First State Geology

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

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Continuously Cored Hole for Investigation of Faults in Northern New Castle County

By Stefanie J. Baxter

Earthquakes, which are generated by slippage along active faults, have been documented in Delaware and the surrounding area since 1677. Despite the fact that earthquakes continue to occur in the state, no surficial expression of such faults has been identified. This is typical of the U.S. east of the Rocky Mountains, but in California, for example, there are many active earthquake faults such as the San Andreas that appear at the earth's surface. Faults are common features of the earth's crust, and although active in the geologic past, most are not so today.

To investigate possible earthquake faults in the eastern U.S. that are hidden in the subsurface, geophysical methods are required. In June 1998 a high-resolution seismic reflection/refraction survey 3 km in length was conducted near New Castle, Del., to identify possible faults that may be associated with earthquakes near Wilmington. This was done by personnel from the DGS and geophysicists from the U.S. Geological Survey offices in Menlo Park, Calif., through a joint cooperative agreement with the USGS (see Winter 1999 issue of *First State Geology*).

Although a final report in cooperation with the USGS researchers is still in progress, preliminary analysis of the data gathered from this phase of the project indicates the crystalline basement rocks and overlying sedimentary rocks of the Potomac Formation (and possibly the Columbia Formation) are highly faulted. The seismic reflection profile shows the basement surface dips approximately 4-5° to the southeast and has local relief of up to 40 meters. Detailed velocity inversion of the refraction data shows significant variations within both the sedimentary and crystalline rock sections.

In May 1999, the DGS contracted with the Eastern Earth Surface Processes Team of the USGS to drill a continuously-cored hole to crystalline basement on the downthrown side of an imaged fault. Drilling is required to lend "ground truth" to the high-resolution seismic line and to enhance the credibility of the seismic interpretation.

A Mobile B-61 wire-line drilling rig retrieved cores in 10-ft sections. After washing to remove drilling mud, the cores were photographed and described in the field by DGS personnel. The total depth drilled was 555 ft. The top of weathered basement (saprolite) occurs at 436 ft, and the top of unweathered basement at 548 ft. Total core recovery was 76 percent. When drilling was complete, borehole geophysical logs (natural gamma and electrical) were run.

The cores and logs provide valuable information that will enhance our understanding of the geologic (and hydrologic) framework of northern Delaware, especially as it relates to structural geology and seismicity. As this continuously cored hole was drilled on the downthrown side of a fault showing offset of reflectors imaged on the seismic reflection profile, plans are for another but non-cored hole to be drilled on the upthrown side of the fault to verify offset of stratigraphic units represented by the reflectors.

Extruding a 10-ft cored section. From left to right, Stefanie Baxter, Tom McKenna, and USGS driller Gene Cobbs.

Stefanie Baxter washing drilling mud off a core.

Cores of weathered crystalline rock (saprolite) from 454-463 ft.

Thermal Imaging of Ground-Water Discharge to the Inland Bays

By Thomas E. McKenna

While swimming in a lake have you ever suddenly encountered a pocket of cold water? Chances are that you swam into an area where relatively cold ground water flows through the lake bottom and into the warmer lake. In the winter the temperature pattern is reversed with warmer ground water discharging into cooler surface water.

Locating these "hot-spots" of ground-water discharge in Delaware's Inland Bays was the mission of a March 1999 aerial thermal-infrared radiometer survey. The flights were run as part of the EPA-funded CISNet (Coastal Intensive Sites Network) project entitled "CISNet: Nutrient Inputs as a Stressor and Net Nutrient Flux as an Indicator of Stress Response in Delaware's Inland Bays Ecosystem" (see winter 1999 issue of *First State Geology*).

Although the idea of using thermal imaging to identify ground-water discharge sites has been around for at least 20 years, rapid advances in technology and commercialization of military equipment over the last 5 years allowed me to rent and operate the newer equipment. In contrast to what is typically known as "night vision," which amplifies visible light, the thermal radiometer produces a picture made up of detected heat with no visible light content whatsoever. It measures the energy (heat) that is emitted from the surface of the water in the thermal infrared band (longer wavelength and lower frequency than visible red). The data were captured continuously (in color) onto standard video tape and as single images in a digital format. Although relative temperature differences are easily discernible in the images, the causes of these differences remain to be investigated over the duration of the three-year project. We are confident that we picked up some signals of warmer ground water (15° C) discharging into cooler bay water (5° C), even after mixing of the waters reduced the strength of the signal. During spring 2000 we plan to instrument up to four of these identified discharge areas with seepage meters and piezometers to measure ground-water flux to the bays.

The thermal imaging system consists of a thermal infrared radiometer, a modified aircraft, standard audio and video recording equipment, and a power supply. The thermal infrared radiometer (THERMACAM) was rented from Inframetrics, Inc. in North Billerica, Mass. It is designed to be used for predictive maintenance (overheating) of industrial equipment, but we easily adapted the technology for the bays research.

The THERMACAM is a small hand-held unit no bigger than a standard video camera with a precision of 0.1° C and an accuracy of 2° C. The instrument was bolted into a custom-built passenger-door mount for a CESSNA 150 aircraft that was finely crafted by Richard Fekete of Black's Flying Service, Millville, N.J. I was able to run the instrument "hands-on" from the passenger seat of the aircraft. The THERMACAM was connected, along with my headset, to an electronics board that sat on my lap with a stereo/audio mixer and VCR. All of the equipment was powered by a 12-volt battery and DC/AC inverter.

The survey was run on March 23, 1999, over Rehoboth and Indian River bays and major tributaries at altitudes from 3400 to 5400 ft and speeds from 70 to 100 mph. Resultant images had widths ranging from 1600 to 2500 ft with pixel sizes ranging from 5 to 8 ft. Richard Fekete expertly piloted the aircraft (sometimes in extreme turbulence!) and used his experience with aerial surveying to greatly enhance the collected images. His experience and cooperation were crucial to the success of the survey and are greatly appreciated. Scott Strohmeier and Tom Smith of the DGS were my primary ground team during the survey. Additional support came from Denise Valitski and Jim Sedowski from Conectiv Energy; John Dimitry and Gary Miller of Entrix; Wendy Carey, Nick Gedamu, Kate Porter, Kent Price, and Bill Ullman from the University of Delaware; Allan Redden and Kenny Hitchens from DelDOT; and Ed Whereat and his volunteer members of the Inland Bays citizen monitor program. Thanks to all for your help in increasing the value of this research.

Richard Fekete, pilot/mechanic/inventor/ aerial-photographer, of Black's Flying Service, Millville, N.J., and the CESSNA 150 aircraft used in the aerial survey.

Geologic Cross Section of Delaware's Atlantic Coast

By Kelvin W. Ramsey

"Cross Section of Pliocene and Quaternary Deposits Along the Atlantic Coast of Delaware" was constructed using data from wells and boreholes between Cape Henlopen and Fenwick Island. The cross section provides a geologic context for interpreting cores and seismic reflection profiles offshore Delaware that were collected over the past few years for identifying potential sand resources in state and federal waters for beach nourishment projects.

The cross section shows the stratigraphic units from land surface to a depth of approximately 150 ft. The units likely extend offshore to where they are truncated by younger units or by the present sea floor.

The oldest unit is the Beaverdam Formation of latest Miocene to Pliocene age. It consists primarily of fine to coarse sand with interbeds of fine silty sand to sandy and clayey silt that was deposited in fluvial to estuarine environments. The Beaverdam is the unit most likely to be a source of sand offshore.

The Omar Formation, ranging from late Pliocene to late Pleistocene age, unconformably overlies the Beaverdam. The dominant lithology in coastal Delaware is a gray clayey sand to sandy silt with scattered beds of sand, shell, and organic-rich silt. Environments represented by the deposits are lagoonal, tidal delta, marsh, and spit. The Omar comprises several depositional episodes, each representing transgressive events associated with rising sea level and sea-level high-stands during interglacial times.

The Holocene deposits are incised within the older deposits and consist of fine to coarse sand, sandy to clayey silt, silty clay, and organic-rich clayey silt. They were deposited over the last 10,000 years during the latest post-glacial sea-level rise in a transgressive barrier-lagoon system.

Published as Delaware Geological Survey

Miscellaneous Map No. 6 (1999), the cross section, with discussion, is the first exclusively digital publication of the DGS. It can be down-loaded from the DGS web site at *http://www.udel.edu/dgs/pub/misc06.pdf*. Paper copies are available and will be printed on demand for a nominal fee by e-mail request at *delgeosurvey@udel.edu* or by calling (302) 831-2833.

Update on the DGS Atlantic Outer Continental Shelf Core and Sample Repository

By Kelvin W. Ramsey

The DGS Atlantic Outer Continental Shelf (OCS) Core and Sample Repository contains samples from all 51 North, Middle, and South Atlantic oil and gas exploratory wells drilled on the Atlantic OCS between 1977 and 1984. Samples include cores, unwashed cuttings, vials containing samples processed for micropaleontology and palynology, thin sections of cores and cuttings, and micropaleontology and palynology slides. These samples are available for use by researchers.

An inventory of all holdings of the repository was recently completed. It includes samples acquired in 1997 from the Texas Bureau of Economic Geology at the University of Texas in Austin. A summary of the holdings can be found on the DGS Web Site at *http://www.udel.edu/dgs/ocsrepos.htm.* The DGS is designated as the primary repository for these samples by the Minerals Management Service of the U.S. Department of the Interior.

The Repository now contains:

- 230 boxes of core material
- 245 boxes of unwashed cuttings (approx. 5000 individual samples)
- 1959 boxes of washed cuttings (approx. 40,000 individual samples)
- 32 boxes of vials (approx. 6500 individual samples)
- 79 boxes of thin sections and slides (approx. 6000 slides)
- geophysical logs, paleontologic summaries, and other data from many of the wells.

New Report on Stream-Gaging Network in Delaware

Delaware Geological Survey Report of Investigations No. 57 (1998), "Evaluation of the Stream-Gaging Network in Delaware" by Edward J. Doheny, U.S. Geological Survey through a cooperative program with the DGS, describes the stream-gaging network in Delaware as of the end of 1997 and provides an evaluation of its representativeness for the state. An inventory of all active and inactive stream-gaging stations is presented along with maps showing the locations of stations.

The Delaware stream-gaging network, begun by the USGS in 1931, is now operated cooperatively between the DGS and the USGS and is a major component of many types of hydrologic investigations. Uses of surface-water discharge data include flood forecasting and analysis; analysis of hydrologic systems; public water-supply, water-quality, and pollution abatement analyses; water resources planning and management; evaluation of drought/no drought conditions; design of bridges, culverts, dams, and sediment control structures; and wildlife and irrigation management.

Temporal trends in numbers of several types of gaging stations operated during water years 1975-1997 were investigated. Results for continuous-record stations indicate (1) significant variability in the number of stations operated over time, especially 1980-84 and 1989-97, (2) most are not being maintained for enough time to account for local temporal hydrologic variations, and (3) stations in small drainage basins (<10 mi^2) are not being maintained, especially during 1981-97. For low-flow partial-record, tidal and nontidal crest-stage partial-record, and surface-water quality stations from 1975 through 1997, there was variable and non-systematic activity except for the tidal crest-stage partial-record stations.

An analysis of the representativeness of the network of active continuous-record stations in Delaware shows that several principal Coastal Plain drainage basins are ungaged; there is a lack of such stations in small, predominantly forested drainage basins and in predominantly urban areas. In the Piedmont, however, there is significantly more spatial coverage because this area is the major source of the surface water which supplies most of northern New Castle County. Approximately 23 percent of Delaware's inhabitants (1990 Census) are residing in drainage basins that are gaged.

The report presents a general strategy and recommendations for improving the network to ensure adequate coverage in underrepresented areas throughout Delaware, especially in areas designated as high growth.

To obtain a copy of Report of Investigations No. 57: call (302) 831-2833, or from our web site at *http://www.udel.edu/dgs/RI57.pdf* , or from the Survey office at the University of Delaware.

DGS Welcomes New Staff Members

Three new persons were added to the professional staff of the DGS in 1999. In February, Lillian T. Wang began her work as a Research Specialist to perform investigations and conduct applied research using Geographic Information System (GIS) and quantitative computer methods. Also in February, project geologist Scott A. Strohmeier, a limited term researcher, was hired to assist in several DGS projects. In June, Peter P. McLaughlin, Jr., joined us as a Senior Scientist to conduct research in the general area of stratigraphy and micropaleontology of the Atlantic Coastal Plain and Outer Continental Shelf.

Lillian Wang has a B.A. degree in geography from the University of Delaware. She was previously employed as an environmental scientist with the Delaware Department of Natural Resources and Environmental Control and before that as a cartographer with the Defense Mapping Agency in Bethesda, Md.

Scott Strohmeier is a recent graduate of the University of Delaware with a B.S. in geology. He has been a research assistant on several projects for the DGS since March 1998, and for about two weeks last summer he was a USGS volunteer on a seismic profiling project in southern California.

Pete McLaughlin comes to us from Houston, Tex., where for the past ten years he served as a research geologist, exploration geologist, and supervisor for Exxon Production Research Company and later Exxon Exploration Company. His areas of expertise include biostratigraphy, seismic interpretation, well-log interpretation, and clastic facies analysis. He is also a graduate of the University of Delaware with a B.S. degree in geology. He received a Ph.D. from Louisiana State University in 1989. His dissertation was an integrated, field-based analysis of the micropaleontology, sedimentology, and basin tectonics of a Neogene basin in the southwestern Dominican Republic.

We welcome our new colleagues and look forward to working with them.

DBPG News

By Elizabeth Brown

The Delaware Board of Professional Geologists (DBPG) consists of seven members who are appointed by the Governor. Four are licensed geologists, one of which is a member of the Delaware Geological Survey, and three are public members. The following people are current board members:

Licensed geologists:

K. Elizabeth Brown, president
R. Peder Hansen, vice president
Eric Trinkle, secretary
Robert R. Jordan, DGS member

Public members:

Bangalore Laksham
Jerome Cooper
Theodore Ressler

All board positions are filled. If you are interested in serving on the board in the future and are a Delaware resident, please call Mary Paskey at (302) 739-4522, ext. 207.

Publications

Recent DGS Publications

Miscellaneous Map Series

No. 6, Cross Section of Pliocene and Quaternary Deposits of the Atlantic Coast of Delaware: Kelvin W. Ramsey, 1999 (digital, down-loadable at *http://www.udel.edu/dgs/pub/misc06.pdf* or on-demand paper copy for a nominal fee).

Other Publications by DGS Staff

T.R. Fenstemaker, J.M. Sharp, Jr., C.T. Simmons, and **Thomas E. McKenna**, 1998, Effects of heterogeneity in salinity, pressure, and permeability on thermohaline convection in the Gulf of Mexico Basin, South Texas (Abstract): EOS, v. 79, no. 45, p. F266.

Staff Notes

Presentations

At the 1999 Spring Meeting of the American Geophysical Union in Boston, June 1-4: **Richard N. Benson**, "Chronology of Continental Flood Basalts and Seaward-Dipping Reflectors of the North American Atlantic Continental Margin" at the Tectonophysics Section symposium "The Earliest Magmatism of the Circum-Atlantic Large Igneous Province;" and **Thomas E. McKenna** and **Stefanie J. Baxter** with Rufus D. Catchings and Mark R. Goldman, U.S. Geological Survey, "High-Resolution Seismic Reflection/Refraction Imaging of Shallow-Depth Faults in the Atlantic Coastal Plain of Delaware."

At the Academy of Lifelong Learning, University of Delaware: **Richard N. Benson**, "The North American Middle Atlantic Continental Margin—Geology and History of Petroleum Exploration," March 26, and "Seismology and Earthquakes in Delaware and Adjacent Areas," April 23; **William S. Schenck**, "Delaware Piedmont Geology: Just What Rocks Are Holding Up Them-Thar Hills?," April 13, and "Geology Question and Answer Session," May 7.

Robert R. Jordan, participated in a panel discussion "Strategic Retreat from the Beach" sponsored by the Delaware Chapter of the Sierra Club, Widener University School of Law, Wilmington Campus, May 4.

Thomas E. McKenna, "Hand-Held Thermal Imaging of Ground-Water Discharge," at The Richard Stockton College of New Jersey, April 1.

William S. Schenck, "Rocks, Minerals, and Fossils and Just What Do Geologists Do?," at elementary workshop for first, second, and third grades, Wilmington, April 23.

Service and Awards

Congratulations to **Stefanie J. Baxter** who was promoted to Research Associate II.

Congratulations to **Thomas E. McKenna** for being the first graduate (1984) of the Geology Department at The Richard Stockton College of New Jersey to earn a Ph.D. in geology.

Externally Supported Projects

From the U.S. Environmental Protection Agency to William J. Ullman, Joseph R. Scudlark, and Kuo-Chuin Wong of the University of Delaware College of Marine Studies, **Thomas E. McKenna** and **A. Scott Andres** of the DGS, John A. Madsen of the University of Delaware Department of Geology, and David E. Krantz of the U.S. Geological Survey for "CISNet: Nutrient Inputs as a Stressor and Net Nutrient Flux as an Indicator of Stress Response in Delaware's Inland Bays Ecosystem."

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