First State Geology

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

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New Piedmont Bedrock Geologic Map and Report

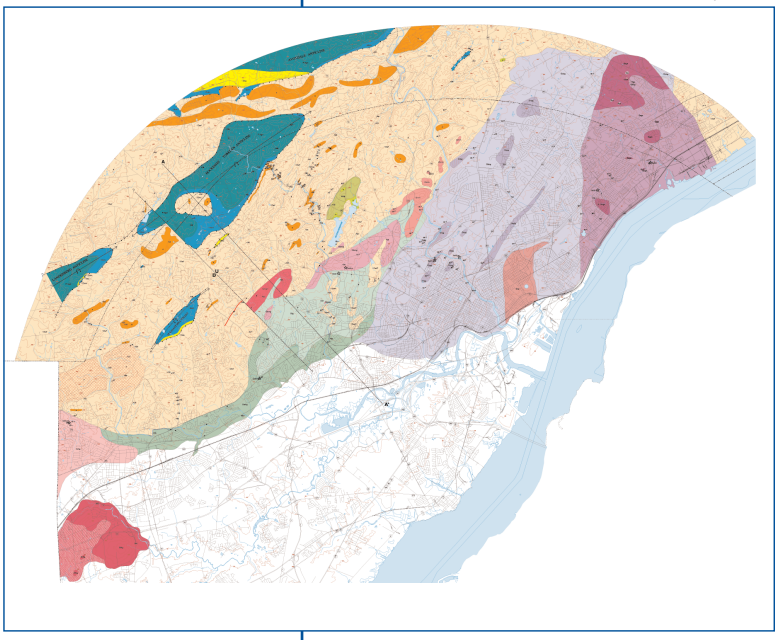
By William S. Schenck

Two new Delaware Geological Survey (DGS) publications describe the geology of the Piedmont of Delaware and a portion of Pennsylvania which is included to show the extent of the Mill Creek Nappe and the Arden Plutonic Supersuite. DGS Geologic Map Series No. 10 (scale 1:36,000), "Bedrock Geologic Map of the Piedmont of Delaware and Adjacent Pennsylvania" is by William S. Schenck, Margaret O. Plank (both DGS), and LeeAnn Srogi (West Chester University). It is included as Plate 1 in the rear cover pocket of DGS Report of Investigations No. 59 (52 p.), "Bedrock Geology of the Piedmont of Delaware and Adjacent Pennsylvania" by Margaret O. Plank, William S. Schenck, and LeeAnn Srogi.

The information provided by the map and report is important not only to geologists but also to hydrologists who wish to understand the distribution of water resources, to engineers who need bedrock information during construction of roads and buildings, to government officials and agencies who are planning for residential and commercial growth, to educators and students, and to citizens who are curious about the bedrock under their homes.

The Appalachian Piedmont Province of Delaware and adjacent Pennsylvania records the collision of a magmatic arc with a continental landmass and adjacent forearc basin sediments during the early Paleozoic Era. As a result of this collision, the rocks are intensely deformed and metamorphosed to the amphibolite and granulite facies. The oldest rocks are Grenville-age layered gneiss, migmatite, and amphibolite that are correlated with the Baltimore Gneiss of Maryland. The Grenville-age rocks are unconformably overlain by the Late Proterozoic to early Paleozoic Setters Formation and the Cockeysville Marble of the Glenarm Group. These three rock units are exposed in the Mill Creek Nappe.

The Wissahickon Formation represents a thick sequence of sediments deposited in a forearc basin that are now metamorphosed and in thrust contact with the rocks of the Mill Creek Nappe. Much of the Wissahickon Formation shows repetition of layers characteristic of distal turbidites. Included within the metamorphosed sediments are an ultramafic-mafic lens, a thin diabase dike, and two types of amphibolites, one with trace element chemistry characteristic of basalts formed at a seafloor-spreading center, and the other with trace element chemistry characteristic of intraplate basalts.



Combined detailed mapping, petrography, geochemistry, and U-Pb geochronology have resulted in the redefinition of two rock units and formal recognition of eleven new units. The new units occur within the redefined Wilmington Complex and are classified as lithodemes. Lithodemic stratigraphy allows for mapping individual rock units within the Wilmington Complex without a complete understanding of the complex relationships that exist between them. The Wilmington Complex includes rocks associated with the development of a Paleozoic magmatic arc: five metaplutonic lithodemes are the Brandywine Blue Gneiss, Montchanin Metagabbro, Mill Creek Metagabbro, Barley Mill Gneiss, and Christianstead Gneiss; three igneous plutons are the Bringhurst Gabbro, Iron Hill Gabbro, and the redefined Arden Plutonic Supersuite comprising the Ardentown Granitic Suite, Perkins Run Gabbronorite Suite, and one lithodeme of biotite tonalite; and three metavolcanic units named the Rockford Park Gneiss, Windy Hills Gneiss, and Faulkland Gneiss.

John N. Aleinikoff of the U. S. Geological Survey determined U-Pb ages on zircons found in seven rock units. They are 434±4 Ma for the Arden Supersuite, 476±6 Ma for the Brandywine Blue Gneiss, 476±4 Ma for the Rockford Park Gneiss, 482±4 Ma for the Faulkland Gneiss, 481±4 Ma for the Windy Hills Gneiss, 470±9 Ma for the Barley Mill Gneiss, and 488±8 Ma for the Christianstead Gneiss.

Geochemical analyses of the mafic rocks provided a breakthrough in efforts to subdivide units within the Wilmington Complex. Samples could be grouped by their trace element concentrations and the groups identified spatially in the field. A detailed report on the geochemistry of these rocks will be published by Plank et al. (in press) as DGS Report of Investigations No. 60.

The geologic map, report, and all data for outcrops used for this study are accessible through the DGS web site at www.udel.edu/dgs/webpubl.html.

New Report on Pesticides in Delaware's Shallow Ground Water

By Scott C. Blaier and Stefanie J. Baxter

A federal regulation proposed in 1996, but not yet implemented, by the U.S. Environmental Protection Agency (USEPA) is to require individual states to develop Pesticide Management Plans (PMPs) to protect ground water from contamination by pesticides. The regulation designates the triazine herbicides atrazine, simazine, and cyanazine, and the acetanilide herbicides alachlor and metolachlor as the first five pesticides that would require a PMP. All five are used primarily for weed control on agricultural crops. The Delaware Department of Agriculture (DDA) is the state agency responsible for development and implementation of the PMPs.

Ground-water monitoring is required for each PMP and offers two important benefits: (1) it identifies areas where pesticides may be leaching into ground water, and (2) it is a means for evaluating and measuring the success of management strategy over time. In 1995, through a cooperative effort between the two agencies and supported in part by the USEPA, the DDA and DGS developed a monitoring strategy to support pending PMPs. This included the design and implementation of a shallow ground-water network for monitoring pesticides by sampling water from domestic, agricultural, and dedicated monitoring wells located throughout Delaware south of U.S. Route 40. From October 1995 to September 1998 approximately 350 ground-water samples from 136 wells were collected and analyzed for the five pesticides designated by the USEPA. Also analyzed, but less extensively, were the herbicides 2,4-D and metribuzin and the insecticides carbofuran and chlorpyrifos.

The results of this study are now available in DGS Report of Investigations No. 61 (23 p.), "The Occurrence and Distribution of Several Agricultural Pesticides in Delaware's Shallow Ground Water" by Scott C. Blaier (DDA) and Stefanie J. Baxter (DGS).

The purpose of the report is to answer three questions: (1) Are agricultural pesticides present in Delaware's shallow ground water? (2) Which pesticides are present and at what concentrations? (3) Where are the pesticides being detected? Data collected as part of this continuing monitoring program will be used to support development of Pesticide Management Plans for Delaware.

Of the 1,725 analyses performed, 96 percent had concentrations less than 1.0 g/l. This includes almost 80 percent of the samples that showed no measurable concentrations of the pesticides studied. Although some analyses indicated the presence of a pesticide, confirmatory tests showed that all domestic wells meet state and federal drinking water standards.

The new publication is available from the Delaware Geological Survey offices at the University of Delaware and can be obtained by calling (302) 831-2833 or via email at delgeosurvey@udel.edu, or from the Delaware Department of Agriculture Pesticides Section at 1-800-282-8685. The report is also available on the Delaware Geological Survey web site at: http://www.udel.edu/dgs/webpubl.html. Continuously updated monitoring data for the monitoring wells can be found at the Delaware Department of Agriculture GIS web site at: http://smartmap.com/dda/.

Two New Publications on Earthquakes

Two publications on earthquakes, both by Stefanie J. Baxter, are now available, but only online, on the DGS web site at http://www.udel.edu/dgs/webpubl.html. "Earthquake Basics," DGS Special Publication No. 23, provides a brief overview of the causes of earthquakes, how they are measured, a glossary of earthquake terminology, and tables noting the largest U.S. earthquakes. Illustrations include, among others, a map of Earth's major tectonic plates, midocean ridges, and trenches; the nature of ground motion produced by four types of seismic waves; three primary types of motion along faults; and a contoured intensity map of the 1973 3.8-magnitude earthquake centered near Wilmington.

"Catalog of Earthquakes in Delaware," DGS Open File Report No. 42, lists and shows with a map the earthquake history of Delaware since 1871. Since that date, 69 earthquakes have been documented or suspected in Delaware. Since 1677, more than 550 earthquakes have been documented within a radius of 150 miles from Delaware. In 1997, the U.S. Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA) reclassified Delaware from a low to a medium seismic risk.

Included in the publication is a brief history of the DGS seismic network of short-period vertical seismometers to detect local earthquake activity. Now there are five such stations operating in the state. Another station near Greenwood is operated by the USGS and is maintained by the DGS. It is part of the U.S. National Seismograph Network and is designed to record the horizontal and vertical earth movements caused by earthquakes of greater than 2.5 magnitude that occur within a 200-mile radius.

Geophysical Logging Offers A Look At Delaware's Subsurface Geology

By Peter P. McLaughlin and Scott A. Strohmeier

Investigations of the subsurface geology and groundwater resources of Delaware depend heavily on subsurface data obtained from wells and boreholes. In many cases, the rock units penetrated are known only from samples obtained during drilling. Another method is geophysical logging which allows us to obtain a continuous, high-resolution record of the physical properties of the rocks and their contained fluids. From this we can interpret the various rock types that were drilled.

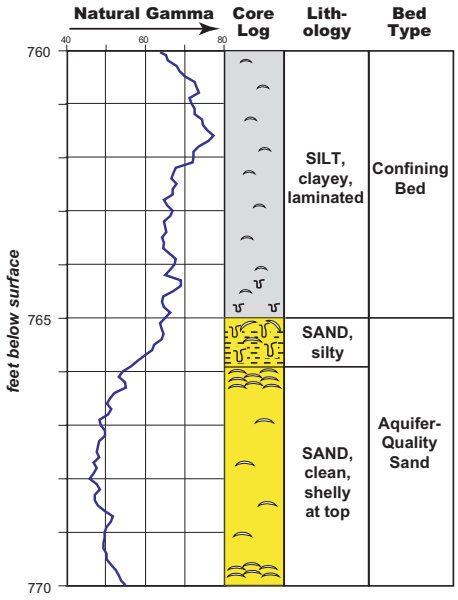
In geophysical logging, a probe designed to measure certain physical properties, such as electrical conductivity, natural radiation, or temperature, is lowered and raised in the borehole by means of a steel cable spooled from a winch. Readings from the sensors on the probe are transmitted electrically through the cable to a data collection unit.

The DGS maintains a geophysical logging program as part of its responsibility for systematic investigation of the geology and water resources of Delaware. Our collection of geophysical logs dates to the late 1950s and currently totals more than 1400 logs from over 1000 wells. In 1998, we upgraded our logging capabilities with the acquisition of a new, portable digital logging system capable of logging to a depth of nearly 1000 ft.

The system includes a suite of four probes. The natural gamma tool measures natural gamma radiation, which can be used as an indicator of the relative content of sand versus clay. Quartz sands are typically distinguished on gamma logs by low values, whereas clay-rich sediments have higher gamma values that reflect the presence of trace amounts of radioactive elements such as uranium, thorium, and potassium-40 (see figure). This tool is the most versatile part of our logging suite and can be run in almost any hole of 2-inch-diameter or greater. The multi-parameter electric-log tool is used to obtain electric logs in uncased boreholes, and simultaneously records five different resistivity logs plus spontaneous potential and natural gamma. The resistivity logs strongly reflect the fluid content of the formation, with fresh-water-bearing intervals such as aquifer sands producing a high-resistivity signal in contrast with low-resistivity clay zones. The magnetic induction tool produces conductivity logs with some similarity to resistivity logs but can be used in PVC-cased wells. Rather than directly measuring the electrical properties in the borehole, this tool measures them indirectly by inducing an electro-magnetic response in the surrounding formation. The three-arm

caliper tool measures the diameter of the hole to help understand drilling conditions and provide for correction of log measurements.

These tools provide significant benefits to geologic and hyrdologic investigations. For example, geophysical logs are important in evaluating aquifers. When drilling a water well, drilling characteristics and drill cuttings are usually used to recognize where an aquifer has been penetrated. However, these criteria are not always definitive, and in problematic cases geophysical logs can help identify the most promising intervals to screen for



Geophysical and lithologic logs from well Qj32-27 at Bethany Beach, Del. Natural gamma log values increase overall upward in this interval, reflecting a lithologic change from sand to clayey silt beds.

water production. Because certain geophysical logs reflect the nature of the pore fluids in a formation, they are also useful in coastal areas to evaluate cases of potential salt-water intrusion of aquifers. In addition, geophysical logs are an integral part of subsurface stratigraphic studies and geological mapping projects and are extensively utilized in areas currently being mapped in central Sussex County. Recognizing the broad utility of geophysical logging, the DGS strives to work with water well drillers as well as other local, state, and federal agencies to coordinate collection and sharing of geophysical logs in areas that further our understanding of the geology of Delaware and at the same time provide data beneficial to others' projects.

Earth Science Week and Coast Day Posters Available Online

Owing to their popularity, the supplies of two DGS posters, one for Earth Science Week 2000 and the other for Coast Day 2000, have been depleted. They are, however, available online.

More than 1500 Earth Science Week posters were distributed to schools and school children and the public who attended activities held at the Delaware Geological Survey. The poster, "Selected Geomorphic Features of Delaware" by Kelvin W. Ramsey, William S. Schenck, and Lillian T. Wang (DGS Special Publication No. 24), shows two maps side by side. One is a black, white, and gray tone, 3-D shaded relief image of Delaware. At a scale of 1 inch to 4 miles, the map was created using digital elevation data, and shows the coastal marshes, rivers, and streams plotted in blue on top of the image. On the accompanying map at the same scale and labeled with cities and towns, selected geomorphic features visible on the shaded relief image are identified including the major drainage divide, ancient Delaware bay and Atlantic coastlines, Carolina bays, sand dunes, an area called "The Levels," Iron and Chestnut hills, Piedmont uplands, Coastal Plain, and the Fall Line.

The Coast Day poster, "Physiographic Regions of the Delaware Atlantic Coast" by Kelvin W. Ramsey, William S. Schenck, and Lillian T. Wang (DGS Special Publication No. 25), is a 1-inch to 1-mile map that identifies the headlands, bay barriers, coastal lagoons, and the Cape Henlopen spit complex along the entire Atlantic coast of Delaware. Other information includes the direction and amount of sediment transport, locations of the pre-1929 inlets and the old Cape Henlopen Lighthouse, and a brief history of the Lewes breakwater. Over 1400 of the posters were distributed for this year's College of Marine Studies Coast Day held at the University of Delaware Campus in Lewes.

Special Publications 24 and 25 are downloadable from the DGS web page at http://www.udel.edu/dgs/webpubl.html. Print on demand copies can be furnished at a cost of $5.00 each by contacting the DGS at (302) 831-2833 or via email at delgeosurvey@udel.edu.

Coast Day 2000

By Lillian Wang

On Sunday, October 1, 2000, The Delaware Geological Survey sponsored a "Dig for Fossils" at the University of Delaware, College of Marine Studies 24th annual open house, Coast Day, in Lewes, Delaware. Children dug up and identified Delaware-area fossils, and Pete McLaughlin was on hand to verify identifications. Lillian Wang distributed 1500 "Coast Day 2000" posters and 400 "Earth Science Week 2000" posters (see article on these publications in this issue). Plans are to publish new posters annually and to distribute them during Coast Day and Earth Science Week, which are both in October.

Pete McLaughlin helping a "budding paleontologist" identify fossils.

Safety Committee of the Month

The University of Delaware Department of Occupational Health and Safety (DOHS) has recognized the Delaware Geological Survey as Department of the Month for January 2001. The safety committee is led by Kelvin Ramsey with members Roland Bounds, Pete McLaughlin, and Tom Smith. The DOHS citation, online at http://www.udel.edu/OHS/, recognizes the DGS for its sessions on chemical hygiene training and right-to-know, use of hydrofluoric acid, boating safety, forklift safety, proper lifting, Lyme disease, and trenching safety. Also noted was the DGS cell phone use policy that phones are not to be used while driving and that cell phones are to be on hand whenever fieldwork is being done, which allows persons working in remote locations to have a way to summon help in the event of an emergency.

From the DOHS, "We appreciate the time and effort this group takes to make safety their first priority. The professionalism demonstrated by this group is certainly worthy of recognition. Please join me in congratulating DGS for their fine effort!"

Gem and Mineral Show

By Roland E. Bounds

The Delaware Mineralogical Society will be holding its annual Earth Science, Gem and Mineral Show on March 3 and 4, 2001, at the Brandywine Terrace, 3416 Philadelphia Pike, Claymont, Delaware. Hours are 10 a.m. to 6 p.m. on Saturday and 11 a.m. to 5 p.m. on Sunday. There will be exhibits, dealers for

minerals, fossils, and jewelry, as well as door prizes, a raffle specimen, and the Junior Booth for kids items. Parking is free and food is available on site. There is an entry fee. For more information contact Wayne Urion at 302-998-0686.

Publications

Recent DGS Publications

Geologic Map Series

No. 10, Bedrock Geologic Map of the Piedmont of Delaware and Adjacent Pennsylvania: William S. Schenck, Margaret O. Plank, and LeeAnn Srogi, 2000, scale 1:36,000.

Reports of Investigations

No. 59, Bedrock Geology of the Piedmont of Delaware and Adjacent Pennsylvania: Margaret O. Plank, William S. Schenck, and LeeAnn Srogi, 2000, 52 p.

No. 61, The Occurrence and Distribution of Several Agricultural Pesticides in Delaware's Shallow Ground Water: Scott C. Blaier and Stefanie J. Baxter, 2000, 23 p.

Special Publications

No. 23, Earthquake Basics: Stefanie J. Baxter, 2000. Available only online at http://www.udel.edu/dgs/pub/SP23.pdf.

No. 24, Selected Geomorphic Features of Delaware: Kelvin W. Ramsey, William S. Schenck, and Lillian T. Wang, 2000, map, one sheet, scale 1 inch to 4 miles. Available only online at http://www.udel.edu/dgs/pub/SP24.pdf.

No. 25, Physiographic Regions of the Delaware Atlantic Coast: Kelvin W. Ramsey, William S. Schenck, and Lillian T. Wang, 2000, map, one sheet, scale 1 inch to 1 mile. Available only online at http://www.udel.edu/dgs/pub/SP25.pdf.

Open File Reports

No. 42. Catalog of Earthquakes in Delaware: Stefanie J. Baxter, 2000, 6 p. Available only online at http://www.udel.edu/dgs/pub/OFR42.pdf.

Other Publications by DGS Staff

Thomas E. McKenna, 2000, Low-Budget, Do It Yourself Thermal-Infrared Imaging of Ground-Water Discharge to Surface Waters [Abstract]: Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A60; with William J. Ullman, Kuo-Chuin Wong, Joseph R. Scudlark, John A. Madsen, David E. Krantz, and **A. Scott. Andres**, 2000, CISNet: Nutrient Inputs as a Stressor and Net Nutrient Flux as an Indicator of Stress Response in Delaware's Inland Bays Ecosystem [Abstract]: Proceedings of the Coastal Intensive Sites Network (CISNet), STAR Grants 2000 Progress Review, EPA Report # EPA600/R-00/060, Environmental Protection Agency, Washington, D. C., p. 13.

Gerald M. Kauffman, Martin W. Wollaston, and **John H. Talley**, 2000, The Drought of 1999: The Efforts of the Governor's Water Supply Task Force in Delaware: Proceedings of American Water Resources Association Conference, Miami, p. 249-253.

Staff Notes

Presentations

At the Geological Society of America Annual Meeting, Reno, Nevada, Nov. 13: **Peter P. McLaughlin, Jr.**, and **Richard N. Benson** with Kenneth G. Miller, and James V. Browning (both Rutgers University), "Regional Correlation of Miocene Sequences, Middle Atlantic Coastal Plain: New Results from Bethany Beach, Delaware;" **Thomas E. McKenna**, "Low-Budget, Do It Yourself Thermal-Infrared Imaging of Ground-Water Discharge to Surface Waters."

At the Delaware GIS Day 2000 Conference, Dover, November 17: **William S. Schenck** and Nicole M. Minni (Water Resources Agency), "GIS may Make Maps Fast, but Cartography is Still an Art;" and **Lillian T. Wang** and **Thomas E. McKenna**, "Digital Delineation of Ground-Water Divides, Inland Bays, Sussex County, DE."

Thomas E. McKenna " Aerial Thermal-Infrared Imaging and 'Ground-Truthing' to Quantify Ground-Water Discharge to a Coastal Estuary on the Atlantic Coast of Delaware," at Department of Geosciences, State University of New York, Stony Brook, October 12 ; "The CISNet Program: Collaborative Research in Delaware's Inland Bays," at Coast Day 2000, University of Delaware, College of Marine Studies, Lewes, October 1.

William S. Schenck, "Geology of Delaware," at the Archaeological Association of Delaware monthly meeting, Greenbank Mill, Wilmington, June 21.

Martin W. Wollaston, Gerald M. Kauffman, and **John H. Talley**, "Report to the Governor and the State Legislature Regarding the Progress of the Delaware Water Supply Coordinating Council," May 31.

Service and Awards

Robert R. Jordan will receive the President's Award of the Division of Environmental Geology (DEG) of the American Association of Petroleum Geologists (AAPG) at the next AAPG convention in June 2001. The award is the highest and most distinguished one of the DEG and is given for the advancement and betterment of the science and profession of environmental geoscience. Jordan is one of the founding members of the DEG.

John H. Talley received the George V. Cohee Public Service Award from the Eastern Section of the American Association of Petroleum Geologists for "His enthusiastic application of geologic science for public benefit."

Congratulations to **William S. Schenck** who has completed 20 years service with the DGS and University of Delaware as of February 16.

First State Geology is published by the Delaware Geological Survey, a State agency established by an Act of the Delaware General Assembly in 1951 and organized as a unit of the University of Delaware.
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