

GEODE
State Rock of Iowa

IOWA GEOLOGY

1994



Iowa Department of Natural Resources

Number 19

IOWA GEOLOGY 1994

Iowa Department of Natural Resources
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COVER:

Iowa's State Rock is the geode. Those having hollow, crystal-lined interiors are prized by mineral collectors. The well-known "Keokuk geodes" (this opened one showing clusters of sparkling quartz crystals) can be found in stream beds and dug from shale outcrops along the Des Moines and Skunk rivers and their tributaries in southeast Iowa.

See "Minerals" pp. 14-19.

Cover design by Patricia Lohmann
Cover photo by Tim Kemmis



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FLOOD OF '93

UNCOVERS

DEVONIAN SEA FLOOR



Floodwaters from the Des Moines River (background) turn Interstate 80 into a causeway connecting remaining segments of dry land in this July 12, 1993, aerial view north of Des Moines.

Steve Kalkhoff, USGS

THE FLOOD

The Flood of 1993 was the costliest, most devastating flood in U.S. history according to the U.S. Geological Survey. Floodwaters covered as many as 23 million acres of agricultural and urban lands in the Upper Midwest for weeks. The unusual duration and magnitude of this event was triggered by a wet-weather pattern that had persisted since early in the year, followed by a series of intense rainstorms in late June and July. Iowa found itself in the center of the catastrophic flooding that resulted.

Among the effects of the 1993 summer floods in Iowa was the overflow of the emergency spillway at

the U.S. Army Corps of Engineers' Coralville Lake, an event which lasted 28 days. The floodwaters ripped out a road and campground, and scoured away as much as 15 feet of glacial-age sediments to expose a remarkable expanse of 375-million-year old (Devonian) fossiliferous bedrock. Thousands of visitors followed in the flood's wake. The broad horizontal surfaces of limestone have provided the public with an opportunity to walk across an ancient sea floor and to see a clearly visible picture of bygone life that thrived in the tropical waters that once covered interior regions of North America.

The Mississippi River lapped at the City of Keokuk on July 7, 1993, as it flooded the municipal water pollution control plant (foreground).

Robert Buchmiller, USGS



THE ICE-AGE RECORD

E. Arthur Bettis III

While much attention is given to the bedrock geology and fossils seen along the floor of the gorge, there are layered deposits revealed along the steep banks of the flood-cut channel that provide a glimpse into the history of the Iowa River valley. Recognized by different colors and textures, these deposits record major periods of accumulation over the last few hundred-thousand years.

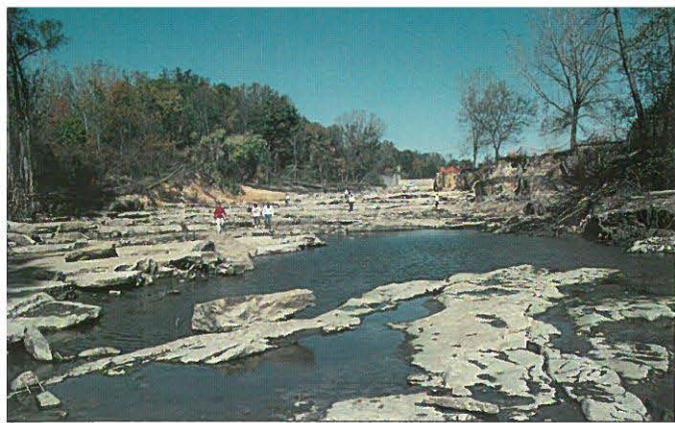
The oldest Quaternary deposit, located immediately above the bedrock, is the most mysterious with regard to age and origin. This dark brown, "greasy" sediment fills irregular

hollows in the rock surface and extends upward for a few feet. The deposit contains a few small igneous pebbles (erratics), a clue that it accumulated sometime after the first glaciers invaded Iowa and brought igneous rocks from the north. The deposit contains no pollen; it is not organic-rich, even though it is dark-colored; and it is unlike any other Quaternary deposit in eastern Iowa. The isolated "mound" in the center of the gorge is composed mostly of this material (photo p. 4, middle). Even the mound's existence presents a question for many visitors. It was protected from the full eroding force of the floodwaters by a pile of large rocks



U.S. Army Corps of Engineers

Cascading floodwaters gnaw away at the Lower Cottonwood Campground below the emergency spillway at the U.S. Army Corps of Engineers' Coralville Lake in Johnson County on July 7, 1993.



Left: Looking back toward the spillway, steep banks along the flood-scoured channel, reveal layers of glacial-age deposits. Broad exposures of fossiliferous limestone form the floor. Below: A stream-lined mound of glacial-age materials is all that remains of deposits that once covered the limestone.

that lodged just upstream during the overflow event.

A thin gravel rests on the unknown deposit, indicating that erosion preceded accumulation of overlying materials. Two later episodes of stream activity are recorded above the gravel. The older unit, reddish-brown silts and clays, formed sometime during the warm (interglacial) period between about 30,000 and 200,000 years ago. These silts and clays are cut out farther down along the gorge exposures and are replaced by a still younger stream deposit that accumulated during the coldest part of the last glacial period, between 22,000 and 16,000 years ago. Tan wind-blown silt (loess) that accumulated between 21,000 and 12,000 years ago, when the Iowa River carried glacial meltwater from north-central Iowa, mantles both of these



preserved stream deposits.

This chapter of the region's geologic history will not remain in view as long as the more resistant limestone. Slumping of the softer materials will eventually cover the diagnostic contacts, and vegetation will further obscure the slopes -- perennial problems for those who study Iowa's Ice-Age record.

A flood-rafted slab of limestone displays interesting patterns caused by the past flow of groundwater along numerous vertical fractures present in the bedrock.



A flood-ravaged road, once traveled by visitors to Coralville Lake, ends abruptly in a series of bedrock ledges that take visitors on an unexpected journey into Iowa's geologic past.



Brian Glenister

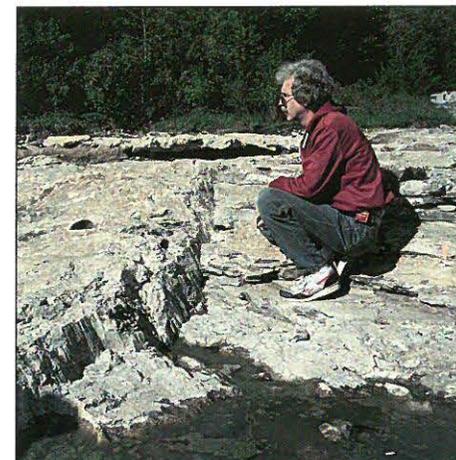
THE FOSSILS

Brian J. Witzke

The fossil shells and skeletons of sea-dwelling animals are seen in abundance in the broad expanses of limestone -- the closer one looks, the more one sees. These fossils are the remains of a multitude of creatures that inhabited a warm tropical seaway covering Iowa about 375 million years ago, during the Devonian period. Most of the fossils seen are from animals that inhabited the sea bottom and filtered small food particles from the water. Brachiopod (clam-like) shells are among the most conspicuous, and a great variety of species can be seen. Some limestone beds are crowded with their shells. Crinoids are also present. Known as "sea lilies," and plant-like in their form, crinoids are actually animals related to starfish.

Most were fragmented into pieces by scavengers and bottom currents before fossilization, and their stem segments are abundant. However, some exceptional specimens at the site were buried intact, displaying their stem, head, and arms as they would have appeared in life (photos, p. 6).

Fossil corals are the namesake for the City of Coralville, and it is certainly fitting that spectacular accumulations of fossil corals are so well displayed at the spillway. Some beds show densely packed concentrations of hemispherical and disc-shaped colonial corals, while horn-shaped solitary corals abound on other surfaces. Bryozoans ("moss animals") are smaller colonial organisms that are seen as small twig-



The beds of Devonian limestone show evidence of faulting. The break along displaced layers of rock, seen here as a step, is marked by "slickensides," polished, grooved surfaces caused by the friction of rock movement in the geologic past.

Non-credited photos on pp. 4-5
by Ray Anderson



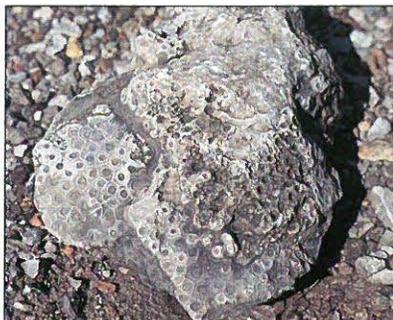
Brian Glenister

like or lacy fossils in many of the limestone beds. Delicate sponges and more massive sponge-like stromatoporoids also occur.

Fossils of trilobites, pillbug-like scavengers that crawled across the sea bottom, can be recognized by visitors who carefully scrutinize the limestone beds. Other creatures burrowed through the soft bottom sediments, and, although these animals lacked hard parts necessary for fossilization, their actions are preserved as tracks and burrows in the now lithified limestone.

Primitive fish swam through the waters of the Devonian seas, and, although rare, their fossil bones and teeth have been found at the spillway.

Right: A fossil colonial coral. Far right: Trilobite tail segments and lacy bryozoans are circled.



Jean Prior



Ray Anderson



Brian Wirzke

Exceptional specimens of crinoid fossils were found. Though plant-like in form, crinoids are actually animals related to starfish. They lived attached to the sea floor by long flexible stems. Their arms, radiating outward from the head, moved with the currents and filtered the sea water for food particles.

The most notable specimen, now removed for display at the Corps of Engineers' Visitor Center, is part of a large bony head-plate of an armored fish (arthrodire). This creature, a predatory giant of its time, reached lengths of 8 to 10 feet.

The fossils at the Coralville spillway have attracted phenomenal interest, and deservedly so. The floodwaters uncovered a window on the past, and visitors can gain first-hand knowledge of the fascinating creatures that lived in the tropical seas that once covered our state.

THE VISITORS

Bill J. Bunker

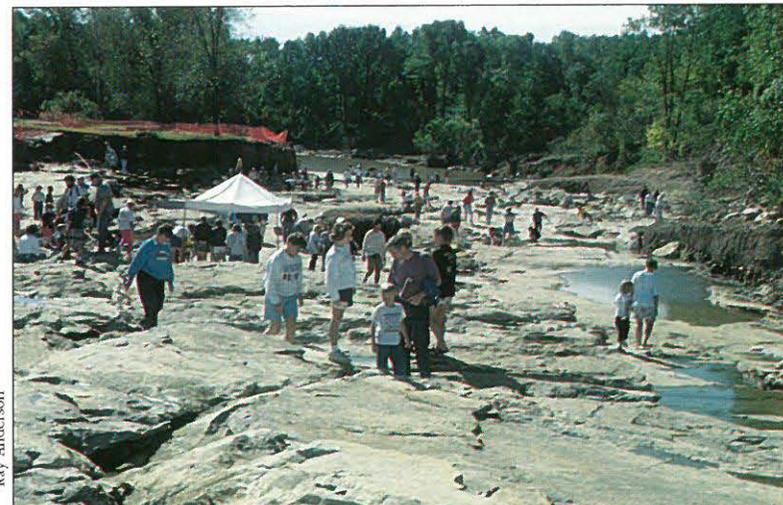
Exposures of Devonian limestone in eastern Iowa are usually limited to vertical quarry faces, roadcuts, and stream cutbanks. The new spillway exposures provide a rare opportunity to see broad horizontal surfaces, many containing spectacularly abundant marine fossils. Although the exposures are of great interest to Iowa geologists, public interest in the rocks, fossils, and flood-carved gorge has been tremendous. The influx of visitors, a broad spectrum of people including young and old, began almost immediately after the overflow ceased. The numbers increased dramatically following nationwide newspaper accounts (also in Europe, Japan, and Australia) as well as broadcasts by Paul Harvey, the ABC Nightly News, and CNN. Conveniently located a few miles north of Interstate 80 in Johnson County, more than 250,000 visitors from throughout the United States and abroad have made the trek across the fossiliferous exposures, and others continue to visit the site each week. Numerous school groups from eastern

Lainey Ostedgaard, a 10-year old visiting with her Girl Scout troop, can't get over how old the fossils are.

"It's weird," she says. "You sit on these rocks and think they're older than my parents -- or even my grandparents."

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Iowa have taken advantage of this learning opportunity, and the site has become an outdoor science laboratory for many. The Geological Survey Bureau prepared hand-out materials to assist visitors with interpreting the rocks, fossils, and glacial deposits. Most visitors comment that they would like to see the site remain available for viewing as it is today. In February of 1994, following a contest sponsored by the Corps of Engineers, the locality was named *Devonian Fossil Gorge*. ❖



Ray Anderson

The flood-carved gorge and its rocks and fossils provide visitors with a unique opportunity to learn more about Iowa's earth history.

GLACIAL-AGE FLOODS

E. ARTHUR BETTIS III AND DEBORAH J. QUADE

Iowa's valley landscapes were formed through the action of flowing water. Iowans experienced this geologic process firsthand during the soggy summer of 1993 when they witnessed some of the worst flooding on record. Although the Flood of '93 was unparalleled in its impact on Iowa's people and economy, its geologic and hydrologic impacts pale in comparison to those associated with glacial meltwater flooding that occurred between 13,500 and 12,000 years ago in valleys draining the Des Moines Lobe of north-central Iowa.

The Des Moines Lobe glacier advanced rapidly into Iowa about 15,000 years ago during a period of climatic warming. The initial advance of the glacier was followed by ice stagnation, then by at least three more rapid advances and longer stagnation phases. While the Des Moines Lobe was in Iowa, voluminous amounts of meltwater were released from on top of, within, and under the glacier into outwash streams that flowed from the ice margins. In many instances, large meltwater floods filled the valleys and had dramatic impacts on the land-

scape. Meltwater floods developed in three different ways: normal seasonal melting of glacial ice; episodes of extreme melting triggered by unusually warm or rainy periods; and sudden bursts of temporary glacial lakes. These events introduced pulses of meltwater that established the major valleys in the upper part of the present-day Des Moines, Boone, Iowa, Little Sioux, Big Sioux, Raccoon, Skunk, and Winnebago river basins. Outside the margin of the Des Moines Lobe (note map, p. 20), where pre-existing valleys weren't covered by the glacier, meltwater floods eroded valley walls, deepened some valleys, and filled others with sand and gravel.

What is the physical evidence of glacial meltwater floods in Iowa's valleys? Affected river valleys display several features that can be traced back to their heritage of glacial floods. These include multiple terrace levels (former floodplains) capped with sand and coarse gravel deposits, many short steep tributaries and few long branching ones, and relatively deep gorges with many sandy terrace levels. Such features formed rapidly during major



Between 20,000 and 9,500 years ago, the Mississippi River valley served as a conduit for glacial meltwater, outwash sediment, and giant floods from the sudden drainage of large glacial lakes in the headwater areas. The valley segment shown in this April 1984 color-infrared photo is northeast of Burlington, Iowa, with Oquawka, Illinois in lower center.

glacial flooding, much like the Devonian Fossil Gorge at Coralville Lake and the Saylorville Gorge in the emergency spillway of Saylorville Dam formed during overflow of their

respective reservoirs in 1993.

Multiple terrace levels in Iowa's valleys record many episodes of powerful glacial-flood-induced downcutting that carved deep valleys.

In Boone County for example, the Des Moines River valley was cut about 220 feet deep during floods of the late glacial period, forming the picturesque gorge characteristic of this part of the valley. Another of Iowa's scenic valleys, the deep and narrow Little Sioux River valley between Gillett Grove and Peterson, formed when the Des Moines Lobe ice front blocked the eastern flow of rivers such as the Ocheyédan, forming Glacial Lake Spencer which then overflowed and drained, swiftly cutting a new course to the west.

The general absence of long, branching tributaries in many glacial-flood-influenced valleys indicates that the valleys formed quickly, with little time for development of an extensive tributary network. The aerial photograph on page 9, of a portion of the broad Mississippi Valley, shows numerous steep, short, tributary valleys (dark-green branching patterns) along the upland margins in Illinois (on the right). Also seen, east of the river

channel, are remnants of a terrace built by meltwater floods and marked by the dimpled patterns of sand dunes and, west of the channel, sweeping braided patterns marking somewhat younger flow paths. (Note barge in middle of channel for scale.) These features formed as glacial meltwater and lake-burst floods forced the river to different levels and positions during glacial retreat in Minnesota, Wisconsin, and Illinois (see also, Mississippi Valley satellite image and geologic map on pp. 24-25, and 26-27).

The layering of sand and gravel in terrace deposits within Iowa's valleys speaks to the great variations in discharge during sediment accumulation. Attempts to estimate the flow conditions that accompanied deposition of the sand and gravel are based on the layering and grain size of the deposits. Estimates of ancient hydrologic conditions indicate that many glacial flood events far exceeded the largest floods ever measured in the recorded history of these streams.

River valleys that drained the Des Moines Lobe ice front in Iowa may have looked similar to this floodplain of a modern outwash stream flowing from the margins of the Klutlan glacier in the Yukon Territory of Canada.



H.E. Wright Jr.

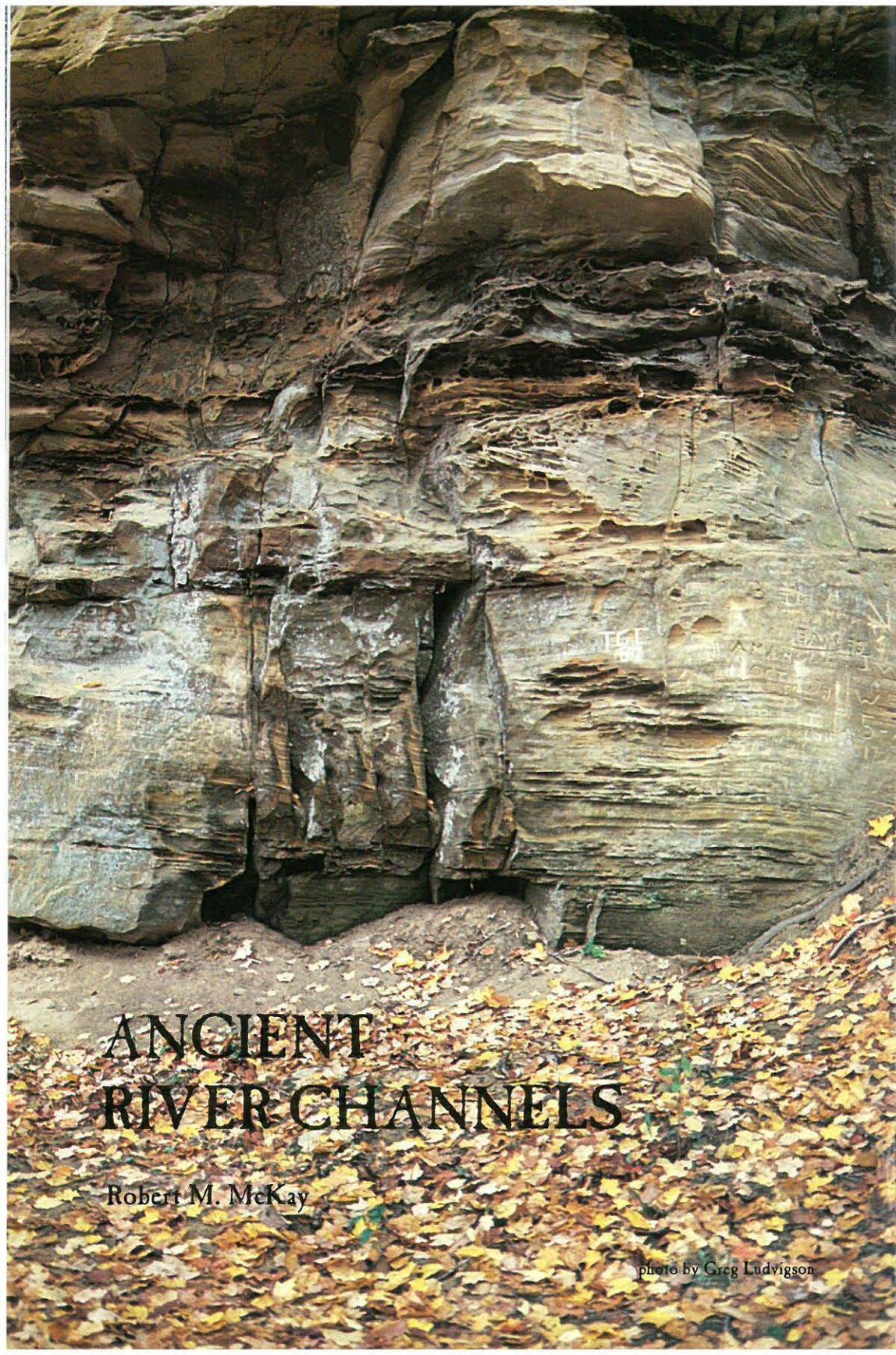
This meltwater lake and its bordering coniferous trees are situated on an ice-cored moraine of the Klutlan glacier in the Yukon Territory, in a scene resembling the stagnant margins of the Des Moines Lobe in north-central Iowa 13,500 to 12,000 years ago.



H.E. Wright Jr.

Further information about glacial-age floods is found in comparing the thickness and properties of sand and gravel in river valleys that were close to the former ice front with deposits more distant from the glacier. Sand and gravel in valleys near the glacial sources tends to be relatively thin -- on the order of 10 to 20 feet, relatively coarse, and deposited in channels that shifted rapidly across the late-glacial floodplain (see photo, left). On the other hand, in valleys distant from the glacier front, such as the Mississippi in Iowa, the late-glacial sand and gravel is much thicker -- over 150 feet in portions of the Mississippi valley shown on p. 9, finer grained, and deposited in braided channels that looked somewhat like the Platte River channel in Nebraska today.

In contrast to most modern floods, whose impacts are often damaging, the impacts of Iowa's glacial floods have been valuable to us. Most sand and gravel aggregate, one of Iowa's largest mineral industries, is obtained from deposits laid down during glacial floods. The size, composition, and thickness of these deposits, which are important to the economics of production, varies along valleys primarily because of variations in flow conditions during glacial meltwater floods. These deposits are also important sources of groundwater for wells, serving many of Iowa's urban centers which were built along river valleys. Finally, the scenic valleys that were carved by these great floods are an integral part of Iowa's landscape diversity. ♦



ANCIENT RIVER CHANNELS

Robert M. McKay

photo by Greg Ludvigson

The scenic and recreational attractions along Iowa's rivers are unique to the valleys in which they flow. Geologically, these valleys are the result of flowing water eroding soft glacial-age materials or older, more resistant bedrock materials. Along steeper sides of the valleys, one frequently sees thin soils mantling prominent rock bluffs. These bluffs often are composed of limestones and dolostones, which are the biological and chemical products of tropical marine seaways that covered vast portions of North America between 65 and 550 million years ago. At other localities, however, river downcutting has exposed massive vertical bluffs of sandstone, sometimes forming steep-walled box canyons.

Scenic examples of such bluffs and canyon-forming sandstones are found along several stretches of the Des Moines valley, the Iowa and Racoon river valleys, and a few smaller stream valleys in eastern and southern Iowa. Many of these picturesque sandstones have been included in Iowa's state parks, preserves, or county conservation lands because of their exceptional scenic and botanical qualities. Good examples include Wildcat Den State Park in Muscatine County (photo, left); Dolliver, Ledges, and Elk Rock state parks in Webster, Boone, and Marion counties; Woodman Hollow State Preserve in Webster County; and Cedar Bluffs Natural Area in Mahaska County.

The majority of these bluff-forming sandstones are 300-million-year old (Pennsylvanian-age) deposits that are part of the Cherokee Group, a major rock sequence throughout much of

Iowa, Missouri, Nebraska, Kansas and Oklahoma. These sandstones typically form elongate, ribbon-shaped sand bodies that were deposited in sinuous channels of ancient rivers and deltas. The sandstone deposits are usually oriented northeast to southwest and are usually less than one mile wide. Their thickness may exceed 100 feet. These ancient river channels meandered across Iowa as part of a vast equatorial ecosystem of lowland rivers and coastal deltas. They drained the interior of North America from the Appalachian Mountains in the east to the edge of a large seaway to the southwest. During this time the coastal margin migrated back and forth between Oklahoma and Illinois, and the river and delta systems deposited clay, mud, peat and channel sands on the land mass between the mountains and the sea. In the course of geologic time, these sediments were compacted and cemented into the familiar sandstone, shale, and coal beds seen today.

Iowa's modern rivers, which had their origins during the relatively recent glacial history of the continent, have removed the covering of glacial deposits and exposed the ancient channel sandstones to view. These rock formations are valuable to Iowans as local sources of groundwater for wells, and also as cool, moist, forested retreats in our state and county parks. During historic settlement of Iowa, many of these channel sandstone deposits were quarried for building and foundation stone. Perhaps the best known examples of this use are the sandstone buildings of the Amana Colonies. ❖



Pointed crystals of white **calcite** and translucent yellow cubes of **fluorite** line the edges of this gray limestone collected near Postville in Allamakee County. Calcite (calcium carbonate, or lime) is the primary mineral in limestone, while fluorite is rare. Such crystal growths are found along open spaces (vugs or fracture traces) within the rock.

MINERALS

Jean Cutler Prior

Minerals are the building blocks of the Earth's rocks. They have a specific chemical composition and a characteristic crystal form. The Iowa minerals shown here display an appealing range of color and shape.

Many people are introduced to the field of geology through the fun of searching for and collecting minerals. Beautiful varieties can be found in Iowa's sedimentary rock strata, outcropping in road cuts, quarries, strip mines, and along stream banks or valley sides. Striking crystals make up many of the coarse-grained igneous and metamorphic cobbles and boulders that lie in pastures and farm fields where they were left by melting glaciers. Gravel pits along Iowa's valleys and the gravel bars within river channels are also good places to find a wide assortment of mineral specimens.

In addition to their crystalline beauty, information about a mineral's geologic age and origins can be obtained from its chemical isotopes and from its association with other minerals. Mineral resources play a significant role in our daily lives, and Iowa's mineral industries are valuable to the state's economy.



Tim Kemmis

"Dog-tooth spar" is the name given to sharply pointed crystals of white **calcite** as seen on this massive piece of gray limestone from Mahaska County. Also prominent are brass-colored masses of **pyrite** crystals, known as "fools gold."

This wind-polished and lichen-covered rock of Sioux **Quartzite** is from Lyon County in the northwest corner of Iowa. Quartzite is composed of compacted **quartz** grains solidly cemented together with **silica**, giving the rock a glassy appearance and a very hard surface. Its resistance to weathering makes it useful as highway and railroad aggregate.



Pat McAdams

Tim Kemmis



Geodes have drab, rounded exteriors with a hard outer layer and partially hollow interiors lined with inwardly projecting mineral crystals. This large geode, containing pink and gray **quartz** crystals, was collected near Keokuk from the Warsaw Shale, a rock formation that outcrops along stream beds in Iowa's southeastern counties.



Galena has a distinct metallic-gray luster and a cube-shaped crystal form. It is very heavy and is the principal ore of **lead**. This mass of crystals is from Dubuque County, where lead ores were mined for over 300 years from veins in the dolomite bedrock.



The tall, slender crystal of **gypsum**, a variety known as **selenite**, is from Appanoose County. It has a soft, easily scratched surface. A related sulfate mineral, also formed by evaporation from seawater, is called **anhydrite** (lower, banded rock). Gypsum is mined in Webster and Des Moines counties for wallboard production.



Limonite is a distinctively yellowish brown ore of **iron**. It takes many forms, including the cellular structure seen in this sample from the historic Iron Hill area near Waukon in Allamakee County.

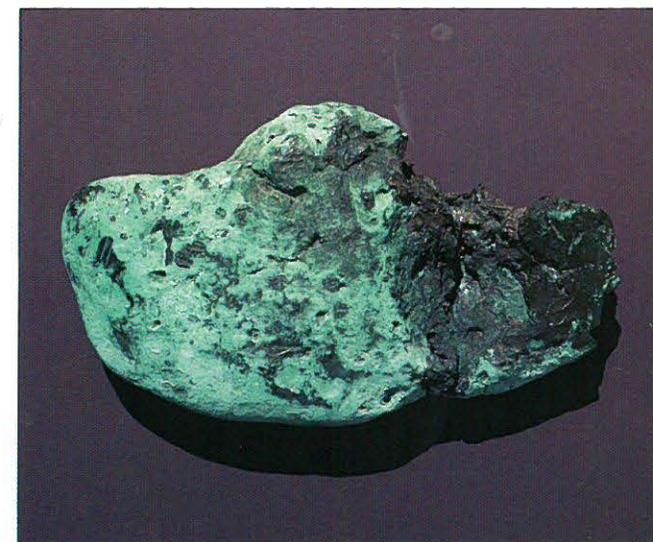


Barite is an unusually heavy mineral. This sample from Fayette County is composed of rounded masses of radiating crystals. Barite is used primarily as an additive in drilling muds and paints.

This pyramid crystal of translucent **calcite** is from Mahaska County. Calcite is the principal mineral in limestone, chalk, and marble. It occurs in a variety of colors and bubbles vigorously when a drop of dilute hydrochloric acid is applied.



Heavy nuggets of the mineral **copper**, a good conductor of heat and electricity, are found on rare occasions in Iowa's glacial deposits. This 67-pounder, tarnished with greenish oxides, probably originated in the Lake Superior area of Michigan's Upper Peninsula.

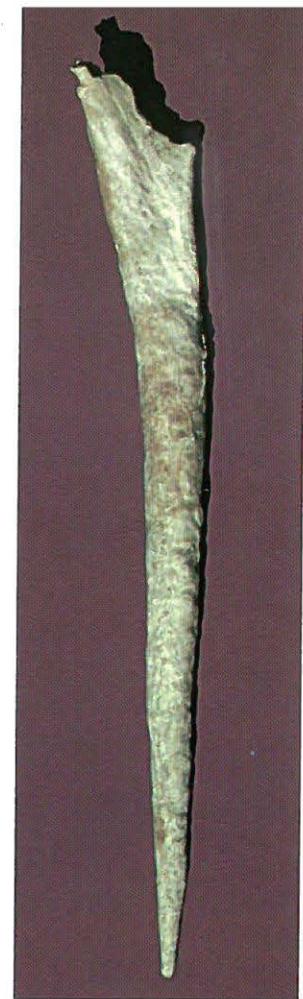


Coal is a combustible rock, rich in **carbon** and formed by compaction of fossil plant remains similar to peat. Thin veins in this piece are filled with **pyrite**, an abundant ore of **sulfur**. Coal was mined from seams in the Pennsylvanian-age rocks of south-central Iowa, with peak production during the early 1900s.

Feldspar is a widespread mineral especially common in igneous rocks such as granite. This blocky fragment of crystalline feldspar was found in gravel deposits along the Cedar River in southeastern Linn County. It probably weathered out of a granite boulder carried into Iowa by a glacier.

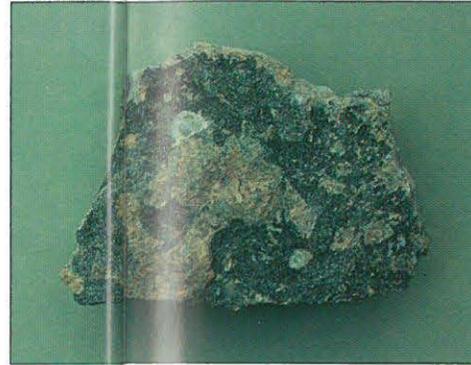


Fragments of **petrified wood** can be picked up from glacial-age gravels along Iowa's rivers. This water-worn piece from the Cedar River in Linn County shows that **silica**, in the form of **chalcedony** or **opal**, completely replaced the original tissue, with tan and dark-brown bands revealing the original wood grain.

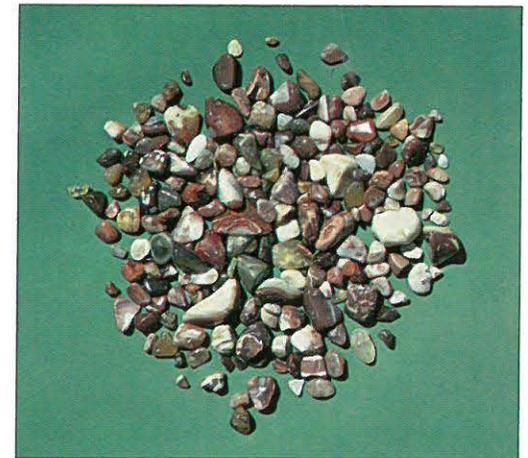


This impressive **stalactite** is from a cave in Winneshiek County. Such cave decorations are composed of the mineral **calcite**, and are deposited in distinctive shapes by the slow dripping of lime-rich groundwater.

Metallic clusters of **pyrite** crystals ("fool's gold") form bumps on a piece of limestone collected in Black Hawk County. The pattern of mineral clusters is a result of mineral growth in the honeycombed openings of a fossil colonial coral in the limestone.



Grains of the mineral **glaucconite** can give sandstone a distinctive greenish color. Glaucconite is found in marine sedimentary rocks, and it indicates a slow rate of sediment accumulation. This glauconitic sandstone outcrops in Allamakee County, along the Upper Iowa River and at Lansing.

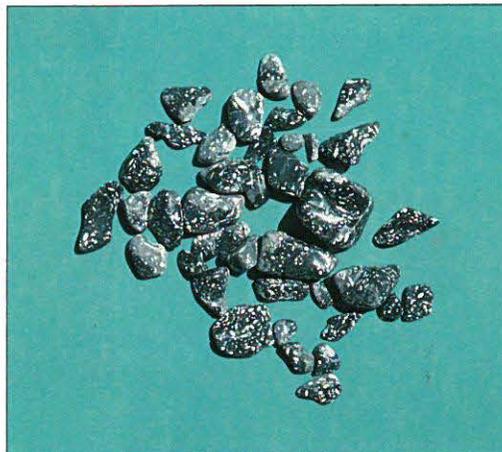


These **agates** (varieties of dense but translucent **quartz**, **chalcedony**, and **opal**) are from Mississippi River gravel deposits in Clayton County and have been tumbled to a high polish. They include the prized Lake Superior agates, known for their fine, alternating bands of rich colors.

Non-credited photographs on pp 14-19
by Paul VanDorpe
Photo setups by Patricia Lohmann

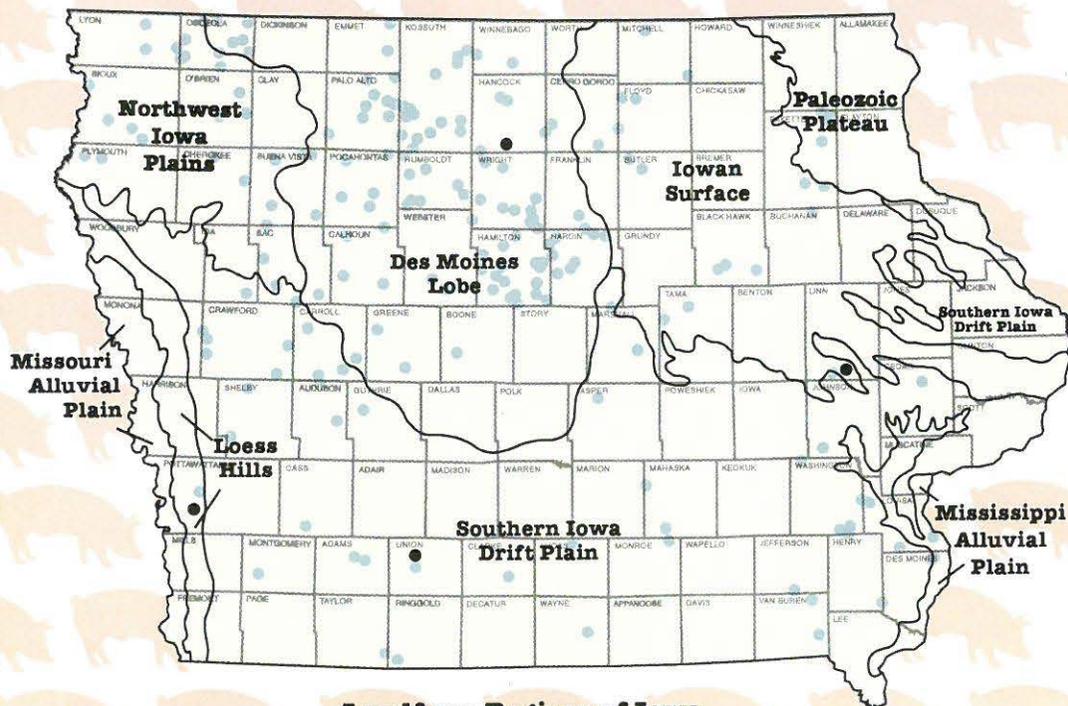


Known to mineral collectors as "**rice agate**," these polished stones of black **chert (flint)** consist of a dense variety of **silica** found in the sedimentary rocks of Montgomery County. The "rice" pattern comes from numerous white shells of fossil **fusulinids**, a tiny marine protozoan.



Hogs and the Environment

Deborah J. Quade
Lynette S. Seigley



Landform Regions of Iowa and Distribution of Hog Confinement Lagoons

● monitored sites ● all lagoons

Iowa is the national leader in hog production, with 24 million marketed in 1993. This number has increased over 20% since 1970, while the number of farms raising hogs has decreased by 60%. The increased concentration of hogs per farm signals a move to larger scale confinement operations. Resulting concerns focus on social, economic, and environmental issues, especially odor and potential groundwater contamination.

In response, the Geological Survey Bureau is monitoring shallow groundwater quality at four manure-storage lagoons at hog confinement operations in different landform regions or geologic settings across Iowa. These four lagoons are constructed of local earthen materials. If a lagoon leaks, the sequence of underlying geologic deposits may either enhance or limit the movement of contaminants to shallow groundwater supplies. Limited funding for the project and difficulty in finding cooperating owners restricted sampling to the sites shown (left).

The site in Hancock County is located on the Des Moines Lobe, a region blanketed by clay-rich glacial till ranging from 50 to 150 feet thick. The general absence of deep vertical fractures in this young, unweathered material should limit the movement of contaminants to wells drilled into the underlying bedrock. Other wells, however, are finished in shallow, porous sand and gravel zones within the glacial clays. Significant sand and gravel deposits also occur beneath the knobs, ridges, and depressions in more hummocky areas (moraines) of the region. These areas have greater potential for leakage to shallow groundwater supplies.

The Linn County site is located on the Iowan Erosion Surface. This region consists of much older, weathered, and deeply fractured glacial tills that are mantled by a variable thickness of loess (windblown silt). Depth to bedrock ranges from 0 to 400 feet. The majority of private water wells are drilled into fractured limestone to

depths over 100 feet. Earlier investigations have shown a greater potential for contaminants to move through fractures in glacial till than previously believed. Karst (sinkhole) areas in this region, having little glacial material covering the bedrock, also are susceptible to groundwater contamination.

The Southern Iowa Drift Plain is represented by a site in Union County. This region contains steeply rolling topography with moderate deposits of loess mantling weathered and fractured glacial tills, similar to those of the Iowan Surface. The majority of private water wells in this region rely on shallow "seepage" wells (30 to 50 feet deep) that are completed in loess or at the interface between the loess and glacial till, making them vulnerable to contamination from surface sources.

The Pottawattamie County site is located in the Loess Hills, along a small valley underlain by silty alluvial (floodplain) deposits derived from loess. The region is characterized by steep slopes and thick loess blanketing older, weathered and fractured glacial tills. Many private water wells in this region are less than 50 feet deep and utilize the seepage-well design seen in the Southern Iowa Drift Plain.

Monitoring wells at each earthen-lagoon site are sampled monthly for changes in water chemistry that will indicate whether animal waste is leaking from the lagoon into shallow groundwater. Results of this study will indicate the effectiveness of earthen lagoons in different geologic and hydrogeologic settings in Iowa. ❖



MAPPING FOR THE NEXT CENTURY:

Satellite images
and computer technology
add new dimensions
to detailed geologic
mapping of Iowa

Greg A. Ludvigson
E. Arthur Bettis III
Bernard E. Hoyer

Passage of the National Geologic Mapping Act of 1992 provided a stimulus for detailed geologic mapping of the U.S. directed towards the resolution of environmental problems. This decade-long mapping program is administered by the U.S. Geological Survey and includes a "STATEMAP" component which offers financial support for geologic mapping to state geological surveys through a competitive grant process. During the first year of the program in 1993-94, the Geological Survey Bureau (GSB) mapped a segment of the Mississippi River valley covered by the Blanchard Island and Letts 7.5 minute quad-

ranges in southern Muscatine and northern Louisa counties. Tools unavailable in the earlier years of traditional geologic mapping were applied. These include satellite images to assist with mapping boundaries between different geologic deposits, and computer technology to convert maps to digital databases, which then can be transferred in electronic form, printed as colored maps, combined with other geographic information, and be easily updated.

Geologic maps (of Iowa) display the location and distribution of various rock types, faults, and sediments deposited by marine seaways, glaciers, wind, streams, and hillslope processes. They also convey information about the three-dimensional geometry of these deposits and their relative age relationships. Such qualities make geologic maps valuable to scientists in understanding the Earth's composition and structure, processes and history. They also are valuable to society, which lives and depends on geologic materials. People need answers to questions such as the best place to locate a landfill, the extent of groundwater contamination problems, sources of road-building aggregate, and geologic hazards affecting subdivision development.

Geographic information systems (GIS) combine computer mapping and assorted databases. This technology can be used to prepare customized

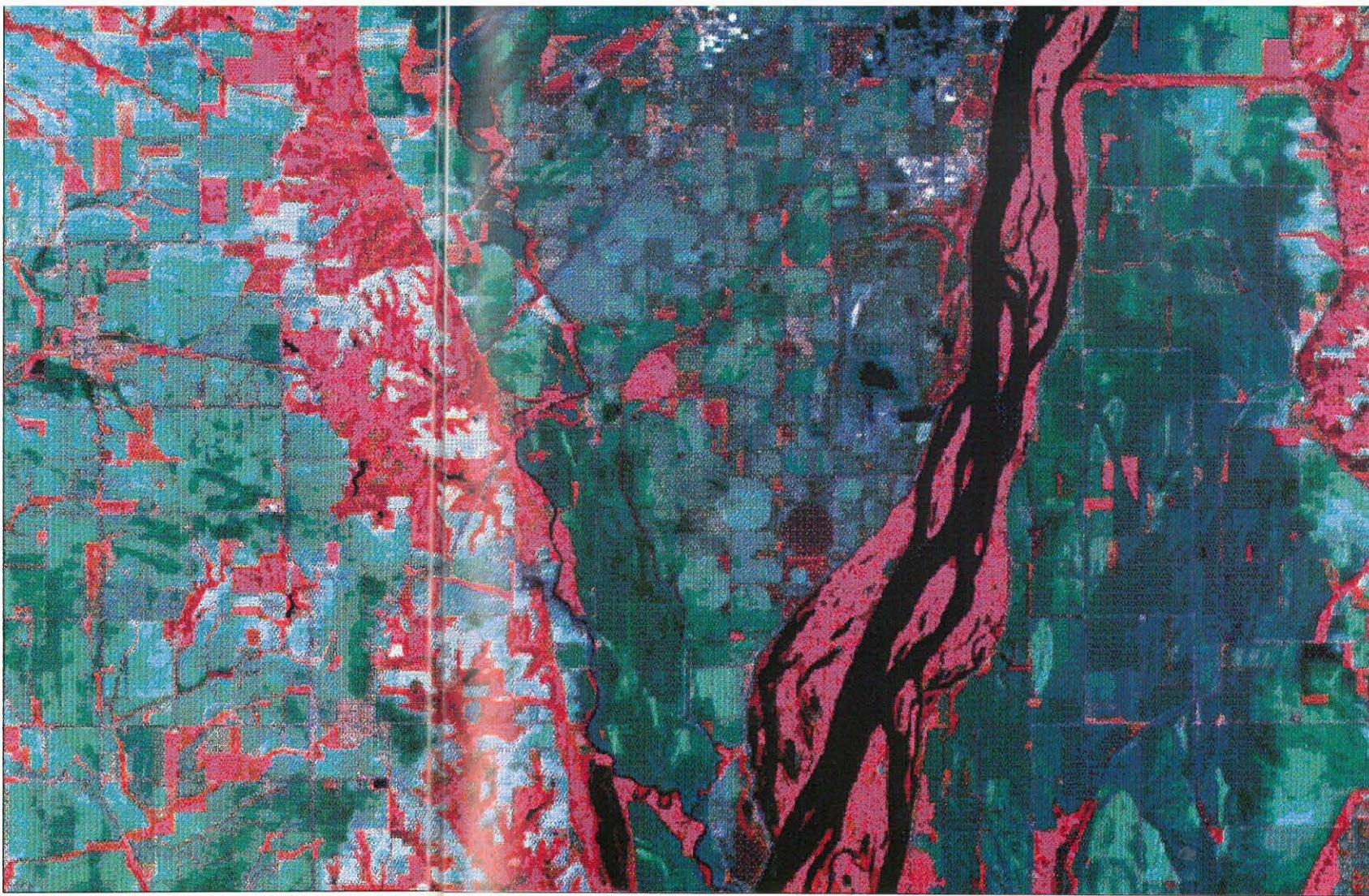
maps derived from geologic maps and accompanying data bases. Features such as water wells and core holes may be selected for display based on their depth, construction, capacity, or their use -- whatever is recorded in the database about them. Similarly, streams, sinkholes, geologic contacts, or faults could be selected by a database criterion. Lakes, sand dunes, or bedrock units may also be selected based on attributes that describe them, such as water quality, thickness, or permeability. The result is that maps may be constructed for one general purpose but can be converted quickly into another, more specialized purpose if appropriate attributes are available in a database.

The completed Letts and Blanchard Island quadrangles encompass about 110 square miles of the

GOAL: Informed decisions on future environmental and natural resource issues.

Mississippi Valley and adjoining uplands south of Muscatine in eastern Iowa and adjacent western Illinois. The goal of the project was to map geologic materials to a depth of five meters (about 18 ft) at 1:24,000 scale (1 in = 2,000 ft) in order to provide baseline geologic information for a host of environmental and resource issues. The mapped area includes Muscatine Island, a portion of the Mississippi Valley under competitive

SATELLITE IMAGE: Taken on May 27, 1989, this color-infrared Landsat TM image of the Mississippi River valley shows the distribution of vegetation (red), bare soil (light blue-greens), and wet soil (dark blue-greens). Sandy, better drained materials (purple) and open water (black) also can be distinguished. These patterns help to differentiate deposits representing thousands of years of floodplain history. Circular features are center-pivot irrigation plots. This image was used to confirm and adjust geologic contacts mapped on pp. 26-27.



pressures from agriculture and industry for land and groundwater. A portion of the Upper Mississippi River navigation system and several wildlife refuges and game management areas also occur in this area and present a series of contrasting resource management issues. Land degradation from soil erosion and headward advance of Mississippi tributary valleys, as well as landfill siting are important issues on the upland.

Several sources of subsurface information, including water well records, engineering boring records obtained from public utilities and the Iowa Dept. of Transportation, monitoring well records of the U.S. Geological Survey, borings made by the GSB, and published soil surveys, were used to construct the geologic maps. This data was compared to landscape patterns

on high-altitude air photos and satellite imagery to formulate and draw the map units. Thirty-two map units, each depicting a unique succession of geologic materials to a depth of five meters, were developed.

The pattern of map units (p. 26-27) shows many elliptical, smooth-edged units that characterize river

deposits in the Mississippi Valley, while the bordering uplands contain mainly two units of loess-mantled glacial drift that are dissected by branching units of younger stream deposits along drainage ways. The map and related cross-sections (not shown) provide a detailed view of the geologic materials that most affect day-

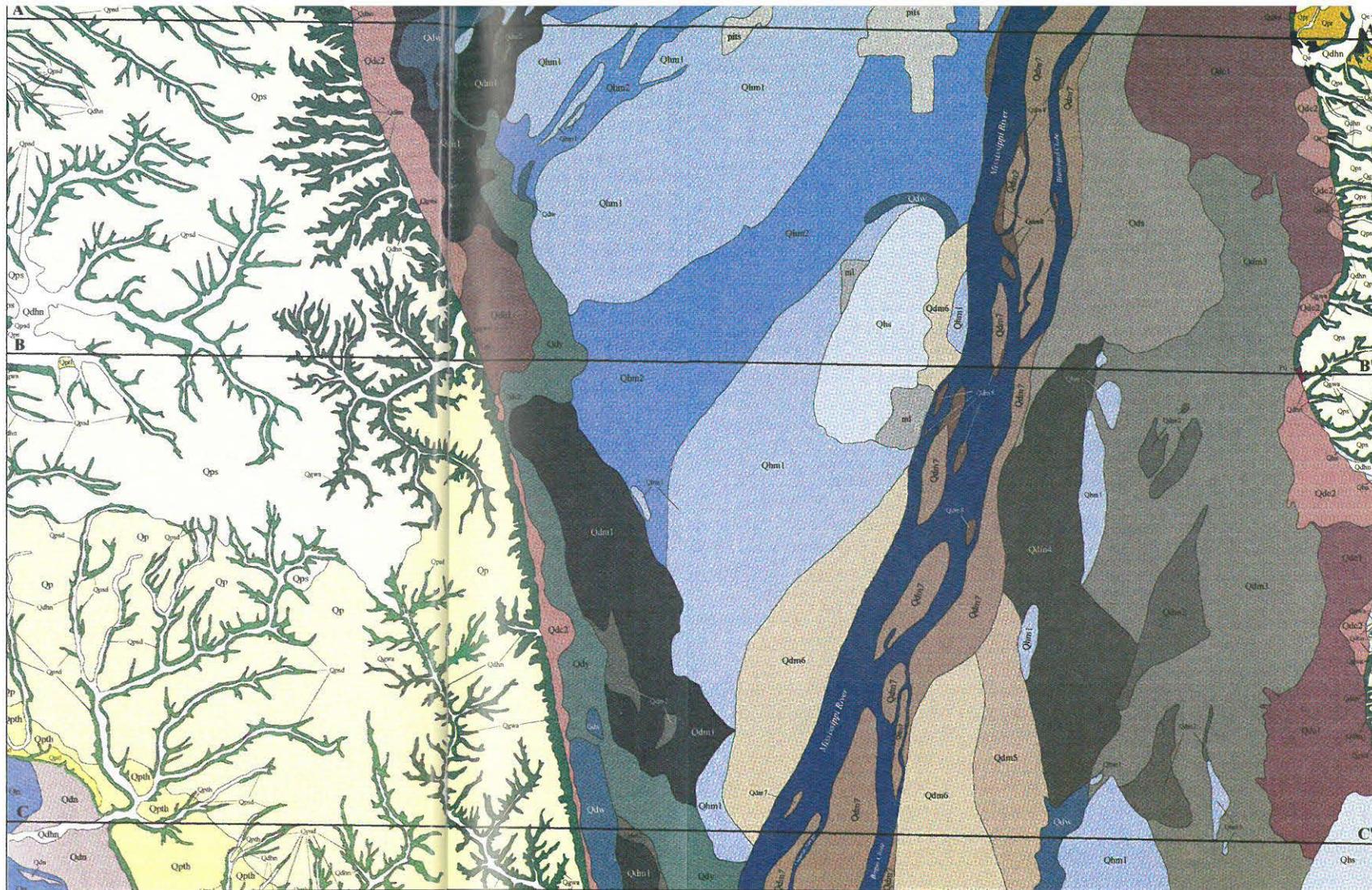
to-day activities in this area and can give planners a sound base of geologic information from which to make resource decisions.

In July 1994, the GSB began work on its second STATEMAP project, with the inauguration of a three-year program to map the shallow geology of Linn County. In compliance with

COMPUTERIZED MAPS:

Geologic maps of the Letts and Blanchard Island quadrangles (along the Mississippi Valley) are combined in this graphic and are the first detailed mapping of the shallow (upper 18 ft) geologic materials in Iowa done under the STATEMAP program. Two major groups of (Quaternary) deposits are present -- those left by glacial ice and wind compose the uplands, and those left by streams occupy the valleys. The information is available in electronic or paper form and can be updated as more subsurface information is acquired.

national program directives, the GSB assembled a statewide geologic mapping advisory panel that consisted of individuals from government, academia, professional societies, engineering firms, and mineral producing firms. This panel, representing potential users of geologic information, selected Linn County as the area where surficial geologic mapping could be most usefully applied to recognized environmental problems. During the 1994-95 project year, the Cedar Rapids North and Marion 7.5 minute quadrangles are being mapped, and the bedrock geology of the entire county is being updated. Specific environmental problems being addressed in these quadrangles include drainage and groundwater contamination, suburban expansion in areas of sinkholes (karst), and long-range plans for the county sanitary landfill. In



addition to the federal award, financial support for the mapping has been provided by the Linn County Engineering, Planning and Zoning, Regional Planning, and Solid Waste agencies, as well as the cities of Cedar Rapids, Hiawatha, and Marion, all of whom are anticipated end users of the map information. All maps are being

compiled using GIS technology and will be stored in DNR's Geographic Information System Library, procedures that will facilitate digital access for many users and provide flexible use of the geologic mapping for various applied purposes in the future.

Today there is a recognized need for more rapid access to more detailed

information. GIS techniques provide an effective means to develop specific information, tailored to specific needs, in a timely manner. The use of this technology enables geologists to develop map information in ways that better assist society in understanding and resolving its environmental and resource problems. ❖

Living with a River . . .

Among Iowa's geologic deposits are sandstone beds recording the position of ancient river channels that flooded Iowa lowlands millions of years ago. Many large river valleys existing today are partially filled with sands and gravels left by surging floodwaters released by glacial melting thousands of years ago. The energy of flooding rivers is responsible for shaping Iowa's valleys, the features of their bottomlands, and the distribution of their soils. While rivers and their floodplains have been around for a long time, people are relatively new to the landscape and tend to be rather short-sighted when it comes to sharing the Earth's surface with on-going geologic processes.

Iowans live with numerous rivers, and most of the time it is a peaceful coexistence. The Flood of '93, however, held our anxious attention as many rivers reclaimed lands that were part of their geologic territory. Failing levees reminded us of the problems of trying to engineer a natural system to accommodate people -- and to the fact that in manipulating the landscape, humans themselves become geologic agents, influencing the course of natural processes in unintended ways. We need to rethink our relationships with rivers. We need to recognize that we often live too close to them, that they need their own space, and that we need to expand our perceptions of them and broaden our understanding of how they function through time.

*Jean Cutler Prior
Editor*

