angles A to B, B to C, etc., are by this method observed separately; and whenever there is sufficient time at the observer's disposal this method should be followed.

Besides measuring single angles, it is desirable to measure independently combined angles—*i. e.*, angles which consist of the sum of two or more single angles. Thus, supposing O to be the observing station and A, B, and C stations sighted on, the observer should measure not only the angles AOB and BOC, but the combined angle AOC. This is necessary not only because this angle may be used directly in the triangulation, but it will be needed in forming conditions for adjusting the angles about the observing station, or the station adjustment, as it is called.

In order to secure the elimination of the errors mentioned above, the following programme must be strictly adhered to:

Pointing on A and readings of both microscopes.

Pointing on B and readings of both microscopes.

Transit telescope and turn microscopes 180°.

Pointing on B and readings of both microscopes.

Pointing on A and readings of both microscopes.

Shift circle by $\frac{180^\circ}{n}$ and proceed as before until n such sets of measures have been obtained.

Then measure the angles B to C to D, etc., including the angle necessary to close the horizon, in the same manner.

A form for record and computation of the results is given below.

When repeating instruments are used, the same programme will be followed except that there should be five pointings instead of one on each of A and B, the circle being read for the first pointing on A and the fifth on B, and again for the sixth pointing on B and the tenth on A.

The importance of having the measures of a set follow in quick succession must be constantly borne in mind. Under ordinarily favorable conditions an observer can make a pointing and read the microscopes once a minute, and a set of five repetitions should be made in five minutes or less.

When several stations or signals are visible and a nonrepeating instrument is used, time may be saved without material loss of precision in the angles, by observing on all the signals successively according to the following programme, the signals being supposed in the order A, B, C, etc., as above.

Pointing on A with microscope readings.
Pointing on B with microscope readings.
Pointing on C with microscope readings.

Pointing on A with microscope readings.
Transit telescope and turn microscopes 180°.
Pointing on A with microscope readings.
Pointing on B with microscope readings.
Pointing on C with microscope readings.

Pointing on A with microscope readings.
Shift circle by $\frac{180°}{n}$ and proceed as before until n such sets have been obtained.

The angles A to B, B to C, etc., read in this way may be computed as in the first method, always combining the measure A to B with the immediately succeeding measure B to A to eliminate twist. There is a theoretical objection to this process of deriving angles founded on the fact that they are not independent, but in secondary work this objection may be ignored as of little weight.

For instruments which read by micrometer microscopes, four (4) sets of measures on as many different parts of the circle will be required; and for the repeating theodolite six (6) sets of measures will be required, all measures being made according to the programmes given above.

Under ordinary circumstances and with due care in centering, angles measured as specified above should show an average error of closure of the triangles not exceeding 5″.

Under specially unfavorable conditions the number of sets of measures should be increased, care being always taken to shift the circle so as to eliminate periodic errors.

The practice of starting the measurement of an angle or series of angles with the microscopes reading 0° and 180°, 90°, and 270°, etc., must be avoided; otherwise the errors of these particular divisions will affect many angles. In shifting the circle it is neither necessary nor desirable to have the new positions differ from the preceding one by exactly $\frac{180^\circ}{n}$. A difference of half a degree either way is unimportant as respects periodic errors, and it is advantageous to have the minutes and seconds differ for the different settings.

Field notes should be clear and full. The date, place, name and number of instrument used, and the names of observer and recorder should be recorded at the beginning of each day's work at a station. The positions of the instrument and signals observed should be defined either by a full statement or reference to such in each day's notes. The time of observations should be noted at intervals to show that the instrument does not stand too long between pointings.

When mistakes are made in the record, the defective figures should not be erased, but simply crossed out, and an explanation furnished in the column of remarks. Great care should be taken not only to avoid "cooking" or "doctoring" notes, but to avoid suspicion thereof.

The following example of form of record is taken from the primary triangulation executed in 1889 in western Kansas by the U. S. Geological Survey:

Record of measurement of horizontal angle.

[Station: Township corner, Kansas, July 1, 1889. Fauth 8-inch theodolite No. 362, one division of micrometer head = 2 seconds.]

Station.	Micr. A.			Micr. B.			Mean reading.			Angle.			Mean.
	Telescope direct.												
	°	′	*Div.*	°	′	*Div.*	°	′	″	°	′	″	″
Walton..........	93	12	11.3	273	12	09.9	93	12	21.2	36	29	03.9	
Newt............	129	41	11.9	309	41	13.2	129	41	25.1				05.9
Newt............	129	41	15.6	309	41	12.1	129	41	27.7			08.0	
Walton..........	93	12	10.6	273	12	09.1	93	12	19.7				
	Telescope reversed.												
Walton..........	138	27	03.2	318	26	28.0	138	27	01.2				
Newt............	174	56	02.8	354	55	28.9	174	56	01.7			00.5	
Newt............	174	56	06.2	354	55	29.5	174	56	05.7				01.8
Walton..........	138	27	05.2	318	26	27.4	138	27	02.6			03.1	
	Telescope reversed.												
Walton..........	183	07	03.0	3	06	27.2	183	07	00.2				
Newt............	219	36	05.0	39	35	29.8	219	36	04.8			04.6	
Newt............	219	36	08.1	39	35	29.5	219	36	07.6				03.9
Walton..........	183	07	06.4	3	06	28.1	183	07	04.5			03.1	
	Telescope direct.												
Walton..........	228	24	28.1	48	24	22.6	228	24	50.7				
Newt............	264	53	27.4	84	53	26.1	264	53	53.5			02.8	
Newt............	264	54	01.1	84	53	26.1	264	53	57.2				04.3
Walton..........	228	24	29.3	48	24	22.1	228	24	51.4			05.8	
													4 | 15″.9
Mean of 4 combined measures*..........										= 36°	29′	03″.98	

* Instrument over center of station.

ORGANIZATION OF PARTIES AND PROSECUTION OF WORK.

A party for carrying on primary triangulation usually comprises only the chief and an assistant, with the addition of a driver and cook, in case the party is living in camp. Frequently, however, a man is employed to superintend the construction of signals, and it is generally found economical to employ such a man. The chief of the party is expected to select the stations and direct the forms of signals to be erected, and to measure angles. In a mountainous country the selection of stations is usually a simple matter. From the summit of a mountain the chief of a party may be able to select stations for considerable distances ahead and to order the erection of signals, turning over to the man employed for that purpose the business of erecting them. On the other hand, in a densely wooded region such as the Cumberland plateau, where the summits have approximately the same elevation, the selection of stations is an extremely difficult matter, requiring great ability and experience and involving an immense amount of labor. In such a region the chief of party finds it necessary to travel great distances, visit many hills, and even has to climb to the summits of the highest trees, in order to select intervisible stations.

The selection of stations must be kept in advance of the reading of angles, but it is not advisable to keep it too far ahead, on account of the danger of the destruction of signals before angles have been read upon them. Therefore, the chief of a party finds it necessary to alternate between the two kinds of work, selecting and preparing three or four stations, then returning and measuring the angles.

When it is necessary to use heliotropes, the party has necessarily to be increased by one man for each heliotrope employed. The proper management of such a party then becomes a matter calling for the exercise of much judgment on the part of the triangulator. If it is convenient for the chief of party to place each heliotroper before observing angles, and to show them where to direct their instruments, men of ordinary intelligence may be employed and the work is one calling rather for time than skill. Where, however, the party is moving almost daily, the observer and heliotropers occupying a different station nearly every day, as is possible in the dry and clear atmosphere usually prevailing in the West, the chief of party has to arrange a schedule for each man, showing the order in which he is to occupy the stations and in what direction he is to flash from each. The heliotroper must be a man having some topographic and technical skill, so that he may find his point, set up on center and direct his flashes to the right place, besides exercising a goodly amount of common sense judgment. A simple code of signals being agreed upon, it then becomes an easy matter for the triangulator to let the heliotropers know that the work is completed, when they at once move to the next designated station.

Reduction of Primary Triangulation.

REDUCTION TO CENTER.

In case any station was occupied off center, the directions as read must first be reduced to center. In the diagram, let x be the

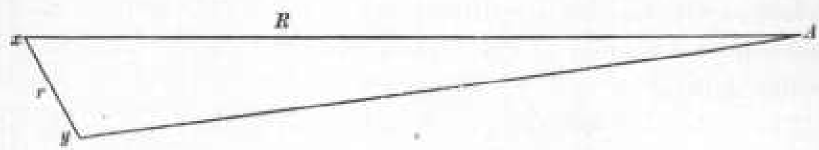


Fig. 22.

point occupied; y, the station, r the distance between them, A the point to which the direction is laid and the angle at that point, and R its distance, approximately known. Then, from the relations between the sides and the angles of the triangle,

$$R : r :: \sin x : \sin A$$

$$\sin A = \frac{r \sin x}{R} \text{ and } A = (\text{in seconds}) \frac{r \sin x}{R \sin 1''}$$

correction in seconds of arc.

The following example will serve to illustrate the form of effecting this reduction. The references are to the diagram on page 304.

Reduction to center of station at Walton △.

[See explanation: Appendix No. 9, page 167, U. S. Coast and Geodetic Survey report for 1882.]

distance, inst. to center = ″.48 log = 9.6812
log feet to meters = 0.5160

distance, inst. to center log meters = 9.1652 = log r.

Direction.	x to n 7°.	x to 0 73°.	x to p 105°.	x to q 185°.	x to r 273°.	x to s 306°.
log sin angle.............	9.0859	9.9806	9.9849	8.9403	9.9994	9.9080
Co. log, distance..........	5.9321	5.9182	6.4228	6.2434	6.0079	6.2514
log r......................	9.1652	9.1652	9.1652	9.1652	9.1652	9.1652
Co. log sin 1″	5.3144	5.3144	5.3144	5.3144	5.3144	5.3144
	9.4976	0.3784	0.8873	9.6633	0.4869	0.6390
Correction to direction..	0″.31	2″.39	7″.71	0″.46	3″.06	4″.46

		″	″		″
Correction to angle	$a = n$ to o	−0.31	+2.39	=	+2.08
	$b = o$ to p	−2.39	+7.71	=	+5.32
	$g = n$ to p	−0.31	+7.71	=	+7.40
	$e = p$ to q	−7.71	−0.46	=	−8.17
	$d = q$ to r	+0.46	−3.06	=	−2.60
	$c = r$ to s	+3.06	−4.36	=	−1.30
	$h = q$ to s	+0.46	−4.36	=	−3.90
	$f = s$ to n	+4.36	+0.31	=	+4.67

The angles are measured on a spherical surface and the sum of the three measured angles of each triangle should equal 180° plus the spherical excess. The latter need be computed and subtracted from the sum of the angles, however, only for the purpose of testing the accuracy of closure of the triangle, as in the reduction the angles are treated as plane angles. When the area of the triangle is large, the spherical excess in seconds (E) should be computed by the equation:

$$E = \frac{S}{r^2 \sin 1''}$$

where S = the area of the triangle in square miles, and r the radius of curvature of the earth in miles. When the triangle (being within the United States) has an area less than 500 square miles, r may be assumed as constant, and the spherical excess may be obtained by dividing the area in square miles by 75.5.

The next step is the adjustment of the angles about the observing station, or the station adjustment, as it is called. Referring to the diagram, which represents the angles read at Walton station, in Kansas, it is seen that eight angles were measured as follows—

	Obs. angle.	Station adjustment.	Correction to center.	Angles locally adjusted and reduced to center.
	° ′ ″	″	″	° ″ ″
a Dunkard—Peabody......	65 45 28.37	+.51	+2.08	65 45 30.96
b Peabody—Newt..........	31 47 58.50	+.52	+5.32	31 48 04.34
Sum..................=	97 33 26.87	....	....	97 33 35.30
g Dunkard—Newt (meas)..	97 33 28.39	−.49	+7.40	97 33 35.30
Difference............=	−1.52	....	....	00.00
d Township cor.—Royer...	87 44 57.41	−.56	−2.60	87 44 54.25
e Royer-Bennett..........	34 00 03.35	−.56	−1.30	34 00 01.49
Sum.................=	121 44 60.76		....	121 44 55.74
h Township cor. Bennett..	121 44 59.05	+.59	−3.90	121 44 55.74
	+1.71	....	....	00.00
f Bennett—Dunkard.......	61 09 26.17	+.02	+4.67	61 09 30.86
g Dunkard—Newt..........	97 33 28.39	−.49	+7.40	97 33 35.30
c Newt—Township cor...	79 32 06.25	+.02	−8.17	79 31 58.10
h Tp. corner.—Bennett....	121 44 59.05	+.59	−3.90	121 44 55.74
Sum..................=	359 59 59.86	....	....	360 00 00.00
	−0.14	....	....	00.00

Of these $a + b$ should $= g$, $d + e$ should $= h$, and $g + c + h + f$ should $= 360°$. Thus are formed in this case three conditions affecting eight unknown quantities. The method by which are found the

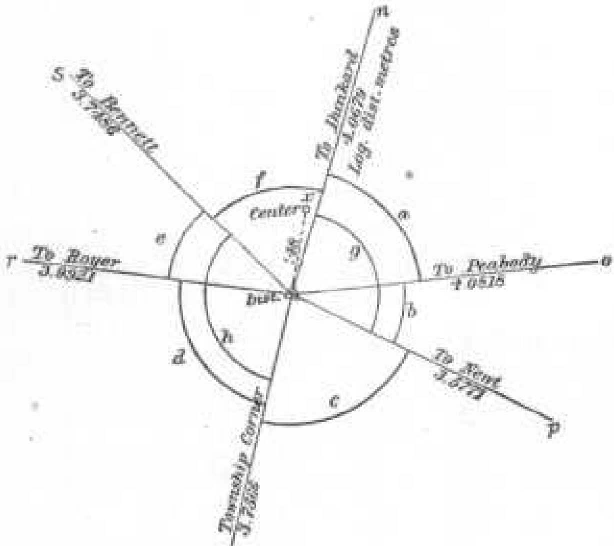


FIG. 23.

corrections which fulfill these conditions is that known as the method of Least Squares. It is unnecessary to explain the theory of this method, but only to show how it is applied in the class of cases under consideration, which can best be done by tracing a case through. There are here three equations of conditions, as follows:

$$(1)\ a + b - g - 1''.52 \qquad = 0$$
$$(2)\ d + e - h + 1''.71 \qquad = 0$$
$$(3)\ f + g + c + h - 0''.14 = 0$$

in which the letters represent, not, as in the diagram, angles, but unknown corrections to the angles. The coefficient of each of these corrections is unity. Arrange them in tabular form, the numbers at the top referring to the equations, thus forming what is called a table of correlates. Now multiply each coefficient by itself and every other in the same horizontal line, and sum them. There result three normal equations, as follows:

	w	y	z
a	1		
b	1		
c			1
d		1	
e		1	
f			1
g	−1		1
h		−1	1

$$1\quad +3.00w \qquad\qquad -1.00z - 1''.52 = 0$$
$$2\quad +3.00y - 1.00z - 1''.71 = 0$$
$$3\quad -1.00w - 1.00y + 4.00z - 0''.14 = 0$$

These three equations involving three unknown quantities, are then solved by elimination, with results as follows:

$$w = +.515''$$
$$y = -.562$$
$$z = +.023$$

These values can now be substituted in the table of correlates, columns 1, 2, 3; the algebraic sum of lines *a*, *b*, *c*, *d*, etc., giving corrections to the angles *a*, *b*, *c*, *d*, etc.

	1	2	3	Corrections to angles. ″
a	+.515			+.515
b	+.515			+.515
c			+.023	+.023
d		−.562		−.562
e		−.562		−.562
f			+.023	+.023
g	−.515		+.023	−4.92
h		+.562	+.023	+.585

FIGURE ADJUSTMENT.

The measurement of the angles having been executed by instruments and methods much better than the needs of the map require, it is not ordinarily necessary to make any figure adjustment, further than an equal distribution of the error of each triangle among the three angles.

Still, as the necessity for a more elaborate adjustment may arise, a description of the method of applying the least square adjustment to geometric figures in triangulation is here given, with a simple example of its application.

Each geometric figure in a system of triangulation is composed of a number of triangles. The measured angles of each triangle should equal 180° plus the spherical excess. Each triangle, therefore, furnishes an equation of condition, which is known as an angle equation.

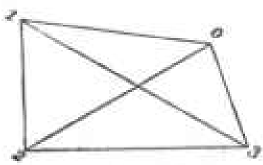


Fig. 24.

The number of angle equations in any figure is equal to the number of closed triangles into which it can be resolved. But since certain of these are a consequence of the others, the number of angle conditions which it is desirable to introduce is less than the number of triangles.

The number of angle equations in any figure is equal to the number of closed lines in the figure plus one, minus the number of stations. Thus, in a closed quadrilateral, the number of angle equations is $6 + 1 - 4 = 3$.

There is another class of conditions, known as side equations, which can be best explained by reference to a figure. In the example, Fig. 24, suppose the figure 0, 1, 2, 3 to represent the projection of a pyramid, of which 1, 2, 3 is the base and 0 the apex. A geometric condition of such figure is that the sums of the logarithmic sines of the angles about the base, taken in one direction, must equal the similar sums taken in the other direction, *i. e.* the product of the sines must be equal. In the present case, log. sin 0, 1, 2 + log. sin 0, 2, 3 + log. sin 1, 3; 0 should equal log. sin 1, 2, 0 + log. sin 2, 3, 0 + log. sin 0, 1, 3.

The number of side equations which can be formed in any figure is equal to the number of lines in the figure, plus 3, minus twice the number of stations in it or $l + 3 - 2n$. In a quadrilateral, $6 + 3 - 8 = 1$.

The numerical term in each angle equation is the difference between the sum of the observed angles on the one hand and 180° + the spherical excess on the other. This is positive when the sum of the observed angles is the greater, and vice versa. The coefficients of the unknown corrections are in each case unity, unless weights are assigned.

The numerical term in each side equation is the difference between the sums of the logarithmic sines, taken in the two directions. The coefficients of the unknown corrections are the differences for one second, in the logarithmic sines of the angles.

The method of making up and solving these equations and applying the corrections to the angles can best be shown by means of an example. That here given is the simplest case involving both angle and side equations, namely, the case of a quadrilateral. The method of forming correlatives and normal equations, and their solution, is similar to that employed in station adjustment, and therefore the details are omitted.

In the equations of conditions and correlatives, the angles are designated by directions, to which the corrections are finally applied. Thus the angle of 302 is designated as — 3/0 + 2/0, the sign — being given to the left-hand and the sign + to the right-hand direction.

Example of figure adjustment by least squares.

		Observed angles.		
		°	′	″
(a)	3.0.1	120	39	14.781
	0.1.3	21	26	17.806
	1.3.0	37	54	37.180
		180	00	09.767
	Spherical excess			= — 0.148
	Closure error			+ 9.619
(b)	0.1.2	81	52	51.222
	1.2.0	62	22	38.500
	2.0.1	35	44	45.861
		180	00	15.583
				— 0.189
	Closure error			+15.394

Observed angles.

		°	′	″
	1.2.3	91	28	38.000
	2.3.1	28	95	10.360
	3.1.2	60	26	33.416
		180	00	21.776
				− 0.234
Closure error			+	21.542
(c) ...	2.3.0	65	59	47.540
	3.0.2	84	54	28.920
	0.2.3	29	05	59.500
		180	00	15.960
			−	0.193
Closure error			+	15.767

Side equation.

[Taking 0 as the pole.]

	Angle	Log. sines of spherical angle.	Tabular differ-ence for 1″.	Correc-tions to log. sines.	Corrected log. sines of spherical angles.	Spher-ical excess.	Log. sines of plane angles.
(d)	0.1.2.........	9.9956249.7	+3.0	−25.0	9.9956224.7	−.063	9.9956224
	0.2.3.........	9.6869340.0	37.9	−127.9	9.6869212.1	−.065	9.6869210
	1.3.0.........	9.7884705.9	27.0	−1.2	9.7884704.7	−.050	9.7884703
	Sum.....=	29.4710295.6			29.4710141.5		29.4710137
	1.2.0.........	9.9474437.5	11.0	−59.4	9.9474378.1	−.063	9.9474378
	2.3.0.........	9.9607184.9	9.4	−77.7	9.9607107.2	−.064	9.9607107
	0.1.3.........	9.5628859.2	53.7	−203.0	9.5628656.2	−.049	9.5628653
	Sum.......	29.4710481.6			29.4710141.5		29.4710137
	From above...	29.4710295.6					
	Difference..	00.0000186.0			000.0		0000.

(d) ....0 = + 186.0 − 3.0 $(\frac{0}{1})$+03.0 $(\frac{2}{1})$−37.9 $(\frac{0}{2})$+37.9 $(\frac{3}{2})$−27.0 $(\frac{1}{3})$+27.0 $(\frac{0}{3})$.
−[−11.0 $(\frac{1}{2})$+11.0 $(\frac{0}{2})$− 9.4 $(\frac{2}{3})$+ 9.4 $(\frac{0}{3})$−53.7 $(\frac{0}{1})$+53.7 $(\frac{3}{1})$.]

Equation of conditions.

(a)..0 = + 9″.619 $- \frac{3}{0} + \frac{1}{0} - \frac{0}{1} + \frac{3}{1} - \frac{1}{3} + \frac{0}{3}$

(b) ....0 = + 15 .394 $- \frac{0}{1} + \frac{2}{1} - \frac{1}{2} + \frac{0}{2} - \frac{2}{0} + \frac{1}{0}$

(c)..0 = + 15 .767 $- \frac{2}{3} + \frac{0}{3} - \frac{3}{0} + \frac{2}{0} - \frac{0}{2} + \frac{3}{2}$

Collecting terms in (d) and dividing through by 100 so as to avoid dealing with large numbers.

(d) ....0 = + 1.86 + .507 $(\frac{0}{1})$ + .030 $\frac{2}{1}$ − .489 $(\frac{0}{2})$ + .379 $(\frac{3}{2})$ − .270 $(\frac{1}{3})$.
+ .176 $(\frac{0}{3})$ + .110 $(\frac{1}{2})$ + .094 $(\frac{2}{3})$ − .537 $(\frac{3}{1})$.

Table of correlatives.

Direc-tion.	*a.*	*b.*	*c.*	*d.*
0/1	−1	−1	....	+.507
0/2	....	+1	−1	−.489
0/3	+1	....	+1	+.176
1/0	+1	+1	....	....
1/2	... .	−1	....	+.110
1/3	−1	....	....	−.270
2/0	....	−1	+1	....
2/1	....	+1	....	+.030
2/3	....	....	−1	+.094
3/0	−1	....	−1	....
3/1	+1	....	....	−.537
3/2	....	....	+1	+.379

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Forming the normal equations in the usual manner, we have:

	″				
(a)	0=+ 9.619	+6.000	+2.000	+2.000	−0.598
(b)	0=+15.394	+2.000	+6.000	−2.000	−1.076
(c)	0=+15.767	+2.000	−2.000	+6.000	+0.950
(d)	0=− 1.860	−0.598	−1.076	+0.950	+1.054

Solving: we find the following values:

$$a = +1.900''$$
$$b = -4.386$$
$$c = -5.208$$
$$d = +3.059$$

Substituting the values of a, b, c, d, in the table of correlatives.

Direction.	A.	B.	C.	D.	Correction to each direction. ″
$\frac{0}{1}$	−1.900	+4.386	....	+1.551	+4.037
$\frac{0}{2}$	....	−4.386	+5.208	−1.496	−0.674
$\frac{0}{3}$	+1.900	....	−5.208	+0.538	−2.770
$\frac{1}{0}$	+1.900	−4.386	....	....	−2.486
$\frac{1}{2}$	....	+4.386	....	+0.336	+4.722
$\frac{1}{3}$	−1.900	....	....	−0.826	−2.726
$\frac{2}{0}$	....	+4.386	−5.208	....	−0.822
$\frac{2}{1}$	....	−4.386	....	+0.092	−4.294
$\frac{2}{3}$	....	....	+5.208	+0.288	+5.496
$\frac{3}{0}$	−1.900	....	+5.208	....	+3.308
$\frac{3}{1}$	+1.900	....	....	−1.643	+0.257
$\frac{3}{2}$	....	....	−5.208	+1.159	−4.049

	Observed angles.			Corrections.	Corrected spherical angles.			Sph. excess.	Plane angles.		
	°	′	″	″ ″	°	′	″	″	°	′	″
3.0.1	120	39	14.781	−3.308−2.486	120	39	08.986	−.049	120	39	08.94
0.1.3	21	26	17.806	−4.037+0.257	21	26	14.026	−.049	21	26	13.98
1.3.0	37	54	37.180	+2.726−2.770	37	54	37.136	−.050	37	54	37.08
					180	00	00.148	−.148	180	00	00.00
0.1.2	81	52	51.222	−4.037−4.294	81	52	42.891	−.063	81	52	42.83
1.2.0	62	22	38.500	−4.722−0.674	62	22	33.104	−.063	62	22	33.04
2.0.1	35	44	45.861	+0.822−2.486	35	44	44.194	−.063	35	44	44.13
					180	00	00.189	−.189	180	00	00.00
1.2.3	91	28	38.000	−4.722−4.049	91	28	29.229	−.078	91	28	29.15
2.3.1	28	05	10.360	−5.496−2.726	28	05	02.138	−.078	28	05	02.06
3.1.2	60	26	33.416	−0.257−4.294	60	26	28.865	−.078	60	26	28.79
					180	00	00.232	−.234	180	00	00.00
2.3.0	65	59	47.540	−5.496−2.770	65	59	39.274	−.064	65	59	39.21
3.0.2	84	54	28.920	−3.308−0.822	84	54	24.794	−.064	84	54	24.73
0.2.3	29	05	59.500	+0.674−4.049	29	05	56.125	−.065	29	05	56.06
					181	00	00.193	−.193	180	00	00.00

For a full discussion of the Method of Least Squares and its application to triangulation see "A Treatise on the Adjustment of Observations, by T. W. Wright, B. A.," pp. 250–370. New York. D. Van Nostrand. 1884.

COMPUTATION OF DISTANCES.

In each triangle, starting with the base line, there is known at least one side and the three angles. The remaining sides are computed by the well-known proportion of sides to sines of opposite angles, or expressed mathematically, $a = \frac{b \sin A}{\sin B}$. In this computation distances should be used in meters, and seven place logarithms should be employed.

The following is an example of the correction of the angles and the computation of the sides of triangles taken from the work in Kansas:

Station.	Angles locally adj. and reduced to center.	⅓ error.	Plane angles.	Log sines.
	° ′ ″	″	° ′ ″	
Township corner......	36 29 04.0	+.5	36 29 04.5	0.2257704
Newt..................	63 58 56.2	+.6	63 58 56.8	9.9535952
Walton................	79 31 58.1	+.6	79 31 58.7	9.9927124
	179 59 58.3			
	Error = −1.7			

Log dist. Newt-Walton	3.5771611
Log sin Newt..	9.9535952
a. c. log sin Township corner	0.2257704
Log dist. Township corner—Walton	3.7565267
Log dist. Newt-Walton	3.5771611
Log sin Walton	9.9927124
a. c. log sin township corner	0.2257704
Log dist. Township corner—Newt	3.7956439

COMPUTATION OF GEODETIC COÖRDINATES.

The next step is the computation of the latitude and longitude of the stations and the azimuth or direction of the lines connecting them. Initially, the latitude and longitude of some point is determined by astronomical observations, and this point is connected with the triangulation. The azimuth, or angle with a south line, of a line connecting this point with some station in the triangulation is also determined by astronomical observations. These, with the observed angles and the computed distances between the stations, form the data from which the latitudes and longitudes of the stations and the azimuths of the lines connecting them are computed. The difference in latitude between two adjoining stations is obtained from the following equation, based upon the Clarke spheroid:

$$-dL = K \cos a' B + K^2 \sin^2 a' C + (dL)^2 D - hK^2 \sin^2 a' E,$$

in which

dL is the difference in latitude.

K, the distance between the stations in meters.

a', the fore azimuth of the line connecting them, measured round clock-wise from the south through the west.

h, the first term.

δL, the approximate difference in latitude, being the sum of the first two terms.

B, C, D, and E, constants derived from the dimensions and figure of the earth.

The difference in longitude is obtained by means of the following formula:

$$dM = \frac{K \sin a' A'}{\cos L'}$$

in which

dM is the difference in longitude.

L', the newly determined latitude.

A', a constant, from tables in Appendix 7, Report U. S. Coast and Geodetic Survey for 1884, and the others as above.

The azimuths at the two ends of a line differ from one another, on account of the convergence of the meridians. That first determined is known as the fore azimuth, the other, the back azimuth. All azimuths are measured from the south point around to the right.

The back azimuth is computed from the formula:

$$-da = dM \frac{\sin \frac{(L + L')}{2}}{\cos \frac{1}{2} dL}$$

where M is the longitude of the first station.

L, the latitude, and

L' the latitude of the second station.

The constants used are those of the Clarke spheroid of 1866.

These formulæ are derived and explained in Appendix No. 7, Report U. S. Coast and Geodetic Survey for 1884.

The following are examples of the use of the formulæ, taken from the triangulation in New Mexico:

		°	′	″
Azimuth a:	Nell—Chusca.	159	29	08.728
Spherical angle:		120	54	13.980
Azimuth a′:	Nell—Zuni.	38	34	54.748
δ a + 180°		179	50	02.124
Azimuth (a):	Zuni—Nell.	218	24	56.872

GEODETIC COÖRDINATES.

LATITUDE.	°	′	″		LONGITUDE.	°	′	″
L:	35	25	13.443	Nell.	λ:	108	37	24.025
δ L		—17	47.546	Geo. Pos. No. 5.	$\delta\lambda$	+	17	15.360
L′	35	07	25.927	Zuni.	λ'	108	54	40.285
				Geo. Pos. No. 6.				

Computation for latitude:

log. K	4.6236305
" B	8.5111933
" cos a′	9.8930500
log (I)	3.0278738
log. K²	9.24726
" C	1.25696
" sin² a′	9.58986
log. (II)	0.09408
log. D	2.3679
" [I + II]²	6.0568
log. (III)	8.4247
log. E	6.0124
" K²sin²a′	8.8371
" (I)	3.0279
log. (IV)	7.8774

	″
(I)	1066.286 +
(II)	1.242 +
(III)	.026 +
(IV)	.008 —
—δL	1067.546 +

[I + II]		1067.528
log. "		3.0283792
" [I + II]²		6.0567584

Check:
Spher. angle
at

Computation for longitude:

log. K	4.6236305
" sin a′	9.7949286
" A′	8.5092394
" sec. L′	0.0872944
Corr. for diff. arc & sin =	—15
log. (V)	3.0150914
	″
$\delta\lambda$	1035.360

Computation of azimuth:

log. (V).	3.015091
" sin $\left(\frac{L + L'}{2}\right)$	9.761522
" sec $\left(\frac{\delta L}{2}\right)$	0.000001
log. (VI)	2.776614
δ a	— 597″.876
	— 9′ 57″.876

Azimuth check.

Computation of Azimuth a, in Book , page .
Spherical angle and distance = K, in Book , page, Triangle No.
Station: Computed by

		°	′	″
Azimuth a:	Chusca—Nell.	339	21	40.150
Spherical angle:		25	11	38.601
Azimuth a′:	Chusca—Zuni.	4	33	18.751
δ a + 180°		179	57	25.650
Azimuth (a):	Zuni—Chusca.	184	30	44.401

GEODETIC COÖRDINATES.

LATITUDE.					LONGITUDE.			
	°	′	″			°	′	″
L:	35	53	06.746	Chusca Geo. Pos. No. 4.	λ:	108	50	14.518
δ L	—	45	40.818		δλ		+ 4	25.768
L′	35	07	25.928	Zuni. Geo. Pos. No. 6.	λ′	108	54	40.28

Computation for Latitude:

log. K	4.9280539
" B	8.5111594
" cos a′	9.9986260
log. (I)	3.4378393
log. K^2	9.85610
" C	1.26435
" $\sin^2 a'$	7.79982
log. (II)	8.92027
log. D	2.3703
" $[I+II]^2$	6.8757
log. (III)	9.2460
log. E	6.0214
" $K^2 \sin^2 a'$	7.6559
" (I)	3.4378
log. (IV)	7.1151

(I)	2740″.560+
(II)	.083+
(III)	.176+
(IV)	.001—
—δ L	+2740.818

[I+II]	2740 643
log. "	3.4378525
" $[I+II]^2$	6.875705

Computation for longitude:

log. K	4.9280539
" sin a′	8.8999280
" A′	8.5092394
" sec. L′	0.0872944
Corr. for diff. arc & sine	—129
log. (V)	2.4245028
δλ	+265″.768

Computation of azimuth:

log. (V)	2.424503
" $\sin\left(\frac{L+L'}{2}\right)$	9.764002
" $\sec.\left(\frac{\delta L}{2}\right)$	0.000009
log. (VI)	2.188514
δ a	— 154″.350
	—2′ 34″.350

Azimuth check:

	°	′	″
	218	24	56.872
	184	30	44.401
Check:	33	54	12.471
Spher. angle at Zuni.	33	54	12.469

Computation of Azimuth a, in Book 67, page 4.
Spherical angle and distance = K, in Book 64, page 12, Triangle No. 3.
Station; Computed by H. M. W.

When the lines are not more than twenty miles in length, the equation for latitude may be simplified without appreciable error by dropping the last two terms.

TRAVERSE LINES FOR PRIMARY CONTROL.

In level country, especially if it is covered with forests, it is very expensive to carry on triangulation, and in some cases practically impossible to do so. Under such circumstances the only means of obtaining an adequate control for maps is by means of traverse lines.

A traverse line consists of a series of direction and distance measurements. Each course, as the direction and the accompanying distance are called, depends upon the one immediately preceding it, and a continuous chain is thus formed. Traverse lines are largely used in the topographic work proper for making minor locations. The primary traverse differs from these only in the fact that it is much more elaborately executed.

The initial point of a primary traverse must be located either by triangulation or by astronomic determinations. The end of the line should, if possible, be a point similarly well located. The line should, if practicable, follow a railroad, in order to obtain the easiest possible grades, and thus avoid errors incident to slope.

The instrument used for measuring directions should have a circle 6 to 8 inches in diameter, and should read by vernier to 10 seconds. A larger or more elaborate instrument is not advisable on account of the difficulties of transporting it and frequently setting it up. Upon short lines instruments reading to minutes may be used.

The readings should be upon signals consisting of poles, and fore and back rodmen must be employed for carrying and setting them. The angular measurements between the poles should be read by both verniers, and it is advisable to note the compass readings at the same time, in order to avoid gross errors. At intervals of 10 to 20 miles, depending upon the number of courses to a mile, observations should be made for azimuth, observing for this purpose upon the pole star, preferably at elongation.

The measurements of distance are effected by the use of steel tapes, and preferably by 300-feet tapes, similar to those used in measuring base lines. Two chainmen should be employed, and in order to avoid errors in the count, it is well to count the rails, in case the work is done upon railroad tracks.

The temperature should be noted by means of thermometers at frequent intervals, in order that the proper corrections may be applied.

The errors incident to running primary traverses are of two classes: errors of direction and errors of distance.

Those of direction are similar to those treated of under the head of Instructions for the Measurement of Horizontal Angles, and need not be specified here.

Owing to the necessity of setting up the theodolite at frequent intervals, it is impracticable to observe at each station the series of angles specified in the above-mentioned instructions, and only a single or at the most a double measure of the included angle, with the reading of each vernier, is practicable for the measurement of direction. It is here provided that observations for azimuth upon Polaris should be much more frequent than in triangulation, and thus an absolute correction to the directions is introduced much oftener. At each azimuth station the new astronomic azimuth should be adopted in place of that carried forward, and in case the discrepancy between the two is sufficiently great to involve perceptible error upon the scale of the map, the correction should be uniformly distributed forward from the first station.

In running these traverses all road crossings should be located, as topographic traverses will be run over the roads and will be connected with the primary traverses at these points. All prominent houses or natural features of any kind in sight from the line must be located by intersection, as they will doubtless be used by the topographers for location.

Lines of traverse exceeding 100 miles in length should be reduced by computation. The distances should be corrected for error of tape, for temperature, and slope, and should be reduced to sea level, in the same manner as above described in treating of the reduction of base lines, in case these corrections are of sufficient amount to affect the length appreciably upon the map.

The courses should be corrected for convergence of meridians. Then, commencing at the initial point, the latitude and departure of each station, one from another, should be computed in feet. The sum of the latitudes converted into seconds of latitude gives the difference in latitude, and the sum of the departures converted into seconds of longitude gives the difference in longitude.

Short lines of traverse may be platted with minute reading protractors, but in this platting the utmost care should be exercised.

Primary Elevations.

Initial elevations may be derived from various sources or may be assumed. Any trustworthy results known to be of a sufficient degree of accuracy for the purpose may be adopted, such as those of the United States Coast and Geodetic Survey or the United States Lake Survey.

Where these determinations are not available, initial bench marks may be obtained from the profiles of railroads. These have been adjusted and the results published in the Dictionary of Altitudes (Bulletin No. 76, U. S. Geological Survey). In case there are no railroads to furnish initial datum points, as may occur in the sparsely settled regions of the West, or the profiles available are regarded as untrustworthy, it may become necessary to use barometric observations. Where a series of these of a year or more in length is available, the result may be regarded as sufficiently trustworthy for this purpose.

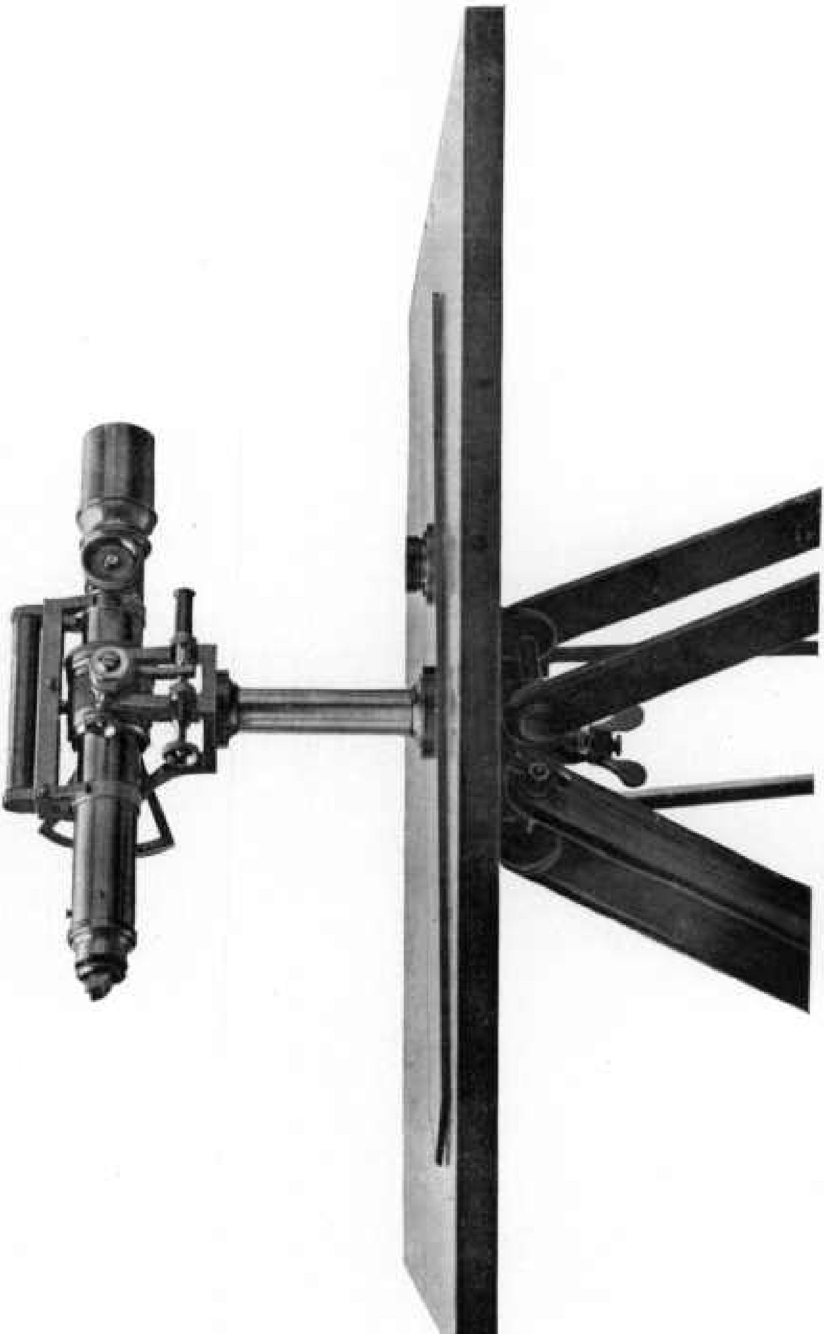
In regions where secondary triangulation is practicable the measurement of heights may be taken up with the plane table directly from datum points, as above indicated, and carried throughout the work by means of this instrument. Otherwise it becomes necessary to do more or less leveling in order to extend and multiply datum points to control the less accurate work connected with the traversing. If practicable, the wye level should be employed.

The extent of the work of the wye level which may be required depends mainly upon the contour interval of the map to be made. It may be said in general, that a single line across a sheet will furnish a sufficient number and a suitable distribution of points for the proper correction of the subsequent work. Wherever practicable such lines should be run along railroads, in order to obtain easy grades and thus lighten the work. When railroads are not available, they should be run along wagon roads, selecting, so far as they will suit the purpose, those having the easiest grades and the straightest courses.

Where the control of the map is effected by means of primary traversing, such traverse should be accompanied by a level line, unless that of the railroad which the traverse follows appears to be of sufficient accuracy.

Secondary Triangulation.

The work of making secondary locations by intersection is done mainly by plane table. The use of the theodolite for this purpose is



JOHNSON PLANE-TABLE.

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restricted to those cases where but little of this kind of location can be effected, and where, therefore, it seems scarcely worth while to prepare plane-table sheets.

By means of the primary triangulation, two or three points are usually located upon each plane-table sheet. Within this primary triangulation, and depending upon it, are then located a large number of points, either by intersection, by traverse, or by both methods, forming a geometric framework upon which the sketching of the map depends.

Location by intersection should be carried as far as practicable—that is, all points capable of being located in this manner should be so located in order to afford the most ample control possible for the traverse lines, by which the intervening areas are to be filled in, it being understood that location by intersection is more accurate and more rapid, and consequently in every way more economic, than location by traverse.

THE PLANE TABLE.

Much misapprehension exists, especially in this country, regarding the character and application of this instrument. This arises, apparently, from the fact that it is little known. For making a map the plane table is a universal instrument. It is applicable to all kinds of country, to all methods of work, and to all scales. For making a map it is the most simple, direct, and economic instrument; its use renders possible the making of the map directly from the country as copy, and renders unnecessary the making of elaborate notes, sketches, photographs, etc., which is not only more expensive, but produces inferior results.

The plane table is essentially very simple, consisting of a board upon which is fastened a sheet of drawing paper. This board is mounted upon a tripod, which, in the more elaborate forms of the instrument, possesses great stiffness and stability. It should be capable of being leveled, of being turned in azimuth, and of being clamped in any position. Upon the paper is produced directly in miniature a representation of the country. When set up at various places within the area in process of being mapped, the edges of the board must always be placed parallel to themselves—that is, a certain edge of the board must always be set at the same angle with the north and south line. This is called orienting the board.

Directions are not read off in degrees and minutes, but platted directly upon the paper. The instrument used for this purpose is known as the alidade, and consists of a ruler with a beveled edge, to which are attached for rough work two raised sights, and for the higher class of work a telescope turning on a horizontal axis. This telescope carries also a delicate level and a vertical arc for the measurement of angles in the vertical plane, from which relative heights are obtained. The method of using this instrument is extremely simple in principle, and becomes difficult in practice only when a high degree of accuracy is required.

The work of making locations from intersections obtained by means of the plane table requires that the instrument have the utmost stability consistent with lightness and portability. It requires an alidade equipped with a telescope of considerable power and good definition. In short, it requires that the plane table be in every respect of the best modern type in order that the highest degree of accuracy possible to represent upon the paper be attained. Various forms of plane-table movement are in use, including the heavy and cumbersome but stable movement of the U. S. Coast and Geodetic Survey, and the light but unstable movement used by the same organization in its less important work. That form which is now in most general use was invented by Mr. W. D. Johnson, which combines the elements of stability, lightness, and facility of operation in a remarkable degree. (Plate XLI.) This movement is essentially an adaptation of the ball-and-socket principle, so made as to furnish the largest practicable amount of bearing surface. It consists of two cups, one set inside the other, the inner surface of one and the outer surface of the other being ground so as to fit accurately to one another. The inner cup is in two parts, or rather consists of two rings one outside the other, the one controlling the movement in level and the other that in azimuth. From each of these rings there projects beneath the movement a screw, and upon each of these screws is a nut edge to suit the scale of work, and carrying upon a column a telescope having a focal distance of 12 to 15 inches and a power of about 15 diameters. It has a vertical arc reading by vernier to single minutes, and a delicate level upon the telescope. In some alidades there is an adjustment to make the zeros of the vertical arc and the vernier coincide, when the telescope is horizontal, while in others it is necessary to read the index error of the vertical arc and correct for it, there being no such adjustment. The telescope turns in a sleeve for adjustment of vertical collimation.

Upon the plane-table sheet is constructed a projection upon the scale of the field work, and upon that are platted such of the primary points as fall upon the sheet. These primary points are first occupied by the plane tabler.

The instrument is set over one of these stations, leveled, and clamped. The ruler edge of the alidade is then laid upon the line connecting this station with a neighboring one upon the sheet, and the table turned until the other station is upon the vertical wire in the telescope. The instrument is then oriented, and, after clamping in azimuth, is ready for work. Keeping the ruler upon the occupied station on the sheet, the telescope is then turned upon other objects which it is desirable to locate, and lines are drawn, in turn, toward them. The instrument is then taken up and moved to a second station, where it is again set up, leveled, and oriented, as before. A sight is then taken, and a line drawn in the direction of each point sighted from the first station, and the intersection of each pair of sight lines is the true position of the corresponding point upon the map. In this way, station after station is occupied by the plane table, and numerous points are located by intersection. If possible, each point thus located should be intersected from at least three stations in order to verify its location.

Any point located on the map may be used afterward as a station. For the location of points which have not been fixed many different methods have been proposed, all of which are graphic solutions of the three-point problem. Probably the simplest and easiest of application is the following. This requires that three located points be visible, and that their distances be approximately known.

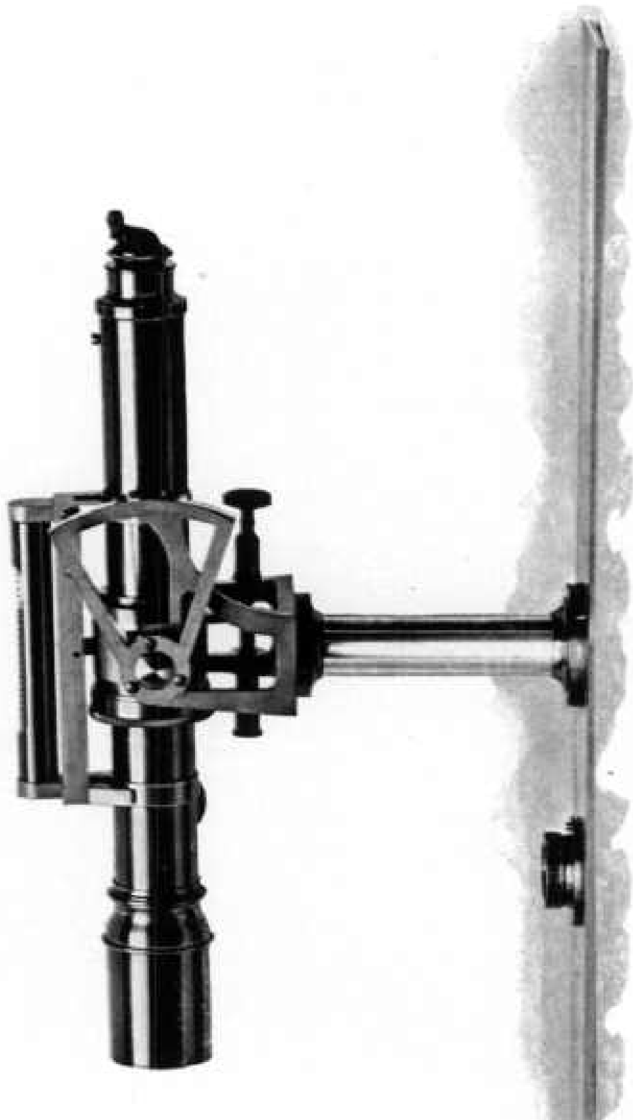
by which it is clamped. There is no tangent screw for either the leveling or the azimuth motion, as none is required. The movement is sustained by a light hard-wood tripod with split legs. The board used generally accommodates a full atlas sheet, but necessarily differs in size, owing to the different scales of field work adopted. The largest board used for this movement holds an atlas sheet upon a scale of 1:45000, and is 24 by 36 inches in size.

The question of paper for the plane-table sheets, especially in intersection work, is of great importance, as paper which expands and contracts differently in different directions under varying conditions of moisture will easily produce errors of magnitude in the work. It matters little if the paper contracts and expands, provided it does so uniformly in all directions, but all paper is made with more or less fiber, and accordingly expands and contracts more in one direction than in another. To counteract this, two thicknesses of paper are used, preferably that known as Paragon paper, mounted with the grain of the two sheets at right angles to one another, and with cloth between the layers. In sheets so prepared it has been found that there is practically no distortion, even under the most severe tests.

The board is generally made of seasoned white pine, from one-half to five-eighths of an inch thick, with cleats across the ends fastened in such a way as to allow the body of the board to contract and expand freely, and therefore without warping. Into the corners of this board and on the edges at points half-way between the corners are set female screws for holding the paper to the board. At corresponding points in the plane-table sheet are punched holes half an inch in diameter which are lined with eyelets, through which pass screws with broad heads fitting into the female screws in the board. The holes in the paper, being larger than the screws, allow the paper to expand or contract freely when the screws are loose. When tightened, the broad heads of the screws bind the paper firmly in place.

THE ALIDADE.

The alidade used with this plane table consists of a ruler of brass or steel 18 inches to 2 feet in length, graduated upon a chamfered



TELESCOPIC ALIDADE.

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Set up, level and clamp the instrument in level and azimuth, after orienting it as nearly as possible. Set the alidade successively on the three points and drawn lines from their platted positions. Then the desired location will be found at a distance from each of these lines, measured at right angles to it, proportional to the distance on the ground between the point occupied and the known point. Thus the point of intersection of these lines at right angles to the lines of sight, is the desired position. Were the distances from the known points to the occupied point accurately known, its position on the paper would be obtained at the first trial. Practically, however, two or three approximations are commonly found necessary.

Another method often used is as follows:

Fasten upon the plane-table board, which necessarily has not yet been oriented, a piece of tracing linen, or, in default of that, a piece of tracing paper. Assume a point upon this linen to represent the station, take sights upon, and draw lines to all located points within the range of vision, and then, loosening the linen from the board, move it about over the map until these sight lines fall upon the proper points upon the map. Then prick through the position of the station from the linen to the map underneath. This location should then be tested by sighting from the point thus found to various objects to see if the sight lines fall upon the points as marked upon the map. This method has the advantage of permitting the use of all located points which may be in sight, but it is not regarded as being as accurate as the method first described.

In case one line of sight upon the required station has been obtained, that sight line may be utilized in making the location as follows by resection: Having leveled the table, place the alidade upon this sight line already drawn, with the telescope pointing toward the object from which the sight was taken. Then turn the table in azimuth until the telescope falls upon this point, and clamp it. The table is now oriented, but the position of the present station is unknown further than that it is known to be upon this line. Then select some station whose direction makes a wide angle with this line, and move the alidade until the cross wire falls upon this selected station, while the ruler at the same time is upon the representation of the station upon the map. The ruler will then cross the sight line at the point desired. By way of check, repeat the process with another station or located point. For this purpose a point in suitable direction is valuable in proportion to its proximity.

Using the instrument as described above, the topographer locates from them all possible points. Then visiting in turn such of them as he finds necessary, perhaps a dozen or twenty, he locates by intersection points all over the sheet in as great number and as well distributed as possible, and with special reference to the needs of the traverse men, who will come after him and whose work will be located by means of his determinations. All this work must be done with the utmost nicety and precision. The setting of the alidade upon the station must bisect the needle hole by which it is marked and the lines of direction must be drawn with a sharp-pointed pencil.

The necessity for precision will be recognized when it is understood that any error introduced in the early part of the plane-table triangulation will be not only perpetuated, but increased many times over as the work progresses, and as soon as an error becomes appreciable it produces difficulties and uncertainties in making locations, which may lead to embarrassing delays, and ultimately require that all the work be repeated.

Measurement of Altitudes.

While making horizontal locations of points with the plane table, their heights must also be measured, relative to that of the point occupied. This is done by means of the vertical arc of the alidade and the level upon the telescope. Pointing upon the object whose relative height is to be measured, the telescope must first be brought to a horizontal position. In case the vertical arc is movable, its zero must then be brought to the zero of the vernier. In case it is not movable, the index error, with its sign, must be read. The telescope is then raised or depressed to the point and the reading obtained. This adjustment of the vertical arc or reading of the index error must be done for each point, as the table cannot be leveled with sufficient accuracy, or cannot be expected to maintain its level, so as to dispense with it. Knowing the horizontal distance to the point and the angle of elevation and depression, the difference in height is obtained by the solution of a right-angled triangle, thus:

$$h = d \text{ tang } a,$$

h being the difference in height, d the distance, and a the angle of elevation or depression. This distance is then to be corrected for curvature of the earth and for refraction by the atmosphere. The correction for the former is obtained with sufficient accuracy by the following empirical rule. The curvature in feet equals two-thirds the square of the distance in miles. It is always positive in sign, whatever may be the sign of the difference in height.

Refraction is an uncertain and variable quantity. It is usually greatest at morning and night and least at midday. It is greater the nearer the line of sight is to the ground. Often in desert regions it is excessive in amount. It is usually assumed at one-seventh the curvature, and is negative.

Tables for the solution of vertical angle work are appended to a previous work by the author (Mono. XXII, U. S. Geol. Surv.). These give differences in height for all angles and distances which should be employed, with corrections for curvature and refraction.

Differences of height should not be measured at greater distances than 10 miles, if it can be avoided. An error of 1′ in the measurement of the angle is at this distance about 15 feet, while the uncertainty of refraction in such a length of line is necessarily great.

Traverse Work.

As stated above, under the head of primary traverses, a traverse line consists of a series of direction and distance measurements depending upon one another. These lines should be connected wherever possible with triangulation points in order to check up accumulated errors. If it were practicable or economic to carry on all the work of location by intersection, this would be the most accurate and on most accounts the best way to effect it, but it is only in limited localities, such as high mountain regions, where bold topographic forms predominate and where there is little or no culture, that the method of intersection is practicable for locating all necessary points.

For executing traverse work various instruments are in use for measuring both distances and directions. For direction there are used theodolites of various forms and prismatic compasses and for distances the stadia, chain, tape and the wheel.

All traverse work should be done with plane tables, upon which the directions and distances are platted directly. The Johnson plane table, with telescopic alidade, may be used for this work. When so used, a compass should be set in the edge of the board, for orienting, as orientation by back sighting is not sufficiently accurate. Another plane table convenient for this purpose is of the simplest possible form, consisting of a board about 15 inches square, into one edge of which is set a narrow box containing a compass needle 3 inches in length. This table is supported by a tripod of light construction, without leveling apparatus, the leveling of the instrument being effected with sufficient accuracy by the tripod legs. A single screw fastens the board to the tripod head and the adjustment in azimuth is made by simply turning the board with the hand. It is held in place by friction. The table is adjusted in azimuth, or oriented, by means of the compass needle—that is, it is turned until the needle rests opposite the zero marks in the compass box, and is thus always made approximately parallel to itself, provided the magnetic declination remains constant.

The alidade consists of a brass ruler, 12 inches long, with folding sights. The edge of the ruler is graduated to facilitate platting of distances. Ordinary drawing paper backed with cloth is used for plane-table sheets, and is attached to the board by thumb tacks.

When traversing is done along roads, as is commonly the case, distances are measured by counting the revolutions of a wheel, usually one of the front wheels of a buggy or buckboard. For counting the revolutions, various automatic devices have been in use. The old form of odometer known as the pendulum was first tried and was unqualifiedly condemned. The form now in general use was devised by Mr. E. M. Douglass of the U. S. Geological Survey. See Fig. 25.

For operating this a cam is placed on the hub of the wheel, which by raising a steel spring as the wheel revolves carries the index forward one division for each revolution. This form is the most trustworthy that has yet been devised, but is not altogether satisfactory, and many topographers prefer to count the revolutions of the wheel directly, using an arrangement by which a bell is rung at each revolution.

An experience covering many thousands of miles of measurement has shown that as a working method of measuring distances on roads the wheel is superior to the stadia, alike as to accuracy and rapidity.

A traverse man is generally assigned a tract of country within which he is instructed to run traverses of all the public roads and of such of the private roads as appear to be necessary in order to control the

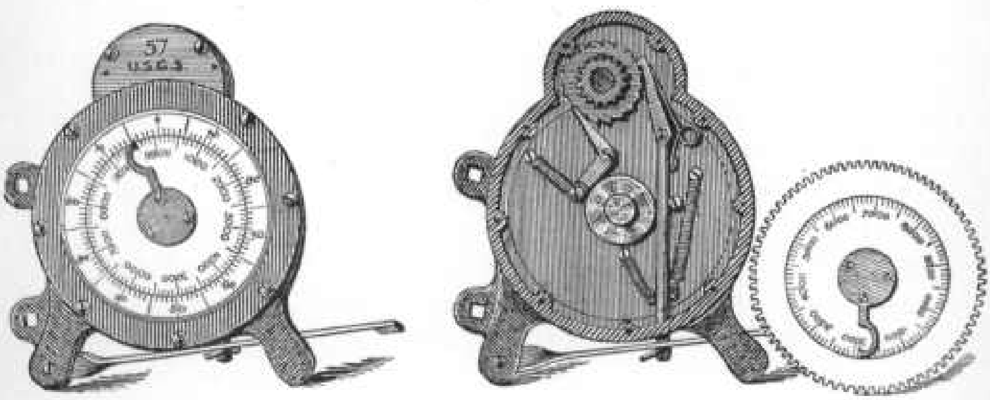


FIG. 25.—Douglass Odometer.

entire tract. If practicable, he is furnished with the positions of the points located within his tract properly platted upon his plane-table sheet, or, if these cannot be furnished, with such descriptions of them as are necessary to enable him to recognize them and close his lines upon them or connect with them by triangulation. He is furnished with a horse and buggy or buckboard, traverse plane table, and aneroid. He has no rodman, but is expected to sight natural objects. Setting up his instrument at his initial station, he levels it roughly by means of the tripod legs, orients it by turning the table until the compass needle is on the zero mark in the compass box, then, marking a point on the paper to represent his initial station, alidade upon it, he points it to an object selected as his second station, and draws a line in that direction. Driving along the road he passes the point sighted at, noting the distance to it by the reading of the odometer, or the count of the revolutions of the wheel, and the height as recorded by the aneroid, and passes on, selecting some point from which he can see the point sighted at. There he stops, sets up his table as before, orients it, and sights upon the same signal which he sighted from his initial station. He plots the distance to the signal along the sight line from his initial station; then from the location of the signal as thus established he plats his second station by the distance measurement and the reverse of the observed direction. In this way the work progresses, a hundred stations or more being occupied in the course of the day. In this work one should aim to make as few stations and to take as long sights as possible consistent with accuracy. Bends of the road between stations can be sketched with all needful accuracy.

During the progress of the work all points off the line which are capable of being located by intersection must be located by sights taken from stations, and special care must be taken to connect them with the points located by the secondary triangulation, in order to obtain as many checks as possible to the accuracy of the traverse line.

Traverse lines should close with but trifling error—one per cent being as great an error as should be permitted—and all errors of closure should be shown. No line should be arbitrarily closed on the traverse sheet.

The traverse man should sketch or locate all country houses, should note all road intersections and all railroad crossings, specifying by simple conventions the character of the crossing, whether over, under, or grade crossing. He should similarly describe all stream crossings, distinguishing fords, ferries, and bridges.

MEASUREMENTS OF HEIGHT IN CONNECTION WITH TRAVERSE LINES.

Height measurements in connection with traverse lines are effected in one of two ways—either by vertical angles with the telescopic alidade or by the use of the aneroid.

In regions where little or no secondary triangulation can be done, it becomes necessary to accompany certain of the traverse lines by profiles determined by vertical angles, using for this purpose a telescopic alidade. Such profiles should be surveyed at intervals of 4 or 5 miles where the contour interval is 20 feet, and at intervals of 8 or 10 miles where it is 50 feet.

The plan of the traverse is run precisely as above sketched, except that a rodman is frequently employed. In running the profile, which is done coincidently with the plan, the points sighted for elevation may be the same as are used for the plan. If a rodman is employed, the target on the rod should be set at the height of the instrument to simplify record and computation.

It must not be understood, however, that it is at all necessary that the survey of the profile should establish the height of all the points located by the traverse. The profile should give the elevation of all valleys and summits, and of all road crossings. The line should be carried forward and these points measured by as few and as long lines of sight as possible. Often the roof of a house will furnish a datum point for use for a mile or two. Indeed, in an open, settled country the line can frequently be carried forward continuously by using housetops as targets.

The reduction of the profile must keep pace with the field work, so that on arriving at a check point the amount of the error may be shown at once. If this is not more than one-fourth or one-fifth of the contour interval, it is not considered as of material account. If, however, it reaches half a contour interval, the work should be examined, and if the error be not discovered the line should be resurveyed.

The heights, as determined, should be written in ink upon the plane-table sheet in their proper places.

THE ANEROID.

In the great majority of traverse work heights may be measured with aneroids. The aneroid consists of a vacuum box of thin corrugated metal, which is compressed by an increase and expanded by a decrease in the pressure of the atmosphere. A train of mechanism magnifies this trifling movement enormously and moves an index upon a graduated dial. This dial is graduated to feet of elevation and also to inches of barometric pressure.

Several sizes of aneroids are made; that having a diameter of $2\frac{1}{2}$ inches is on the whole the most satisfactory.

Owing mainly to its extreme delicacy the aneroid is a very uncertain instrument. It should be used differentially only, and for small differences in height and small intervals of time. Its indications should be checked by reference to known elevations whenever opportunity is afforded during the day, and at the beginning and ending of each day's work.

On commencing work the movable scale on the aneroid should be

FIG. 26.—Interior of Aneroid.

set at the known height of the starting point and a note made of its reading on the inch scale. Elevations should then be read directly from the scale of feet. The heights of all points along the line of traverse which will be required in making the contour sketch should be read and written upon the traverse. Every depression and elevation, road crossing, etc., should thus be measured. There is, however, no necessity for reading the aneroid at every station in the traverse. It will merely encumber the work with a mass of useless data.

Upon reaching a check point, comparison should be made with the indications of the aneroid. If the difference is considerable—*i. e.* more than a contour interval—the error should be distributed backward along the line in proportion to distance. If it is small, it may be neglected.

In all this work notebooks are not required, except as a convenient form of carrying paper upon which to make the trifling computations required. The plane-table sheets comprise all the records necessary. The work, as it progresses, criticises itself by its closures in position and elevation, and, wherever necessary, is revised immediately.

Organization of Parties and Distribution of Work.

Secondary triangulation, traversing, measuring of heights, and sketching are commonly carried on by one party. This consists of the chief of party, who directs all the operations, and who does all the sketching; an assistant who carries on the secondary triangulation, selected as possessing special fitness for that work, and one, two, or more assistants, who are engaged in traversing, the number of these assistants depending upon the rapidity with which the country can be sketched relative to the rate at which the traversing progresses. If possible, the different items of work of such a party should follow one another in a certain order. The secondary triangulation should be done first in order that the traverse men may be furnished with positions and heights for locating and checking their traverse lines. The traversing should follow, in order that all the control may be furnished to the chief of party for his use in sketching. This order, which is followed as closely as practicable, requires that the members of the party be scattered over a considerable area of country, and if they are living in camp it requires that they remain away from it a considerable part of the time, or else that a large amount of traveling be done in order to reach camp at night. Where they are not living in camp, the most economical disposition is to scatter them at various places within their fields of work. In any case, constant communication must be had between the chief of party and his assistants, in order that they may work in accord.

Stadia Measurement.

Under certain circumstances it is found advisable to use the stadia method for measuring distances in place of the wheel. This is the case where lines are to be run without reference to roads, and consequently where the wheel cannot be employed with advantage. The instrument used for the stadia or telemeter method of measuring distances may be anything carrying a telescope. To the reticule of the telescope are added two or more fixed horizontal wires placed at a certain distance apart. A rod or board subdivided to suit the interval between the wires and painted in glaring colors forms part of the outfit. When this rod is set up at a distance from the telescope, that distance is ascertained from the number of subdivisions of the rod which are subtended between the wires of the telescope, the value of each division of the rod being known.

The rods are commonly 14 feet in length and hinged so as to close to 7 feet. The intervals upon the rods are of one foot each. The wires in the telescope should, for convenience, be so spaced that when the rod is at a distance of 100 feet, the space between the two extreme wires will subtend one foot on the rod. At a distance of 1,400 feet, therefore, this space will subtend the entire length of the rod, while at a distance of 2,800 feet two adjacent wires in the telescope will subtend the entire length of the rod. Distances less than 100 feet are estimated by means of the fractional part of a foot upon the rod, which is included between the wires. The distances are read off upon the rod by the surveyor at the instrument.

In measuring distance upon slopes, correction must be made to reduce the inclination measured to horizontal distance. Where the slope is slight it is not regarded as necessary to make this reduction, especially where there are frequent points for checking and correcting the line.

The rod may be used also for measurement of the profile of the traverse line. For this purpose, a point should be marked upon it at the same height as the telescope of the instrument and vertical angles taken to this point.

The foregoing matter applies most directly to maps upon scales ranging from one to eight miles to an inch and covering large areas of country. It applies also, though less fully and directly, to maps upon larger scales, and those made for specific purposes. Among these may be mentioned maps of mining districts, of watersheds, made for drainage purposes or water supply, of railroad and canal lines, of parks, town sites, etc. In making such maps, whose scales, instead of being expressed in miles to an inch, are expressed in hundreds of feet to an inch, we deal with inches instead of feet, both in horizontal and vertical measurements, and consequently greater accuracy must be obtained as expressed in units of the ground surveyed, but in units of the map, the standard of accuracy is unchanged. An error of 1/50 of an inch on the map is as large as should be permitted. The enlarged scale and reduced area under survey permits the use of certain instruments which upon smaller scales are not economical, and also permits the more extended use of certain others. The use of the stadia instrument, in connection with the plane table, here becomes economic, and it should be used extensively. After executing a primary triangulation the work should be relegated to the plane table, with which such secondary triangulation may be effected as seems expedient. Then the stadia comes into play, and using one, two, or more rodmen, as may be economic, the topographer will locate points by direction and distance measurements from his station, reaching out perhaps one-fourth of a mile in all directions and measuring heights by vertical angles on the rod, at the same time that he locates the horizontal position of the points. In this way he will locate points which control the contour or he may locate points on the contours directly, as seems expedient. If the country is nearly level, it may be best to do the latter, but if there is much relief, he will find it more expedient to locate only controlling points, and sketch the contours with reference to them.

From one station, he will pass to another, and so cover the country, mainly by stadia locations.

This is by far the most accurate, thorough and rapid method of making detailed maps of small areas.

In making a location map of a railroad or canal line, the method is necessarily varied to some extent. The line itself is measured with accuracy with a tape, and should be platted on the plane table as measured, and thus will serve as a continuous base line. The topography of either side should be taken by stadia, two rodmen, one on each side of the line, being employed.

Sketching.

This, being by far the most important part of the work of map making, should be done by the most competent man for this work in the party—as a rule, by its chief. Besides the fact that he is presumably the best sketcher in the party, there is another reason for requiring that he should execute the sketching. He is held responsible for the quality of the work, not only of the sketching, but also of the accuracy and the sufficiency of the control. In the sketching of the map he has the best possible opportunity for examining into the condition of the control and of remedying any weaknesses.

Upon the completion of the secondary triangulation, the traverse work, and the measurement of heights, in short, of the control, within an area, which may be large or small according to convenience, he should cause all this control to be assembled upon one sheet. The traverse lines with all points located from them should be adjusted to the secondary locations, and all measurements of height should be platted upon this skeleton, thus presenting in complete form all the control within the area. With this sheet upon a sketching board the chief of party should go over the ground, sketching the drainage, culture, and forms of relief, and generalizing the features to suit the scale of his map. The relief should be sketched in actual continuous contours, direct from the country as copy, so that upon leaving the sketching stations the only work remaining to complete the map will be inking and lettering. In heavy country, however, where the contours follow one another closely, it may often be sufficient to put in on the stations only a part of the contours—every fifth one, for instance—in order to economize time in the field. Stations for sketching may be selected with the utmost freedom. An exact location is unnecessary. Any point on or off the road which affords an outlook will serve. As a rule, frequent stations should be made, and one should not attempt to sketch at great distances unless the conditions are favorable, as they may be in a country of large, bold features. It may be necessary to travel over all the roads which have been traversed and to climb many hills in order to sketch the entire area satisfactorily. On the other hand, in a different region the entire area may be sketched by a limited amount of travel or from a few elevated points. In a low country of small features much travel will be required, as these details must be sketched from near points. In a bold country of high relief, which may be sketched entirely from a few points, care must be exercised in the selection of sketching stations. From a great altitude the lower details will be dwarfed and will measurably disappear, while from low points the relations, forms, and masses of the greater elevations cannot be properly seen. In such a country stations at different elevations must be selected in order to see all parts of the country to the best advantage. The extreme summits will prove of little service as sketching stations.

Sketching is artistic work. The power of seeing topographic forms in their proper shapes and proportions and of transferring these impressions to paper faithfully is of all acquirements one of the most difficult to obtain. The difficulty is increased by the necessity of expressing form by means of continuous contour lines at fixed intervals. This work involves a knowledge of the elements of structural geology and good judgment in applying them.

Every map, whatever its scale, is a reduction from nature and consequently must in the nature of things be more or less generalized. It is therefore impossible that any map, whatever its scale, can be an accurate, faithful picture of the country it represents. Moreover, the smaller the scale, the higher must be the degree of generalization, and the farther must the map necessarily depart from the original.

Now, it is in this matter of generalization that the judgment of the topographer is most severely tested. He must be able to take a broad as well as a detailed view of the country; he must understand the meaning of its broad features, and then must be able to interpret details in the light of those features. Thus, and thus only, will he be competent to make just generalizations. This will enable him to decide what details should be omitted and what ones preserved, and, where details are omitted, what to put in their places in order to bring out the dominant features.

It is not possible to define the degree of detail which the maps should represent. The limit commonly given—that is, the limit imposed by the scale of the map—is not always the best. In representing country which has little plan or system, such as moraines or sand dunes, it is well to work in as much detail as the scale will bear. But where the country shows a system in its structure to which the minor detail is subordinate, the omission of some of this detail may give greater prominence to the larger features. The amount of detail thus omitted must necessarily be left to the judgment of the topographer, but no more should be omitted than is necessary to give full expression to the general features of the country.

Scale of Field Work.

The scale upon which the field work is executed is commonly larger than that upon which the maps are to be published, because the drawing in the field is necessarily coarser than is possible in the office. Indeed, it will generally be found convenient to make the plane-table sheets on scales 50 to 100 per cent larger than that on which the maps are to be published.

Office Work.

The office work of the topographers consists in the reduction and transfer of the work from plane-table sheets to the original maps. The reduction is most conveniently effected by photography, this method having been found the most accurate and economical way of effecting it.

It is often the practice to simply complete the plane-table sheet by inking and lettering it, making it serve as the original sheet, and this practice is, on many accounts, advisable.

The original sheets are to serve as the original record of work and as manuscript for publication. To answer these purposes, they are made complete in all respects. Every original sheet should contain within itself all matter which is to be engraved or placed on record, except as hereafter noted.

The method, by which the map is to be published should have much influence upon the preparation of the original map. In case it is to be photo-lithographed or photo-engraved, it must be carefully drawn upon a scale much larger than that of publication by a skilled draughtsman. If it is to be engraved, however, it is unnecessary to waste the time of a skilled draughtsman upon it, as the engraver requires merely clearness and legibility, and should be drawn upon the scale upon which it is to be published, in order that the engraving may be done directly from the original map rather than from a photograph.

Projections.

The projection almost universally used is the polyconic.

The construction of a projection, for a limited area, is a simple matter, but requires care and accuracy and the use of the best draughting instruments.

Tables for this projection are published by the U. S. Coast and Geodetic Survey, which are applicable to all scales of map, the measurements given being the absolute lengths on the earth's surface, which must be reduced to the scale of the map. Tables are published in Bulletin 50, U. S. Geological Survey, which are directly applicable to certain scales, without reduction.

First draw a line down the middle of the sheet. Lay off on this line the length of the several projection spaces in latitude, by taking from the projection table for the scale the length of say 5 minutes of latitude and lay it off repeatedly, thus establishing the points of intersection of parallels at say 5 minutes with the middle meridian. Through these points draw lines across the sheet at right angles to the middle meridian, using beam compasses for this purpose. Lay off on these lines the dm's corresponding to the latitude for 2′ 30″ and 7′ 30″ from the middle meridian on each side, and at these points erect short perpendiculars. On these lay off the dp's corresponding to the dm's and through the points thus obtained draw and ink the projection lines.

For other areas the process is quite similar, but when a large area such as that of the United States is to be projected the mechanical difficulties greatly increase.

THE MAPS AND MAP-MAKERS OF MARYLAND.

BY

EDWARD B. MATHEWS.

INTRODUCTION.

Since the days of Rameses II (B. C. 1300), men have attempted with their rude drawings on wood and papyrus showing the location of roads and the courses of streams filled with crocodiles and fishes, to keep their bearings and record their discoveries by means of maps; and the subsequent study of these drawings has aided in the elucidation of controverted questions in geography, ethnology, and history. Although few maps of detailed accuracy were made prior to the discovery of the American continent, it is of interest to consider briefly the development of cartographic representation down to that time.

The earliest attempts at map-making consist in the tracings in sand and in the rude modeling of the savages, while the first permanent records seem to be in the form of road maps with occasional indications regarding the location of streams and lakes. Before such sketches could be carried over large areas without grotesque distortions, it became necessary to determine by astronomical observations the latitude and longitude of certain points for control. Such observations were early made by the Greeks and represented by Anaximander (B. C. 560) in his map of the world. Subsequently Ptolemy collected a great number of these determinations and made calculations, which unfortunately involved several fundamental errors. Ptolemy's work, translated into Latin in 1409, aroused great interest in cartographic subjects on its appearance in 1475, and served as a basis for many of the maps of the world published during the close of the fifteenth, and the beginning of the sixteenth centuries.[1] These Ptolemaic maps all involve the errors of Ptolemy, and may usually be recognized by them. For example, the Mediterranean is too long and Europe is too narrow, while Asia extends much too far east, and southern Africa is broader than it should be. These mistakes, which were current in the most authentic maps of the time, had a marked influence in establishing Columbus' faith in the possibility of reaching Asia by a westward course.

In spite, however, of the strong influence exerted by Ptolemy in the location of points and in the delineation of shore lines, the early maps seldom possessed parallels of latitude or meridians of longitude, since down to this time no satisfactory method had been devised for the rapid determination of longitude at sea. Latitude was determined with tolerable accuracy; but mariners who used the charts seemed to care little for these determinations, preferring to get their locations by compass direction from certain fixed points, as shown in Fig. 27. For this reason the old maps are covered with a network of lines running in all directions from the central points, called "wind roses" ("rose de vent"). This lack of means for determining the longitude influenced the character of all the larger maps, which frequently show distortion east and west, until 1736, when John Harrison perfected his chronometer. The erroneous views held by the Farrers (Plate XLV) would not have gained credence if it had been possible for Drake and Smith to determine the longitude of the lands which they explored.

The cartographic achievements of the fifteenth, sixteenth and seventeenth centuries were so great that it may seem strange to find so few references to them in the succeeding pages. Such references, however, would be out of place since all of the maps in the great atlases of Mercator, Bleau, Ortelius, and their contemporaries base their delineation of the Chesapeake and its shores on the scanty information furnished by Ayllon and Gomez or on the much more detailed work of Smith. When these sources have been discussed there is little left to mention beyond an occasional advance in the use of names or in the art of engraving. With increased skill in the preparation of

[1] Winsor, Bull. Harvard Lib., No. 19.

the large "Mappe Monde," or maps of the world, the publishers added illustrations and illuminations of brilliant colors, gold, silver, wild animals, plants, and fanciful designs, which gave additional information concerning the country represented. From these figures much may be learned regarding the contemporaneous impressions given by the tales of wanderers returned from their voyages.

In the succeeding pages, the attempt is made to present the information concerning the few maps which represent an increase in knowledge, based on observation of the territory depicted, in such a way that it may be of interest to the engineer, the student of local history and the intelligent citizen of the state.

Among the facts which it is desirable to know concerning any map are those pertaining to the men who made the sketches and surveys, to the time devoted and to the circumstances which led to the preparation of them. The latter are especially necessary, since from them is determined the personal bias of the author, which often finds expression in the delineation of boundaries, swamps, mountains, and streams. Upon these factors is based the estimated accuracy and reliability of the work. Moreover, a comparison of the finished product with the most authentic maps of the present day often indicates changes which have taken place in the location and character of the shoreline; and in a few instances, suggests the course of the explorations followed during the prosecution of the survey. All of these features, as well as the more strictly bibliographic facts, have been brought together. Among them may be found many which, heretofore, have been overlooked.

Early Continental Maps.

Ayllon's Map, 1527.

The enthusiasm aroused in Spain by the return of Columbus and the narration of his successful voyage to the New World led many men of high rank and possessions to look to the new-found continent as a source of easily acquired wealth and increased power. Many requests for patents allowing explorers to possess any lands which might be discovered were filed with the royal officers in the years immediately succeeding. Among the most hardy and most powerful of these enterprising Spaniards was Ayllon, who sent out between the years 1520 (?) and 1530 at least three expeditions to explore and gain for Spain, Christianity and himself the lands lying northward of the already discovered Florida coast. Early in June of 1526,

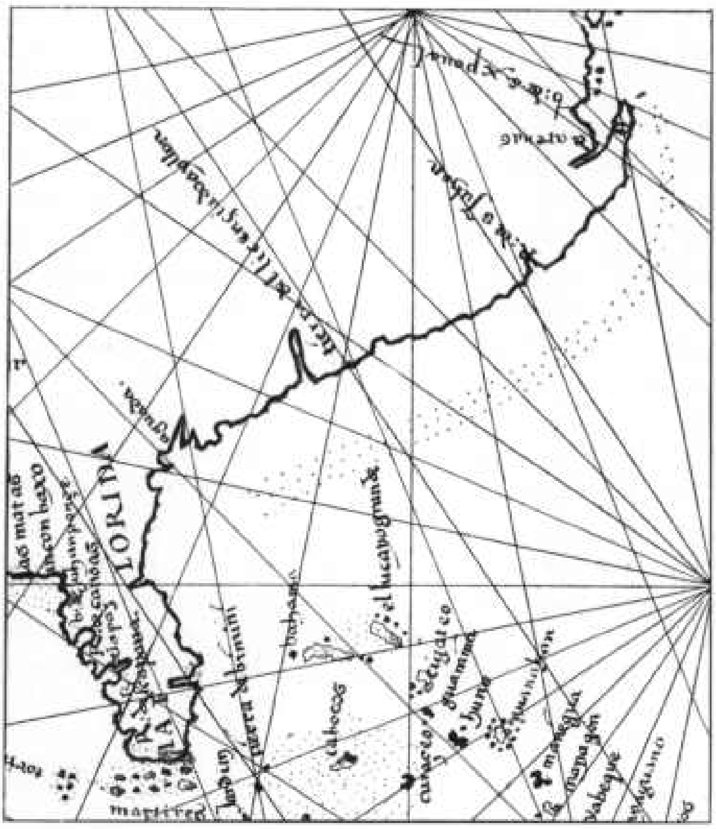


Fig. 27.—Portion of Ayllon's Map, 1527.

Ayllon sailed from Puerto de la Plata with three large vessels, which carried six hundred persons of both sexes, including clergymen and physicians, beside one hundred horses. They reached the coast[1] of

[1] J. G. Shea, "Ancient Florida" in Winsor's Narrative and Critical History of America, vol. ii, 1886, pp. 240-41.

Florida probably not far from the Wateree river, where they encountered their first misfortune in the loss of their brigantine. Ayllon immediately replaced this loss by a small vessel with which he explored the adjacent coast. His Indian guide, Francisco, deserted him, "and the parties sent to explore the interior brought back such unfavorable accounts that Ayllon resolved to seek a more fertile district." According to his original permit, he was required to run at least eight hundred leagues along the coast; and he, as well as Gomez, was to seek a strait or estuary leading to the Spice Islands. As the result of this expedition, the Chesapeake Bay was entered as possibly affording the passage sought. The soil of the country bordering on the bay, superior to that of the sandy region south of it, seemed to him better suited for the purposes of a settlement. He at last reached Guandape and began the settlement of San Miguel, where the English in the next century founded Jamestown. The map which was produced on Ayllon's return to Spain shows in a general way the position of the Chesapeake Bay, which it is supposed he entered and explored. His information, however, could not have been more than vague, as is shown by the accompanying figure, which represents the Chesapeake simply as an inlet with the phrase "tiera del licencia del Ayllon" (Fig. 27). This sketch is supposed to furnish the first representation of Chesapeake Bay based upon authentic information. In his work entitled *Die beiden ältesten General-Karten von Amerika*, Kohl gives the following reasons for considering the bay indicated on the map an attempt to represent the Chesapeake Bay:

"(Bay of St. Mary.) This bay Ribero puts between 34° and 35° N. lat. He places this there as quite important, extending for some distance from southwest to northeast and towards the sea he gives a row of small islands which have many entrances between them. He makes two rivers enter, one of which he calls 'R. del Espiritu Santo' (River of the Holy Ghost). The other is without a name. Oviedo calls it the 'R. Salado' (salt water river), and does not have it penetrate very far inland. I acknowledge that all these circumstances seem to indicate that this 'St. Mary's Bay' of Ribero or Ayllon is our present Pamlico Sound, which extends with the width indicated, is shut off from the sea by several small islands, offers different entrances and in its greatest expansion extends from northeast to southwest.

Nevertheless later geographers and maps make it more probable that we must regard the St. Mary's Bay so often mentioned later and so well known among the Spaniards, not as our Pamlico Sound, but probably as our better known Chesapeake Bay.

Oviedo (about 1545) said that the 'Bahia St. Maria' in 30⅔° N. lat., lies midway between Cape San Juan and Cape Trafalgar. Much later Barcia places the bay repeatedly in 37° N. lat., which is exactly the latitude of our Chesapeake Bay. Diego Homem (1558) has this bay in 38°; Vaz Dourado in his atlas in 36½°. Diego Homem, however, sketches somewhat differently from Ribero. He gives a smaller entrance and leaves out the islands, although he has both of the rivers of Ribero which appear numberless times on the maps of the sixteenth century under the names given above. The 'R. del Espiritu Santo' is always directly to the left of the entrance of the bay. The 'R. Salado' is, however, at the right and penetrates generally northward into the land, and this circumstance as well as its name speaks also for Chesapeake Bay. It is this long northward trending channel of the bay filled with salt water which the Spanish are accustomed to designate as R. Salado. The 'R. del Espiritu Santo' would then be our James River.

The most decisive proof, however, for interpreting the 'St. Mary's Bay' of the Spanish as our Chesapeake Bay and not as Pamlico Sound I find in the report by the Spanish seafarer Don Pedro Menendez Marquez of his reconnaissance along this coast in the year 1573 which he made in order to produce a map of the same. This map was never published, but Barcia has retained for us verbal extracts of historically invaluable statements in the historical references.

In this report Menendez says—after he has mentioned a dangerous sandy promontory in 35° N. lat. which according to all conditions can be nothing else but our Cape Hatteras—that from this promontory the 'Bahia de St. Maria' lies 30 miles distant. This is very nearly the difference between Cape Hatteras and Chesapeake Bay. Then he describes very exactly and correctly the coast which lies between and finally sailing into St. Mary's Bay, he gives the following description of it: 'At the entrance this Bay is three leagues broad (exactly the distance between Cape Henry and Cape Charles). You sail into it, in a N. N. W. direction (that is the direction of the chief channel of the Bay). At the entrance on the southern side near the land the water has a depth of from 9-13 fathoms, on the north side, however, only 5-7 fathoms. Within the Bay itself you have 15-16 fathoms depth. Within the Bay are numerous harbors and rivers and on both sides ships may go for anchor.' These statements concerning the depths correspond very exactly with the depth conditions of our Chesapeake Bay, while they correspond just as little with our Pamlico Sound as the 'many appreciated harbors and rivers.'

All these circumstances, I believe, place the question beyond all doubt after the time when Oviedo wrote his second volume (about 1545?) and after the time when Menendez reconnoitred (1573). In order to explain the variations from our map of 1529 there remain only two means, namely, either to assume that at Ayllon's time they gave the name 'B. de Santa Maria' to Pamlico Sound or that Ribero and his authority erred somewhat as to the latitude of this bay.

For the first of these theories we have no support at all, since we know absolutely nothing of two 'St. Maria Bays' in this region. We are unable to mention any mariner who could have introduced a second bay of this name. All geographers speak here always of St. Maria Bay only and all maps, whether they place this bay falsely in 35° or correctly in 37° north latitude represent this always according to the ancient example of Ribero and Aylion with two rivers, as though supplied with two horns, with a 'Rio Salado' and 'Rio del Espiritu Santo.'

There remains, therefore, nothing else than to assume that the ships and the pilots of Ayllon certainly first discovered Chesapeake Bay in the year 1526, but that they erred a little regarding its latitude."

The map was produced by Kohl and bears near the main inscription the figure of a Chinaman and an elephant—tokens of the ancient belief in the Asiatic connections of North America. This vague outline of the coast has been reproduced in several well-known histories.[1]

RIBERO'S MAP, 1529.

The second map referred to and reproduced by Kohl in the above mentioned volume was drawn by Diego Ribero, a Portuguese, in the service of Spain, who was the Royal Cosmographer from 1523 to 1533. "As the official cosmographer of the Spanish Crown, and as one of the hydrographers consulted at the Badajoz conference of 1524, by which Alexander VI's line of demarcation dividing the world into two hemispheres between Spain and Portugal was finally decided on, . . . Ribero was especially qualified to design this map, . . . the most important of the early Mappes Mondi and the first in which the world was delineated in a manner that approaches the scientific accuracy of modern cartographers. It contains the first graphic record of many of the most significant discoveries that led to a knowledge of the true form of the globe, and as a masterpiece of exact and well-informed map construction stands far above the crude essays of Juan de la Casa, Amerigo Vespucci."[2] . . .

There has been considerable doubt as to the source whence Ribero drew his information, but later investigations have shown that this map clearly represents a record of the discoveries of Gomez, who was at one time a pilot on one of Ayllon's expeditions. Gomez, after

[1] Winsor, op. cit., vol. ii, p. 285; Brown, "Genesis of the U. S.," and "The Magazine of American History," vol. ii, 1878, p. 257.

[2] B. Quaritch Catalogue No. 129. November, 1892, p. 3.

sailing north and examining the coast of Labrador, turned southward and leisurely explored the whole coast from Cape Race to Florida. From this point he sailed to Santiago de Cuba and thence to Corruña, entering that port after ten months' absence. He failed to discover the desired channel to the eastern coast of Asia, and we have

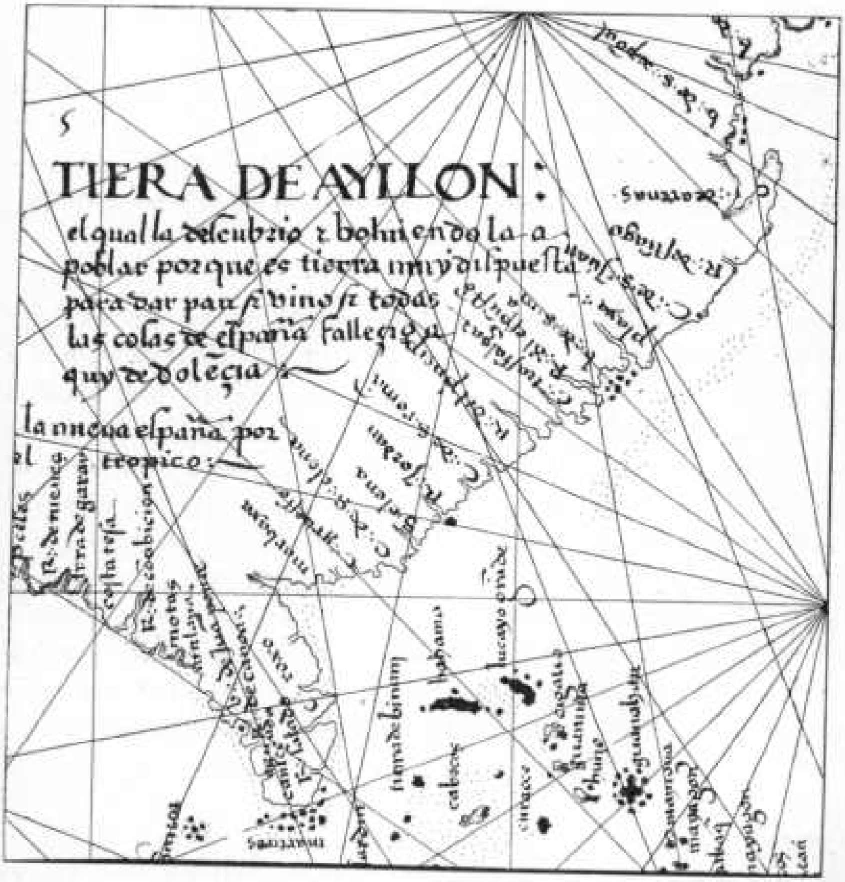


FIG. 28.—Portion of Ribero's Map, 1529.

no detailed information regarding his explorations along the Maryland-Virginia coast beyond that furnished by the map of Ribero, which records his discoveries and gives many names along the coastline which were undoubtedly bestowed by Gomez. Shea seems to think that the larger bay given on the Ribero map represents the

Delaware, although there seem to be about equal grounds for assuming that the Chesapeake is the bay thus vaguely represented.

This map of Ribero, to judge from the fac-simile reproduction by Mr. W. Griggs, is a broad sheet 57x24 inches, colored and gilded. Quaritch,[1] however, seems to regard this copy as a somewhat reduced fac-simile. "Ribero's map served as a base for the Venice map of 1534,[2] and the Bellero map of 1554. With a slight modification, this map was used as an authority in so late a chart as Hood's, published in 1592."

"There are two early copies of this map, of which a small section is here given; both are on parchment, and are preserved respectively at Weimar and Rome, though Thomassy[3] says there is a third copy. The Roman copy is in the Archivio del Collegio di Propaganda Fide, and is said to have belonged to Cardinal Borgia. The North American sections of the map have been several times reproduced in connection with discussions of the voyages of Gomez and Verrazano. The entire American continent was first engraved by M. C. Sprengel in 1795, after a copy then in Büttner's library at Jena, when it was appended to a German translation of Muñoz, with a memoir upon it which was also printed separately as *Ueber Ribero's älteste Weltkarte*. . . . The most serviceable of the modern reproductions of the American parts is that given by Kohl in his *Die beiden ältesten General-Karten von Amerika*, though several other drafts are open to the student in Santarem's *Atlas* (pl. XXV), Lelewel's *Moyen-âge* (pl. XLI), Ruge's *Geschichte des Zeitalters der Entdeckungen*, and Bancroft's *Central America* (i, 146)."[4]

The Ayllon and Ribero maps, regarded by many as the work of the latter, together with those of Nuño, Garcia, and Detoreno, established a type of the American coastline which prevailed for some time. They represent the degree of information regarding the Chesapeake and its tributaries possessed by the highest authorities in Europe up to the beginning of the 17th century, when John White made his manuscript map of Virginia about the year 1585. Even this

[1] Quaritch's Catalogue No. 133. April, 1893, p. 2.
[2] Stevens' notes.
[3] Les papes géographes, p. 118.
[4] Winsor, op. cit., vol. iv, p. 38.

map, which extends only to the waters between the Capes, gives us no information regarding the territory now occupied by Maryland; and so far as we know, no information was gathered by actual exploration of the upper waters of the Chesapeake until John Smith made his well-known voyage along the eastern and western shores of the bay in 1608. Maps published between the time of the appearance of these earliest sketches, and the more detailed drawings of Smith, show some increase in the knowledge of the names given to the area; for instance, the map by Cornelius Judaeis entitled "Americae pars borealis, Florida, Baccalaos, Canada, Corterealis," 1593, published in his "Speculum Orbis terrarum," and reproduced by Winsor,[1] gives us such terms as "Chesepooc Sinus," "Virginia," and "Apalchen."

First Detailed or "Mother Maps."

At the beginning of the 17th century the people of Europe, and especially of England, made the first determined effort to plant colonies in America north of the Spanish possessions. A great wave of colonizing and exploring excitement swept over the country and resulted in the development of small communities in New England, New York, Delaware and along the shores of the Chesapeake.

Earlier attempts had been made by Sir Walter Raleigh to found a colony in Virginia, but these were all unsuccessful, so that the first settlement which may be regarded as permanent in the territory adjacent to the present limits of Maryland is that of Virginia, established early in April, 1607. The colonists embarked from England in three small vessels of less than 100 tons each and sailed for America by the circuitous route of the Canary and West India Islands. Among their number were several adventurous spirits, notably Captain John Smith, Bartholomew Gosnold and Captain Christopher Newport. These one hundred and five colonists, filled with enthusiasm for their project and a desire to obtain more settlers for the community, set about to explore the land in which they dwelt and sent back to England glowing accounts of the country which they possessed. The zeal and enthusiasm of some of the leaders led to

[1] Op. cit., vol. 4, p. 97.

an exploration and mapping of Chesapeake Bay and to the publication of Smith's map, which "is absolutely the first engraved picture of English America and the first account of its real colonization.[1]

THE SMITH MAP.

The leader in all this work, Captain John Smith, was a man of marked personality. His reputation has varied in the minds of historians. By some he is considered a rival to Munchausen, by others a much maligned Christian gentleman. It is interesting in this connection to note the words of John Fiske, the most voluminous and accurate historian of Colonial America, as he remarks in his "Old Virginia and her Neighbors" (Vol. 1, p. 118), that "Smith's map is a living refutation of John Smith's detractors; none but a man of heroic mould could have done the geographical work involved in making it."

Born in Lincolnshire, January, 1579, Smith, before reaching the age of sixteen, had determined that the inactive life of a counting room was unendurable. During the years when most of the present generation are preparing for active life, Smith became a soldier of fortune and experienced more vicissitudes before attaining his majority than fall to the lot of ordinary men during an entire lifetime. He traveled on the Continent, fought in Transylvania, was a slave in Turkey, a fugitive in Russia and a knighted nobleman of Transylvania before he was twenty-five. Although but little over twenty-seven years of age when he landed in Virginia, he soon became the president of the Council and the ruling spirit of the colony, while his presence among them was necessary to the well-being and safety of the colonists. Although the means of saving the colony from starvation, Smith became the subject of many intrigues during the two years which he spent at Jamestown.

In the summer of 1608, to avoid encounters with his personal enemies in the colony, Smith determined to carry out the "instructions given by way of advice for the intended voyage to Virginia" by the London Virginia Company, which commanded as follows: "You

[1] Quaritch, 1880, p. 1242.

must observe if you can whether the river on which you plant doth spring out of mountains or out of lakes. If it be out of any lake, a passage of the other sea will be more easy, and is like enough, that out of the same lake you shall find some spring which runs the contrary way towards the East India sea." With little notion of finding a short cut to the east coast of Asia, Smith undertook to explore the Chesapeake. According to his "map of Virginia," published at Oxford in 1612—

"On the second of Iune, 1608. *Smith* left the fort, to perform his discoverie; with this companie.

Walter Russell Doctour of Physicke		Anas Todkill	
Ralph Morton		Robert Small	
Thomas Momford		Iames VVatkins	Sould.
William Cantrill		Iohn Powell	
Richard Fetherstone		Iames Read, blacke smith	
Iames Bourne	Gent.	Richard Keale, fishmonger	
Michael Sicklemore		Ionas Profit, fisher	

These being in an open barge of two tunnes burden . . . . Leaving the Phoenix at Cape-Henry, we crossed the bay to the Easterne shore, and fell with the Isles called *Smiths* Iles." [1]

The following extracts from the above-mentioned work give some notion of the course which these early explorers took and the many difficulties which they encountered in their first trip along the banks of Maryland territory:

"Passing along the coast, searching every inlet and bay fit for harbours and habitations: [and] seeing many Iles in the midst of the bay, we bore vp for them; but ere wee could attaine them, such an extreame gust of wind, raine, thunder, and lightning happened, that with great daunger we escaped the vnmercifull raging of that ocean-like water.

The next day, searching those inhabitable Iles (which we called Russels Isles [Tangier]) to provide fresh water; the defect whereof forced vs to follow the next Easterne channell, which brought vs to the river *Wighcocomoco* [Pocomoke]" . . .

We digged and search many places but ere the end of two daies, [the length of time devoted to the study of Somerset and Wicomico counties] wee would haue refused two barricoes of gold for one of that puddle water of *Wighcocomoco.*

[1] The Proceedings of the English Colonies in Virginia since their first beginning from England in the yeare of our Lord 1606, till this present 1612, with all their accidents that befell them in their Iournies and Discoveries. By W. S. At Oxford. Printed by Joseph Barnes, 1612.

Being past these Isles, falling with a high land vpon the maine, wee found a great pond of fresh water; [ ] but so exceeding hot, that we supposed it some bath. That place we called Point ployer.

Being thus refreshed, in crossing over from the maine to other Iles, the wind and waters so much increased with thunder lightning and raine, that our fore-mast blew overbord; and much mightie waues overwrought vs in that smal barge, that with great labour wee kept her from sinking, by freeing out the water.

2 daies we were inforced to inhabit these vninhabited Iles; which (for the extremitie of gusts, thunder, raine, stormes, and il weather) we called *Limbo.* [Hooper's or Kedge's Straits.]

Repairing our fore saile with our shirts, we set saile for the maine; and fel with a fair river on the East called Kuskaranaocke [Nanticoke?], [later] wee returned to Limbo. . . . But finding this Easterne shore, shallow broken Isles, and for the mostpart without fresh water, we passed by the straits of *Limbo* for the Westerne shore; so broad is the bay here, we could scarce perceiue the great high clifts on the other side: by them we Anchored that night and called them *Riccards Cliftes* [Calvert Cliffs]. 30 leagues we sayled more Northwards not finding any inhabitants, leaving all the Eastern shore, lowe Islandes, but ouergrowne with wood, as all the Coast beyond them so farre as wee could see; the Westerne shore by which we sayled we found all along well watered, but very mountanous and barren, the vallies very fertile, but extreame thicke of small wood so well as trees, and much frequented with wolues, Beares, Deere, and other wild beasts. We passed many shallow creekes, but the first we found Navigable for a ship, we called *Bolus* [Patapsco]."

Beside all the difficulties arising from lack of water, Smith was hampered by the choice of his companions and the lack of sufficient food to keep the party in spirits. How low their spirits became is shown by the following extract from Purchas:[1]—

"The barge Smith went in was hardly two tunnes and had in it but twelve men to performe this Discouery, wherein they lay aboue the space of twelve weekes vpon those great waters in these vnknown Countries, having nothing but a little Meale or Oat-meale and water to feed them, and scarce halfe sufficient of that for halfe that time, but that by the Sauages, and by the plenty of fish they found in all places, they made themselves prouision as opportunity served; and yet they had not a Mariner or any that had skill to trimme their Sayles, vse their Oares, or any businesse belonging to the Barge, but two or three. The rest being Gentlemen, or as ignorant in such toyle and labour, yet necessitie in a short time by their Captaines diligence and example taught them to be become so perfect, that what they did by such small meanes, I leaue to the censure of the Reader to indulge by this Discourse and the annexed Map."

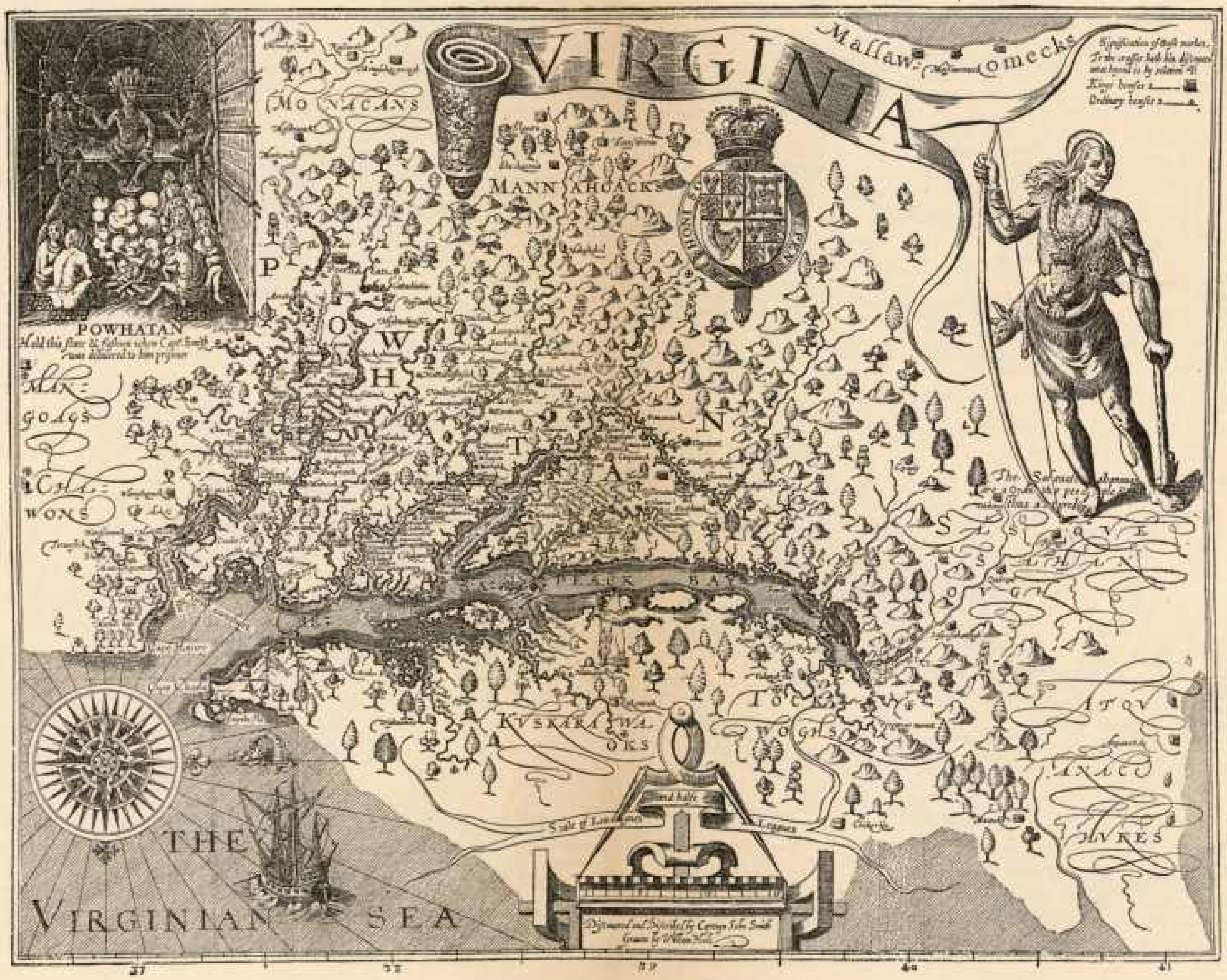
Smith, while lying off the present harbor of Baltimore [June 13 (?)], attempted to overcome the despondency of his companions

[1] Purchas his Pilgrimes, 1627, vol. 4, leaf 9, chapter 3, p. 1693.

with a grandiloquent speech, which has come down to us in his account of this voyage. It served only to revive his companions temporarily, however, for after three or four days of rainy weather we find the whole company returning to the Potomac, which they reached June 16. They sailed up the Potomac some thirty miles to Onawfarment [a small Indian town on the Virginia shore opposite the mouth of Wicomico creek]. There they had trouble, and finally, after exchanging hostages, "James Watkins one of the soldiers was sent six miles up the woods to their Kings habitation." The next day they sailed near the present location of Washington, whence they went nine or ten miles up the country in search of an antimony mine. They arrived at Jamestown, June 21, after having spent scarcely two weeks in an exploration of nearly a thousand miles of shore line.

Later in the summer Smith made a second and more successful attempt to explore the headwaters of the Chesapeake. Leaving Jamestown on the 24th of July, he picked up the lines of his exploration at the "Bolus" on the 28th or 29th inst. Two days were spent in exploring the Gunpowder and Bush rivers, when the party crossed the head of the bay and had an encounter with the local Indians. Smith evidently stayed about Port Deposit and North East a week or two parleying and treating with the Susquehanna Indians, who came down the river to meet the alleged conqueror of the Massawamacks. No doubt some of this interval of waiting was used in exploring the land north of Elkton and bordering the Sassafras river, for we find indications that Smith visited Gunther's Harbor [North East] and Peregrin's Mount [Gray's Hill (Bozman) or Beacon Hill (Johnston)]. So far as the map and the account indicate, little or no time was spent after the conference with the Indians in exploring the shores of the bay, for we find that considerable time was spent in exploring the Rappahannock as far west as Fredericksburg before the return of the party to Jamestown, where they arrived September 7.

Smith continued his explorations of the country about the settlement of Jamestown in the succeeding year. During one of his trips up the James, while lying on a bag of gunpowder in a canoe, the



SMITH'S MAP, 1608 (REDUCED).

FROM WINSOR'S NARRATIVE AND CRITICAL HISTORY.

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powder became ignited and Smith very nearly lost his life through jumping overboard in his frenzy of pain. The injuries he underwent were so severe that he left Jamestown on the 4th of October, 1609, having spent scarcely two and a half years in exploring an unknown country and establishing a colony which was successful during his presence among the colonists but destined to decline as soon as his personal influence with the Indians and with the people was removed.

Little can be gained as to the amount of money expended in the preparation of the manuscript of this map. The only facts which have been met with are found in Purchas' account, in which he quotes Smith as saying the "beginnings here and there cost me neare 5 yeares [1604-1609] worke, and more than 500 pounds of my owne estates, besides all the dangers, miseries, and incumbrances I endured gratis; where I stayed till I left 500 better provided than euer I was."

This historic map is 11.5 inches high by 14.75 broad. At the upper left and right-hand corners as shown in Plate XLIII[1] are sketches illustrating incidents in Smith's life during his stay in Virginia, while between the two unrolls an ornate scroll with the inscription "Virginia," and just below is the coat-of-arms of the ruling house in England. In the lower left-hand corner is the "Virginian sea" bearing the representation of a contemporaneous vessel and the compass; in the centre at the base is a pair of drawing compasses and a "scale of Leagues and halfe Leagues" with the inscription "Discouered and Described by Captayn John Smith 1606" [O. S.]. On later editions of the map Smith's coat-of-arms, with its "Three Turks' heads,"[2] is drawn in a somewhat inconspicuous manner to the right of

[1] This plate is published by permission of Messrs. Houghton, Mifflin & Co., publishers of Winsor's Nar. and Crit. Hist. of America, from which the plate is taken.

[2] This shield with its "three Turks' heads" and its motto recalls one of Smith's most successful adventures. He was a soldier under Count Meldritch during the siege of a fortress at Gegal. The siege became monotonous so Lord Turbashaw challenged any captain in the besieging army to single combat. Smith accepted the challenge and came off victor with the head of the Lord Turbashaw. Grualgo, resolving to avenge his bosom friend, challenged Smith. They met and Grualgo's head was carried

the scale of leagues. The two larger figures are of sufficient interest to warrant a more extended notice. The picture on the left, with the inscription "Powhatan Held this state & fashion when Capt. Smith was delivered to him prisoner 1607," refers to one of the events rendered familiar by the story of Pocahontas. Smith, taking only two of the party which had left Jamestown with him some days before to explore the Chickahominy river, started in a small canoe to search the headwaters of the stream. During this attempt he was captured by the Indians after the death of his two companions. As an unusual prisoner he was taken to the emperor of the local tribes Powhatan, before whom he was tried and condemned to death. This sketch represents the customary manner of holding the council, while a similar sketch on the map of "Ould Virginia" illustrates the incident of his rescue by the generous pity of Pocahontas.

The figure of the Indian on the right is thus described by Smith:

> The picture of the greatest of them [the Susquehanocks] is signified in the Mappe. The calfe of whose leg was 3 quarters of a yard about: and all the rest of his limbes so answerable to that proportion, that he seemed the goodliest man that euer we beheld. His haire, the one side was long, the other shore close with a ridge over his crown like a cock's combe. His arrowes were fiue [5] quarters [of a yard] long, headed with flints or splinters of stones, in forme like a heart, an inch broad, and an inch and a halfe or more long. These he wore in a woolves skinne at his backe for his quiver, his bow in the one hand and his clubbe in the other, as is described.

Of the many little houses represented on the map, ten of them are within the limits of Maryland and represent the principal Indian towns rather than any European settlement, since none of the latter had been made in this area at the time Smith made his explorations. Trees which are scattered over the map are evidently intended to represent in some degree both the size and the character of the forest-growths. There are four different types varying in abundance.

off in triumph. Finally Smith challenged any of the besieged and Bonny Mulgro accepted only to furnish the third head. For all these successes Smith was made a major, and received a patent of nobility and a coat of arms with three Turks' heads in a shield with the motto "Vincere est Vivere." The reproduction in Scharf and other histories seems to be a new drawing of a late copy since it lacks any page number and has this motto spelled "vincere est vinere," evidently a copyist's substitute of an *n* for the *u* in the old spelling "*viuere.*"

In the territory of Maryland twenty-seven of these are oval-shaped, representing perhaps the pine, seven are what may represent the cypress, and seven others the tulip or poplar, while the remaining sixteen may be intended to represent the development of maples and oaks. Thus there are fifty-eight of these little figures scattered over the state, thirty-two being situated on the western shore and twenty-six on the eastern shore. Neither animals nor Indians appear in the Maryland portion of the map, though such occur in the territory southwest of Jamestown. The difference between the lowlands of our Coastal Plain and the more rugged scenery of the Piedmont Plateau was recognized by the explorers, and is indicated by the lack of any little hills or mountains on the area southeast of the line connecting Naebrughquena [Washington] and Gunther's Harbor [North East]. Three little hills are near the Patuxent river and are evidently intended to represent Rickards [Calvert] Cliffs. In the western portion of the map, near the headwaters of the Potomac, is represented a somewhat larger mountain with three peaks which probably indicates that Smith learned something of the size and location of the Blue Ridge.

A careful study of the features represented in a reproduction of this map, and a comparison with our knowledge of the country, lead to the following estimate of the work done: First leaving Virginia at Watkins Point the lines, although rounded and generalized, show a careful exploration and sketching of the necks between the Wighco [Pocomoke] and the Kus [Nanticoke]. Just north of Watkins Point there is an attempt to represent Crisfield harbor and James Island Marsh and the course of the Big Annemessex river, which apparently was not entered, as its length seems to have been estimated by the breadth of its mouth. There is an evident attempt to represent the most prominent indentations on Potato neck, such as Mine creek and Teague creek, but from Hazards Point to the point between the Manokin river and Moine Bay the sketching is poor. Deal's Island and Low's Thoroughfare seem to have been noticed and some effort made to represent Haines Point, Back creek and Long Point. Smith evidently passed directly across Moine Bay from the southern point to the mouth of the Nanticoke, since Wingates Point between the Moine and the Wicomico is not noticed. The Nanticoke was explored and platted to some point not far from the present town of Seaford, Delaware. That Smith went no farther is indicated by the little Maltese cross beyond which, according to the legend, the information is all hearsay. The inaccuracies of the map show that after exploring the Nanticoke, Smith passed through Limbo[1] [Hooper's Straits] and sailed for a short distance along the coast, perhaps to James Point, and then left the eastern shore unexplored at least to the northern end of Kent Island. The map seems to indicate that he left the coast before reaching Barren Island and that he sketched the shore line as it appeared to him during his quartering across the bay, a view which is substantiated by Smith's own words. This deflection to the western shore explains the generalized lines of the Winstone Isles, especially on their eastern sides, where they are clearly separated from the mainland. The interpretation of these isles as given in Scharf, seems to be the more natural one, for it is very evident from the map that "he [Smith] clearly mistook the deeply indented peninsulas of Dorchester and Talbot counties for islands which he grouped with Kent Island to form the three Winstone Isles."

North of Kent Island, as the shores of the bay approach each other, the accuracy of detail seems to be much better. "Bomes poynt" seems to be intended for Swan Point with its two creeks on the southeast and somewhat regular northwestern shore line. The outlines of what probably are intended for the Sassafras and Elk rivers suggest that in this part of Smith's exploration he became somewhat turned about as to his location on account of cloudy weather, or, as Herman found later, a troublesome tribe of Indians. The course of the Sassafras from its mouth upward, turns more to the south than it should. This, if we may trust the crosses, is not due to lack of exploration, for Smith professes to have traced the course to some point near the pres-

[1] It is usually considered that "Limbo" represents Hooper's Straits, the inference being based, apparently, on the assumption that such would be the normal course. The map, however, represents several small islands between the larger [Bloodsworth's?] island and the mainland which are not found on any of the later Coast and Geodetic Survey maps. There is therefore cause for doubt as to the accuracy of this location.

ent head at Sassafras P. O., and the account of his second tour of discovery shows that considerable time was spent about the head of the bay parleying with the Indians and visiting their settlements. The course of the Elk is more carefully outlined, though even here there seems to be a failure to appreciate the relative size of the eastern and western creeks, due perhaps to the more marshy character of the land in the seventeenth century.[1] The northeastern corner of the map about the head of the bay discloses the prevailing misconception as to the position of the 40th parallel of latitude. It was thought to cross the Susquehanna just south of the present town of Port Deposit [39° 36′ N.].

The outline of the western side of the head of the bay is drawn less accurately than the eastern. Spesutie Island forms part of an unnamed headland, while the area between this and Bush river is represented as a big bog or marsh. "Willowbyes flu" [Bush river] is very loosely drawn and apparently is based on imagination rather than accurate information. Smith may have had some basis for the three head streams in the three creeks rising in the vicinity of Jarrettsville, but it seems more natural to regard this as an instance of a happy chance generalization. "Powels Iles" is probably a generalization for Pool's Island off the mouth of the Gunpowder. The rest of the shore line indicates either that there is a very loose generalization of marshy lowlands or that some of the smaller points and islands are of recent development, probably the former. The outline of the Bolus river bears a fairly close resemblance to the Patapsco of to-day until one reaches the union of the two branches above Woodstock, when the streams seem to have been confused in their relative importance. The " Blands. C " of later editions may represent Mineral Hill or some other mineral locality to which the Indians might have conducted Smith. The shore line of Anne Arundel county is very much generalized considering the prominence of its features and it becomes difficult to associate satisfactorily the various unnamed bays and headlands with those known to-day. Smith clearly saw the highly indented character of the shore, but bad weather, illness and discontent on the first voyage, together with eager haste on the

[1] See Danker and Sluyter's Journal.

second, leave these topographic features very inadequately represented in comparison with the earlier work on the Eastern Shore.

The Patuxent river is more accurately outlined than some of the work on the Eastern Shore, but its straight course seems to have been overlooked while the western branch is entirely unrepresented. There is no cross on the map to indicate that this stream was explored at all. If this be true, the representation is *exceptionally* accurate for the information at Smith's command. Rickards Cliffs are represented by three or four elevations, the only ones placed on the Coastal Plain. The bay between Cedar Point and Point No Point left a strong impression, for it is delineated as fully ten miles deep. From the shading it may be suggested that part of the present land was then marsh land.[1]

Smith's representation of the shores of the Potomac should be the most accurate portion of the Maryland territory, for he spent considerable time along the coast and was not as much disturbed by storms, illness and Indians. A comparative study of the lines shows, however, that the details laid down on the map represent a far greater irregularity of the coast line than is now displayed. No points can be accurately correlated between Point Lookout [Sparkes poynt] and Port Tobacco [Potapaco]. There is a similarity in location of prominent points and well-marked bays, but on the whole the re-entrants and intervening salients are drawn too sharply angular. There is no doubt that some local changes have taken place along the Potomac since the beginning of the seventeenth century, but an interpretation of the drawings involving changes in the character of the coast line should not be pushed too far. The upper portions of the river show the same tendency to represent the water-line as more intricate than it is to-day. The Piscataway river is recognized but unnamed. The same is true of the Anacostia. Beyond Great Falls the course of the Potomac is straightened and generalized and is of little value.

There has always been some dispute as to just when the Smith

[1] The present topographic sheets do not contradict this view since the lands immediately adjacent to the shore are low and there is a moderately well marked ridge half to three-quarters of a mile back of the present water line.

THE HELIOTYPE PRINTING CO. BOSTON

CALVERT CLIFFS, ON THE CHESAPEAKE BAY.

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map was drawn. It is the common opinion at present that the sketch of this map was made subsequent to the sailing of Captain Nelson in June, 1608, and that it was completed and ready for shipment in the fall of the same year. This view is based upon the fact that no mention is made of it in the title of the "True Relation," which was entered at Stationer's Hall, London, August 13, 1608, under the following title, which differs from the printed one, as it mentions Nelson's name: "A true relation of such occurrences and accidents of note as have happened in Virginia synce the first planting of that Colonye which is nowe resident in the south parte of Virginia till master Nelson's comminge away from them, etc." [1]

The opinion that the map was finished before November of 1608 is based upon a letter which Smith wrote "to the Treasurer and Councell of Virginia" before the sailing of Captain Newport on that date. This letter was not printed till 1624 in the third book of Smith's "General Historie." In the copy of this letter given by Brown in his "Genesis of the United States," we find the following:

> "Now that you should know, I have made you as great a discovery as he, for lesse charge than he spendeth you every meale; I haue sent you this Mappe of the Bay and Rivers, with an annexed Relation of the Countries and Nations that inhabit them, as you may see at large. Also two barrels of stones, and such as I take to be good Iron ore at the least; so devided, as by their notes you may see in what places I found them."

This map arrived in England in January, 1609, and Phillips [2] has shown that it must have been published prior to the Oxford edition of "A Map of Virginia, With a description of the Coventry." This view is based upon the following extracts from "Purchas His Pilgrimage," folio, London, 1613, p. 1634, and entered at Stationer's Hall August 7, 1612. [3]

> "Concerening the latter, Captain Iohn Smith, partly by word of mouth, partly by his Mappe thereof in print, and more fully by a manuscript which hee courtiously communicated to mee, hath acquainted mee with that whereof himselfe with great perill and paine, had been the discouerer, being in his discoueries taken prisoner, and escaping their furie, yea receiving much honour and admiration among them, by reacon of his discourses to them of the motion of the Sunne, of the parts of the World, of the Sea, etc.,

[1] Phillips, "Virginia Cartography," Smithsonian Misc. Collections, No. 1039, 1896, p. 21. [2] Op. cit., p. 22.

[3] "Purchas His Pilgrimes" is a distinct work published somewhat later.

which was occasioned by a Dyall then found about him. They carried him prisoner to Powhatan, and there beganne the English acquaintance with the Sauage Emperour."

The first part of "A map of Virginia" is evidently an expanded and revised text of that "Mappe" and "Relation" referred to in the letter to the Treasurer and Council. It is a circumstance of extraordinary rarity to find the genuine map in this book of 1612, for most of the impressions seen are taken from the same plate, which was used subsequently for the map of Virginia in Smith's "Generall Historie" and "Purchas His Pilgrimes." In the former instance the reference to "Page 41 Smith" was added in the right-hand lower corner and in the latter the reference "1690" or "1691" was superadded in the upper left-hand corner. There are thus at least six impressions of the Smith map which are original. The first is referred to in "Purchas His Pilgrimage" and is without figures in either upper or lower right-hand corners. [Harvard Library.] The second was intended for "Purchas His Pilgrimes" and has the pagination 1692 or 1693 at the top. This copy lacks names for several localities mentioned in the third impression, which was published in Smith's "Generall Historie," 1624. This latter impression has "41 Smith" in the lower right-hand corner. Subsequently the Purchas pagination appears on the revised impression of Smith and may be "1690" or "1691." One of these two impressions has also no engraver mentioned, and the date 1606 directly under "Discouered and Described" and not under Smith as in the others. The fac-simile reproductions so far as seen seem to be based upon one of the later Purchas' impressions. That in the edition of Smith's works by Edward Arber[1] has the figures "Page 41 Smith" and "1691." The fac-similes published in local histories, like that in Scharf's History of Maryland, differ from one another, but all have the error of writing Smith's motto "vincere est vinere" instead of "vincere est viuere." The copy in Scharf likewise lacks the numbers indicating the pagination. The present reduction (Plate XLIII), which is from Winsor's Narrative and Critical History,[2] is without the pagination and the personal coat-of-arms of the later editions, and is somewhat different in the southeast corner.

[1] English Scholar's Library No. 16, Birmingham, 1884. [2] Vol. iii, p. 166.

Smith's map was the source of information for almost all of the maps which were published during the fifty years succeeding its first appearance. Winsor gives a list of many which are believed to be based on this copy, and Phillips enumerates, in the course of his descriptions, many others similarly influenced.

According to Winsor, De Bry "re-engraved it in part xiii of his *Great Voyages*, printed in German, 1627, and in Latin, 1634; and in part xiv in German in 1630 (*Carter-Brown Catalogue*, i, 370-71). It was also re-engraved for Gottfriedt's *Newe Welt*, published at Frankfort, and marked "Erforshet und beschriben durch Capitain Iohan Schmidt." The compiler of this last book was J. Ph. Abelin, who had been one of De Bry's co-workers, and he made this work in some sort an abridgment of De Bry's, use being made of his plates, often inserting them in the text, the book being first issued in 1631 and again in 1655. (Muller's *Books on America* (1872), No. 636, and (1877) No. 1,269.) The map was next used in two English editions of Hondy's *Mercator*, "Englished by W. S.", 1635, etc., but with some fanciful additions, as Mr. Deane says (Bohn's *Lowndes*, p. 1103). The map of the coast in De Laet, 1633 and 1640, was, it would seem, founded upon it for the Chesapeake region; cf. also the map of Virginia and Florida called "par Mercator," of date 1633, and the maps by Bleau, of 1655 and 1696.

Once more Smith's plot adorned, in 1671, Ogilby's large folio on *America*, p. 193, as it had also found place in the prototype of Ogilby, the Amsterdam Montanus of 1671 and 1673. In these two books (1671-73) also appeared the map "Virginiae, partis australis et Floridae, partis orientalis, nova descriptio," which shows the coast from the Chesapeake down to the 30th degree of north latitude.

Smith's map was finally substantially copied as late as 1735, as the best available source, in *A Short Account of the First Settlement of the Provinces*, etc., London, 1735,—a contribution to the literature of the boundary dispute, and was doubtless the basis of the map in Keith's *Virginia* in 1738; but it finally gave place to Fry and Jefferson's map of the region in 1750.

A phototype fac-simile, reduced about one quarter, of the earliest state of the original map in the Harvard College copy of the Oxford tract of 1612 is given herewith. A similar fac-simile, full size, is given in Mr. Deane's reprint of the *True Relation*, though it was not published in that tract. A lithographic fac-simile, full size, but without the pictures in the upper corners, is given in the Hakluyt Society's edition of Strachey, p. 23. Other reproductions will be found in Scharf's *Maryland*, i, 6, Scharf's *Baltimore City and County*, 1881, p. 38, and in Cassell's *United States*, p. 27. That in the Richmond (1819) reprint of the *Generall Historie* is well done, full size, on copper. This copper-plate was rescued in 1867 from the brazier's pot by the late Thomas H. Wynne, and at the sale of his library in 1875 was purchased for the State Library of Virginia."

Winsor[1] evidently made a mistake in regarding the Lord Baltimore

[1] The Kohl Collection of maps relating to America. Bibliographical Contributions No. 19, Harvard University, 1886, p. 38.

map as a copy of that by Smith, since the proportions are different and the character of the eastern shore and the names of the local points are quite unlike.

No one can realize the conditions under which Smith made his explorations and drew his map or study the features there laid down without being impressed with the wonderful fidelity and geographical sympathy with which he recognized and portrayed the principal features of the country through which he traveled. If all knowledge of the region were lost it is doubtful if many, even of the most highly trained topographers with Smith's instruments and methods, could spend less than a month in exploring Chesapeake Bay and produce a sketch of the country which would be as free from distortion and exaggeration as the map drawn by Smith in 1608. Yet during all of Smith's explorations he was journeying along unknown shores, surrounded by a sick and discouraged company without healthy food and liable to attack from numberless and cruel savages.

THE LORD BALTIMORE MAP, 1635.[1]

The Lord Baltimore map, according to the fac-simile reproduction in Ogilby's *America*, is 9 by 11 inches and includes the territory from Cape May and Harper's Ferry on the north to Cape Henry and Jamestown on the south. The title "Nova Terrae-Mariae tabula" is framed in a scroll, and the various portions of the map are ornamented by the coat-of-arms of the king and of the Calverts, a fancy scale of 20 sea leagues, and a compass.

The mapping of the Maryland territory is far below that of Smith, although it seems as if the latter had been seen by the compiler of the present map. It is evident that Smith, if followed at all, was used more or less from memory, for the Baltimore map is distorted and generalized so far that the local points are rarely determinable. Beyond the presence of "Wighco flu." [Pocomoke], "Watkins point" and the three islands along the eastern side of the bay, there is little to suggest the accuracy and detail of the Smith map.

The principal features which are new in this sketch fall into two

[1]Through an error in proof-reading, this map was credited to Herman in the author's list of maps published in vol. i of this series.

divisions, viz., the improvements over Smith, and those features in which this map is less valuable than the earlier one. We find that

FIG. 39.—The Lord Baltimore Map, 1635, reduced.

the neck of land south of the Little Choptank is more fully recognized and delineated than in the Smith map, and that English names are given to several points on the Potomac river; such as "St. Michaells Poynt," "St. Maries," "Heron Iland," "S. Clement Ile," and "Cedar Poynt." Port Tobacco has already become "Portobacke" in place of the "Potapaco" of Smith, while the name "Pascatoway" has been applied to a tributary of the Potomac, already recognized but unnamed by the latter. The errors in the map arise from a too bountiful scattering of mountains over all of the eastern shore and in two or three places on the western shore. There is none of Smith's care exercised in the position of these mountains, though there is an evident effort to represent the Calvert Cliffs and the higher land near Elk Ridge Landing. The outlines of the upper bay are very poor and the Susquehanna is represented as smaller than the North East, while the unnamed Patapsco is regarded as a large bay. The most interesting feature of the map which has been emphasized in all of the discussions of the southern boundary is the dotted line indicating the southern limits of Lord Baltimore's territory as claimed by the Proprietor. This line runs west from Chincoteague inlet to some point below Smith's Point (Cinquack), thence along *on* the southern bank of the Potomac to Potomac or Acquia creeks, probably the latter, up which it runs on its southern bank.

This map was first published in a pamphlet with the following title page:

"A Relation of Maryland; Together with a Map of the Country, The Conditions of Plantation, His Majesties Charter to the Lord Baltemore, translated into English. These bookes are to bee had, at Master William Peasley,[1] Esq.; his house, on the back-side of Drury Lane, neere the Cock-pit Playhouse; or, in his absence, at Master Iohn Morgan's house in high Holbourn, over against the Dolphin, London, September the 8. Anno Dom. 1635." 1 p. l. 56, 25 pp. sm 4° 1 fold. map.

The earlier pamphlet relating to Lord Baltimore's Maryland colony, published the preceding year and entitled "A relation of the successful beginnings of the Lord Baltimore's Plantation in Mary-land, being an extract of certaine letter's written from thence by some of the Adventurers to their friends in England. [London] Anno Dom. 1634," 1 p. l. 14 pp., did not contain a map. Most of

[1] Wm. Peasley was a brother-in-law of Lord Baltimore.

the original copies of the later work now extant lack the map, but Phillips reports a perfect copy in the Library of Congress.[1]

Several reproductions either in fac-simile or on reduced scale, as in the present instance, have been made of this Baltimore chart. Full sized fac-similes are found accompanying a reprint of the "Relation" made by Francis L. Hawkes in 1865[2] in a "Map to accompany the report of the Commissioners of the Boundary Line between Virginia and Maryland, 1873." Reduced reproductions have also been given in several local histories as well as in Scharf's History of Maryland,[3] and Winsor's Narrative and Critical History of America.[4]

THE FARRER MAP, 1651.

The Lenox Library in New York possesses a supposed representation of the country drawn by Virginia Farrer, entitled "A mapp of Virginia discouered to ye Hills, and in it's Latt: From 35 deg: & 1/2 neer Florida to 41 deg: bounds of new England," which is here reproduced after Winsor. Virginia Farrer, according to various volumes of biography, was the daughter of John Farrer and the niece of Nicolas Farrer, who was at one time connected with the London Virginia Company. She remained a spinster and died in January, 1687. This map of the Farrers is a strange mixture of truth, imagination and probably willful misrepresentation, since contemporaneous maps such as that by Speed were much nearer the truth. The original sheet from which Winsor made his somewhat reduced fac-simile is 10.5 by 13.75 inches and was owned by Mr. John Cadwalader of Philadelphia. The fac-simile is here reproduced as Plate XLV,[5] and from it is derived the following description:

The entire map has a marked warp to prove that "in ten dayes march with 50 foote and 30 horsemen from the head of Ieames River, ouer those hills and through the rich adiacent Vallyes beautyfied with as proffitable rivers which necessarily must run into y^t peace-

[1] Op. cit., p. 28. [2] Sabin's Reprints, vol. i, No. 6. [3] Vol. i, p. 529.
[4] Vol. iii, p. 525.
[5] Nar. and Crit. Hist., iii, p. 465. This map is published with the permission of Messrs. Houghton, Mifflin and Co., who allowed electros to be taken from the Winsor plate.

full Indian sea" one might arrive in New Albion [California] "to the exceeding benefit of Great Britain, and soye of all true English."

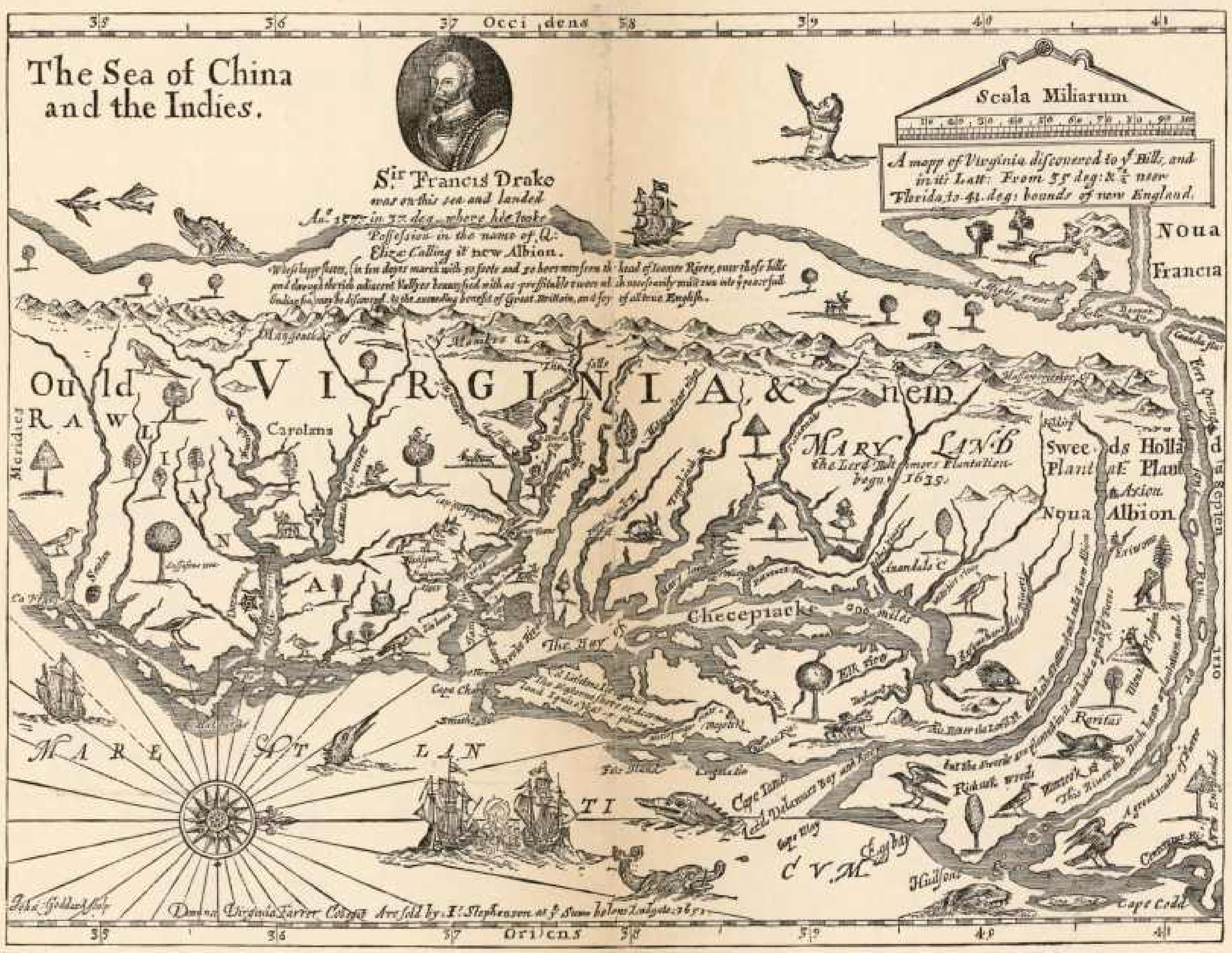
The mountains which have the regular northerly trend first noticed in Blaeu, 1635, may stand, as Winsor says,[1] "for the Appalachians seen from the east, and for the Sierra Nevadas seen from the west, involving a complete annihilation of the great Mississippi Valley, if nothing more, which, to be sure, Marquette has not yet discovered, but which some geographers, certainly for a century, had had due conception of so far as it represented a great breadth of continent."

The fact that the Massawomeckes, the great enemies of the Susquehannocks, inhabited this country shows that the Farrers were thinking more particularly of the Appalachians. It is hardly worth while to discuss in detail a map on which the Hudson empties into the sea in the same latitude as the head of the Chesapeake and rises in "A Mighty great Lake" which empties into the "Sea of China and the Indies."

The differences between this map and that by Smith are marked. The eastern shore is much more cut up; the Pocomoke, which is unnamed, is too broad, and the name Rappahanok seems to have been applied to the Nanticoke and not to the Little Choptank or Fishing Bay as Smith used it. Choptank river also is roughly outlined and there is a river emptying into the bay not far from Worton Point which is possibly intended to represent the Chester. This flows northwest and is called the "Elk," although the present Elk is indicated without any name. The Sassafras is present as the Tunhanok, probably of the same derivation as Smith's "Tockwogh flu." The course of the Susquehanna, which is very similar to that given by Smith, is broader, however, and feels somewhat the distortion necessary to conform to the general notion of the map. The western shore of Maryland is even more poorly drawn than the eastern shore and gives nothing new beyond the fact that "the Lord Baltimor's Plantation begun in 1635." St. Mary's is located on the "Maryland river," while the name "Pataomak" is reserved for Acquia creek.

A portion of Baltimore county north of the mouth of the Bolus

[1] Mass. Hist. Soc. Proc., xx, p. 102.



FARRER'S MAP, 1651 (REDUCED).

FROM WINSOR'S NARRATIVE AND CRITICAL HISTORY.

[Patapsco] is called " Anandale C." The information that " Checepeacke " is 200 miles long is probably derived from the text describing Smith's map. The latitude of 40° N. lat. is close to the mouth of the Hudson.

THE ALSOP MAP, 1666.

Fifteen years after Farrer's work appeared, there was published the fifth map of Maryland, which was based upon personal observations in the country represented. This appeared in a small pamphlet in 1666. The original tract was a very small volume, the printed matter being 2.1 inches wide by 4.8 inches long. The style of the work was cheap and sometimes vulgar, and the author evidently fully understood the men to whom he was writing glowing accounts of the charms of Maryland scenery and hospitality. So far as can be judged from the inscription on his portrait which was published with this little tract, George Alsop was born in 1638. He evidently was not a very tractable youth, for after two years' apprenticeship to some trade in London he became a source of trouble to his friends, and because of the hearty contempt for Cromwell and his party which he showed in his pamphlet, it is inferred that he was shipped to Maryland to serve a four years' term as a redemptioner. He certainly does not seem to have been a pauper or wanting in money, for he speaks contemptuously of those redemptioners who enslaved themselves in return for their passage money, which amounted to about $30. From the letters which accompany his " Character of Maryland," it is evident that Alsop sailed from Gravesend September 7, 1658, and arrived in Maryland some months later, as the first letter from there is dated January 17 [1659]. He lived in apparent comfort in Baltimore county, and from his roving disposition and easy masters, there is little doubt that he came to know the country of the province fairly well. His chief reputation has been gained from the accuracy and vividness with which he described the " Wilde and Naked Indians (or Susquehanokes) of Mary-land, their Customs, Manners, Absurdities, & Religion."

The map prepared by Alsop (Figure 30) is apparently based on " experimental knowledge of the country, and not from [on]

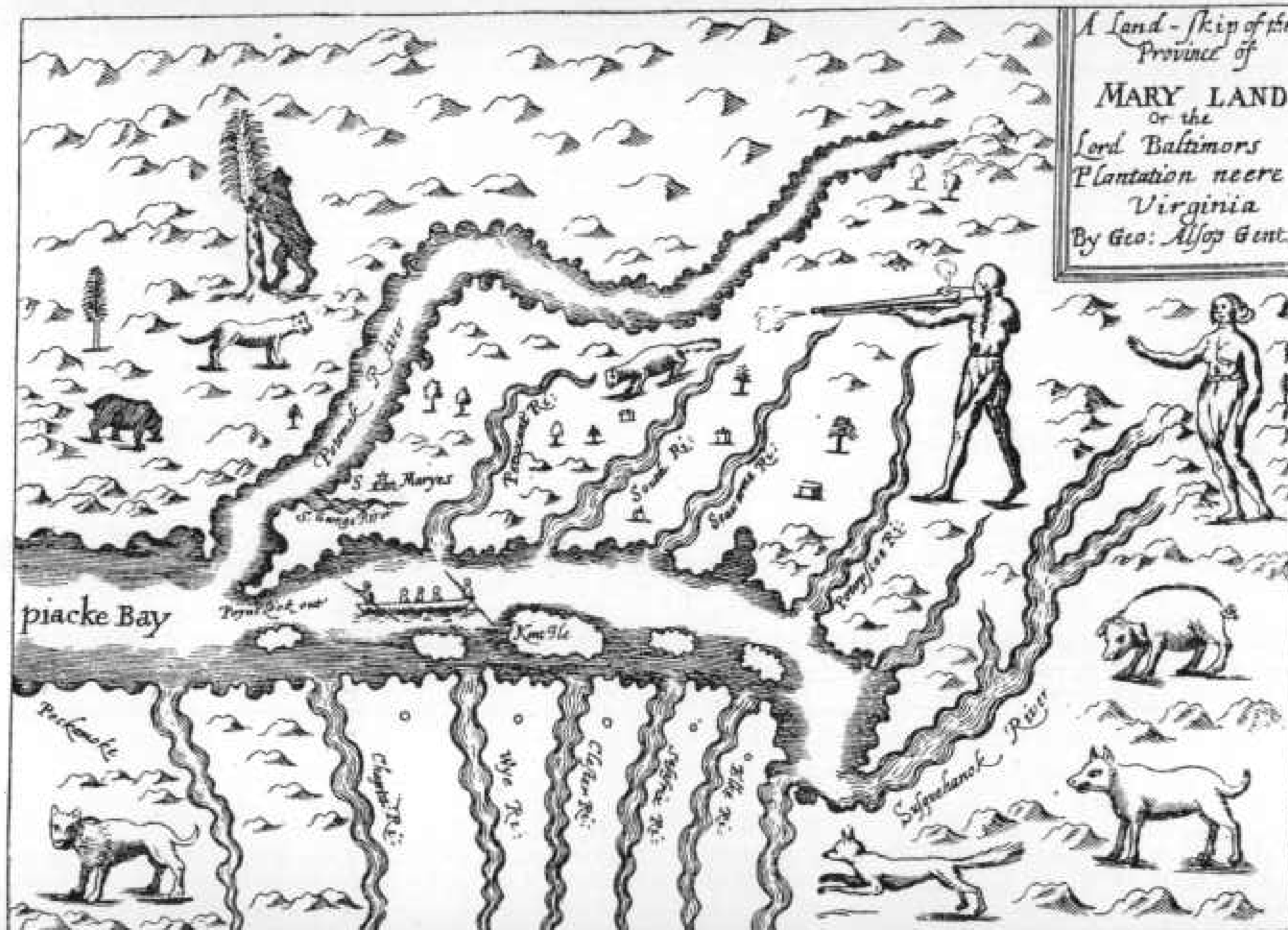


FIG. 30.—Alsop's Map, 1666.

imaginary superstition." In the upper right-hand corner is the title "A Land-skip of the Province of Mary land Or the Lord Baltimors Plantation neere Virginia By Geo: Alsop Gent:" It is probable that he was familiar with a copy of Smith's map, or some work based upon it, for the Chesapeake Bay is named "—piacke Bay." This, however, is not the same in spelling as the Smith map and its position is wholly different. In the same way it does not correspond with the Lord Baltimore map. In fact, it seems to have just the sort of relation to earlier maps that an easy-going fellow would incorporate in a sketch after a sojourn of four or five years in the area. There are about a dozen figures present which indicate the method of illumination and illustration then in vogue. Among these the representations of the male and female savages are of particular interest because of the costumes and manner of dressing the hair, and especially because of the figure of a man in the act of firing a flint-lock musket. The various animals scattered over the little map serve as illustrations to the text in which the author gives a brief account of "the wilde Animals of this Country, which loosely inhabits the Woods in multitudes." [1]

The map shows marked distortion and many generalizations and is in accuracy far below that by Smith. Its rivers are broad and without individuality, while its coast line is roughly represented by a series of sinuous lines bearing no relation to the natural indentations of the bay. The small mountains of the map are not as judiciously placed as by Smith, for, as in the Lord Baltimore map, they are scattered indiscriminately over the Coastal Plain wherever the width between the rivers seemed to call for additional illustration. Both maps represent high land on the right bank of the Patapsco and possibly thereby try to indicate the rapid rise at the "fall line." Although quaint with figures, the value of the map lies in the use of names which have come down to us. There is given here for the first time on a map made by one who had been in Maryland the names of the "Choptank," "Wye," "Chester," "Sasafrix," "Patapsco," "Seauorne" [Severn], and "South" rivers. In the same way "Kent Ile" and "Poynt Look out" appear in their proper

[1] Gowan's Bibliotheca Americana, vol. i [Shea's reprint], p. 38.

places. It is not safe to say that this is the earliest use of these terms on a map, since the names creep in on reissues of old maps. Among those studied by the writer, however, this is the first work based on personal information which uses these terms.

The little "Character of Mary land" in which this map appears was first published in London in 1636 with the following title page: "A Character Of the Province of Mary-Land, Wherein is Described in four distinct Parts, (Viz.)

I. The Scituation, and plenty of the Province.

II. The Laws, Customs, and natural Demeanor of the Inhabitant.

III. The worst and best Vsage of a Mary-Land Servant, opened in view.

IV. The Traffique, and Vendable Commodities of the Countrey, also A small Treatise on the Wilde and Naked INDIANS (or Susquehanokes) of Mary-Land, their Customs, Manners, Absurdities, & Religion. Together with a Collection of Historical LETTERS. By George Alsop. London, Printed by T. J. for Peter Dring, at the sign of the Sun in the Poultrey; 1666."

When Mr. Gowan first attempted to reproduce the work he was unable to find a copy in this country which was entirely satisfactory. The one owned by Mr. Bancroft, the historian, appeared defective in text and deficient in the portrait of the author and also lacking the map. A copy was ultimately found which was complete, and this was edited by J. G. Shea. This reprint by Gowan was published in New York in 1869 as the first volume of Gowan's "Bibliotheca Americana." A later issue of this same work has been brought out as No. 15 of the Maryland Historical Society Fund Publications.

THE HERMAN MAP, 1670.

The map of Virginia constructed by John Smith was the high-water mark in cartographic representation of the territory along the Chesapeake Bay for fully two-thirds of a century. All other maps published between 1612 and 1673 are of much lower standard, or are copied directly from Smith, with perhaps now and then an additional feature or two indicating the gradual growth in the geographic knowledge of the area. In 1670 there was completed within the territory of Maryland a map which is to be ranked with Smith's as representing the highest grade of surveying and drafting conducted in the colonies during the seventeenth century. This map is the one drawn by Augustine Herman, engraved by W. Faithorne in 1673 and copyrighted in 1674, with the title "Virginia and Maryland As it is Planted and Inhabited this present Year 1670 Surveyed and Exactly Drawne by the Only Labour & Endeavour of Augustin Herrman Bohemiensis". Since this is one of the three maps which have exerted a marked influence on all the cartographic representations of the territory from the founding of the colony in 1634 to the appointment of an official topographical engineer in 1833, it will be of interest to bring together all of the available information concerning the man who made the map and the conditions under which it was prepared.

There seems to be considerable doubt as to the correct spelling of the author's name,[1] and there is some difficulty in choosing the most acceptable spelling. There is also some doubt concerning the place and time of his birth. A copy of his will, which was published by Gilbert Cope in the Pennsylvania Magazine of History,[2] contains the statement that this document is dated September 27, 1684, and under Herman's name appears in the same handwriting "Aetatis 63." According to this, Herman seems to have regarded the date of his birth as 1621, a date which would make many of his achievements the products of boyish bravado and enthusiasm. From our present-day standpoint, Herman in 1649-1650 would be regarded as too young to be entrusted with important missions, but at the beginning of the seventeenth century, as shown by the deeds of Smith before he reached his majority, such activity in very young men did not seem abnormal or exceptionally precocious. The

[1] According to the different documents the name is variously spelled:
Augustine Herrman (Map and autograph).
Augustine Hermans (Johnston, History Cecil Co., p. 35).
Augustyn Heermans (Doc. Hist. N. Y., vol. i, p. 430; His journal).
Augustin Herman (Doc. His. N. Y., vol. i, p. 469).
Augustine Heemans (ibid., vol. ii, pp. 80, 84).
Augustyn Hermans (Ibid., p. 98).
Augustine Herman (Md. Archives, vol. xv, p. 18).
Harman (Mem. Long Island Hist. Soc., vol. i, 1867, p. 230).
Augustine Herrmann (Dictionary Nat. Biography).
Augustine Hermen (Doc. His. N. Y.).
Augustyn Herrman (The Will, see Penn. Mag. Hist., vol. xv, p. 326).

[2] Vol. xv, pp. 321-326.

other view that Herman was born in 1605 or 1608 seems to be more commonly held, perhaps from the fact that this copy of the will is little known. According to James,[1] there are two theories regarding Herman's birthplace. The view that he was born at Prague is better established than the assumption that he was born in some town in Germany. We find it definitely stated in a memorandum signed by Herman on June 13, 1681, that he is a Bohemian,[2] while in making his petition for naturalization papers on September 17, 1663, we find the assertion that[3] he was from Prague. Nothing is known regarding his early schooling or training, but it seems quite probable from the handwriting and phraseology of his will, as well as from the accuracy of his map, that he acquired an education rather above that usual for his time. From various sources it is learned that "as early as the year 1633 he had been employed by the West India Company, and in its services had made voyages to Holland and elsewhere. Afterward he was engaged in commercial enterprises, not always of a peaceful character, for he is mentioned as having been engaged in privateering, to which, in that day, no odium attached."[4] He first settled in New Amsterdam "on or before 1647,[5] in which year he was appointed by the Director and Council at New Netherland one of the "Nine Men, a body of citizens selected to assist the government by their counsel and advice." It is certain that he went out to New Amsterdam in the Maecht van Enchuysen as a clerk or factor to John and Charles Gabry of Amsterdam.[6] While in New Amsterdam Herman became a very prominent man in the affairs of the colony and had much to do with the government under Peter Stuyvesant during the years 1649-1650 [O. S.]. His name appears as a "Sellectman" of the town, and in April, 1651, he was sent to Rhode Island as a special ambassador bearing a letter from Governor Baxter to Governor Coddington of the latter colony. Since this letter

[1] James, in his dissertation on the Labadists, asserts that such a will was never recorded although we know that a record of the will was stolen from the State papers. [2] Md. Hist. Fund. Pub., No. 3 App., p. 29.

[3] Archives of Maryland, vol. i, p. 462.

[4] Ward, Penn. Mag. Hist., vol. vi, p. 88.

[5] Mem. Long Island Hist. Soc., vol. i, p. 230.

[6] N. Y. Doc. Hist. N. Y., vol. i, p. 431.

seemed to show treason against the colonies of New England and of Rhode Island particularly, Herman and his companion, Adrien Keysey, were compelled "to give bail in the sum of 100 lbs. stirling till their innocence should be proved." They finally received a certificate from their superiors certifying that as bearers of the letter they were ignorant of its contents and entitled to their freedom.

Although occupying a prominent position under the administration of Stuyvesant, Herman's lot was not always a happy one, for we find that his business affairs at times were not in the best of order. In 1669 petitions were presented "to their High Mightinesses in the name and on the behalf of John and Charles Gabry, merchants at Amsterdam, praying that their High Mightinesses' favorable letters and recommendation to Petrus Stuyvesant, Director General in New Netherlands, to lend a helping hand to the Petitioners or their attorneys, that they may receive from Augustin Herman, their factor in those parts, due account, proof and remainder of the goods which he hath had to dispose of from the Petitioners and their co-partners." About this same time also, Herman writes a wailing letter complaining that everything is going to the bad in the new country and that he fears he is liable to arrest because he will not sign "that he knows and can say nothing of Director Stuyvesant but what is honest and honourable." [1]

Either as a debtor or as a political prisoner it seems that Herman suffered an arrest and incarceration—incidents giving color to one of the most interesting of the many traditions centering about his name. According to one story, "Herman returned to New York, some time after his settlement in Maryland, to find his estate in this city seized by a squatter, and when Herman protested, he was himself placed under arrest. He feigned insanity, the story goes, and refused to be parted from the horse which he had ridden all the way from Bohemia Manor. Accordingly he was bidden to ride his own horse to the second story of a stone warehouse, where he and the horse were securely locked in. But when all his enemies had departed, Herman mounted his horse and rode straight at the closed window of his prison. Horse and man went through the window and

[1] Doc. Hist. N. Y., vol. i, p. 453.

landed safe on the stones below, but with such force that blood gushed from the nostrils of the horse. The escaping prisoner then rode straight to the Hudson, swam his horse to the Jersey shore, and in due time arrived at Bohemia Manor, having in the course of his journey swum also the Delaware on the back of his horse. One legend is that the animal died soon after this second feat; the other, that he carried his master straight to the manor house. . . . At any rate, there are two or three pictures extant of Herman and his horse, the master being represented as standing beside the horse with the blood of the faithful creature reddening his hands. It is pretty well authenticated that Herman himself caused at least one of these pictures to be painted." According to the account of Lednum,[1] one of the halls of the mansion was lined with old and valuable paintings, which had belonged to Augustine Herman himself. Among them were his likeness and that of his lady, together with the painting representing his flight from New York. These were destroyed by fire in 1815.

Herman's first acquaintance with Maryland came about through the aggressiveness of the Council, who ordered that Col. Nathaniel Utie "do make his repaire to the pretended Governor of the people seated in Deleware Bay, within his Lordship's Province, and that he do give them to understand that they are seated within this, his Lordship's Province without notice given to his Lordship's Lieutenant *here*, and do require them to depart this Province."

The Dutch were very badly frightened by Utie's behavior, and immediately sent messengers overland to Manhattan to inform Stuyvesant of the demands he had made. Fearing that the messengers might meet with some disaster, the next day they dispatched a vessel for the same purpose. Governor Stuyvesant, upon being informed of the condition of affairs on the Delaware, dispatched Augustine Hermen and Resolved (or Rosevelt) Waldron upon a mission to Maryland for the purpose of adjusting the difficulty. They came by way of New Amstel and left there on the 13th of September, 1659.

A journal which they kept has been preserved in the Albany Records, 18th volume, pp. 337-364; in the Documentary History of

[1] Methodism in America, p. 277.

New York, vol. II, pp. 88-98, and republished in abstract in Scharf's History of Maryland, vol. I, pp. 244-249. This gives an account of their journeyings down the bay from South Point near Elkton to Kent Island on the eastern shore and thence across the bay and down to St. Mary's. Their experiences in a leaky boat as ambassadors to a somewhat unfriendly people were quite arduous as well as dangerous. Herman was the ambassador and Waldron served simply as an interpreter. That the former was well fitted for his work as a diplomatist is evident from the fact that he was the first one to emphasize the weakness in Lord Baltimore's charter through which it was impossible for the Calverts to embrace any territory which was inhabited by Europeans at the time the charter was granted. After negotiating with the Governor of Maryland, Augustine Herman set out for Virginia, October 21/11 in order to gain the good-will of the authorities of the latter so that they would either take the part of the Dutch or at least not aid the Marylanders. Before leaving St. Mary's Herman wrote a letter to Stuyvesant, which is of considerable interest, as showing that his first plan was to make a map of the head of the bay which should be an accurate basis on which to base a treaty between the colonists at New Amsterdam and those on the Chesapeake. This letter closes with the following paragraph: "But, first of all, the South river [Delaware] and the Virginias, with the lands and kills between both, ought to be laid down on an exact scale as to longitude and latitude, in a perfect map, that the extent of country on both sides may be correctly seen, and the work afterwards proceeded with, for some maps which the English have here are utterly imperfect and prejudicial to us. The sooner this is done, the better, before Baltamoor whispers in the ears of the States of England and thus makes the matter much more difficult."

From the above quotation it is evident, perhaps, for the first time, that Herman first offered to make a map of Maryland territory in the interests of the inhabitants of New Amsterdam. Stuyvesant probably felt that this was looking out in too great detail for the affairs of a poor little colony down on the Delaware and evidently let the proposition go by unnoticed.

Herman remained in Virginia some time, for the authorities at New Amsterdam, when dispatching Captain Newton and Barlette to Maryland on a mission in February, 1660, instructed them to inquire in Maryland if danger threatened the South river and to avail themselves of the "aid and tongue of Augustine Hermann."[1]

On his way to and from Virginia, Herman passed through that portion of Maryland which he subsequently named Cecil county. This area, together with the fact that his suggestion concerning the preparation of a detailed map for Stuyvesant was neglected, led Herman to offer to make a map of Lord Baltimore's territory in return for a manor along the Bohemia river. This offer was accepted by Lord Baltimore in 1660, and as soon as the letter of denization was granted to Herman and his family he moved his whole establishment down to the site of the present Bohemia Manor. During the following decade Herman was busy with the preparation of his map and the clearing of the lands about his new home. His own native ability and the wide acquaintance gained in his business as a surveyor soon brought him into considerable prominence, and we find him a Justice of Baltimore county, a Commissioner with Jacob Young to treat with the Indians,[2] and empowered to grant passes[3] to traders in the area. He was also on exceptionally good terms with the authorities of Delaware, for we find that a road was built at the latter's expense from Newcastle half-way to his manor, while Maryland built the other half. His home was a favorite resort for the higher officials of Maryland, and Charles Lord Baltimore is said to have spent much of his time at Bohemia Manor.

In 1650[5] Augustine Herman married a daughter of Nicholas Varleth, one of the richest merchants of New Amsterdam. By this marriage there were two sons and three daughters, who were brought to Maryland with Herman in 1660. The father was apparently the only strong man of the family, for his children seem to have been weak, not altogether attractive, and the source of little comfort to

[1] Johnston, History of Cecil Co., p. 35.

[2] The Commission may be found in Johnston's History of Cecil Co., p. 79.

[3] Archives of Maryland, vol. i, p. 193.

[4] Slaughter, Memoir of Col. Joshua Fry.

[5] Johnston (p. 36) says 1651.

Herman in his old age. Herman's second marriage was to Miss Catherine Ward of Cecil county in the year 1666. There is a rumor, which has come down to us, that this second marriage was a source of great trouble to the old man, and that domestic affairs finally became so strained that none of the children could live with their stepmother. Certain it is that little attention was paid to the second wife in Herman's will. It is now generally accepted that Herman's death occurred in 1686, as his will, which was written two years earlier, was recorded at that time. The original record was torn from the colonial files, and Herman's son-in-law, Mr. Vanderleaden, was compelled to ask that a new copy be recorded in order that his wife might not be disturbed in the possession of her property.[1] A phototype of a parchment copy with the names of witnesses cut off was published by Gilbert Cope[2] in 1891. From the preceding narration of some of the many facts which have come down to us it is evident that Herman was a man of exceptional power and acumen. He was skilled in diplomacy, polished in speech and pleasing in his personality. As a surveyor and artist he seems to have been far above the average, as is evidenced by his sketch[3] of New Amsterdam, which was engraved on Nicholas Jan Visscher's map, "Novi Belgii Novaeque Angliae nec non partes Virginiae,"[4] published in 1650-56, and also by one on a reduced scale from Visscher's map, which was prefixed to the second edition of Vanderdonck's "Description of New Netherland." Not only was Herman a good diplomatist and surveyor, but he was also a man of affairs who became prominent in local politics and in the promotion of ambitious enterprises for the internal improvement of the country.[5]

The thought of preparing a map of Maryland, as already shown, came to Herman's mind when, as an ambassador to Governor Fen-

[1] Archives of Md., vol. xii, 1894, p. 418.

[2] Penn. Mag. Hist., vol. xv, pp. 321-326.

[3] Wilson, J. G., in "A Maryland Manor," Md. Hist. Soc. Fund Pub. No. 30, p. 10.

[4] This map is of especial interest because of its use in defining the territory granted to Wm. Penn. See portion relating to Boundary Controversies.

[5] He is supposed to have chosen his site for a home with an eye to the construction of a canal connecting the Delaware and Chesapeake bays.

dall, he suggested to Stuyvesant the great advantage of having the territory under dispute accurately represented on some plat or drawing. So firmly was he imbued with this idea, that when Stuyvesant failed to accept the suggestion, Herman proposed to make a map in the interests of Lord Baltimore. The difficulties which Herman undertook to overcome in making this map of Maryland may be better appreciated when it is realized that ordinary roads at this time "were only spaces or paths cleared of trees, and often so narrow and obscure that it was very difficult to follow them." It was not until 1704 that it was enacted that the public roads should be cleared and grubbed at least twenty feet wide, and that overseers should be appointed to keep them in repair and erect bridges over heads of rivers, creeks, branches and swamps where they were required. This act also directed that all roads leading to the court houses in the several counties should be marked "by two notches cut in the trees on both sides of the roads aforesaid, and another notch a distance above the other two. . . . Roads leading to a church were to be marked at the entrance into the same; and at the leaving of any other road with a slip cut down the face of the tree, near the ground. Roads leading to a ferry were to be marked with three notches. When roads ran through old fields they were to be marked by stakes discernible from each other, and notched like the trees." [1]

According to Herman's account, he was employed in the preparation of his map of the area for nearly ten years and spent about £200 sterling, a large sum of money at that early period, and equivalent at the present time to at least $10,000. The expenditure of so much money seemed to be necessary on account of the degree of accuracy which was expected by Lord Baltimore and enjoined in the following extract from papers sent to the Council of the colony, December 13, 1761: [2]

"Whereas Mr. Augustine Herman now Resident in or sd Province has (as wee are well informed and satisfyed) taken great paines and Care in order to the Draweing and Composeing of a certeine Mapp or Card of our said Province & of the Limits and boundaryes of the same, And is shortly

[1] Johnston, History of Cecil County, p. 79.
[2] Archives of Md., vol. xv, p. 18-19.

Fig. 31.—Portion of Herman's Map, 1670. Original Scale.

intended to print and publish the same, wee Doe will and Require you that after the said Map or Card shalbe printed and published, and in case upon the strict perusall and Examination of the same you shall finde that the said Herman has done us Right in stateing the said Limits and boundaryes of our said Province Justly and truly and pticulerly in the True stateing of the said boundaryes and Limits in relation to Watkins Pointe and Delaware Bay that in such Case you recommend the said Herman heartily and Effectually in our name to the Generall Assembly of our said Province than next after to be called or summoned in order to the Receiving some Reward from them for his Paynes and Care, and that in the meane time you assure the said Herman in our name that in case he doe us Right as aforesayd upon the first notice to us thereof Given from you our said Leivetennant Generall or you our said Councill wee will give Directions and orders for his imediate naturalization as he hath desired of us. Given under or hand and Seale at armes the sixteenth day of ffebruary in the four & Thirtieth yeare of our Dominion over our said Province. Annoque Domini One Thowsand six hundred sixty five."

That the map satisfied the demands and desires of Lord Baltimore is seen in the following extract from a summary statement relating to Bohemia Manor which was apparently drawn up by Augustine Herman:

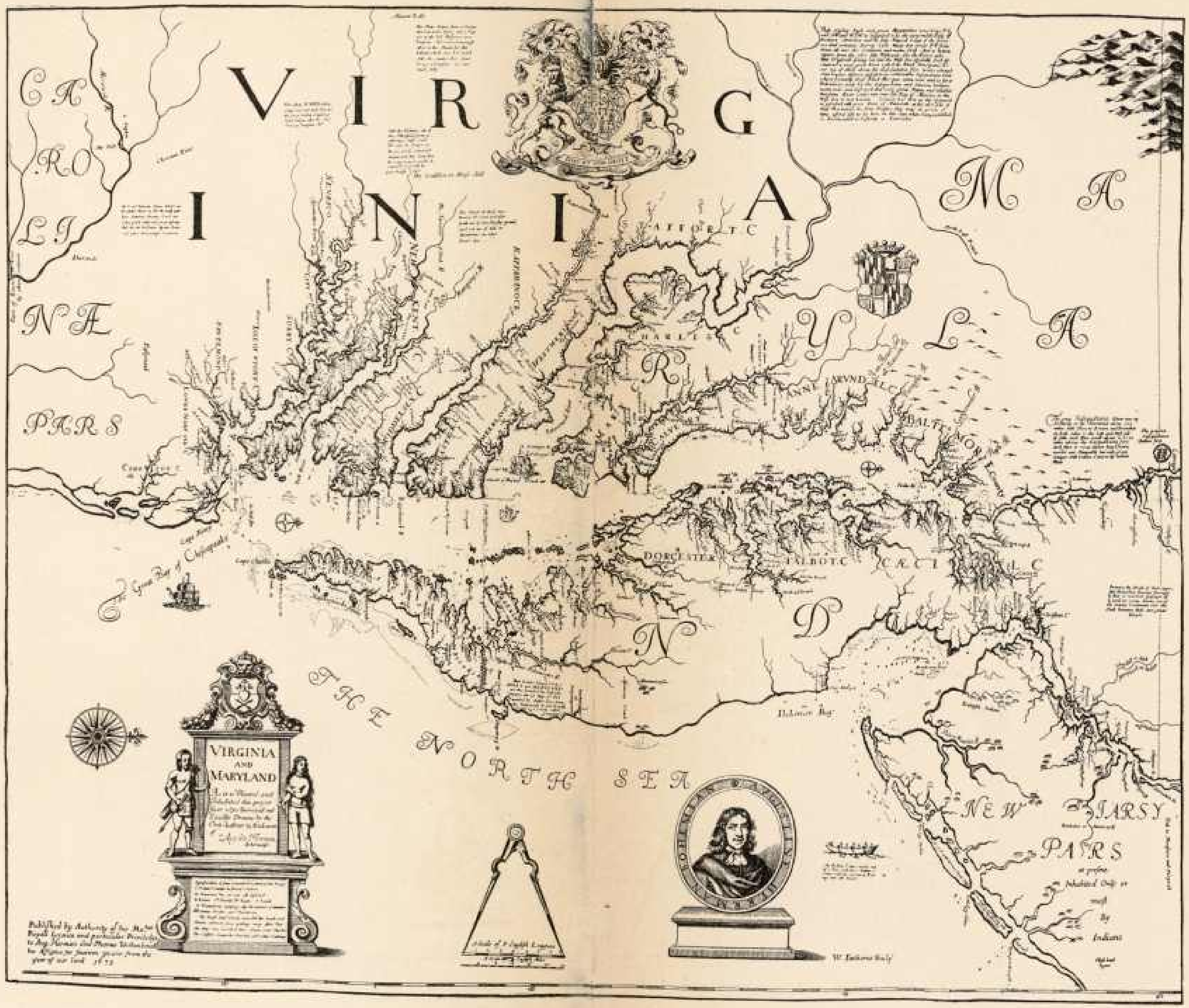
"Augustine Herman haveing his Mapp finished upon his own Cost and Charge no less than to the value of about 200 pounds Sterling besides his own Labour and Sent into England, he then Informed his Lordship there, that within the Naturall bounds of his Mannor were more Acres found to bee; then in his Pattents Specified & therefore Requesteth that it might be Amplifyed and added in his said Pattents whereupon his Lordship Replyed by Lettr Sepr. 3rd & Novr 12 That his Lordship had Received no small Satisfaction by the Rarity of that Mapp and the Kings Majasty his Royl Highness and all others Commended the Exactness of the work.

Aplauding it to be the best mapp, that was Ever Drawn of any Country whatsoever, with recommendation to the Press, his Lordship assuring further that his son then comming Over Governor again should not deny the additionall Amplification Desired nor anything Els whatsoever in Reason should be Expected." [1]

Stuyvesant endeavored to obtain possession of this valuable map, and later Washington remarked that "it was admirably planned and equally well executed." [2]

The grant for exclusive publication of this map may be found in the Calendar of State Papers, Colonial America and West Indies, 1669-1674, page 551, and is here inserted:

[1] Wilson, loc. cit., p. 32. [2] Wilson, op. cit., p. 13.



HERMAN'S MAP OF VIRGINIA AND MARYLAND, 1670 (REDUCED).

Jany 21. 1674.
Whitehall.

1210. Grant to Augustine Hermann of the privilege of the sole printing of his map of Virginia and Maryland. Whereas he has by the King's command been for several years past engaged in making a Survey of his Majesty's countries of Virginia and Maryland, and hath made a map of the Same, consisting of four Sheets of paper, with all the rivers, creeks and Soundings, etc., being the work of very great pains and charge, and for the King's especial service; and whereas the copying or counterfeiting of said map would be very much to said Herman's prejudice and discouragement, all his Majesty's Subjects are hereby Strictly forbidden to copy, epitomize, or reprint, in whole or in part, any part of said map, within the term of fourteen years next ensuing without the consent of said Herman, his heirs, or assigns. [Dom. Entry Bk., Chas. II, vol. xxxvi, pp. 323, 324.] [1]

The map under discussion, of which only one copy is known to exist (now in the Grenville Library of the British Museum), was originally printed in four sheets, which, when put together, measured 36 by 31 inches. The two plates accompanying this report indicate the general appearance of the map on a greatly reduced size, and a portion of the same on its true scale representing the region about the head of the bay. This indicates the most detailed portion of the work, for it includes the territory adjacent to Bohemia Manor, Herman's home. Mr. Phillips, Custodian of Maps in the Library of Congress, possesses a photograph of this exceedingly rare map on its original scale, and there is a facsimile made from the original copy which was published among the "Maps accompanying the report of the Commissioners on the boundary line between Virginia and Maryland, Richmond, 1783." The following description is based upon a study of the facsimile photograph and the reduced copy: [2]

In the center above are the royal arms of Great Britain. Toward the right below is a portrait on a pedestal of Augustine Herman, with an inscription telling some of the features of the map, while at one side is a legend explaining some of the symbols employed. Some-

[1] Quoted by Phillips, op. cit., p. 36-37.

[2] A copy differing in minor details from either of the foregoing is in the possession of Richard Bayard, Esq., of Baltimore, present owner of the Bohemia Manor estate. The two plates here given are taken from this copy, which was generously loaned for the purpose.

what below and to the right of the British coat-of-arms is a smaller shield representing the insignia of the Baltimores. In various places on the map are short accounts elucidating or expanding some of the features suggested in the drawing, as, for example, the comment on the southern boundary on the eastern shore which says:

"These Limits between VIRGINIA and MARYLAND are thus bounded by both sides Deputies the 27 May A° 1668 Marked by dubble Trees from this Pokomoake EAST to the Seaside to a Creeke called Swansecut Cr."

The delineation of the map is good. The names are distinct, and in almost all instances may be read with comparative ease. The map shows evidences of great care in execution, although Herman criticised it, remarking that it "is slobbered over by the engraver Faithorne, defiling the prints with many errors." The full title is as follows: "Virginia and Maryland As it is Planted and Inhabited this present Year 1670 Surveyed and Exactly Drawne by the Only Labour & Endeavour of Augustin Herrman Bohemiensis. Published by Authority of His Maties Royall Licence and particular Priviledge of Aug. Herman and Thomas Withinbrook his Assignee for fourteen yeares from the year of our lord 1673 W. Faithorne Sculpt."

The amount of area included in the drawing extends from the fortieth degree of north latitude to some point in North Carolina, and westward to an irregular line in the longitude of Washington and the Great Falls of the Potomac. Over the area which is now part of Maryland there are eight county names, but no boundaries are laid down between the divisions. These are St. Mary's, Calvert, Charles, including Prince George's, Anne Arundel, and Baltimore, the last two including the present Howard, Carroll, and Harford. On the eastern shore are Cecil, including Kent; Talbot, including Caroline and Queen Anne; and Dorchester, including Worcester, Wicomico, and Somerset. A detailed study of the features of the Herman map leads to the following conclusions:

The lower neck of the eastern shore below the Maryland-Virginia boundary is too narrow and the sounds on the eastern side are too broad. If, however, the delineation is good there has been a marked amount of sedimentation along the shore since Herman's time. On the other hand, Chincoteague is represented as about five miles long, instead of nine as at present. The rest of the shore is generalized, and no islands or bays are given, and it seems probable that Herman never studied this portion of the coast. "Cedar Ile" may mean either Mills Island or Middlemoor Island.

A study of the shores of Somerset county seems to indicate that considerable filling in has taken place since the date of the map. The estuaries of Morumsco creek and Fisher creek are represented as large bays, the latter with not over three or four feet of water. Portions of the coast, such as James Island Marsh, Hazard Point and Deal's Island, and possibly Nanticoke Point, are represented by Herman as islands clearly separated from the mainland, while Holland, South Marsh and Smith's Islands are delineated as small archipelagoes. The outlines of the rivers are better than those by Smith, although sometimes, as in the case of the Nanticoke, the expression of the curves is not as sympathetic as in the earlier map.

The coast line of Dorchester county is very greatly improved over that of any pre-existing map. The country seems to be so well delineated that one is justified in making some comparison with the present state of the land. The most interesting deviation is in the representation of Griffiths Neck between the Nanticoke and the Transquaking. The shore line is here much farther north, and the Chicacomico does not empty into the "St. Catherine als Trequagin" river, but seems to flow directly into the bay. The mouths of the two streams are separated by "Philips Point," which is the only evidence of the headland now terminating at Clay Island. The drawing of Bishop's Head just to the westward indicates a similar change, since the bay extends farther north, and much of the present Bishop's Head Neck was shallow water or marsh and an archipelago of islands. The whole western coast of Dorchester presents the same conditions. It is skirted by a series of islands, and the small streams empty directly into the bay. The neck between the Little Choptank and the Choptank is particularly well outlined, and the map shows the usage of many terms now appended to the same points. The spellings are frequently different, as Tobacco Stick is called "Tobaco Sicks," and Choptank is written "Chaptanck."

As the territory delineated approaches Herman's home, Bohemia Manor, the details increase, until in the territory between the Sassafras and the North East they become so many that the map darkens, and the names, though few, are not very distinct. The description of the country between the Delaware and the Susquehanna is increased by the following information: "Between the Heads of these opposite Branches beeing Swampy is but a narrow passage of Land to come downe out of the maine Continent into the Neck between these two great Rivers."

The names along the Susquehanna located within the present limits of the state are Octora-aro [Octorara] and Canooawengh [Conowingo]. The northern bounds of the colony extending to 40 north latitude and the Susquehanna, which is more carefully sketched than in previous maps, is represented beyond "the Fort" [opposite Columbia], and this additional information is given: "The great Sassquahana River runs up Northerly to the Sinnicus [Harrisburg?] above 200 miles with Divers Rivers and Branches on both sides to the East and West full of falls and Iles until about 10 or 12 miles aboue the Sasquahana fort and then runs cleare but Downwards not Navigable but with great danger with Indian Canoos by Indian Pilots."

The coast line between the head of the bay and the Patapsco shows considerable detail, especially about the mouth of the Gunpowder, but that portion of the map intended to represent the area between Back and Middle rivers is poorly drawn and more or less widely generalized. The Patapsco is not as well outlined as in the Smith map, although there is more detail along the shore south and east of the present site of Baltimore. Following the coast below Bodkin Point, the representation is good as far as the mouth of the Magothy river [unnamed], where for some reason Gibson's Island is not represented either as a point or an island. Sandy and Greenbury Points, with intervening inlets, are indicated somewhat generalized with distorted shape and trend. The "Ann Arundel als Seavorn R" is too broad, but its general trend is well shown as far as Round Bay, above which the outline is generalized, with the headwaters following gracefully curving courses. On the south bank of the river at the present site of Annapolis is "Arundelton." Between Annapolis and Cove Point the amount of detail shown is an advance over that given in preceding maps, especially about South and West rivers, although these show the constant error of being too broad. This, however, is a feature which is common to the rivers of this and many other maps of the seventeenth and eighteenth centuries.

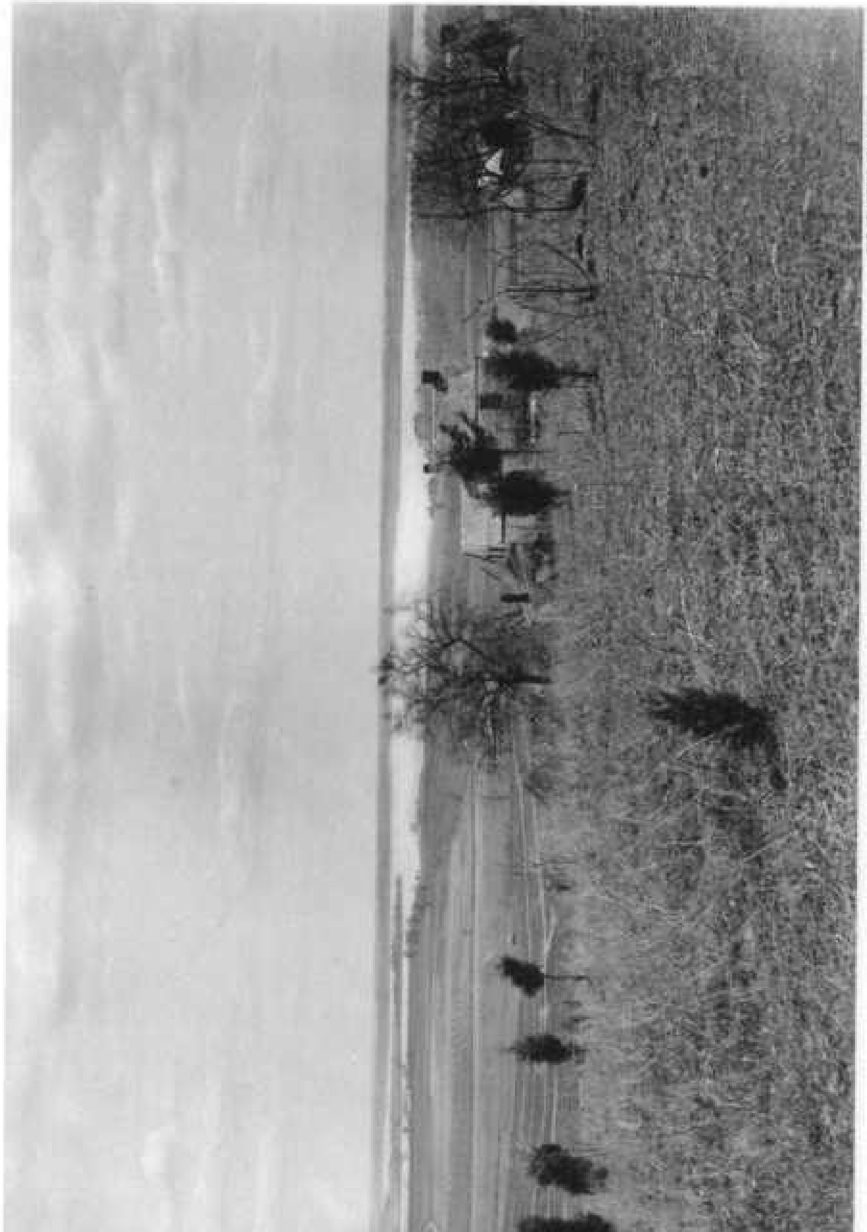
The drawing of the Patuxent, which evidently was explored as far as Upper Marlboro, is good, but is not a great improvement over that of the Baltimore and Smith maps, which represent the general course of the stream even more accurately in some of the prominent details, such as the sinuosities east of Charlotte Hall.

The small streams, especially on the west bank, seem to have confused Herman, since they become generalized and placed at more regular intervals with conventional courses. The largest side stream, named "Calvert Cr," has not been identified satisfactorily. It seems probable that a large estuary seen while skirting along the shore was mistaken for the mouth of a large stream and so interpreted.

The shore line all along the Rappahannock and York and James rivers seems to have been drawn with detail equal to that of the Maryland portion, and the names of creeks and places are especially abundant along the last two rivers. It is not known that Herman spent much time in studying this part of the country, but there is an increase in local names and details over preceding maps which indicates that he was tolerably familiar with the area. The remark on the map that a part of the "Roanoke" river is "by others relation," implies that the rest of the map is based on personal observations. The weakest portion of the entire work is the drawing of the Potomac above Maryland Point. Between the latter spot and the present site of Washington the curves are broad and generalized, the necks of land are unevenly emphasized or distorted, and some of the streams flow at an angle to their true courses and empty into the Potomac some distance from their present mouths. These differences are not due to changes in the topography so much as to ignorance of the country represented. Below Maryland Point the Potomac shore line is more accurate in its delineation, but the various bays and points are, in the majority of instances, without names, and often they cannot be identified with the features recognized to-day.

In the upper right-hand corner of the map, besides a group of mountains which may represent either the Blue Ridge or the Alleghanies, is the following explanatory note: "These mighty High and great Mountaines trenching N:E and S:W and WSW. is Supposed to be the very middle Ridg of Northern America and the only Naturall Cause of the fiercenes and extreame Stormy Cold Winds that comes N:W from thence all over this Continent and makes frost. And as Indians reports from the other side Westwards doe the Rivers take their Origin all issuing out into the West Sea especially first discouered a very great river called the Black Mincquaas River [?] out of which aboue the Sassquahana fort [opposite Columbia] meetes a branch Some leagues distance opposit to one another out of the Sassquahana River where formerly those Black Mincquas came over and as far as Delaware to trade but the Sassquahana and Sinnicus Indians went over and destroyed that very great Nation and whether that same River comes out into the Bay of Mexico or the West Sea is not known. Certain it is that as the Spaniard is possessed with great Store of Minneralls at the other side of these Mountains the same Treasure they may in proces of time afford also to us here on this Side when Occupyed which is Recommended to Posterity to Remember."

The first copy of the map, as already indicated, was engraved by Faithorne who was at the time distinguished for his crayon portraits and his delicate copper-plate engraving. It is not known that more than one edition was taken from this plate, and it seems probable that very few impressions were made, since at the present day only one copy, that in the Grenville Library of the British Museum, is known to be extant. Even before the lapse of the copyright, this map, with various changes and omissions, was republished in 1676 under the title of "a map of Virginia and Maryland sold by Thomas Basset and



THE HELIOTYPE PRINTING CO. BOSTON

ELK AND BOHEMIA RIVERS, FROM ELK NECK.

AT THE HEAD OF CHESAPEAKE BAY.

P. 384 B

Richard Chiswell. T. Lamb Sculpt." in Speed's "Prospect of the most famous Parts of the World." [1]

Somewhat later the map entitled "Virginia, Maryland, Pennsilvania, East & West Jarsey," by John Thornton and Will Fisher, was based primarily on the Herman map. In 1708 a reduced copy of Herman's map was published to illustrate Oldmixon's "British Empire in America," and the credit was given to Herman Moll. The same cartographer used the drawing of Herman in the preparation of maps for many subsequent volumes, notably the "Atlas Geographus" in 1717 and "Atlas Minor" in 1736. Even Homann, as late as 1759, published the Moll map found in Oldmixon's "British Empire" in his "Atlas Geographicus Maior." About the same time John Senex, another noted map publisher, used the Herman map in modified form in his "A New General Atlas," published in 1721, while in 1747 Eman. Bowen claims to furnish "a new and accurate map of Virginia & Maryland. Laid down from surveys and regulated on Astron'l Observat'ns," which Philips says is from Herman's map. Copies from this plate were republished in 1752.

The various editions of the English Pilot contain maps of the lower Chesapeake Bay, which are thought by Philips to be based upon the Herman map. They may, however, be compilations from the Smith and Hoxton charts. From the middle of the eighteenth century until after the Civil War the American map seems to have been lost sight of, and it was only during the careful searches conducted by the Virginia Commissioners on the Southern Boundary question that it was learned that a copy of the Herman map was still extant. A photograph from this rare map was reproduced in a report of the Virginia Commission in 1873, but even this report is now quite rare, and the appearance of the Herman map is practically unknown to the inhabitants of Maryland.

When compared with its predecessors, the map shows a marked increase in detail and evidence of much greater time and labor spent in its preparation. Compared with the Smith map, it shows that while Herman was a more skillful draftsman and a better surveyor,

[1] Philips, p. 42.

he did not possess the geographic sense shown by Smith in the preparation of his map. Although Herman spent ten years in a study of the area, and Smith scarcely as many weeks, the latter showed a clearer grasp of the salient differences between the topography of the Coastal Plain and the Piedmont Plateau than did the former. Smith not only recognized the differences in the character of the eastern and western shores, but seemed to be impressed with the distribution of the irregularities in the territory which he represented. Herman, however, distributed his mountainous area more diagrammatically and conventionally, and did not seem to attempt to give a sympathetic interpretation of the many features which he must have observed. It is of course possible that these slight features in the drawings are among those referred to by Herman in his criticisms of his engraver. The influence of Herman on later works seems to have been about equal to that of Smith, since in the minds of the prominent map and atlas publishers of the last of the seventeenth and the first of the eighteenth centuries, these two men stand as the chief authorities for the cartographic representation of the territory on either side of the Chesapeake Bay.

HOXTON'S MAP OF THE CHESAPEAKE, 1735.

No large map of the Chesapeake shores was published as the result of additional surveys after the appearance of Herman's map until 1735. At that time Walter Hoxton, who seems to have been a captain in the merchant service between London and Virginia, issued his draft entitled "To the Merchants of London Trading to Virginia and Maryland This Mapp of the Bay of Chesepeack, with the Rivers Potomack, Potapsco North East and part of Chester, Is humbly Dedicated & Presented, by Walter Hoxton. 1735." The only information which we have regarding the preparation of this map is incorporated as text upon it. The fullest statement is as follows: "In this Draught all the Principal Points, and all the Shoals and Soundings are Exactly Laid Down, but as I have not had Oppertunity to Survey all of ye Bays, Rivers and Creeks, I have distinguisht what is my own doing by a Shading within the Line, from the outer part of the Coast which to make this Map as complete as at present I am able, have borrow'd from the Old Map, & are Traced by a Single Line without Shading. N. B. The Depths of Water are set down in Fathoms as farr up as Spes Utie Island, but above that in Feet." A study of the map and of the areas shaded as above described shows that the author claimed that he traced the principal portions of the shore line from Cape Henry to "Newport Neues" and Back River (Virginia). From the latter point to the mouth of the Potomac are only a few details regarding the promontories. Both shores of the Potomac are shown from its mouth to the Great Falls, and the names of the tributary creeks are given, although few are indicated farther than their mouths. Along the main shores of the bay, beginning at Point Lookout, the points and portions of the inlet are given as far as North East and thence southward along the Eastern Shore as far as Sharp's Island. The author states at this point that the "Coast from Craddich to Hoopers Streights (on Eastern Side of the Bay) I have not yet Survey'd." The shores of the Patapsco are given with especial detail as far as the Elkridge Landing. The waters of the bay, as already indicated in the quoted text, are covered with figures denoting the depth of the channel in the various portions of the bay.

The sheet on which the map is drawn is 56 by 37 inches in size and the scale is approximately five miles to the inch. In the lower right-hand corner are the statements "Price Eight Shillings & Six pence pasted on Cloth," "London Printed for the Author and Sold by W. Betts at the Virginia and Maryland Coffee house near the Royal Exchange, and E. Baldwin at Ratcliff Cross.

Certain peculiarities regarding the spelling of names and the sketching of the natural features are of interest. Tangier is spelled "Tangere" and Magothy river is spelled "Maggoty." Kent's Island is separated from the mainland by "Wading Place Ferry," and Holland Island from Holland Point by a small estuary.

In the southeast corner of the map is a large sketch of Herring Bay $21\frac{1}{4}$ by 22 inches in size which was drawn in 1732. On this are set down the depth of the water in feet, the houses, the sailing directions and other features of interest. The scale used is two miles to the inch.

Advance beyond the Blue Ridge.

Prior to the fourth decade of the eighteenth century, little information concerning the country west of the Blue Ridge had been gained, and the representations found on the maps published before that time are all vague and fanciful. The attempts of cartographers had been limited to an elaboration of the details in the shore line of the Chesapeake Bay and of the Potomac. After the energy displayed by Lord Fairfax in placing settlers on his lands west of the Shenandoah valley the colonists in Maryland began to push farther westward, and with this movement of the population came an increase in the knowledge of the natural features of that portion of the state now included in Washington, Allegany and Garrett counties. Most of the information gathered was brought together by Virginians or Pennsylvanians, since, with the exception of a crude sketch by Cresap, the work of Marylanders is limited to the tidewater portion of the province.

The "Mayo" Map, 1736-7.

During his exile, Charles II granted to several of his fugitive friends a tract of land in Virginia between the Rappahannock and Potomac rivers. Little by little the property passed into the possession of fewer holders, until in the year 1688 the whole title had vested in Thomas, Lord Culpeper, from whom this property came later into the possession of his son-in-law, Lord Fairfax, who petitioned the King in 1733 for a survey and determination of the limits of his territory. The petition was granted and six commissioners were allowed, three representing Virginia and three the Crown. Three years later, in September, 1736, the Commissioners met and appointed Messrs. Wm. Mayo, Robert Brook, —— Winslow, and —— Savage as surveyors "to examine the main branch of the Potowmack river called Cohungoruton to the head spring thereof." "These being all first sworn, were order'd by thier Several Warrants to begin at the Confluence of that River with Sharando and from thence to run the Courses, and Measure the Distances thereof to its first Spring; And of all this to return an Exact Plat, shewing all the Streams runing into the same on either side, together with a fair Copy of their Feild-Notes. We also directed them to take the Latitude, and observe particularly where the said River intersects the 40th Degree."

Surveyors were also appointed to examine and survey both branches of the Rappahannock to their sources. "According to the order of the Virginia Commissioners Maj^r Mayo form'd a very elegant Map of the whole Northern Neck by joining all the particular Survey's together," which was prepared for the meeting held August 3, 1737. "In this Map were very neatly and very plainly delineated the several Branches of the Rappanhannock River quite up to their several Sources, together with all the Creeks that flow into the same on either Side. The River Powtomack was therein likewise traced with great Exactness from the Mouth, up to the Fork a little beyond the Blue Ridge of Mountains, and from thence up the North Branch call'd Cohungoruton—quite away to the Head Springs thereof with all the Waters that discharge themselves into it. And the Distance Cohungoruton runs from its Confluence with Sharando, is according to the Meanders thereof 206 Miles to its Foundation. From the Hills out of which this River arises, may be seen other Waters which run Westward, and may be the Springs of one of the Branches of Missasippi, probably that commonly called Allegany. In this Map the Courses of Sharando are not described, but just where it parts with Cohungoruton, by reason such Description cou'd give no light to the Controversy betwixt His Majesty and the Lord Fairfax.

"And here I think I ought to do Justice not only to the uncommon Skill, but also to the Courage and Indefatiguable Industry of Maj^r Mayo and two of the other Surveyors, employ'd in this long and difficult Task, Neither the unexpected Distance, nor the Danger of being doubly Starved by Hunger and excessive Cold, could in the least discourage them from going thro' with Their Work, tho' at one time they were almost reduced to the hard necessity of cutting up the most useless Person among them, M^r Savage, in order to Support and save the lives of the rest. But Providence prevented that dreadfull Blow by an unexpected Supply another way, and so the Blind Surveyor escapt." [1]

The party which performed this work consisted of the four surveyors with thirteen assistants, six of them chain-carriers, employed at three shillings per day.

A copy of the map resulting from this survey, and probably a copy of that prepared by Maj. Mayo, is in the library of Harvard University. It bears the title "A Survey of the Northern Neck of Virginia, being the Lands belonging to the Rt. Honourable Thomas Lord Fairfax Baron Cameron, bounded by & within the Bay of Chesapoyocke and between the Rivers Rappahannock and Potowmack: with the Courses of the Rivers Rappahannock and Potowmack in Virginia, as surveyed according to Order in the Years 1736 & 1737." The map is a little sheet, about ten inches square, with the latitude represented to the minutes. It embraces 2° 15′, extending from 37° 45′ to 40° 00′ N. lat., and has no longitude indicated. The scale is about twelve miles to the inch. The chief interest arises, in the present instance, from the names employed and from the platting, probably for the first time, of the entire course of the Potomac from the Fairfax Stone to Point Lookout. This sketch likewise embodies the first accurate representation of the mountains of Garrett and Allegany counties, sinee upon it are located the "Allagany Mountains" [Savage Mt. and Dan's Mt.], as well as the smaller ridges lying east of the great bend in the Potomac where Cumberland is now situated.

The map is little ornamented. Besides the border for the title and the scale, the coat-of-arms of Lord Fairfax is the only indication of attempts at embellishing a sketch which was only intended to illustrate the grant of territory as agreed upon by the Proprietor and his sovereign. Among the names employed to describe features of Maryland territory may be noticed the following variations from present usage: East^{n} Branch [Anacostia], Monokasy [Monocacy], Kittokton [Catoctin], Conigochego [Conococheague], Cohongo-

[1] Byrd, William. History of the Dividing Line and Other Tracts. From the Papers of William Byrd, of Westover, in Virginia, Esquire. Vol. ii, Journey to the Land of Eden, etc. Richmond, Va., 1866, pp. 116-117.

ronta [Upper Potomac], "Wappacomo, also Great S° Fork," "Savage River also N° Fork," and Allagany Mountains. Although the map was credited to Lewis and to Byrd in the list of maps published in the first volume of these reports, it seems, after a study of the circumstances surrounding its preparation, that it should be credited to Wm. Mayo and his colleagues, who actually did the work, although several authors are accustomed to mention it as the "Byrd Map," since Col. Byrd was one of the Commissioners appointed to supplement the work and subsequently published a lengthy account of the "Dividing Line" controversy.

THE FRY AND JEFFERSON MAP, 1751.

The most important map of the Middle British Colonies published during the second half of the eighteenth century was the result of the joint labors of Professor Joshua Fry and Mr. Peter Jefferson, two Virginia surveyors of marked influence and experience throughout all of the territory of Virginia lying on either side of the Blue Ridge.

Joshua Fry, born in England during the latter part of the seventeenth century, was in 1728 appointed master of the grammar school at Williamsburg (subsequently William and Mary College), where he was afterwards advanced to the chair of mathematics. The facts concerning his life are so few that Slaughter in his Memoir says: "I know of no other person in our history of like social position, wealth, capacity, character and public services as Col. Fry, about whom there is so little to be found in print, and that little so scattered in infinitesimal items."[1] Fry was appointed Justice of the Peace and County Surveyor of Albemarle county, Virginia, in 1745, and was soon in intimate association with Jefferson, who likewise became a Justice of the Peace and a Deputy County Surveyor. Fry died at Fort Cumberland, Maryland, on his march against Fort Duquesne, May 31, 1754, when his command fell to George Washington, who was at the same time Fry's chief military subordinate and his Deputy Governor.

[1] Slaughter, P. Memoir of Col. Joshua Fry, sometime Professor in William and Mary College, Virginia, and Washington's Senior in Command of Virginia Forces, 1754, etc., etc., p. 17. [Richmond, 1881.]

Peter Jefferson was born February 29, 1708, and had a scanty early education, but possessed such a desire for knowledge and such great strength of character that he subsequently made up the deficiency by study and reading. From the time of his settlement in Albemarle county in 1738, Jefferson became an important member of the community, and was appointed to the offices of Justice of the Peace and County Surveyor, involving high responsibility and considerable education, for at that time Justices of the Peace were selected only from gentlemen of the first consideration, and County Surveyors were obliged to submit to examinations given by the professors at William and Mary College. During the years 1745 to 1750 both Fry and Jefferson were engaged in laying out government grants and in surveying the western limits of the "northern neck" by running a line from the head springs of the Rappahannock to those of the Potomac (1745), and in extending westward the boundary line between Virginia and North Carolina (1749). During these surveys both men had occasion to explore the country west of the Blue Ridge for a distance of nearly one hundred miles, and to travel over a large part of the territory west of the Shenandoah valley. Fry particularly, as we learn from his obituary notice, had acquired great experience and personal knowledge of the country which he was to traverse in his passage from Fort Cumberland to Fort Duquesne. Both men are described as possessing exceptional skill in their judgment of the due proportion of areas and distances, and it is probable that the information represented on the map indicates the highest degree of knowledge of the country attainable at that time.

The preparation of this map, which includes the territory between North Carolina and New York, Ohio and Maryland, was not hastily undertaken, but was a subject which had long been held in mind, especially by Fry, as is shown by the following notice which appeared in the *Virginia Gazette*, Williamsburg, January 5th, 1737: "Towards the close of the last session of Assembly, a proposition was presented to the House by Mr. Joshua Fry, Major Robert Brooke, and Major Wm. Mayo, to make an exact survey of the colony, and print and publish a map thereof in which shall be laid down the bays, navigable rivers, with the soundings, counties, parishes, towns and gentlemen's seats, with whatever is useful or remarkable, if the House should see fit to encourage the same. But as said proposition was presented too late in the session, it was ordered that the consideration thereof should be postponed to the next session of Assembly." [1] The facts accumulated during the various surveys were brought together and the map apparently was completed in the year 1749, although it is dated 1751. It was published under the auspices of Virginia, and was based on much besides conjectural data. While there are many inaccuracies, and the map is often generalized from a small amount of information, it is a highly creditable production and ranks as one of the three or four maps which have exerted a great influence on the subsequent cartography of the area delineated. The work was first published under the title "A map of the most inhabited part of Virginia containing the whole province of Maryland with parts of Pennsilvania, New Jersey and North Carolina. Drawn by Joshua Fry and Peter Jefferson in 1751. To the Right Honourable George Dunk, Earl of Halifax, (etc) this map is most humbly inscribed by Thos. Jefferys engrav'd and Publish'd according to Act of Parliament by Thos. Jefferys, London." [after Philips.]

The copy published in "The American Atlas, London, 1775," which is the same as the edition of 1751, consists of two parts which unite to form a single sheet 37 3/8 by 29 3/4 inches. The drawing is on a scale of something more than 10 miles to the inch (approximately that of the Mayo map of 1737). It is uncolored except along the streams, water-lines and boundaries, where there are bands of hand-laid colors differing for each colony. The title, however, is ornamented in black and white by a contemporaneous wharf scene, in which the merchant sits at a table awaiting refreshments while he converses with two friends who stand near by. On the left are negroes moving and repairing casks, while in the background is a clerk taking account of the cargo.

The Maryland portion of the sheet does not adequately represent the high character of the map, since there is little indicated besides

[1] Slaughter, Memoir of Joshua Fry, pp. 18-19.

names and a few roads on the Maryland portion, while Virginia streams and roads are carefully delineated with their names attached. The roads are only such as were main thoroughfares connecting different portions of Virginia with Philadelphia. Two things of especial interest may be noted in the 1775 copy of the map, viz., the simultaneous representation of Baltimore on the Bush river with the Baltimore Iron Works on the Patapsco, and the location of a coal mine[1] on the left bank of the Potomac not far above the mouth of the Savage river.

The relief indicated, which is so characteristic of the map and its various modifications, shows a grasp of the linear arrangement of the ridges in a N.E.-S.W. direction, but otherwise is arbitrary and mechanical. In this respect the work of Fry and Jefferson is not to be compared with that of Griffith, which appeared only seventeen years later. In the latter the representation of the Blue Ridge and the Catoctin mountain is far superior.

From the similarity in scale and draughting, as well as the close friendship between the authors of this map and the surveyors of the Fairfax lands, it is evident that considerable credit should be given to William Mayo and his colleagues of the survey of the Northern Neck. Wherever the credit for it should be placed, this map has exerted a great influence on the cartographic representation of Maryland, and in a greater degree on that of Virginia, from the time of its first publication in 1751 till the work of Alexander (1834-40) in Maryland and the survey of Virginia during 1828-29.

CRESAP'S MAP OF THE SOURCES OF THE POTOMAC, 1754.

The Cresap map of the area, based on personal observation, was drawn by Col. Thomas Cresap. The author of this map was a well-known settler in the extreme western portion of the province, a typical frontiersman who was familiar with the country and engaged in all sorts of exploring and hunting expeditions through the moun-

[1] This is also seen on the Dalrymple map of 1755, which claimed to be "from information collected on the spot and entered in his journal" by the author. Its appearance suggests a very liberal use of Fry and Jefferson's work of 1751, and in the lower sheet the information is credited to them at least in part.

tain wildernesses about the branches of the Potomac. At the request of the Maryland Council, Cresap undertook a survey of both the north and south branches of the Potomac, in order that their true position and relative length might be accurately laid down on a map which should serve as a basis for the settlement of the western boundary line between the territories of Lord Baltimore and Lord Fairfax. The work of surveying was first attempted in 1754 and some sort of a map was placed in the hands of Governor Sharpe in the early part of June (Arch. Md., vi, p. 72), but the outbreak of the French and Indian war prevented any satisfactory study of the territory, and Cresap, in 1756, was compelled to write to the Proprietary that "no survey could be safely made within 80 miles of the South Branch by less than a body of 100 or 200 men." The amount of information gathered during this attempted survey and already acquired in previous expeditions through the territory by the author are found roughly represented in a sketch-map of the area which has been reproduced in Appendix D of "The Report of the Committee on the Western Boundary of Maryland."[1] This map was drawn approximately on the scale of twenty miles to an inch, and possessed little information beyond a general outline of the courses of the north and south branches of the Potomac and the location of the boundary lines drawn from the North Fountain and the South Fountain respectively. The Monongahela is described as "A large River navigable for small Crafts, a Branch of Ohio River, runs into Mississippi."

The work of Cresap, embodied in the map of 1754, is of importance since by it was first established beyond doubt the fact that the northern bend of the Potomac at Cumberland is not north of the Mason and Dixon line, as it was feared by the Marylanders and claimed by their neighbors. The original draft of the Cresap map was deposited in the Land Office in 1771.

EVANS' MAP, 1755.

The energy of the Virginians which led to the publication of the Fry and Jefferson map was ably supplemented by the intelligent zeal of the inhabitants of Philadelphia, which stimulated Lewis Evans

[1] Maryland Hist. Soc. Fund Pub. No. 29, Balto., 1890.

to bring forth one of the most carefully compiled maps constructed in the colonies during the third quarter of the eighteenth century. This was accompanied by a small quarto volume containing "An Analysis Of a General Map of the Middle British Colonies in America, (etc.)," which was intended as the first of a series of "Political, Philosophical and Mechanical Essays." [1]

It is difficult to estimate just what credit should be given to Evans for this map, and for an earlier one published in 1749 bearing the title "A Map of Pensilvania, New-Jersey, New York, And the Three Delaware Counties: By Lewis Evans. MDCCXLIX." [2] The latter abounds in interesting meteorological observations which may have originated with Evans' publisher, Benj. Franklin, while the former is frankly acknowledged in the "Analysis" to be a compilation of existing information supplemented by that gained through personal observations in many portions of the territory depicted. That he was regarded as a loyal Pennsylvanian who might allow his partisan allegiance in the disputes over the boundary line between Maryland and Pennsylvania to overbalance an accurate representation of the natural features may be seen in the following extract from a letter [3] of Calvert to Governor Sharpe, dated April 17, 1754:

"Entre nous, I understand Mr. Evans is a man of no good Character, and has been a time Serving man to the Messieurs Penns. The Map from whence the Articles of Agreement with the Late Lord and Messieurs Penns was by Artificial means imposed on the Late Governor and sent by him to the late Lord, [has been] the Product of much Uneasyness to the present Proprietor."

Referring to the preparation of his map of 1755, Evans says: "I am obliged to the same Map [Fry and Jefferson], and Capt. Hoxton's chart of *Chesapeak Bay*, for *Mariland.* But this Colony is the worst done of all the Settlements in mine, yet the Bay from Annapolis to the Head, I have lately had an Opportunity of adjusting;

[1] Philips, in his "Cartography of Virginia," p. 50, gives the title as "Geographical, historical, political, philosophical, and mechanical essays." This is apparently the form in the first edition, as the shorter form is from the second edition published during the same year.

[2] See W. M. Davis, Jour. Franklin Inst., Feb., 1889.

[3] Archives of Maryland, vol. vi, 1888, p. 50.

as well as to measure the Isthmus across from the Head of Elk to Delaware River, about three Miles below New-Castle. There is a considerable Error in my General Map, which came Time enough to my Knowledge to be mentioned here, tho' not to be rectified; and that is, the Breadth of the Peninsula from Fenwick's Island to the South Side of Little Choptank, which I make 65 Miles, whereas, Mr. Parsons, one of the Surveyors, who ran the line across, informs me that it should have been 70" (p. 5). The Evans' map thus follows the Fry and Jefferson map in the western portion of the state, but differs from it in these particulars. Since "an actual Survey from Philadelphia to the Mountains, near the great Bent of Potowmack, by the Pensilvania Surveyors in 1738, enabled me to give the just Longitude of that Place from Philadelphia, which they [Fry and Jefferson] mistook by 10 to 12 Miles; and this obliges me to give Potomack, and the whole Country, a Position somewhat different. As that Performance [Fry and Jefferson's] is very valuable, I contrived mine to interfere as little as possible with it; and omitted the Counties and numerous Gentlemens Seats that it contains, to give Room for the Roads, Inspection-houses, Court-houses, and the Seats of some half a Dozen Gentlemen, noted in a literary Way."

This advance in the location of the great bend in the Potomac is hardly noticeable without a close comparison of the different maps, but serves as one of the means by which maps based on Evans' authority may be distinguished from those after the earlier work of Fry and Jefferson.

Little is known concerning the first publication of the Evans map of 1755 beyond the facts already recorded, but the impression left on subsequent drawings of the same area is marked. During the year following its first appearance in America it was republished in London, and two years later it was published "with improvements" by I. Gibson and by Thomas Jefferys. The last serves as plate No. 32 in Jefferys' "A General topography of North America and the West Indies," London, 1768, and as No. 18 in his "American Atlas" of 1775. About the same time (1776) I. Pownall, Governor of Pennsylvania, published in London a "General Map of the British

Middle Colonies," which was engraved by T. Almon. The work, because of Pownall's position and his previous explorations, became an authority which was reproduced or acknowledged as a basis in most of the maps published in Europe to illustrate the situation of the contending forces during the Revolutionary war. In this capacity it appeared with corrections in "The American Military Pocket Atlas" published by R. Sayer and J. Bennett in 1776; in enlarged form in 1786; and finally somewhat modified in the various editions of "A New Universal Atlas" by Thomas Kitchin. (The latest of these issues seen was dated 1799.) The different editions show variations in spelling, in the towns chosen for representation, and even in the location of the different places. For instance, all of the sheets seen are characterized by the towns of Onions and Kingsberry in Baltimore county, while Cresaps (variously spelled) is located not far from the mouth of the south branch of the Potomac instead of in the meadow lands of Will's mountain as at present.

Although credited to Pownall, these various sheets are little more than modified editions of Evans, who, in turn, with the exceptions noted, followed the map of Fry and Jefferson, who were probably familiar with the earlier work of Mayo and the Fairfax Commission.

GRIFFITH'S MAP, 1794.

The very close of the century was marked by the publication of the best compilation of existing geographical information concerning Maryland up to the work of the Topographical Engineer of the state, J. H. Alexander, during the fourth decade of the present century. This work, which will stand comparison with the best maps yet published of the northern border of the state, was drawn by Dennis Griffith, a Philadelphian, and copyrighted June 20th, 1794, with the somewhat lengthy title,

"Map of the State of Maryland Laid down from an actual Survey of all the principal Waters, public Roads, and Divisions of the Counties therein; describing the Situation of the Cities, Towns, Villages, Houses of Worship and other public Buildings, Furnaces, Forges, Mills, and other remarkable Places; and of the Federal Territory; as also a Sketch of the State of Delaware; showing the probable Connection of the Chesapeake and Delaware Bays; by Dennis Griffith."

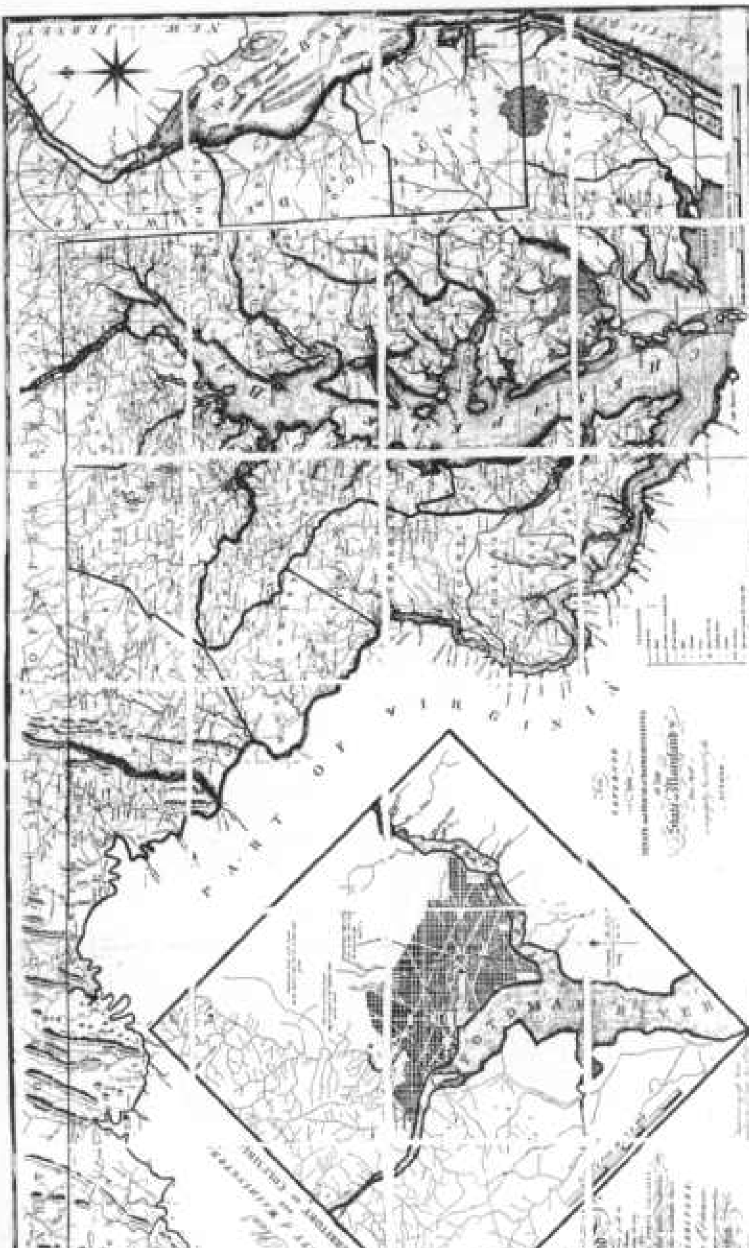


FIG. 32.—Griffith's Map of Maryland, 1794, reduced.

The first edition of this large work was published in Philadelphia, June 6th, 1795, by J. Vallance, who was the engraver of the map. Eighteen years later (May 28th, 1813) a second edition was published by John Melish. There is evidently little difference between the two issues, since a copy of the second edition in the Harvard Library has the change in edition and publisher pasted over a portion of the title while the date of copyright remains the same. The engravers in the later issue are J. Thackara and J. Vallance.

This map, which reminds one very forcibly of the county maps of seventy-five years later, is a sheet 52x30 inches in size, and the scale is between four and five miles to the inch. On this base in different colors are outlined the counties of the state, and wherever occasion demands, the roads, towns and waterways as indicated in the title. Although it is claimed by the author that "the lines have been laid down from an actual survey," it has been impossible to find any reference to the man or his work beyond the date of his marriage. It seems accordingly somewhat doubtful that more than certain portions of the area were visited by him. The work is executed with more than usual skill, and possesses considerable interest in the present connection from the indication of iron works in Washington county, north of Elkton, at Principio, etc.; glass works at Middletown, copper mines at Creegarstown, etc. There is also evidence of several attempts to change the names of well-known towns. For example, Hagerstown is given the name of Elizabethtown, Havre de Grace is called Susquehanna City, while Rockville is still indicated as Montgomery C. H.

Between the issuance of the first and second editions this work of Griffith's gained considerable influence in Europe, in a reduced and translated form, as "Maryland und Delaware von D. F. Sotzman," which was published in Ebeling's "Erdbeschreibung von Amerika" in 1797.

Later Work on the Chesapeake.

While the first accurate knowledge of the country west of the Blue Ridge was being gathered in the form of maps, the work along the shores of the Chesapeake Bay was continued in greater detail, especially with reference to the hydrography of the region. From this activity resulted three maps of considerable importance and in one instance of some influence. The subjects treated are the Eastern Shore, the waters of the Bay, and territory adjacent to Havre de Grace.

CHURCHMAN'S MAP, 1778.

The active interest developed at Philadelphia in the study of the natural resources of the colonies, and the public-spirited endeavors to improve the communication between the scattered settlements, led a few enterprising citizens to ask the American Philosophical Society to institute a survey of a portion of the peninsula between the Chesapeake and Delaware Bays, in order to ascertain the possibility of the construction of a canal between these two bodies of water. It is probable that John Churchman, Sr., was actively engaged in this work, for the Churchmans lived in the neighborhood and might be "termed a family of surveyors, as the calling was exercised by the two Johns, father and son; by George, son of the second John, and by John, Micajah and Joseph, sons of George." The information acquired at the time and the general trend of investigations in this region seem to have descended to John Churchman, Jr., or John the Philosopher, as he was sometimes called, who was born in 1753 and died in 1805. This eminent surveyor and geometrician published a series of maps, charts and atlases, among which are two of marked importance, entitled "To the American Philosophical Society This Map of the Peninsula Between Delaware and Chesapeake Bays with the said Bays and Shores adjacent drawn from the most accurate Surveys is inscribed by John Churchman" and a "Magnetic atlas, or Variation Charts of the whole terraqueous Globe, London, 1794." The latter brought him into prominent notice both in America and abroad, where he was highly esteemed as an authority on scientific subjects, while the former is of especial interest from the fact that a claim exists that it "is upon the largest scale of any ancient map we have seen, and altogether the most accurate, except that it is singularly erroneous in the location of Tangier and Watts island." [1] The scale

[1] Rept. and accompanying documents of the Virginia Commissioners appointed to ascertain the Boundary Line between Maryland and Virginia. Richmond, 1873, p. 50. This seems to show a lack of familiarity with the

is approximately ten miles to the inch, and the legend, as above cited, is in the southeastern corner of the map, which is ornamented by smaller sketches and figures. The area included embraces the territory of eastern Virginia, Eastern Shore of Maryland and Delaware, and all the land between the Chesapeake and Atlantic ocean. The Western Shore of the former is also roughly sketched. The recognized counties of the Eastern Shore (except Wicomico [1]) are separated from each other by hand-colored boundaries. The creeks are broad and the roads are drawn freehand. Along the water-line and in the bay are represented the shoals and sandbanks of both the Chesapeake and Delaware waters, while over the map are scattered the names of the principal towns. The map was published without date or place. The year given is based on Johnston's statement on page 526 of his "History of Cecil County." The map itself points to an earlier date, since on it appears "West New Jersey," which was not in use after 1776. It cannot be assigned to a much earlier date because of the youth of the author.

ANTHONY SMITH'S CHART, 1776.

The chart of Chesapeake Bay which was best known during and just subsequent to the Revolutionary war was published in the "North American Pilot" in its various editions. In its earliest form, as published by Sayer and Bennett (?), it bears the title "A new and Accurate Chart of the Bay of Chesapeake with all the Shoals, Channels, Islands, Entrances, Soundings and Sailors marks, as far as the Navigable Part of the Rivers Potowmack, Patapsco and North East. Drawn from several Draughts made by the most experienced navigators chiefly from those of Anthony Smith, Pilot of St. Mary's." Some of the editions add "compared with the Modern Surveys of Virginia and Maryland." On the map is also a "Plan of Herring Bay in Maryland" on an enlarged scale.

Nothing is known of the actual authorship of this chart, although it is here assigned to an Anthony Smith of St. Mary's. No record

Anthony Smith and Hoxton charts, as well as a lapse in memory regarding the scale of the Herman map.

[1] Wicomico was not a separate county at that time.

has been found concerning this man, who, to judge from the charts, must have been exceptionally well informed regarding the subaqueous and littoral characteristics of Chesapeake Bay and its estuarine rivers. Certain copies of the chart have a text upon their face indicating that the work was done by some naval officer who employed Smith as his pilot. Such certainly was the arrangement in making a survey of the Potomac, although earlier less authentic but apparently no less accurate soundings had been made with considerable system.

This Smith chart was composed of four large sheets each 18 by 27 inches, combined to form a single map 36 by 54 inches, the size and scale, about 3½ miles to an inch, affording sufficient room for a large amount of detail. Apparently all of the prominent houses visible from the water are indicated with a manifest effort to represent the shape, size and relative positions of the different structures, which are distinguished by the names of their owners. On the blank portions of the sheets are given sailing directions, involving mention of many of the buildings placed on the headlands. Besides these features, which might prove of historical interest, there are many figures and lines showing the courses to be followed, the bearings of prominent landmarks, and the depth of water along the streams and bay. This map has the longitude in degrees from London.

Subsequent to its first appearance in London, a French edition was published in 1778, and English editions appeared in "Norman's American Pilot, 1798," and the North American Pilot, part two, 1800.

HAUDUCOEUR'S MAP, 1799.

The third map mentioned, that of the territory about Havre de Grace, seems to be the product of an attempt to make this place a prominent port and city for the transhipment of freight. The sheet, which resembles the charts prepared by the U. S. Coast and Geodetic Survey, is beautifully executed, and the topography of each side of the Susquehanna is as well represented in hachure as in any map of the region yet published. The territory included in the sheet, which is 22 by 29.5 inches, extends from Spesutia Narrows to a point about five miles north of the Mason and Dixon line. Over this district on either side of the river the roads, streams, property lines, houses and state of cultivation are represented with apparent fidelity. Many of the roads and farms bear names. The streams and banks of the river are well drawn, and considerable effort was made to represent the character of the bottom underlying the river and the head of the bay. In the river the different falls are indicated, and below Havre de Grace the depth of water is given in feet. "The Soundings here quoted," the text says, "have been taken in the months of September and October the driest time of the Year. They are the result and average of fourteen days observations at different hours hence more water will be found in wetter seasons and full tides." The text in addition gives the following: "By repeated Hydraulic and Hydrostatical observations the Author has found that the River Susquehannah discharges in every second of time a volume of 70,450 Cubic feet of water he computes that this volume of water is generally increased in a triple proportion in high freshes."

The fall in the Susquehanna from Luff's Island near the state line to tide is 57½ feet.

The latitude of Havre de Grace is 39° 33′. The longitude from Washington is 58′ E. and from Philadelphia is 59′ W.

In connection with this map and the prophecies thereon contained, it is interesting to compare a "Chart of the Mouth of Susquehanna River and Head Waters of Chesapeake Bay, Maryland. Surveyed by order of Congress Under the direction of G. W. Hughes, U. S. Civil Engineer, by J. T. Lee and C. N. Hagner. Drawn by T. J. Lee, 1836." This sheet includes about the same territory on approximately the same scale. A great many soundings are given, especially along the present channel, and bathymetric contours are given for each three feet. In the upper right-hand corner of the later sheet is given a copy of Hauducoeur's soundings, 1799. A comparison of the two sets of determinations seems to indicate a silting of the sides and re-entrants, with a slight scouring and straightening of the channel in a few places. The Eastern Channel toward Turkey Point is much shallower in the later map.

The Era of Internal Improvements.

As soon as the leading men of colonial days realized that their colonies were merged into a republic they recognized the fact that there could be no permanency without easy communication and interchange of thought and goods between the scattered members of the United States. To establish the political life begun and to increase the material resources of the yet undeveloped country, the general government, states, syndicates, and private citizens began a series of far-reaching internal improvements.[1] This wave of enthusiasm, which

[1] The following are among the more important enterprises undertaken in Maryland:

1767 Chesapeake and Delaware Canal proposed.
1783 Susquehanna Canal.
1784 "Potomac Company."
1784 Canal from Basin to Ferry Branch of Patapsco.
1796 Improvement of.
1799 Revival of Chesapeake and Delaware Canal project.
1812 Revival of Chesapeake and Delaware Canal project.
1817 Patapsco Canal.
Canal from Curtis Creek to Severn.
Canal from Severn to Potomac (Washington and Baltimore Canal Co.).
1822 Chesapeake and Delaware Canal.
1822 Baltimore and Conewago Canal.
1823 Chesapeake and Ohio Canal.
Baltimore Canal.
1824 Canal from Fishing Bay to Nanticoke River.
1825 Canal in Dorchester County.
Canal from Quantico Creek to Nanticoke.
1825 Susquehanna and Potomac Canal.
Maryland Canal.
1826 Baltimore and Ohio R. R.
1827 Elkton and Wilmington R. R.
New Castle and Frenchtown.
1828 Baltimore and Washington Turnpike.
Baltimore and Susquehanna R. R.
Frederick County Canal.
Annapolis and Potomac Canal.
1830 Washington Branch Baltimore and Ohio R. R.
1831 Wilmington and Smyrna R. R.
Alleghany Coal Mine R. R.
Sam's Creek R. R.
1832 Baltimore and Port Deposit R. R.
Lewis and Pocomoke Canal Co.
Delaware and Maryland R. R.
1836 Eastern Shore R. R.
1837 Wilmington and Susquehanna.

was at its height during the second and third decades of this century, swept the country, leaving as a result long lines of public highways, canals and railroads. Each class of works required a knowledge of territory hitherto unexplored, which was acquired by many detailed surveys and recorded in musty field-notes and a few old maps. The latter are of little value in the present connection.

Each of the three classes of enterprise—canals, highways and railroads—found earnest advocates in Maryland, and within the state are three of the most important products of this eventful epoch—the Cumberland and National Road, the Chesapeake and Ohio Canal, and the Baltimore and Ohio Railroad. Besides these are others of less extended influence which mark the less successful attempts to control the growth and direction of trade for the sake of Baltimore. Three problems stood uppermost in the minds of Marylanders. The first was the avoidance of the long sail down the Chesapeake and up the Atlantic by means of canals across the low-lying Eastern Shore; the second was the development of some means by which the trade of the Susquehanna valley would be diverted from Philadelphia to Baltimore; and the third was the capture of the future western trade by easy means of communication across the Alleghanies.

THE CANAL MAPS.—CHESAPEAKE AND DELAWARE CANAL.

The solution of the first problem stimulated the survey of the territory along the Sassafras, the Choptank and the Transquakin, and resulted ultimately in the construction of the present Chesapeake and Delaware Canal. As early as the last of the seventeenth century Augustine Herman appreciated the probable drift of enterprise and settled on the Bohemia river, believing that this body of water would sometime be a portion of an inland watercourse between the cities of the Atlantic coast. It is reported that this far-sighted colonist actually made a preliminary survey of the country between the two bays to determine the practicability of this scheme. Nothing came of the project, however, until it was revived nearly a century later. From an old work on the "Internal Navigation of the United States," published anonymously at Philadelphia in 1824, "we find, that as early at least as the year 1767 or 1768, the matter was seriously taken up, and prosecuted by Mr. Thomas Gilpin and other gentlemen; who were at great pains in accomplishing a number of surveys, and giving estimates to the public, for a canal from Duck Creek to the head of Chester. In 1769, a condensed view of all that had been done, was presented by Mr. Gilpin to a committee of merchants, formed in Philadelphia, for the purpose of improving the trade of the province; as also to the American Philosophical; and this was soon followed by a survey, and remarks upon another route; viz. from Bohemia river to Appoquiminink; after which the Elk route was also examined" (p. 80). This canal, for which so many surveys were made, was actually commenced in 1824 and finished a few years later. The work of Thomas Gilpin was finally brought together in a volume by his son Joshua Gilpin, one of the directors of this canal company, and published at Wilmington under the title "A Memoir on the rise, progress, and present state of the Chesapeake and Delaware Canal accompanied with original documents and maps." This little volume shows that the surveys made by Thomas Gilpin were conducted during the years 1767-68, and the report is accompanied by five small maps as indicated below:

a. The route from Chester to Duck Creek by T. Gilpin, 1769.

b. The route from Bohemia to Appoquiminink.

c. The route from Elk to Christiania.

d. General surveys of canals, roads, etc., made by the Philosophical Society in 1770.

e. Map of the present designated route.

All these maps are small and represent little increase in knowledge regarding the territory beyond the accurate location of given points along the course of the proposed canal. In a few instances the profiles accompanying the sketches give some data regarding the topography of the territory traversed. It is highly probable that the information recorded on these maps was in possession of Griffith, and probably Evans, when they made their maps of the territory.

The efforts to increase the trade of Baltimore by canals fall into two groups determined by the country traversed. The trade along the Susquehanna was approached by the Baltimore and Conewago and the Port Deposit and Baltimore Canals, while that of the Potomac and the West anticipated the use of the Maryland and the Chesapeake and Ohio Canals. These various undertakings, involving the construction of more than 500 miles of canal across mountainous and hilly country, were never wholly completed, and the last named is the only one now in active operation. Each of the four schemes, however, fostered one or more surveys of intervening territory, which resulted in the acquisition of a large amount of detailed information regarding the topography of the state, and many of the reports made by the surveyors were accompanied by maps showing something new in the delineation of the areas represented.

BALTIMORE AND CONEWAGO CANAL.

The investigations of the commissioners appointed by the state in 1822 to lay out and survey a route for a canal which should connect the waters of the Susquehanna with the city of Baltimore, etc., led to several surveys of the country between Baltimore and York Haven on the Susquehanna, some forty miles above Mason and Dixon's line, and the preparation of a report accompanied by two maps. A line of levels was carried by Mr. Poppleton from tidewater at Baltimore along the York Pike to York, Pennsylvania, thence via York Haven to the head of the Conewago Falls, and thence up the river to Harrisburg. At the same time Captain Hartman Bache and Lieutenants Eakin, Graham, and Boyce carried a series of levels from the head of Conewago Falls down the right bank of the Susquehanna to tide at Lapidum, opposite Port Deposit, and Messrs. Bridges and Jehu Bouldin, the latter city surveyor of Baltimore, surveyed the country between Havre de Grace and Baltimore along the upper edge of the Coastal Plain. These various surveys added considerable information regarding the territory of Harford and Baltimore counties, which up to this time had received little attention since the time of Herman. The data obtained were incorporated in a "Topographic map of the route of the proposed canal and the country between Conewago and Baltimore drawn by direction of the Canal Commissioners by F. Lucas, Jr." This map, which is 18.7 by 15.7 inches in size, on the scale of 3.7 miles to an inch, is drawn in black and white, with hand-colored zones indicating the boundaries between the counties and states, the water area between the shores of the Susquehanna, and the location of the proposed canal. Somewhat generalized roads are drawn over the interior portions of the map representing the various pikes radiating from Baltimore and Belair, on which are given the altitudes of the various rivers and streams intersected by different lines of levels, especially along the York Road. The streams which are indicated on the map include drainage lines such as the "Gwinne's Falles," Jones' Falls, Great and Little Gunpowder, Deer creek, and many small streams flowing into the bay. These are apparently well located at their mouths and at their intersections with the turnpikes surveyed, but the parts of their courses between such intersections are drawn arbitrarily, with only an approximation toward the general curves of their courses and with no accurate detail. The map, however, is the first one to represent the accurate sources and general courses of several of the streams of this region. Lines of hachures indicate the "fall line," or the boundary between the Coastal Plain and the Piedmont Plateau, and the "Slate Ridge." As the latter is recognized in the text as but a part of a zone of high land extending from the Potomac to the Susquehanna, this seems to be the first recognition of the general elevation of the country now included in Parr's Ridge.

Although an improvement over preceding maps in its delineation of the interior of the country, it is far below them in the accuracy with which it represents the shore line. This shows frequent distortions and wavings of the coast line which are wholly contrary to nature. Moreover, certain of the streams, such as Romney creek, are entirely different in their shape and character, since they are represented as large estuaries running in directions sometimes nearly at right angles to the courses represented in the most authoritative drawings.

The second map accompanying this report is entitled "A map showing the extent of the Susquehanna country and its Practicable Canal Routes as designated by the Susquehanna Commissioners." This adds nothing to the pre-existing knowledge of the area, although much information had been acquired concerning the northeastern portion of the state. The base of the map, while redrawn by B. T. Welch, is really only a modified copy of the well-known map of Fry and Jefferson published some seventy-five years earlier.

A third map, which seems to be the result of the same commission, is entitled "Map of the route for a Canal and Still Water Navigation from Port Deposit to Baltimore. Drawn under the direction of the Commissioners by W. F. Small, Engineer." This sheet is 17.8 by 14.2 inches in size and possesses hand-colored waterways and boundaries. The scale is approximately 4.75 miles to an inch, and the territory represented extends from McCall's Ferry and Philadelphia on the north and east to Baltimore on the southwest. The map is very similar to the first, or "Lucas," map, from which it differs, however, in size, scale, and minor features. There are indicated a "Saters Ridge" [Setters Ridge], a "Slate Ridge," "Highlands of Pennsylvania," and three small hills near Elkton, each showing marked vertical exaggeration. The whole map, as is the case with several of those by Lucas, suggests a generous use of the Griffith map, but the names and the cultural features are variously modified.

MARYLAND CANAL.

The extension of canal communications from Baltimore to the Potomac resulted during 1838 in the survey of several routes for the proposed Maryland Canal, which was never built. The work was under the direction of Col. J. J. Abert of the U. S. Topographical Engineers, who examined the country of Anne Arundel, Howard, Carroll, Montgomery, and Prince George's counties in search of the most advantageous location. The first three choices for the route were platted on a map which was apparently published in Annapolis in 1838 and subsequently reprinted for the use of the U. S. Engineers, 1874. This reprint is 28 by 22 inches in size and includes the country between the Patuxent and the Monocacy from the Liberty Road to Rockville, on a scale of approximately a mile to an inch. According to a portion of the legend this is "compiled by T. J. Lee from actual surveys made in 1838" and bears the title "Map of the Country embraced in the Surveys made in 1838 under the direction of Col. J. J. Abert for routes for the proposed Maryland Canal." The drawing is clear, the locations of the proposed sites for the canal, its feeders and the intersecting roads, are given with considerable detail. The streams also are drawn with care, while the broad outlines of the topography of Parr's Ridge are given in hachure. These features of the topography and drainage show an advance over the earlier maps, but are inferior in completeness to the work of Alexander published in 1840.

THE CHESAPEAKE AND OHIO CANAL.

The most important and far-reaching in influence of the canals constructed in Maryland is the Chesapeake and Ohio Canal. The credit for first proposing such a stupendous undertaking belongs to Richard Henry Lee, who suggested the enterprise to the Virginia legislature as early as 1769. Later the Potomac Canal Company in the years following 1784 constructed a canal part way up the Potomac.

The location of the Chesapeake and Ohio Canal furnished occasion for many preliminary and location surveys which largely increased the existing knowledge of the country along its course, but so far as it has been possible to learn, most of the information then acquired was not published in the form of maps constructed accurately from the surveyors' field-notes. Manuscript maps, however, were published and accompanied many of the reports. Some of these are still in existence, while others have slipped out of the knowledge of the engineers now in charge. According to a report on the extension of the Chesapeake and Ohio Canal to the Ohio river by Major William E. Merrill, Corps of U. S. Engineers, made to the Secretary of War in 1824,[1] the first examination and survey of the routes for a canal to connect the Chesapeake Bay and the Potomac river on the eastern, with the Youghiogheny and Monongahela valleys on the western slope of the Alleghany mountains, was made in the summer of 1824, and was chiefly to determine the practicability of the undertaking. This was almost entirely restricted to the examination of the moun-

[1] House Executive Documents, 43rd Congress, First Session, No. 208, p. 59.

tain or summit section from Cumberland and the north branch of the Potomac to the junction of the Youghiogheny and Castleman rivers at Turkeyfoot. The route surveyed in 1824 was by the north branch of the Potomac to the mouth of Savage river, thence by Savage river, Crabtree creek and a branch of Crabtree creek to Bear and Deep creeks, and thence by the Youghiogheny to Turkeyfoot. That part of the route from Cumberland to the mouth of Savage river was surveyed by Major J. J. Abert, Topographical Engineers, and the remaining portion by Captain Wm. G. McNeill, Topographical Engineers. During the next year a more careful and detailed survey was made to determine the route to be recommended, and also to obtain the data necessary to frame a general plan of the work and a preliminary estimate of the expense. The report for 1826 was more complete than the former one and discussed the character and general features of another route—that by the valley of Wills creek leading northerly and easterly from Cumberland and crossing the mountains to the valley of Flaugherty creek, which empties into Myer's Mill, and thence into Castleman river, a branch of the Youghiogheny which it joins at Turkeyfoot, near Confluence. Various reports, presented either as annual reports, reports of the engineers or reports of the Board of Internal Improvement between the years 1825 and 1875, contain many facts on the flow of streams, their profiles and the general character of the country, especial emphasis being laid on the rainfall, the rate of evaporation and other subjects so essential to the successful operation of a canal.

Although a large amount of literature has been published in the Congressional Documents, in the reports of the Virginia and the Maryland Legislatures, and in separate pamphlets, there is really little of the actual results of the surveys contained therein, and the maps accompanying them are almost all poor drafts, incommensurate with the amount of information acquired by skilled engineers. The chief causes of the publication of so much literature were the difficulties in raising money for the completion of the work, and the litigation arising from the dispute with the Baltimore and Ohio Railroad regarding the right of way in the valley of the Potomac between the Point of Rocks and the Savage river.

THE RAILROAD MAPS.—BALTIMORE AND OHIO RAILROAD.

While the advocates of the canal system were energetically endeavoring to show that waterways were more economical and beneficial than highways, engineers were actively engaged in devising the machinery and in pushing forward the work on railroads. It is a fact well known to Marylanders that in this early promotion of railroading none surpassed in zeal and skill certain eminent engineers of the Baltimore and Ohio Railroad. Although carefully executed surveys were conducted as described in the succeeding pages, the topographic facts acquired found expression in but few maps constructed by the engineers of the company. The information gained during the building of the road from 1827-1839, however, must have been in the hands of Alexander when he constructed his large manuscript map of the state in 1840, while accurate locations of the Patapsco, Bush creek, and the Monocacy were first gained by the work of the railroad surveyors.

As early as 1827 Col. Stephen H. Long and Jonathan Knight were selected to make surveys of the proposed road, and the following engineers were detailed by the United States to assist in the work—Capt. Wm. Gibbs McNeill, Lieuts. Joshua Barney, Isaac Trimble, Richard E. Hazzard, Wm. Cook, Walter Gwynn, John L. Dellahunty and Wm. Harrison, Jr. These surveyors made a reconnaissance between Baltimore and Washington and thence up the Potomac across the mountains to the Ohio, and a report was prepared by Messrs. Long and Knight in April, 1828. The annual report of the president of the road published during this same year contains a small sketch, 13.4 by 7.7 inches, drawn on a scale of about a mile to an inch, which represents in black and white the location of the railroad as far as Ellicott City. With the third annual report of the president which appeared the succeeding year (1829) is a "Map of the Country Embracing the various Routes surveyed for the Baltimore & Ohio Railroad by order of the Board of Engineers Drawn by Lt. T. Barney, U. S. A." This sheet, which is 23.5 by 9.7 inches in size, is drawn in black and white on a scale of approximately 3.1 miles to an inch. On it are represented by hachures the hills and drainage of the country bordering what is now the "main line" of the railroad. So far as is known, this is the first detailed delineation of Howard and Carroll counties based on careful work, and as far as it extends it has remained of value in indicating the hills adjacent to the railroad. This map was republished in the succeeding year, and no doubt served as a basis for maps of the eastern end of the road for several years. In 1833 B. H. Latrobe prepared a "Map & Profile of the Projected Lateral Railroad to the City of Washington [etc.]," which accompanied the seventh annual report of the president. This was drawn on the scale of a mile to an inch and represents the intersecting roads and drainage of the area traversed. Somewhat later (1835) Jonathan Knight prepared a "Map of the Country between Cumberland and the Ohio representing the Routes reconnoitred with a view to the extension of the Baltimore & Ohio Rail Road to that River." This map, which was drawn by Mr. H. R. Hazelhurst on a scale of five miles to an inch, accompanied the ninth annual report of the president and represents practically all of the original mapping done by the railroad engineers until the appearance of Latrobe's "Map and Profile" in 1850, which marks the completion of the pioneer work across the state. The location of the Baltimore and Ohio Railroad has furnished a carefully surveyed and leveled line which has served as a datum upon which to construct profiles or from which to run levels across less accessible portions of the state. The work does not represent the first mapping of the region, especially along the Potomac, neither does it give the first determination of the slope of the country, for the "total descent of the river as well as its length were determined by examination and by survey by the Potomac Co., created in 1784 at the instance of Gen. George Washington." [1] The levels were extended to Deep creek in the Glades of Garrett county about 1824.

Every railroad operated within the state has given rise to one or more surveys, and the results obtained by the surveyors have often been expressed in maps. The time when these maps have been published and their own character have precluded the opportunity to represent many new features of the country surveyed. For this reason the later work has not been discussed in detail.

[1] House Doc., 20th Cong., 1st Sess., No. 47, p. 89.

THE SHRIVER MAP.

Although the numerous surveys for canals and highways were often productive of increased detailed information concerning places already explored, their influence on the cartography of the state, lay in the increased tendency to travel, which developed a demand for maps and clarified the previously confused conceptions of much of the territory opened to travel. Many of the maps which came into prominence during the period under discussion were prepared by engineers who were employed in some phase of the work, and no one of them was of greater importance to the western portion of the state than that by Jas. Shriver, a nephew of David Shriver, who was engineer in charge of the eastern half of the National Road from Cumberland to Wheeling.

Shriver's "Map of the Country through which a Canal to connect the waters of the Chesapeake and Ohio is proposed to pass and of the National Road between Cumberland and Wheeling with adjacent Country from Actual Survey," was originally published by F. Lucas, Jr., of Baltimore, as a sheet 18 by 27 inches in size.

This sheet includes all of the state west of Cumberland, as the routes to Pittsburg and to Wheeling are both represented. The topography of the region is expressed in some detail, especially in that portion of the state west of Little Back Bone Mountain, where Shriver did most of his work. The mountains are drawn in hachures with considerable sympathy and accuracy, and the names now in use are almost always employed. The swamps are indicated by conventional signs or words, while the meadow lands and glades are faintly tinted, and the cultural features, such as the roads, towns and residences of prominent citizens, are given with considerable fidelity to the facts. Scattered over the sheets are such words as "iron ore," "coal," "sugar maples," etc., indicating sources of wealth.

In the lower left-hand corner of the sheet is "an enlarged section of the summit level," 6 by 9 inches in size, drawn on a scale of approximately 1.5 miles to an inch. This shows the slope and distribution of the glades on either side of Deep creek. Although out of date, the location of immovable features compares favorably with any of the maps existing prior to the recent work of the Federal surveyors. This secondary map represents the results of a large amount of work by its author while in charge of the surveys of the glade country and of a study of the water supply for the summit level of the Chesapeake and Ohio Canal.

The Work of John H. Alexander, 1833-1840.

The year 1834 marks the beginning of an undertaking which, if carried out, would have rendered Maryland at its completion one of the most thoroughly surveyed states in the Union and in the possession of a map unexcelled in accuracy and completeness of detail. Before John H. Alexander had reached the age of twenty-one he had conceived the project of carefully examining and surveying the entire territory of the state with a degree of minuteness sufficient to warrant the construction of a map equal to the most detailed products of the larger official organizations. Born in Annapolis, June 26, 1812, and graduating from St. John's College with the highest honors in 1827, Alexander at first undertook the study of law. The suddenly aroused activity in questions of internal improvements, such as the construction of canals, post-roads and railroads, appealed to the student as a line of work full of fruitful possibilities to those fitted for leadership. Accordingly, Alexander gave up the study of law to devote himself to applied science, and became a subordinate assistant in the survey of the Susquehanna, now the Northern Central Railroad. It was during his work on this line that he realized the necessity and value of accurate maps of those areas through which highways were to be constructed. Realizing at the same time that maps alone would not set forth all the facts necessary for the stimulation of immigration and settlement, he united with Professor J. T. Ducatel, professor of chemistry in the Medical Department of the Maryland University, in emphasizing the need of a new map of the state before the Legislative Assembly, with the result that in 1832, upon a resolution of the Legislature, he was appointed with Ducatel to make the necessary preliminary reconnoissance of the state.

This introductory survey resulted in the report on the "Projected Survey of the State of Maryland," published in Annapolis in 1834, which was accompanied by the map of the state of Maryland representing the most reliable data which could be collected by Alexander and Ducatel. This first work had for its aim "a general reconnoissance of the entire territory of the state with a view of the proper arrangement for subsequent Topographic and Geologic examination, and, inquiry after, and collection of all such authentic information, contained in maps or charts, as covers any part of the said territory of Maryland." The reconnoissance consisted of visits to the chief towns in each of the counties and the examination of a few of the more important and noticeable features of the state. The time occupied was a little over three months. A catalogue was prepared of all the maps regarded at the time as authorities, which was deposited with the librarian of the state. This, however, cannot be found in the library at Annapolis at the present time. The enumeration of charts and maps numbers over sixty, since map No. 63 is taken as one of the authorities for the preliminary draft accompanying the report. The first map of the state prepared by Alexander accompanying the report already referred to is a small black and white drawing of the territory included between the Atlantic ocean and the western boundary. It shows evidence of familiarity with the local features and presents many improvements regarding individual outlines. There are, however, numerous minor distortions in the coast line, and likewise in the outline of some of the streams, which are sketched with considerable accuracy. The numbers of the names on the map are evenly distributed, and as much effort was made, apparently, to attain their uniform distribution as to bring out the location of the more important towns of the state. Among these names may be noticed occasionally a difference in spelling from that in vogue at the present time, as "Emmettburg" instead of Emmitsburg. This map, which is 13.7 by 7.6, is approximately on the scale of 18 miles to an inch. Judging from the text, the map published is the reduction of a larger map made on the scale of 1:200,000 and is based upon observations of latitude and longitude in Baltimore and Washington and on the following pre-existing maps. "The portion of territory, eastward of the meridian, passing between these places, has been laid down from Mr. Lucas' chart; a work published not very long since, upon data and calculations which are near approximations of those used in the present instance. Westward of this meridian, the course of the Potomac was found in Map No. 63 of the table; and actual survey of the Board of Internal Improvement. This line in default of astronomical observations has been used for defining the western boundary of the state. Still further west, the map of Virginia has furnished the Geography of the country adjacent to the South Branch of the Potomac." On the surface of the manuscript map were also drawn contour lines 100 feet apart vertically, and a number of profiles which were drawn on the same horizontal scale as that of the map with a vertical proportion on the scale of 1:40,000. The statistical columns which accompany this map may be the same as those published in the small sketch in the report, but the text seems to indicate that more facts were collected on the manuscript than are published on the map which has come down to us.

During the summer of 1834 Alexander seems to have been occupied for a very long field season as the topographic engineer for a commission appointed to survey the sounds lying on the Eastern Shore of Virginia, Maryland, and Delaware,[1] and to ascertain the distance between Cape Charles and Cape Henlopen on the eastern or seaward side of the peninsula. The work was conducted from carefully measured base on Smith's Island in coöperation with the U. S. Coast and Geodetic Survey, according to the mode of procedure laid down by the latter organization. The plan of coöperation seems to have called for a primary triangulation by the Federal bureau, and a complete filling in of the secondary and tertiary triangulation by Alexander and his party. The degree of detail sought by Alexander would have rendered any specific survey for local internal improvements unnecessary, thereby saving to the state in the course of years immense sums of money. The prosecution of this work led to the preparation of six maps enumerated by Alexander in the report on the "New Map of Maryland, 1835," page 5, as follows:

"1. A chart of the headlands between Chincoteague inlet and Fenwick's island: the one point being somewhat below the stone between

[1] Report of Progress of the Survey of the Sounds lying on the Eastern Shore of Virginia, Maryland and Delaware. Annapolis, 1834. 23 pp.

the northern line of Virginia—the other containing a boundary stone between Maryland and Delaware. 2. A map of the line run to ascertain the direction of the Canal in the neighborhood of Berlin—from Ayres Mill, at the head of Trap creek, to the head of Herring creek. 3. A map of the location of the Canal from Assawoman, across Turkey Branch creek to White's creek in the state of Delaware. 4. A map of the location from Rehoboth bay, at Warren's creek, to Woolff's branch of Lewes creek. 5. The profiles of the several lines and locations. 6. The Project of the triangles to be made use of in the survey of Rehoboth bay."

Besides these maps, which so far as can be learned are no longer in existence, Alexander prepared others representing the location proposed for the canal between the Choptank and Blackwater, the results of a survey of the Piscataway creek and the proposed drainage of Zakia Swamp, or Allen's Fresh Canal; a plan of a portion of the triangles of the Western Shore of Maryland, and two maps of southeastern and southern Maryland which have been preserved in the reports published for that year. The first three maps are drawn on large scale and really represent little more than carefully constructed meanders and sketches of the bottom land and slopes of the valleys through which the streams surveyed flow. The method of representation is in black and white, with the different hills drawn in delicate hachures with a considerable degree of accuracy. The streams also are sketched and the limits of the marsh lands often meandered.

The map representing the triangulation of the western shore of the bay is of interest in showing the location points for what was "almost the only survey and, it is believed, the first in the United States, based upon the proper principles and conducted by a skilled and scientific observer." The degree of accuracy sought was within the limit of error of one-fortieth of a foot. More than 60 stations are represented, and the work here indicated was probably the basis of all the maps constructed prior to the careful work of the Coast and Geodetic Survey, and even later beyond the limits of the latter's work. There are indications that a line of tertiary triangulation was conducted along certain of the waterways, especially in the vicinity of Baltimore.

The size and shape of these maps have already been indicated in the list published in the first volume of these reports.

The two remaining maps published with the report for 1835 and described as "Map A" and "Map B" are of particular interest, since they represent a marked increase in the knowledge of the topographic features of the state and give the first accurate delineation of the surface of the country at a distance from the shore line which had been made in any detail. Map A is a black and white sketch 23 by 15 inches in size, drawn on the scale of 1:211,200, and includes all the territory of the state between the Choptank, Chesapeake and the Atlantic ocean, or the area now occupied by Worcester, Somerset, Wicomico and Dorchester counties. According to the description in the text, "Besides containing the positions of the various places, the course of the streams, &c., and the geological indications, which speak for, and explain themselves; the Map A contains also an elucidation of the topographical features of the country. There has been introduced into this, with as much general accuracy as possible, the system of horizontal planes, indicative of precise differences of level, as well as exhibiting to an eye but a little familiarized the contour and relief of the ground." At first glance the aims enumerated seem accomplished and the impression is left that this is a map possessing accuracy sufficient for all future cartographic representation, since few maps in America are made on a contour interval of less than ten feet. A close examination of the map, and a comparison with the work accomplished in later years, shows that this impression is quite erroneous. Instead of this map showing accuracy of detail normally to be expected with four-foot contours, it is full of distortions, not of a simple sort, east and west, north and south, but in different directions in different portions of the map. The more marked distortion arises, however, from a tendency toward elongation in an east and west direction. This is specially emphasized also by a straightening of the coast lines, which run in a west-southwesterly direction to a due west course—a distortion which is well shown at the mouth of the Monie river, where the north shore of the Jericho marshes is so straight that the southern shore of Dames Quarter has been distorted to the northeast in order to represent the impression received of the Monie estuary. Not only is there a distortion in the distribution of the points and in the general shape of the coast, but there is likewise a marked lack of detail, or else arbitrary generalization, in the sketch of the shore line. This is carried so far that many of the medium-sized estuaries are completely lacking or are merged into a single bay, in some instances are entirely replaced by land eight or ten feet high, and, in the case of Fish creek, one of the smaller streams emptying into the Pocomoke sound, the sketching of the rivers is poor in direction for the scale of the map, and is lacking in expression, the courses being generalized in almost diagrammatic manner. A third error noticeable in the map is in the platting of the contours, which seems to disregard in great measure any difference between the low marsh lands along the shore and the bench of firm land lying often several miles from the actual water-line. While an appreciation of the difficulties encountered and a consideration of the pioneer character of the work are borne in mind, it is also necessary to realize that these maps are not satisfactory as a basis for cartographic representation. In many features, notably the distortion, this map is far the inferior of the two maps published fully a century earlier. The chief increase of knowledge gained from the sketch by Alexander lies in the triangulation and increased detail along the eastern side of the peninsula, especially on Chincoteague Bay, and in the contours which indicate the first attempt at an accurate representation of the surface configuration of Maryland territory.

Seattered over the surface of the map are terms indicating something of the geological constitution and mineral wealth of the territory. Among the more important deposits, judging from this map, are bog ore and trap, which now are recognized as boulders brought down by the waters and ice from the northern portions of the state. The additional facts regarding the distribution and character of the soils render this one of the earliest agricultural maps published in the country and perhaps in the world.

"Map B," or "a geological map of the counties of St. Mary, Charles, and a part of Prince George on the western shore," which

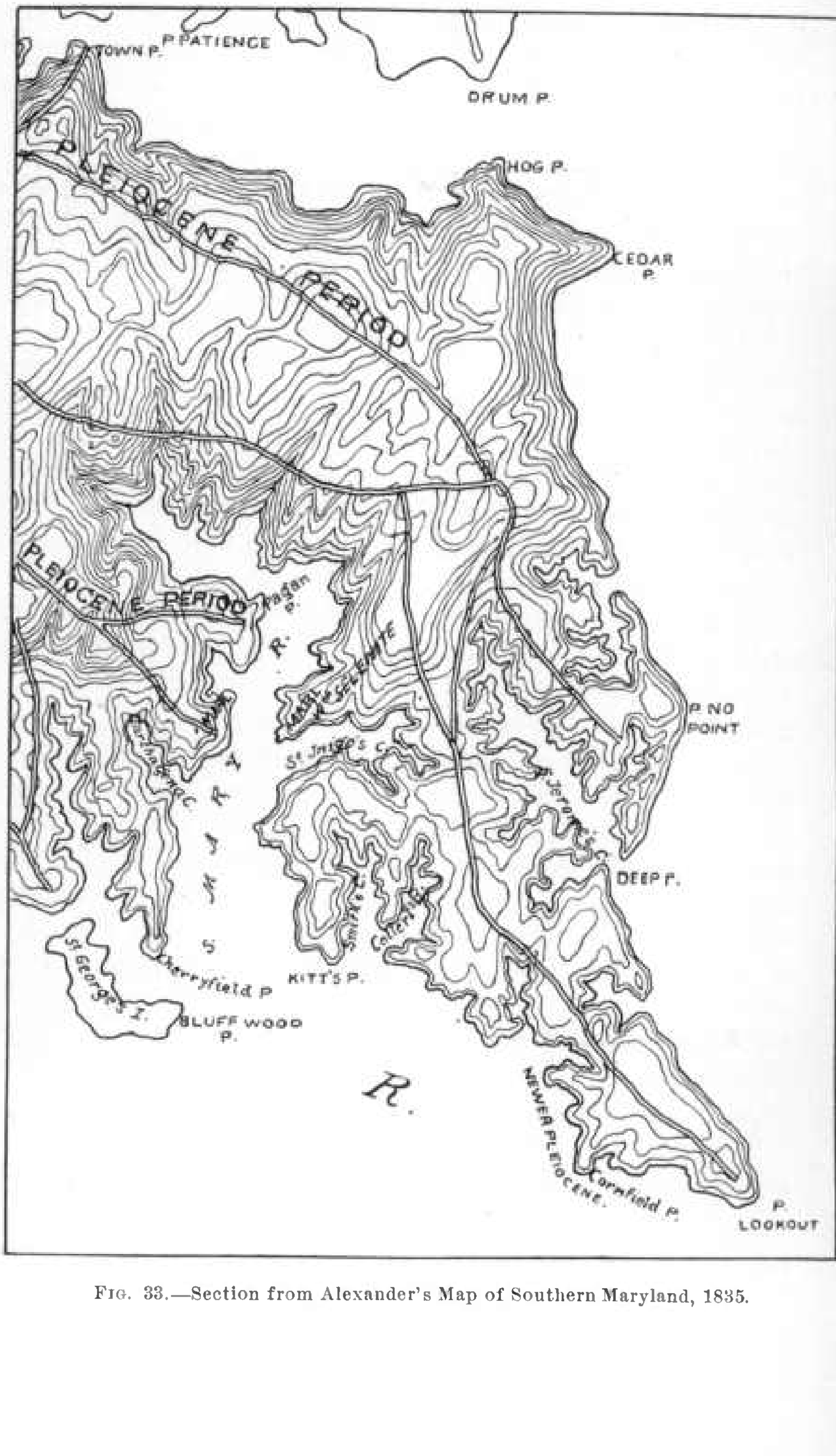


FIG. 33.—Section from Alexander's Map of Southern Maryland, 1835.

is reproduced in part as Figure 33, is drawn on somewhat larger scale (1:200,000) with a contour interval of ten feet. This map shows errors in construction similar to those noted in the preceding one, but here, instead of an elongation in an east and west direction, there seems to be something of an inclination to shortening. There is a similar disregard of the lowlands near the shore, since the slope is represented as almost uniform in gradient from the water-line to the higher elevation, although occasionally an attempt is made to represent benches in the slope. This map is richer in geological detail than any preceding map of the territory, and there is an evident attempt to correlate the formations and to establish their position in the geological column. Remarks are also made regarding their character. In order that the increased amount of detail should not lessen the clearness of the map, the geological and topographical information was printed in two different colors upon the same sheet. This is regarded as new and an advance in the manner of expressing detailed information.[1]

The first two years of the state survey were occupied almost entirely in the prosecution of local surveys in considerable detail. Alexander records, in his report for 1837, the fact that upwards of 200 miles of actual location were made and that maps and estimates upon that length were constructed by himself and a single assistant. The cause for such a diversion of activity from the trigonometric survey of the state was the inability and tardiness of the U. S. Coast Survey to push forward the primary triangulation essential to any undistorted mapping. These location surveys furnished Alexander with very detailed information in certain portions of the state which he attempted to connect by preliminary reconnoissances over the intervening area. The combination of this general detailed work found expression in a series of maps published in the annual reports. These were accompanied by profiles and traverses representing more detailed information concerning certain localities.

The most prominent of these general maps published prior to 1837 are a topographic map of Calvert and parts of Anne Arundel, Prince

[1] The lithographic work was done by A. Schwanecker, 57 Water St. (Baltimore?).

George's, Charles, and St. Mary's counties contiguous to the Potomac; a topographic map of that portion of the semi-bituminous coal region now known as the George's Creek Coal Field, and a topographic map of the country along the eastern base of South or Catoctin Mountain from Frederick to the Pennsylvania line. These maps are all drawn in hachure and have, across their base, information regarding the soil, the geological formations, the fossils, the mine openings and in some instances the exposures observed. The first map, that of Calvert county, is a clear hachured map on the scale of 1:150000 or 0.4224 inches per mile. This was a continuation of the map published in the report for 1836 but cannot be connected with that since it differs from it in scale and in style, the former being in contours, the latter in hachures. The territory mapped extends from Drum Point up either side of the Patuxent and along the Chesapeake to the Magothy river. The general outline of the shores and banks of the river is only moderately accurate considering the scale of the map. The same weakness noticed in preceding maps is evident still. There is a lack of appreciation of topographic forms and the appearance of the sketch is hard and somewhat diagrammatic. It is somewhat difficult to determine the amount of information used in sketching this map, for the hachures apparently are not applied with uniformity and the valleys and slopes are frequently generalized, or misinterpreted, in trend and elevation. In these respects the work of 1836-37 is inferior to that accomplished in the earlier years of the survey. Scattered over this map is detailed information in the form of remarks indicating the character of the soils and the location of fossil deposits, amber and lignite. Although inferior in type to some of the previous work and far inferior to the later work, this represents the best expression of the topographic work of the interior portions of Calvert county prior to the preparation of the sheets made by the present U. S. Geological Survey.

The second map of the report for 1836 is a small lithographic sheet covering the territory between Savage Mountain and Dan's Mountain from the Mason and Dixon line to Elk-Lick river, West Virginia. This represents the results of a plane table and trigonometric survey of the region undertaken in the spring of 1837 at the personal expense of Mr. Alexander, who had become interested in the development of the coal deposits of this area. From the information on the map and in the text it is impossible to determine how accurately this survey was made. Since the elevations of the openings of the principal mines are given with their location, the first impression received regarding the map is that it is one of considerable accuracy. A closer study, however, and a comparison with the latest cartographic representations show that in many of its features this earlier sketch is far from correct. Although drawn on the scale of 1:84480, the actual amount of work upon which it is based seems to be a rough traverse over a few of the streams, notably George's creek itself, and sketching from certain plane table stations. The map shows errors in the direction of the streams and their intersections with one another, as well as in the actual drainage systems. Even the National road is not accurately represented, and the majority of the smaller streams seem to be generalized, or drawn somewhat arbitrarily in their courses. The greatest weakness in the map seems to arise from careless drafting. The streams sometimes stop or are disconnected midway in their course, and frequently the hachuring is so indefinite that it is impossible, at first sight, to determine where these omitted streams should flow. The most pronounced errors are along the borders of the map. Near the northern boundary and on the slopes of Savage Mountain and Dan's Mountain the detail is less than along the valley of George's creek, which is somewhat more accurate. Another criticism which should be considered is that in Alexander's representation of altitudes by hachures there is no constancy in the value of his shading, so that some of the eastern portions of the state seem more rugged and mountainous than the territory represented in the present sketch. The same criticism seems to hold even within the limits of a single map, so that little information may be gained beyond the impression of the general nature of the surface. This map of Alexander's has been used as the basis of many of the maps of the George's Creek Coal Basin, which have been so frequently published by the different coal operators in the region. With the opening up of the country, and the increased facilities for mapping, there has gradually been introduced into this earlier hachured sketch more and more accuracy until at the present time the representations used are fairly correct, although the trend of the mountains is too nearly north and south.

The third general map published by the state engineer during the years 1836-37 represents the material gathered in three preliminary surveys for the location of a railroad from Frederick northward through the Frederick valley to the Pennsylvania line. During the work in this region three trial lines were surveyed, one half-way between the Monocacy and the foot of the mountains, a second along the foot of the Catoctin Mountain, and the third along the banks of the Monocacy. Thus, for a certain distance on each side of these lines, the topography is compiled from measurements or minute estimates; the rest was taken from the best maps obtainable and checked by a general reconnoissance of the entire region. This map seems to be the most accurately platted of any of the maps prepared by Alexander up to this time. The territory covered is included between the western bank of the Monocacy, the foot of the Catoctin Mountain, Frederick and the Pennsylvania line. The only map available at the present time, of sufficient accuracy to warrant a comparison of the expressions of the topography, is that published by the Western Maryland Railroad from data obtained by the U. S. Coast and Geodetic Survey. Compared with this map the Alexander sketch seems to be more accurate in the lowlands along the Monocacy and less detailed along the foot-hills of the mountains. On the whole, the Alexander map expresses more, with greater accuracy, than any other map of the region which is now obtainable. The county maps, which will be considered in a later portion of this paper, show more roads and houses but fail to represent the surface of the country.

When the work was completed at the end of 1837, Alexander presented his resignation on the ground that the original intention of the act of 1834, establishing the Geological and Topographical Survey, had been practically nullified by the many local bills introduced in the subsequent legislatures compelling the topographical engineer to conduct many small location surveys for canals and railroads. The formation of a complete well-established map of the state seems to have passed from the minds of the legislators in their eagerness to gain the services of a skilled engineer at the low figure of $2000 a year and no expenses. This resignation was accepted, and all the cartographic work done in the remaining years of the Survey's existence was through the generosity of Alexander, who prepared the maps for his former colleague without expense to the state. With the severance of the connection between the state and the topographical engineer, the official preparation of a state map apparently ceased. Whatever work was done after that time was done entirely by Alexander, at his own expense, as he found time from his other duties. The plan which had been inaugurated in the earlier years of the Survey by which succeeding annual reports were accompanied by topographic-geologic maps of one or more portions of the state was continued, but the type of maps produced rapidly changed. Prior to 1837 there had been no unity either in the type of maps or the scales on which they were made. Subsequent to this time, with a single exception, the scale adopted was 1:200000, and the style of representation remained approximately constant. The earlier maps showed attempts at representing the surface with four-foot contours, ten-foot contours, or hachures of varying value. The report of 1837 by Ducatel, which dealt with the geology of Kent, Cecil, and Montgomery counties, was accompanied by two of the later type maps. The first, covering the area of Kent and Cecil counties, was drawn with hachures on the scale of 1:150000 and shows an increased accuracy in the representation of the coast-line and an effort to represent the differences between the topography of the Coastal Plain and that of the harder rocks to the north. This map remained the best delineation of the country prior to the work of the present State Geological Survey in the preparation of its Elkton sheet. The system of sketching in this map is intermediate between that of the preexisting ones and that of those sheets which followed in the subsequent reports of Ducatel. The system of drainage in the area seems to have been from the standpoint of certain elevations rather than that of the drainage-lines, the result is that the map is dotted with a series of conical hills of more or less uniform height representing in their distribution the appearance of an area of volcanic cones, similar to that of central France. Over the surface are notes indicating the location of fossil beds and the character of the rocks forming the principal ridges of the region.

The second map of the 1837 report is of Montgomery county embracing the territory between Sugar Loaf Mountain and Ridgeville on the west, and Georgetown or Bladensburg on the south. The scale is 1:200000. The style of hachuring is improved, since there seems to be an evident effort to have the degree of shading correspond approximately to the elevation of the country represented. The ridges lose much of their detail especially along their tops by the printing of geological information in place of the hachures. The notes distributed in this way over the map are intended to supply whatever knowledge has been gained regarding the general composition of the ridge to which they are attached. Although by far the most carefully executed of the maps constructed by Alexander at this time, Ducatel speaks of it as lacking in detail and having less actual information as its basis than is the case with any of the previously mentioned maps.

No maps accompanied the report for 1838, but in 1839 the plan adopted in 1837 was carried out more fully by two maps which complete the representation of all the north-central portion of the state from Harper's Ferry to the Delaware line. This information is represented in two maps: the first, of Frederick and portions of Carroll counties, embraces the territory from Westminster to Harper's Ferry. This is on the scale of 1:200000, and shows a higher grade of skill in hachuring than has heretofore been evident. This may perhaps be cited as an illustration of the highest grade of mapping produced by Alexander. The hachures are arranged with considerable care, and there is a suggestion of underlying contours, thus expressing with greater accuracy the surface configuration. There is a return in the method of portraying the geological information to that used in 1835 but in an improved form, since the colored type used in the latter instance is of a more neutral tone which, while sufficiently distinct, does not mar so much the unity of the map.

The second sheet in this report for 1839 embraces all of the territory between the Susquehanna and Westminster, *i. e.* Harford and Baltimore counties with parts of Carroll county. This is entirely in harmony with the maps of Montgomery county already discussed, so that there was prepared by Alexander a continuous sketch of the territory from the Susquehanna to the Hagerstown valley, on the scale of 1:200000. This latest sheet differs from the preceding ones by having indicated upon it the locations of the more important triangulation stations. There is also some indication of the ore pits of the region which have been of some economic importance.

The report for 1840 was the last one given by Ducatel as geologist of the state. The difficulties of the position and the friction between local interests had rendered the office of State Geologist so obnoxious to some of the people that it was deemed wise to abolish it even before the completion of the final report on which Ducatel based the permanency and the character of his reputation as a scientific worker. Much of the last year's work by the State Geologist seems to have been carried on through the liberality of persons outside the state who had become interested in the coal deposits of Allegany county, which had been developed through the activity of the Geological Survey. The former topographical engineer had already become interested in the problems of this region, and together Alexander and Ducatel prepared the first accurate representation of the region embraced within Washington, Allegany, and Garrett counties in a map entitled "Map illustrative of Allegany and Washington counties." This sheet, which is 16.5 by 6.8 inches in size, is drawn on the scale of 1:400000, and embraces all the territory between the Blue Ridge and the western boundary of the state. The representation of Washington county seems to be little more than a sketch of the territory as seen from the National road combined with the information concerning the course of the Potomac given in such maps as that by Fry and Jefferson and the drafts of the engineers of the Chesapeake and Ohio Canal. There is of course a marked increase in the accuracy of the sinuosities of the Potomac, but even in this sketch there are frequent bends which are either distorted or contrary to the actual facts in nature. Allegany county, which then included both Allegany and Garrett, is much more accurately drawn, and the general trend of the mountains is very sharply brought out by the somewhat diagrammatic hachuring of the map. The drafting of the minor details, especially about George's creek, closely follows that of 1836. The errors noticed in the latter map have in almost all instances been perpetuated, but the scale has been so greatly reduced that they are no longer so evident as in the first instance.

Although the official representatives of the people seem to have lost all interest in the preparation of a map of the state, this aim had constantly remained before the former topographical engineer who, in 1840, brought out somewhat officially and yet apparently at his own expense, a large manuscript map of the entire state on a scale of 1:200000. This map is 79 by 41 inches in size and is contoured east of the Monocacy with fifty-foot contours and west of the same stream with one hundred-foot contours. It is entitled "1840 Geological Map of Maryland in which are also shown the chief topographic features to aid in the Triangulation under the direction of J. H. Alexander, Engineer of the State." It is not known how many copies were originally prepared, but there must have been at least two. One, which was deposited in the library at Annapolis on its completion in December, 1840, has long since disappeared from the archives, leaving no trace as to its final disposition. A second copy has been preserved by the family of the original draftsman and is now in the possession of his son, J. J. Alexander. From this copy Mr. Bates of the U. S. Coast Survey, at the instance of General Scott, made an exact tracing in 1861. This is still preserved in the War Department at Washington, and from it the State Geological Survey has received photographic prints on the original scale. The description of the map is based upon such prints, and the accompanying plate, which is taken from one of the earlier maps, illustrates the general type of Alexander's work.

According to the legend on the original map, the material employed in its compilation is as follows:

The published & MS. paper of Mason and Dixon,
Surveys of the Chesapeake and Ohio Canal,
" in Chesapeake Bay by H. B. M. officers, 1774, 1781,
" by Capt. Brantz and Lt. Sherburne,
Special surveys of U. S. War Department,
Surveys by a Commission from the States of Delaware, Maryland and Virginia.
Survey of the Eastern Shore Railroad,
" New Castle and Frenchtown Railroad,
" Chesapeake and Delaware Canal,
" Philadelphia and Wilmington Railroad,
" Tidewater Canal,
" Canal from Baltimore to Havre de Grace.
" Baltimore and Port Deposit Railroad,
" Water supply for Baltimore,
" Baltimore and Susquehanna Railroad,
" Reisterstown turnpike Road,
" Baltimore and Ohio Railroad,
" Washington Branch Railroad,
" Annapolis and Elkridge Railroad,
" Maryland Canal (proposed),
" Cumberland Turnpike,
" Susquehanna River by Hauducoeur,
Special surveys by Engineer of the State.
" The enumeration above covers all published and MS information existing up to the date of compilation, Octr.-Decr., 1840."

The greatest stress seems to have been laid in all instances, as was natural, on Alexander's own work, for it was found on comparison with the single sheets, already published by the state in the various geological reports previously enumerated that there is a great similarity in the sketching between that of the earlier maps and this larger complete drawing of the entire state. The latter shows a repetition of many of the errors already noticed in the smaller maps, although there is no evidence of tracing or mechanical reproduction of the earlier results. Instead, the whole map seems to have been redrawn, for the points and re-entrants along the coast show differences in detail from any preceding map. These are such as might arise from a somewhat hasty copying of the earlier sketches. The information represented in earlier maps on different scales has been reduced to uniformity, and wherever the sketching was formerly in hachure, it has been changed to contours of the intervals already cited. When one realizes that this is almost, if not quite, the first detailed contoured map of an entire state ever made in America, that the Baltimore and Ohio Railroad extended only to Martinsburg, that many of the other railroads had not been thought of, and that several of the turnpikes radiating from the larger towns were still features of the future, one must regard this map of Alexander's as a pioneer work of the highest type which should have received from the state that it represents the fullest recognition. The breadth of view shown in the original plans proposed for the new map of Maryland and the high standard of accuracy established, together with the helpful coöperation promised from the U. S. Coast and Geodetic Survey, if accepted by the state at that time, would have placed Maryland in the foremost rank of those commonwealths which appreciate the value of an intimate knowledge of their resources and the generous patronage of educational forces at work within the state. Unfortunately, through the seeming neglect of possibly a few officials, almost every trace of the early work of both Ducatel and Alexander has been destroyed, so that at the present time there is scarcely a complete set of maps and reports in the possession of any state, public or private library.

The Maps of the Boundary Controversies.

Few, if any, of the states composing the Union have had more earnest or more protracted struggles regarding territorial limits than Maryland. They began with the settlement of the first colony on the Potomac and have, in a single instance, still to reach their conclusion. In every case Maryland has come off the loser. Beginning with all the area between the Potomac and the fortieth parallel of north latitude, there have been successively taken from her the greater portion of Delaware, the southern part of Pennsylvania, and several counties of what is now West Virginia. The controversies, which have sometimes led to border warfare, and often to the miscarriage of justice, may be grouped as those of the Northern Boundary, the Southern Boundary, and the Western Boundary. These controversies have given rise to a voluminous literature, but it is apropos at this point to give only summary reviews of them, since each has brought into prominence otherwise insignificant maps, or caused surveys which have furnished some of the most detailed maps of Maryland territory yet constructed.

THE NORTHERN AND EASTERN BOUNDARY.

The *Northern Boundary* troubles include also those of the Eastern Shore along the borders of Delaware. The first grant given by Charles I to the First Lord Baltimore presented the territory from the Potomac to the 40th parallel of north latitude provided it was still uninhabited. This limiting proviso (" hactenus inculta ") has been the cause of most of the misunderstandings. Prior to the Baltimore grant, a few Dutch settlers lived for a short time along the Delaware, and somewhat later the Swedes made a permanent settlement on the western shore of that bay. Neither nation possessed the land by right of discovery, and their possessions were ultimately acquired by the Duke of York, who sold his claim on the western shore of the bay and river to William Penn in 1682. The latter's title was immediately disputed, and the Duke of York, then James II, ordered a decree of his Council in 1685 to the effect " that for avoiding further differences, the tract of land lying between the Bay of Delaware and the eastern sea on the one side, and the Chesapeake Bay on the other, be divided into equal parts by a line from the latitude of Cape Henlopen to the fortieth degree of north latitude, the southern boundary of Pennsylvania by charter, . . . and that half thereof lying toward the Bay of Delaware and the eastern sea, be adjudged to belong to his majesty, and the other half to the Lord Baltimore, as comprised in his charter." Since this decree was retroactive and established Penn's title there was little for the Proprietor of Maryland to do. From their relation to this decree two maps are of particular interest in elucidating its terms. The first is by Visscher and the second by Smith.

Justin Winsor[1] gives this note concerning the former: " In the Ellis sale, London, Nov., 1885, No. 232 was a map Novi Belgii; Novaeque Angliae [etc] by Nicholas Visscher (Amsterdam about 1651) which had belonged to William Penn and was indorsed by him, 'The map by which the Privy Council, 1685, settled the bounds between Lord Baltimore and I, and Maryland, Pennsylvania and Territorys or annexed Countys—W. P.' "

[1] Nar. and Crit. Hist., vol. v, p. 272.

"A correct copy and imitation" of an edition of this map, published in 1659, was republished [in London?] in 1833. It is a sheet 21.5 by 18.2 inches, colored and ornamented by a picture of the village at New York, drawn by Augustine Herman. The scale is about seven and a half German miles to an inch. If this copy is like the sheet to which Penn attached his note it sets at rest forever the calumnies against him in which he is charged with wilfully misrepresenting Cape Henlopen in the more southerly position. The date of publication given by Winsor indicates that he thought the original was drawn while Penn was a boy less than ten years old. The locus of our present Cape Henlopen on this map is called "C. Carnelius," while "C. Hinlopen" is attached to some point farther south (Fenwick Island). The whole representation of Maryland is directly taken from Smith's map, but the cartographic work is not as detailed and accurate.

The second map, that by Smith, was wrong in placing the 40th parallel so far south that there would be an unallotted strip between that parallel and the southern limit of Pennsylvania if that was placed twenty miles north of New Castle.

This ambiguity, together with the doubtful nature of the "middle point" of the peninsula and the location of Cape Henlopen, allowed latitude for disputes which continued until May 10th, 1732, when Charles (Fifth Lord Baltimore), and the sons of William Penn agreed "that a semi-circle should be drawn at twelve English Statute miles around New Castle, agreeable to the deed of the Duke of York to William Penn in 1682; that an east and west line should be drawn, beginning at Cape Henlopen—which was admitted to be below Cape Cornelius [the present Cape Henlopen]—and running westward to the exact middle of the Peninsula, between the two Bays of Chesapeake and Delaware, and the ends of the line intersecting it in the latitude of Cape Henlopen, a line should be run northward, so as to form a tangent with the periphery of the semi-circle at New Castle, drawn with the radius of twelve English statute miles, such a line should take a due north course or not; that after the said northwardly line should touch the New Castle semi-circle, it should be run further northward until it reached the same latitude as fifteen English statute miles due south of the most southern part of the city of Philadelphia; that from the northern point of such line, a due west line should be run at least for the present, across the Susquehanna river, and twenty-five miles beyond it,—and to the western limits of Pennsylvania when occasion and the improvements of the country should require; that that part of the due west line not actually run, though imaginary, should be considered to be the true boundary of Maryland and Pennsylvania." The distance north from New Castle according to this agreement was reduced from twenty to twelve miles, and the artifice of a semi-circle was devised to overcome the difficulty suggested by Smith's erroneous locations. The map by which this second agreement was illustrated was constructed by the famous mapmaker and publisher, John Senex, and the circumstances surrounding its preparation are given in the Penn Breviate drawn up for the Chancery proceedings of 1750-1. The defendants between August 16th, 1731, and May 10th, 1732, carried the map to Senex, who engraved it and was paid for it by the two parties to the proceedings. In May, 1732, the draft of the agreement was redelivered to the complainants' solicitors to be engraved. Six several parts were immediately engrossed on parchment with the defendants' map impressed in the margin thereof.[1] All six copies were completed by May 10th, and ten days later Thomas Penn embarked for Pennsylvania with the agreement while a copy was also sent to the Deputy-Governor of Maryland.[2]

[1] A free expansion of the abbreviated statement by Penn in Pa. Arch. 2nd Ser., vol. vii, pp. 301-400. Papers relating to the Boundary Dispute between Pennsylvania and Maryland, 1734-1760.

[2] Four copies of the manuscript maps referred to are now in the library of the Maryland Historical Society. They show the general outline of the bay and its tributary drainage for some distance up the Susquehanna river. The names of the streams are given, and in general, these conform with the usage of the present time. The boundary lines separating the present territories of Maryland, Delaware and Pennsylvania are laid down in red. The personal copy belonging to Lord Baltimore had lines laid down in ink and numerous notes regarding the location of unmentioned streams and certain tracts of land. From a cartographic standpoint these maps are far below the standard of the best contemporaneous work. The map referred to in the discussion of Lewis Evans' map, p. 396, has not been seen.

By this time the Baltimores realized that a loss of territory was a foregone conclusion, and there was apparently inaugurated a consistent series of efforts to delay the final settlement by the use of the most trivial means, which continued until the final settlement of the question. The first line actually run (1739) was made under the terms of the temporary agreement of 1737, by which the line east of the Susquehanna was fifteen miles and a quarter south of Philadelphia and only fourteen miles and three-quarters on the west side of the same river. This "temporary line" extended as far west as "the westernmost of the Kittochtining Hills" [*i. e.* near Hancock?], but was not sanctioned by Maryland west of the Susquehanna. The Penns finally took the whole matter into Chancery, where the Lord Chancellor in 1750 and 1751 directed that new commissioners be appointed; that the centre of the circle be at the centre of New Castle; that Cape Henlopen be at Fenwick's Island (fifteen miles south of the present Cape Henlopen); and that the miles measured should be horizontal and not according to the inequalities of the surface. The work of this commission was commenced in 1752, but new troubles arose which were not quieted until another commission was appointed to run the lines agreed upon. The work of the surveyors employed was difficult and slow, and little more than the southern line of Delaware and the radius from New Castle had been determined when the disputants hired Charles Mason and Jeremiah Dixon to complete the work.

These eminent surveyors, who had such problems to solve as the running of a circular line through a forest and the measurement of a degree of latitude in a wilderness, arrived in Philadelphia in November, 1763, and were duly commissioned for their task by the 9th of December of the same year. The fulfillment of the conditions of their contract occupied them a little less than four years, for the line so far as surveyed was certified to be marked November 9th, 1768, and the surveyors were honorably discharged on the 26th of December following.

So far as known, no map was published[1] as the direct result of their

[1] Large maps were, however, prepared by the Commissioners, and two copies are now in the possession of the Maryland Historical Society. These

labors, but their field-notes abound in detailed comments concerning the country surveyed. The expense of their work was met jointly by the Proprietors of Maryland and Pennsylvania, the latter paying £34,200 in colonial currency as his share. The accuracy of the work is attested by the fact that Col. Graham's survey in 1849-'50 did not show two inches of deviation to the right or left of the centre of the post at the end of the due north line.

This survey by Col. Graham was conducted by a full corps of assistant engineers and such men for field service as were required by him. The work was conducted by means of chain and transit, and was finally checked by theodolite and chronometer. The topography was noted and offsets were measured at all houses, fences, streams and other remarkable objects within a reasonable distance of the lines. This survey, which was inaugurated because of the discrepancies between the plattings of the north-south line and the north-east corner, resulted in a report by Col. Graham, which was accompanied by a small map illustrating the general location of the points under discussion. No additional information concerning the territory was incorporated in this map.

THE SOUTHERN BOUNDARY.

The southern boundary troubles began almost upon the arrival of Lord Baltimore's colony at St. Mary's in 1634, but no actual determinations in the field were made until 1668, although during the occupancy of Kent Island by William Claiborne he was instructed to make a map of the region indicating the territory in dispute. So

bear the title "A plan of the Boundary Lines between the Province of Maryland and the Three Lower Counties on Delaware with Part of the Parallel of Latitude which is the boundary between the province of Maryland and Pennsylvania." The sheets, which are 75x26 inches large, include pen drawings of the territory on either side of the north and south, and east and west lines on the scale of 4¼ miles to an inch. The territory depicted is a belt about seven miles wide along the entire length of the boundary of Maryland. In this little strip are represented the houses, drainage, roads and mountains, as well as the more prominent points of the line. The latter are given in red. Beside this delineation of the territory traversed is an agreement signed and sealed by five commissioners from each state.

far as is known this map is not now in existence, and no evidence has been found to indicate that Claiborne carried out the instructions given him. In 1663 the trouble over the boundary between Maryland and Virginia on the Eastern Shore became more acute, and letters were frequently interchanged between the governors of the two colonies. Nothing, however, was accomplished until the date mentioned above (1668), when Edmund Scarbrough, Surveyor-General of Virginia, on the part of Virginia, and Philip Calvert, Chancellor of Maryland, on the part of Maryland, were appointed to meet at Watkins' Point and run a divisional line to the ocean. This they accomplished, and on June 25th, 1668, they signed an agreement regarding the location of Watkins' Point and the line which they had run according to instructions. It is not known that these surveyors actually prepared a map for publication indicating the physical features on either side of their line. Since the date of their agreement, however, several maps have been published indicating where this line was established. The most prominent of these was that by John de la Camp, entitled "Southern Boundary of Maryland between Smith's Point and the Atlantic Laid down in conformity with the agreement made June 25, 1668. Between Phillip Calvert, Chancellor of Maryland and Edmund Scarbrugh, Surveyor Gen[l] of Virginia. . . ." This sheet, which is 30.5 by 10.7 inches in size, is compiled from the original maps of the survey made in 1858 by Lieut. Michler, U. S. Topographical Engineer, and from maps and other data obtained from the office of the U. S. Coast Survey. The scale of the map is 1:128000. It was published to illustrate a paper on the "Southern Boundary of Maryland" by Thomas G. Lee.

The discovery of valuable beds of oysters in Pocomoke Sound, which in later years have proved to be causes of dispute, made the question of jurisdiction dependent upon the location of the state boundary the subject of needed settlement. Several attempts were made by Virginia and Maryland to find some common ground upon which they could agree regarding the location of the line separating Somerset county, Maryland, and Accomac county, Virginia. It was not until 1858 that commissioners were appointed to obtain, in addition to the evidence already at hand, the best local information by an actual survey of the vicinity of the boundary. The work of surveying for this commission was done by Lieut. Michler, U. S. Corps of Engineers, who made a minute survey of the whole boundary, preparatory to the final location of such lines as might be agreed upon. Michler's work was incorporated in a map of fifteen sheets 44 inches in length by 21.25 inches wide. A set of these maps was prepared in duplicate for deposit with the land offices in Richmond and Annapolis.

With the outbreak of the war the question of the southern boundary remained unsettled and was not finally determined[1] until 1873-'74, when a final award was given determining the location of the boundary between Maryland and Virginia from Smith's Point across Smith's Island and Tangier Sound through Pocomoke Bay to the beginning of the old Calvert-Scarbrough line. No new map resulted at the final settlement of this controversy, as the line agreed upon was platted upon the charts of the U. S. Coast Survey embracing that territory. Such copies certified by the governors or commissioners of the interested states were deposited in the various public libraries for reference. One may be seen in the Peabody Library at Baltimore.

The controversy regarding the location of the southern boundary, while resulting in the preparation of but two or three maps of the region, has been of marked influence on the cartographic knowledge of the state. Through it the Herman map was rediscovered and republished, and many points regarding the preparation and publication of early colonial maps were first brought out in the endeavor to interpret the terms of the original agreements. No other subject has caused such an extensive searching of the documents relating to Maryland now deposited in Europe and America.[2]

[1] Even at the present time there are special committees appointed to investigate and report upon any modifications or changes that may be desirable in the boundary line between the states of Virginia and Maryland.

[2] A discussion of the question and the maps relating to it may be found in the following papers:

Jones, Isaac D. Report of the Commissioners appointed by the Legislatures of Maryland and Virginia to run and mark the Division Line between

WESTERN BOUNDARY.

Unlike the controversies relating to the northern boundary of the state, that concerning the western boundary has been little influenced by delineations of the territory in existing maps. In the same way, while the northern boundary resulted in no maps giving the details accruing from the survey of the line, the western boundary survey included a study of the surface configuration of the country passed over and an incorporation of the results into a map which has remained since its completion the most authentic picture of the territory traversed.

The historical and legal problems relating to the western boundary have been so clearly set forth in the papers of the Maryland Historical Society and the brief prepared for the suit against West Virginia that little needs to be recalled in this connection. The earliest controversies regarding the location of this western line resulted, as already shown, in the Cresap map; while the Mayo map, or that of the Northern Neck, delimiting the possessions of Lord Fairfax, introduced certain geographic points which have remained in the controversy ever since. Subsequent to the Revolution, Deakins made a survey of a portion of the country adjacent to the western boundary in order that he might lay off the grants of land given to the soldiers. He took pains, however, to embrace no land within the disputed zone. His work resulted in a map,[1] little more than a

Maryland and Virginia, on the Eastern Shore of Chesapeake Bay. Annapolis, 1868, 36 pp.

Lee, Thos. J. Southern Boundary of Maryland, 1860.

McDonald, A. Extract from the report of Col. A. McDonald in March, 1861, to the Governor of Virginia, [etc.] Md. Senate and House Documents, 1872, W.

Wise, Henry A., et al. Report and accompanying documents of the Virginia Commissioners appointed to ascertain the Boundary Line between Maryland and Virginia. Richmond, 1873. 146 pp. Appendix 314 pp. Atlas.

Anon. Final Reports of the Virginia Commissioners on the Maryland and Virginia Boundary to the Governor of Virginia. Richmond, 1874, 221 pp.

Jones, I. D. Report and Journal of Proceedings of the Joint Commissioners to Adjust the Boundary Line of the States of Maryland and Virginia. Annapolis, 1874. Md. House Doc., 1874 J; Senate Doc. E.

[1] This map bears the title "Map Military Lots, tracts, etc. Westward of Fort Cumberland—Awarded Officers and Soldiers of Maryland Line for

land plat, and a boundary line which has been one of the elements in the boundary disputes. This map is deposited in the Land Office and, so far as known, has never been published.

The work conducted under the joint commission appointed for Maryland in 1852 and Virginia in 1858 by Lieutenant N. Michler, U. S. Topographical Engineers, resulted in the first detailed map of the region. The work under Lieut. Michler was carried on with the assistance of John de la Camp and L. Daser during the seasons of 1859 and 1860, and the map resulting from the work was drawn by de la Camp in 1868. This cartographic work was originally prepared in the form of eight large sheets, on the scale of 1:12000, which were deposited among the archives of the states in the controversy. The map in its published form, however, did not appear until the beginning of the present suit. The printed sheet is approximately 40 inches long and 10 inches wide, and the territory represented is a strip on either side of the Michler line varying in width from 3 to 9 miles. The style of mapping is with hachures, and the scale adopted is 1:60000, or 5000 feet to the inch. The region represented extends north and south from the Fairfax stone to the Mason and Dixon line.

The recent survey establishing the Brown-Bauer line has developed several new facts regarding the territory surveyed. This work has shown that the head of the Potomac is not at the Fairfax stone, where the spring is intermittent, but at the head of Laurel Run in Potomac Spring. This latter point is 125 feet higher in altitude than the Fairfax stone and is within 300 feet in distance of the crest of the Big Backbone Mountain, a portion of the main divide between the waters running into the Atlantic and into the Gulf of Mexico. Assuming the Potomac Spring as a starting point, the territory traversed by the line of 1897 is west of that represented in the Michler or de la Camp map just described. No published map has appeared incorporating the newly acquired information, but a manuscript has been prepared for use in court which shows in detail all of the claims

Services During the Revolution—4165 Lots—50 acres each. By Francis Deakins, Appointed under a resolution passed by Gen'l Assembly in 1787." The sheet is 59 inches long by 71.5 inches wide.

of the contesting states. The size of this sheet is approximately 15 feet in length or about 6 inches to a mile. The actual surveying represented in this new map includes a complete survey of all the streams at the head of the north branch of the Potomac and a sketching of the territory along either side of the line by the engineer in charge, W. McCulloh Brown. At the same time Dr. L. A. Bauer was assigned the verification of the Michler meridian line, which started at the Fairfax stone, the determination and tracing of a new meridian line starting at the Potomac stone, and the determination of the magnetic elements at as many points as possible along the line of survey. The work by Dr. Bauer was carried out between August 16 and October 16, 1897, under the direction of the Maryland Geological Survey, with the coöperation of the U. S. Coast and Geodetic Survey.

The County Atlases.

Partially as the result of personal interest, and partially because of the information acquired by the work of Alexander, the local surveyors in various portions of the state began about 1855 to meet the demands for county atlases which would give in considerable detail the election districts, roads, houses, drainage and other features of interest within their immediate neighborhood. All of these county atlases are of approximately the same character as that represented in Fig. 34, which is a photographic reproduction without color, of one of the county maps by Hopkins published in 1878. None of the various atlases attempt to express with accuracy the surface configuration of the regions depicted. The engineers devoted almost their entire attention to the location of the roads and a few of the houses of greater importance. Hachures were occasionally used to roughly represent the more rugged portion of the region. The election districts are usually distinguished from one another by differences in color, and the drainage is sketched with some accuracy adjacent to the roads traversed. All of the work seems to have been done by the use of buggy- or wheelbarrow-odometers. For this character of work the maps are above the average in accuracy.

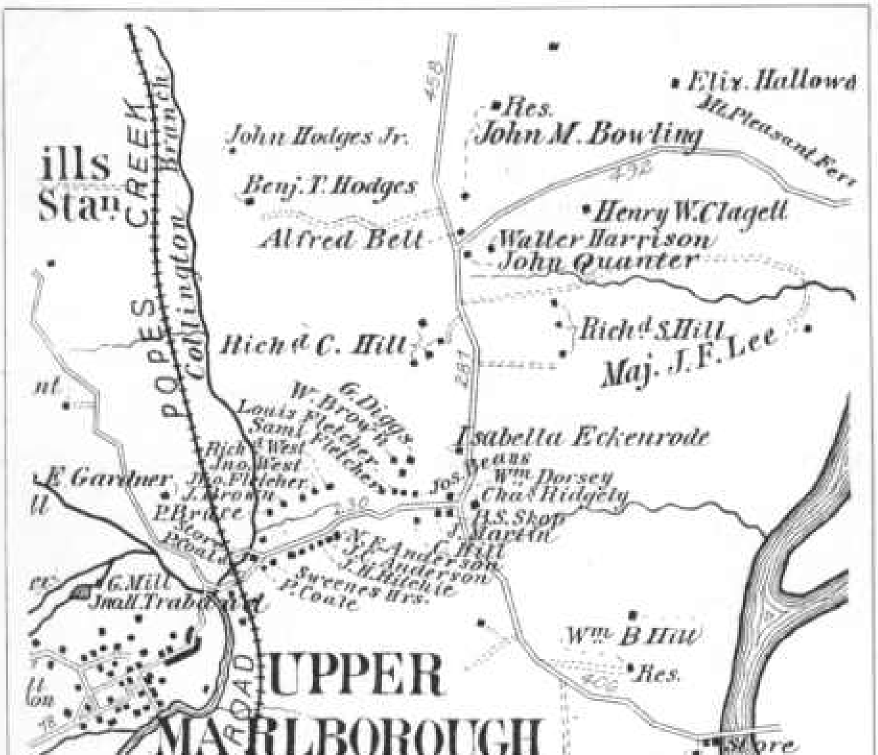


Fig. 34.—Section from a county atlas, 1878.

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MARTENET'S ATLASES.

The foremost engineer in the preparation of these county atlases of the entire state was the late Simon J. Martenet, for many years the City Surveyor of Baltimore. During the financial crisis of 1857, when his business had somewhat fallen off in the general depression of that period, to fill up his time he commenced the survey of Cecil county with the design of making a map of the same which should be only one of many representing the counties of the state. These he hoped to combine, ultimately, into a large map of the entire state. Prior to the war he had completed surveys and maps of Cecil, Howard, Kent, Anne Arundel and Prince George's counties, and had commenced the work in several others. Subsequent to the war, the work was taken up anew and maps were made of Carroll and Harford counties. The remaining counties of the state were also surveyed for the purposes of the state map. No individual atlases were prepared of the western counties because of the lack of demand immediately subsequent to the war. In all, it is estimated that approximately 15,000 miles were traversed for the state map, which remains to-day the best authority on several parts of the state. It is also the best single map in print.

In order that the large map above mentioned might be completed, Martenet introduced a bill into the Legislature of 1865 praying for assistance in its publication. According to the records, no amount is stated in the bill, which was finally passed during the last hours of the session. The financial aid of greatest value to the publication of this map was obtained about ten years later, when another bill was passed which authorized Martenet to supply copies of his map to each of the counties as official maps of the state, and the superintendents of the schools to furnish only the Martenet map to county schools making requisitions for a state map. This bill immediately introduced a considerable demand for sheets, which were sold at the rate of $7 apiece.

Although all of the various Martenet maps are published without individualizing the names of the surveyors active in their preparation, it is certain that few, if any except Cecil county, were prepared by

S. J. Martenet himself. Carroll and Anne Arundel counties were surveyed by his brother, George W. Martenet; Queen Anne's and Worcester by J. R. Rhodes; Montgomery by Shipley; and the other counties by various assistants. The rate of work done in these county surveys is not definitely known, since the field-notes are not dated from day to day; but it seems probable from information at hand that the average distance traversed per day was approximately ten miles.

The maps and atlases published by S. J. Martenet himself are as follows:

Cecil county, 1858. This is a wall map with the roads drawn in outline on the scale of 1½ inches to a mile. The total size of the sheet is 41 by 41. At present the map is out of print and copies are very scarce.

Anne Arundel county, 1860.

Howard county, 1860. This sheet is drawn on the same scale as that for Cecil county, and is of the same general character. It is a wall map, 53 by 32 inches in size.

Kent county, 1860. This map was prepared by Mr. Baker, County Surveyor of Kent, and published by Martenet. This sheet is on the scale of a mile to an inch, and is like the preceding in character. It forms a wall map 32 by 35 inches.

Carroll county, 1862. The scale of this wall map is approximately two-thirds of a mile to an inch and forms a sheet 44 by 52 inches in size.

[*Allegany and Garrett counties, 1864.*] A map bearing this title was drawn in manuscript on the scale of approximately four-fifths of a mile to an inch, but was never published. This is a portion of the material which was prepared for the completion of the state map.

Montgomery county, 1865. This is drawn on the scale of a mile to the inch and is 35 by 30 inches in size.

Wicomico, Somerset, and Worcester counties, 1877. This map is drawn on a smaller scale than the preceding (3 miles to an inch), and serves more as an index map to the numerous larger scaled sheets of the different election districts which it accompanies in atlas form. The size of the sheet is somewhat over 12 by 14 inches. With the atlas are twenty-seven smaller maps ranging in scale from 3 inches to a mile to one-half an inch to a mile, the average being about one and a half inches to a mile.

Harford county, 1878. This sheet is very much like the map of Cecil county. It is drawn on the same scale and, like the latter, is very rarely met with.

[*Frederick county, 1880?*] A manuscript map which apparently served as a base for a county map for Frederick county is deposited in the library of the American Geographical Society. There is, however, no record of the publication of such a map by Martenet. It is drawn on the scale of 2 miles to an inch, the drainage is blue, the roads are in red, and the railroads in black.

The State. The first Martenet map of the state in its entirety was published in 1865 in four sheets, 36 by 21 inches in size, on a scale of 1:221760, or 3.5 miles to an inch. This map was roughly hachured and conforms almost wholly to the lines laid down in the sheets now on sale by the S. J. Martenet Company. During the same year atlas and wall editions of the state map were published on the scale of 1:950400, or approximately 15 miles to an inch. This base is the one which has served for the map of Maryland in many of the atlases published in subsequent years. Later editions of the larger and smaller scaled maps were published in 1885. These are apparently from the same stone, somewhat corrected and brought up to date by the introduction of new roads and additional cultural lines. At the present time the larger map is issued in several forms. It has been printed as a single sheet with or without colors and in three overlapping sheets embracing respectively the eastern, central, and western portions of the state. No improvements have been made in this map since 1885, as the stones have been lost through fire. The field-notes also and the original drafts are in some instances misplaced.

Although the Martenet maps have been somewhat severely criticised because of the inaccuracies in the textural description of the boundary lines as well as in the location of a few points, the sheet shows the result of conscientious work in the compilation of the information acquired. There are of course many errors in the sheet arising from the way in which the surveying was done, and there are others the result of somewhat careless sketching. For example, in the most of the county atlases, as well as in several instances in the state map, the streams are made to rise within the area delineated, although they may have entered the county or state from some outside source. The sheets, however, are richer in local names and in certain features of local detail than any other maps of the state.

OTHER ATLASES.

Other atlases than those by Martenet have been published, notably by Martenet, Walling and Gray, by George M. Hopkins, and by Lake, Griffing, and Stevenson. In many instances these maps are simply reproductions of Martenet's work with the author's consent. Frequently they were published on a royalty. The Hopkins atlases include a map of the state in 1877 on the scale of 1:506886, or approximately 8 miles to an inch; an atlas of Baltimore county, as well as of Baltimore and vicinity in the same year. An atlas of 15 miles around Washington, including portions of Prince George's, Montgomery, and Fairfax counties; and another of 15 miles around Baltimore, including portions of Anne Arundel, Howard, and Baltimore counties were published in 1878. The latter appeared in at least two forms; the first to attract the inhabitants of Howard county, and the second those of Anne Arundel county. Each atlas, however, has the same maps, which are on scales varying from an inch to a mile to 3 inches to a mile. The Lake, Griffing and Stevenson work includes atlases of Kent and Queen Anne's counties, of Cecil, of Talbot and Dorchester, of Washington, and of Carroll counties. All of these were published in 1877 and are composed of outline maps of the different counties usually on the scale of 2 miles to an inch with many maps of election districts on much larger scales. There are from 15 to 30 of these larger maps in each of the atlases enumerated.

Besides the work of Martenet and the atlases by map publishers enumerated above, there appeared from time to time single counties usually in the form of wall maps. The earliest of these is of Frederick county by Isaac Bond. It is on the scale of 1 mile to an inch and is 34 by 44 inches in size. A year later a map of Talbot county was published by W. H. Dilworth, and one of Washington county was prepared by Thomas Taggart. The latter is an outline road map for the wall on the scale of 2 inches to a mile. It is a sheet 51 by 68 inches. In 1873 an atlas of Frederick county, prepared by J. D. Luke, was published by C. A. Titus & Company of Philadelphia. In the same year a map of Caroline county made by John B. Isler was copyrighted, but this did not appear in published form until 1875. It is on the scale of 1.62 inches to a mile and represents the roads and the drainage districts. It is a sheet 61 by 37 inches. A map of Queen Anne's county by Strong is mentioned by Williams in his list of Maryland maps. This has not been seen.

The Cartographic Work of the United States Coast and Geodetic Survey.

The early history of the organization which, finally, has become the U. S. Coast and Geodetic Survey, shows many difficulties overcome, and a broad outline of work laid out and partially accomplished prior to work within the state of Maryland. Established by act of Congress in 1807, and subsequently suspended in 1818, the real work of the present organization did not begin until 1832, and it was not until eleven years later that the surveying of Chesapeake Bay and its tributaries was commenced.

Mr. J. H. Alexander, soon after his appointment as Topographical Engineer in 1833, endeavored to secure the coöperation of Professor Hassler, the first Superintendent of the Coast Survey, in order that he might have an accurate primary triangulation upon which to base his topography. This effort unfortunately proved unsuccessful because the Maryland committee was not ready to perform its part in compliance with the agreement adopted.

The work, according to the general plan of the Coast Survey, which included the major and minor triangulation, topography and hydrography of all the lands and waters seen by mariners sailing along the coast or in the navigable estuaries, was commenced in the vicinity of New York, and already in 1842 had been pushed across New Jersey to the Delaware. The extension of the triangulation from this point to the Potomac during the season of 1843 was the first systematic work conducted within the present borders of the state and marks the beginning of operations which have been carried on almost continuously ever since. The following year it was found necessary to verify this primary triangulation by the introduction of a second base line, measured on the western shore of Kent Island, lying not far from the centre of the tidewater portion of the state.

TOPOGRAPHY.

Work was immediately commenced on the topographic mapping, and before the end of the season seven manuscript sheets were completed on the scale of 1:10000, which embraced most of the shore line from Annapolis to Baltimore, including two sheets devoted to the Severn river. While work was being prosecuted on this part of the bay shore line, another party was engaged in surveying the course of the North East river. The work in this area, however, was not completed until the succeeding year.

The summer following (1845) was devoted to the upper portion of Chesapeake Bay, especially along the shores of Baltimore, Harford and Cecil counties between Bohemia river and Baltimore. Although the work was not completed over the entire region, the main outlines of the coast line were platted and detailed surveys were made of the Susquehanna between Spesutie Narrows and Port Deposit and of the mouth of the Magothy river. The work already undertaken was pushed forward with energy until at the opening of the season of 1847 the shores of the bay north of a line connecting Point Thomas on the Western Shore and Kent Island on the Eastern Shore had been carefully drawn either on the scale of 1:10000 or 1:20000 of nature. From this point the topographic work was extended southward until it included the Pocomoke and Point Lookout in 1851, while the work already commenced on the small strip of Maryland bordered by the Atlantic reached its completion in 1850. Thus it is seen that the U. S. Coast and Geodetic Survey with increased facilities for transportation, improved instruments and the results of all previous work for initial knowledge, employed seven years in its first survey of a portion of the territory which Smith represented with tolerable accuracy after a single month's exploration of unknown shores in an open boat under trying circumstances. In these two instances the work is utterly different in character, and the comparison is not a disparagement, but rather a commendation for both.

The operation of the Federal organization between 1851 and the outbreak of the war, as conducted within the state of Maryland, consisted of revising, and, in several cases, resurveying certain of the more prominent waterways along which there were plans for making improvements. In this way manuscript sheets were prepared of the Patapsco (1851-54), the Sassafras (1854), the Bohemia and the South rivers (1855), and Chincoteague Bay (1857).

The Potomac and Patuxent rivers were the last features in Maryland to receive detailed mapping, although topographic sheets containing the mouths of both of these waterways had been prepared in 1848 and 1849. The survey of the Patuxent was extended to Lower Marlboro in 1860, but the mapping of the Potomac was not completed until two or three years later. Although the work about St. Mary's and St. George's was well under way in 1859, the greater portion of the Potomac was surveyed in 1862, when sheets were prepared embracing the Potomac from Blackistone Island to Fort Washington. During the year following, the survey was continued from Broad creek (opposite Alexandria) to Little Falls, but it was not until the close of the year 1866 that the field work was completed for sheets covering the valley of the Potomac from its mouth to a point opposite Shepherdstown, West Virginia.

HYDROGRAPHY.

The topographic mapping was accompanied, or immediately followed, by a study of the character and form of the bed of Chesapeake Bay and its tributaries. The investigations conducted have extended through most of the field seasons from 1844 to the present time (1897), but certain years are marked by increased activity within the borders of the state. The years 1844-'48, 1862, 1866, 1869-'70 and 1876-'77 are the periods of important surveys. During the first four years of operation in the state, hydrographic sheets were prepared covering almost the entire shore line of the Chesapeake Bay with the exception of the indented estuaries between Watkins' Point and the mouth of the Nanticoke, which were studied until the seasons of 1858 and 1859. The season of 1862 was devoted to a study of the Potomac, and that of 1866 to the Patapsco. With the opening of the season of 1869 work was commenced on the estuaries and smaller streams of the Eastern Shore. This was conducted so successfully that by the close of 1871 manuscripts had been prepared representing in detail the stream beds of the Pocomoke, Chester, Choptank and Sassafras rivers to the head of navigation in each. During 1876-'77 a detailed resurvey of Baltimore harbor was made, which resulted in the preparation of five sheets of wharf, pier and shore line maps, which include full hydrographic details. In the years intervening between those already mentioned, work was not suspended within the state, for the average annual output was about three manuscript maps.

Very few of the topographic and hydrographic sheets referred to in the foregoing discussion have been published, but the data which they contain are combined in a series of 15 charts on different scales which are obtainable [1] from the proper authorities.

Since the charts of the Coast Survey are constructed primarily as an aid for seamen, the topography seldom extends more than two or three miles inward from the shore line. Frequently the limit is the first road running parallel to the coast. Wherever the topography is delineated hachures are used, while the trees, houses, cultivated fields, swamps and property lines are represented by conventional signs. The line between the land and water at mean low tide is carefully outlined, while the character of the bottom is described as "hard,"

[1] A list of these charts giving the character, scale, size, date of publication and price, together with directions for their procurement is given in Volume I of the Maryland Geological Survey Reports, p. 138. Plate IV of the same volume represents graphically the territory included within the boundaries of each chart. Detailed information concerning the men engaged in the surveys, the time employed, the baseline measurements, the stations utilized as triangulation points or occupied for the determination of astronomical position, gravity or magnetic force are given in the same volume, pp. 115-125.

"soft," "sticky," "rock," etc. The depth of the water is also given in fathoms and feet. Along the shore, where the water is less than 18 feet (3 fathoms) deep, the shape of subaqueous surface is indicated with three grades of shading, one for each fathom, the heaviest near the shore. By this means it becomes easy to distinguish the shape, extent and character of the shoals at a glance. Besides the various soundings, there are scattered over the charts concise statements regarding the rise and fall of tides, sailing courses and bearings, latitude and longitude of given points, the location and description of buoys, lighthouses and lightships, and the magnetic variation for the sheet.

The charts, engraved on copper, are perhaps the most accurate delineations of extensive portions of the country which have been made, and their authoritative statements are of especial interest to Maryland. The extension of the Chesapeake Bay across almost the entire state from north to south renders the miles of shore line (2800) relatively high for the area (12,210 square miles), and the information collected by the members of the Federal organization especially valuable to the citizens in the tidewater portions of the state.

The preparation of maps of detailed accuracy is an expensive operation, as shown by the following estimates made by Gen. Comstock[1] (I) on the work from 1858-1872[2] and by Gen. Wheeler at the time of the Venice Congress (II).

	I.	II
Cost of triangulation per square inch	$ 25	$120
Cost of topography per square inch	333	403
Cost of hydrography per square inch	93	80
Cost of surveying per square inch	426	483

These estimates are the most accurate that have been published, and show that though the amount expended for triangulation is decreasing, that for topography and hydrography remains about the same. The rate per square inch is not excessive for good work, but is far in advance of any sum available from state treasuries.

[1] Senate Ex. Doc., 45th Cong., 3rd Sess., No. 212, January 30, 1879.
[2] House Ex. Doc., 48th Cong., 2nd Sess., No. 270, p. 533. Dec. 10, 1883.

THE CARTOGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY.

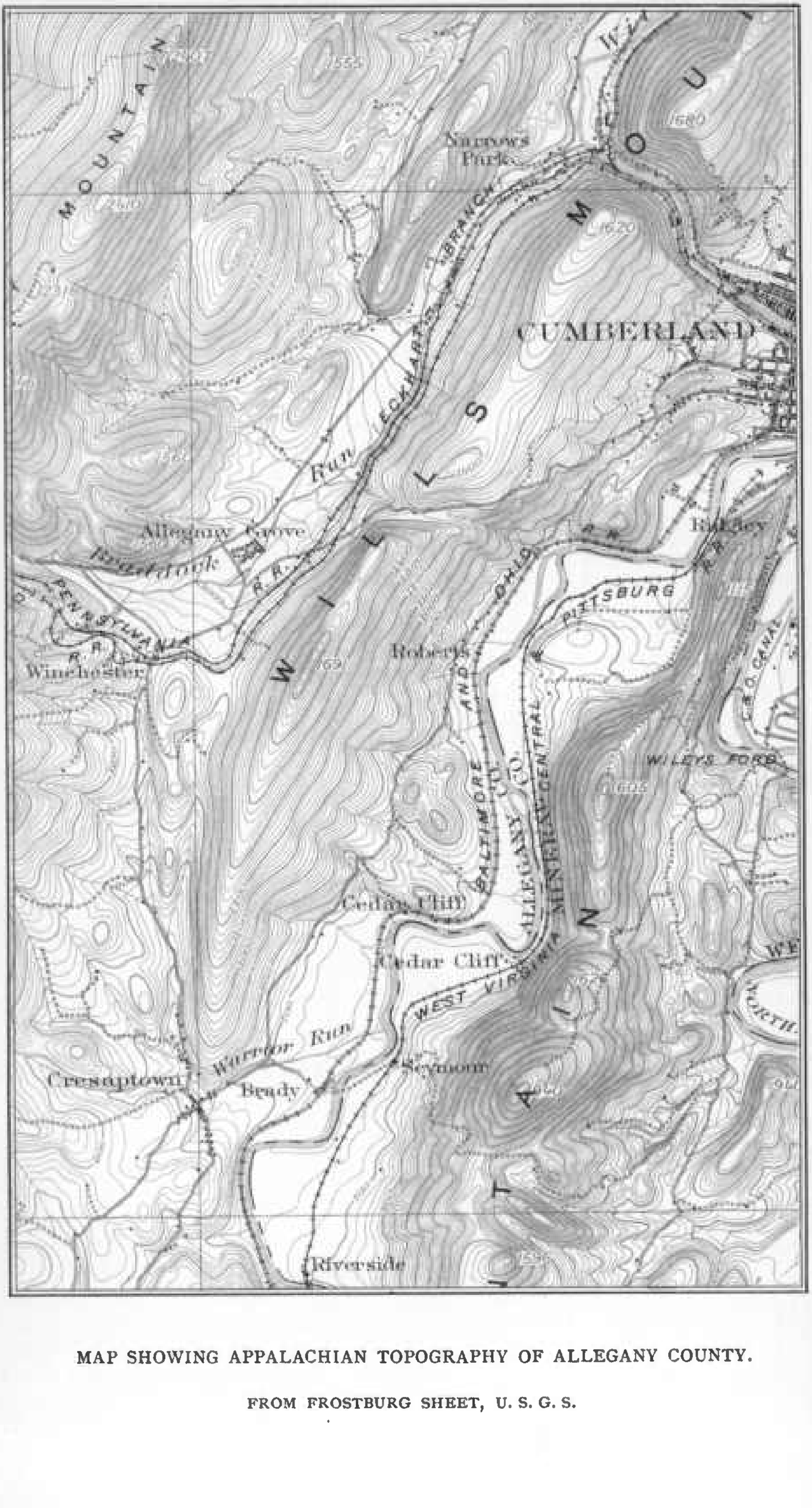
Prior to the consolidation of the different geological surveys of the United States into the present organization, the U. S. Coast and Geodetic Survey had commenced a triangulation across the continent to connect its stations on the seacoasts of the Atlantic and the Pacific. When it was seen that the intervening territory was to be mapped in an adequate manner by another official bureau, the Coast and Geodetic Survey relinquished a portion of its plans of operation to the latter organization. In the state of Maryland, before the inception of the work by the topographers of the Geological Survey, considerable work had been done by the Coast Survey, as indicated in the preceding pages, which has proved of considerable value. There were established several points of major triangulation, as, for example, at Sugar Loaf and Maryland Heights. The coast line of the Potomac and the Chesapeake had also been carefully platted so that much of the work was in a fair state for immediate utilization. The Coast and Geodetic Survey also furnished its manuscript data to the Department of the Interior, as desired, thereby decreasing the amount of time and the expense in the preparation of new sheets. The style of work accomplished by the Coast Survey was such that intervening territory between the Potomac and Chesapeake needed to be surveyed in some detail. West of Washington a topographic map had been made on the scale of 1:125000 with one hundred-foot contours.

With this large amount of initial information regarding the domain to be surveyed, work was inaugurated in the western portion of the state in 1883, when a party early in July entered the field at Cumberland. The methods introduced by the Geological Survey differed somewhat from those of the Coast Survey, and followed the lines as laid down in the preceding paper by Mr. Gannett. After the triangulation of the territory has been established for control, the topography is mapped by means of traverses, lines of travel, and also by plane table and contour sketching. Subordinate secondary and tertiary triangulation is used to establish control points for the topography. Starting out with a new corps of men, the work at first was necessarily slow and considerable attention was paid to the compilation of preëxisting cartographic information.

The original plans of the U. S. Geological Survey contemplated the preparation of a map on a scale of 1:250000, or about 4 miles to an inch, with contours at intervals of 100 feet. Later this scale was replaced by that of 1:125000, or about 2 miles to an inch, and for several years was continued upon the latter basis. When the mapping of the region was carried into the low-lying, but intricate, topography of the Coastal Plain, where the country is more thickly populated, the scale of 1:62500, or about 1 mile to an inch, was adopted. This scale has, however, been abandoned in the final publication of the maps south of the parallel 39° 30′ N. latitude. The successive shifting of scales, together with the inexperience and haste of the earlier surveyors, has required several revisions of portions of the state before accurate maps have resulted. These revisions will be more evident from the following discussion of the work upon the individual quadrangles.

The number of sheets, including Maryland territory prepared, and in many cases engraved and published by the U. S. Geological Survey, amounts to thirteen, on the scale of 1:125000 of nature, and twenty-seven on 1:62500. Many of these were made under such different conditions that they are no longer regarded as equal to the standard now adopted for the topographic maps constructed at the present time. Some of them have never been engraved, but the manuscript data are available for the preparation of sheets to represent the territory included.

Beginning work in the western portion of the state in 1883, a party consisting of three or four topographers was kept in the field during the seasons following until the close of 1886, when most of the territory north and west of Washington had been surveyed with varying accuracy. The first year's work, west of Cumberland, was for publication on the scale of 1:250000, or four miles to an inch. This scale, however, was changed the following year, and the work already accomplished was redrawn to a larger scale. The rate at which this territory was surveyed, 450 to 700 square miles per month for a single party, and the cost per square mile, estimated in 1885 at $3, shows that the amount of work done in the area could not adequately



MAP SHOWING APPALACHIAN TOPOGRAPHY OF ALLEGANY COUNTY.

FROM FROSTBURG SHEET, U. S. G. S.

P. 4515

express the complex topography of the region, although it is true that triangulations previously made by the Coast and Geodetic Survey greatly reduced the expense and time necessary for the work. The United States Geological Survey has never published any maps representing this work, although manuscript copies were prepared and the Piedmont and Romney sheets were engraved in 1887. After the revision of the early work of the Coast and Geodetic Survey in 1885, a map was prepared for the Western Maryland Railroad by Mr. E. H. Fowler, which appeared in two editions, on the scales of approximately 1.5 and 3 miles to an inch. The larger of these sheets is 36 by 30 inches, and the smaller 18 by 15. These give the roads, railroads and drainage, as well as the surface configuration by 100-foot contours, of all the territory from the fortieth parallel to 39° 15′ between Cherry Run and Frederick Junction. The work remains to the present day as the best contour map of the region north of 39° 30′, and in the smaller map is a high grade sheet for its scale. At the same time a much rougher map, with hachures, was prepared for the same company by John Laing, embracing the territory between Sabillasville and Edgemont Station. This map extends north of the state line to Gettysburg Gap.

While this more rapid reconnoissance work was being pushed in the western portion of the state, field work and the compilation of existing data was commenced on the territory immediately surrounding Washington. This ultimately resulted in the East and West Washington sheets, engraved in 1888, on the scale of 1:62500 with 20-foot contours. Much of the country within the limits of the District of Columbia had just been surveyed in considerable detail by the District authorities, and the Coast and Geodetic Survey had made a manuscript map on the Maryland side of the Potomac river to Great Falls, including a zone of country three miles in width. The work for these sheets was conducted by means of stadia and plane tables, based upon the bench marks and triangulation of the Coast and Geodetic Survey. The scale of the sketching was twice that of final publication, or approximately 1:30000. During the succeeding year the Baltimore sheet was made on the scale of 1:62500. This sheet is based upon the work of the U. S. Coast and Geodetic Survey, and only 178 square miles of the territory were surveyed by the Geological Survey. This was on the scale of 1:40000. The work was done by the plane table and road traverses and stadia observations. In the early portion of 1888 the Frederick quadrangle was surveyed, work being completed in the early August of that year. The territory examined included 400 square miles.

From the information acquired between these years, 1883-'89, six sheets have been retained as sufficiently accurate. These are the East[1] and West Washington, Harper's Ferry, Fredericksburg, Baltimore and Mt. Vernon sheets. The Piedmont and Romney sheets which were first engraved in 1887 were revised in 1894 and 1891 respectively. In 1889-'90, little work was done in the state. The field work in Maryland for the season of 1890 was devoted to the mapping of the entire western shore of Chesapeake Bay, extending northward to the head of the bay and westward to the Mount Vernon and Frederick sheets. Within this territory the Baltimore and East Washington quadrangle had already been surveyed. One topographer, with two assistants, was engaged in this work, embracing 2450 square miles (12 atlas sheets), on the scale of 1:62500, from early June until the middle of December. Thus the territory was mapped in six months at the rate of over 400 miles per month. This apparently rapid work was possible, since the triangulation and coast line of the entire area, together with some of the topography near the water-line, had been secured by the U. S. Coast and Geodetic Survey some 30 and 40 years earlier. The territory surveyed is represented on the following sheets: Annapolis, Baltimore, Brandywine, Drum Point, Ellicott, Laurel, Leonardtown, Montross, Owensville, Piney Point, Point Lookout, Prince Frederick, Relay, Wicomico. The following year the work of surveying the remaining territory on the western shore was completed, furnishing data for the Gunpowder, North Point and Sharps Island. The last sheet, however, was not fully completed until the succeeding year.

The work enumerated above completes that conducted in the state by the topographers of the U. S. Geological Survey prior to the

[1] Portions of the East Washington sheet were resurveyed in 1896.

establishment of the Maryland Geological Survey. When the latter organization commenced its work a plan of coöperation with the national survey was accomplished by which activity in the area was renewed. Agreeably to this arrangement, a large force was placed in the field on the eastern shore of Maryland in May, 1896, which prosecuted the survey so rapidly that by July first, six sheets had been completed for publication, each 15 minutes square. These six, however, are parts of three sheets to be published, on the scale of 1:125000, which will bear the names Tolchester, Choptank and St. Mary's. Much of the information contained on these maps is based upon the work of the U. S. Coast and Geodetic Survey, since they embrace little more than the shore line on either side of the bay.

Later in the same season the remaining territory of the state lying east of Rising Sun and Chestertown was surveyed for publication as the Elkton and Dover sheets. The latter is on the scale of 1:125-000, with 20-foot contours, and represents portions of Cecil, Kent, Queen Anne's and Caroline counties. The former is on the scale of 1:62500, with 20-foot contours, and includes portions of Maryland, Delaware and Pennsylvania. The succeeding season was devoted to the triangulation and mapping of the territory in the western part of the state. At its end the Frostburg quadrangle had been mapped and considerable progress made on the Flintstone quadrangle. During the season of 1898, work has been conducted upon four quadrangles, namely, the Flintstone, Paw Paw, Grantsville and Accident. The Paw Paw sheet includes 140 square miles of Maryland territory, the Flintstone 190, the Grantsville 210, and the Accident 220. In the preparation of these sheets accurate spirit levels were run over several hundreds of miles, and some thousands of linear miles of road were traversed. All of the topography is controlled by adequate triangulation. The difference in the detail and accuracy of these later maps, when compared with those of the first survey of the territory, is shown in the fact that the cost per square mile has increased from $3 to $13.

Upon the topographic sheets of the region already discussed the Federal Government has already published several geological folios representing the results of detailed geological investigations in the quadrangles delineated. Each folio includes a general introductory sketch concerning the fundamental facts of geology and topographic mapping, a more detailed account of the geological formations found within the quadrangle, and three or more maps representing the topography, the areal geology, and the economic geology of the region. Much of the information included in these sheets has been published in advanced form in scientific magazines, illustrating scientific papers on the problems involved. Many of these preliminary maps are discussed in the subsequent pages. All of the folios embracing territory south of 39° 30′ are on the scale of 1:125000, or approximately 2 miles to an inch. Among those which have already appeared from the government press are the Piedmont, Harper's Ferry, Fredericksburg and Nomini.

Geological Maps.

Among all of the surveys which have served as the foundation for the maps considered in the foregoing discussion, little attention has been given to the collection of geological information. Smith, it is true, collected and sent to England barrels of carefully labeled specimens, among which he hoped skilled chemists might find some ores of value. He thought that among the treasures found were deposits of antimony. There are, however, no indications of his economic proclivities displayed on this map. Later cartographers, such as Griffith or Shriver, have indicated by occasional words the location of ore deposits, but the cartographic representation of the mineral wealth and the geological features belongs to a distinct class of students, who have utilized the maps at hand as bases upon which to record their geological observations. The resulting maps may be considered under four heads, according as the information incorporated treats of Maryland in general terms, as a part of a larger area, or more specifically, as a unit covering a portion or all of the state. Convenience and geological relations suggest a grouping into those dealing with the whole, the Coastal Plain, the Piedmont Plateau, and the Appalachian Region of the state. Deviations from this arrangement, however, are advantageous in the case of men, like Ducatel, who had undertaken a detailed study of the entire state and published in parts.

GEOLOGICAL MAPS OF THE ENTIRE STATE.

General Maps.

The earliest map to correlate the geological formations of Maryland with the divisions already recognized in Europe is the work of William Maclure. This was first prepared in 1809 to accompany a paper of the author's before the American Philosophical Society. Concerning the base used (a map published by Bradley), and the manner of platting his information regarding a portion of Virginia, the author makes the following remarks: "The map of the United States on which those divisions are delineated, though I believe the best yet published, is exceedingly defective in the situation and range of the mountains, courses and windings of rivers, etc., but as the specimens which I collected every half-mile, as well as the boundaries of the different formations, are from the positive situation of the different places, the relative arrangement of the map cannot change them, but must become more exact, as the geographical part is made more accurate."[1]

There seems to be more than one edition of this volume, and in the volume seen the map was missing. The text says that, owing to the absence of the author, a copy of Lewis' map was used.

In the second edition of his paper published in 1817, Maclure used as a base a map published by John Melish, a well-known map publisher of the day. On this base are five or six hand-washed colors representing the various formations. The mapping in Maryland seems to be determined almost wholly from information gained in Virginia and Pennsylvania. The broader divisions, as now recognized, are represented, but the limits of the different formations are inaccurate. All of the Coastal Plain is given as "Alluvial," with the exception of a zone of Cretaceous across Cecil county to the head of the Chesapeake, where it stops abruptly. The Piedmont Plateau is "Transition," which extends to the red sandstones of Carroll, Frederick and Montgomery counties. The line between the "Secondary" and the "Primative" runs along the top of the Blue Ridge. West-

[1] Trans. Amer. Philos. Soc. vol. vi, 1809, p. 427.

ward from this formation extends the "Transition," till it is replaced by the Old Red Sandstone in northwestern Garrett county.

Although discrepancies may be easily seen, this map is epoch-making from the marvellous accuracy of its generalizations, which were based on a few scattered and unsystematized observations. The influence of the work was far-reaching; its errors even were reproduced by Lyell (1845) and Marcou (1853), who failed to continue the Cretaceous across from Havre de Grace to Fredericksburg, Virginia. The map by Lyell, prepared after his visit to this country in 1844, is much more detailed than any general map of the United States then published. Twenty colors and several devices were used to distinguish the different formations. The scale, however, is too small to represent all the geological subdivisions of the Appalachians in their many alternations. There are, for this reason, instances where only the top and bottom members of folds are given. While there are many variations from the interpretations now accepted, and in several copies errors in the registration of the hand-laid colors, the whole map in the western portion of the state shows a marked increase in knowledge. This increase in detailed information is due to the personal observations of Lyell in the region about Cumberland, and in the numerous facts gathered during the existence of the State Survey by Ducatel. The most evident errors in the map lie in the locations of the different formations, which are usually too far east, and in the generalized character of the Coastal Plain. The representation of the latter is, however, more detailed than in the map by Maclure.

The map by Marcou (1853) is on so inaccurate a base that the course of the Potomac is generalized, and the Shenandoah does not even connect with it. The locations of geological formations are accordingly lacking in accurate details. Although the map shows an increase in knowledge regarding the southwestern territory of the United States, there is no evident advance in the portrayal of Maryland geology.

During the preparation of the 9th United States Census, Charles H. Hitchcock and W. P. Blake were entrusted with the compilation of a geological map of the United States. Their labors resulted in a sheet 21 by 33 inches, printed in nine colors, drawn on a scale of 90 miles to an inch. The representation of Maryland is based on Tyson's map, published twelve years earlier, on nearly ten times this scale. This sheet, which was republished several times between its first appearance and 1880, represents the best sketch on the scale until the appearance of the sheets, prepared under the direction of W J McGee, which accompany the 5th and 14th Ann. Repts. U. S. Geol. Survey in 1885 and 1894.

The Ducatel Maps, 1834-1840.

The greatest advance in the information concerning the distribution of the geological formations throughout the state recorded on maps between 1817 and 1859 is on the maps constructed by the State Geologist, J. T. Ducatel, on base maps furnished by the State Topographical Engineer, J. H. Alexander. At first this information consisted of scattered facts indicating the location of ore pits and fossil deposits, but as the work progressed westward into the southern counties of the western shore there was a manifest attempt at correlating the clays and sands there found with certain of the broader geological divisions, such as the Upper and Lower Pleiocene. Occasionally, also, according to the maps and text, there is a suggested correlation between the greenish sands and marls of Maryland and the better known "green sands" of New Jersey. Maps in still later reports show an effort to designate the constitution of individual ridges in the Piedmont region, but the distribution of facts placed on the maps does not indicate anything of the geological structure of the area. There is a suggestion of the general trend of the formations passing in a northeasterly-southwesterly direction across the state. In all of the maps furnished by this survey, numbering eight or ten, there was no effort made to distinguish the different formations by colors. On the contrary, with two exceptions, all of the information is in type of the same color as the general map. Where this is not so the change in color is given to all of the geological information to avoid confusion through too great detail. That this method is the result of predetermination may easily be seen from the text which the map accompanies, for the State Geologist constantly held before himself the hope of ultimately preparing a complete final report which would give a comprehensive discussion of the entire physiographic, geologic, and economic aspects of the state. This end was never accomplished, and all the scientific data which had been reserved for this final volume were lost through the abandonment of the survey just prior to its logical completion. This hasty termination of a bureau which had proved itself helpful to the agricultural and mining communities deprived the state of a scientific position which it could have acquired with almost no additional expense beyond the publication of the mass of facts which had been already accumulated.

The Tyson Map, 1859.

The preparation of a geological map such as Ducatel had in mind was actually accomplished by Philip T. Tyson for his report published in 1860. Mr. Tyson had long been interested in the mineralogical and geological features of the state, so that this map, though published in his first report, is based on a large amount of slowly and carefully acquired information. The work is of especial interest and value upon several grounds. It is the first detailed geological map of the entire state, and its representation of the geological formations is by far the most complete which had been attempted up to that time. The twenty-four colors and patterns employed are printed from stone and not hand-laid, as in most of the previous instances. It is accompanied by profiles, giving the first complete diagrammatic indications of the geological structure across the state from Laurel Hill in Garrett county to Bodkin Point; from Washington to St. Georges Island; and from the Mason and Dixon line to Pocomoke Bay. This map is 25.5 by 13.4 inches, and is drawn on the scale of 9.75 [1] miles to an inch on a base compiled by Mr. August Faul from all the available data. The streams are clearly drawn, and their names, together with the names of towns, are given in considerable abundance. The courses given, however, are in

[1] Through some oversight this was given as 12 miles to an inch in vol. I, p. 68.

many instances poorly or inaccurately drawn. For example, the Octorora is given as a small creek rising within the limits of the state, while the Deer and the Gunpowder are made to head south of the Mason and Dixon line.

Considering the areal distribution of the different geological formations, one is struck immediately with the rounded, indefinite character of the boundaries laid down, especially in the Piedmont Plateau. Here there seem to be many points indicating that Tyson was not familiar with the extent and distribution of certain of the formations. For example, the serpentine of Broad creek in Harford county is represented as a single small mass lying south of the creek, while masses of similar rock about White Hall and Hereford are indicated as much larger than found at present. Other variations from present day interpretation may be seen in the boundaries between the Cretaceous and Tertiary in Anne Arundel county, or between the Tertiary and post-Tertiary of Dorchester county. Similar differences may be detected in the mapping of the western counties. In spite, however, of all the criticisms which may be made on the details, the map represents a marked improvement over all preëxisting attempts at representing the geology of the state, and shows such a great increase in knowledge that it has remained the best authority on the territory involved up to the beginning of the present decade. Even now it is not surpassed by more than two or three published maps of the territory, and these have utilized all of the accurate information of the Tyson map.

The Williams Map, 1893.

The largest geological map of the state is the result of the combined work of several observers, notably N. H. Darton, G. H. Williams, A. Keith, H. R. Geiger, P. T. Tyson, and I. C. White, under the editorship of G. H. Williams. It bears the title "A preliminary Geological Map of Maryland," and appeared as one of the illustrations in "Maryland; its Resources, Industries and Institutions," which was prepared for the "Board of World's Fair Managers of Maryland" in 1893.

This map, which is approximately 30 by 18 inches, is laid down upon a new base which was prepared especially for this work. The style of drawing is clear, and the detailed drafting of the coast line and drainage surpasses in accuracy any of the previously published maps. The manuscript copy was made on the scale of 5 miles to an inch, and the published base is reduced to 8 miles to an inch. That a few errors crept in and were overlooked is perhaps to be expected, considering the time allowed for its preparation. The most noticeable of these oversights is that relating to the boundary between Somerset and Worcester counties. The map seems to indicate that the boundary is along the Pocomoke to Parkers Bridge instead of along Dividing creek. This error arose from the use of Martenet's map of the state, where parts of several of the county boundaries are omitted.

The geology of the state is more fully represented than in any previously published map. Thirty-two colors and patterns are used to indicate the different formations. The small index map shows that the Coastal Plain is based on Darton, the Piedmont Plateau on Williams, the Blue Ridge on Keith, and the country west of the Hagerstown Valley on Geiger, Tyson and White.

The first division of the work follows closely the lines given by Darton in some of his smaller maps, and indicates considerable familiarity with all of the Western Shore and the northern portion of the Eastern Shore. South of Queen Anne's there is no attempt to separate the Miocene, Pliocene and Pleistocene deposits. While considerably generalized from the known thickness and position of the formations at scattered localities, the mapping shows a greater degree of detailed accuracy than any of the earlier maps. Criticisms made on some of the more specialized maps apply to the present one though in less degree (see p. 471).

The greatest advance is in the mapping of the Piedmont Plateau, where Williams gives general expression to conclusions based on several years' work. Many of the lines were derived originally from Tyson and subsequently corrected by Williams. The area about Baltimore is mapped after detailed observations, while that along the northern part of Cecil, Harford, Baltimore and Carroll counties is based upon a few hurried reconnoissance trips taken by Williams or his students at widely separated intervals. The boundaries laid down on this map have been checked in almost all instances, showing that the author had a clear appreciation of the general distribution of the different rocks. The details are necessarily wanting in accuracy where the lines laid down are derived from hurried preliminary surveys. Among the changes which have been adopted since the publication of this map are those based on Keith's detailed work along the boundary between the gneisses and phyllites in Montgomery, Howard, Frederick and Carroll counties. These indicate that the arbitrary boundary given by Williams is not a simple line, but, instead, is a highly complex one representing an intricate interfolding of the two formations. The map also shows the omission of many small bodies of altered andesite (Catoctin schist), diabase and serpentine, which have been located by Keith, Mathews and others who have worked in the area.

That portion of the map credited to Keith, including the Blue Ridge and the Catoctin Mountain, represents at the same time one of the most complex and most carefully studied portions of the state. The lines delineating the various formations are based almost entirely on his work, while the interpretation of the original characters af the quartz porphyry and diabase as rhyolite and basalt are based on the detailed petrographical work of Williams and Miss Bascom. The areal distribution indicated by Keith has been followed in the maps published by the present State Geological Survey.

West of Hagerstown the mapping, with the exception of that in the coal regions, is based almost entirely on Tyson and the reconnoissance work of Geiger along the Potomac (1885-'88). This is the most generalized part of the map, but accords in a considerable degree with the present knowledge of the area which has been greatly increased in Garrett and Allegany counties. The failure, however, to recognizo a transverse fold in Garrett county renders the northwestern corner of that county of little value.

The economic value of this map is greatly increased by a correlation of the soils with the underlying formations, thereby rendering the geological boundaries serviceable as an agricultural map.

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Maryland Geological Survey Map, 1897.

The latest and most authentic geological map of the state appeared as plate xiii of the first volume of the present series of reports. This map, prepared by the Maryland Geological Survey, is a compilation of all the reliable information available checked by a preliminary survey of the entire state and represents a summary of existing knowledge at the time of its publication.

The base upon which it is drawn is printed from two newly engraved copper-plates of exceptional geographic fidelity and execution. Since the map of 1893 was used as the general authority, the present map follows it in the erroneous representation of the boundary between Somerset and Worcester counties and the heads of the Gunpowder and Deer creek. Each of these streams rise outside of Maryland. There is also a slight error in the drawing of the curved boundary about New Castle, Delaware, since the tangent point is just south of the Baltimore and Ohio Railroad instead of some miles north of it. The direction of the eastern boundary of the state north of this intersection is also incorrect, since it is a meridian line and not a continuation of the northerly line from the middle of the peninsula.

Like the base upon which they are laid, the geological formations are represented with the highest skill in execution attainable, with the result that there is no harshness in general effect, although thirty-four different divisions are clearly distinguished from each other. The colors are also so arranged that they bring out the three major divisions of the state—the Coastal Plain, the Piedmont Plateau, and the Appalachians—without destroying the unity of the sheet.[1]

Drawn on the small scale of 16 miles to an inch, or 1:1000000 of nature, it is impossible to incorporate all of the detailed information acquired by a complete reconnoissance of the entire state which was accomplished prior to the appearance of the map. There is, nevertheless, more detail on this small-sized sheet than has been published in any other geological map of the entire area. Certain of the additional features are worthy of more extended notice.

Within the area of the Coastal Plain the mapping of the forma-

[1] The map was lithographed by A. Hoen & Co., under the personal supervision of Mr. A. B. Hoen.

tions by the distribution of their colors brings out the eastward transgression of the later over the Cretaceous. The lines between these formations were given in some detail by Darton on the Williams map just described, but the broad geographic relations existing between the divisions of the Tertiary formations were not expressed cartographically before the publication of this map. The subdivision of the Cretaceous is likewise more fully given than on any previous map of similar scale as the result of recent work by Professor Clark.

In the area of the Piedmont Plateau the additional information of the writer in Cecil, Harford and Baltimore counties, and the detailed work of Keith in the western portion of the district, are represented by many improvements in the delineation of the formations. Changes are especially noticeable in the territory studied by Keith. The large belt of granite extending from Selbysport to Great Falls, and the numerous small bands of diorite within the same area, are improvements in the interpretation and determination of the rocks exposed. The various narrow strips of serpentine and phyllite show a sharper separation of these rocks from the enclosing "country" gneiss. The colors of the map make the limits of the different rocks appear much sharper, however, than they are in nature, where it is sometimes quite difficult to determine the exact point of passage from one formation to the other. This is particularly true in the location of the general line between the gneisses and phyllites. Compared with the generalized line laid down by Williams, the present boundary has been moved several miles farther west at its southern end, and the whole manner of representing the contact has been changed as a result of the detailed work along the entire boundary. In a similar manner, the belt of phyllites has been separated into two broad bands by zones of infolded lenses of limestone and Catoctin schist which follow the general trend of the formation. West of the Blue Ridge the changes introduced in the survey map are based upon the reconnoissance by members of the state organization. Few prominent changes have been introduced in the map, but in almost all portions of the region the folds have been sharpened and modified in their extent to conform to the more recently acquired information. Certain of the beds, like the Hampshire east of Town creek, are stopped before reaching the Mason and Dixon line in order that the map may harmonize with the work of the Second Pennsylvania Survey. The greatest change is in the representation of the Lower and Upper Coal Measures on the east side of Savage Mountain, although considerable differences are noticeable in the mapping of the northwestern portion of Garrett county. In the former instance, many outliers of the Fairfax formation are indicated between the different streams flowing from Mount Savage into the Potomac between Bayard and Piedmont, West Virginia. These are entirely lacking in the earlier map by Williams, and their location is determined in great measure from the mapping of the Piedmont sheet by Darton and Taff. A still more important difference in mapping lies in the representation of the so-called "Frostburg" formation, which is regarded as probably of Permian age. Many other features of minor importance indicate additions to the cartographic representation of the state.

While there has been a marked increase in the accuracy of detail, as well as in the execution in these maps by the present survey, there are, unfortunately, one or two errors which escaped notice during the proof-reading of the sheet. For example, in Cecil county, the eastward trending tongue of gabbro is represented as extending too far. Again, in the Blue Ridge, by an interchange in the legend, the rhyolitic or acid rocks are described as basic volcanics, while the basalts or Catoctin schists are described as acid volcanics. The limits and delineations of the two formations are accurate with this interchange in legend. That portion of Garrett county north of 39° 30′ represents the knowledge of the territory as understood at the time the map was published. Later work in the preparation of the county reports has shown that the view there expressed is unwarranted, and that the distribution of the various formations is much more complicated than there represented because of the presence of a transverse fold whose axis is some ten miles north of Deer Park.

Although the general appearance of this geological map indicates that the work in the region has been successfully accomplished, it really represents no more than the best founded generalizations regarding a large portion of the territory of the state. Up to the time of the organization of the present survey no accurate maps were available upon which to lay down the geological characteristics of all of the territory north of the latitude 39° 30′. The same is true of the greater portion of the Eastern Shore. Without the aid of such maps, it has been inexpedient to make detailed studies in these territories, and only after the preparation of adequate maps, now undertaken, will it be possible to present in cartographic form any detailed results of studies in the region.

GEOLOGICAL MAPS OF THE COASTAL PLAIN.

Enough has been given already in the preceding discussion of the geological maps embracing Maryland to show that from them much may be gained regarding the personal interpretation of the phenomenon studied by various investigators. This feature, however, is even more evident when the larger scaled individual maps of restricted areas are considered, for from them one is able to derive information regarding an author's interpretation, not only of the broader problems involved, but also of special deposits in different portions of the regions studied. In the study of the Coastal Plain there are a few men particularly prominent who have expressed their conceptions in text and maps.

Chester, 1884. Considering the cartographic work of these students in something of a chronologic order, the first map devoted to the problems of the Coastal Plain is found to be by F. D. Chester and entitled "Maps showing Distribution of Delaware Gravels—Northern Area." This little map, comprising the greater portion of New Castle county, Delaware, and all of Cecil county, Maryland, was drawn to illustrate a paper in the American Journal of Science.[1] The chief value lies in the fact that it shows the boundary between the crystalline rocks and the overlying Potomac or Delaware gravels, and that these gravels extend as far south as the Sassafras. The map is somewhat crudely drawn in a single pattern, and no attempt is made to indicate such outliers of the older rocks as the gabbro and serpen-

[1] Amer. Jour. Sci., 3rd ser., vol. xxvii, 1884, p. 192.

tine masses between Elkton and Iron Hill Station on the Pennsylvania Railroad.

Heilprin, 1884. During the same year, as an illustration for his paper on the "Tertiary Geology and Paleontology of the United States," Heilprin[1] gives a map entitled "The Tertiary Geology of Eastern and Southern United States," which is composed in reality of two parts. On the general map no Eocene is represented on the eastern peninsula between Annapolis and New Jersey, while on the larger scale map of this same region are shown two indefinitely bounded areas of Eocene in Kent county. The representations are without boundaries, and there is no indication of the gradual transgression of the Miocene eastward. Although six colors, or symbols, are used to indicate the subdivisions of the Miocene, Oligocene, and Eocene, that portion of the map representing Maryland is covered only by the Miocene and Eocene pattern, as the Oligocene is not recognized in the state. The base on which the map is drawn is rather poor and somewhat indefinite, so that exact correlation of the lines indicating boundaries between the different formations is impossible.

McGee, 1888. Subsequent to the formation of the Potomac Division of Geology in July, 1883, W J McGee spent considerable time in studying the Coastal Plain region adjacent to the Potomac river in the District of Columbia, Maryland, and Virginia and also in an investigation of the same formations along the greater portion of the Middle Atlantic Slope. During his studies in 1886, Mr. McGee made several visits to the region about the head of the Chesapeake Bay, which resulted in a paper on "The Geology of the Head of Chesapeake Bay."[2] This paper was illustrated by maps and stereograms. The former, entitled a "Map of the Head of Chesapeake Bay, Showing the Distribution of the Columbia Formation," is drawn on a clearly outlined base on the scale of about 5 miles to an inch. The geological features are indicated by a new style of cartographic representation, by which not only distribution, but also the coarseness and the thickness of the gravels are represented by the frequency and the diameter of the colored circles. This map is scarcely more than its

[1] Jour. Acad. Nat. Sci., Phila., 2nd ser., vol. ix, 1884.
[2] Seventh Ann. Rept. U. S. Geol. Surv., 1888, pp. 537-646, plates 56-71.

title implies, and is accompanied by a stereogram of the Middle Atlantic Slope, which illustrates clearly the author's conception of the relation between the Coastal deposits and the underlying rocks. This is drawn on a horizontal scale of 35 miles to an inch, and a vertical scale of 35,000 feet to an inch.

Uhler, 1888. During the same year an untitled map was published by Professor P. R. Uhler to illustrate his paper on the distribution of the Albirupean formation in Maryland. This is a small sketch 4 by 3.6 inches in size, drawn in black and white, on the scale of about 20 miles to an inch. It represents the drainage, and uses 3 patterns to indicate the geological formations distinguished. Northwest of the Upper Cretaceous formations are shown the Albirupean and Baltimorean (Potomac) formations. The boundaries between these different deposits differ somewhat from those adopted by the present State Geological Survey, but have been accepted by certain members of the U. S. Geological Survey and represent clearly the interpretation of this very complex problem as given by Professor Uhler.[1]

Darton, 1889. In 1889 N. H. Darton was assigned to work in the Coastal Plain region of Maryland and adjoining states, and spent the next five years in almost continuous field work in the area making preliminary reconnoissances along the shores of the Maryland rivers. Detailed mapping over much of the territory was also carried on for the folios of the geologic atlases of the United States. This work resulted in a number of papers which have been illustrated by small maps and in several folios including Maryland territory. The first of these minor maps appeared accompanying a paper on the "Mesozoic and Cenozoic Formations of Eastern Virginia and Maryland."[2] It is 4.75 by 7.50 inches in size and is drawn in 7 patterns in black and white, on the scale of 25 miles to an inch. The base used is fairly good but just enough indefinite to make the detailed interpretation of the mapping unsatisfactory. Compared with the present views held

[1] The statement given in vol. i, p. 302, as a summary of the paper which this map accompanies suggested an apparent disparagement of Professor Uhler's conclusions. Such was not the intention and the writer apologizes for his unfortunate phraseology.

[2] Bull. Geol. Soc. Amer., vol. ii, 1891, p. 431.

regarding the distribution of the various formations represented, there are variations in the delineation of the Potomac north of the Pennsylvania Railroad, between Elkton and the state line, since there is no indication of the presence of the gabbros and serpentines platted by Chester on his map of the Delaware gravels.[1] The Potomac seen at the base of the cliffs just south of the mouth of the Sassafras river has also led to the representation of too large a band of this formation, since it is represented as extending some distance inland from the shore of the bay. On the whole, however, the map is very good, for its scale and most of the errors in the few spots indicated on the Eastern Shore are recognized by the author to be only approximate representations. This is especially true in the mapping of the region along the Chesapeake and Delaware canal, where the Cretaceous (Monmouth and Rancocas) is erroneously represented as Eocene (Pamunkey).

Another small map published by Darton in 1893 to illustrate his paper on the "Magothy formation of Northeastern Maryland," gives a small sketch drawn on the scale of 10 miles to an inch in 5 patterns. In this map the representation of the Eocene (Pamunkey) is at the other extreme from that of Heilprin, for it is made to extend from near Swan Point to beyond the Sassafras river as a single broad band. Just north of the latter point it is suddenly limited across its strike. Compared with the earlier map, it is noticed that the sketching is more detailed and that certain of the lines of the western shore, notably about the Magothy river, are very different from those of the earlier map. There is, however, an advance in clearness and neatness over preceding sketches by this author, and a sharp contrast with a map published a little later in the Journal of Geology to illustrate the author's conception of the Pleistocene submergence. This latter map is apparently drawn somewhat carelessly on an inaccurate base. The scale is about 50 miles to an inch. A second small map in the article in the Journal of Geology above-mentioned is on the small scale of 50 miles to an inch, but is better drawn and shows Darton's conception of the deformation of the Tertiary peneplain expressed in 100-foot contours. The map also represents the extent of the Lafay-

[1] Bull. U. S. Geol. Surv. No. 59, p. 7.

ette and the post-Columbia ocean. Although the sketching brings out the geological features distinctly, the general effect is harsh and there is little or no attempt at detailed accuracy.

Clark, 1896. Accompanying a paper on the "Eocene Deposits of the Middle Atlantic Slope in Delaware, Maryland and Virginia,"[1] by Wm. B. Clark, is a small page map showing the distribution of the Eocene strata. The scale of the map is small and does not permit of accurate delineation of the formation represented with the pattern used. The lines laid down as the limits of the formation differ somewhat from those given in the succeeding map. Here the Eocene is represented as extending in a broad band across the Eastern Shore from the Sassafras to the southern bank of the Chester. This indicates a much greater northward extension of the Eocene than is now accepted. The same general criticism may be made of the mapping of the Western Shore, although the lines are so generalized that this difference from the later maps is not so noticeable. This sheet represents the sum of knowledge regarding the Eocene existing at the time of its publication.

Clark, 1897. In a general paper by Wm. B. Clark[2] on the "Upper Cretaceous Formations of New Jersey, Delaware and Maryland," are maps and half-tones illustrating the text. Among the maps is one "showing the distribution of the Upper Cretaceous Formations in Maryland and Delaware." On a sheet, 8 by 10 inches in size, is included the territory between the Potomac and the Delaware. The three divisions of the Upper Cretaceous are indicated by threo body colors.

The lines laid down between the different subdivisions are almost the same as those given in the smaller-scaled map by the Maryland Geological Survey, already described. The details are more evident because the scale of the map has been increased to 8 miles to an inch. Two features of the areal distribution are especially brought out. These are the large areas of Cretaceous on the Eastern Shore with simple, almost straight, boundaries; and the narrow intricately outlined areas of the Western Shore. The narrowing of the formations brings out the Eocene with its increasing transgression westward.

[1] Bull. 121 U. S. Geol. Surv., 1896.

[2] Bull. Geol. Soc. Amer., vol. viii, 1896, p. 328.

GEOLOGICAL MAPS OF THE PIEDMONT PLATEAU.

Almost all of the maps representing the geological features of this portion of Maryland are the result of work carried on under the United States Geological Survey by the late Professor Williams and his students or members of the permanent staff of the Federal organization. Considering the various maps in chronological sequence, it is possible to gain some conception of the progress made in the knowledge and interpretation of the entire region during the years succeeding 1886.

Williams, 1886. The first detailed work, subsequent to that of Tyson conducted before the war, was commenced about the city of Baltimore and resulted in the publication of a Bulletin of the United States Geological Survey[1] on the gabbros of Baltimore and vicinity, by George H. Williams. This work is illustrated by a "Geological Map of the Baltimore Gabbro-Area," which is drawn on the Johns Hopkins University excursion map as a base. Five colors are used to indicate the limits of the different rocks considered, and a difference is made between the observed exposures and the inferred extent of the formations. The territory embraced in the geological portion of the map extends from Lake Roland to Ellicott City. Although most of the observations appear to have been made along the highways and railroads, the map gives a large amount of detailed information concerning the formations discussed, and this map has served as the basis in the delineation of the Baltimore gabbro area in all subsequent maps published by the Johns Hopkins University and the U. S. Geological Survey.

Chester, 1890. As a result of the work by Williams and in continuation of the investigations carried on by him, F. D. Chester published a second bulletin[2] on the gabbro area of Delaware, which is also illustrated by a "Map of Gabbro-Area in Delaware." This map is drawn on a scale of approximately three miles to an inch and is almost entirely devoted to Delaware territory. There is, however, a somewhat roughly-drawn extension of the gabbro area on the western side of the Delaware boundary. The limits laid down are only ap-

[1] Bull. U. S. Geol. Surv. No. 28, 1886. [2] Bull. U. S. Geol. Surv. No. 59, 1890.

proximate, and no attempt has been made to distinguish the mass of serpentine cut by the railroad west of Iron Hill Station.

Keith, 1891. Illustrating the paper by Geiger and Keith on "The Structure of the Blue Ridge near Harper's Ferry"[1] is a small plate drawn by the junior author, Arthur Keith, on a scale of 6 miles to an inch. On this sketch, in six black and white patterns, is laid down the areal distribution of the various formations occurring between Harper's Ferry and Point of Rocks. The amount of detail expressed is necessarily somewhat limited by the scale of the map, but is far greater than had been published prior to its appearance. Accompanying the plate are a series of sections representing the structural interpretation.

Williams, 1891. In the same volume[2] is the first expression by Williams of his interpretation of the general structure of the Maryland portion of the Piedmont Plateau. The mapping, which is on the scale of about 14 miles to an inch, indicates little of the distribution of the formations of the Piedmont Plateau, which is bordered by patterns indicating the limits of the Coastal Plain deposits, the limestones of the Frederick Valley, and the Triassic sandstones. For the first time the Triassic dike is mapped in its entirety. No indication is given, however, of the subordinate dikes adjacent to it on the east. Across the otherwise unpatterned Piedmont Plateau are lines indicating the boundary of the semi-crystalline against the crystalline rocks and the supposed axis of the deformation of the Piedmont region. The expression of the boundary between the crystalline and semi-crystallines of Montgomery and Carroll counties is given here for the first time on any map.

Williams, 1892. In order to illustrate more fully the geological and topographic features of Baltimore and vicinity to the visiting mining engineers in 1892, several maps were published under the editorship of George H. Williams. The geological maps of this series are based upon the work of members of the U. S. Geological Survey, especially N. H Darton, on the sedimentary formations, and the editor on the crystalline rocks. The base on which their results are laid down is the ordinary topographic base of the U. S. Geological

[1] Bull. Geol. Soc. Amer., vol. ii, 1891, pl. 4, p. 158. [2] Ibid, pl. 12, p. 301.

Survey, drawn on the scale of approximately one mile to an inch, or 1:62500 of nature. The surface of the territory is represented in 20-foot contours. The first issue of this work included only the territory of the Baltimore quadrangle, and was printed in part to test the color scheme recently adopted by the Federal bureau. This edition appeared in two forms. There was one complete map showing all of the different formations of the Piedmont Plateau and Coastal Plain included within the map, and a second giving the territory of the Piedmont Plateau in a pale tint with the features of the Coastal Plain brought out in their full detail. The colors adopted in the more complete map were unsatisfactory, as the appearance of the sheet is not pleasing or harmonious in its color tones. These two forms of printing the Baltimore sheet were only preliminary and have never been put forward in final form by the U. S. Geological Survey. In coöperation, however, with this organization, the Johns Hopkins University brought out a larger map including the same territory and portions of contiguous quadrangles. This sheet is approximately 24 inches square, and embraces all of the country from Guilford and Stoney Point on the south to Worthington's Valley on the north, and from Marriottsville on the west to Back river on the east. The base upon which the geological formations are laid down is the same as in the preceding prints, but the colors employed in the representation of the various formations are different and do not wholly conform to the color scheme adopted by the U. S. Geological Survey. Twenty colors are used in representing the various formations, and the detail of the map is greater than in any previously prepared in the state. The work remains to the present as authoritative, and indicates the fidelity with which the details of these intricate portions of the territory were worked out. An especially interesting feature of the mapping lies in the representation of the schistosity in the gneisses of the region by the direction of the hachure overprint, in which the individual hachures follow the strike of the local schistosity. By this contrivance it was possible to represent the extremely distorted and complex character of the gneissic formation which otherwise might have appeared as exceedingly simple.

Russell, 1892. Among the maps illustrating I. C. Russell's essay on the Newark[1] is one representing the distribution of this formation between New York and Virginia. It is a small map 8 by 10 inches in size, upon which are represented in four colors the post-Newark, Newark sediments, Newark trap, and pre-Newark formations. The mapping of the boundary between these various deposits is in considerable detail and indicates the general relations between them. In the outline of the Newark deposits of Maryland there are some differences noticed between the delineation on this map and that based on the latest field observations. This is particularly true just east of the Potomac river, where the sediments have been narrowed considerably until their limits are west of the trap dike instead of extending for some distance on the eastern side, as mapped at present. The distribution of the igneous masses near the northern boundary of the state is also different. The main mass or sheet, extends south of the Mason and Dixon line in later representations instead of terminating north of that line as on the Russell map. Some of the smaller dikes across the state are also omitted, for example, east of Emmitsburg, near Westminster, and in Cecil county. It is not strange that such omissions are evident upon this sheet, which is based upon the best information at hand when the map was published. The omissions noted have become evident through subsequent field investigation.

Keith, 1894. Continuing the work outlined in the paper of 1891, Arthur Keith published in 1894[2] a general paper on "The Geology of the Catoctin Belt," which is profusely illustrated with photographs, maps and sections. Of these, the most valuable addition is in the geologic map of the Catoctin belt, which is drawn on the scale of 1:375000 of nature, with contour intervals of 200 feet. The sheet, which is 10 by 13 inches in size, embraces the territory between Monterey, Pennsylvania, and the Rappahannock river. It thus includes a zone across the state extending from North mountain to Frederick. This sheet is the first adequate cartographic delineation of the complex region of the Blue Ridge. On it, for the first time, are outlined the various areas of Catoctin schist, granite, sedimentary

[1] Bull. U. S. Geol. Surv. No. 85, 1892.
[2] 14th Ann. Rept. U. S. Geol. Surv., Washington, 1894, part ii.

and volcanic rocks present in the area. The interpretation given in the earlier map by Geiger and Keith is not followed, since the complexity of the region is now known to be the result of faults rather than of simple folds. This map represents the most detailed and perfect delineation of the territory yet published.

Accompanying this general geological map is another on a similar base representing the form of the Tertiary base-level with 100-foot contours. Along with these maps are several plates and diagrams indicating cartographically the variations in the character of the granite, the thickness and character of the Loudoun formation, and the Weverton sandstone.

Other maps, such as those accompanying Keyes' paper on "The Central Maryland Granites"[1] and Grimsley's thesis on "The Granites of Port Deposit,"[2] represent detailed mapping in the field, but most of the information therein contained is incorporated in the general map of the state by Williams, under whose direction the field work was conducted. The sketch by Grimsley, which is somewhat crudely drawn, represents the general distribution of the various formations by six patterns in black and white. The territory included is along the east bank of the Susquehanna river from Perryville to the Pennsylvania line, and the location of the boundaries is the joint work of Grimsley and A. G. Leonard. Keyes' paper has a map showing the distribution of the granitic masses described in the text, the granite areas being colored upon a black and white background representing the culture and drainage of the territory between the Susquehanna and the Potomac. The individual areas are represented in some detail, but they conform in their interpretation to the earlier view as held by Williams, rather than to the views expressed in later maps. This is especially evident in the masses between Sykesville and Washington, which are now united to form a single area following Keith. The lines of demarkation between the granites, the granite gneisses, and the gneisses are not particularly sharp in nature, thereby permitting some latitude in interpretation.

[1] 15th Ann. Rept. U. S. Geol. Surv., 1895.
[2] Jour. Cincin. Soc. Nat Hist., 1894.

GEOLOGICAL MAPS OF WESTERN MARYLAND.

The western portion of Maryland, unlike those parts already discussed, has had little detailed work upon it resulting in local geological maps of the region. While Lyell, Hall, Silliman and others have studied in the area, few have presented other than the most generalized results relating to the local geology. As early as the second half of the seventeenth century the maps show that the presence of coal had been recognized in the George's creek basin, for we find on the Fry and Jefferson map of 1755 a coal mine located on the North Branch of the Potomac river not far from the mouth of Savage river. There are also occasional notes regarding the resources of the region in such maps as that of Griffith in 1794.

Alexander, 1837. The first map with any detailed information regarding the territory, however, was that published by J. H. Alexander in the Report of the State Geologist for 1837. This sheet, which is drawn on the scale of 1.25 miles to an inch, gives the location of the coal veins and the opening of the mines then in operation. The accuracy of the base upon which these lines are drawn has already been discussed in the preceding pages. This work of Alexander has remained as the basis for commercial maps of the territory, although many modifications and changes have been introduced to keep the map in harmony with the present workings of the region. One of the latest of the commercial maps of the George's creek region was published in a souvenir volume commemorating the visit of Sir Archibald Geikie to the mines in the spring of 1897.

Hall, 1874. In 1874 James Hall prepared[1] a map illustrating his paper on the relations of the Niagara and Lower Helderberg Formations. This sheet, on the scale of approximately 55 miles to an inch, gives the supposed location of these two formations between North Mountain and the western boundary of the state. The interpretations of the formations as given on this map differ widely from those accepted at the present day, since at least four bands of Helderberg are represented as crossing the state west of Cumberland. Now a single line of exposures is indicated on the map.

[1] 28th Ann. Rept. N. Y. State Museum, Albany, 1877.

White, 1891. In his map of the Upper and Middle Carboniferous formations, I. C. White[1] gives the first geological map of these formations subsequent to that published by Tyson in 1859. The Lower Carboniferous and the Upper Coal Measures with intervening members of the series are mapped very much in the same way as on the Williams map of 1893, which credits White with the western portion of the sheet. The difference between the lines there laid down and those accepted at the present time are shown by a comparison of the geological map published in the first volume of these reports and Plate XXX of the present volume representing the distribution of the sandstones and conglomerates of the state.

Weeks, 1894. Somewhat later J. D. Weeks published a black and white sketch of the upper Potomac and Elkgarden coal basins to illustrate a paper[2] on the area. This sheet, which forms a two-page plate on the scale of 3¾ miles to an inch, represents the physiography of the region and the limits of the coal formation. The only portion of Maryland represented is that between the North Branch of the Potomac and Great Backbone Mountain.

Special Topical Maps.

Besides the great number of geological maps which have been made representing the geology in various portions of the state, there have been published from time to time other topical maps dealing with various subjects, such as the distribution of the soils, the climatic, magnetic or medical conditions of the state. Perhaps the most interesting of these various maps which have been published are those indicating the character of the soils overlying the different geological formations.

AGRICULTURAL SOIL MAPS.

Philip Tyson was the first to emphasize the relations existing between the soils and the underlying rocks in his report as agricultural chemist in 1860. A careful study of the text of this report in conjunction with the geological map allows one to gain a general view

[1] Bull. 65, U. S. Geol. Survey, 1891.
[2] 14th Ann. Rept. U. S. Geol. Surv., part ii, 1894.

of the character of the soils in the different portions of the state. Later, after extended studies on the characteristic soils, especially in the eastern part of Maryland, Milton Whitney made a similar correlation of the soils and geological formations which appears on the geological map edited by Williams in 1893. About the same time a small map was published by the same author in Bulletin 21 of the Maryland Agricultural Experiment Station "showing the area and distribution of the principal soil formations in Maryland." Upon this little map, which is drawn on the scale of about 25 miles to an inch, are represented twelve different soils, distinguished in many cases by the percentage of clay found in each. The soils of the Eastern Shore are not classified because the region had not then been studied.

CLIMATOLOGICAL MAPS.

Climatological maps relating to Maryland first appeared in a Martenet atlas of the state published in 1873. The sheet was prepared by L. Blodgett on the scale of ten miles to an inch, and was accompanied by a short sketch describing the climatic conditions of the region.

With the organization of the Maryland State Weather Service in 1891, under the direction of Professor Clark, the interest in meteorological and climatological subjects increased, and in the first number of the second volume of the monthly reports of this service appeared the first of a series of maps showing the precipitation and the lines of mean temperature for each succeeding month. Since the summer of 1896, when the monthly reports of the State Weather Service were merged into the Crop Bulletin of the U. S. Weather Bureau, the latter organization has continued to publish monthly maps representing the rainfall and the temperature. With this change a new base was introduced, slightly different in size and character, and the overprint was changed from red to blue.

The Maryland State Weather Service, from the data acquired during its work, has also published in each of its biennial reports five maps representing the average temperature and precipitation for each of the seasons as well as for the entire year. These maps are drawn on a scale of about 15 miles to an inch, and represent the precipitation in blue, the temperature in red. Still more elaborate and valuable maps were published by this same organization in 1893 in the form of a series of "Climatic Charts of Maryland including Delaware and the District of Columbia." This series embraces five maps in blue showing the average precipitation for the year and for each of the four seasons. The precipitation is represented in five shades, to indicate the difference in rainfall for the various portions of the state. There are likewise five charts showing the average temperature for each of the seasons and for the year drawn in red with an overprinting of the isothermal lines in deeper red. All of these charts are drawn on the base previously described on page 463. It is on the scale of 8 miles to an inch or 1:500000. These charts represent the most detailed cartographic delineations of the territory yet published.

MAGNETIC MAPS.

Magnetic maps showing the distribution of the lines of magnetic force, or the values of the horizontal declination of the needle at different periods, have been published at various times during the last century. The earliest map of this nature giving any considerable information regarding Maryland territory was published by Churchman before the close of the last century. Similar maps have likewise been employed to illustrate the various papers on terrestrial magnetism published in the reports of the Superintendent of the U. S. Coast and Geodetic Survey.[1]

The latest magnetic map of the state, based upon nearly twice as many observations as previously recorded in any paper, appeared in the first report of the present series. It is entitled "A preliminary Isogonic map of Maryland, including Delaware and the District of Columbia, for January 1, 1900, by L. A. Bauer." The isogonic lines, or lines of equal magnetic declination, are drawn for every half degree, and show that the constant variation is about 2° greater in the eastern portion of the state than in the western portion. A comparison of this map with the geological map of the same territory shows

[1] See Schott, C. A., Md. Geol. Surv, Rept., vol. i, p. 330.

an interesting relationship between the isogonic lines and the underlying formations.

A small map showing lines of equal magnetic inclination and equal horizontal force is also given.

MISCELLANEOUS MAPS.

Various maps have been published from time to time illustrating the character and source of the water supply in various parts of the state. Among the earliest of these water maps is one by Dr. Toner, published in the Transactions of the Medical and Chirurgical Faculty of Maryland. This is really little more than a sketch-map showing the distribution of the different formations of the Coastal Plain which are represented as differing in the character of the waters which they bear. The most exhaustive work on the waters of the state is by N. H. Darton of the U. S. Geological Survey.[1] Illustrating that portion of the paper dealing with Maryland are three maps and several sections. The maps are entitled respectively:

Map of Baltimore Region illustrating features of underground waters.

Map of a portion of District of Columbia illustrating features of underground waters.

Map of Eastern Virginia showing distribution of underground waters.

The first two maps use as a base the topographic sheets of the Survey on the scale of 1:62500. They show the contours, culture and drainage of these maps and represent the exposure and approximate catchment area of the Potomac waters, the area of the crystalline rocks, and the territory underlain by the Potomac at a depth greater than fifty feet. Heavy blue lines across the sheet indicate the depth below sea level of the contact between the gravels and the underlying crystalline rocks, while dotted over the sheets are symbols indicating the location of successful and unsuccessful wells. The third sheet is on a much smaller scale, and represents the regions respectively underlain by the Chesapeake, Pamunkey, and Potomac waters, together

[1] Artesian Well Prospects in the Atlantic Coastal Plain Region. Bull. 138 U. S. Geol. Surv., pp. 124-161.

with the limits of the crystalline rocks. The portion of Maryland embraced in this map consists of the Western Shore south of Washington and the Eastern Shore along the edge of the bay. These maps represent at a glance the depth at which water-bearing zones may be expected in the different portions of the Coastal Plain.

Somewhat related to the preceding maps are several prepared under the direction of W J McGee,[1] representing the supposed condition of the territory of the Coastal Plain during several of the later geological periods. These are all drawn on a uniform base on the scale of 1:5000000. The physiography of the continental platform is represented with 100-foot contours on the land and with 100-fathom contours in the submarine portion. The running water is in blue and still water is in pale green. On this base McGee represents the general distribution of the Lafayette and Columbia formations, the physiography of the territory in Lafayette time, in post-Lafayette and pre-Columbia time, and the submergence in the Columbia time. The means employed in this representation are shiftings of the running and still water over-prints of supposed aërial and submarine contours, and contours representing the supposed deformation of the country at the different periods. While on too small a scale to represent in detail the oscillations which have taken place in any individual locality in Maryland, these maps are of great value in giving at a glance the latest conceptions of the broad continental changes which have taken place over the entire eastern portion of the Middle Atlantic slope. The constant presence of the physiography of the land as it exists today facilitates a comparison which brings out the changes that have taken place and greatly increases the value of these maps.

Summary.

A summary of the many details given in preceding pages may be expressed by the tracing of the growth in knowledge regarding the natural features of the state, in the summary of maps available for reference in illustration of the different historical periods, or in the enumeration of the best maps available at the present day for the different portions of the state.

[1] 12th Ann. Report U. S. Geol. Surv., vol. i, Washington, 1891.

DEVELOPMENT OF KNOWLEDGE.

The early cartographic representation of the territory of Maryland is devoted almost exclusively to the delineation of the shores and lands bordering on the Chesapeake and the Potomac. No attempt was made during the first century subsequent to the settlement of the English in Jamestown to depict with any degree of accuracy the character of the interior portions of the country. In fact, they were not known except along one or two of the larger waterways. The growth of knowledge regarding the land adjoining the bay was made for the most part at a few periods. Smith, in his memorable voyage of discovery up to the mouth of the Susquehanna gained more information regarding the character of Chesapeake Bay than did any of his successors. His knowledge was accurate and detailed regarding those portions of the land which he visited, but was naturally inaccurate in many of the intervening portions portrayed in his map. The features of particular value in the Smith map are the shores of Somerset, Dorchester, and Cecil counties, and the coast-line between the Patapsco and Point Lookout. The mapping of the Potomac is based on a fairly careful reconnoissance, but the accuracy of the work is not as great as in the portions of the map just enumerated.

The Lord Baltimore and Alsop maps show some slight advance in knowledge, especially along the Eastern Shore and the Potomac, but no marked step forward was taken prior to the careful work of Augustine Herman between 1660 and 1670. The Herman map for the first time presents an accurate delineation of the intricate shore-line between Cambridge and Chestertown. No earlier map in any wise equals it in the abundance of local names or in the faithfulness with which the sinuosities of the shore-line are portrayed.

From the time of Herman until the later portion of the eighteenth century little improvement was made in the representation of the Chesapeake. The charts of Anthony Smith, published in various editions from 1776 to 1800, are on a much larger scale than had been attempted in any previous map, and show a great increase in the cultural details represented. The map is full of symbols, representing with considerable faithfulness the various structures along the water-front. About the same time there appeared the first of the accurate maps representing the region about Havre de Grace at the head of the Chesapeake Bay.

It was not until the second quarter of the eighteenth century that any knowledge was acquired regarding the regions of the Appalachians west of the Blue Ridge and the valley of the Shenandoah; even then this information was limited almost exclusively to the valley of the Potomac. Scarcely anything was known of the mountainous country lying at any distance from the North Branch or the South Branch of the Potomac. The map drawn by Fry and Jefferson in 1751 gives some information, but it was not until Griffith's map of 1794 was published that the slowly acquired knowledge of the western portion of the state was rendered available. Even this map, which stands far superior to the majority of the cartographic works published in America just subsequent to the Revolutionary war, is far from full in the details which it depicts. The extended and well authenticated topographic information of the surveys which progressed during the era of internal improvement was necessary before many of the gaps in the contemporary knowledge could be filled up.

No attempt was made to delineate the inequalities of the surface until the inauguration of the work by Alexander and Ducatel, while little was attempted in the way of road traversing prior to the extensive surveys by Martenet. Earlier maps show many roads and hachured hills, but the representations are in almost all instances sketched and not the result of carefully prosecuted surveys.

STATE OF CARTOGRAPHIC INFORMATION.

Reviewing all of the maps which have been published from original material, one may enumerate the following maps which represent the most accurate cartographic information available for use at the present time. All of the territory west of Hancock and south of Washington has been surveyed by the topographic corps of the United States Geological Survey. Their work has likewise extended to the territory between Baltimore and Washington south of 39° 30′, with some work along the western portion of the Eastern Shore. Much of the material which has been gathered together by this bureau has been published, and there will soon be available, besides the sheets enumerated in the first volume of the present series of reports, several others which are now in the hands of the draftsmen or engravers. The work as now conducted furnishes all of the information which may reasonably be expected upon maps of the scale adopted.

The Coast and Geodetic Survey has prepared with great accuracy charts representing the territory adjacent to and underlying the Chesapeake waters. From these charts, enumerated in an earlier report, one may acquire all of the information desirable for general knowledge, while under special restrictions more detailed information may be obtained from the manuscript archives of the Federal bureau.

The maps prepared by these two bureaus unfortunately do not cover the entire territory of the state, and there still remain here and there local areas which are found best represented in scattered localized sheets. For general information regarding any of these officially unmapped portions, it is best to make use of the state maps published by Martenet, although these are at present at least ten years out of date. The changes which take place in such a length of time are especially noticeable in maps of the Martenet type, since they deal almost entirely with cultural features and do not attempt the delineation of surface topography. On the Eastern Shore of Maryland, when procurable, the early atlases published about twenty years ago are the most accurate and detailed. The same is also true respecting the northern portions of Cecil, Baltimore and Carroll counties. Harford county has been represented on a wall map which was brought up to date some years ago by Mr. McNair. This, however, seems to be practically out of print.

Although the U. S. Geological Survey has published a map covering the Frederick quadrangle, which includes that portion of Maryland between Parr's Ridge and the Catoctin Mountain, it has been found that this is not up to the usual standard of accuracy. It is, nevertheless, the most accurate yet published, and will soon be greatly improved.

The surface included in the western part of the Frederick sheet and extending westward to North Mountain is represented on maps published by the Western Maryland Railroad. The best of these is that compiled from the work of the Coast Survey, which was published in 1885.

The present summary of the present status of the accurate mapping of the state clearly indicates that at the present day there is no wholly satisfactory map, or series of maps, upon which to represent the detailed information acquired regarding the physical features of Maryland territory. The work already inaugurated by the present Geological Survey, in coöperation with the U. S. Geological Survey, is rapidly reducing the unmapped portions of the state, and it is hoped that within the course of a very few years sufficient work may be done to furnish material for an adequate representation of the physiography of the state upon a large and uniform scale.

NOTE.—It has seemed desirable in the report on the Maps and Map-makers of Maryland to omit any discussion of the maps and plats of the cities and towns of the state as any adequate treatment of the subject would have greatly swelled the present volume. Much valuable information bearing upon municipal cartography has been collected which could be made the basis of a subsequent report if there should be a demand for it.

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