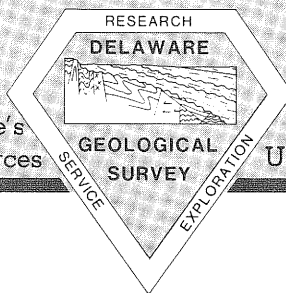


First State Geology

Current information about Delaware's geology, hydrology and mineral resources



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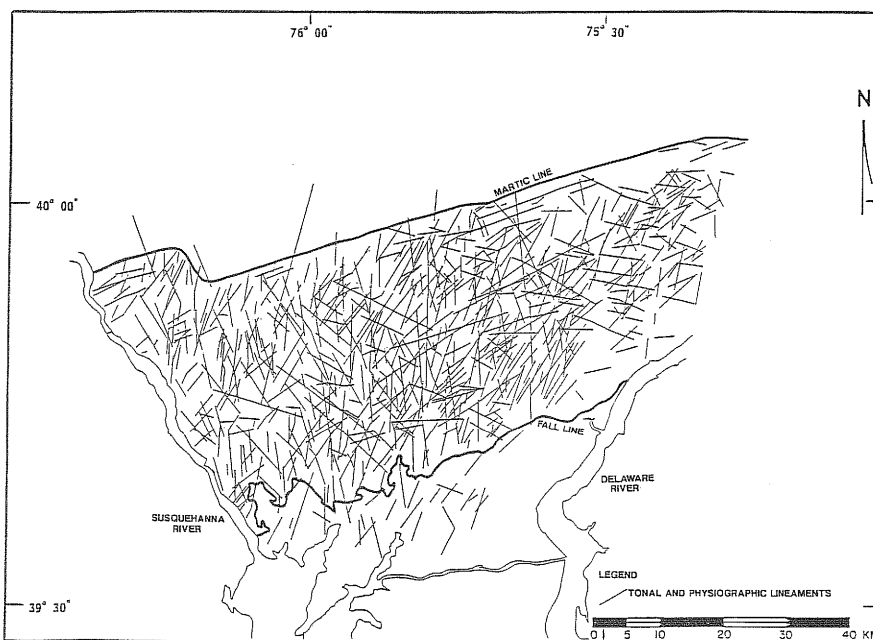
Vol. 8, No. 2

Summer 1990

DGS Hosts Atlantic Margin Workshop

On May 2, the Delaware Geological Survey hosted the Atlantic Margin Workshop cosponsored by the Minerals Management Service (MMS) of the U. S. Department of the Interior and the Association of American State Geologists (AASG). The workshop, held in the conference room of the Delaware Geological Survey Building, was attended by representatives of 12 of the Atlantic coastal state geological surveys from Maine to Florida, the Minerals Management Service, the U. S. Department of Interior Office of Territorial and International Affairs, the University of Texas at Austin, the University of Delaware, and the U. S. Geological Survey. The purpose of the meeting was to discuss the results of Atlantic coastal state geological survey research funded by the MMS over the past two years, and projects proposed for funding next year.

Research by the state surveys is devoted to furthering knowledge and understanding of the geology and resource potential of the United States continental margins, both onshore and offshore. Studies cover two basic areas, (1) geologic framework/petroleum related and/or (2) critical/strategic minerals. The first five years of participation in the program by the DGS were devoted to study of the deeper subsurface geology and hydrocarbon resource potential of Delaware and adjacent onshore and offshore areas. Funding for years 6 and 7 supported research of the general stratigraphic framework of Delaware's surficial sand and gravel deposits with a view toward extending these studies into the adjacent offshore region.



Lineament map of Dressel's study area.

Three New Studies of the Delaware Piedmont

By Richard N. Benson

Within the past year, graduate students in the Department of Geology have produced three Master of Science theses, each dealing with different aspects of the geology of the Piedmont of northern Delaware and adjacent areas of Pennsylvania and Maryland. "Analysis of the brittle structures in the Piedmont of Delaware and adjacent areas" by Peter J. Dressel, "Metamorphism in the Wissahickon Formation of Delaware and adjacent areas of Maryland and Pennsylvania" by Margaret O. Plank, and "Petrology and evolution of the plutonic igneous rocks of the Wilmington

Complex, northeastern Delaware and southeastern Pennsylvania" by Bernhard Dirksa were directed by Allan M. Thompson, the professor in charge of the theses.

Over the area he studied, Dressel traced lineaments from LANDSAT-4 imagery and National High Altitude Program photography (see map). Lineaments may be recognized as physiographic, i.e., anomalously linear stream valleys or ridges on a map or image, or tonal as represented by linear contrasts in texture or tone that may reflect contrasts in vegetation, soil moisture, or land vs. water.

Lineaments may be related to geologic structures such as joints or faults that were produced by brittle deformation of the earth's crust. Dressel also conducted field investigations of three major lineaments and of the pattern of joints in the study area for comparison with lineament trends.

The lineament pattern does not reflect the pattern of joints. Instead, lineament trends are statistically equivalent to the trends of early Mesozoic dikes of the mid-Atlantic region that formed during the continental rifting stage prior to separation of Africa from North America and the formation of the Atlantic Ocean basin. Also, concentrations of lineaments in the 10°-40° azimuth range are coincident with the epicenters of several earthquakes in the study area.

Dressel recognized two systems of joints. One set that trends NNE to WNW developed in response to waning compressive stresses that deformed the Piedmont rocks during the Paleozoic. The other set, with a NE trend parallel with that of the early Mesozoic dikes, formed by southeast-northwest extension during early Mesozoic rifting.

Plank's field and laboratory studies of the Wissahickon Formation focused on the west to east increase in metamorphism from amphibolite to granulite facies. She mapped reaction-isograds that define metamorphic zones and that cross-cut the regional structural strike of N40°-45°E (see map). Zone I in the west is the lowest grade representing peak metamorphic temperatures and pressures

of differential uplift that exposes deep crustal levels in the east and to heat from a local source, possibly the Wilmington Complex.

Dirska's petrographic and chemical analyses of samples from three gabbroic plutons (bodies of intrusive igneous rocks) in northern Delaware, Arden pluton, Bringham gabbro, and Iron Hill gabbro (see map), were directed toward determining if the three can be related to each other and if the small felsic bodies of the Arden pluton form an evolutionary sequence from the mafic rocks they intrude.

Using a variety of discriminatory techniques applied to his data, Dirska concluded that the plutons are not related to each other. Also, the mafic rocks of the Arden pluton are unrelated to the Arden felsic rock bodies. The Arden pluton gabbros formed first followed by intrusion of the Arden pluton felsic rocks and the Bringham gabbro, respectively. The relative age of the Iron Hill gabbro remains unknown; it is an outlier in the Coastal Plain whereas the other two are part of the Wilmington Complex.

Dirska could not determine the tectonic environments of formation of the plutons. He suggests that the two within

beds of silt and clay. These sediments are a very important natural resource because they form the major groundwater reservoirs in the state and are also the sources of material used in road construction and beach nourishment.

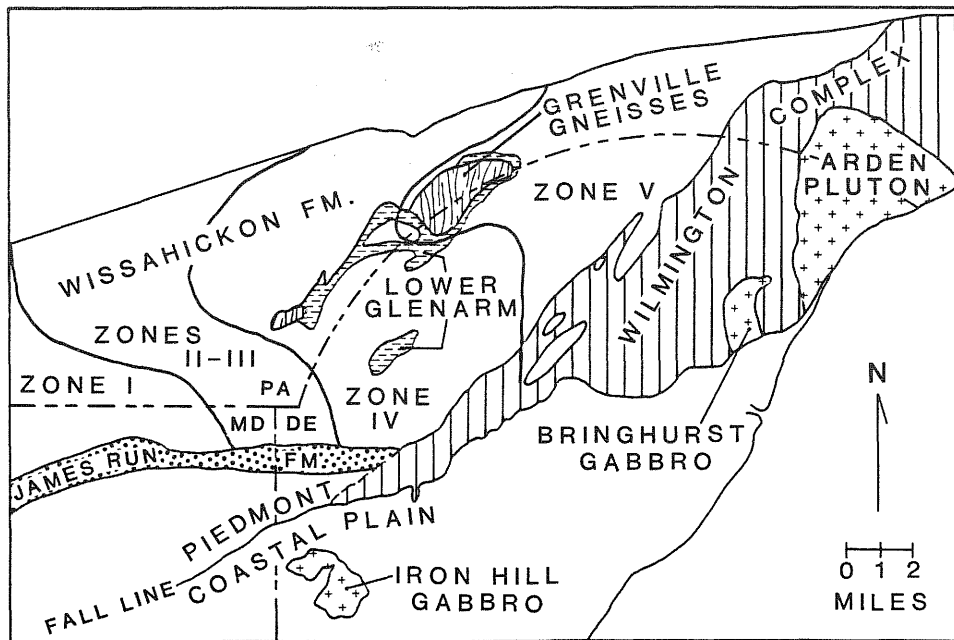
In spite of their widespread occurrence and economic importance, relatively little is known about their ages and environments of deposition. On the basis of their grain size and mineralogy, the surficial sediments are assigned to three geologic formations: Columbia, Omar, and Beaverdam.

Until recently, no fossils were known to occur in these formations, except in the Omar, which has yielded fossil oyster shells in a few places. But during the last few years, fossil pollen of both conifers and flowering plants has been found in all of the formations.

Fossil pollen grains of trees and herbs and spores of ferns and mosses are commonly found in fine-grained sediments in very great numbers (several hundred per gram of sediment). These tiny fossils can provide clues to the age of the sediment in which they are found, the environment of deposition (whether a body of fresh or brackish water, for instance), and the climate that existed at the time of deposition. Thus, the investigation of fossil pollen and spores can be a powerful tool, leading to a better understanding of the origin of and the relationship between the surficial geologic formations.

Results to date indicate that the Columbia Formation, covering much of New Castle and Kent counties and parts of Sussex County, was largely deposited during a period of cool-temperate climate, probably during a time of a melting continental glacier. However, some parts of this formation in southern Kent and northern Sussex contain fossil pollen indicating a temperate climate, similar to that of the present. In many places, the Columbia sediments are overlain by deposits containing cold-climate indicators such as spruce and birch. At the time that those deposits were formed, a boreal forest or taiga covered most of Delaware; radiocarbon dating indicates that this occurred during the last glaciation between 16,000 and 28,000 years ago.

The Omar Formation of southeastern Sussex County, composed of sands with silt and clay beds, has yielded many thousands of fossil pollen and spores that testify to its very complex origin. The upper part of this formation contains fossil pollen indicating temperate as well as cold climates; the lower part has yielded some pollen of trees that no longer grow in North America but are still living in the eastern part of Asia (see photograph of *Pterocarya*). It is thought that the Omar Formation ranges in age from late Quaternary (the last 500,000 years) to late Pliocene (about 2 million years before present) and was deposited in a great



Map showing the rocks studied by Plank and Dirska.

of 600 ± 50°C and 5 to 6 kilobars, respectively, and Zone V in the east is the highest grade corresponding to 750 ± 50°C and 6 to 7 kilobars. The westward bends of the isograds are probably the result of the emplacement of the Mill Creek-Landenberg anticlinal structure that exposes Grenville gneisses and rocks of the lower Glenarm Series.

Plank explains the shape of the isograd pattern and the increase in metamorphism from west to east as the result

the Wilmington Complex intruded thick continental crust whereas the Iron Hill gabbro was likely to have been oceanic.

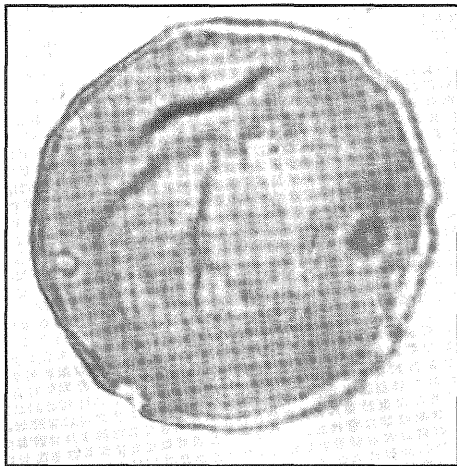
Study of the Surficial Deposits of Delaware

By Johan J. Groot

Delaware's surficial sediments consist mainly of sands and gravels, with some

variety of environments: bogs, ponds, estuaries or lagoons. Deposition was certainly not continuous, but interrupted by periods of erosion or nondeposition.

The Beaverdam Formation of Sussex County has yielded numerous fossil pollen which are now extinct in North America. Pollen assemblages indicate that the age of this formation ranges from approximately 5 million to about 2 million years before present, and at least its lower part originated during a time when the climate was considerably warmer than it is today.



Pollen grain of Pterocarya, a tree that grew in Delaware until about 1.7 million years ago and still is found in the Caucasus Mountains and east Asia. Size of pollen grain is one thousandth of an inch.

Results of studies of the Omar and Beaverdam formations are included in recently published DGS Report of Investigations No. 47. Johan J. Groot, Kelvin W. Ramsey, and John F. Wehmiller are authors of the report entitled "Ages of the Bethany, Beaverdam, and Omar formations of southern Delaware."

The study of fossil pollen, called paleopalynology, is not only giving some insights with regard to the ages and environments of deposition of the surficial sediments, but also is demonstrating that many climate changes occurred during the last several million years, long before man started adding some carbon dioxide to the atmosphere.

DGS Receives Donation of Fossil Collection

By Roland E. Bounds

John and Nancy Hall of Oxford, Pennsylvania, recently donated a large collection of fossils to the DGS. The collection comprises 150 boxes of labeled specimens and includes many now hard-to-find species from the Chesapeake and

Delaware Canal as well as an assortment of fossils from other localities around the country. The specimens combined with other DGS fossils will be a reference-study collection for the area.

Of primary interest to the DGS staff are the Cretaceous fossils from the C & D Canal. Others include Miocene fossils from the Calvert Cliffs, Maryland, and a pelvis of a large land mammal from the western United States.

The acquisition of this type of collection highlights the importance of the devoted hobbyist in the gathering of important scientific data which might otherwise have been lost. Many of the fossils were originally collected by Martha Sanders, a former Delaware resident and long-time rock shop proprietor. Without her knowledge, dedication, and conscientious labeling, most of this material would have little or no scientific value.

Talking to Public School Children is a Joy!

Members of the DGS staff are often asked to talk about rocks, fossils, maps, and geology to pupils in elementary and middle schools throughout the state. Usually, the talks are given to individual classes with 20 to 30 pupils. However, there are occasions when the Survey members are confronted by enthusiastic groups made up of several classes exceeding 80 or 90 pupils.

It is always very gratifying to see the interest and enthusiasm displayed by the children; every talk is followed by lively discussions and relentless questions asked by the pupils.

It is especially rewarding to receive thank-you letters from the pupils after they have had a chance to assimilate and digest the material covered in the talk. Excerpts from a few examples follow.

Thank you for coming to our class. You have interesting rocks. I am keeping my rock in a special place. I remember the name of the rock sillimanite. You are a nice man. When I grow up, I want to be like you.

Thank you for coming I really liked it. It was so fun. I liked the big one It was heavy. And pretty. I like green sand. And Sillimanite It is neat. Perhaps I can come sometime The names are waerd

Thank you for coming and spending your time with us. Thank you for the gifts, because I'm starting a rock collection. Thank you for the state mineral. Last night I learned about quartz, and that quartz is a crystal. In the same book you found out how to make a crystal. The rock coal is burned sunshine.

Delaware Geological Association Founded

The Delaware Geological Association was founded on April 4 during the fourth of a series of field trips sponsored by the DGS for geological staff of the Department of Natural Resources and Environmental Control. The Association is open to anyone who has an interest in the geology of Delaware. We plan subsequent field trips and meetings. To become a member and receive mailings, send your name and address to Thomas E. Pickett at the Delaware Geological Survey.

Hydrology News

Pilot Project Mapping Ground-Water Recharge Areas

By A. Scott Andres

Just begun is a one-year pilot study to test methods for mapping ground-water (aquifer) recharge areas and for ranking the areas in terms of their capability to transmit water to deeper parts of the aquifer. The study focuses on the area in eastern Sussex County covered by the Fairmount and Frankford 7.5-minute topographic maps where much of the needed geologic and hydrologic data have already been generated by the Delaware Geological Survey's hydrologic mapping program. The study is supported by the Department of Natural Resources and Environmental Control.

Ground water is an important Delaware resource. Almost all fresh ground water is derived from infiltration of precipitation to the water-table aquifer through a process known as recharge. Although recharge of the aquifer occurs throughout the State, not all land is a ground-water (aquifer) recharge area, and some recharge areas are better than others. By understanding the distribution of recharge areas and how they work, ground-water resources can be better managed.

Cockeysville Formation Study

By Kenneth D. Woodruff

The Hockessin area in northern Delaware is the focus of a detailed hydrologic and geologic study of the Cockeysville Formation. The formation is composed mainly of marble and underlies the Hockessin Valley and the smaller Pleasant Hill Valley to the west. Rapid growth in both areas has been of concern to State and New Castle County officials because of the possible effects on local ground-water supplies. The Cockeysville supports a major well field of the Artesian Water Company and hundreds of

domestic wells. Sinkhole development in the marble has also been documented at over a dozen locations, mostly in the Hockessin area.

Several approaches are being used to determine how much pumping the formation can sustain, the source of the ground water, and how development may affect recharge. The U. S. Geological Survey, through an agreement with the DGS, is conducting the major portion of the hydrologic investigations. The DGS is concentrating on gathering geologic information and providing the framework for the hydrologic portion of the study.

In early March, a recording stream gage was installed on Mill Creek at the southern end of the Hockessin Valley to measure the amount of water leaving the area. The gage measurements, along with other stream flow readings, will aid in calculating a water budget. Various geophysical techniques are being used to help determine the thickness and geologic structure of the marble. For instance, values of the local gravity field have been measured at about 200 sites to date, and more measurements are planned. These data reflect the rock type and underlying geologic structure. Temperature measurements being made in existing wells may prove useful in determining ground-water flow paths.

The study began in November 1989 and will end in October 1991. Contributors include New Castle County, DNREC, and the Artesian Water Company. Many residents of the study area have offered their assistance by allowing access to their property or their private wells or by volunteering to read rain gages.

Coastal Sussex County Ground-Water Quality Survey

By A. Scott Andres

After nearly three years, the coastal

Sussex County ground-water quality survey is nearing its scheduled completion. More than 500 water samples and over 1,500 water-level measurements have been taken in an effort to gain a better understanding of current ground-water quality conditions and ground-water flow in the Columbia aquifer. Project results will be presented in a series of publications; the first will include basic data and initial analysis and is expected to be completed in September. The results of more detailed research focusing on quantification of ground-water quality conditions and analysis of ground-water flow paths will be published later. The results of this project will have important applications to the State's Inland Bays Recovery Initiative.

Publications

Recent DGS Publications

Reports of Investigations

No. 47 Ages of the Bethany, Beaverdam, and Omar Formations of Southern Delaware: J. J. Groot, K. W. Ramsey, J. F. Wehmiller, 1990, 19 p.

Open File Report

No. 31 The Storm of July 5, 1989: Hydrologic Conditions: J. H. Talley, 1989, 29 p.

Atlas Series

Newark East Quadrangle (NEE): N. Spoljaric, editor.

Newark West Quadrangle (NEW): N. Spoljaric, editor.

Forthcoming DGS Publications

Oligocene and hydrologic studies of Oligocene-Pleistocene section, boreholes Oh25-02 through 05 near Lewes, Delaware: R. N. Benson, editor.

Geologic map of southern Delaware: K. W. Ramsey, and W. S. Schenck.

Kennett Square Quadrangle Atlas (KES): N. Spoljaric, editor.
Marcus Hook Quadrangle Atlas (MAH): N. Spoljaric, editor.

Staff Notes

Roland E. Bounds completed 10 years of service on January 20. He received his length-of-service award from the University on April 12. On May 22, **A. Scott Andres** and **Richard N. Benson** received 5-year and 15-year length-of-service awards, respectively.

Robert R. Jordan will receive the George V. Cohee Public Service Award at the September meeting of the Eastern Section of the American Association of Petroleum Geologists. Also, Jordan has been appointed a member of the Newark Water Quality Committee.

Thomas E. Pickett led a field trip for the Delaware Nature Society on March 17 to the outstanding geologic localities in New Castle County. Pickett and **Kenneth D. Woodruff** participated in the cluster meeting of eastern state geological surveys with the U. S. Geological Survey at Columbus, Ohio, March 5-7.

Charles T. Smith and **Roland E. Bounds** participated in the Delaware Water Well Association's seminar on well grouting, April 7.

Presentations

Thomas E. Pickett, "Stratigraphy of the mid-Atlantic Coastal Plain" at the Department of Geology seminar, Indiana University/Purdue University, Indianapolis, April 16.

Kelvin W. Ramsey with T. E. Skrabal and R. D. Henry, "Monitoring results of a beach replenishment project at Fenwick Island, Delaware," at the National Conference on Beach Preservation Technology, St. Petersburg, Florida, February 15.

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