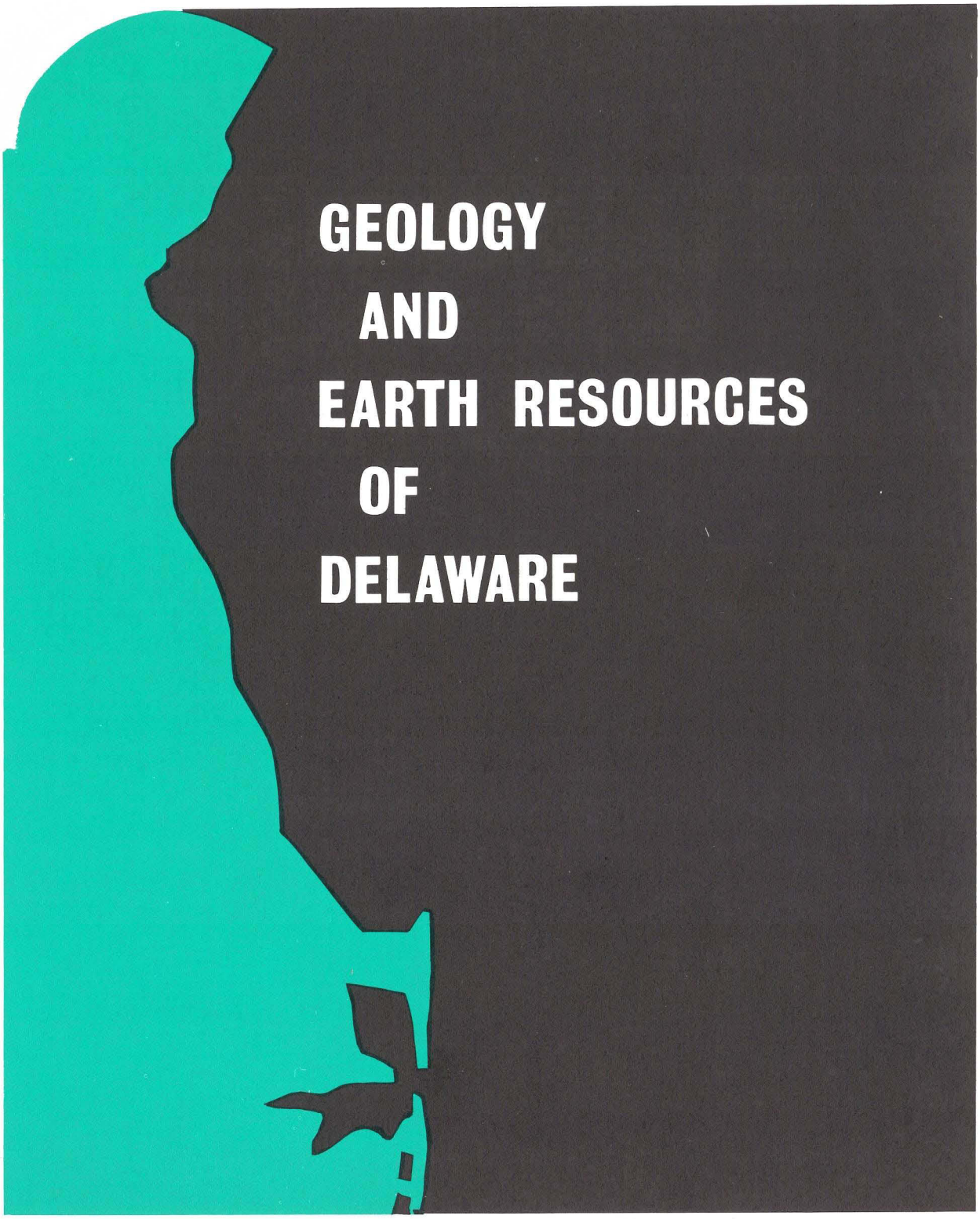


GEOLOGY AND EARTH RESOURCES OF DELAWARE

INTRODUCTION

The purpose of this booklet is to discuss briefly the geological history of Delaware and to describe the earth resources of the State.

Delaware lies within two geologic provinces. The Appalachian Piedmont Province (northern 5% of the State) is composed of old, hard, crystalline rocks which are principally metamorphic. Building stone is the main earth resource of this region. The remaining 95% of the State is within the Atlantic Coastal Plain Province. In this Province the rocks are loose (unconsolidated) sediments of far younger age than the Piedmont rocks. Ground water is the principal earth resource; however, gravels, sands and clays of various types are abundantly available for exploitation.

STATE OF DELAWARE

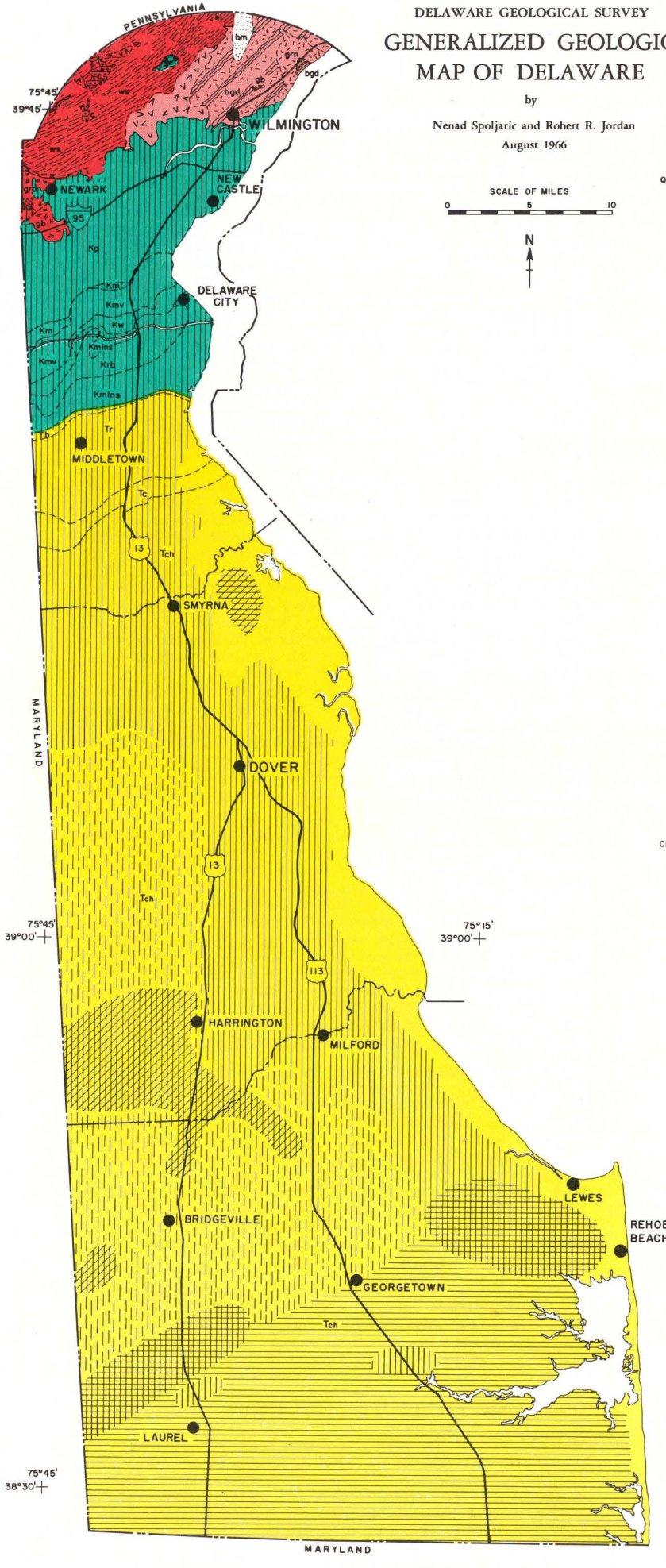
DELAWARE GEOLOGICAL SURVEY

GENERALIZED GEOLOGIC MAP OF DELAWARE

by

Nenad Spoljaric and Robert R. Jordan

August 1966



EXPLANATION

QUATERNARY — PLEISTOCENE — COLUMBIA GROUP

- SHORE-LINE DEPOSITS — YELLOW AND WHITE, WELL SORTED, MEDIUM QUARTZ SAND OF BEACHES AND DUNES
- ESTUARINE DEPOSITS — MOTTLED, GRAY AND BROWN, SILT AND CLAYEY QUARTZ SAND
- OTHER NEARSHORE DEPOSITS — YELLOW AND GRAY QUARTZ SAND WITH SOME INTERBEDDED GRAY SILTS, CHIEFLY NERITIC, OFFSHORE BAR, AND LAGOONAL FACIES

COLUMBIA FM. — YELLOW AND REDDISH BROWN QUARTZ SAND WITH GRAVEL AND LITTLE CLAY

AGE UNDETERMINED

- BRYN MAWR FM. (bm) — RED AND BROWN QUARTZ SAND WITH SILT, CLAY AND FINE GRAVEL

TERTIARY

MIOCENE

- CHESAPEAKE GROUP (Tch) — BLUISH GRAY SILT WITH QUARTZ SAND AND SOME SHELL BEDS

EOCENE

- UNIT C (Tc) — GRAYISH-GREEN, CLAYEY GLAUCONITIC SILT AND SAND
- RANCOCAS FM. (Tr) — GRAYISH-GREEN AND GREEN, SILTY, GLAUCONITIC SAND

PALEOCENE

- UNIT B (Tb) — GREENISH-GRAY SANDY AND CLAYEY GLAUCONITIC SILT

CRETACEOUS

UPPER CRETACEOUS — MONMOUTH GROUP

- REDBANK FM. (Krb) — REDDISH-BROWN, SLIGHTLY MICACEOUS AND GLAUCONITIC, FINE TO MEDIUM SAND
- MT. LAUREL-NAVESINK FM. (Kmins) — DARK GREENISH-BROWN AND DARK GRAY, HIGHLY GLAUCONITIC SANDY SILT AND SILTY SAND

UPPER CRETACEOUS — MATAWAN GROUP

- WENONAH FM. (Kw) — GRAY AND RUST-BROWN FINE TO MEDIUM, MICACEOUS, SPARINGLY GLAUCONITIC QUARTZ SAND
- MERCHANTVILLE FM. (Kmv) — DARK GRAY TO BLUISH-GRAY SLIGHTLY GLAUCONITIC, MICACEOUS SILTY, VERY FINE SAND
- MAGOTHY FM. (Km) — WHITE AND BUFF QUARTZ SAND WITH BEDS OF GRAY AND BLACK CLAYEY SILT

LOWER CRETACEOUS

- POTOMAC FM. (Kp) — VARIEGATED SILTS AND CLAYS WITH BEDS OF QUARTZ SAND

PALEOZOIC (?)

- PORT DEPOSIT GRANODIORITE (grd)

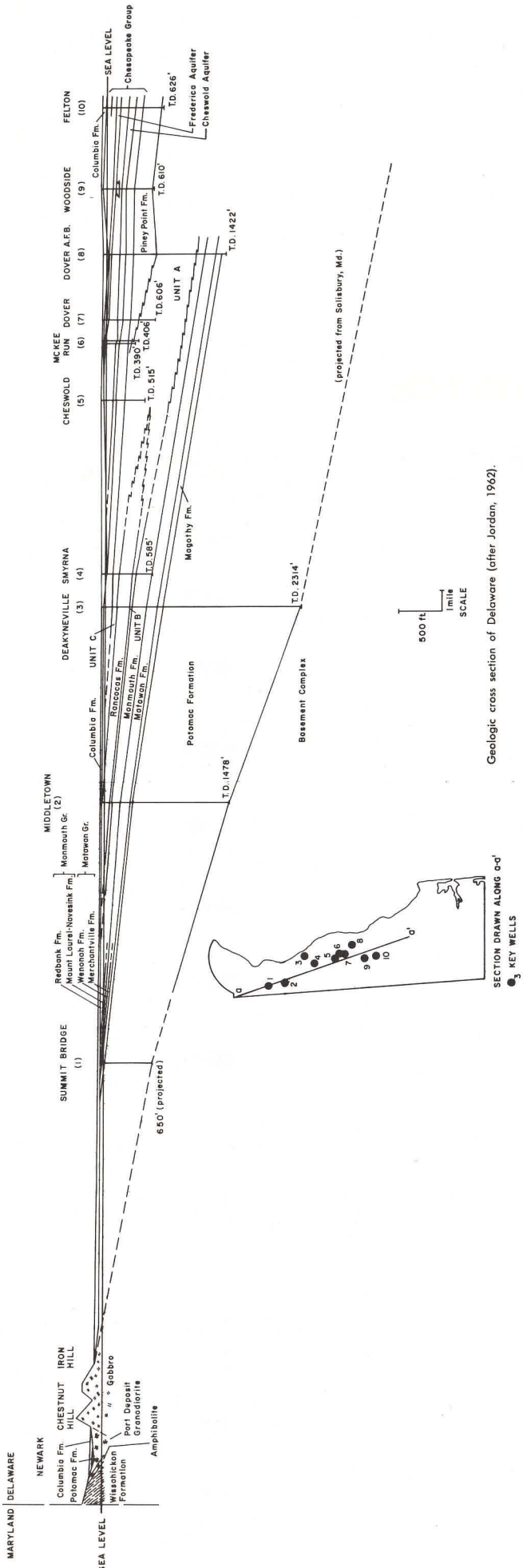
WILMINGTON COMPLEX

- BANDED GNEISS (bdg)
- GABBRO (gb)
- ARDEN GRANITE (grn)
- AMPHIBOLITE (amp)

LOWER PALEOZOIC (?) — GLENARM SERIES

- WISSAHICKON SCHIST (ws) — DENSE MICACEOUS SCHIST, GNEISS AND MIGMATITE
- COCKEYSVILLE MARBLE (c) — DENSE, WHITE CRYSTALLINE LIMESTONE AND DOLOMITE

SERPENTINE (sp)



GEOLOGIC HISTORY OF DELAWARE

Severe metamorphism has obscured the exact age relationships of the rocks of the Piedmont. This regional metamorphism is a product of crustal upheavals which built the Appalachian Mountain System. The major events in the evolution of these rocks occurred between 550 and 200 million years ago.

A great period of time, of which there is no record in Delaware, passed before the deposition of the oldest sediments of the Coastal Plain, the Potomac Formation, during the latter part of Early Cretaceous time, about 120 million years ago. Streams transported clays with interbedded sands from the Appalachians which lay to the northwest. This process continued into Late Cretaceous time and built a wedge with a thickness of about 4,000 feet in southern Delaware. A small unconformity, or period of nondeposition, separates the Potomac from the overlying Magothy Formation. The white sands and lignitic black silts of the Magothy form a distinctive marker indicating the transition from the older nonmarine sediments to the later marine deposits, from which they are separated by another small unconformity.

The sea now encroached deeply upon the land and remained over most of Delaware until at least Middle Eocene time; a sequence of varied marine sedimentary rocks was deposited essentially continuously during this interval. The oldest of these sediments from the Matawan Group, consisting of the Merchantville and Wenonah Formations. Neither of these persist as distinct entities far into the subsurface, and so the Matawan is relegated to formational status at depth, as is shown on the cross-section. Above the Matawan is the Monmouth sequence, also divisible into two formations near the surface, the Mount Laurel-Navesink and the Redbank, but comprising a single Monmouth Formation in the deeper subsurface. These marine Upper Cretaceous formations have been well exposed in the Chesapeake and Delaware Canal (Groot, et al, 1954), where the Mount Laurel-Navesink is particularly fossiliferous (Richards and Shapiro, 1963). Of the four marine formations, the sandy, quartzose Wenonah and Redbank represent periods of relative regression and the silty, glauconitic Merchantville and Mount Laurel-Navesink indicate transgression.

In the northern half of the Delaware Coastal Plain the time boundary between the Cretaceous and Tertiary (ca. 70 million years) is located within unit B. Farther south, in the subsurface, unit B, the upper part of the underlying Monmouth Formation, the Paleocene-to-Eocene Rancocas Formation, and unit C grade into a thick clay-silt mass termed unit A. The interrelationships of these rocks in the subsurface may be seen on the cross-section and are described by Jordan (1962). The subsurface Piney Point Formation, a quartz-glauconite sand which is the youngest of the Eocene units, is, in part, the time equivalent of units A and C and is, in part, younger. All of these marine sediments are truncated by a major unconformity; no Oligocene deposits are present.

During the Miocene, the sea returned to cover the State, and deposition of sediment resumed. A sequence of three silts separated by two sand intervals forms most of the Chesapeake Group. Additional sands and silts are added toward the southeast where the Chesapeake attains its maximum thickness in Delaware of over 1,000 feet. Sands within the Chesapeake supply important amounts of water and are named, from oldest to youngest, the Cheswold, Frederica, Manokin, and Pocomoke aquifers. No sediments of proven Pliocene age are known from the Coastal Plain, and the Chesapeake sediments are beveled by another major erosional unconformity.

During Pleistocene time, the advance and retreat of the continental glaciers brought about profound changes in sea level and in the streams which drained into Delaware. The Columbia Formation, consisting mostly of coarse sand with gravel, was deposited on the stream-channeled surface formed by the truncated edges of the Cretaceous and Tertiary beds and thus is a sheet of irregular thickness overlying all of the Coastal Plain. During a later period of higher-than-present sea level, the sea reworked these continental deposits in the southern part of the State where they may be subdivided into the Omar and Beaverdam (and probably other) formations (Jordan, 1964). The general nature of the Columbia deposits is shown on the geologic map by patterns overlying the symbols of the older rocks; these are dashed where the character is mixed or presently in doubt.

MINERAL RESOURCES

Water Supplies

Water is the most important mineral resource in Delaware. In the Piedmont Province, most water is derived from streams, but in the Coastal Plain unconsolidated sedimentary rocks (sands and gravels) form the principal sources of water. The Delaware Geological Survey is engaged in a continuing program of refining our knowledge of the occurrence and hydraulic properties of the State's ground-water reservoirs. Some of these studies are done in cooperation with the U. S. Geological Survey, the Water Resources Center of the University of Delaware, and the Water and Air Resources Commission. The latter is mainly engaged in allocation of water supplies and pollution abatement.

Other Earth Resources

Numerous sand and gravel pits are located in Pleistocene sediments throughout the State. Not only is the sand and gravel valuable for use in construction, but preliminary testing shows that some sands may be suitable for glass sands, heavy minerals, or traction sands. Greensand (glauconite) abounds in the Rancocas Formation in the Odessa-Middletown area. Greensand is a source of potash and has been used as a fertilizer and also in water softeners. Some of the greensand at Drawyers Creek near Odessa is 95% glauconite.

Clay in Delaware has potential uses which have not been exploited. Research on clays by the Delaware Geological Survey and the U. S. Bureau of Mines indicates that virtually all of the Potomac Formation clay makes good face brick. Recent marsh deposits of clay near the Delaware River have potential use as sources of lightweight aggregate (fired, bloated clay fragments). Other clays are useful as raw material for ceramic tiles.

Other useful rocks and minerals in Delaware include: garnets for abrasives from the northern Piedmont area, kaolin for fine china from Piedmont pegmatite dikes, serpentine and gabbro for building stone from the Piedmont. Iron ore (limonite) is found as crusts in Pleistocene gravels. Feldspars and micas are found in Piedmont pegmatite dikes.

Mineral Production in Delaware

Mineral production in Delaware (clays, sand, gravel, and stone) exceeded $2.5 million officially in 1967 with a total tonnage in excess of 2 million short tons. Production is increasing over the years. From 1966 to 1967 there was an increase in tonnage of over 27% and an increase in value of more than 28%. Clays, in particular, have the potential for large increases in production and value because they are plentiful and largely unexploited.

Soils Maps

The water table is contoured on engineering soils maps published by the U. S. Geological Survey in cooperation with the Delaware Geological Survey and the State Highway Department.

SELECTED REFERENCES

For further information, contact the Delaware Geological Survey. Much unpublished data on mineral resources, including water, are on open file. The following basic references are also useful:

Adams, J. K., and Jordan, R. R., 1961. "Possibilities for the Storage of Natural Gas in Delaware." *Del. Geol. Survey Rept. Invest. No. 4.*

Baker, W. W., Varrin, R. D., Groot, J. J., and Jordan, R. R., 1966. "Evaluation of the Water Resources of Delaware." *Del. Geol. Survey Rept. Invest. No. 8.*

Groot, J. J., and Rasmussen, W. C., 1954. "Geology and ground-water Resources of the Newark Area, Delaware." *Del. Geol. Survey Bull. 2.*

Groot, J. J., Organist, D. M., and Richards, H. G., 1954. "Marine Upper Cretaceous Formations of the Chesapeake and Delaware Canal." *Del. Geol. Survey Bull. 3.*

Groot, J. J., 1955, "Sedimentary Petrology of the Cretaceous Sediments of Northern Delaware in Relation to Paleogeographic Problems." *Del. Geol. Survey Bull. 5.*

Jordan, R. R., 1962. "Stratigraphy of the Sedimentary Rocks of Delaware." *Del. Geol. Survey Bull. 9.*

Jordan, R. R., 1964. "Columbia (Pleistocene) Sediments of Delaware." *Del. Geol. Survey Bull. 12.*

Marine, I. W., and Rasmussen. W. C., 1955. "Preliminary Report on the Geology and Ground-water Resources of Delaware." *Del. Geol. Survey Bull. 4.*

Rasmussen, W. C., and Haigler, L. B., 1953. "Ground-water Problems in Highway Construction and Maintenance." *Del. Geol. Survey Bull. 1.*

Rasmussen, W. C., Groot, J. J., Martin, R. O. R., McCarren, E. F., Behn, V. C., and others, 1956. "The Water Resources of Northern Delaware." *Del. Geol. Survey Bull. 6.*

Rasmussen, W. C., Wilkens, R. A., and Beall, R. M., 1960. "Water Resources of Sussex County, Delaware — A progress Report." *Del. Geol. Survey Bull. 8.*

Richards, H. G., and Shapiro, E., 1963. "An Invertebrate Macrofauna from the Upper Cretaceous of Delaware." *Del. Geol. Survey Rept. Invest. No. 7.*

Rima, D. R., Coskery, O. J., and Anderson, P. W., 1964. "Ground-water Resources of Southern New Castle County, Delaware." *Del. Geol. Survey Bull. 11.*

Spangler, W. B., and Peterson, J. J., 1950. "Geology of Atlantic Coastal Plain in New Jersey, Delaware, Maryland, and Virginia." *Am. Assoc. Petroleum Geologists Bull.,* v. 34, no. 1, p. 1-99.

Spoljaric, N., 1967. "Pleistocene Channels of New Castle County, Delaware." *Del. Geol. Survey Rept. Invest. No. 10.*

Sundstrom, R. W., and others, 1967. *The Availability of Ground Water from the Potomac Formation in the Chesapeake and Delaware Canal Area, Delaware.* University of Delaware Water Resources Center.

Sundstrom, R. W., and Pickett, T. E., 1968. *The Availability of Ground Water in Kent County, Delaware with Special Reference to the Dover Area.* University of Delaware Water Resources Center.

Ward, R. F., and Groot, J. J., 1957. "Engineering materials of Northern New Castle County." *Del. Geol. Survey Bull. 7*

Ward, R. F, 1959. "Petrology and Metamorphism of the Wilmington Complex, Delaware, Pennsylvania, and Maryland." *Geol. Soc. American Bull.,* v. 70, p. 1425-1458.

Watson, E. H., 1957. "Crystalline Rocks of the Philadelphia Area," p. 153-180 *in* Dorf, E., ed., Guidebook for Field Trips, Atlantic City Meeting. Geol. Soc. America.

Woodruff, K. D., 1967. "Ground-water Levels in Delaware, January, 1962 — June, 1966." *Del. Geol. Survey Rept. Invest. No. 9.*

Prepared by the Delaware Geological Survey, University of Delaware, Newark. In cooperation with the State Development Department, 45 The Green, Dover, Delaware.