UNEARTHING NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY
Department of Environmental Protection
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MESSAGE FROM THE STATE GEOLOGIST

The New Jersey Geological Survey (NJGS) provides geoscience information to government agencies, consultants, industry, environmental groups and the public. The work of the Survey covers large regional issues of environmental concern and economic development, as well as smaller, educational studies. This volume of *Unearthing New Jersey* highlights four projects that illustrate the wide range of work performed at NJGS.

Geologic events during the past 10 million years are Scott Stanford's newsletter subject. The landscape and surface features that we see today in New Jersey were shaped during this time. Valleys, ridges, plains, and uplands all were formed by river erosion and deposition and glacial activity in northern New Jersey. Scott has reconstructed past New Jersey landscapes, tied them to changes in sea level and linked them to North America's glacial history. Geologic evidence of changing sea level not only provides information to scientists on the possible impact of future global climate change, but informs government agencies and elected officials who are concerned with this important issue.

Mike Serfes and Ray Bousenberry present information on the redesigned Ambient Ground-Water Quality Monitoring Network (AGWQMN). This network consists of shallow wells that are sampled periodically to evaluate land use impacts on ground-water quality in agricultural, urban, suburban and undeveloped areas. The data shows that total dissolved solids and a variety of trace elements, nutrients, volatile organic hydrocarbons (VOC) and pesticides are present at significantly higher levels in wells located in agricultural and urban areas in comparison to undeveloped areas. This clearly illustrates the impact of our land use on ground water quality.

Steve Spayd and Mike Serfes summarize the Survey's work investigating the distribution of arsenic in wells that draw ground water from Piedmont Aquifers. Their study of the source, nature, and extent of arsenic in ground water has determined it to be naturally occurring in aquifers located in the Stockton, Passaic, and Lockatong Formations. The number of private wells exceeding the new standard (effective January 2006) of 5 ug/L (5ppb) is around 15% in the Piedmont. Helping to remedy this problem, the Survey coordinated a study of efficient, cost effective, user friendly, and environmentally sound water treatment technologies that remove arsenic from residential well water.

Finally, John Dooley presents new findings on the formation of rare minerals on pyrite (FeS_2) nodules from the Woodbridge Clay Member of the Raritan Formation (Upper Cretaceous) near Sayreville. After collection, the nodules were found coated with a fuzzy white bloom of metal sulfates formed by the oxidation of pyrite. In the natural environment, weathering and dissolution of these sulfate minerals during storm runoff can acidify streams, lead to acidic groundwater and rapidly increase metal loading to surface waters.

The Survey welcomes feedback on the content and format of the newsletter (http://www.njgeology.org/comments.html). Other recent geologic activities and digital publications of the Survey are noted in the newsletter and elsewhere on the Survey's Web site. Printed maps and reports are available to the public through the DEP Maps and Publications Office (609) 777-1038, P.O. Box 438, Trenton, N.J. 08625-0438, and a publications price list is maintained on the Web. Staff are available to answer your questions 8 a.m. - 5 p.m. Monday through Friday by calling (609) 292-1185.

Karl W. Muessig
New Jersey State Geologist

THE GEOLOGIC HISTORY OF NEW JERSEY'S LANDSCAPE

By Scott Stanford

The rocks under New Jersey were formed by geologic events occurring as long ago as 1.3 billion years, but the landscape etched into those rocks is much younger. Within the past 10 million years rivers formed the valleys, ridges, plains, and uplands of the state by erosion and deposition. In northern New Jersey, glaciers shaped the final surface features of the landscape within the past 2 million years. Sediments that were laid down by rivers and glaciers, and by marine currents in estuaries and coastal areas, are the record of these events. These sediments, known as surficial deposits, overlie bedrock and Coastal Plain deposits and are distinguished from the older formations by their recognizable relationship to landforms associated with today's geography.

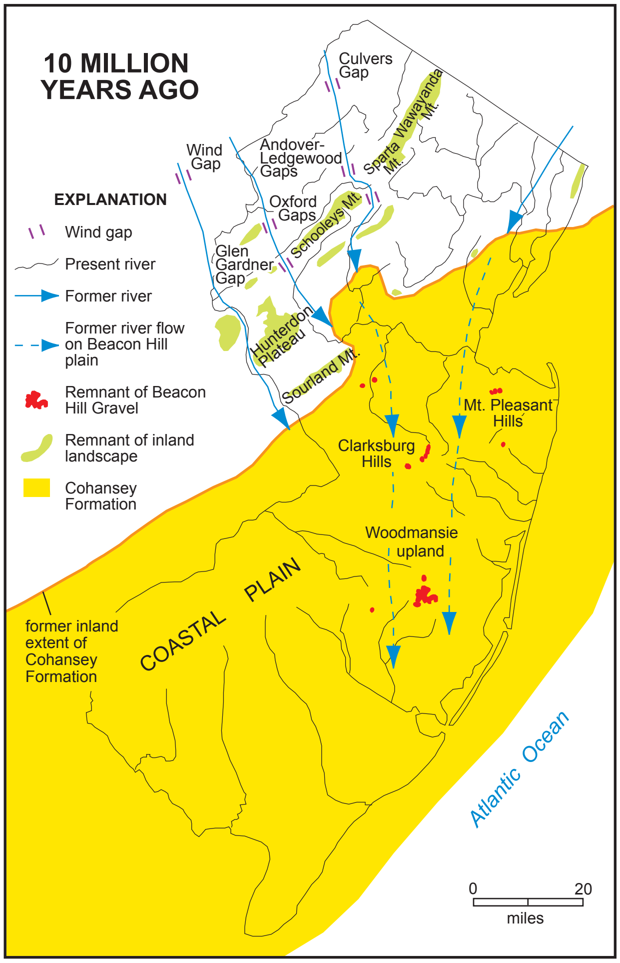

Figure 1. Landscape features ten million years ago.

By mapping these deposits we can reconstruct past landscapes.

As a coastal state, the history of New Jersey's landscape is closely tied to changes in sea level. Located in a tectonically quiet area where the land rises and subsides very slowly and moderately, sea level in New Jersey mostly reflects the amount of water in the ocean. The global volume of sea water is largely determined by the size of glaciers in Antarctica and the northern polar regions. Vast amounts of water have alternately been locked up as ice or melted into the oceans. Thus, the development of New Jersey's landscape is directly linked to the Earth's glacial history.

10 MILLION YEARS AGO

Between 15 and 10 million years ago there was a significant increase in the size of Antarctic glaciers. In fact, so much water evaporated from the oceans and fell as snow in the polar regions that global sea level dropped between 150 and 250 feet. Across the southeastern two-thirds of New Jersey the sea withdrew and sand was deposited in beaches, tidal channels and deltas, and nearshore bars. Today these sands comprise the Cohansey Formation, which covers much of southern New Jersey. The current northern edge of the Cohansey is at an elevation of about 350 feet in some places, indicating that these sands once extended inland to about the position shown on figure 1.

By about 10 million years ago, sea level had dropped and exposed a flat sandy coastal plain. Rivers flowing across this plain to the Atlantic Ocean deposited a broad, thin sheet of sand and gravel, the remnants of which are known as the Beacon Hill Gravel (fig. 1), preserved on the highest hills in the Coastal Plain. These include the Clarksburg and Mount Pleasant Hills in Monmouth County and the Woodmansie upland in Ocean and Burlington Counties. Similar upland river gravels dating from this time occur along the inner edge of the Coastal Plain in Pennsylvania, Delaware, Maryland, and Virginia.

The Beacon Hill deposits do not extend into northern New Jersey. However, the gravel sources have been identified, and together with the slope of the Beacon Hill river plain, indicate that the northern part of the state was at that time crossed by several south-flowing rivers (fig. 1). Evidence of these vanished rivers are seen in the aligned sets of gaps in Kittatinny Mountain and the Highlands, through which no rivers flow today, which are located several hundred feet above modern valley bottoms. Such gaps are known as *wind gaps* and mark former river courses. The position of these gaps high above present valleys show that during deposition of the Beacon Hill Gravel, the landscape of northern New Jersey was more subdued than it is today. Ridges and uplands like Kittatinny Mountain and the Highlands rose gently, perhaps 100-300 feet above surrounding lowlands, rather than the 500- 1000 feet of today. The flat tops of Schooleys Mountain, Sourland Mountain, and the Hunterdon Plateau (fig. 1) are relicts of that subdued landscape. Similar flat-summit areas were likely present farther north, such as atop the Sparta Mountain-Wawayanda Mountain upland, but these were subsequently eroded by glaciers and are no longer flat.

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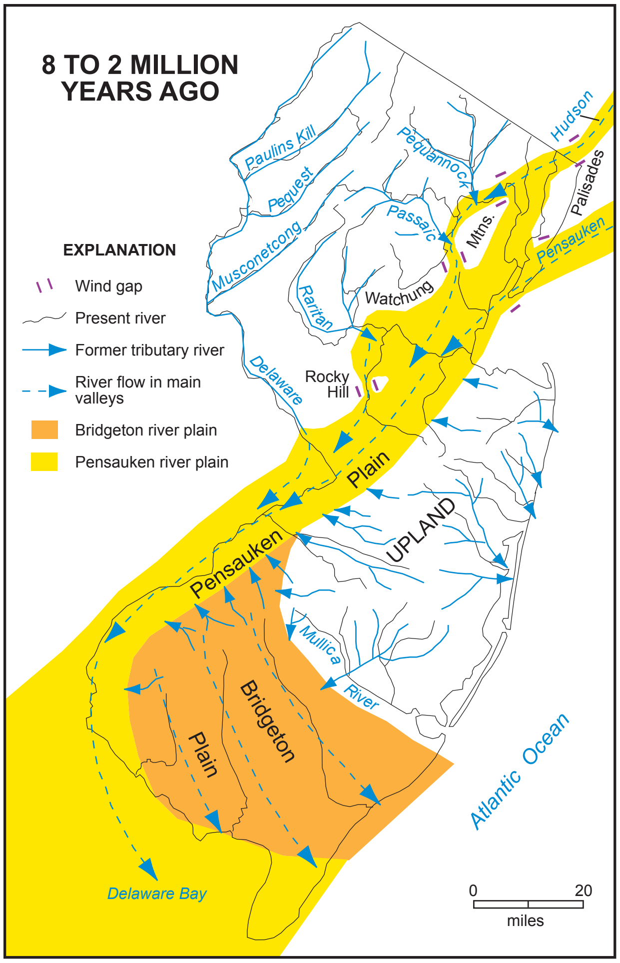

Figure 2. Landscape features between eight and two million years ago.

The south-flowing river system in the Coastal Plain gradually shifted to the southwest and, by perhaps 8 million years ago, eroded a new valley west of the Beacon Hill Plain. A lower sand and gravel river plain was deposited by this system across southern New Jersey (fig. 2). These deposits are known as the Bridgeton Formation. Today remnants of this plain form the flat uplands between the Mullica River and Delaware Bay. As the new valley was eroded and the Bridgeton Plain laid down, the region to the northeast of the plain became an upland. Local streams draining this upland cut shallow valleys and deposited gravel that had been eroded from the Beacon Hill deposits capping the upland. Today, the courses of these streams are marked by gravel deposits atop hills and ridges. These ridges formed by a process known as *topographic inversion*. As streams deepened their valleys, they washed away the sand along the sides of the valley, while gravels in the old stream channels resisted erosion and remained behind to eventually form ridges.

8 MILLION YEARS AGO

Between 8 and 5 million years ago, the Coastal Plain river system shifted southwesterly yet again, cutting a new, deeper valley to the west of the Bridgeton Plain. This new valley, situated along the inland edge of the Coastal Plain, was eroded to slightly below modern sea level. This placed it as much as 300 feet below the level of the Beacon Hill Plain and 200 feet below the Bridgeton Plain. The main trunk of the river system that carved this valley no longer exists. Known as the Pensauken, this trunk river flowed southwestward from what is now the Long Island Sound lowland (fig. 2). The Delaware, Raritan, and Hudson rivers were tributaries to the Pensauken. The Pensauken may also have included drainage from southern New England, perhaps including the Connecticut River Basin. The routes of the ancestral Hudson, Raritan, and Pensauken Rivers in northeastern New Jersey are marked by a series of wind gaps in the Watchung Mountains, Palisades ridge, and Rocky Hill (fig. 2). These gaps formed when the rivers eroded downward through a cover of Beacon Hill sand and gravel and encountered the underlying bedrock that today constitute these ridges.

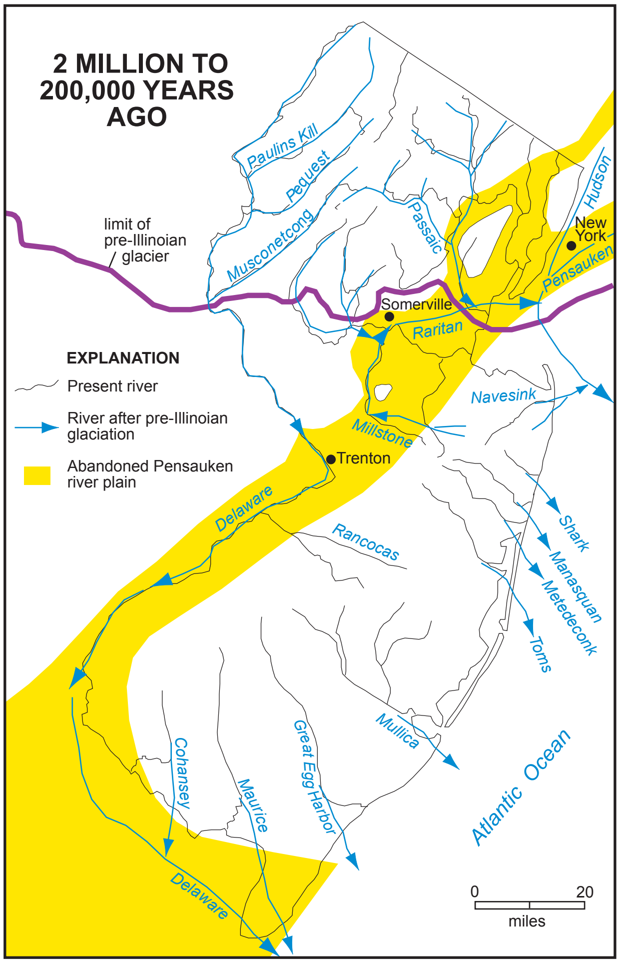

Figure 3. Landscape features between two million and 200,000 years ago.

As the Pensauken River deepened its valley, so did its tributaries. Streams that ran on limestone and shale bedrock deepened valleys more rapidly than those on more resistant rock, like quartzite and gneiss, because limestone is prone to dissolve in water and shale is mechanically weak. The streams flowing on these erodible rocks, which trend northeast-southwest over much of northern New Jersey, gradually intercepted the southeast-flowing streams held up on more resistant rock in a process known as *stream capture*. Between 10 and 5 million years ago a series of such captures consolidated the several southeast-flowing streams in northern New Jersey into a single drainage, the present-day Delaware River. Lower portions of the former streams, below the points of capture, became the Raritan and Passaic Rivers.

Between 4 and 3 million years ago, global sea level rose, most likely because of partial melting of Antarctic ice. This rise caused the Pensauken River to deposit a plain of sand and gravel, filling its valley with sediment up to 140 feet deep. This deposit is known as the Pensauken Formation (fig. 2). Local tributaries draining the Coastal Plain upland southeast of the Pensauken Valley, an upland that now included the former Bridgeton Plain, are marked today by topographically inverted gravels that cap ridges and hilltops. In northern New Jersey, rivers draining to the Pensauken River began to broaden their valleys when the Pensauken plain was deposited, forming flat lowlands and valley bottoms, primarily on shale and limestone bedrock.

2 MILLION YEARS AGO

Around 2.5 million years ago, glaciers began to form in the northern polar regions, again gradually lowering sea level. The first ice sheet to cover North America advanced about 2 million years ago and is called the pre-Illinoian glaciation. In New Jersey, this ice sheet reached as far south as Somerville (fig. 3) and blocked the Pensauken Valley in the New York City area. Glacial erosion and deposition altered the valley so that when the ice melted back, the Pensauken and Hudson Rivers drained directly southeast to the Atlantic Ocean through a new valley that breached the former Coastal Plain upland. The Pensauken Plain between New York and Trenton was abandoned. A new drainage network that included the lower Raritan, Millstone, and Delaware (below Trenton) Rivers, was established on the abandoned plain. Over the next 1.5 million years these rivers, responding to the lowered sea level caused by continued northern hemisphere glaciation, eroded narrow inner valleys from 50 to 100 feet below the level of the Pensauken Plain. At the same time, inner valleys were eroded between 50 and 200 feet into the broad valley bottoms and lowlands upstream from the Pensauken Plain in northern New Jersey and the Coastal Plain upland. This episode of valley deepening created the basic form of the present landscape. Within the past 200,000 years most landform change has involved deposition and erosion by streams, glaciers, and hillslope movement within

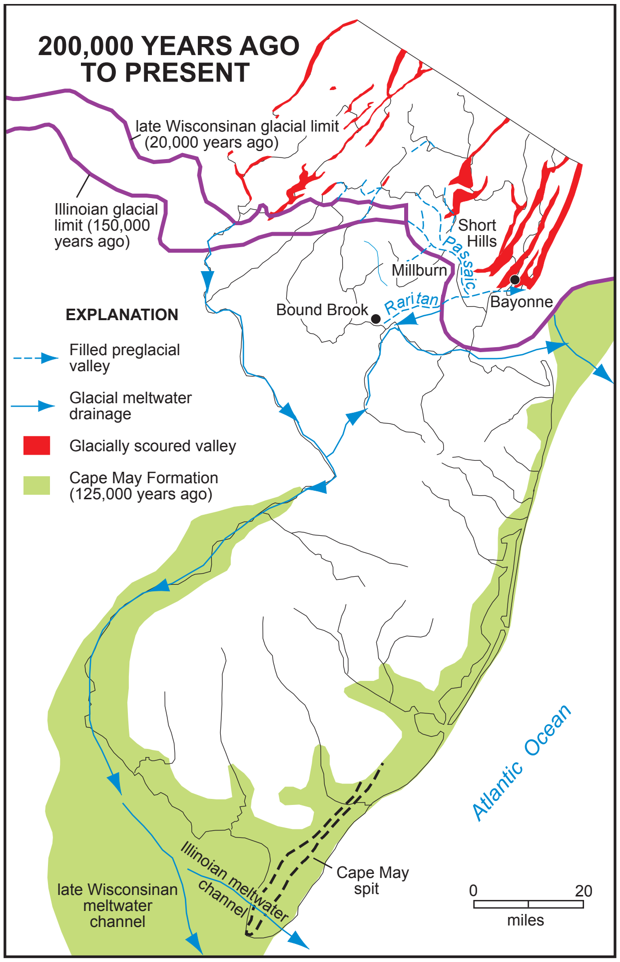

Figure 4. Landscape features in the past 200,000 years.

this landscape, as climate varied from cold glacial periods to warm interglacials.

Large ice sheets grew and melted in North America about 10 times within the past 800,000 years. At least two of these glaciers covered the northern third of New Jersey (fig. 4), most recently about 20,000 years ago (late Wisconsinan), and the one earlier, perhaps 150,000 years ago (Illinoian). With each advance, glacial ice eroded soil and older surficial sediment and shaped the underlying bedrock. Ledges and cliffs were formed on the hard rock of ridges and uplands and troughs scoured in softer rock in valleys and lowlands. In places, these scourings deepened preglacial valley bottoms by 300 feet. As the melting ice front receded northward, sediment in the ice was deposited in lakes, river plains, and moraines. These sediments now fill some valleys with as much as 350 feet of material.

200,000 YEARS AGO

The combination of valley scouring and filling caused some rivers to shift from their preglacial courses (fig. 4). The most noteworthy shifts occurred in the Passaic and Raritan Valleys. The preglacial Raritan River flowed northeasterly from near Bound Brook to the Bayonne area where it emptied into the Hudson. The preglacial Passaic Basin drained southward into the Raritan River through gaps in the Watchung Mountains at Short Hills and Millburn. The lower part of the Raritan Valley and the Short Hills gap were filled with glacial deposits, deflecting the rivers into their present, separate courses. Smaller reroutings occurred in the Rockaway, Lamington, and Musconetcong Valleys. Other shifts farther north are less clear because glacial erosion has removed most of the preglacial valley form.

In areas not covered by glaciers, the tundra-like climate during glacial maxima created some subtle landform details that remain visible today. Most prominent are *thermokarst* basins, which are small, shallow depressions that may contain seasonal wetlands or small ponds. These features are widespread in the Coastal Plain and formed when permafrost melted.

Between glacial periods, climate warmed and sea level rose as the northern ice sheets melted. During these interglacial periods, rising sea water flooded the lower reaches of river valleys, forming estuaries and bays like those found today along the coast. During the warmest interglacials, sea level rose higher than it is at present. Shoreline and estuarine deposits laid down during these periods of high water today form terraces up to 70 feet in altitude that border the state's coastal areas. Collectively, these deposits are known as the Cape May Formation (fig. 4). The most prominent of these marine terraces was laid down 125,000 years ago during the most-recent interglacial when sea level was about 20 feet higher than now. Those deposits ring the coast just inland of modern beaches and salt marshes. The Cape May Peninsula is a former beach spit that grew southward across Delaware Bay during this time.

Future glaciations and interglacials will continue to shape the New Jersey landscape. From a human perspective, geologic evidence of changing sea level due to glaciation and deglaciation are concrete reminders of the far-reaching and profound effects of global climate change. For example, if global warming melts part of the Antarctic or Greenland ice sheets, the ocean could rise to its level of 125,000 years ago, submerging the coast to the same extent it was when the Cape May Formation was deposited (fig. 4). As with lessons from human history, we do well to learn from the natural history of our landscape.

◆ FeS_2 ◆

NEW JERSEY'S REDESIGNED AMBIENT-GROUND-WATER-QUALITY MONITORING NETWORK

By Mike Serfes and Ray Bousenberry

Pollution impacting New Jersey's ground-water resources can be broadly classified as spatially defined point sources, such as leaky underground storage tanks, and spatially diffuse non-point sources, such as areas where agricultural chemicals are being applied. The identification, investigation and remediation of point sources of pollution in the state have been a key function of the New Jersey Department of Environmental Protection (NJDEP) for many years. In contrast, the evaluation of non-point source pollution of

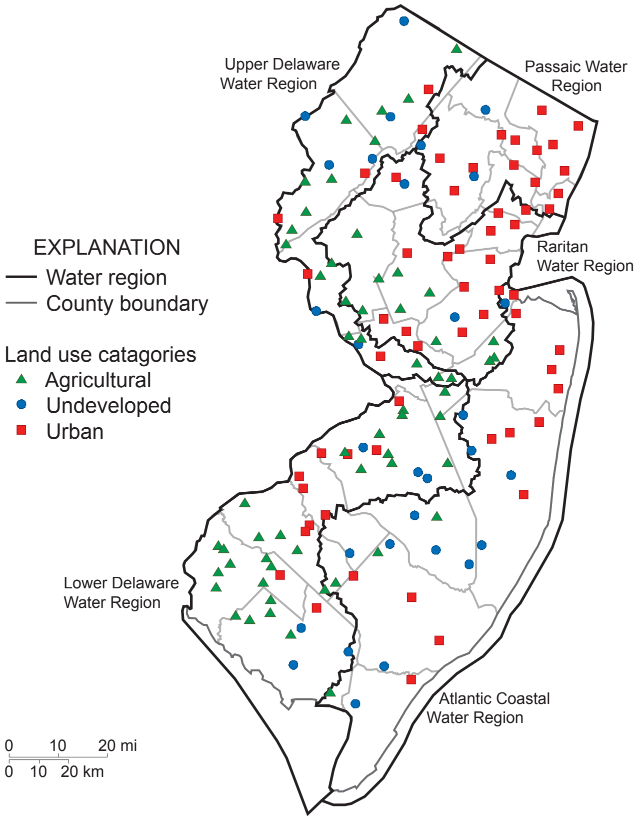

Figure 1. New Jersey's Ambient Groundwater Quality Monitoring Network, 1999-2004.

ground-water has only recently been undertaken.

The redesigned Ambient Ground-Water Quality Monitoring Network (AGWQMN) is a cooperative project between the NJDEP and the United States Geological Survey (USGS) in which shallow wells are sampled periodically to evaluate land use impacts to ground-water quality in agricultural, urban/suburban and undeveloped areas. The original (pre 1999) network used existing wells to determine the influence of geology on ground-water quality in New Jersey. The goals of the recently completed well network are to determine the status and trends of shallow ground-water quality as a function of land use related non-point source pollution. One hundred and fifty wells were installed for the network and carefully screened at the water table. Thirty of them are to be sampled each year on a 5-year cycle. The first cycle was completed, and the second started in 2004. The New Jersey Geological Survey (NJGS) manages the network design, well installation, well maintenance and data interpretation and reporting. The NJDEP Bureau of Fresh Water and Biological Monitoring and the USGS collect the well-water samples, and the USGS laboratory in Denver, Colorado analyzes them. Chemical and physical parameters analyzed at each well include: field parameters such as pH, specific conductance (SC), dissolved oxygen (DO), temperature (T), alkalinity, major ions, trace elements, gross-alpha particle activity, volatile organic compounds, and pesticides.

The ground-water quality data is currently available in an NJDEP I-MAP format at: http://www.state.nj.us/dep/gis/depsplash.htm, in annual USGS Water Resources Reports for New Jersey and online at the USGS database, http://waterdata.usgs.gov/nwis/. Some of these data are presented in New Jersey's integrated water-quality report, which currently focuses on the New Jersey Coastal Plain and can be obtained at: http://www.state.nj.us/dep/wmm/sgwqt/wat/integratedlist/docs/Part%20IV.pdf. Some interesting findings from the network data are presented below.

Ground-water quality data from 150 shallow AGWQMN wells in New Jersey are grouped according to land use in one of three categories: undeveloped, urban or agricultural (fig. 1). Well water quality in undeveloped area's form a good baseline for evaluating contaminant loads in agricultural and urban land uses introduced by human activities. Total dissolved solids concentrations, as well as the concentration, frequency, and variety of trace elements, nutrients, volatile organic hydrocarbons (VOC) and pesticides are found at significantly higher levels in wells located in agricultural and urban areas than from wells in undeveloped areas. This clearly illustrates human impact on nature.

Shallow ground water in agricultural land use areas have the highest frequency of pesticide detection, highest median nitrate concentrations (maximum up to 56 mg/L) and gross alpha particle activity. These concentrations are likely related to the application of agricultural chemicals (fig. 2).

In urban areas, there is generally lower dissolved oxygen, higher total dissolved solids, dissolved iron, chloride, and VOC (such as MTBE) concentrations found in the ground water. Again, this is a clear demonstration of the effects of human activity on the natural ground-water system.

This kind of regional assessment is critical to help show that land use related activities of people can negatively impact the state's important ground-water resources. The AGWQMN is designed to detect pollutants from recent activities that lead to degradation of ground-water quality so

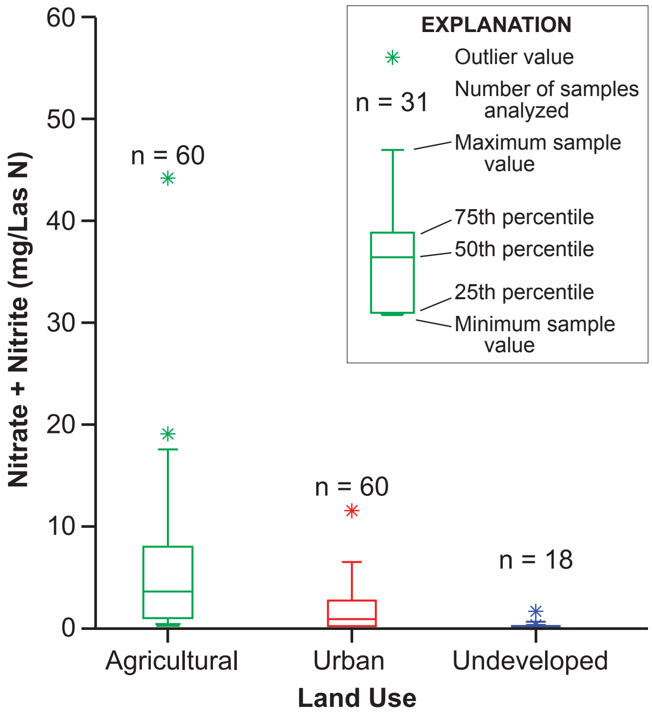

Figure 2. Nitrogen in Ambient Groundwater Quality Monitoring Network, 1999-2004.

that appropriate responses can be applied early.

A significant amount of shallow ground water recharges deeper aquifers by flowing downward. Pollutants can flow with that ground water and have an impact on wells drawing water from deeper aquifers. Finally, because most streams in New Jersey are recharged by ground-water to some extent, the attributes of that ground water can also influence the quality of surface water.

FeS_2

ARSENIC IN THE PIEDMONT AQUIFERS

By Steven Spayd and Mike Serfes

Arsenic: we can't smell it, see it, or taste it in our water. It has been known to be toxic for over 2,000 years, but can be found only by testing the water. More recently, it has been identified as a known human carcinogen and as a risk factor for heart disease and Type 2 diabetes. The New Jersey Geological Survey (NJGS) has discovered that wells drawing ground water from Piedmont aquifers may contain arsenic in elevated concentrations.

Since 1942 the drinking water standard for arsenic has been 50 micrograms per liter (ug/L). This will change, however, in January 2006 when the United States Environmental Protection Agency is scheduled to lower the federal arsenic standard to a stricter 10 ug/L. Meanwhile, the New Jersey Department of Environmental Protection has adopted the most protective arsenic drinking water standard in the nation at 5 ug/L, also effective January 2006.

Historically, arsenic was not considered a drinking water threat in New Jersey. But with the identification of new health risks, adoption of more protective standards, and identification of public and residential wells exceeding those standards, arsenic in New Jersey's Piedmont aquifers is now recognized as a hazard that can, and should, be eliminated.

The NJGS is actively addressing the arsenic issue. A study of the source, nature, and extent of arsenic in the state's ground water has found it to be naturally occurring in the Piedmont aquifers. These aquifers are located in the sedimentary rocks of the Stockton, Passaic, and Lockatong Formations, as well as the diabase intrusions within them. A review of water quality data for public wells, ambient network monitoring wells, residential wells sampled under the Private Well Testing Act, and residential wells specifically targeted for arsenic sampling by NJGS, have shown the major area of concern for arsenic in New Jersey to be the Piedmont Physiographic Province (fig. 1). The overall number of private wells exceeding the new standard of 5 ug/L is around 15% in the Piedmont, and some areas have up to 45% exceeding this standard. The highest arsenic concentration found in a residential well is 215 ug/l. It is expected that about 130 public wells in the Piedmont will exceed the new standard. Additional information on the nature, extent, and source of arsenic is available in an NJGS Information Circular online at http://www.njgeology.org.

The NJGS has also lead a study of water treatment solutions for wells exceeding the new standard. This study looked for the most efficient, cost effective, user friendly, and environmentally sound water treatment technologies to remove arsenic from residential well water in New Jersey. Recommendations for arsenic water treatment can be found in another NJGS Information circular available online at http://www.state.nj.us/dep/pwta/Arsenic_Treatment.pdf.

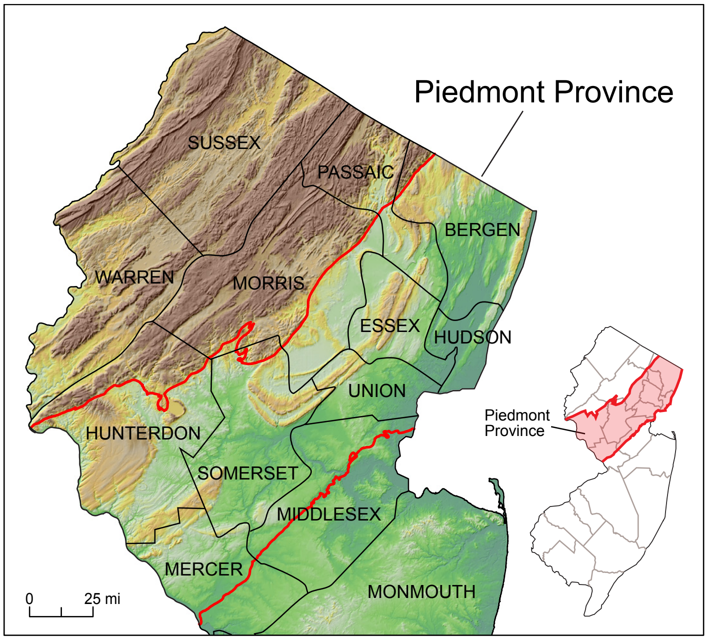

Figure 1. Location of Piedmont Physiographic Province.

There may be arsenic in the Piedmont aquifers, but NJDEP's protective standard and required testing of wells, combined with the NJGS's identification of the source, nature and extent, as well as treatment solutions, has made it possible to effectively and efficiently deal with this hazard.

FeS_2

WHAT'S ON MY BLOOMIN' PYRITE?

By John H. Dooley

Nodules consisting of pyrite (FeS_2) and quartz sand were collected from the Woodbridge Clay member of the Raritan Formation near Sayreville, New Jersey for analysis of their trace element concentrations. The samples were rinsed with water to remove surface clay and silt and then dried at room temperature for approximately 18 hours.

Two days later, the silvery to brassy nodules were variously coated with a white, powdery efflorescence or bloom (flowering) of salts. By the tenth day, a well developed, fuzzy, white efflorescence coated the now crumbling nodules. Microscopic examination of the salts revealed: 1) a transparent, colorless, vitreous mineral with a curved, fibrous habit, and 2) a snow-white, matte to pearly luster, powdery mineral.

The particular efflorescent mineral or minerals could not be identified with optical microscopy, which necessitated the use of x-ray diffraction (XRD). XRD provides a unique fingerprint of the atomic arrangement in crystals, making possible accurate identification of the particular mineral(s). Using XRD it was discovered that salts that developed after two days are rozenite ($FeSO_4 \cdot 4H_2O$) and starkeyite ($MgSO_4 \cdot 4H_2O$). This may be the first documented occurrence of these minerals in New Jersey. The well developed efflorescence from the 10-day growth consists of mainly halotrichite ($Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O$) (fig. 1) and szomolnokite ($FeSO_4 \cdot H_2O$) with minor epsomite ($MgSO_4 \cdot 7H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$). Halotrichite group minerals and epsomite are commonly referred to as “hair-salts”.


Figure 1. Efflorescence of szomolnokite and halotrichite with a trace of rhomboclase and gypsum on pyrite nodule, Sayreville, New Jersey. Approximately 12x magnification.

Most pyrite samples lack or do not develop such spectacular efflorescence. The oxidation (weathering) of pyrite to form sulfate involves a series of chemical reactions. The resulting acidic, sulfate-rich pore water contains dissolved iron, magnesium, aluminum, sodium, potassium, and calcium derived from minerals that have been susceptible to dissolution by the ensuing acidic solutions. Evaporation of the pore water leads to supersaturation resulting in the precipitation of soluble, hydrated, metal sulfates. Therefore, the composition of the soluble, metal sulfate minerals are linked to the composition of the pyrite oxidized as well as to the composition of the minerals that have been susceptible to dissolution by the ensuing acidic solutions.

Which mineral precipitates as the stable phase is directly related to relative humidity. Melanterite ($FeSO_4 \cdot 7H_2O$), one of the most common soluble sulfates minerals found in nature, dehydrates to rozenite or to szomolnokite with decreasing relative humidity and (or) increasing temperature. The melanterite-rozenite transition occurs at 59% relative humidity at 20ºC.

The hydrated, metal sulfate minerals are listed as being “very rare” owing to their water solubility. Precipitation of these minerals is favored where evaporation exceeds rainfall. Significantly large deposits of these sulfate minerals are known from very arid regions in Peru and in mineshafts sheltered from rainfall. Metal sulfate minerals are short-lived in certain sediments of the temperate New Jersey Coastal Plain. Efflorescence develops during prolonged dry periods and dissolves during rainfall. Dissolution of the sulfate minerals during storm runoff can acidify streams, lead to the development of acidic groundwaters, and can rapidly increase metal loading to surface waters.

Check your collections! Perhaps you collected some reactive pyrite, threw it in a box, and now have a crumbled mass of pyrite encrusted with rare sulfate minerals. Caution: the box may be disintegrated by the sulfuric acid produced by pyrite weathering. By the way, growth of the metal sulfate minerals is the cause for the crumbling of the pyrite host.

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NEW PUBLICATIONS

NJGS GEOLOGICAL SURVEY REPORT (GSR)
NEW REPORT. Ground-Water Quality in the Bedrock Aquifers of the Highlands and Valley and Ridge Physiographic Provinces of New Jersey, Serfes, Michael E., n2004, 28 p., 4 illus., 8 tables. GSR 39. $5.00

NJGS GEOLOGIC MAP SERIES (GMS)
NEW MAP. Surficial Geologic Map of the Culvers Gap Quadrangle, Sussex County, New Jersey, Witte, Ron W. and Epstein, Jack B., 2005, scale: 1 to 24,000, 2 plates, sizes 31x34 and 34x36, 1 cross-section, 1 figure, 1 table, 20-page pamphlet. GMS 04-1. $20.00

NEW MAP. Bedrock Geologic Map of the Chatham Quadrangle, Morris, Somerset and Union Counties, New Jersey, Monteverde, Donald H. and Volkert, Richard A., 2005, scale: 1 to 24,000, size 32 x 44, 1 cross-section, 1 figure. GMS 04-2. $10.00

NJGS OPEN-FILE MAP SERIES (OFM)
NEW MAP. Surficial Geology of the Ramsey Quadrangle, Bergen and Passaic Counties, New Jersey, Stanford, Scott D., 2004, scale: 1 to 24,000, size 36x47, 4 cross-sections, 1 figure, 33-page pamphlet. OFM 62. $10.00

NEW MAP. Surficial Geology of the Moorestown Quadrangle, Burlington and Camden Counties, New Jersey, Stanford, Scott D., 2005, scale: 1 to 24,000, size 32x33, 2 cross-sections. OFM 63. $10.00

NEW MAP. Bedrock Geology of the Moorestown Quadrangle, Burlington and Camden Counties, New Jersey, Stanford, Scott D. and Sugarman, Peter J., 2005, scale: 1 to 24,000, size 36x38, 2 cross-sections. OFM 64. $10.00

ENVIRONMENTAL EDUCATION
NEW BOOKLET. Geology of High Point State Park, Sussex County, New Jersey, Witte, Ron W. and Monteverde, Don H., 2005, 44 p., 30 illus. $2.00

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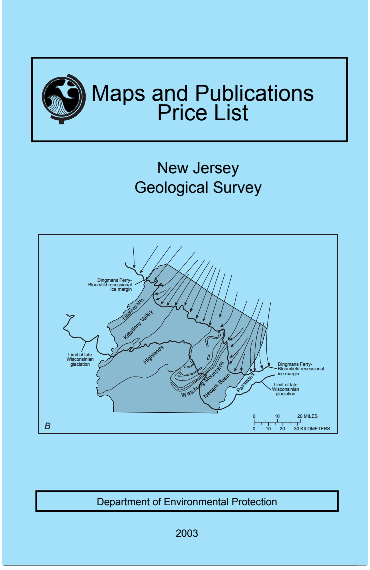
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Title banner: A collage of photographs showing efflorescence of the hydrated, iron sulfate minerals halotrichite and szomolnokite developed on a pyrite [FeS_2] nodule from Sayreville, New Jersey. An example of "hair-salts" as described in **What's On My Bloomin' Pyrite?** on page 6.

By John H. Dooley
Banner photos by J.H.Dooley

Celebrate **Earth Science Week 2005**! From October 9-15, join participants in all 50 states and countries worldwide in exploring the theme "Geoscientists Explore the Earth". The focus will be on careers and what geoscientists do that is so important to society. Check out the Earth Science Week website at www.earthsciweek.org for lesson plans, field trip ideas, digital teaching resources, and much more. Earth Science Week is organized by the American Geological Institute.

CROSSWORD RIDGES

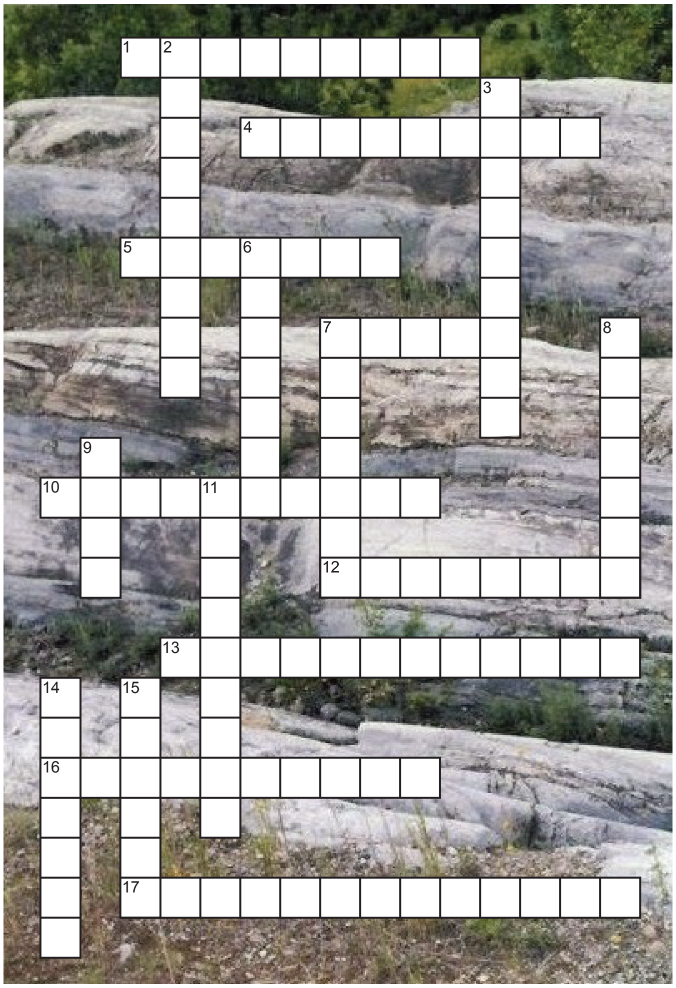

Photo by J. Curran

ACROSS

1. Name of the river deposit laid down in central New Jersey between about 4 and 2 million years ago is known as the ____ Formation.
4. Gravel deposits laid down in river beds that now cap hilltops are an example of topographic ____.
5. Element that is an active poison.
7. Fluid which forms rivers, lakes, and seas and can be pumped from wells.
10. Substance that causes cancer.
12. Physiographic province in New Jersey where arsenic occurs in well water.
13. Warm period between glaciations.
16. Thermokarst basins form when ____ melts.
17. Process or product of chemical "blooming".

DOWN

2. Mineral precipitated as a result of evaporation.
3. Unit of mass equal to one millionth of a gram.
6. Removal of material by running water, waves and current, moving ice, or wind.
7. Notch in a ridge through which a river once ran.
8. Existing or present on all sides.
9. Epsomite is a "____ salt".
11. Glacier that reached New Jersey about 150,000 years ago.
14. Stream eroding rapidly headward through soft rock so as to tap and lead off the waters of another stream flowing on resistant rock.
15. FeS_2.

FeS_2

CROSSWORD PUZZLE ANSWERS. Across: (1) Pensauken, (4) inversion, (5) arsenic, (7) water, (10) carcinogen, (12) Piedmont, (13) interglacial, (16) permafrost, (17) efflorescence. **Down:** (2) evaporite, (3) microgram, (6) erosion, (7) wind gap, (8) ambient, (9) hair, (11) Illinoian, (14) capture, (15) pyrite.