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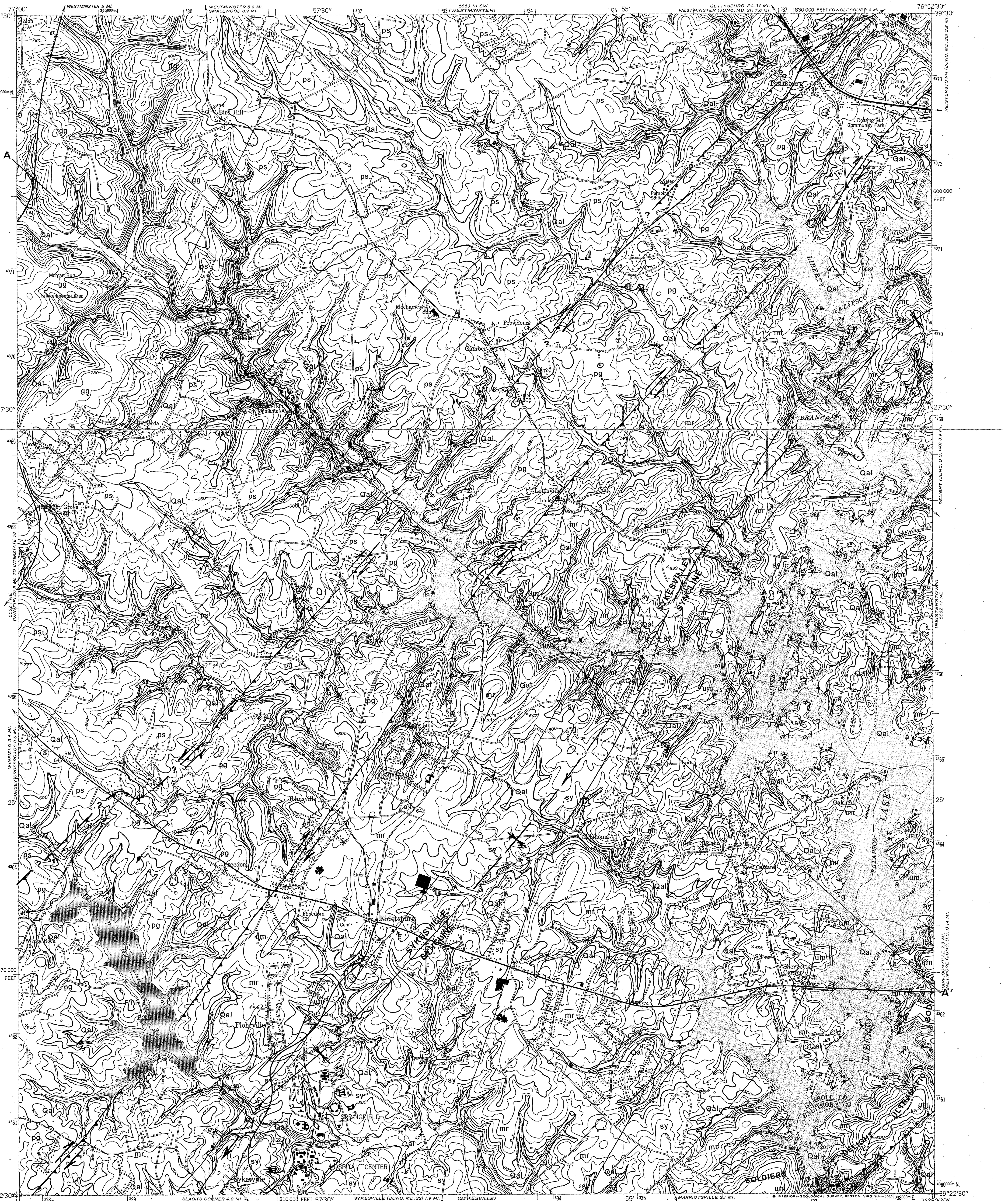
MARYLAND GEOLOGICAL SURVEY
Emery T. Cleaves, Director

GEOLOGIC MAP OF THE FINKSBURG QUADRANGLE, CARROLL AND BALTIMORE COUNTIES, MARYLAND

by
Peter D. Muller
1994



Base map from U.S. Geological Survey
7.5-Minute Series (Topographic)
Finksburg Quadrangle, 1953 (photorevised 1979)

Field mapping done 1982-1984
Additional data from field notes of
W.P. Crowley, 1976-1977

UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Copies of this map available from
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NOTES ON STRATIGRAPHY, STRUCTURE, AND METAMORPHISM

The bedrock of the Finksburg Quadrangle is part of an extensive terrane of polydeformed rocks that underlies the Piedmont Province of central Maryland. Because of structural complexity, lack of fossils, and limited exposure, the age and subsurface geometry of this dominantly metaclastic sequence are poorly known. Thickness estimates have little stratigraphic value because of the complex folding, faulting, and associated tectonic thinning, thickening, transposition of layering, and metamorphic recrystallization. Therefore, all of these units are considered to have indeterminate thickness.

Of the six major crystalline rock units described in the explanation, only the Sykesville Formation is in reasonably certain stratigraphic order relative to the adjacent Morgan Run Formation. The Sykesville is assumed to be younger than the Morgan Run based on the presence of clast lithologies in the Sykesville which are identical to Morgan Run bedrock lithologies (Table 1; and Muller and others, 1989). The key lithology is a distinctive, fine-grained, buff-colored garnet-hornblende-epidote quartzite found as lenses in the Morgan Run mica schists.

In Maryland, the Morgan Run Formation and the overlying Sykesville Formation comprise the Liberty Complex (Muller and others, 1989), a metamorphosed allochthonous subduction complex which was emplaced from the east onto the Loch Raven and Pleasant Grove sequences during the Taconic Orogeny. The Morgan Run is a tectonic mélange which originated as an accretionary wedge in a trench-floor or slope-basin environment at the front of a volcanic island arc, far removed from its final location on the continental margin. This assemblage was metamorphosed and the lithologic elements were tectonically disrupted into block-in-matrix mélange and broken formation during accretion in the hanging wall of a subduction zone. The Morgan Run Formation corresponds to the Piney Run Formation and parts of the schist member of the Sykesville Formation as mapped by Crowley (1977) immediately east of Liberty Reservoir, and is equivalent to the Piney Run as mapped by Muller (1985) along strike to the northeast. To the south, the Morgan Run correlates in Maryland with the metagraywacke facies of the Wissahickon Formation (Fisher, 1963, 1970; Fisher and others, 1979), and in northern Virginia with the Peters Creek Schist as mapped by Drake (1985).

The Sykesville Formation as described here is an olistrostromal blanket of sedimentary mélange equivalent to the Sykesville Formation of Hopson (1964), the diamictite facies of the Wissahickon Formation (Higgins and Fisher, 1971; Fisher and others, 1979), and the gneiss member of the Sykesville Formation (Crowley, 1976). With the initiation of obduction, slumping and erosion of the uplifting accretionary wedge of Morgan Run sediments transported debris directly onto the eroded surface of the structurally lower parts of the assemblage where it was deposited as the Sykesville mélange. Suturing of the forearc and arc onto the continent during the final stages of subduction transported the entire Liberty Complex westward onto the continental margin as an allochthon.

The contact between the Sykesville and the underlying Morgan Run Formation is fairly sharp and may be strongly sheared. Where mapped in the vicinity of Liberty Reservoir, this contact appears to be an unconformity (Muller and others, 1989). Contacts of the Morgan Run with the structurally underlying Loch Raven Formation on the east and the Pleasant Grove Formation on the west are interpreted to be pre- to synmetamorphic thrust faults (Crowley and others, 1976; Crowley, 1977; Muller and others, 1989).

The contact between the Pleasant Grove and Morgan Run Formations was mapped on the basis of the first occurrence of fine-grained schist exhibiting 'oyster-shell structure' west of the belt of rocks typical of the Morgan Run. The Pleasant Grove Formation as described here includes lithologies mapped in part as Prettyboy Schist by Crowley and others (1976) and as Pleasant Grove Schist by Crowley (1976). On the geologic map of Carroll County (Jonas, 1928) this unit is shown as part of the Peters Creek Formation.

The intensely strained, mylonitic(?) rocks of the Pleasant Grove Formation have been recently interpreted as a major tectonic boundary, designated the Pleasant Grove Zone (Muller and Edwards, 1985). Several major lithologic, structural, and igneous features of the Piedmont Province in general change across this belt. Therefore, the premetamorphic stratigraphic relationship of units lying northwest of and including the Pleasant Grove Formation to formations to the southeast is highly uncertain as a result of the existence of this zone (Muller and Edwards, 1985). The Pleasant Grove Zone is almost certainly a polygenetic structure with significant pre- to synmetamorphic displacement. Based on a variety of kinematic indicators, Krol and others (1990) have shown that the latest ductile shearing in the Pleasant Grove zone was of a right-lateral, strike-slip nature, and utilized existing steep foliations (Muller, 1991).

The Prettyboy Schist and Gillis Group formerly were included in the upper pelitic schist facies (Cleaves and others, 1968), or in the pelitic schist facies (Higgins and Fisher, 1971; Fisher and others, 1979) of the Wissahickon Formation. The contact between the Prettyboy Schist and the Pleasant Grove Formation was mapped at the first occurrence of distinctly medium-grained mica schist with millimeter-sized porphyroblasts, which characterize the Prettyboy Schist, northwest of the belt of fine-grained phyllonitic schist of the Pleasant Grove Formation. This contact ranges from gradational to sharp as a result of the shearing overprint in the Pleasant Grove.

The Gillis Group, originally called Gillis Formation by Edwards (1986), is composed of lithologies equivalent to the Marburg, Ijamsville, and Urbana Formations in western Carroll and eastern Frederick Counties. The contact between the Gillis Formation and the Prettyboy Schist is gradational. The Gillis has here been separated on the basis of the occurrence of silver-gray, pyrite-bearing phyllite northwest of typical fine- to medium-grained Prettyboy Schist.

The Loch Raven Formation was previously mapped as Oella Formation by Crowley and others (1976). However, the Oella-type lithology is here interpreted to be a quartzofeldspathic facies within a mixed pelitic-psammitic Loch Raven Formation.

The grade of metamorphism in the Finksburg Quadrangle ranges from low grade (chlorite zone) within the Gillis Group on the northwest to medium grade (garnet-hornblende zone) within the Morgan Run Formation on the south and east. The transition from low to medium grade coincides with the Pleasant Grove Zone. The effects of retrograde metamorphism, such as chloritization of garnet and biotite, are present to a minor degree throughout the quadrangle.

The dominant planar structure in rocks of the Finksburg Quadrangle is a foliation produced by the early Paleozoic ductile deformation. This is expressed as mica schistosity and phyllitic foliation. Transposed compositional layering and isoclinal folds with axial planes parallel to foliation are more prevalent in the Prettyboy and Morgan Run Formations, but are less apparent in the Loch Raven and Gillis. All rocks exhibit both mesoscopic and microscopic evidence of polyphase deformation and metamorphism (e.g., refolded folds, multiple cleavages, and retrograde metamorphism). The major northeast-southwest-trending fold structure, the Sykesville syncline, is superimposed on the main schistosity.

Figure 1 depicts chronologically the deformations recognized within the Liberty Complex. Relict soft-sediment deformation features (slump folds and clastic dikes) are preserved locally in thick metagraywacke units. Zones of well developed, spaced crenulation cleavage are common in the metadiamictite and in the thick metagraywackes, but are not pervasive.

All contacts between the major rock units are structurally conformable where observed, i.e., foliations on both sides of the contacts are subparallel. This does not necessarily imply premetamorphic stratigraphic conformity between units, because intense tectonism may have either obscured or obliterated field evidence for discordance and offset. Therefore, most contacts have been shown on the map simply as undifferentiated geologic contacts. However, the presence of clasts of Morgan Run Formation in the Sykesville Formation, as well as broad-scale contact relationships in the vicinity of Liberty Reservoir, indicate a significant unconformity between these two units. Likewise, the southern contact of the Soldiers Delight ultramafic body with the Loch Raven Formation and the contact between the Morgan Run and Pleasant Grove Formations are interpreted to lie along a single, folded, pre- to synmetamorphic thrust fault surface. Much, if not all, of the crystalline sequence of the Maryland Piedmont is considered to be allochthonous, and comprises one or more thrust sheets (Rankin, 1975; Drake and Lyttle, 1981; Drake and Morgan, 1981; Edwards, 1984; Muller and Edwards, 1985; Muller and others, 1989).

REFERENCES

Cleaves, E.T., Edwards, J. Jr., and Glaser, J.D. (compilers), 1968, Geologic map of Maryland: Maryland Geological Survey, Scale 1:250,000.

Crowley, W.P., 1976, The geology of the crystalline rocks near Baltimore and its bearing on the evolution of the eastern Maryland Piedmont: Maryland Geological Survey Report of Investigations No. 27, 40 p.

_____, 1977, Geologic map of the Reisterstown Quadrangle, Maryland: Maryland Geological Survey, scale 1:24,000.

Crowley, W.P., Reinhardt, J., and Cleaves, E.T., 1976, Geologic map of Baltimore County and City: Maryland Geological Survey, Scale 1:62,500.

Drake, A.A., 1985, Tectonic implications of the Indian Run Formation; A newly recognized sedimentary mélange in the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1324, 12 p.

Drake, A.A., and Lyttle, P.T., 1981, The Accotink Schist, Lake Barcroft Metasandstone, and Popes Head Formation - keys to an understanding of the tectonic evolution of the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1205, 16 p.

Drake, A.A., and Morgan, B.A., 1981, The Piney Branch Complex - a metamorphosed fragment of the central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 281, no. 4, p. 484-508.

Edwards, J. Jr., 1984, The Linganore fault: key to age of Sams Creek Formation in the Piedmont of Maryland: Geological Society of America Abstracts with Programs, v. 16, No. 3, p. 135.

_____, 1986, Geologic map of the Union Bridge Quadrangle, Carroll and Frederick Counties, Maryland: Maryland Geological Survey, scale 1:24,000.

Fisher, G.W., 1963, The petrology and structure of the crystalline rocks along the Potomac River near Washington, D.C.: unpub. PhD dissertation, The Johns Hopkins University, Baltimore, Maryland, 241 p.

_____, 1970, The metamorphosed sedimentary rocks along the Potomac River near Washington, D.C., *in* Fisher, G.W., Pettyjohn, F.J., Reed, J.C., Jr., and Weaver, K.N., eds., Studies of Appalachian geology; Central and southern: New York, Wiley-Interscience, p. 299-315.

Fisher, G.W., Higgins, M.W., and Zietz, I., 1979, Geological interpretations of aeromagnetic maps of the crystalline rocks in the Appalachians of northern Virginia to New Jersey: Maryland Geological Survey Report of Investigations 32, 43 p.

Higgins, M.W., and Fisher, G.W., 1971, A further revision of the stratigraphic nomenclature of the Wissahickon Formation in Maryland: Geological Society of America Bulletin, v.82, p. 1523-1528.

Hopson, C.A., 1964, The crystalline rocks of Howard and Montgomery Counties, *in* Maryland Geological Survey, The geology of Howard and Montgomery Counties: Baltimore, Maryland Geological Survey, pp. 27-215.

Jonas, A.I., 1928, Map of Carroll County showing the geological formations: Maryland Geological Survey, scale 1:62,500.

Krol, M.A., Onasch, C.M., and Muller, P.D., 1990, Kinematic analysis of the Pleasant Grove shear zone, eastern Maryland Piedmont: Geological Society of America Abstracts with Programs, v. 22, p. 28-29.

Muller, P.D., 1985, Geologic map of the Hereford Quadrangle, Maryland: Maryland Geological Survey, scale 1:24,000.

_____, 1991, Geologic map of the Hampstead Quadrangle, Maryland: Maryland Geological Survey, scale 1:24,000.

Muller, P.D., Candela, P.A., and Wylie, A.G., 1989, Liberty Complex: Polygenetic melange in the central Maryland Piedmont, *in* Horton, J.W., Jr., and Rast, N., Melanges and olistostromes of the U.S. Appalachians: Geological Society of America Special Paper 228, p. 113-134.

Muller, P.D., and Edwards, J. Jr., 1985, Tectonostratigraphic relationships in the central Maryland Piedmont: Geological Society of America Abstracts with Programs, v. 17, no. 1, p. 55.

Rankin, D.W., 1975, The continental margin of eastern North America: the opening and closing of the proto-Atlantic Ocean: American Journal of Science, v. 275A, p. 298-336.

EXPLANATION

QUATERNARY

Qal

ALLUVIUM
Thickness 1 to 5 meters
not mapped where estimated less than 1 meter

Interbedded, variably sorted, light-gray to brown gravel, sand, silt, and gray-blue to gray-brown clay. Confined to floodplains of streams. Sediment size and mineralogy reflect adjacent country rock and geomorphic setting. Gravel composition is dominantly quartz with lesser amounts of quartzite, schist, amphibolite, and ultramafic rock. Sand and silt are dominantly quartz-mica mixtures with variable amounts of metamorphic aluminosilicates and iron-titanium oxides. Includes some undifferentiated alluvium-colluvium along steep valley sides. Thickness where mapped ranges between 1 and 5 meters.

unconformity

PROTEROZOIC Z TO CAMBRO-ORDOVICIAN

gg

GILLIS GROUP (undivided)
Green-gray, purple-gray, and silver-gray phyllite containing variable amounts of muscovite, chlorite, and quartz. Limonitized pyrite cubes and irregular veins and segregations of quartz are common. Minor intercalated centimeters- to meters-thick quartzites are present locally. Thicker quartzites may be pebbly.

ps

PRETTYBOY SCHIST
Fine- to medium-grained, gray-green, quartz-mica schist (quartz-muscovite-chlorite-plagioclase-magnetite ± epidote ± garnet ± pyrite) with minor intercalated micaceous epidote-quartzite and epidote-chlorite schist. Stringers, pods, and locally well-developed rods (sheared-out isoclinal fold hinges) of quartz are common.

pg

PLEASANT GROVE FORMATION
Fine-grained, lustrous, green-gray to gray-green quartz-mica schist (quartz-muscovite-chlorite-epidote-plagioclase-magnetite ± biotite ± garnet) interlayered on a millimeter to decimeter scale with fine-grained, quartzitic metagraywacke exhibiting differing percentages of the same minerals. The schist possesses a distinctive phacoidal parting referred to informally as 'oyster-shell structure', the result of an anastomosing mylonitic(?) foliation. In contrast, the more quartzofeldspathic lithologies commonly display a uniform pinstriped appearance. Stringers and pods of quartz, representing the limbs and hinges of sheared-out isoclinal folds, are pervasive throughout the formation.

LIBERTY COMPLEX

sy

SYKESVILLE FORMATION
Medium- to coarse-grained, gray, massive to schistose, weakly layered to unlayered polymictic metadiamictite with a matrix assemblage of quartz-plagioclase-biotite-muscovite-magnetite ± garnet ± chlorite ± epidote. Clasts range upward in size from granules to boulders and slabs tens of meters in length and are typically matrix-supported although both barren and clast-choked exposures are present. In the Finksburg Quadrangle, clast lithologies within the Sykesville Formation are, in order of decreasing abundance:

1. vein quartz
2. medium-grained garnet-mica schist
3. fine-grained, micaceous graywacke
4. fine-grained, buff to light-gray garnet-hornblende-epidote quartzite and garnet-biotite-epidote quartzite
5. garnet-chlorite-biotite schist with felsic segregations and veins
6. amphibolite
7. ultramafic rocks, including chlorite-amphibole schist ± talc and epidote fels

These lithologies are identical to bedrock lithologies that make up the Morgan Run Formation (see Table 1). In exposures of strongly foliated Sykesville Formation, the included clasts are generally lensoidal and oriented parallel to the matrix foliation; whereas clasts in massive unfoliated metadiamictite may be equant as well as lensoidal. Relict foliation or layering in clasts ranges from concordant to discordant with the matrix foliation.

a mr um g

MORGAN RUN FORMATION
Fine- to medium-grained, lustrous, silver-gray to greenish-gray, garnetiferous mica schist and quartz-mica schist (chlorite/biotite-muscovite-quartz) containing intercalated fine-grained, buff to light-greenish-gray garnet-hornblende-epidote quartzite and garnet-biotite-epidote quartzite in discontinuous layers and lenses 5 cm to 1 meter thick. Interlayered zones of fine- to medium-grained micaceous metagraywacke approximately 3 to 30 meters thick also occur, and in places contain granules of detrital quartz and feldspar. Metagraywacke units exhibit centimeter- to meter-scale layering defined by thin intercalations of mica schist, and some layers display relict graded bedding. Probable soft-sediment slump folds and clastic dikes are preserved locally as well. Quartz-rich diamictite layers 1 to 3 meters thick exposed near the junction of the Patapsco River and Beaver Run arms of Liberty Reservoir are considered to be units in the Morgan Run, not the Sykesville Formation, but are not distinguished separately on the map.

a — Fine- to medium-grained, dark-green to black epidote amphibolite and amphibolite ± garnet. Felsite veinlets and segregations are common. Occur in discontinuous layers and lenses approximately 0.2 to 50 meters thick.

um — Undifferentiated ultramafic and mafic rock. Fine- to medium-grained, gray to dark-green to black chlorite-amphibole schist and fels, chlorite-talc schist, talc schist, epidote-amphibolite, serpentinite, and foliated metagabbro. Occur in discontinuous layers and lenses that range from several meters to several hundred meters thick. The Soldiers Delight ultramafic body is the largest such mass within the formation in Maryland. A lens of ultramafic-mafic breccia is exposed at the foot of Liberty Dam at the contact of the Soldiers Delight body and the underlying Loch Raven Formation. Slivers of mica schist and metadiamictite occur locally in the Soldiers Delight body north of Liberty Dam along the Baltimore County side of Liberty Reservoir.

g — Medium-grained, light-gray to white, foliated muscovite granite ± garnet. Occurs in concordant to discordant dikes 0.2 to 10 meters thick. The granite has not been isotopically dated. However, because the rock is foliated and the dikes locally have been folded, it is assumed that they were deformed by the Taconic Orogeny and are therefore older than medial (?) Ordovician.

thrust fault

l

LOCH RAVEN FORMATION
Fine- to medium-grained, gray, layered quartzofeldspathic schist (quartz-plagioclase-muscovite-biotite-magnetite ± garnet ± chlorite) with minor intercalated mica schist and biotite quartzite. Scattered stringers and pods of quartz and quartz-feldspar ± mica also occur.

TABLE 1
COMPARISON OF MODAL DATA FROM MORGAN RUN FORMATION BEDROCK AND SYKESVILLE FORMATION CLASTS AND MATRIX*
(from Muller and others, 1989)

MODAL PERCENTAGES FOR ESSENTIAL MINERALS†

SAMPLE	QUARTZ	PLAGIOCLASE	EPIDOTE	AMPHIBOLE / BIOTITE (bi)
EPIDOTE-QUARTZ AMPHIBOLITE				
FB-9B(MR)	18	18	4	60
FB-35(MR)	4	13	21	61
FB-37(MR)	12	16	8	64
FB-47A(MR)	12	9	9	69
FB-131B(MR)	4	15	11	62
FB-137B(MR)	8	18	7	62
FB-153C(MR)	9	2	12	75
FB-153D(MR	6	24	11	56
Average (MR)	9	14	10	64
FB-31B(MR)	12	4	19	56
FB-71(SY)	7	10	8	71
FB-120A-(SY)	16	5	22	57
Average (SY)	12	6	16	61
AMPHIBOLE/BIOTITE-EPIDOTE QUARTZITE (METACHERT)				
FB-15B(MR)	72	9	10	7
FB-167(MR)	73	3	7	13(bi)
FB-153B(MR)	75	12	6	5
Average (MR)	73	8	8	8
FB-24/25(SY)	78	3	13	4
SY-C1-2(SY)	73	7	16	7(bi)
FB-119B(SY)	86	4	4	0
FB-119C(SY)	86	1	0	7
Average (SY)	79	4	8	5
PLAGIOCLASE-QUARTZ-EPIDOTE GRANOFELS				
FB-42(MR)	42	10	3	10(bi)
FB-124(SY)	34	12	48	2(bi)
FB-65A(SY)	32	18	40	8

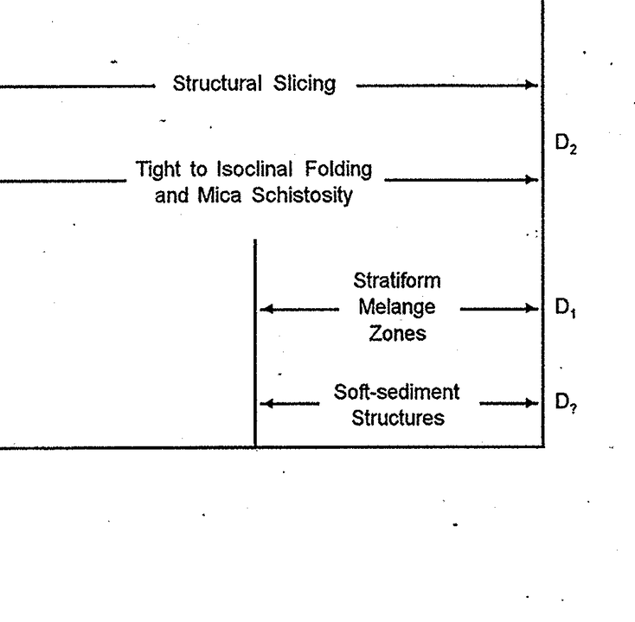
SAMPLE	QUARTZ	PLAGIOCLASE	BIOTITE / CHLORITE (chl)	EPIDOTE (cz) / MUSCOVITE (mu)
EPIDOTE-BIOTITE-PLAGIOCLASE-QUARTZ SCHIST (METAGRAYWACKE)				
FB-15C(MR)	42	25§	14	12
FB-44C(MR)	72	22	6	0
FB-47B(MR)	60	24	8	6
FB-168(MR)	47	19§	3	10+12(mu)
Average (MR)	55	23	8	7
SY-C1-6(SY)	46	24	11	13
SY-C1-4(SY)	55	18§	16	7
FB-25B(SY)	73	11§	4	10
Average (SY)	58	18	10	10
PLAGIOCLASE-MICA-QUARTZ SCHIST (METAGRAYWACKE)				
FB-23A(MR)	46	26	7	20
FB-31B(MR)	32	16	31	23
FB-24A(MR)	37	14	18	26
FB-137C(MR)	46	18	16	21
PR-FB-S-5(MR)	49	18	10	18
FB-26A(MR)	42	7	19(chl)	27
PR-FB-S-4(MR)	50	9	26	10
PR-FB-S-1(MR)	51	16	8	21
Average (MR)	44	16	17	21
FB-25C(SY)	47	19	13	21
SY-C1-3(SY)	41	23	15	16+5(cz)
SY-C1-5(SY)	46	23	20	8+5(cz)
FB-25D(SY)	52	16	13	17
FB-26A(SY)	53	9	20	16
FB-24(SY)	43	25	15	17
Average (SY)	47	19	16	16
MICA-QUARTZ-PLAGIOCLASE SCHIST AND GRANULITE (SYKESVILLE MATRIX)				
SY-C1-8-m	33	30	12	23
SY-C1-7-m	28	43	25	3
SY-C1-4-m	36	25	18	21
FB-119A	25	45	4	17
Average	31	36	15	16

* (MR) denotes Morgan Run Formation, (SY) denotes Sykesville Formation; all samples from Finksburg, MD 7.5-minute Quadrangle.

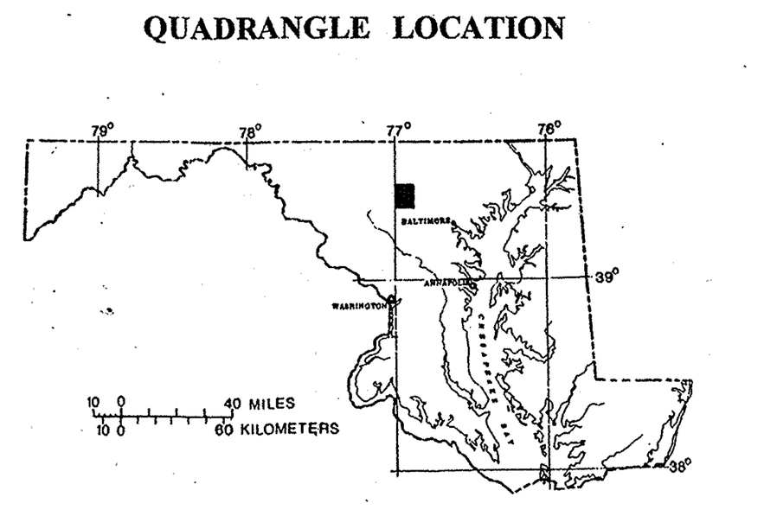
† Modal percentages may not add to 100 because of the presence of accessory phases; percentages rounded to nearest whole number based on 100 points counted.

§ Two distinct plagioclase feldspars; one is coarse and detrital, the other is fine, interstitial, and metamorphic.

FIGURE 1
SUMMARY OF DEFORMATIONS RECOGNIZED IN ROCKS OF THE LIBERTY COMPLEX
(From Muller and others, 1989)



QUADRANGLE LOCATION



GEOLOGIC SYMBOLS

Contact — generally approximate or inferred.

Schistosity or phyllitic foliation
inclined
vertical

Spaced crenulation cleavage
inclined
vertical

Trend or plunge of minor fold axes and/or quartz rods
dextral rotation
sinistral rotation
symmetrical

Generalized strike of strongly crenulated or folded foliation

Thrust fault — teeth on upper plate (arrows indicate post-thrust, right-lateral, strike-slip shear)

Axial trace of syncline

GEOLOGIC CROSS SECTION
Horizontal scale same as map scale, no vertical exaggeration
Dashes represent trace of main foliation
Alluvium not shown

⊗ Strike-slip movement away from viewer as seen in cross-section
⊙ Strike-slip movement toward viewer as seen in cross-section