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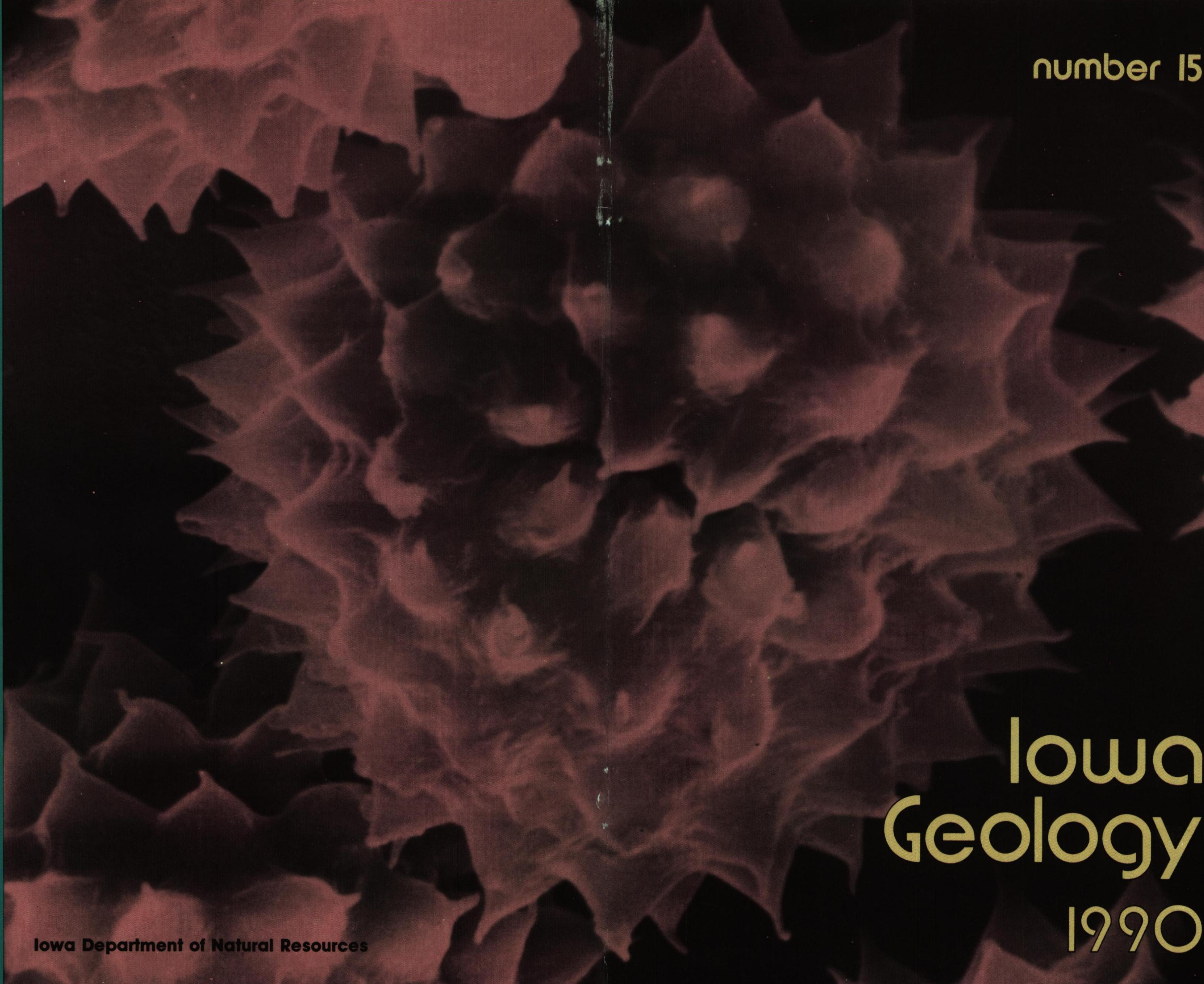

Iowa Geology

1990

Iowa Department of Natural Resources

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Department of Natural Resources

Larry J. Wilson, Director

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Donald L. Koch
State Geologist and Bureau Chief

COVER:

A dramatic increase of ragweed pollen in deposits at the bottom of Klum Lake indicates regional disturbance of natural vegetation communities and marks the onset of agriculture in Iowa about 1840. The grain shown here (enlarged 10,000 times) was photographed through a scanning electron microscope.

Cover design by Patricia Lohmann
from a black and white photograph taken by
R. Sanders Rhodes II.

Jean C. Prior .... Editor
Patricia J. Lohmann .... Publications Designer, Artist

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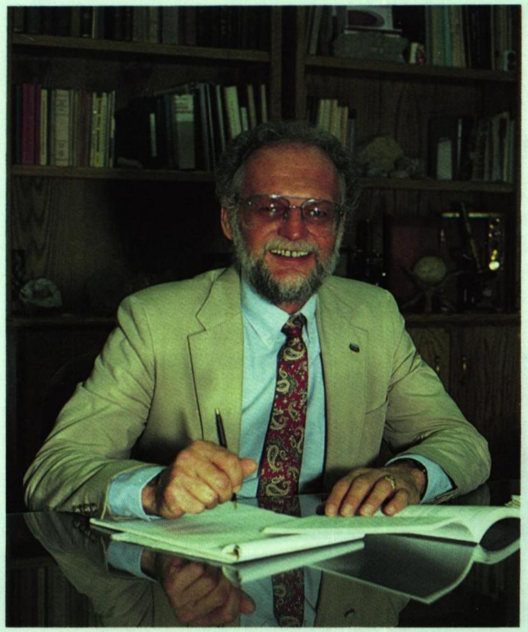


STATE GEOLOGIST'S VIEWPOINT

The state's geology is a vital aspect of our lives. Professionals dedicated to its study in Iowa are always seeking new information and new understandings of old information to apply to the state's diverse resource needs and issues. This issue of *Iowa Geology* displays the great span of time represented in Iowa's geologic record, the changing geological processes that have affected the state, the range of depths from which information is recovered, the diverse technologies that aid our investigations, and the scope of practical, economic, and environmental applications this information offers Iowa.

The drought of 1989 made possible the collection of sediment cores from the dried bed of Klum Lake. Millions of dollars recently spent in oil exploration provided our first glimpse of Iowa's deepest sedimentary rocks. The Iowa General Assembly funded a statewide sampling of rural drinking-water supplies as well as a focused study of how cropland management can affect groundwater quality. Orbiting satellites and sophisticated computers generate unique geographic comparisons of land-surface resources. Biologists needing geological answers to wetland management and protection strategies await the results of our first systematic look at Iowa's groundwater-saturated peat deposits. Geological investigations of environmental changes recorded in Iowa's ice-age deposits may help answer some questions about the long-term effects of global warming and droughts. Continuing geological investigations of the thickness and characteristics of the state's mantle of glacial deposits enables more informed decisions by resource managers and planners, thereby improving our protection of the state's valuable groundwater supplies.

Learning more about Iowa's geology is a matter of being flexible enough to take advantage of rare opportunities that fit well with long-term planning and research efforts, and looking for unexpected connections between seemingly separate programs and projects. The variety of projects mentioned above, as divergent as they might seem in location and purpose, are all capable of illuminating a dark corner of yet another geological investigation or environmental issue.

Geology and hydrology are inseparable from many of the important issues facing Iowa today. The state's success in addressing these multi-faceted concerns was recognized by The National Association of State Energy Officials at their August meeting in Montana, where their highest honor, the National Energy Program Award, was conferred on Iowa for its efforts to resolve environmental problems through attention to the relationships that exist between environmental protection, energy resources, and a sound economy. The adoption of new agricultural management practices demonstrating that farm chemicals can be used more efficiently has direct implications for energy conservation, groundwater and surface-water protection, and economic profitability.

Looking for connections and applications thus benefits not only our understanding of the state's geological setting but also our ability to successfully address related statewide environmental challenges.

Donald L. Koch

Donald L. Koch
State Geologist and Bureau Chief

FOSSIL PLANT LIFE AT KLUM LAKE

Brenda K. Nations

There are many types of Iowa wetlands, such as marshes and fens, found in various landscape settings, each with its own vegetational history. The details of these past plant communities are unique to each site and related to the local geographic and topographic conditions. At the same time, the vegetational history preserved in wetland deposits also records broad similarities which reflect regional vegetation patterns. Klum Lake is a riverine wetland located along the Mississippi River valley in Louisa County, south of Muscatine, Iowa. The wetland is within the Klum Lake State Game Management Area, a public-access and hunting area managed by the Iowa Department of Natural Resources. Beneath the existing marsh vegetation lies a peat deposit nearly 10 feet thick, containing a wealth of information that has enabled paleobotanists to interpret earlier vegetation communities within the Upper Mississippi Valley. Cores of accumulated sediment taken from Klum Lake contain microscopic grains of fossil plant pollen (see cover), as well as larger plant remains such as seeds and leaves. This fossil evidence establishes the sequence of vegetation on and around the wetland during the last 10,300 years, and reveals that Klum Lake has changed dramatically over this period of time.

Klum Lake is located at the base of steep bluffs which form the western wall of the Mississippi Valley. The lake is actually a remnant of a more widespread wetland which once occupied the west side of the Mississippi floodplain from Muscatine south to Lake Odessa, an area known today as "Muscatine Island." Most of the area has been drained to facilitate agriculture, and only the deepest segments, such as Klum Lake and Lake Odessa, as well as the Muscatine Slough drainageway, remain today as wetlands.

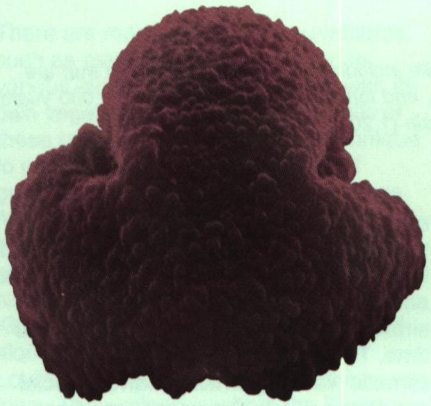
Klum Lake originated as a channel of the Mississippi River that was abandoned sometime between 10,500 and 10,300 years ago, as determined by radiocarbon dating of buried organic deposits. At that time it became a lake, similar in character to present-day Lake Odessa to the south. The lake began as an open body of water and slowly filled with sediment as it evolved to a shallow wetland area. Because the lake was isolated from periodic flood waters of the Mississippi, organic matter such as peat was deposited rather than mineral silts or muds. It is these organic sediments, containing fossil pollen and seeds, that are favorable materials for interpreting the area's vegetation history.

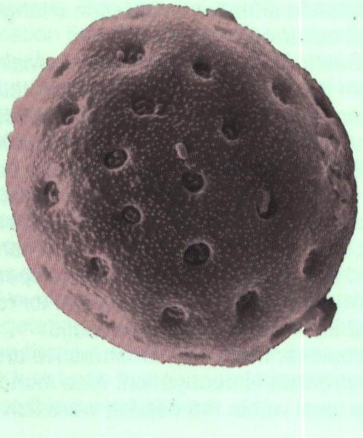
By studying fossil pollen and seeds produced by once-living plants, the vegetational history of an area can be reconstructed and even climatic inferences can be drawn. Pollen is transported by both wind and insects; wind-pollinated plant species are most commonly found in deposits because of their greater pollen production. The interpretation of regional vegetation patterns is then possible from pollen analyses because its long-distance transportation provides a good picture of the vegetation types existing over a broad area. Seeds, on the other hand, are not transported far from where they grow. Fossil seeds can assist paleobotanists with interpretations of which plant species grew locally and how the vegetation changed through time in a specific area. Seeds also are more readily preserved as fossils, mainly because they are more durable than leaves and other fragile plant parts. Therefore, by using both fossil pollen and seeds, a picture of both regional and local vegetation types emerges. The ability to use Carbon-14 dating methods on these organic deposits further enables scientists to examine the timing of vegetation changes as well as facilitating comparison with other strata containing fossil pollen and plant material.

Organic deposits found in the bottom of Klum Lake include fossil seeds and pollen that are used to interprete changes in vegetation, climate, and landscape during the last 10,000 years. Left: *pondweed seed (15x).* Right: *pine pollen grain (1,200x).*

Results of the fossil pollen and seed studies from Klum Lake made possible the identification of three distinct zones within the deposit. Each zone represents a different stage in the wetland's evolution as well as accompanying changes in local and regional vegetation communities. The lowest and oldest zone, dating from about 10,300 to 7,300 years ago, contains pollen that shows deciduous trees were the dominant vegetation type in the region. Oak and elm were abundant, while hickory, willow, maple, birch, and pine also were present (see photo, above). Pollen from other eastern Iowa wetlands, such as marshes in abandoned Mississippi River channels near Savanna and Rock Island, Illinois, also indicate similar vegetation conditions during this time. This period was one of general climatic warming which followed glacial conditions. Early during this warming period, hardwood forests replaced the coniferous forests that had existed during glacial times. Klum Lake came into existence after this vegetation change had occurred.

Seeds and other fossil plant remains from this oldest zone are representative of an aquatic environment. The seeds indicate that from about 10,300 to 7,300 years ago Klum Lake was an open body of water rimmed by pondweed, cattails, mud-plantain, and arrowhead. Wild rice probably grew in the deeper, southern end of the lake. Several of these species were used by Native Americans for food and fiber and, with other aquatic resources, made this an attractive area for prehistoric occupation. Also found at this level within the deposit were fish





scales, a small frog or fish vertebra, and the shell of a small clam.

A second, younger vegetational period occurred from 7,300 to about 2,500 years ago and was dominated by grass and goosefoot pollen, with decreased percentages of tree pollen. These shifts in pollen abundance indicate that prairie vegetation was now present on uplands to the west of the valley as well as on large, sandy, river terraces within the Mississippi Valley to the east and south. Although reduced in numbers over the region, trees still inhabited the steep valley slopes and rimmed the wetlands such as Klum Lake and the Mississippi River channel. These changes in the regional vegetation are reflected in other wetlands across Iowa and resulted from the post-glacial warming and drying trend that culminated approximately 6,000 years ago.

As the pollen analyses reflect a climatic shift to drier conditions, the seeds themselves indicate a shallowing of the lake. As the climate became drier, the level of the lake dropped, exposing accumulated vegetation to the air. The rate of decomposition of organic matter in the wetland increased. At the same time, more mineral sediment accumulated in the wetland from periodic overbank flooding along Muscatine Slough. The combined effect was a dominance of silts and muds and an infilling of the wetland. Less aquatic and more marsh-like plant species are found in this interval, with sedges, spikerush,

Top: *Goosefoot seed (15x) indicates disturbance around the shallow wetland margins; these plants possibly were cultivated by Indians for food.* Middle: *Oak pollen (2,000x) was abundant 7,000 to 10,000 years ago as deciduous trees replaced ice-age coniferous forests.* Bottom: *Goosefoot pollen (1,800x) increased, along with grass pollen, in response to warm, dry climates that culminated about 6,000 years ago.*

and smartweed as common seeds representing this time period. Seeds of several tree species, including important Native American food resources such as the pecan, have been recovered from nearby Mississippi River sediments of the same age.

The third and youngest vegetation zone is marked by an increase in pollen species that reflect disturbance of the land surface. This change represents the clearing of forests and the onset of agriculture during Euro-American settlement, which began about 1840. This zone is similar in age to sediments cored from a marsh in an abandoned channel of the Cedar River near Nichols, in western Muscatine County. Oak pollen also increases and grass pollen percentages decrease in this interval. During this time, the water table apparently rose in response to increased precipitation, and tree species increased in abundance but did not attain the dominance they displayed in the earliest zone. Regionally, the rise of ragweed pollen to high percentages is one of the most obvious markers of the Historic period (see cover). Ragweed grows on disturbed ground and is apparent to some degree in all three zones at Klum Lake. Most likely this plant also inhabited the exposed areas around the wetland margins during the dry periods mentioned earlier.

Seeds from the upper zone are dominated by woodland and disturbed-ground species. Wild grape was found, indicating a woodland environment. Goosefoot and grass seeds from this interval indicate disturbed ground, probably around the wetland margin. The large goosefoot seeds appear to be a species thought to have been cultivated by Native Americans as a food source (see photo, top left).

Today Klum Lake does not always contain standing water, but it is usually quite wet. Dredging on the north end of the wetland has produced a narrow stretch of open water around the Muscatine Slough water-control structure which maintains seasonal water levels in the wetland. During the drought of 1988 and 1989, the water table dropped below the wetland surface, making it possible to walk out to the middle of the area and collect the cylindrical cores of sediment used in this study. By the spring of 1990 however, standing water was again present across most of the wetland as the drought ended. Today the vegetation on the marsh is dominated by river bullrush, a member of the sedge family which grows in aquatic or wetland environments. Willow and other water-tolerant trees rim the wetland, while hickory, oak, and elm grow on the drier, steep valley wall to the west.

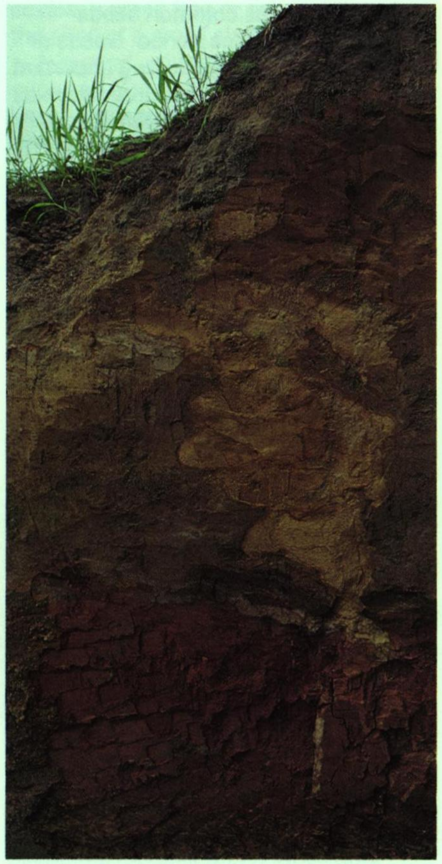
The changes that affected Klum Lake and other riverine wetlands along the Mississippi Valley during the time period examined here demonstrate that vegetational communities do not remain static. Shifts in composition of vegetation are clearly influenced by regional climate, local landscape changes (such as river-channel abandonment and wetland infilling), as well as human activities. Information obtained from study of the vegetation and sedimentation history of riverine wetlands allows us to see how these habitats are altered through time in response to changes in climate and local environmental conditions. This in turn provides us with a better picture of the natural stages through which these environments evolve, from recently abandoned open-water lakes through silted-in marshes. Such information is essential for providing us with an historical framework for managing modern riverine wetlands in various stages of evolution. These records are also invaluable for interpreting relationships between environmental influences and cultural change, as well as for providing information to archaeologists about food resources available to the prehistoric peoples who utilized these riverine environments. □

INTERPRETING ICE-AGE ENVIRONMENTS

E. Arthur Bettis III
John P. Littke

Iowa's climate supported the state's vast native prairie and eastern woodlands prior to the time of settlement, and makes today's agricultural economy possible. The long-term weather patterns which make up the modern climate, however, are but a small part of the climate's dynamic existence throughout the Quaternary period of geologic time. During the Quaternary, approximately the last two million years, the Upper Midwest witnessed repeated continental glaciations, or ice ages, separated by interglacial periods when climate and vegetation were more like those of the last few thousand years. To us, the present interglacial climate and environment seem normal, yet study of the past reveals that climatic conditions as warm as those of the recent past have existed only during 10 to 15 percent of the entire span of Quaternary time.

Several avenues of research allow geologists and other scientists interested in past environments to piece together a picture of these earlier conditions from fragmentary remains in the geological record. The composition and position of geologic deposits beneath the land surface provide information about the environment that existed during the time of deposition. For example, till is an unsorted mixture of clay, sand, and pebbles deposited by glaciers, and when several tills are found layered in a stratigraphic sequence, this indicates repeated episodes of glacial advance; or a stream deposit (alluvium) that consists of sorted silt and clay overlying gravel is interpreted as deposition first by rapidly flowing water in a channel, followed by shifting of the channel to another location and accumulation of silt and clay during subsequent episodes of overbank flooding.



Dean Thompson

This exposure of Quaternary deposits in Polk County contains a buried soil (reddish-brown clay) developed during a warm, interglacial period. This ancient soil is covered by a younger interval of wind-blown silt (loess) containing a sand wedge (yellow-brown) which formed in cracked, frozen ground during an intensely cold period between 20,000 and 16,000 years ago.

Soils, on the other hand, develop in deposits exposed on landscapes that are relatively stable for long periods of time. The presence and characteristics of ancient, buried soils (paleosols) in stratigraphic sequences provides several important pieces of environmental information, such as: 1) the location of former land surfaces, 2) the nature of the vegetation growing on those surfaces, 3) the former lay of the land and conditions of natural drainage, 4) in some instances, the nature of the climate that prevailed during development of the paleosol, and 5) the relative length of time over which the paleosol developed and the land surface was exposed. The well-developed paleosol shown in the accompanying photo is a product of long-term weathering on a land surface exposed from about 100,000 to 30,000 years ago during the interglacial period (Sangamon) which preceded the last glaciation of Iowa. The irregular wedge of sand extending from the overlying loess mantle into the upper part of the paleosol reflects a contrasting environment in which the ground froze, cracked, and was filled with wind-blown sand during an intensely cold period between 20,000 and 16,000 years ago, just before the last glacier advanced into north-central Iowa. Plant and animal fossils associated with similar-age deposits elsewhere in the state indicate that Iowa's environment was similar to the tundra of northern Canada at this time.

Fossil remains of plants, animals, and insects associated with various geologic deposits also provide information on past environmental conditions (see Klum Lake, p. 4). These remains enable geologists, paleobotanists, and others to reconstruct the ancient vegetation, temperature, and rainfall conditions through comparisons with the modern geographic distribution and life cycle of similar organisms. The geochemistry of isotopes of carbon found in lime concretions can be used to trace the type of vegetation inhabiting former land surfaces. In addition, oxygen isotopes in fossil snail shells can provide a generalized temperature history and, in some instances, relative ages of the host deposits. Applying radiometric dating techniques such as the Carbon-14 and Uranium-Thorium methods to organic and inorganic remains (see *Iowa Geology 1985*) ties all these lines of evidence to an absolute time scale so that the rate of environmental change can be assessed.

As converging lines of evidence begin to provide detailed reconstructions of past environments, they indicate that some of these past climates and vegetation communities may not have exact modern counterparts. This suggests that an ecosystem is very dynamic and, like organisms, evolves through time. Our knowledge of Iowa's Quaternary environments just before, during, and since the last advance of continental glaciers into the Upper Midwest has expanded rapidly over the last two decades, but environmental conditions prior to 25,000 years ago still remain largely unknown. We therefore have limited older paleoenvironmental information with which to compare the interglacial conditions of the last 10,500 years.

An understanding of how climate, vegetation, and other environmental systems interact and change through time is important for formulating models that can accurately portray the consequences of phenomena such as global warming, acid rain, sea level rise, and drought. Information from reconstructions of past environments provides the boundary conditions for these models, as well as insights into the sensitivity of environmental systems to change, and the direction that change is likely to take. These are issues that affect us all and the generations to come. □

GEOGRAPHIC INFORMATION SYSTEM:

JOHNSON COUNTY STUDY

James D. Giglierano

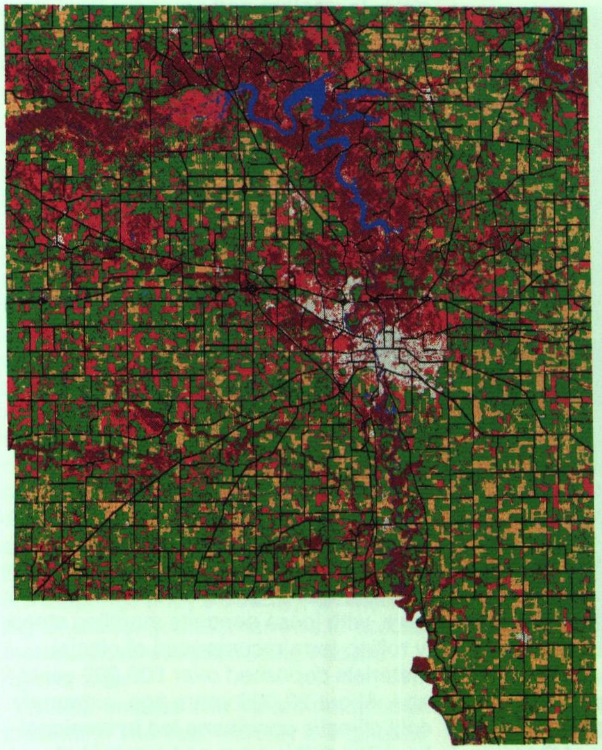
There is a growing need in Iowa and elsewhere for rapid, accurate information about the condition of the Earth's surface. A project demonstrating the use of satellite imagery and computer technology for monitoring soil conservation practices was started in 1988 by the Iowa Department of Natural Resources, Geological Survey Bureau and the U.S. Soil Conservation Service (SCS). The area chosen for this project was Johnson County. Specifically, the SCS was looking for new technologies to help monitor compliance with various conservation programs. Images from earth-watching satellites were seen as a fast and efficient way to collect soil and crop information at critical times during the year. Also needed was a system that could maintain information on crop histories, soil properties, and conservation practices. The approach used involved a set of computer programs called a geographic information system (GIS), which can create, store, analyze, and display a digital database of geographically referenced information. This system was used to integrate different types of natural resource information covering Johnson County.

Images came from the Landsat 5 earth-resources satellite. A sensor called the Thematic Mapper (TM) scanned the Earth's surface. Each TM image records information in seven spectral-wavelength bands: blue, green, red, three near-infrared, and one thermal-infrared band. Different land-cover features reflect sunlight at different levels in each spectral band. Corn, for example, has a different pattern than bare soil. It is then possible to classify each part of an image as a particular land cover. Then the results are loaded into the GIS for analysis and display in combination with other data. The accompanying map shows a generalized view of a combined three-year, land-cover classification. Iowa City and Coralville are the main urban areas near the center.

Satellite data was also used to look at crop residues left on fields to protect soil from erosion. The ratio of two of the infrared bands was found to have a moderate relationship to the amount of residue left on a field, indicating a potential for quickly monitoring large areas.

The SCS also is interested in preserving remaining wetlands in Johnson County. Combining soil-type and land-cover information in the GIS database, a new map was produced of land cover on wetland soils only. This was useful for identifying possible wetland vegetation, row crops on wetland soils, and flood-prone areas.

Monitoring compliance with soil-conservation programs was demonstrated using the analytical and inventory capabilities of the GIS. The Conservation Reserve Program (CRP), for example, contracts with farmers to take erosion-prone land out of production and plant a cover-crop for a 10-year period. Checking for crops other than the contract cover-crop was done by overlaying digitized CRP field boundaries with the actual land-cover data. If CRP fields were planted in corn instead of grass, for example, the system could easily recognize a non-compliance situation.



Another SCS program monitors conservation compliance on highly erodible lands. Crop production on these areas cannot exceed established soil-loss limits in order to qualify for government aid programs. After identifying highly erodible lands by using soils and slope data in the GIS, and adding information on conservation practices and land-cover type, estimates of soil-loss were calculated using the Universal Soil-Loss Equation. Areas designated as highly erodible and having a soil-loss greater than the allowable limit are determined to be in non-compliance.

While this project was successful within the context of soil conservation programs, the activities of other government agencies could likewise be influenced. The most obvious advantage of a GIS is the ability to relate one type of information to many others. In addition, maps in computer form are easily updated and do not have to be obsolete when they are published. The main functions of GIS will be to enhance or replace existing procedures involving paper records and maps. These materials will first need to be computerized, and this conversion can be time consuming and expensive. The increasing need to provide information to the public, however, will gradually bring the benefits of GIS use to the inner workings of many government entities. □

GLACIAL BOULDERS IN IOWA

Raymond R. Anderson
Jean C. Prior

"Peculiar," "irregular," and "uncommon," are words used to describe one class of Iowa rocks — glacial boulders or "erratics." Geologists define erratics as stones or boulders that have been carried from their place of origin by a glacier and then left stranded by melting ice on bedrock of a different composition. In Iowa, glacial erratics are commonly observed where glacial deposits occur at the land surface, primarily in the north-central and northeastern parts of the state. In western and southern Iowa, erratics generally lie buried beneath wind-deposited silts (loess) that cover the glacial materials. In these areas, erratics generally are restricted to valleys, where streams have eroded through the loess and into the underlying glacial deposits.

The erratics seen in north-central Iowa are the most recent to arrive in the state. They are found on the Des Moines Lobe, the region last covered by glacial ice 14,000 years ago. The ice sheet entered Iowa from Minnesota and moved southward between what is now Mason City and Spencer, advancing as far as the capital city of Des Moines. This ice melted away about 12,500 years ago. Northeastern Iowa also has a significant concentration of boulders across the landscape (see photo, right), and the greatest number of exceptionally large erratics. This region, known as the Iowan Surface, was once much like southern Iowa, with loess deposits mantling steeply rolling terrain composed of glacial materials deposited over 500,000 years ago. About 20,000 years ago, extremely cold climatic conditions led to erosional beveling of this area and removal of much of the finer-grained glacial materials, thus concentrating the larger pebbles and boulders at the land surface.

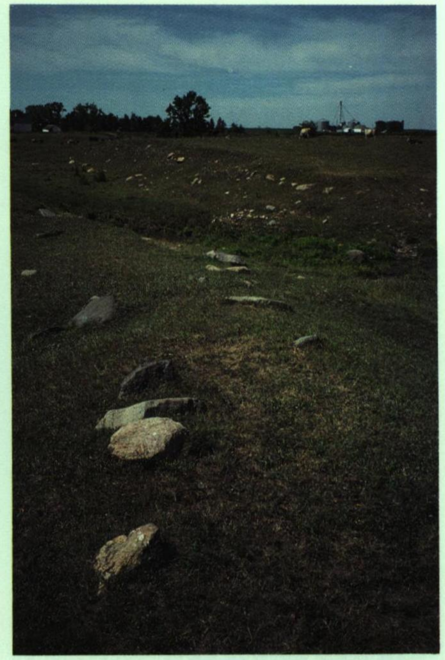
Holmes Semken

Glacial grooves and striations inscribe the limestone bedrock exposed in a Des Moines County quarry. These sets of parallel furrows and lines were gouged by glacial boulders embedded in the base of a slowly moving ice sheet.

When these areas of the state were settled, farmers had to clear fields of the rock obstacles in order to plow. Many of the erratics were used to build fences and foundations, while others were just piled along fence rows or into unused field corners where they are seen today. Clearing farm fields of glacial erratics is a frequent chore wherever glacial deposits are cultivated. Over time, seasonal freezes and thaws work these rocks upward from below the plow zone to the land surface. Smaller glacial erratics can be hauled from fields; larger ones were frequently blasted by dynamite and the pieces hauled away; some of the largest are just left in place and avoided. At the municipal park in Nora Springs (Floyd County), an adjoining city street actually narrows to accommodate an erratic protruding into the right-of-way.

Glacial erratics in Iowa are not difficult to identify. The vast majority are igneous or metamorphic rocks, rather than the usual sedimentary rocks of sandstone, limestone, dolomite, and shale that constitute the bedrock under most of Iowa. If you pick up a granite rock, composed of interlocking crystals of pink feldspar and glassy quartz, you can be sure that it came from outside the state, most likely carried by glacial ice.

Most glacial erratics appear worn and rounded, and sometimes include beveled or faceted surfaces. During the course of their journey, the rocks were jostled against other erratics or scraped against the underlying bedrock, rounding off corners and planing smooth surfaces. Glacial transport also caused some boulders to fracture, producing fresh angular edges. Rocks carried by rivers also undergo abrasion and become rounded in the process. In fact, most of the igneous and metamorphic rocks in Iowa's river valleys were originally transported into the general area by glaciers, then eroded from the glacial deposits and moved some additional distance by water.



Pat Lohmann

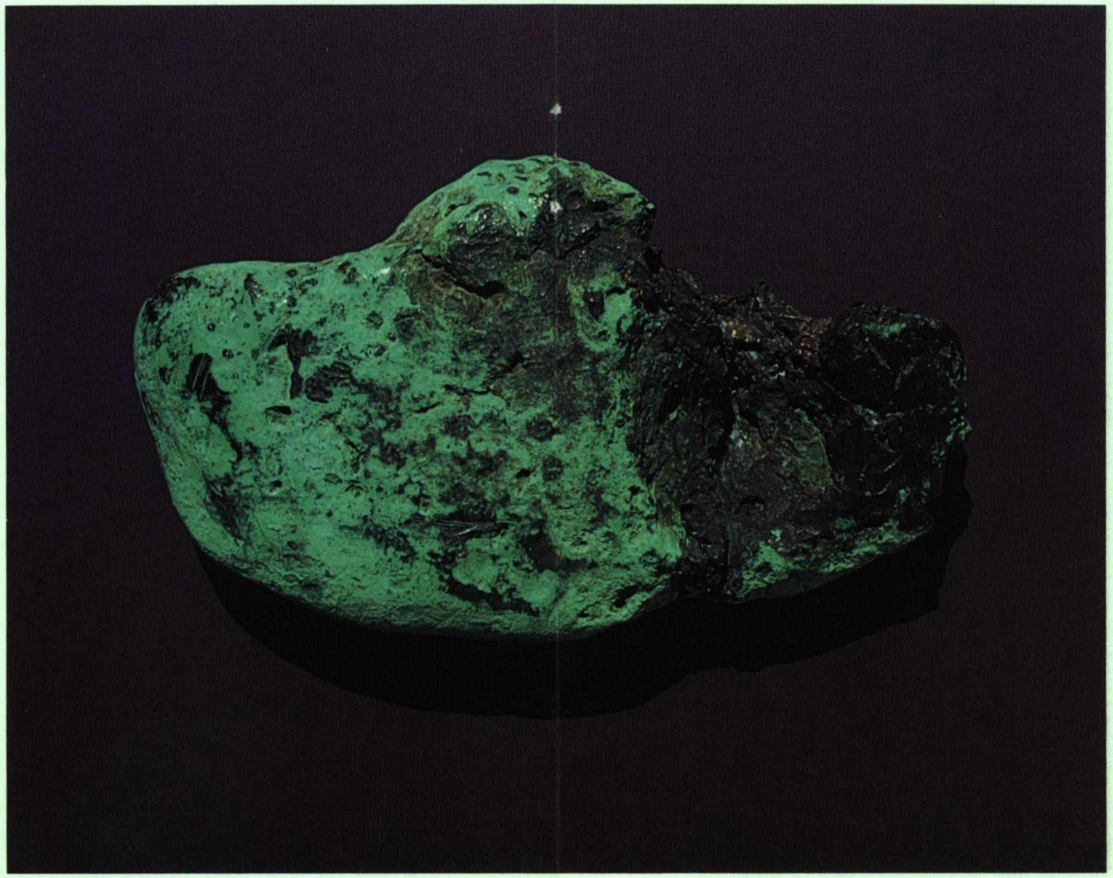
This Black Hawk County field strewn with glacial erratics is typical of many pastures on the Iowan Surface of northeastern Iowa.

Transportation by glacial ice produces some other features unique to this mode of travel. The most easily observed of these tell-tale signs are glacial striations, a series of parallel lines or fine grooves gouged across the beveled faces of erratics or inscribed on the underlying bedrock surface (see photo, left). These glacial furrows are produced when an erratic, frozen firmly in the slowly moving ice, grinds against another erratic or against the bedrock surface over which the glacier is moving. Glacial grooves and striations can be used to identify the direction of ice movement.

The composition of glacial erratics can often lead to identification of their point of origin and thereby provide some specific information about the direction of ice movement. At times, a string of erratics of similar composition can be observed across a broad region. These "boulder trains" are defined as a series of erratics that have come from the same bedrock source, usually with some special characteristic that makes it easy to recognize their common origin. Boulder trains appear as long lines or fans of erratics extending outward from their source in the direction of ice flow. Erratics from a given area are nearly always more numerous near their source and diminish in number with distance.

A large-scale example of a boulder train that can be observed in Iowa is the distribution of glacial erratics composed of the distinctive Sioux Quartzite, a very hard, uniformly pink rock. Outcrops of this Precambrian-age, quartz-rich rock occur in the extreme northwest corner of Iowa and on across the border into southwest Minnesota, where they span an area from the town of New Ulm, westward to Mitchell, South Dakota. Since the glacial ice that moved through northwestern and north-central Iowa travelled generally southward, erratics of Sioux Quartzite are most common in the area west and southwest of Estherville (south of New Ulm, Minnesota) and are generally absent east of there. One of the largest examples of a Sioux Quartzite erratic is known as Pilot Rock and is seen about three miles south of Cherokee, perched above the eastern edge of the Little Sioux River valley — doubtless an important landmark for early travellers through the area. Another example of a boulder train involves rare diamonds recovered from some Midwestern glacial deposits. Attempts to trace them back to a northern source area, however, have been unsuccessful.

Glacial erratics are known to have been transported great distances by the ice sheets that covered the midcontinent region. An erratic composed of solid native copper, and probably originating from the Lake Superior region along the Upper Peninsula of Michigan, was recovered from glacial deposits in southern Illinois, more than 600 miles from its source. Native copper erratics also have been recovered in Iowa, a journey of about 500 miles. One such copper erratic weighing 67 pounds is on display in the "Minerals of Iowa" exhibit in Trowbridge Hall on the University of Iowa campus in Iowa City (see photo, above).



Paul VanDorpe

This 67-pound nugget of native copper, tinged with greenish oxides, is one of the most distinctive glacial erratics found in Iowa and probably originated from the Lake Superior area along the Upper Peninsula of Michigan. (Specimen is 15 inches long and 9 inches wide.)

Glacial erratics range in size from pebbles to giant boulders. The greatest number of giant erratics are seen on the Iowan Surface of northeastern Iowa. They were described in a 1970 Iowa Academy of Science article by Drake University professors Richard Dirks and Carl Busch, who noted that 80 percent of the giant boulders had a similar composition, a light-colored, coarse-grained granite. They concluded from the boulders' composition and the direction of glacial striations on the underlying bedrock surface that these erratics probably originated in central and west-central Minnesota.

In another Iowa Academy of Science article in 1961, geologist Charles Gwynne of Iowa State University described the fate of a large Black Hawk County erratic near Waterloo. It originally measured 30 feet long, by 20 feet wide, by 27 feet high and was broken up in 1891; the pieces were used to construct the Boulder Church which housed the congregation of the First Presbyterian Church in Waterloo. This building was used as late as 1961 by the Salvation Army. The 1916 Annual Report of the Iowa Geological Survey described a boulder in Floyd County, about three miles west of Nashua, as the largest erratic remaining in Iowa. Its dimensions then were 50 feet long by 40 feet wide by 11.5 feet above the ground, with a nearby fragment measuring 17 feet by 7 feet by 1.5 feet apparently broken from the larger rock. In 1961, this same erratic was listed as being 40 feet by 30 feet by 12 feet. Other large erratics that can still be seen are St. Peter's Rock four miles southeast of Alta Vista in Chickasaw County, a granite specimen five miles west of Cedar Falls in Grundy County, and a granite boulder in Grammer Grove Park in Marshall County.

Glacial erratics are an easily observed piece of Iowa's geological history (see photo, inside back cover). Each one has a story to tell about its original composition, its point of origin, its journey to Iowa, and its final resting place. Find some for yourself and see what they tell you. □

GROUNDWATER VULNERABILITY

Donivan L. Gordon

As we have come to learn through numerous, though inadvertent mistakes, the Earth's underground water resources are vulnerable to the effects of human activities going on at the land's surface. Our level of awareness and concern about groundwater quality has risen in the last decade with the detection of numerous manufactured chemicals and wastes in our drinking water supplies. We now know that all current and future actions concerning the land must be planned very carefully to safeguard the quality of our groundwater resources.

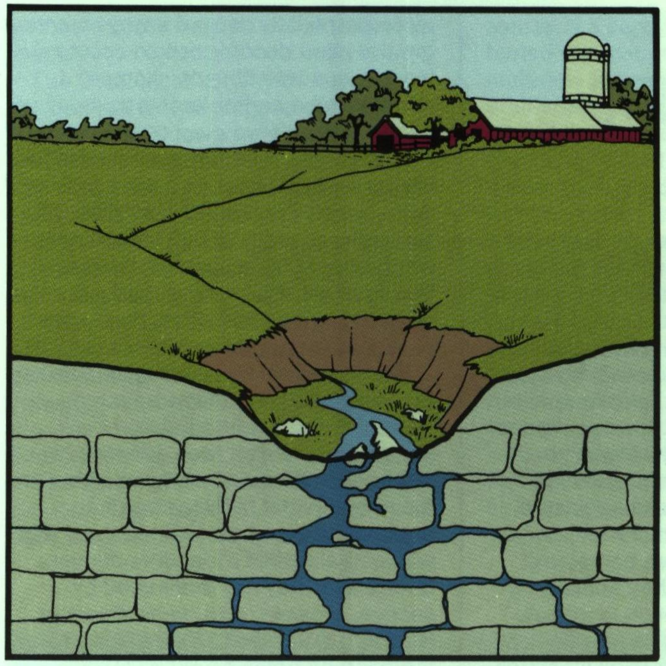
In certain situations, these groundwater resources are more vulnerable to our activities than in others. Basically, the most highly vulnerable settings are those where there is comparatively free interaction between water on the land surface and the underlying groundwater environment — areas of groundwater recharge.

During years that Iowa receives its normal 32 inches of precipitation, about 1.5 to 2.5 inches percolates through soil and rock materials to recharge our state's groundwater reserves. In the process, percolating water reacts with mineral matter and other substances contained within the geologic environment. This means that anything on the land surface or buried beneath it can influence the quality of water migrating to the underground environment. In the past, people have been somewhat comforted by the fact that earth materials have the natural capability to filter and cleanse objectionable substances from percolating water. We now know that this is only marginally the case. Society, through technological developments, has been able to create a host of substances that are environmentally stable, and simply do not deteriorate under the physical and chemical mechanisms of the environment as assumed in the past. Consequently, under certain conditions our groundwater resources are highly vulnerable to degradation and contamination by these materials.

Below the land surface, layers of soil and rock materials act as containers for storing groundwater. Where these containers are thick enough, laterally continuous over broad geographic areas, and permeable to the movement of water, they function as aquifers and will yield water to wells tapping them. In Iowa several different types of aquifers are used to obtain water for our various purposes. Along most of the state's rivers and streams are shallow deposits of porous sand and gravel that will yield appreciable quantities of groundwater to wells. In more widespread areas of the state, shallow wells (generally less than 50 feet in depth) can also produce groundwater from less predictable sand or gravel layers within upland deposits of glacial drift. Large numbers of rural Iowans in southern and western Iowa depend on large-diameter, shallow wells that collect groundwater seeping along a zone between porous and less porous materials. Major sources of abundant groundwater supplies in Iowa are the regional rock aquifer systems which underlie broad areas of the state. These aquifers are comprised mostly of creviced limestone and dolomite as well as porous sandstone formations. All of these aquifer types receive direct recharge from precipitation.

The vulnerability of these aquifers to loss of quality increases in direct proportion to an aquifer's proximity to the land surface. Susceptibility to contamination also increases where overlying soils are thin or where the overlying materials are light textured, silty or sandy. Land surface topography also influences vulnerability — flat land promotes less runoff and more infiltration than sloping land. Specific geologic conditions such as karst, which occurs in shallow, creviced limestone and results in topographic features such as sinkholes and disappearing streams, can increase aquifer vulnerability (see diagram). However, these conditions and influences, in and of themselves are not paramount. The key to vulnerability is the use and development of the land surface above aquifers, and particularly in areas where aquifers are recharged.

In the past too little attention was paid, or hydrologic conditions were not well enough understood, to avoid land development over vulnerable aquifers. The result has been groundwater pollution and degradation. We are now in a period of renewed awareness. Groundwater is more fully understood, as are the various activities of society which affect the quality of this resource. Beginning in 1988, the Geological Survey Bureau of the Iowa Department of Natural Resources has implemented a vigorous program to develop groundwater vulnerability maps for all 99 Iowa counties. These maps summarize such information as the thickness of stream and glacial deposits as well as topography of the underlying bedrock surface. When completed these maps will provide resource managers and planners with an excellent information base upon which to make future development decisions — decisions which should at the same time protect the state's vulnerable and valuable groundwater supplies. □



Groundwater supplies obtained from limestone aquifers are especially susceptible to contamination infiltrating from the land surface where soil materials are thin, underlying limestone is fractured and creviced, and sinkholes are present.

IOWA'S PEATLANDS

Carol A. Thompson

Mention wetlands to an Iowan and they think of low, watery areas with abundant cattails, marsh grasses, and waterfowl. Mention peatlands and the response is likely quite different. Few Iowans are aware that the state has deposits of peat. Peatlands, or mires as they are sometimes called, are more characteristic of northern boreal and subarctic regions, but they actually occur in many climates, even in tropical areas. In the United States, deposits of peat are known to occur in all 50 states.

Peat by definition is a deposit of incompletely decomposed plant remains. Water plays an important role in peat development and evolution, as perennial waterlogging of soil slows the rate of plant decomposition and can lead to the accumulation of peat. The absorbency of peat itself can then affect water movement and perpetuate the conditions for continued peat accumulation.

Most of the world's peatlands are classified as bogs. Bog is from the Celtic word "bocc," meaning "soft," which is a rather apt description of these waterlogged terrains. A bog is an acidic peatland which depends entirely on rainfall, thus leading to nutrient-poor conditions. Because there is less decomposition in these environments, very fibrous peats are produced. The term "fen," from the Anglo-Saxon meaning "mud," is used to describe another type of peatland which depends on a groundwater source in addition to rainfall, and has a rich nutrient status. Iowa's peatlands are fens. In these more chemically neutral environments, greater plant decomposition occurs leading to a less fibrous, more mineralized material known as muck or peaty muck.

Much of the peat mined in the United States today is used as a soil conditioner and for potting soil. In 1988, 23 states produced 900,000 tons of peat, worth about $20 million; Florida and Michigan are the leading producers. Approximately 14,000 tons of peat were produced from Iowa peatlands in 1988.

The Preserves and Ecological Services Bureau of the Iowa Department of Natural Resources conducted a statewide survey of fens, locating over 100 sites in 23 counties. Iowa's fens are found on upland hillslopes and drainageways, on stream terraces, and within abandoned meanders of rivers. Botanically they are dominated by sedges, grasses, and reeds. Peats in Northern Europe and Minnesota have radiocarbon dates as old as 10,000 years, but dates from the base of some Midwestern peat deposits only range from 5,500 to 1,200 years old.

Iowa's fens are home to more than 200 species of plants, including 24 rare species. Twelve of these rare plants are restricted to fen habitats. As such, fens provide important sites for preserving Iowa's botanical diversity. Because these sites depend on groundwater flow, fens may be threatened by deteriorating groundwater quality or by changes in groundwater flow paths. Since Iowa is dominantly an agricultural state, most fens are surrounded by row crops, primarily corn and soybeans which receive heavy applications of agricultural chemicals. Peats do have a great capacity to take up additional nutrients, which is why they have been used to treat sewage sludges. Some studies have shown, however, that excess nutrients, particularly nitrogen, can lead to shifts in species composition and lower species diversity. A shift to more nutrient-tolerant plants could seriously affect survival of the rarer species.

The Geological Survey Bureau is evaluating the hydrology and water chemistry of 20 Iowa fens across the northern part of the state. Monitoring wells have been installed just upslope of each fen. The samples collected during drilling were examined to determine the character of the surrounding geologic materials and, in particular, the characteristics of the deposit recharging each fen. In 1989, water samples were collected from the wells to evaluate incoming groundwater quality, and from the fens to evaluate chemical interactions within the peat deposit.

The fens can be grouped into four basic geologic settings. The majority of sites are those whose groundwater source is a sand and gravel deposit buried within more clayey glacial materials (inter-till). Past erosion along a drainageway has removed other geologic deposits leaving the sand and gravel unit near the surface, resulting in a seep over which the peat has formed. Another geologic setting includes fens whose groundwater source is an alluvial or glacial outwash sand and gravel originally deposited at the land surface. A few fens appear to be recharged by underlying limestone aquifers; still others are found in abandoned river meanders which may recharge slowly through surrounding alluvium.

Knowledge of these various geologic settings enables an assessment of the vulnerability of Iowa fens to loss or degradation. Fens that have sand and

Carol Thompson

Groundwater seeping from this Cerro Gordo County hillside has created a permanently saturated deposit of peat that may have been accumulating for several thousand years. Determining the source and quality of recharge waters is an important aspect of protecting these fen sites.

Jean Prior

An unusual upwelling of mineralized groundwater at Silver Lake Fen State Preserve in Dickinson County collects in elongated pools forming a fragile wetland habitat for rare plants, such as the delicate bloom of grass of Parnassis shown here.

gravel at the surface, such as in an alluvial or terrace setting, are highly vulnerable to contaminants infiltrating from the land surface. The vulnerability of fens whose source is a buried sand and gravel is more dependent on the characteristics of the surrounding geologic materials.

There are noticeable differences between the fens in eastern and western Iowa. Eastern sites respond quickly to changes in precipitation, which is also reflected in their vegetation. During drought conditions, eastern fens are drier; during wetter periods, the fens recover quickly. The western fens also respond to changes in precipitation, but on a delayed basis. Exceptions to this are the western fens in alluvial or terrace settings where precipitation changes are rapidly translated to the fen. The reasons for these variations relate to differences in geologic materials surrounding the fens. The materials upslope of the eastern sites are more permeable and allow rapid flow-through of water. The glacial deposits around the western fens have slower infiltration rates and also allow more water to be stored, thus damping precipitation response.

There are also differences in water chemistry between eastern and western fens. Western sites have higher dissolved-mineral concentrations than eastern sites in the groundwater sampled from both the upslope wells and within the fens. This trend is particularly noticeable for calcium, magnesium, and sulfate concentrations. These differences may be the result of the climatic gradient across the state, which becomes drier to the northwest. Alternately the trend may be related to differences in the geologic materials. Slower recharge rates allow more time for minerals to be leached from the surrounding glacial deposits. Also, western Iowa glacial materials often contain gypsum, a calcium-sulfate mineral.

Nitrate concentrations at the fens are high, with 8 of 20 sites having concentrations over the drinking water standard (45 mg/L as NO_3), and 14 of 20 sites having concentrations elevated over normal background concentrations. Nitrate concentrations decrease to the west, a reverse trend from that of most chemical ions. The higher recharge rates for the eastern Iowa sites and the alluvial and terrace settings in western Iowa allow nitrate from the surface to move more readily into the aquifer and then into the fen.

Pesticides were found at 11 sites in 7 wells and 10 fens. Atrazine, cyanazine, metolachlor, alachlor, metribuzin, and trifluralin were all detected, most at concentrations just above the detection limit. Of note was the fact that different pesticides were found in the wells in contrast to the fens. There are several possible explanations. The movement of pesticides in fens may be retarded with the result that the pesticides may represent last year's or even older field applications. Alternately, pesticides in the fens may be entering by different pathways, such as surface runoff (although this appears minimal at many sites) or through rainfall.

Direct physical threats also exist to Iowa's fens. Cattle trampling can cause serious and sometimes irreversible damage. Draining of fens is another irreversible alteration. Even tapping fens for watering livestock can alter their flow characteristics and cause detrimental changes.

Our studies of Iowa fens are continuing. Further stratigraphic studies will include topographic mapping, peat-thickness mapping, and collecting samples for radiocarbon dates. Detailed water-quality studies will be done on selected sites. This will help define the groundwater flow paths at these sites, and also allow an assessment of variations in water quality over time.

Peatlands world-wide are being threatened. Although many virgin peatlands still exist, only a small percent are protected in most countries. Only 7 of Iowa's fens are protected in parks, preserves, or wildlife areas. Hydrogeologic data will provide us with important information about the sources of the groundwater system, potential threats to the system, and possible remedial actions to restore damaged fens. This, in turn, will enable development of a more complete protection strategy, such as the use of buffer lands and easements for protection of present and potential fen preserves. □

PEAT FACTS

- *Peat has been used in a variety of ways for hundreds of years. Its use as a domestic fuel dates back at least to Roman times. The U.S.S.R. introduced its first peat-burning generating plant in 1914. Ireland generates about one-third of its energy requirements from peat. North America's first peat-fired powerplant started operation in Maine in 1990 and produces 22.8 megawatts of electricity hourly.*

- *Various crops are harvested from peatlands including blueberries, cranberries, wood, grains, and hay. Cranberries have a commercial value of over $600 million annually in the U.S.*

- *Because of the absorbent properties of peat, it has been used to diaper children, as surgical dressings, and recently as an absorbent agent for use on oil spills. Peat has been used as insulation in homes, blended to make plywood, peat cork and peatcrete, and as a wood preservative. Peat baths have been used as a treatment for various injuries and medical conditions. Peatlands have also been used to treat sewage.*

- *Bronze and Iron Age artifacts are frequently found in European peats including jewelry, clothing, weapons, and musical instruments. European bogs have yielded over 2,000 well-preserved human bodies, most dating from 800 B.C. to A.D. 400. In Florida bogs, several hundred bodies from the Archaic period were found and brain tissue and associated DNA recovered.*

- *Peatlands appear in the writings of Tacitus, Shakespeare, Linnaeus, and Emily Dickinson. Sir Arthur Conan Doyle in* The Hound of the Baskervilles *wrote, "Rank reeds and lush, slimy water-plants sent an odour of decay...while a false step plunged us more than once thigh deep into the dark, quivering mire."*

RURAL WATER WELLS:

STATEWIDE SAMPLING

George R. Hallberg
Matthew A. Culp
Burton C. Kross*

The Statewide Rural Well-Water Survey (SWRL) is a systematic, statistical sampling of private drinking-water supplies used by rural Iowans. It was implemented as part of the Iowa Groundwater Protection Act of 1987. The Iowa Department of Natural Resources and The University of Iowa Center for Health Effects of Environmental Contamination conducted the survey between March 1988 and June 1989.

Results of the SWRL study provide the first valid, statewide estimates of groundwater contamination in Iowa's rural private wells. Primarily a one-time sampling, SWRL provides a snapshot of the condition of 686 private well-water supplies, and some insight into the overall condition of the state's groundwater resource. The results may also serve as a baseline for measuring future changes and trends in groundwater quality.

While the well-water samples were analyzed for many chemical characteristics, the results here focus on bacteria, nitrate, and pesticides — the constituents of greatest interest from an environmental health perspective. Contamination problems with bacteria and nitrate are particularly widespread: 44.6% of wells statewide exhibited the presence of total coliform bacteria, a potentially unsafe condition. A subset of samples was also analyzed for fecal coliforms, which are more indicative of acute bacteria problems. Only 5.4% of the rural well-water supplies had detectable fecal coliform.

For nitrate, SWRL confirms the findings of other Iowa studies, indicating that nitrate contamination of groundwater is a significant environmental health concern; 18.3% of Iowa's private, rural wells contained nitrate concentrations exceeding the recommended health-advisory level of 45 milligrams per liter (as NO_3).

A total of 11 commonly used agricultural pesticides and 5 pesticide by-products were detected in SWRL survey wells. From these findings, 13.6% of the private, rural drinking-water wells in Iowa are estimated to be contaminated with one or more pesticide. The concentration of pesticides detected was generally less than 1.0 part-per-billion. In 1.2% of the wells, however, concentrations did exceed lifetime health-advisory levels. Atrazine was the most frequently detected individual pesticide, both statewide and within each region. Approximately 8.0% of the rural, private drinking-water wells in Iowa were contaminated with atrazine and/or its by-products.

Statewide, these contaminants are more common and exhibit higher concentrations in wells that are less than 50 feet deep. Approximately 28% of Iowa's private drinking-water wells are less than 50 feet deep; in southern and western Iowa this figure rises to over 50%, and SWRL results emphasize persistant water-quality problems for rural residents in these areas. Statewide, over one-third of all wells less than 50 feet deep exceed the recommended nitrate level. In areas where deeper wells tend to be used, this threat to Iowa's groundwater resource is not as apparent because, at present, deeper aquifers are better protected from contamination.

In addition to the well sampling at each SWRL site, extensive interviews were conducted to obtain information about well construction, farm-chemical use on the property, past water problems, waste-disposal practices, and health histories. The accumulated information will provide further insights on landuse and water quality, as well as water quality and public health.

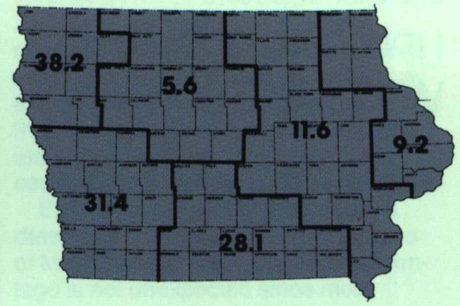
Ideally, this survey would have been conducted under normal climatic conditions. Unfortunately, 1988 and 1989 were the two driest consecutive years in Iowa's recorded history, with the statewide average precipitation more than 18 inches below normal. During the drought, recharge to groundwater was greatly restricted, and movement of contaminants from the soil or land surface was slowed. While the SWRL findings likely present a "best-case" situation, they still provide an important overview of the condition of Iowa's rural groundwater supplies.

This study only addresses groundwater contamination in rural areas. While groundwater is the predominant source of drinking water in Iowa, many residents of southern Iowa depend on rural water systems that utilize surface-water supplies. Other studies show that peak pesticide concentrations are greater in surface-water systems than in groundwater. When the SWRL data are combined with past monitoring of public water supplies, including rural water districts, it is clear that 35% to 40% of ALL Iowans are using drinking water that contains some detectable concentration of pesticides during the course of a year. While only a low percentage of these detections have exceeded lifetime health-advisory levels, and while high detection levels are likely intermittent, it is the large proportion of Iowa's population being exposed that is cause for concern from a public health perspective. □

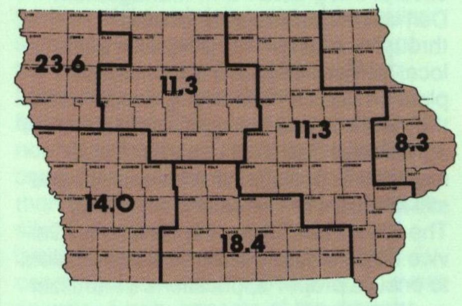
* *Burt Kross: The University of Iowa, Dept. of Preventive Medicine and Environmental Health*

Percentage of Wells Affected by:

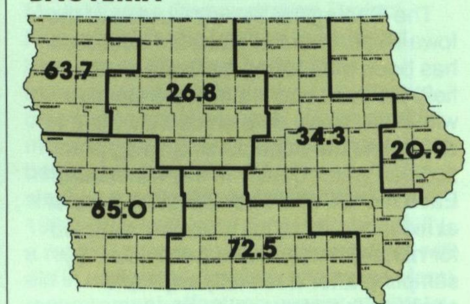
NITRATE



PESTICIDES



BACTERIA



WATER QUALITY PROJECT:

UPPER BLUEGRASS WATERSHED

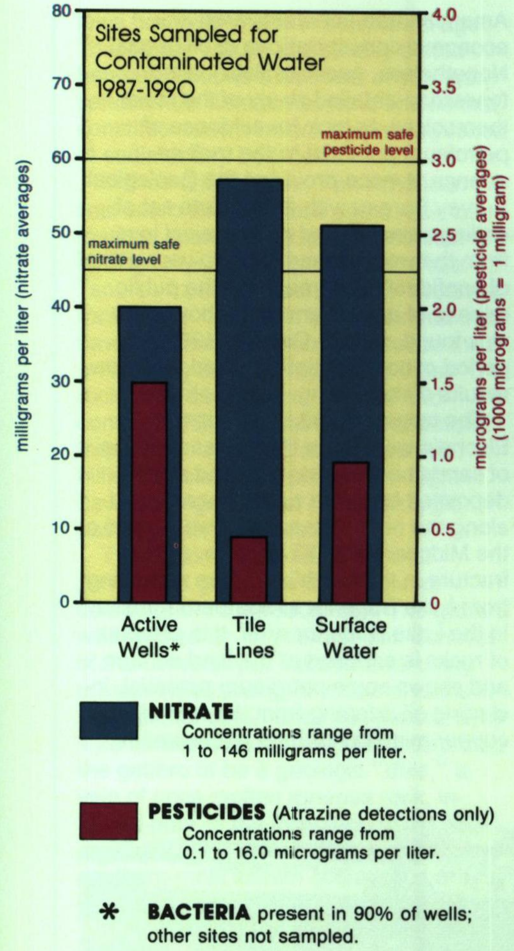
Lynette S. Seigley

The Upper Bluegrass Watershed Project, a 1,024-acre drainage basin in north-central Audubon County, is one of several Integrated Farm-Management Demonstration Projects located throughout Iowa. This program helps local farmers establish demonstration plots on part of their crop ground, where they work to find the right combination of agricultural chemical use and tillage methods to protect the environment and still maintain or increase farm profits. The Iowa State University Extension Service helps set up the demonstration plots to ensure proper applications of fertilizer or pesticide for study comparisons. They also provide "scouts" to monitor fields for insect pests and determine the need for insecticide use.

The Geological Survey Bureau of the Iowa Department of Natural Resources has been monitoring 4 private wells, 11 field-tile lines and 1 surface-water site within the study area since May 1987 to determine the impacts of farming practices on water quality in the watershed. Each month, and after rainfall events of at least one inch, the sites are sampled for nitrate, bacteria and pesticides. By sampling after a rainfall, any rapid changes in water quality can be monitored. Nitrate, bacteria and pesticides are analyzed because they are the contaminants of greatest concern to health professionals. Sources of nitrate include septic systems, animal manure, and nitrogen fertilizers. Bacteria can enter wells as a result of poor well construction, leaking septic systems, animal feedlot runoff, or from the surrounding soil. Pesticide contamination can occur locally through a spill or back-siphoning of tank-mixed chemicals into a well, or over a broad area through normal spraying of farm fields. The presence of these contaminants in groundwater supplies clearly shows these chemicals are escaping their intended environment. More emphasis is being placed on reaching an optimum use of chemicals while minimizing their impact on drinking-water supplies.

The majority of wells in rural Audubon County are large-diameter, "seepage wells" about 20 to 40 feet deep. These wells draw water from shallow portions of the groundwater system — along the zone between porous loess (wind-blown silt) and underlying, slowly permeable deposits of more clayey glacial till — and are easily impacted by human activities at the land surface.

The accompanying graph shows the average nitrate concentration for the active wells, tile lines, and surface-water site that are being sampled. The tile lines and surface water have average nitrate concentrations higher than the drinking-water standard of 45 mg/L (NO_3). The tile lines drain primarily corn and soybean fields. For all three site categories, the average nitrate concentration declined significantly from 1987 to 1989. The years 1988 and 1989, however, were the two driest consecutive years of record in Iowa. This lack of rain may have contributed to the reduced nitrate levels, as nitrogen that was unused by plants remained in the soil rather than infiltrating to the groundwater. Better nitrogen management in the watershed may also have helped reduce the nitrate concentrations. This year has had above normal rainfall, and so far all sites show an increase in



nitrate concentrations from 1989 levels. The rainfall may be mobilizing nitrogen built up in the soil from the previous dry years. It is not clear what impacts the drought or changes in farm management practices in the watershed may have had on these nitrate concentrations.

Since sampling began, 407 samples have been analyzed for 18 pesticides; of those samples, 114 (28%) had detections of one or more herbicides at concentrations of 0.1 micrograms per liter (μg/L) or greater. Sixty-two percent of the 114 samples had detections of a single herbicide, and 38% detected more than one herbicide. Atrazine, the most commonly detected herbicide, was found in 23% of the 407 pesticide samples. Concentrations for all herbicides ranged from 0.1 to 24.0 μg/L. No insecticide has been detected. The graph shows the average atrazine detection for the different sites; the majority of these detections were less than 1.0 μg/L, while two unusually high atrazine detections from active wells cause the average to be 1.5 μg/L.

Eighty-five percent of the pesticide detections occurred during the months of May to September. This high percentage is not unexpected since most pesticide applications occur between April and June which, when combined with timely rainfall, allows movement of these chemicals to the water table. Comparison of the rainfall event with regular sampling for pesticides showed that of the 114 samples with pesticide detections, 48% were associated with a rainfall event and 52% were associated with normal sampling. In general, the herbicide concentrations were higher for event than for regular samples at each sample site. For active wells, most of the herbicide detections, especially the high concentrations, occurred following an event sample. Again, impacts of the drought on herbicide detections are unclear.

Study of the Upper Bluegrass Watershed continues this year as part of the Model Farms Demonstration Project. Five model farms located throughout Iowa are addressing better farm management practices through various crop demonstration plots. Water-quality monitoring continues with additional data being gathered from 12 small-diameter, shallow monitoring wells installed in 1989. The additional data, and hopefully a return to more normal precipitation, will aid in understanding how changes in farm management affect movement of nitrate and pesticides to the groundwater. □

IOWA'S DEEPEST WELL

Raymond R. Anderson

On October 28, 1987, Pan American Petroleum Company, an exploration subsidiary of Amoco Production Company, plugged the M.G. Eischeid #1 exploration well, located just northeast of Halbur, a Carroll County town in west-central Iowa. At 17,851 feet deep, the well is by far the deepest ever drilled in Iowa, or in the northern midcontinent. Hopes ran high throughout Iowa that this well might produce hydrocarbons and begin an oil boom in the state. Plugging and abandoning the well shortly after drilling was finished indicated that Pan American had not discovered any economic concentrations of oil or gas. Nonetheless, geoscientists looked forward to detailed study of the rocks themselves, to look for evidence of petroleum potential in the rock sequence. Amoco provided the Geological Survey Bureau with a complete set of drilling samples and geophysical logs from the well; however, a two-year period of confidentiality precluded the public release of any information about what was found. Late in October 1989, this period of confidentiality ended, and now results of the drilling can be shared.

The target sought in drilling the Eischeid well was a thick accumulation of sandstones, siltstones, and shales deposited by rivers which once flowed along the northeast to southwest trend of the Midcontinent Rift System, a giant fracture in the Earth's surface stretching from Lake Superior to southern Kansas. In the Lake Superior area, this complex of rocks is exposed at the land surface, and shows some petroleum potential, including oil dripping from the roof of a copper mine in northern Michigan. In Iowa however, these Precambrian-age "basement" rocks are usually buried beneath 1,500 to 5,000 feet of younger sandstones, limestones, and shales that constitute Iowa's better known sequence of sedimentary bedrock.

In their drilling here, Pan American was searching for those same rock formations seen in the Upper Peninsula of Michigan — dark, organic-rich, shale "source rock," red sandstone "reservoir rock," and "traps" in the strata that may have confined petroleum. Because their preliminary studies suggested these rocks may be present, and the Midcontinent Rift may have large structural traps, Pan American concluded that billions of barrels of petroleum might have been generated in the geologic past and still be present.

The bottom of the Eischeid well penetrated gabbro, a dark-colored, coarse-grained igneous rock. The gabbro was studied by W. Randall Van Schmus of the University of Kansas and, using uranium-lead dating of zircon crystals in the rock, he determined the gabbro to be 1.28 billion years old. He also interpreted the gabbro to be a geologic "dike," a vein of once-molten igneous rock, intruded prior to the formation of the Midcontinent Rift System. This is the southern-most known occurrence of a dike of this age in North America.

Although no economic deposits of petroleum were encountered in the Eischeid well, much information has been learned about the rocks of the Midcontinent Rift System and their petroleum potential. Some traces of natural gas were detected between 10,510 and 17,700 feet. Perhaps the most significant discovery was the identification of a 200 to 300-foot thick sequence of black, organic-rich shale within the interval between 14,980 and 16,450 feet. Studies of the source rock potential of this sequence by U.S. Geological Survey geologist James Palacas revealed an average total-organic content of 0.6%, with some values as high as 1.4%; 0.5% is considered a minimum content for source rock. However, geochemistry studies of these organic materials indicate that in the past they were heated by deep burial and hydrothermal activity to temperatures above the "oil window" or the temperature at which oil is generated in a source rock. This suggests that these rocks, at one time, may have produced significant amounts of petroleum, reaching a peak of petroleum generation about 800 million years ago. Also, black residues observed in some sandstone samples suggest that petroleum later migrated through these rocks.

Does any petroleum remain today? We don't know. Most petroleum geologists agree that 800 million years is a long time for petroleum to remain trapped and not escape to the surface. However, Iowa is located in the "stable midcontinent" region, and the lack of major movement of the Earth's crust here in the last 500 million years argues that some oil may remain. It also appears that the organic-rich shales seen between 14,980 and 16,450 feet in the Eischeid well extend out farther from the center of the Rift and may not have been buried as deeply, nor have undergone the hydrothermal heating. These rocks may have passed through the "oil window" much later in their history, and the petroleum that was generated may still be present.

The possibility of deep deposits of oil associated with the Midcontinent Rift in Iowa has not been ruled out by findings from the Eischeid well, but exploration for these resources is expensive, and it is unlikely that any new, deep exploration drilling will take place here in the near future.

A detailed technical report summarizing the stratigraphy, petrology, depositional environments, and hydrocarbon potential of the Eischeid well samples is available (see page 28). □

Ray Anderson

Sections of steel casing, 40 feet long and 13 inches in diameter, were used to support the interval between 500 and 3,684 feet in a petroleum exploration well drilled to 17,851 feet in Carroll County. This well was over three times deeper than any well previously drilled in Iowa.

SELECTED SURVEY PUBLICATIONS

GROUNDWATER MONITORING IN THE BIG SPRING BASIN 1984-1987: A SUMMARY REVIEW
DNR-Geological Survey Bureau Technical Information Series 16, 68 pages, by G. R. Hallberg, R. D. Libra, D. J. Quade, J. Littke, and B. Nations (1989). A summary of water quality data with particular reference to nitrate and pesticides. Price $2.00, plus $1.00 post./hand.

WATER RESOURCES OF NORTHEAST IOWA
DNR-Geological Survey Bureau Water Atlas No. 8, 133 pages, by P. J. Horick (1989). An overview of surface and groundwater resources in 11 northeastern Iowa counties. Includes maps of elevation, thickness, potentiometric surface, yield, and dissolved solids concentration for most major aquifers. Price $12.50, plus $1.25 post./hand.

ABANDONED UNDERGROUND COAL MINES OF DES MOINES, IOWA AND VICINITY
DNR-Geological Survey Bureau Technical Paper No. 8, 92 pages and 1 map plate, by M. R. Howes, M. A. Culp, and H. Greenburg (1989). A compilation of coal mine locations and dates of operation in the Des Moines area. Includes a summary of geology in the Des Moines area. Price $4.50, plus $1.50 post./hand.

THE AMOCO M. G. EISCHEID #1 DEEP PETROLEUM TEST, CARROLL COUNTY, IOWA, PRELIMINARY INVESTIGATIONS
DNR-Geological Survey Bureau Special Report Series No. 2, 185 pages, edited by R. R. Anderson (1990). A collection of technical papers on the stratigraphy, petrology, depositional environments, and hydrocarbon potential of the samples collected during drilling of a 17,851-foot well in Carroll County. Price $8.00, plus $1.50 post./hand.

THE IOWA STATE-WIDE RURAL WELL-WATER SURVEY DESIGN REPORT: A SYSTEMATIC SAMPLE OF DOMESTIC DRINKING WATER QUALITY
DNR-Geological Survey Bureau Technical Information Series 17, 135 pages, by G. R. Hallberg, B. C. Kross, R. D. Libra, L. F. Burmeister, L. M. B. Weih, C. F. Lynch, D. R. Bruner, M. Q. Lewis, K. L. Cherryholmes, J. K. Johnson, and M. A. Culp (1990). A description of the methodology and framework for a rural water survey collected between April 1988 and June 1989. Price $2.50, plus $0.90 post./hand.

STRATIGRAPHY AND PALEOENVIRONMENTS OF MISSISSIPPIAN STRATA IN KEOKUK AND WASHINGTON COUNTIES, SOUTHEAST IOWA
DNR-Geological Survey Bureau Guidebook Series No. 10, 105 pages, by B. J. Witzke, R. M. McKay, B. J. Bunker, and F. J. Woodson (1990). A review of Mississippian stratigraphy and paleoenvironments. Includes trip discussions and outcrop descriptions from the 54th Tri-State Geological Field Conference held Oct. 5-7, 1990. Price $3.00, plus $0.90 post./hand.

Calvin Collection — The University of Iowa

A large, weathered and rounded boulder of granite in this turn-of-the-century photograph of a Mason City neighborhood is a monument to the massive glacier that bought it south over 500,000 years ago. The nearest bedrock source of this erratic is central Minnesota.