First State Geology

RESEARCH DELAWARE GEOLOGICAL SURVEY SERVICE EXPLORATION

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Hurricane Gloria

John H. Talley

Hurricane Gloria passed through Delaware on September 27, 1985 at speeds between 20 and 25 mph and was accompanied by relatively heavy precipitation (3.26 to 5.35 inches statewide) and strong east, northeast, north, and northwest winds. The fast-moving hurricane tracked north-northeast approximately 30 miles off the coast of Delaware. Strong northeast winds (30-45 mph) with gusts up to 58 mph buffeted coastal Delaware prior to the passage of the eye of Gloria. During passage of the eye between 7:45 and 8:15 a.m. in coastal Delaware, winds shifted from east-northeast to northwest, and wind speeds increased to 40 to 65 mph with gusts up to 78 mph (Figure 1).

The low barometric pressure and high east-northeast winds which coincided with the high-tide cycle resulted in tides substantially above normal along the coast and in Delaware Bay. Waters remained relatively high for only one tidal cycle, with most flooding occurring during the morning high tide. Rapid shifts in wind direction and increases in wind speed associated with the passage of the eye of the storm blew waters out of the Bay and marshes and resulted in a below-normal low tide within six to seven hours of the above-normal high tide. For example, at Breakwater Harbor in Lewes, the water level declined approximately ten feet in seven hours. The high rate of water-level decline created spectacular conditions in marshes bordering Delaware Bay where water draining them could be seen cascading down tributary channels, forming standing waves and small waterfalls (Figure 2.)

Maximum heights of tides recorded at four tidal-crest-stage, partial-record stations did not reach levels as high as those attained during many previous storm events documented since 1962.

The storm surge, high east-northeast winds, and passage of the center of the hurricane close to Delaware during high tide resulted in structural damage to several shore-front structures in Rehoboth Beach, Bethany Beach, and South Bethany. Beach erosion and dune destruction ranged from moderate to severe. Areas where dunes were breached or wash-overs occurred were concentrated, for the most part, in highly developed and heavily used beach areas where dunes have narrow bases, are relatively low in elevation, or are non-existent. Erosion and/or destruction of dunes was most prevalent between Indian River Inlet and the Old Coast Guard Station, and in Fenwick Island.

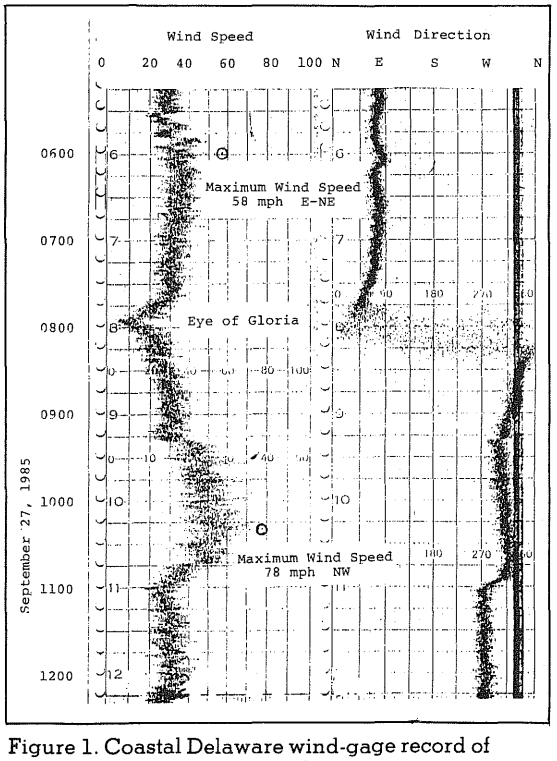


Figure 1. Coastal Delaware wind-gage record of Hurricane Gloria, Old Coast Guard Station (courtesy of Anthony P. Pratt, DNREC).

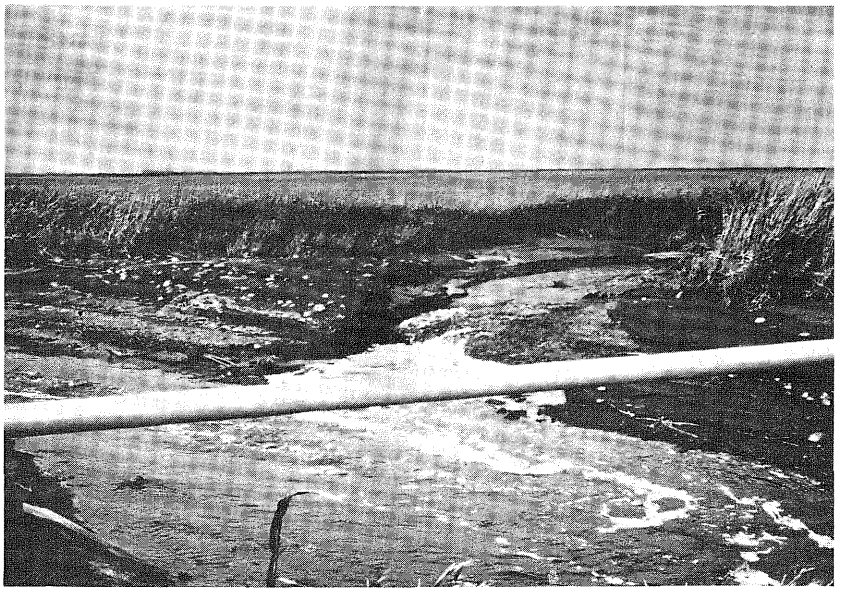


Figure 2. Cascading waters draining marsh bordering Delaware Bay at Port Mahon during low tide following passage of Hurricane Gloria.

More Earthquakes

Kenneth D. Woodruff

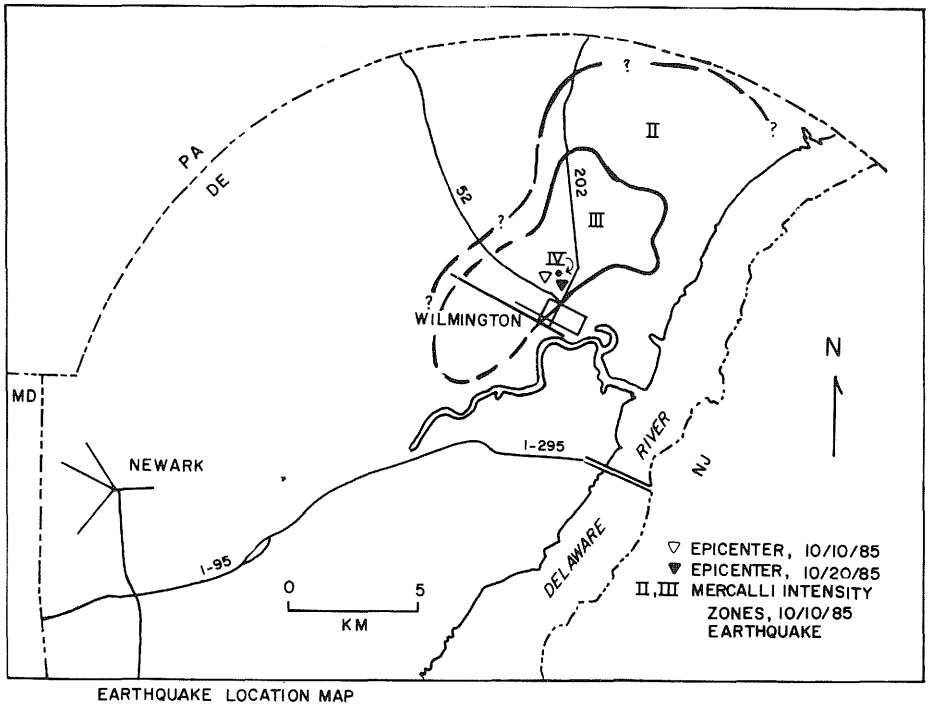
After nearly two years of relative quiet, the Wilmington area was once again shaken by two small earthquakes during October 1985. The first occurred at about 9:47 p.m. on October 10 and was centered in the Brandywine Creek just southwest of the Alapocas Woods area. Calculations indicated the magnitude was about 1.9. The second event took place on October 20 at 3:55 a.m. and registered a magnitude of 1.7. The epicenter was immediately north of Route I-95, about 0.4 mile east of Brandywine Creek.

The October 10 event was felt from McDaniel Heights southwest to near Elsmere. Those living closest to the epicenter reported hearing a sharp explosion with some shaking. Reports coming from farther away indicated that the earthquake sounded like thunder or a passing truck. These reports were used to draw an intensity map (see accompanying figure) which indicates how people perceived the event. The area of highest intensities and the calculated epicenters agree fairly closely.

Deployment by the DGS of two new seismographs in the Wilmington area last year paid off as both earthquakes were accurately located from the instrument data. The epicenters were within a triangle formed by joining the locations of the two new stations and an existing station west of Wilmington.

Compounding our data-collection efforts was the occurrence of two other larger earthquakes just north of New York City at about the same time as the Delaware ones. On the morning of October 19 a magnitude 3.8 tremor shook much of the northeastern U.S. and was followed by a smaller aftershock of 2.8 magnitude at 6:42 a.m. on October 21. The initial event was one of the largest on the east coast to be recorded in the last 100 years and was apparently felt in northern Delaware. The New York earthquakes were recorded by all five stations of the DGS seismic network, and the data may provide a great deal of valuable information about local deep geologic structures. A magnitude 3.0 earthquake also occurred near Boston on October 15 but was not recorded in Delaware.

The intriguing question for geologists is whether or not there is a direct relationship between these events separated by distances of two or three hundred miles. There is no single, mapped, fault trace or surface of recent origin that connects these locations, despite repeated speculations to the contrary. However, the directions and distribution of stresses in the earth's crust may be related to a common source or series of sources. The resulting earthquakes, in many cases, appear to occur along pre-existing zones of much older faulting. Unlike major west coast seismic zones, earthquakes in the east present a more puzzling case because there are no known mapped faults along which recent movement has been demonstrated. Statistical evidence for frequency of occurrence is also insufficient because of the relatively long time between significant events. Nevertheless, because of the large population in the region, continuing efforts to understand and characterize eastern earthquakes are important.



EARTHQUAKE LOCATION MAP

Coastal Aquifers Project

The Coastal Aquifers Project, begun in spring 1985, is a two-year joint study with the U.S. Geological Survey to monitor seasonal trends in ground-water levels and chloride concentrations in wells in the upper Chesapeake Group aquifers of coastal Delaware and Maryland (see previous issue of *First State Geology*). John H. Talley and A. Scott Andres are the DGS hydrogeologists working on the project in Delaware.

Andres reports that the results from this past summer's intensive data collection effort are now being tabulated and entered into the DGS and USGS computerized data bases. An unexpectedly high chloride concentration (indicating contamination by salt water) was found in a new well drilled for a bathhouse at Delaware Seashore State Park near Fenwick Island. The well is being sampled frequently to check seasonal variations in quality, and the source of the salty water is under investigation. Of paramount importance is whether or not the salty water comes from the screened aquifer or enters the well from overlying units known to contain salt water. The answer to this has implications for the future water supply potential of Fenwick Island.

Radon Accumulation in Buildings

Kenneth D. Woodruff

The potential for the accumulation of radioactive gaseous radon in buildings, including homes, in Delaware is being investigated in a joint study by the DGS, the Delaware Division of Public Health, and the Department of Natural Resources and Environmental Control (DNREC). The University of Delaware Safety Office is also providing technical help. The joint effort will gather background information on natural radon levels in buildings and soils in selected areas of northern Delaware. Radon is a naturally occurring gas that results from the radioactive decay of minute quantities of uranium or radium in the bedrock or soil. Radon itself has a short half-life (3-4 days), and as it decays it emits alpha particles, a weak radiation which has little penetrating power. Outdoors, radon is dissipated in the air, and in buildings it is prevented from reaching high accumulations by adequate ventilation. However, in some circumstances radon from the soil may enter a confined or poorly

ventilated space through openings in buildings such as foundation cracks or utility openings. Levels may then rise high enough to present a potential health hazard, although it is still not clear what the acceptable health limits might be. Present risk estimates by the Environmental Protection Agency (EPA) suggest that a radon concentration of 1 picocurie per liter (pCi/L) is the upper limit for long-term exposure. This is approximately equivalent to the risk of getting lung cancer by smoking one cigarette per day.

The risk of lung cancer from radon exposure is due, paradoxically, to the fact that the low energy alpha particles are trapped in lung tissues rather than passing through them as higher energy particles might.

Local and regional concerns have been prompted by the investigations in Pennsylvania in the area known as the Reading Prong. This is a relatively narrow ridge of diverse rock types that extends from near Easton, Pennsylvania southwest to near Reading. Equivalent rock types extend northeasterly into New Jersey and New York. Both localized uranium mineralization and diffuse, higher-than-normal uranium concentrations in these rocks have the potential for generating high radon accumulations in many areas over the Prong. Other general areas of concern include terrains underlain by rocks of granitic composition and by black shales.

Recent meetings and discussions with geological survey personnel from neighboring states indicate that a great number of variables affect local concentrations of radon. These include bedrock type, depth and type of soil or weathered rock, type of building construction, the heating or ventilation system, time of year, moisture content of the soil, wind speed and air pressure.

Delaware's study is aimed at preliminary screening of areas in the Piedmont Province, which is that area of the northernmost part of the State underlain by crystalline rocks of the Wissahickon Formation and Wilmington Complex. Analysis of radon is not straightforward and involves both time for an adequate sample and the use of techniques not now available in Delaware. The bulk of actual analyses will be done by a firm specializing in such techniques. The DGS will provide guidance in the selection of sampling areas based on the geology and soil type, while DNREC and the Division of Health will oversee the actual sample collection and analysis. It is expected that about a year of effort will be needed to produce results that are statistically valid.

U. S. Geological Survey Profiles Delaware Bay

During July 1985, personnel of the U.S. Geological Survey (USGS), as part of their coastal, estuarine, and lacustrine studies project, conducted a scientific cruise of Delaware Bay aboard the *Asterias*, a research vessel contracted by USGS from the Woods Hole Oceanographic Institution. Harley J. Knebel of the USGS Branch of Atlantic Marine Geology located at Woods Hole, Massachusetts was the Chief Scientist. Richard N. Benson and Thomas E. Pickett of the DGS were aboard the *Asterias* on July 11 when the vessel twice crossed the widest part of the Bay.

The purpose of the cruise was to collect high-resolution seismic-reflection profiles and sidescan-sonar records to define the geologic and geophysical characteristics of the bottom and subbottom sediments in lower Delaware Bay. By analyzing these data, the scientists hope to determine (1) the shallow subbottom stratigraphy and the Holocene and pre-Holocene depositional history of the bay; (2) the types of bottom morphology; and (3) possible areas of sediment accumulation and erosion.

During ten days of surveying, 592 line kilometers of both Uniboom (seismic profiles) and Klein sidescan-sonar data were collected. Records are being interpreted by Knebel with the aid of scientific information supplied by DGS and researchers of the University of Delaware Department of Geology.

Benson and Pickett report that the seismic profiling records reveal the ancient valley of the Delaware River when sea level was lowered during glacial times. Also, within the sedimentary fill of the ancient valley, the records indicate one or more events of cut and fill that may reflect additional fluctuations of sea level.

The results of the study will provide a significant contribution to our understanding of the geologic history of the Delaware River and Delaware Bay.

New Publication on Subsurface Geology of Central Delaware

The DGS has released a 69-page report on the subsurface geology of central Delaware. It is based on a study of 140 cores of sedimentary rock from a 1,422-foot-deep well drilled in 1957 at the Dover Air Force Base. Data from the test well have been used in many past geological and hydrological studies. Published as DGS Bulletin No. 17, "Geological Studies of Cretaceous and Tertiary Section, Test Well Je32-04, Central Delaware," the report was authored by Richard N. Benson, Robert R. Jordan, and Nenad Spoljaric.

Rock texture, mineralogy, chemical composition, and fossil content were studied. Interpretations of this information include the ages, depositional environments and geologic history of the sedimentary rocks. The detailed information and interpretations are displayed on three large plates accompanying the report.

Allowing for uncertainties due to the lack of areal investigation, the formations identified are: Potomac, Magothy, Merchantville, "Englishtown," "Marshalltown," Pamunkey(?), Piney Point, Calvert, and Columbia. They range in age from late Cretaceous to Pleistocene.

Transgression in Santonian time resulted in deposition of the Magothy Formation on older, continental rocks. Marine conditions persisted into the Bartonian. The greatest water depths were present in the Paleocene and Eocene. Subaerial erosion occurred in late Eocene-early Oligocene, followed by marine deposition from late Oligocene to mid-Miocene. The Tertiary closed with another interval of subaerial erosion.

Three disconformities record the intervals of subaerial exposure. Three additional disconformities are recognized by missing biozones within the marine section: middle Maastrichtian-Danian, Danian-Thanetian, and Ypresian-Lutetian.

The Bulletin provides much new information and revises previous interpretations. It will serve as a basis for subsurface correlation of the sedimentary rocks of Delaware and adjacent parts of the Atlantic Coastal Plain and also in nearby offshore areas that have been drilled in the search for oil and gas.

Publications

Recent DGS Publications

Bulletins

No. 17 Geological Studies of Cretaceous and Tertiary Section, Test Well Je32-04, Central Delaware: R. N. Benson, R. R. Jordan, and N. Spoljaric, 1985, 69 p., 3 pls.

Miscellaneous Map Series

No. 3 Geologic Cross-Section of Delaware River, Red Lion Creek to Killcohook National Wildlife Refuge: J. H. Talley, 1985.

Special Publication

List of Publications: 1985: J. H. Talley and D. C. Windish.

Forthcoming DGS Publications

Seismic Stratigraphy and Depositional History of the Post-Choptank Chesapeake Group: A. S. Andres.

Geology of the South-Central Kent County Area, Delaware: T. E. Pickett and R. N. Benson.

DGS Drill Rig Manual: R. E. Bounds

Taylors Bridge Quadrangle: N. Spoljaric, editor.

Sodium Concentration in Ground Water from the Piney Point Formation, Central Delaware: N. Spoljaric

Other Publications by DGS Staff

R. R. Jordan, 1985, Citation for William L. Fisher, Recipient of Public Service Award of American Institute of Professional Geologists: *The Professional Geologist*, v. 22, p. 365.

Staff Notes

The DGS welcomes two new staff members. **Michael G. Kramer** fills our newly established technician position. As Senior Research Technician, he will be in charge of laboratory analyses and geophysical instrumentation. He earned a B.S. degree in geophysics at the University of Delaware. **Tracy S. Stapleford** is a new temporary employee hired as a cartographic technician with funds from a one-time State appropriation to the DGS to aid the Delaware State Boundary Commission in establishment and conservation of Delaware's boundary markers. Tracy earned her B. A. at the University of Delaware as a combined geography-geology major.

William S. (Sandy) Schenck, Research Associate II and a DGS staff member supported by contract funds since 1980, is now a permanent staff member effective October 1, 1985 as a result of his position now being funded by State appropriation. Sandy will continue handling inquiries for services and information and managing the benchmark repository and DGS Cartographic Information Center.

Schenck hosted a conference of the Northeastern State Affiliates of the National Cartographic Information Center on July 12. States from Massachusetts to West Virginia were represented, and representatives from the U. S. Geological Survey attended.

Although not officially a DGS staff member, **John Roberts**, graduate student in the University of Delaware Geology Department and a graduate of Lehigh University, is the recipient of the first DGS Research Assistantship for the academic year 1985-86 and fall semester 1986. Funds for the assistantship are provided by the U. S. Department of Interior's Minerals Management Service in a cooperative agreement with the Association of American State Geologists. John will be working under the supervision of Richard N. Benson, Senior Scientist, studying the subsurface geology and petroleum potential of Delaware and the adjacent offshore area.

Robert R. Jordan, Director and State Geologist, was appointed by Secretary of the Interior Hodel, on the nomination of Governor Castle, to the Outer Continental Shelf (OCS) Policy Committee and the Mid-Atlantic OCS Regional Technical Working Group. Both units advise the Secretary on the OCS oil and gas leasing program. Jordan was reappointed by Governor Castle to the Delaware State Boundary Commission and the Delaware State Board of Registration of Geologists. He also will serve on the State Committee on Leaking Underground Storage Tanks, according to the provisions of Senate Bill 244 passed in June 1985. Jordan was appointed to the North American Commission on Stratigraphic Nomenclature for a three-year term by the president of the American Association of Petroleum Geologists, William L. Fisher.

Jordan also participated in the following: the Annual Conference of the Delaware Inland Bays Committee as a member of the panel discussing "Our Threatened Drinking Water: What Can Be Done To Protect It?" at Rehoboth Beach, July 12, 1985; the International Symposium on Foreland Basins at the University of Fribourg, Fribourg, Switzerland, September 2-4, 1985, where he presented a paper "Correlation of Controls of Deposition in Mid-Atlantic Margin of USA" in poster format and also participated in pre- and post-meeting field trips in the Swiss Molasse Basin and the Northern Apennines; as citationist for the recipient of the Public Service Award of the American Institute of Professional Geologists, Dr. William L. Fisher of Texas, at the Annual Meeting of the Institute, September 19, 1985, St. Paul, Minnesota.

Richard N. Benson, Senior Scientist, represented Delaware at the Plenary Session of the North, Mid-, and South Atlantic Regional Technical Working Groups of the U.S. Department of Interior's Outer Continental Shelf (OCS) Advisory Board in Arlington, Virginia, September 6, 1985. The meeting was preceded by the first annual Atlantic OCS Region Information Transfer Meeting, September 4-6. Benson also participated in a panel presentation on environmental and policy considerations for Delaware as part of the Delaware Nature Education Society's symposium "Ocean incineration: a possible solution to toxic wastes," at Ashland Nature Center, November 6, 1985.

Thomas E. Pickett, Associate Director, presented a paper "A Comparison of Mesozoic Stratigraphy in Southern England and the U. S. Middle Atlantic States Margin," at the Annual Meeting of the Geological Society of America in Orlando, Florida, October 28-31, 1985.

John H. Talley, Scientist, presided over a technical session titled "Vadose Zone Transport and Monitoring," at the 28th Annual Meeting of the Association of Engineering Geologists held in conjunction with the International Symposium on the Management of Hazardous Chemical Waste Sites , Winston Salem, NC, October 7-11, 1985. Talley was also reappointed by Governor Castle to the Delaware State Board of Registration of Geologists.

Nenad Spoljaric, Senior Scientist, presented a talk entitled "Glauconitic Greensand, a Geologic Problem in Need of a Solution," to the Philadelphia Geological Society at Bryn Mawr College, Pennsylvania, November 6, 1985.

Kenneth D. Woodruff, Associate Director, conducted a short course on ground-water and well-logging fundamentals at the Utah Division of Oil, Gas, and Mining, September 26 - 31, 1985. The course was given at the invitation of the Division and was followed by an inspection trip to coal mines in eastern Utah.

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