

CHESAPEAKE BAY
EARTH SCIENCE ATLAS NO. 2

MAP 2-1

SAMPLING LOCATIONS

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SULFUR CONTENT

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EXPLANATION

Introduction

Chesapeake Bay Earth Science Atlas 1 and 2 represent the fourth in a series of maps which depict geologic and mineral characteristics of the basin sediments of Chesapeake Bay. These atlases are a product of a major research effort by the Department of Natural Resources and Virginia in cooperation with the Chesapeake Bay Program of the Environmental Protection Agency to map the distribution of sediments, to identify the sites of deposition and erosion of such sediments, and to map the distribution of carbon and sulfur in the sediments.

The Maryland Geological Survey and the Virginia Institute of Marine Science conducted a cooperative program in each of their respective states to provide detailed information about the sediments of the Bay. This research effort is the first attempt to provide such information on a Bay-wide basis. Past studies of the Bay sediments have been either very localized and site specific (Borner and Swainson, 1965; Bagan, 1967; Palmer, 1972; Silliker, 1975) or reconnaissance in nature (Ryan, 1953).

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The success of such a scientific endeavor could not have been accomplished without the dedicated professional services of the geologists and staff of the entire Maryland Geological Survey, and without the support and encouraging leadership of Dr. Kenneth N. Weaver and Dr. Barry T. Clavier. Collection of samples was accomplished on the Research Vessel Monitor and Discovery, the Captain, Gerald Cox, and the first mate, James Hovary, deserve credit for a well maintained safe research vessel from which the sediment sampling was performed. We also extend our gratitude and appreciation to the many people whose invaluable comments and suggestions helped initiate this project and contributed to completion of these Atlases. A very special thanks goes out to the geographers whose excellent work has provided a clear and usable product, Cindy Lane-Risher.

Physiographic and Geologic Setting

The Chesapeake Bay is located in the embayed section of the Atlantic Coastal Plain Province. The Bay is an estuary formed by the great Annapolis and York rivers which descend the lower valley of the Susquehanna River. River sediments from the Susquehanna River bed developed an extensive drainage network in unconsolidated to weakly consolidated sediments of Cretaceous, Tertiary, and Quaternary age. The sedimentary units become progressively younger southward along the Bay from the Cretaceous formations in the upper Bay to the Quaternary sediments along the lower eastern shore.

As shown in these Atlases, the western shore differs markedly from that of the eastern shore. Along the western shore (Stafford and Harford Counties), the coast is low-lying, irregular shoreline with numerous tidal creeks, bays and fringing marshes. Several major river systems dissect the interior into a rolling topography. The drowned mouths of these rivers suggest the absence of a tectonic setting with irregular, low banks. The terrain is underlain by Quaternary sediments of the Talbot Formation (Glaser, 1975). The Talbot Formation is a graded sequence with an upper silt-clay unit. Glaser (1976) has reported the Talbot Formation as a fluvial sequence deposited during interglacial conditions, probably Sangamonian or older.

Along the eastern shore, seaward cliffs as high as 50 feet border most of Annapolis and the northern section of Anne Arundel County. The southern section of Anne Arundel County, the Stafford River in Annapolis, the Sassafras River in Annapolis and the Chester River in Annapolis. Numerous tidal creeks and marshes are present along the shore.

The sediments are Cretaceous and Tertiary in age capped by Quaternary sediments. The Cretaceous formations crop out along the high cliffs at the head of the Bay and along the cliffs of the Stafford River. The Potomac Group, of continental origin, is exposed at the head of the Bay with the Magnay and Hudson Formations exposed along the Sassafras River. Quaternary sediments crop out in the low banks of Annapolis.

SAMPLING LOCATIONS

The design plan for collection of bottom sediments is based on a uniform grid for systematic Bay-wide sampling. The grid concept of sampling defines a more efficient strategy for spatial correlation than most other sampling systems (McMahon, 1971). The grid is based on the Universal Transverse Mercator Projection with one meter grid lines generated from a sheet grid at 700000 meters. The grid lines projection lines intersect the mean high water line along the Bay shoreline. The grid system was established by the Chesapeake Bay Program (1980) and is shown on the map. The grid system was established by 300 meters (shore normal) to a water depth of 3 meters.

Location, in the field, was determined by the use of a Teledyne-Brandenburg navigational system. Accuracy of the system is 10-15 meters. The sampling locations were preplotted, based on the grid design, and converted to the Teledyne coordinate system. This coordinate system provides the basis for actual field locations. Measurements were made on the grid system was expanded to one kilometer by 300 meters. Location was determined by shore based triangulation methods.

Our initial 1 kilometer interval sampling grid was based on the rasterization lines of the Teledyne navigational system. In the upper section of this map, this is readily apparent in the narrow and curved sampling pattern. Improvements in our navigational system made possible greater conformity to the UTM grid. This can be seen in the lower section of the map where the sample locations are more orthogonal.

A total of 776 sediment samples were collected and analyzed for textural parameters, as well as water, carbon, and sulfur content. The data are plotted on a series of overlays using the base map of the sample locations as reference.

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SULFUR CONTENT

Introduction

Many chemical reactions occurring in the Chesapeake Bay estuary depend upon the availability of sulfur. In addition, the concentration of this element can serve as a pollution level indicator, since in the location of sites with potentially high concentrations of heavy metals and other pollutants.

The sulfur measured in Bay sediments is largely a by-product of the metabolic processes of sulfate-reducing bacteria. In the anoxic sediments, sulfate-reducing bacteria transform sulfate into hydrogen sulfide. The sulfate then combines with reactive metals, such as iron and manganese, forming metal sulfides. These metal sulfides are stable in the sediments as long as the environment remains anoxic. However, if these sediments are disturbed and introduced into an oxidizing environment (e.g., through dredging), the following could occur: 1) the oxidation of an oxygen demand proportional to the concentration of organic matter and reduced sulfur compounds in the sediments; 2) the formation of oxidation products analogous to the concentration of organic matter and reduced sulfur compounds in the sediments; 3) the release of nutrients and trace metals into the environment. Thus, knowing the sulfur content of the sediments can play a role in identifying areas of anoxic sediments and estimating potentially deleterious effects should these sediments be disturbed.

Sulfur analysis was done on approximately one out of every four samples collected from the deeper waters of the Bay. Samples from shallower depths generally contain amounts of sulfur below the detection level of the analytical equipment and, thus, were not analyzed. In general, the same sample (i.e., sample with less than 128 meters) were not analyzed for sulfur. Sulfur content was determined for 125 sediment samples using a LECO Inducto-Titrator Model 932-0001 in conjunction with a LECO Reduction Furnace Model 9301-2000. Contour lines shown were interpolated between analyzed stations on the basis of the Sediment Distribution Map (Map 2-2).

Distribution

Dry weight percent sulfur in this area of the Bay averages 0.38%, ranging from less than 0.20% in the unconsolidated sediments to 1.5% in the fossiliferous zone (Table 1). The broad range of values, however, below the comparatively uniform distribution of sulfur, is a sharp contrast to areas further south in the Bay, the mean sulfur content of sediments other than muds does not increase with decreasing grain size. Overall, sulfur concentrations are also much lower. Consistently low values of sulfur across sediment types are attributable to the dominating presence of sulfate in the overlying water column as seawater is diluted by freshwater. Bacterially-mediated sulfate reduction is independent of sulfate concentration greater than 10 millimoles (M) (Froelich, 1971). Below that limit, the growth of sulfate-reducing bacteria and the rate at which sulfate is converted to sulfide are controlled by sulfate concentration. The salinity corresponding to a concentration of 10 M sulfate is approximately 15 ppt. Average salinity of surface water measured at the southern boundary of the map area is approximately 15 ppt (Froelich, 1971). Thus, the reaction of sulfate to sulfide in these sediments is sulfate-limited. In addition, localized spots with high sulfur concentrations coincide, for the most part, with spoil disposal areas.

Table 1. Dry weight percent sulfur measured in the different sediment size classifications.

TYPE	RANGE %	MEAN %	SUMMARY
SAND	0.21-0.18	0.46	18
SILTY SAND	0.18-0.16	0.16	3
CLAYEY SAND	0.20-0.19	0.19	6
(SANDS)	(0.07-0.30)	(0.10)	(27)
SILT	-	-	-
SANDY SILT	0.24-0.55	0.35	19
(SILTS)	(0.24-0.55)	(0.35)	(19)
CLAY	0.38	0.38	1
SANDY CLAY	0.12-1.79	0.35	63
(CLAYS)	(0.12-1.79)	(0.35)	(64)
SAND/SILT/CLAY	0.14-0.83	0.33	15
TOTAL	0.01-1.79	0.30	125

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LEGEND
SULFUR VALUE % DRY WEIGHT
CONTOUR INTERVAL 0.3%

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