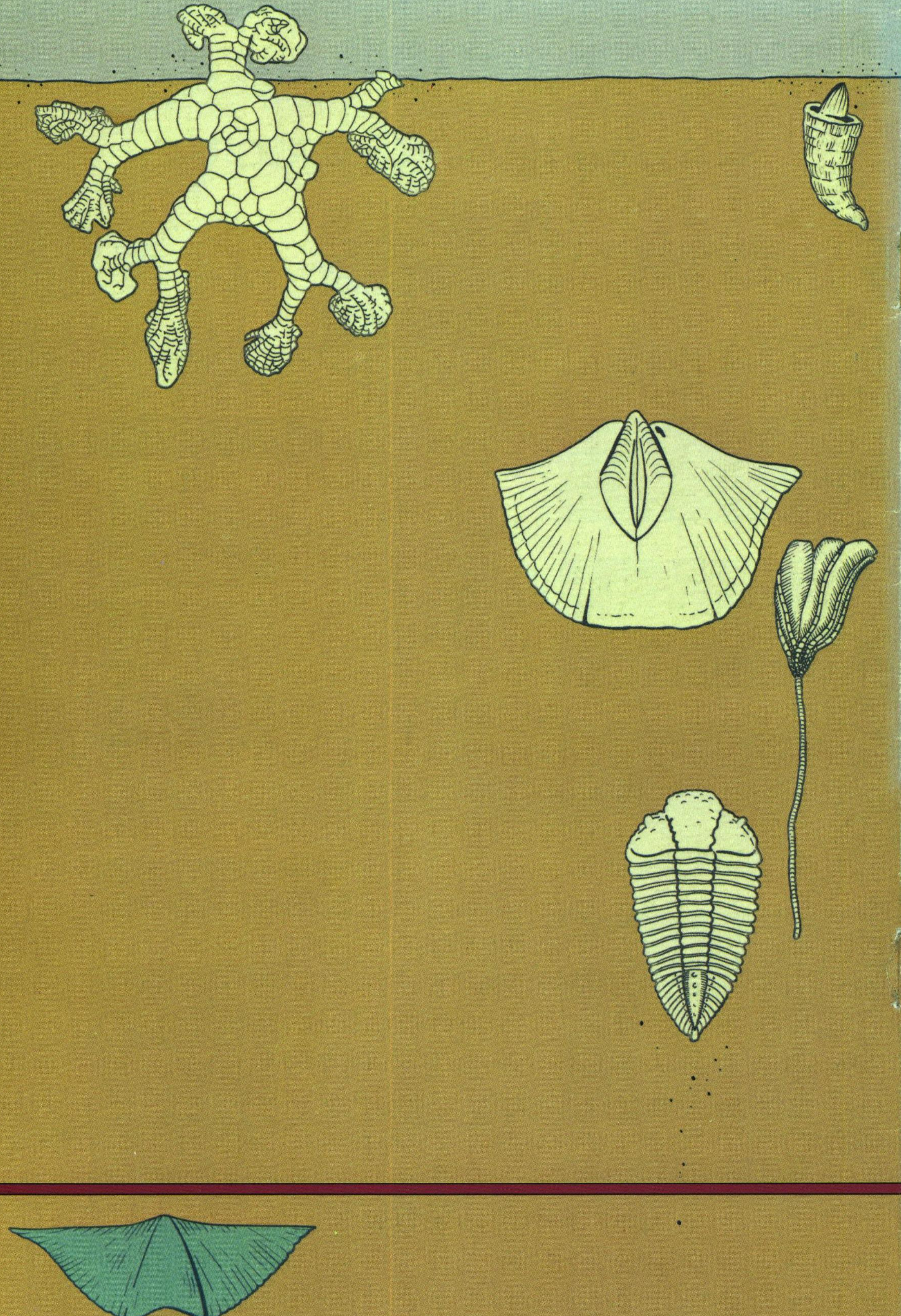

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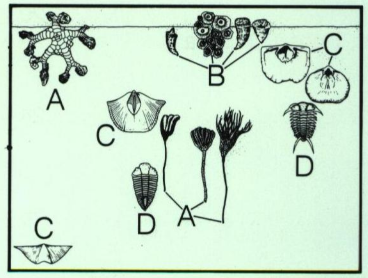

Cover Design:
Paleozoic-age marine invertebrate fossils found in Iowa
A Crinoids
B Corals
C Brachiopods
D Trilobites
Cover illustration by Patricia Lohmann

Bernard E. Hoyer .... Editor
Jean C. Prior .... Assistant Editor
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Editor's note: I wish to acknowledge the professional assistance of Laurie E. Comstock.

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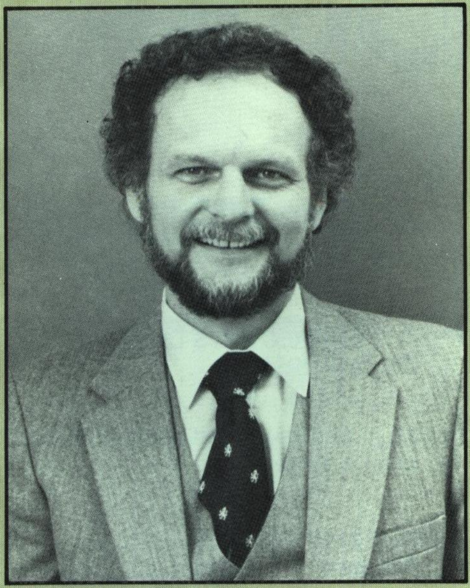
FROM THE DIRECTOR'S DESK



Articles in *Iowa Geology* are designed to inform readers about interesting aspects of the geology and hydrology of the state. Usually, the main articles relate to current projects of Survey staff, organized around a central theme, such as water resources. This issue contains a wider variety of articles that provide "something for everyone." Geologists often are criticized for not being able to communicate effectively with legislators, governmental agencies, business/industrial leaders, and private citizens who require geologic information for the proper development and management of our natural resources. *Iowa Geology* is one way that we can bridge this communication gap and, at the same time, promote a greater awareness of the impact that geology has on our environment and daily living.

Fossils, such as appear on the cover, present a new world of beauty and wonder for the hobbyist. Many collectors go far beyond mere storage of their prizes in a shoe box. As their interest grows they learn to classify and identify specimens by genera and species. Both occasional and avid collectors have advanced our knowledge of ancient life forms through discovery of previously unknown fossils. The study and use of fossils by professional paleontologists is important to geologial studies in Iowa, particularly as a means of correlating rock units for mineral and water-resource evaluation. Iowa has its share of world-famous fossil localities, such as the crinoid beds at LeGrand and the prolific brachiopod shells near Rockford.

Discovery of oil has been an evasive dream of many people since 1900 when the first recorded oil exploration test hole was drilled in Iowa. About 410 barrels of crude were produced in 1963 from a well in Washington County, but an economical deposit has yet to be discovered. Recently, there has been a great deal of leasing activity in Iowa. "In Search of Iowa Oil" outlines the preliminary steps used in exploration and describes the basic geologic ingredients needed for a potential oil field to exist. In addition to the Forest City Basin, a new potential target for oil exploration is examined, but test holes will be significantly deeper than in any previous effort.

Soil erosion is a natural geologic process that always has existed. Gully formation, a particularly intensive form of erosion, is especially severe today in western Iowa. But these deep gullies, as you will read later, are not new to this part of the state. The geologic record shows that gullying has been part of the natural process of landscape evolution in western Iowa for several thousand years. Settlement and agricultural activity cannot be singled out as the sole cause of this erosion, though landuse changes undoubtedly have aggravated the problem. Erosion is part of our future. Clearly, we must continue our efforts to understand the process involved and our attempts to lessen the rate of soil loss here and across the state.

The materials deposited by the youngest glacial advance into Iowa have left diverse landscape patterns and also comprise an important natural resource. Interestingly, the landforms and deposits of the Des Moines Lobe and its margins can be compared with those of modern glaciers, existing elsewhere in the world. Studies of the Des Moines Lobe will provide valuable information useful to agriculture, engineering, and environmental protection.

Sinkholes, caves, and springs abound in northeast Iowa. Sinkholes are funnel-shaped depressions on the land surface that develop from the collapse of rock and soil into underlying openings in limestone. Over 12,000 of these features have been mapped in eastern Iowa! Sinkholes can lead into underground caverns, and some of these, such as Cold Water Cave in northwestern Winneshiek County, are decorated with a wide variety of colorful dripstone formations. Water that moves into sinkholes and underground drainage networks often emerges as springs that appear cool and inviting, but may be contaminated with nitrate, harmful bacteria, or even pesticides. We need to critically examine landuse management practices and make appropriate adjustments that will reduce contamination of our water resources.

Another hazard to our environment — not a geologic hazard, but one of our own doing — innumerable gasoline stations with buried storage tanks, many of which are in need of repair or have been abandoned and forgotten. Spillage and leakage over past decades haunt us now with increasing incidences of tainted and contaminated groundwater. Fortunately, most future incidences will be localized and will not affect major sources of water supply.

All of these topics, fossils and oil, sinkholes and water, glaciers and gullies, are fascinating in themselves and reflect the past existence of an amazing array of geological environments here in Iowa. It is the understanding of these past environments and processes that is so fundamental to practical problem-solving of matters that relate to the earth today. I believe that these articles, and the remaining short news notes, will be interesting reading, acquainting you with a variety of projects handled by Survey geologists. At the same time, I hope we have communicated the important applications these studies have to our state and that we have encouraged further inquiry and understanding of the topics and issues brought to your attention.

Donald L. Koch

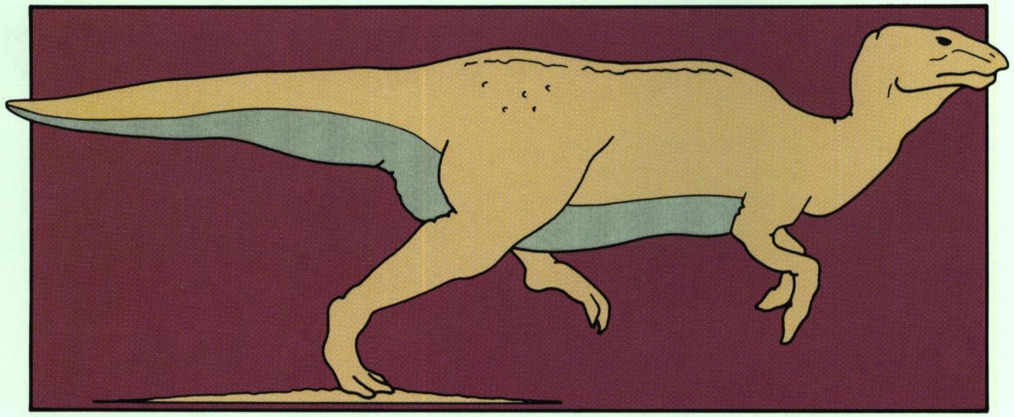
Donald L. Koch
State Geologist and Director

FOSSILS: EVIDENCE OF ANCIENT LIFE IN IOWA

Brian J. Witzke

Fossils are the remains or traces of ancient animals or plants which have been preserved by natural processes within sediments or sedimentary rocks of the earth's crust. Most of Iowa's fossil record is preserved within limestone, shale, and sandstone layers deposited in ancient coastal lowlands or seaways that once covered the state. The dead remains of many organisms were buried and preserved by accumulating layers of sediment in these ancient environments. Soft-bodied remains of these organisms are only rarely preserved within the geologic record, primarily because soft tissues generally decay as sediment accumulates. However, the hard parts of organisms, especially shells and bones, are more resistant to decay and erosion, and, as such, most fossils found in the geologic record represent only the hard parts of these ancient life forms. Fossils are preserved in several ways: 1) original hard parts are preserved with little or no modification; 2) hard parts are replaced by different minerals after burial; 3) mineral substances are deposited within the porous space of hard parts or tissues; 4) hard parts are dissolved from the enclosing sediment leaving a mold or impression in the adjoining rock; 5) plant or animal tissue is compressed into a thin film of carbon; and 6) trace fossils (tracks, trails, burrows) are preserved as distinct structures within sedimentary rocks.

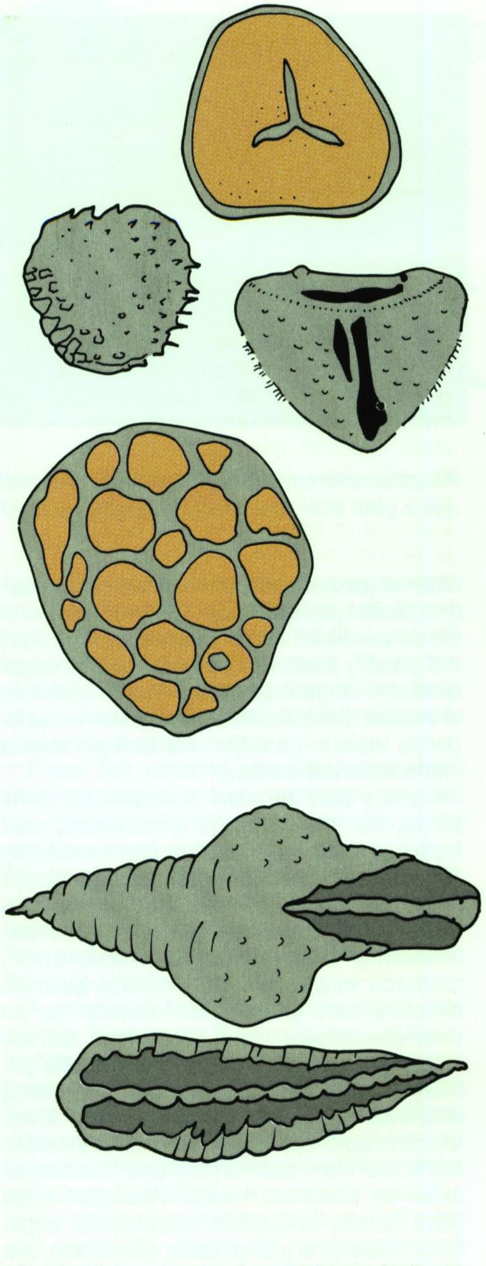
A tremendous variety and abundance of fossils have been found in Iowa, and some are world famous for their beauty or rarity.



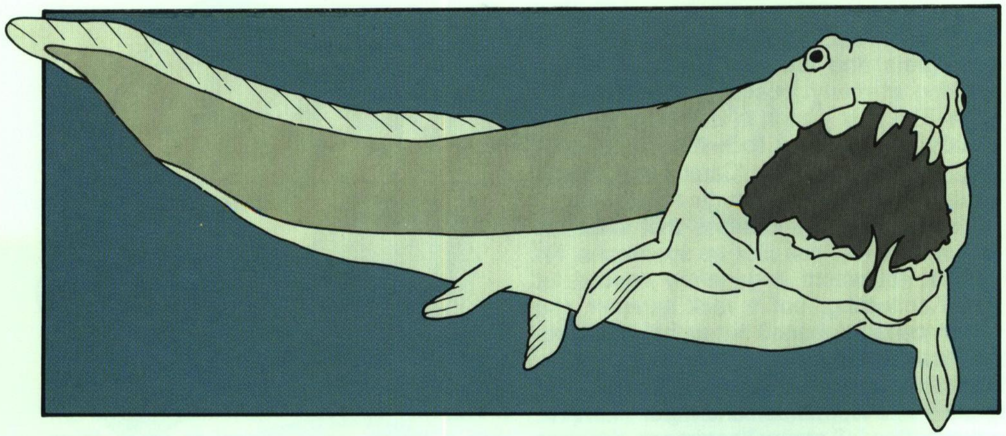
Dinosaurs once lived in Iowa, although the fossil evidence is meager. Shown is a reconstruction of a duck-billed dinosaur about 30 feet long.

Over the past 125 years, large collections have been accumulated by professional geologists and amateur fossil collectors working at many localities throughout the state. The best places to look for fossils are usually along natural rock exposures, road excavations, or quarries. Careful searching is usually necessary, although fossils are so abundant at some localities that even the casual observer can pick up specimens. No special equipment is generally needed for fossil collecting, but a rock hammer and chisel come in handy when attempting to remove fossils from large blocks of rock. Cleaning most fossils is an easy task accomplished with tooth brush and water. However, preparation of some specimens requires special techniques and a great deal of patience. Many people collect fossils in Iowa as a hobby, and these dedicated collectors continue to unearth specimens of great beauty and scientific importance. Collectors often visit the Iowa Geological Survey and the geology departments at Iowa's colleges and universities with fossil specimens in need of identification.

Paleontology is the science that deals with the study of fossils, and paleontologists apply principles from both the geological and biological sciences in their research. Why study fossils? Why are they important? There are several major reasons, each of interest both academically as well as for solving practical geologic problems. Scientists are particularly interested in fossils because they provide direct evidence of ancient life, including many life forms that no longer live in the modern world. The study of fossils helps answer some basic questions: what kind of animals and plants lived in the geologic past, and how have they changed through time? By determining the sequence, or order, in which different fossil groups appear within the sedimentary rock record in different areas of the world, an understanding of the history of life on earth can be approached. The sequence of fossils from the geologic record at any one locality is determined by utilizing a simple rule: younger strata are deposited above older strata. Only in areas of intense mountain-building activity have



Microfossils are commonly used for geologic correlations. These microscopic fossil plant spores (above) and conodonts (bottom two fossils) are from coal-bearing strata in Iowa.



Placoderms, or armor-headed fish, lived in the middle Paleozoic seas of Iowa. The illustrated placoderm was a giant of its time, reaching lengths up to 20 feet.

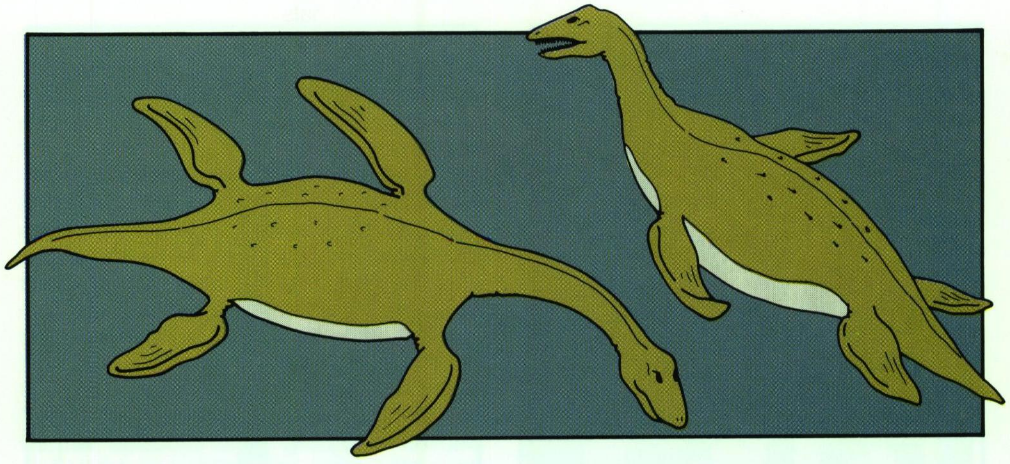
older strata been thrust or folded into a position above younger rock. The progression of life as portrayed in the fossil record provides the primary basis for recognition of the major divisions of geologic time. These divisions are used by scientists worldwide to categorize various geologic and biologic events into a historical context.

Fossils also provide a means for comparing the relative age of sedimentary rock layers at different localities and correlating rock layers of the same general age across broad geographic regions. Rock correlation is fundamental to many geologic endeavors, including mineral and oil exploration, resource evaluation, determining geologic structure, and groundwater studies. As an example, recent Iowa Geological Survey research found that fossils provided the primary basis for correlating and evaluating coal-bearing strata in south-central Iowa. Microscopic fossils (microfossils) were extracted from coal layers and associated rocks by chemical means. Abundant fossil plant spores and other microfossils, especially those of a group called conodonts, are particularly useful for correlating these strata.

Different groups of organisms inhabit different kinds of environments in the modern world, and ancient organisms, as seen in the fossil record, undoubtedly had specific environmental requirements when they were alive as well. For example, organisms that live in a tropical rain forest have considerably different environmental requirements than those that live in the ocean depths. The composition and structure of sedimentary rocks and their contained fossils provide important clues for interpreting ancient environments.

Iowa's fossil record dates back some 515 million years when a shallow seaway covered much of the state. Ancient seas continued to advance and retreat across Iowa throughout much of the Paleozoic Era, leaving behind a record of ancient life that spans portions of the interval dating between 285 and 515 million years ago. Paleozoic means "ancient life," and the fossils of the Paleozoic Era include the remains of many organisms that would be unfamiliar in the modern world. A great variety of organisms inhabited the ancient seas that covered Iowa, and their fossil remains are abundantly represented in the rock record.

Many of the most common fossils in Iowa are the remains of animals that lived on the ancient sea bottom. Most of these bottom dwellers captured or filtered out microscopic plants and animals and other food particles from the sea water. Common bottom dwellers in the Paleozoic seas include a variety of sponges, corals, bryozoans ("moss animals"), brachiopods ("lamp shells"), clams, and crinoids ("sea lilies"). Examples may be seen on the front and back covers of *Iowa Geology*. Dense accumulations of corals formed reef-like masses at times on the Iowa sea floor. Brachiopod shells are among the most familiar of Iowa fossils, and hundreds of different species have been recognized. Crinoids are among the most beautiful of Iowa fossils, although complete crinoid specimens are usually quite rare. However, crinoids are so abundant in some places that their broken skeletal remains make up entire layers of rock. Although crinoids superficially resemble plants, they represent a group of animals related to starfish.

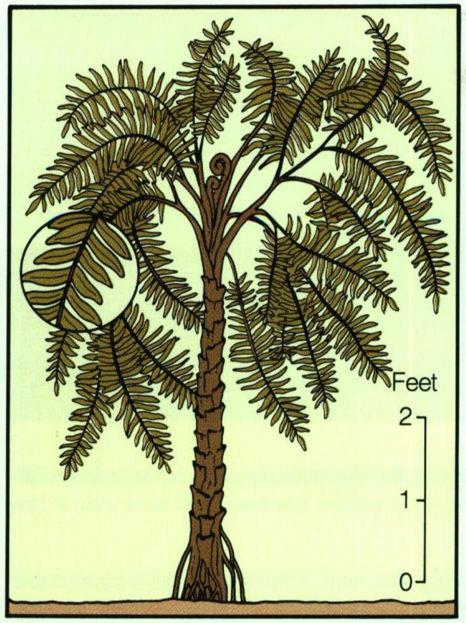


Plesiosaurs, an extinct group of sea-going reptiles, lived in the Mesozoic seas that covered Iowa. The illustrated plesiosaurs are about 20 feet long.

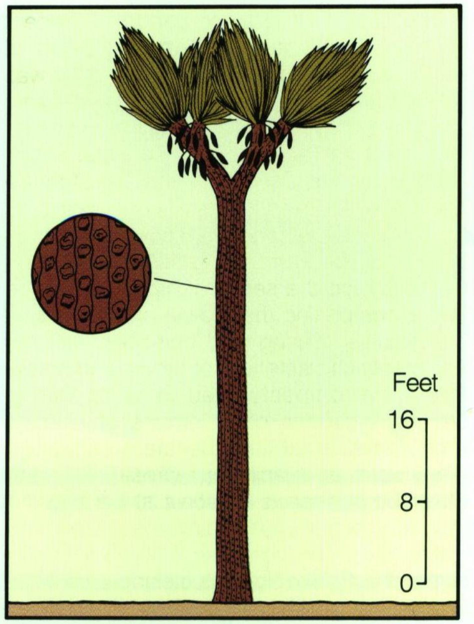
Other animal groups that inhabited the ancient Iowa seas include active predators and scavengers that crawled on the sea bottom or swam in the sea water. Fossil representatives from this group of mobile creatures include snails, cephalopods, worms, crustaceans, trilobites, starfish, and sea urchins. A diversity of extinct shelled cephalopods, ancient relatives of the modern chambered nautilus, have been found in Iowa. In the early Paleozoic seas of Iowa some cephalopods reached lengths of 10 feet, and are among the largest animals known from that time. Trilobites are among the most popular of Iowa fossils, and are highly prized by fossil collectors. These fascinating creatures represent an extinct group of sea-dwelling arthropods distantly related to modern horseshoe crabs.

Fossil fish remains also are known from Paleozoic rocks in Iowa, although they are not common. The oldest fish remains in the state are small skin plates of extinct jawless fish from rocks about 470 million years old. In younger rock layers, fish remains have been found that include sharks, extinct bony fish, and an extinct group of armor-headed fish called placoderms.

A great variety of microscopic plants and animals lived in the Paleozoic seas of Iowa, and these served as the primary food source for many of the larger animals that inhabited these seas. Various types of fossil algae provide evidence of ancient plant life on the sea bottom. In the early Paleozoic when animals and plants flourished in the shallow seas, the land surface remained largely barren of plant and animal life. Plants did not become well established on the land until middle and late Paleozoic time. Plant fossils are particularly abundant in the coal-bearing strata of Iowa, and a great variety of extinct plants are



A seed fern (Medullosa); Late Paleozoic coal swamps of Iowa.



A scale tree (Sigillaria); Late Paleozoic coal swamps of Iowa.

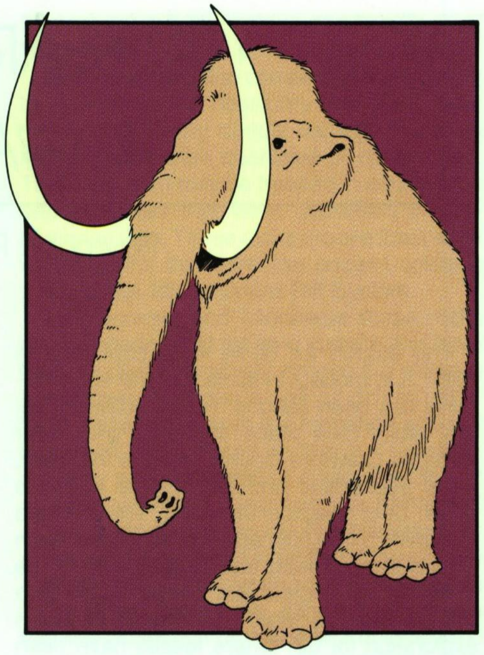
noted. Lush tropical vegetation covered the coastal lowlands, and the remains of these plants accumulated in swampy areas, later to be changed to coal. Fossils of ferns, seed ferns, scale trees, and giant horsetails are among the most common plants found in the coal-bearing strata.

The last 50 million years of Paleozoic history is not represented in the state's rock and fossil record, primarily because of extensive erosion. However, sediment again accumulated in parts of Iowa during the latter half of the Mesozoic Era, or period of "middle life." Preserved within these rocks are fossil remains from the "Age of Dinosaurs." The oldest Mesozoic rocks in Iowa are exposed in the gypsum mines at Fort Dodge, and these rocks were probably deposited along the margin of an ancient seaway that covered much of the western U.S. Plant spores are the only fossils recovered from these rocks. Later in the Mesozoic, about 100 million years ago, sediment accumulated in ancient river systems in western Iowa. Fossil leaves from flowering plants, such as magnolias, are preserved within these deposits and represent some of the oldest flowering plant (angiosperm) fossils known. Did dinosaurs once roam Iowa? Yes, but the record is meager: a single dinosaur bone fragment was recently found in Guthrie County. It provides the first direct evidence that dinosaurs lived in the state. Careful searching by fossil collectors will surely uncover additional evidence.

A shallow seaway advanced across much of Iowa from the west during the late Mesozoic, the last time sea water covered part of the state. A great variety of microscopic plants and animals lived in this sea. Relatively few animals lived on the sea bottom, although species of clams were abundant at times. A great variety of fish and sharks inhabited the surface waters. In addition, fossils of large sea-going reptiles called plesiosaurs have been found in Iowa.

The Cenozoic Era, or period of "recent life," occupied the last 65 million years of earth history. Most of Cenozoic time was marked by erosion in Iowa, and only the last few million years are commonly represented in the sedimentary record of the state. These latter deposits date from the Pleistocene epoch, or "Ice Age," a time when vast continental sheets of glacial ice covered parts of Iowa. Fossils from the state's Pleistocene deposits record a series of climatic changes that accompanied the growth and melting of the glaciers. During cold episodes, animals and plants characteristic of tundra and boreal forest environments lived in Iowa. During warmer episodes other groups of animals and plants inhabited the state. Although many species of animals represented in the Pleistocene deposits of Iowa still live in the modern world, a great many species of large Pleistocene land animals found as fossils became extinct in the last ten or twelve thousand years. Giant ground-sloths, horses, peccaries, camels, caribou, musk oxen, long-horned bison, giant beavers, mammoths (elephants), and mastodons roamed the Pleistocene landscape of Iowa. Many of these now-extinct animals were apparently hunted by prehistoric peoples. Continuing studies in Iowa and adjacent areas may help clarify some of the mysteries of their relatively recent extinctions.

As interest in the water, hydrocarbon, and mineral resources of Iowa continues to grow, fossils will continue to be used as an aid to stratigraphic correlation and geologic interpretation. In addition to such practical pursuits, fossils provide Iowans with a unique heritage preserved in rock, a physical link with times long past. Iowa's fossil record conjures up images of coral-studded tropical seas, of dinosaurs browsing in subtropical forests, and of elephants wandering the icy landscape. But no one today has ever witnessed such scenes. The silent testimony of the rock and fossil record is all that remains. ☐



Mammoths (elephants) lived in Iowa during the "Ice Age."

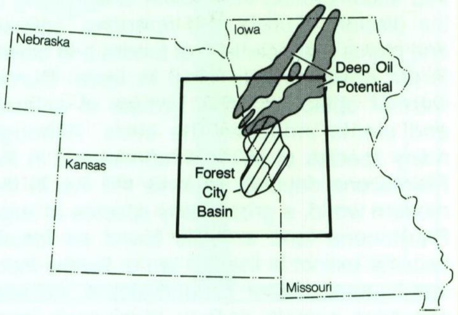
Additional Reading: The following sources are suggested for readers interested in further information about fossils. Books covering Iowa fossils include three published in 1983 by Iowa State University Press: *Geology of Iowa, Over Two Billion Years of Change* by W.I. Anderson (268 p.), *From Rift to Drift, Iowa's Story in Stone* by J.C. Troeger (152 p.), and *Fossils of Iowa, Field Guide to Paleozoic Deposits* by R.C. Wolf (198 p.). A valuable source still available in libraries is *Fossils and Rocks of Eastern Iowa* by J.N. Rose (147 p.) published in 1967 by the Iowa Geological Survey. Two more general books on fossils are *The Fossil Book: A Record of Prehistoric Life* by C.L. Fenton and M.A. Fenton (482 p.) published by Doubleday and Co., Inc., Garden City, NY (1959), and *A Pictorial Guide to Fossils* by G.R. Case (514 p.) published by Van Nostrand Reinhold Co., NY (1982). Two good books on dinosaurs and Ice-Age animals are *Dinosaurs of North America* by H.R. Sattler (151 p.) published in 1981 by Lothrop, Lee, and Shepard Books, NY, and *Pleistocene Mammals of North America* by B. Kurten and E. Anderson (442 p.) published in 1980 by Columbia Univ. Press, NY.

IN SEARCH OF IOWA OIL

Raymond R. Anderson

The search for oil in Iowa continued in 1982. It is modest in scale, but the effort certainly has been serious. Actual drilling of oil-test wells took place this past year near Kiron, in Crawford County, but it is the other, more systematic and less visible activities which best describe the effort. We estimate that over 3,000,000 acres of land has been leased in southwest and central Iowa by as many as ten companies. These leases give companies the legal "go-ahead" to begin exploration for oil. Where leases have been obtained, geophysical surveys can be conducted, and these surveys enable geologists to evaluate potential oil-test sites.

The leasing of oil rights, like the leasing of other mineral rights in Iowa, is a legal agreement between the owner of the oil rights beneath a property (usually the landowner) and an exploration or land speculation company. The lease usually gives the buyer permission to enter the property, explore for oil, drill test wells, and produce oil if it is found. Usually the landowner is paid a flat fee, commonly $1 per acre, plus an annual fee of about $.50 per acre. The agreement usually offers the landowner a percentage of the income derived from any oil produced, and commonly includes provisions that require payment for damages to crops, drainage tile, fences, or other property. Special provisions and restrictions also may be included. Currently, there are no legal requirements that these leases be recorded unless property is sold.



Shaded and striped areas have oil potential. The area covered by the Forest City Basin maps is outlined.

For an oil field to exist, three key geologic conditions are needed. The first requirement is a "source rock," a geologic unit very rich in organic material. These source rocks are most commonly shales which formed in oceans, far from shore. The second key factor is enough heat and pressure to convert the organic material to oil. This is usually accomplished by deep burial of the source rocks in a basin. The final requirement is a "trap," which captures the oil as it moves through the subsurface formations. The trap consists of a "reservoir rock," usually a porous unit such as sandstone, in which the oil can accumulate, and a "cap rock" or a non-porous overlying rock unit that will not permit the oil to migrate further.

Prior to test drilling, a geologic technique called "seismic profiling" is often conducted. This exploration technique sends vibrations into the ground, usually from a large truck equipped with special vibrators. The waves of energy are reflected by various geologic structures, and recorded as they return to the land surface. Accurate measurements of travel times and intensities are recorded in order to interpret the size, shape, and depth of structures which have potential for containing oil. Although these vibrations may travel many tens of thousands of feet down and back, they are very weak and do not damage tiles lines, foundations, or buildings. In fact, the instruments which measure these vibrations must be highly sensitive in order to detect the returning signals. After sufficient seismic profiling has been completed, the recovered data, combined with other available geologic information, will be used to determine the best locations for test drilling. Several test wells are usually drilled before any production wells are attempted.

The Forest City Basin area of southwestern Iowa has received the most recent attention for oil exploration in the state. This basin began developing almost 300 million years ago as the earth's crust slowly subsided. Older, organic-rich rocks within the basin were progressively buried by porous sandstones and non-porous shales. Thus, a potentially suitable environment to develop and trap oil may have existed in southwest Iowa. Small fields are producing oil from the basin in adjacent Missouri, Nebraska, and Kansas, so similar fields may also exist in Iowa.

The state geological surveys of Kansas, Missouri, and Nebraska have joined with the Iowa Geological Survey to produce a series of maps showing the geologic details of the Forest City Basin. These maps are designed to aid companies in their evaluation and exploration of oil potential throughout the area. Five maps are currently available and include a "Bouguer Gravity Anomaly Map" and a "Magnetic Map" which display variations in the earth's gravity and magnetic fields respectively. Also completed is a "Lineament Map" which shows linear and curvalinear trends in surface topography — often a reflection of underlying rock trends; a map of the "Precambrian Configuration," or the elevation on top of the oldest rocks of the region; and a "Structure Contour Map on the Base of the Kansas City Group," which delineates the shape and structure of the basin shortly after it was formed. Future maps will include the location of deep drill holes, the economic geology, and thickness and structure maps of potential oil-bearing rock units. The first five maps are available from the Iowa Geological Survey for $2 each (plus $.75 postage and handling), or $10 per set (plus $2 postage and handling).

Several exploration companies have begun to investigate the possibility that even older rocks, buried very deeply beneath the state might contain vast quantities of oil and gas. This petroleum may be trapped in sandstones and siltstones that were deposited in Precambrian time. These rocks are predominantly within basins that flank the ancient volcanic rocks of the Midcontinent Rift System.

In Wisconsin and Minnesota these rocks can be observed at the land surface and have been studied extensively. Among the oldest is the Nonesuch Shale, a unit so rich in petroleum that oil drips from the formation where it has been encountered in mines. This shale probably was deposited in a lake, and the oil was derived from the fossil organic remains of algae, bacteria, and fungi. The Nonesuch or similar units have been identified at the surface in northwestern Wisconsin and in drill cores as far south as Minneapolis. Although we believe that the Nonesuch or equivalent units extend into Iowa, there has been no exploratory drilling to verify that these oil-rich rocks are present. If they are, they may be deeply buried, perhaps as much as 40,000 feet in depth. Our knowledge is meager; many questions remain. Is a suitable organic-rich source rock present in Iowa? Did favorable geologic conditions trap oil? We don't know; but if the key geologic requirements are present, and if oil exploration continues, Iowa could become an important petroleum producing area. □

Editor's Note: In July, 1983, Kewa Exploration, Inc. of Denver, Colorado, began an extensive deep-seismic survey in central and southwest Iowa. The seismic profiling will initially include work in Hamilton, Webster, and Boone Counties, but will expand to Audubon, Guthrie, Pottawattamie, Mills, and Montgomery Counties before the end of the year. This survey will provide information on deep structures in the area and help geologists choose locations for potential future test drilling.

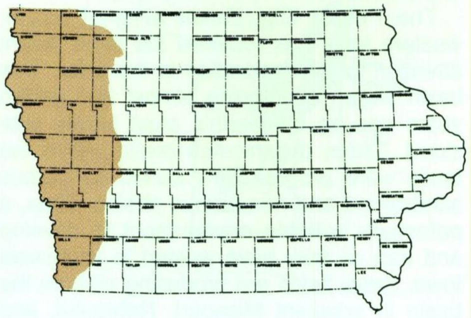
GULLY EROSION

E. Arthur Bettis

Western Iowa, a 10,811 mi² area encompassing all of thirteen and portions of nine other counties, has a national reputation for high sediment loads in streams and severe gully erosion problems. Estimates indicate that 5,000 to 10,000 acres of potential cropland are lost or removed from production annually as a result of gully growth in this region. Large amounts of time and money are spent on maintaining drainage ditches and stream channels which become choked with sediment eroded from gullies. Bridge failures resulting from gully widening are also a common and costly problem for counties in western Iowa. Numerous other problems directly or indirectly associated with the growth of gullies plague residents of this region.

A gully is a relatively deep, vertical-walled channel, recently formed within a valley where no well-defined channel previously existed. Western Iowa gullies range from five to over 80 feet in depth and from three to 100 feet in width. Some gullies are several miles long while others are as short as 100 feet. All have nearly vertical walls and contain streams which have extreme variations in discharge throughout the year. Gullies in large valleys such as Keg Creek and Silver Creek contain streams which usually flow year round, but streams in most gullies are dry during portions of the year.

Gullies develop because of a decrease in the erosional resistance of the land surface or an increase in the erosional forces acting on the land surface. What causes gullies to form, when and where they do is poorly understood. Field and laboratory studies indicate that certain reaches of a valley are more prone to gully development than others. However the timing of the initial downcutting and which of the "most probable" reaches develops into a gully cannot be predicted with certainty.



Location of severe gully erosion problems in western Iowa.

Once a gully has formed, the processes whereby it lengthens and widens are much better understood. The upper end of a gully is marked by a headwall, a vertical scarp, separating the ungullied portion of the valley floor from the gully below. Water flows over the headwall during runoff and falls into a plunge pool at the base of the headwall. The water then erodes the base and sides of the pool, undercutting the headwall. When undercutting reaches an advanced stage the headwall fails and topples into the gully, thereby lengthening the trench. This process is repeated many times as a gully advances up the drainageway.

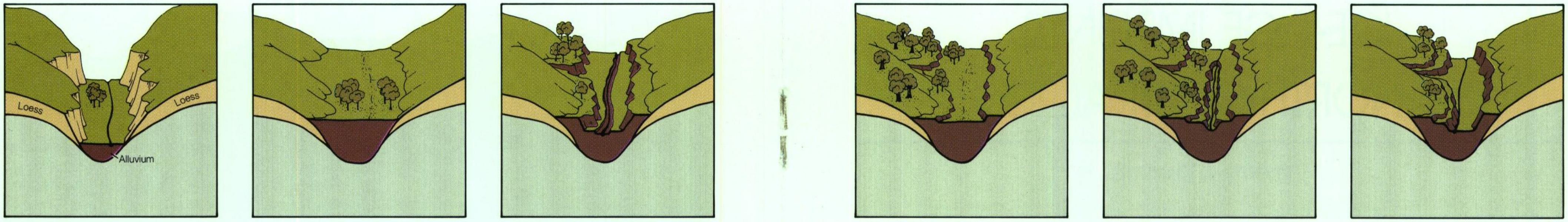
When first formed, most gullies are quite narrow and have vertical sidewalls. Increased pore pressure from groundwater moving toward the gully, coupled with some undercutting of the sidewalls causes deep rotational slumps along the sidewalls. If enough water is flowing through the gully to carry away the slumped material, additional slumping can occur. This causes the gully to widen. Widening also occurs when upper portions of gully walls separate and topple into the gully. This phenomena is most common following heavy spring rains and during freeze-thaw cycles in the late winter and early spring. If water intermittently flowing through the gully continues to clean out debris derived from the headwall and sidewalls, the gully continues to grow. When more debris accumulates than is transported away, the gully stabilizes and begins to fill.

Arthur Bettis

Soil slumping and water cascading over the headwall advanced this gully beyond a fence.

Numerous researchers have pointed the finger at agriculture as the cause of western Iowa's gully problems. Specifically, they cite the increases in runoff that result from land clearing, overgrazing, cultivation, and stream channelization. Numerous federal, state, and county agencies spend millions of dollars annually to control existing gullies and promote land management practices which reduce runoff in an attempt to alleviate the gully problem.

Many of today's gullies are cut into alluvium, the sediment transported and deposited by flowing water in streams. In most of western Iowa, the source of the alluvium is the silty loess found on valley slopes. Vertical gully walls, such as those shown in the accompanying photograph, often expose several distinct layers of alluvium. Layers of similar sediments can be traced within a single valley and also can be recognized from one valley to the next, a process called correlation. Thus far, six distinct layers, or alluvial fills, can be recognized in small valleys throughout western Iowa. Extensive core drilling in these valleys and interpretation of exposures formed along gully walls prove that these alluvial fills accumulated in old gullies.



Stages of valley development
3500 years ago *2000 years ago* *1800 years ago* *1000 years ago* *800 years ago* *Present*

Occasionally, buried tree stumps, logs, or charcoal are found enclosed in these old alluvial fills where they are exposed along modern gully walls. These organic remains have been radiocarbon-dated and a chronology of gully cutting and filling constructed. More than 100 such radiocarbon dates indicate that the six major alluvial fills recognized in western Iowa valleys represent regionally synchronous episodes of gully cutting and filling during the last 12,000 years. Four of these episodes occurred during the last 4,000 years, and the deposits associated with them are rather well preserved and understood. Accompanying illustrations graphically represent changes in the valley landscape during these four episodes.

About 3,500 to 4,000 years ago, deep gullies much larger than today's dominated the landscape in small western Iowa valleys. In many cases these gullies occupied the entire valley floor. Beginning shortly after 3,500 and continuing until about 2,000 years ago, gully growth stopped and alluvium accumulated in the gullies. By 2,000 years ago the gullied areas were completely filled with silty sediment washed from the adjacent valley slopes, and marshy areas occupied the central portion of the former gullied areas.

Sometime during the 200-year period between 2,000 and 1,800 years ago another gully cycle began. Gullies extended up all moderate-sized valleys and some of their lateral tributaries. Gullying did not extend into small drainages at the upper end of the drainage network as it had during the previous cycle. In extent, depth, and width of gullying, this cycle is analogous to modern gullying in the area. Shortly after 1,800 years ago alluvium again began to accumulate in the gullies, eventually filling them by about 1,000 years ago.

The third gullying cycle began about 800 years ago. In this cycle, gullying was restricted to moderate-sized and larger valleys and did not extend as far up valleys or into smaller valleys as it had during either of the previous episodes. These new gullies were restricted to central portions of the area gullied during the previous cycle. Further, these gullies were not as deep or as wide as earlier gullies had been. Shortly after the gullies developed they began to fill with alluvium. Sediment accumulated until the gullies were completely filled and portions of the surfaces bordering the gullies were buried a few feet. Counts of growth rings in trees growing on alluvium filling these gullies indicate that sedimentation may have continued until about 100 years ago.

The most recent western Iowa gully cycle began around 100 years ago. Numerous accounts in local histories, original land surveys and early reports of the Iowa Geological Survey indicate that until about 1860 gullies were not widspread in the area. By 1900 reports of problems arising from gully growth, such as the need for bridges at crossings, became common and indicated that the historic period of gully growth was in full swing. In some valleys, gullies have formed and been filled several times during this historic cycle, a process which also occurred during the prehistoric episodes but is too obscure to be interpreted from the geologic alluvial-fill record.

The geologic record contained in western Iowa valleys shows that major gullying is not new to the area. Several episodes, some more widespread than that which affects the area today, occurred prior to Euramerican settlement and the spread of modern agriculture. Gullying is part of the natural process of landscape evolution in western Iowa. The modern gullying which causes so much concern is also part of this natural process. No doubt, landuse changes accompanying the spread of agriculture and urbanization have aggravated and possibly accelerated the growth and extension of gullies in western Iowa. However, the geologic record suggests that the area was "due" for an episode of gullying prior to the 1850's. Gullies grew and filled several times in the past when man was not significantly influencing runoff or vegetation patterns. This indicates that modern man affects gullies in this area but does not cause them.

Recognition of the fact that gullies are "native" to western Iowa is important because it indicates that gullies are not a unique phenomena resulting entirely from man's modification of the landscape. Through recognition of gully-prone valley sections and the promotion of landuse aimed at preventing or lessening the factors causing gullies in those areas, we can avoid gully growth or lessen its impacts. During the last 12,000 years, gullies and the erosion resulting from their growth have molded the western Iowa landscape into that which we see today. This process is active today and will continue to be so far into the future. Currently our knowledge of the factors contributing to gully initiation is very incomplete. Somewhat better understood are the processes and factors involved in gully growth and degradation. These are areas of urgent research needs. Through a better understanding of the processes affecting gully growth and filling, we can lessen the impact our activities have in promoting the gully problem and plan around those portions of the gully network which are too costly or not likely to be controlled. □

Editor's Note: Dean Thompson, an archaeologist with the U.S. Soil Conservation Service, is acknowledged for his considerable contributions to our understanding of Iowa gullies. Thompson and Bettis have collaborated extensively, collecting data used to interpret the history presented in this article.

ICE-AGE IMPRINTS ON NORTH-CENTRAL IOWA

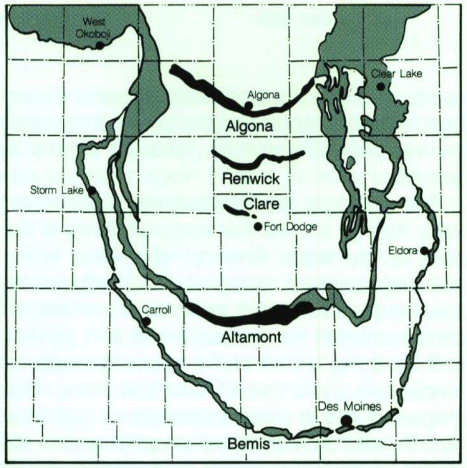
Timothy J. Kemmis

The region we study although as a whole comparatively level is by no means the monotonous prairie that some people are wont to imagine.

T. H. Macbride
The Geology of Hamilton and Wright Counties (Iowa) 1909

The traveller crossing north-central Iowa often is lulled into the impression that the surrounding landscape is a featureless plain, part of the "flat Iowa" stereotype. Yet, closer scrutiny reveals remarkable variations in the terrain. For example, there are striking contrasts between the level, unchanging plains south of Ft. Dodge and the rough, knobby topography around Pilot Knob State Park in Hancock and Winnebago Counties. Similar areas of irregular terrain are also found farther west in the vicinity of Spirit Lake and East and West Okoboji Lakes in Dickinson County. Prominent, south-facing ridges over 100 feet high can be seen from miles away extending east-west across Greene and Boone Counties, and farther to the north across Palo Alto, Kossuth and Hancock Counties. As Macbride noted:

> *It requires but a little careful attention to discover that even the surface of the county varies from township to township if not from section to section and a wider and larger survey may even reduce such variation to order and raise the suspicion, at least, that the diversity discovered is after all intelligible, proceeds in order, and follows as effect to some widely efficient cause.*



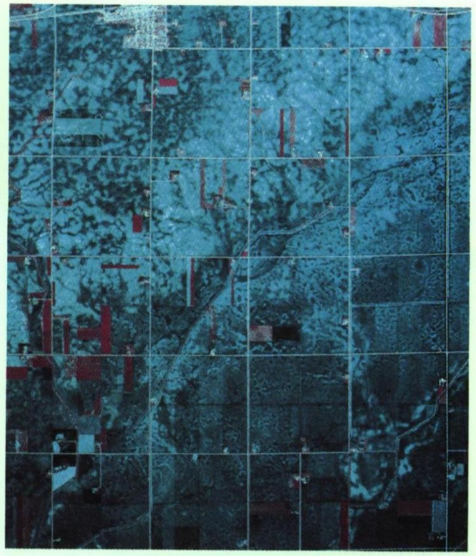
Des Moines Lobe end moraines: frontal margins — smooth, escarpment-like ridges (black); lateral margins — rough, knobby topography (blue).

The "widely efficient cause" was recognized as Ice-Age glaciation even before Macbride's time. We now know that great expanses of thick glacial ice advanced over Iowa numerous times during the past two million years. North-central Iowa was the scene of the final glacial advance into the state between 14,000 and 12,000 years ago. This region is known as the "Des Moines Lobe," a reference to the location of the state's capital city at the southernmost extension of this mass of ice. This region is further outlined by towns such as Clear Lake, Eldora, Carroll, Storm Lake and West Okoboji.

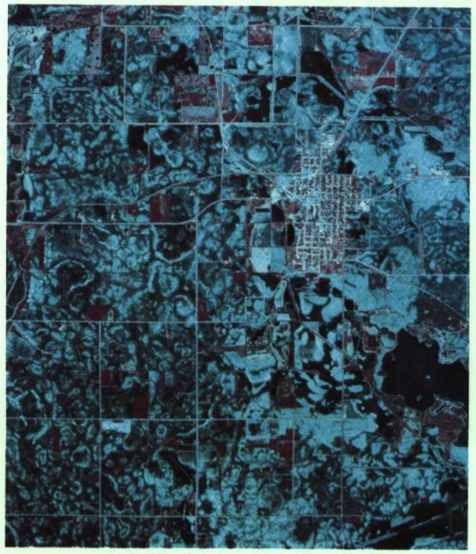
In addition, we now see that the diversity of landforms on the Des Moines Lobe also has the "order" suspected by Macbride. New tools of observation, such as satellite images and high-altitude aerial photography, provide perspectives of the land surface which enable us to identify and differentiate many subtly different types of glacial landforms. These views reveal a systematic distribution of these landforms across the Des Moines Lobe. We can now map the distribution of these different terrain features and explore their relationships.

The changes in landscape would be of little significance to us if not for the fact that individual landforms are composed of different types of glacial deposits, which in turn reflect their different glacial origins. Geology is, in part, a science of comparisons of past and present environments, but it has been difficult to compare the characteristics of glacial deposits in Iowa with similar conditions in existing glaciers. The modern glacial environment is neither easily accessible nor hospitable, so knowledge of existing glaciers has come slowly. Only in the past few years have geologists begun to understand the full range of glacial processes and their related deposits. Now we can compare specific characteristics of glacial deposits comprising the Des Moines Lobe landforms, such as texture, mineralogy, stratigraphy, and sedimentary structures, to similar properties of deposits formed by known processes at modern glaciers. This comparison enables us to reconstruct the past glacial history and the origins of different landforms seen on the Des Moines Lobe.

The most prominent patterns of landforms and deposits identified on the Des Moines Lobe are related to major end moraines. These ridge-like features mark the maximum extensions of ice advances, as well as positions of pause during the melting retreat of the ice front. The morainal ridges which cross the central portion of the Lobe are smooth, prominent, south-facing escarpments over 100 feet high. These steep slopes mark the front of the Altamont Moraine through Greene and western Boone Counties, and the Algona Moraine through Palo Alto, Kossuth, and eastern Hancock Counties. The roughly east-west trending ridges swing into a more north-south orienta-



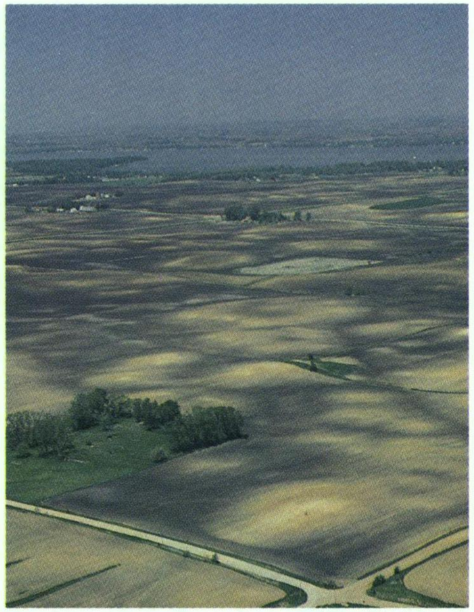
Infrared aerial photo of the Algona Moraine, Hancock and Kossuth Counties, near Wesley. Lake deposits are south of the light-colored moraine.



Infrared aerial photo of a hummocky area, Winnebago County. Rice Lake is southeast of Lake Mills. Road patterns outline square-mile sections.

tion as shown on the accompanying diagram. The terrain of these lateral margins, in sharp contrast to that of the frontal margins, consists of narrow, hummocky ridges or sets of sub-parallel ridges along the southern portions which then grade into broader belts of hummocky terrain in the northwestern and northeastern portions of the Lobe near the Iowa-Minnesota border.

Coincident with the change in topography from frontal to lateral portions of the moraines is a major shift in the type of glacial deposits which underlie the landscape. The frontal margins of the moraines near the center of the Lobe are composed dominantly of thick, massive sequences of uniform, dense, pebbly loam. In contrast, the hummocky lateral margins consist of sequences of pebbly loam and sandy loams interbedded with sorted sands, gravels, and silts which vary considerably both horizontally and vertically. A model of the former glacier's behavior can help to explain this distribution of deposits along the moraines. The central portion of the Des Moines Lobe probably consisted of active, high-velocity ice. Debris eroded by the glacier was transported primarily at the base of the ice, and subsequently was deposited beneath the flowing ice as "basal till," the dense pebbly loam. The lateral portions of the ice lobe, on the other hand, were probably slower moving and eventually became stagnant. The ice was greatly compressed near the margin, and as a result, the basally-derived debris was transported up into the glacier where it eventually melted out onto the ice surface. There it was subject to various mass-wasting processes, as well as reworking in meltwater channels, pools, and lakes on the ice surface. The sequence of pebbly loams, sandy loams, and interbedded meltwater deposits are a result of this complex history of ice transport and melting. Such models aid in understanding the patterns of sediment deposition by the Des Moines Lobe ice, and also are useful for predicting where specific types of deposits can be found today.



Timothy Kemmis

Hummocky topography featuring eroded, sandy knobs and Rice Lake near Lake Mills.

There are a wide variety of other glacial landforms and deposits on the Lobe in areas between the end moraines. Heavy-textured soils deposited in glacial-age lakes have recently been recognized. These deposits mantle broad areas covering hundreds of square miles in southern Kossuth and Hancock Counties, and also extend in a band through Wright, Hamilton, and southern Webster Counties. Extensive areas of "minor moraines" occur in the central and southern portions of the Des Moines Lobe. These areas consist of low-relief, linear landforms set upon broader topographic swells and swales. The sediments comprising minor moraines appear to be primarily basal tills. These moraines, almost invisible on the ground but plainly seen from the air, are especially prominent in Story and Hardin Counties. Sands and gravels deposited by glacial meltwater streams are found in narrow bands bordering the end moraines and along the major glacial drainageways that are now courses of prominent rivers such as the Shell Rock, Iowa, Skunk, Des Moines, Raccoon, Boyer, and Little Sioux.

Timothy Kemmis

Corn growing on the gentle, smooth, frontal margin of the Altamont Moraine in Greene County.

The glacial deposits of the Des Moines Lobe are among the state's most important natural resources, and they influence the daily lives of nearly everyone in north-central Iowa. For farmers, the glacial deposits determine the characteristics of the soils in which their crops grow. Homes, factories, grain elevators, and roads are all built upon deposits of glacial origin. Many residents obtain their drinking water from permeable sand and gravel aquifers within the Des Moines Lobe deposits. These deposits also serve as the receptacle into which trash and wastes are disposed. Thus, detailed and accurate information about these glacial-age resources is essential for understanding the origin and distribution of soil materials, for evaluating the location of sites suitable for waste disposal, for identifying potential engineering and construction problems, and for identifying compatible landuse and land-management practices. For example, IGS studies, in conjunction with soil-mapping programs of the USDA Soil Conservation Service, have identified extensive areas on the Des Moines Lobe where the soil parent materials are significantly different than expected, and have not previously been encountered in Iowa. Recognition of these new soils means that agricultural researchers can now design optimal management techniques for tillage, fertilizer application, and pesticide control. Likewise, understanding variations in glacial deposits across the Des Moines Lobe can provide a rational basis for site-specific preliminary engineering investigations and for determining the most economical and effective foundation designs for construction projects. □

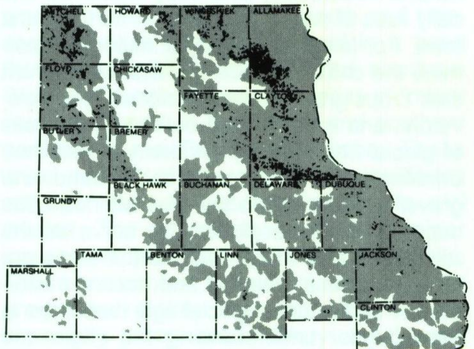
CONTAMINATION OF CARBONATE AQUIFERS

George R. Hallberg, Bernard E. Hoyer, E. Arthur Bettis, Robert D. Libra

Most rural Iowans depend on private wells for their domestic and farm-business needs. These wells are drilled to water-bearing rock formations called aquifers, located beneath their land. In northeast Iowa, private wells usually are drilled to aquifers within carbonate rocks, which consist of limestones and dolomites. In recent years, increasing concerns have been expressed about the safety of these carbonate aquifers as sources of drinking water. Farmers, well drillers, and health officials report an increasing incidence of high nitrate values obtained from testing water quality in the region. Nitrate is a contaminant which can be harmful to infants and new-born farm animals, and there is growing concern that high nitrate in drinking water may be harmful to adults as well. Bacterial contamination is also a common water-quality problem. Indeed, a survey revealed groundwater quality as the number one environmental issue among northeast Iowa residents.

What is the extent of the water-quality problem throughout northeast Iowa? Are there other contaminants, especially herbicides and insecticides, getting into drinking water? What can be done about it? These are questions Iowa Geological Survey (IGS) geologists were asked to address by the Iowa Department of Environmental Quality and the U.S. Soil Conservation Service. With their combined funds providing partial financial support for the research, and with the additional cooperative services of the University Hygienic Laboratory and the Iowa Conservation Commission, IGS is studying these questions. Thus far, a regional analysis of northeast Iowa has been completed. In addition, a detailed analysis of a single groundwater basin, covering about 100 square miles in Clayton County north of the Big Spring Fish Hatchery, has been in progress for about 18 months. As a result, our knowledge has grown considerably, and answers to these and other questions are beginning to take form.

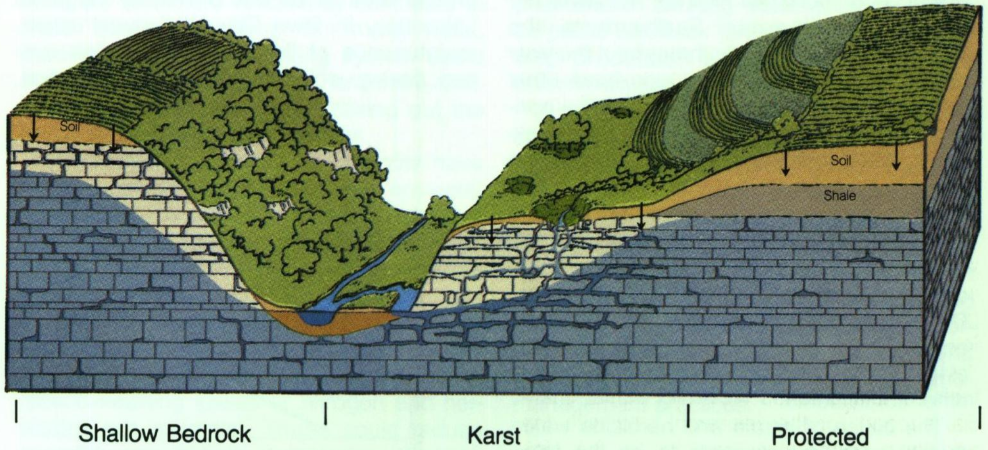
In carbonate aquifers, the water is contained within fractures in the rock formation. Rainwater, which is slightly acidic, infiltrates slowly through the soil and enters these small fractures in the rock. Rock is slowly dissolved, and over time, as the fractures enlarge, more water can move through the system. Under favorable conditions, this process can proceed to an extreme: fractures develop into caves and unsupported surface materials collapse forming sinkholes, which allow surface drainage to directly enter the groundwater supply. Thus, two processes are known to recharge the carbonate aquifer: 1) infiltration — the slow, diffuse percolation through soil, and 2) direct in-flow — a fast, localized process where surface runoff flows into sinkholes. Some geologic circumstances favor one; in others, both are active. Each process has a different effect on groundwater quality.



Geologic settings which reflect relative hazards to carbonate aquifers are mapped for northeast Iowa. Protected = white; Shallow Bedrock = gray; Karst = black. Each is illustrated on the facing page.

Northeast Iowa can be divided into three geologic settings which affect the region's carbonate aquifers: protected, shallow bedrock, and karst areas. "Protected areas" have relatively few water-quality problems. Aquifer recharge is solely by slow infiltration. Protection is provided where soil materials, which bury the aquifer, are more than 50 feet thick, or where slowly permeable shale formations overlie the aquifer. Both the thick soil and the shale reduce the infiltration of surface waters percolating down from above. Under these conditions, nitrate concentrations in the groundwater are nearly zero, and other surface contaminants are also very low. In these areas, bacteria problems may be found in the drinking water, but this contamination results from the individual water system, not the aquifer. The probable causes of such bacterial problems are poorly constructed wells and old or poorly maintained water-distribution or water-storage facilities, especially cisterns. With a good water system and no unusual local conditions, even relatively shallow wells completed in these protected carbonate aquifers generally yield safe water.

Areas where the soil materials are less than 50 feet thick above carbonate aquifers are referred to as "shallow bedrock areas." They are relatively unprotected. Rainwater easily percolates through the soils and downward into the aquifer, carrying whatever is dissolved within the water. The thinner the soil, the greater the rate at which aquifer recharge occurs. In these regions, nitrates have become a significant problem, especially in wells less than 150 feet deep. Most wells have nitrate levels within acceptable limits, but about 50% have concentrations above 20 milligrams per liter (mg/l) and nearly 25% of the wells have nitrate values above 45 mg/l, the current maximum level recommended for drinking water. Nitrate concentrations may vary somewhat through the year, but the values do not generally fluc-



The diagram illustrates three geologic settings and their influence on carbonate-aquifer water quality. Increasing thickness of soil cover and shale reduce infiltration; sinkholes allow direct contamination from the land surface.

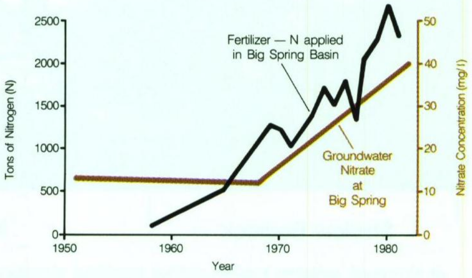
tuate widely.

Little is known about herbicides in these areas because widespead sampling for them has not been done. However, intensive water-quality sampling in Clayton County has revealed atrazine and several other herbicides in the groundwater. Atrazine is a herbicide widely used for weed control in corn fields. In the detailed, Big Spring study area, analysis revealed that as much as 84% of the atrazine found in groundwater comes from infiltration. The levels found are very low, generally less than one part per billion and far below toxic levels. In some areas, atrazine was detected in the groundwater only during spring and summer, but in other areas, it persisted year round. Other herbicides were found only during late spring.

The "karst areas" have sinkholes developed at the land surface, and bedrock is very shallow. These areas exhibit the poorest water quality of the three geologic settings. High nitrate concentrations are all too commonly present, with more than 25% of the wells less than 200 feet deep exceeding 45 mg/l. Herbicides are found in low concentrations, but the levels are higher and more persistent than in the shallow bedrock areas. Atrazine concentrations in groundwater were found as high as 15 parts per billion in karst areas. Furthermore, the atrazine persisted locally throughout the year at low levels. These areas also have other problems. Groundwater flow varies considerably as surface runoff enters the sinkholes. If well water turns "muddy" following a heavy rain or during runoff from snow melt, it likely is drawn from a major underground conduit in the rock which links the groundwater supply and the land surface. Water quality from such a well will fluctuate widely. During runoff events, the well water will likely contain bacteria and peak loads of herbicides, perhaps even insecticides, as well as other constituents.

The cause of nitrate and herbicide water-quality problems appears to be the interaction of natural recharge processes in carbonate aquifers with modern agriculture. Background levels of nitrate in protected aquifers are almost zero. In unprotected aquifers, however, levels approaching or exceeding health standards are becoming common. Historical evidence suggests that this increase in nitrate in groundwater is recent. Nitrate at Big Spring apparently was stable through the 1950s and 1960s at about 13 mg/l. In 1982, it averaged 40 mg/l, and the lowest values were about twice that of earlier high values. This corresponded to the time period when total nitrogen (N) applied to the land as fertilizer increased by about 250%. Losses of N fertilizer because of leaching are well known, but they formerly had not been measured in groundwater. During 1982, 27 pounds of N per acre were lost from the Big Spring study area. This is equivalent to approximately 33% of all nitrogen that was applied as fertilizer in the area. More than half went into the Galena aquifer. The only source of herbicides is agriculture. In our study area about 0.04% of the atrazine applied was leached to the groundwater below. Such losses are very low. Unfortunately, the health effects of low levels of herbicide are largely unknown.

Individuals who suspect problems with their water supplies should consult local health officials, well drillers, and plumbers. Water should be tested at one of the many private labs or at the University Hygienic Laboratory in Iowa City. Well construction, maintenance of the water distribution system, casing, well depth, geographic location, the water source, and the geologic conditions are all factors which may contribute to water quality problems. For many wells, modifications of the existing system could improve the water quality — for others, drilling to a deeper aquifer and casing out the upper aquifer, is the only solution.



Increased nitrogen fertilization has elevated nitrate levels at Big Spring.


George Hallberg

Modern agriculture is affecting groundwater resources throughout much of northeast Iowa.

The original questions asked now have partial answers. Based on these answers, constructive discussion can begin on the last question — "What can be done about it?" People need to be informed about groundwater conditions. In the long range, changes in farm technology and management are necessary to improve and protect the water quality in these aquifers. Practices which reduce leaching losses of nitrogen and herbicides are essential. These could reduce contaminants in both the shallow bedrock and karst areas. Soil conservation measures can help reduce peak pesticide levels in karst regions. More research must be conducted on land-management practices, farm chemicals, and the effects of nitrates and pesticides in drinking water. Then an informed public can seek to balance our needs for crop production with our needs for safe drinking water.

A good start has been made both towards characterizing carbonate aquifer contamination and understanding how it occurs. Cooperative research efforts continue in Clayton County, and with additional financial aid from the U.S. Environmental Protection Agency, detailed research has begun in another major karst area, Mitchell and Floyd Counties. This should increase our understanding of carbonate aquifer systems and help assess them under different land-management practices. ☐

UNDERGROUND LEAKAGE OF GASOLINE AND OIL

George R. Hallberg

A homeowner notices the smell of gasoline in the basement or the taste and odor of gasoline in the family's drinking water. Worse, gasoline is coming into the basement sump. Or perhaps an engineer or contractor notes petroleum fumes when drilling borings or excavating for a foundation. Difficult to believe perhaps, but these are all actual examples of a growing problem in Iowa — the leakage and underground movement of petroleum products from buried storage tanks, pipelines, or from surface spills.

Leaks normally affect localized areas and they can occur wherever a gasoline station or storage tank is located. Though, local in occurrence, the problem is increasingly common throughout the state. Local fire marshalls and the Iowa Department of Environmental Quality get hundreds of calls each year about petroleum spills and leaks. The Emergency Response Group from DEQ averages one call per day about an incident involving a petroleum spill. On the average of once a month, they handle situations which involve underground petroleum problems. Many of these problems are minor, but some pose serious hazards because petroleum products are highly flammable. Where fumes accumulate they pose the danger of explosion. Even at very low concentrations, traces of fumes or the taste of petroleum products may be an irritant or cause discomfort to people. It is possible to taste and smell traces of product at concentrations lower than some laboratory equipment can detect it. Such conditions are less dangerous, but just as annoying.

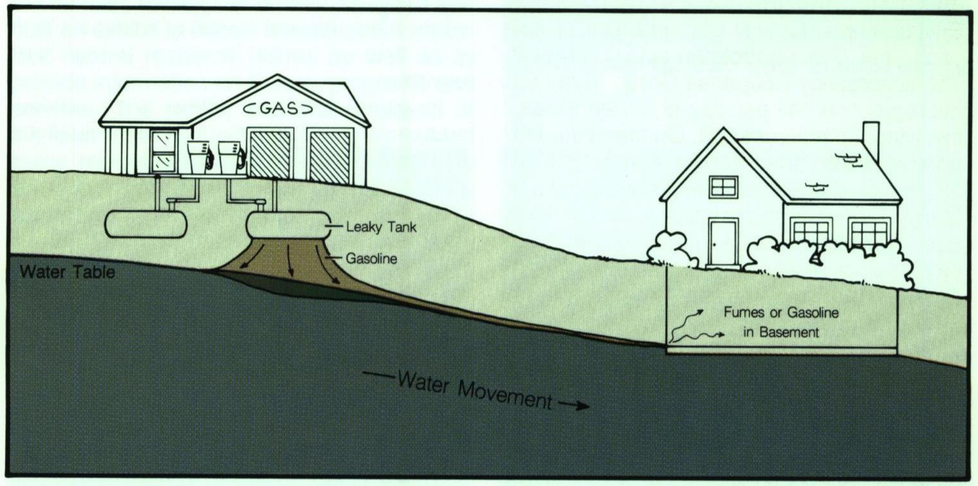
Surface spills commonly occur when storage tanks are filled and then overflow when a shutoff valve fails. These types of spills are generally noted immediately and then can be cleaned up by various methods. More extensive problems occur when leaks take place beneath the land surface. Storage tanks and pipelines may develop leaks from corrosion and old age or by accidental punctures. This allows the product to seep into surrounding soil and rock. Often the most difficult of these problems to solve are those involving slow leaks which persist over long periods of time, or leaks or spills of large quantities of product which are forgotten because there was no obvious immediate problem in the area. The product then may flow slowly through the pores in the soil, just as water does, until it seeps into a basement or a well. Leakage may not be detected for months, or even years after the leak begins because of the slow travel times in the underground environment.

In some instances, there is no obvious source for the product. In these situations, the Iowa Geological Survey staff often assist the Department of Environmental Quality in the investigation. Complicated problems may require drilling test borings and establishing observation wells to analyze the configuration of the water table and the extent of the contamination. This is necessary to trace the products back to their point of origin. In one case, for example, the source was a gas station which no longer existed; the station had been torn down and replaced by a new office building.

These cases seem to breed misconceptions, such as the suggestion that gasoline — unlike water — can flow "uphill." Petroleum products obey the same natural laws as any liquid in the ground; gasoline from a saturated soil flows downward and outward from the leak until it reaches the local water table. Once the gasoline joins the water table, it flows with the water — down gradient. Refined petroleum products are lighter than water, and they will "float" on the water table surface, travelling along until they intercept and possibly seep into a house basement, as shown in the example. Complications arise because the plume of gasoline also spreads to the "uphill" side of the tank. This creates an apparent, but not a real, contradiction because "uphill" is in relation to the ground surface, not in relation to the flow beneath the surface. But the final area of contamination still is generally controlled by the overall configuration of the water table. Tracing backwards along the zone of contamination delineates and defines the source area of the gasoline.

These types of problems have become more common in Iowa and other states. During World War II, gasoline-storage tanks were placed underground as a safety measure. With the expansion of local gasoline stations during the 1950s and 60s, numerous underground tanks were installed. These tanks may be reaching the end of their "life expectancy" — a sobering thought considering their number and location — and this may be the reason for the apparent increase in cases.

Remedial measures for such problems can be complex depending on the hydrogeological setting and on the nature of the personal property involved. In some cases, the petroleum products are pumped out of the ground. In others, excavation processes may be initiated to drain the area, draw product away from the home or business, or promote evaporation. The best control measures are preventative. Companies are now relining old tanks or installing new, safer tanks and pipelines which are better protected from corrosion. Considering that gas stations may be located almost anywhere, it's important that preventative measures be installed and that remedial measures be available. □



Schematic example of a petroleum leakage problem. Gasoline moves downward from an underground storage tank to the surface of the water-saturated zone.

STAFF LEAD GEOLOGICAL TRIPS

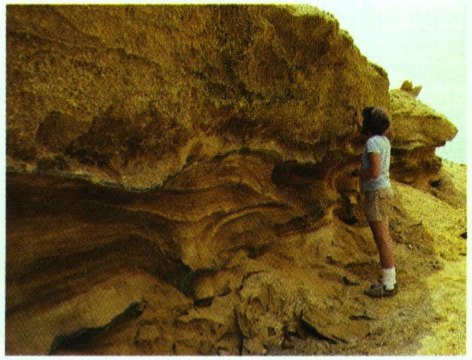
Field conferences provide opportunities for professional colleagues to get together informally to examine and discuss the field evidence supporting geologic interpretations. These trips also give participants a first-hand opportunity to understand the results of recent geologic investigations. They don't replace professional articles and papers, but they certainly do make learning easier and more fun.

On a cold weekend, April 3-4, 1982, following a spring snowstorm, Art Bettis, IGS, and Dean Thompson, an archaeologist with the U.S. Soil Conservation Service, led such a trip near Sioux City. Fifty participants bundled up to hike through some deep western Iowa gullies, review their history of erosion and deposition, and observe the archaeological sites which are buried and preserved within the valley deposits. The trip was sponsored by the Association of Iowa Archaeologists and the University of South Dakota, Archaeology Laboratory-Vermillion. The trip leaders had worked together for several years evaluating the impact of SCS construction projects on the archaeological resources buried within valleys throughout western Iowa. The geologic history reviewed in this issue of *Iowa Geology* (page 12), is an outgrowth of their work.

IGS research on groundwater resources in northwest Iowa led to another field trip on October 9, 1982, which dealt primarily with the Dakota Sandstone. Brian Witzke and Greg Ludvigson, both IGS geologists, led the field conference hosted by the Geological Society of Iowa at Springbrook State Park. The Dakota Sandstone is the major aquifer providing water to northwest Iowa. It is exposed to view in Guthrie County where the Middle Raccoon River has cut down into bedrock. The most productive water-bearing zone of the aquifer is called the Nishnabotna Member. It consists of coarse gravel and sand which was deposited by long-vanished rivers flowing from highlands in Wisconsin toward an ancient ocean located where the Great Plains are today. These sands and gravels were deposited approximately 100 million years ago, when dinosaurs roamed North America. Iowa's first dinosaur bone was recently found in a gravel pit excavated into the Nishnabotna Member of the Dakota Sandstone. □

Bernard Hoyer

Bettis explains that this 30 foot deep gully begins abruptly at the headwall exposed at his feet.



Brian Witzke

Ludvigson studies the coarse sand and gravel deposits of the Dakota Formation in Guthrie County.

IGS HOSTS CONFERENCES

In November, 1982, the Legislative Interim Committee on Water Resources met in Iowa City to discuss state water-information needs, progress in program development, and IGS facilities and programs. State-agency reorganization and other recent legislative actions have underscored the General Assembly's emphasis on water issues.

The 27th Annual Midwest Groundwater Conference was hosted by the U.S. Geological Survey and IGS in October, 1982. This meeting brought 87 scientists and engineers from 14 states together to hear presentations and discuss subjects related to the occurrence, quality, and management of underground water supplies.

An informal state geological survey conference was hosted by IGS in May, 1982. Despite state financial crises, about 25 people from geological surveys in adjacent states met in Iowa City to consider disputed geological interpretations, share data and information, develop cooperative projects, and discuss issues common to state surveys.

The results of such gatherings are difficult to assess, but developing and maintaining communications on resource issues, both intrastate and interstate, are essential for program success. □

EXHIBIT AT STATE FAIR

The Iowa Geological Survey designed and built an exhibit to inform Iowans about important natural resource issues as well as to provide information on Survey programs and services. The exhibit was first displayed at the Iowa State Fair in 1982. There it provided many residents from around the state with an opportunity to inquire about various aspects of Iowa geology. Water problems, oil exploration and maps seemed to be the most common topics of interest. The exhibit featured a three-dimensional model of Iowa's rock strata, a large, crystalline geode — Iowa's state rock, and individual, topic-oriented display panels.

Since the fair, portions of the exhibit have been displayed at the State Capitol Building, the Tri-State Geological Field Conference, and the annual meeting of the Iowa Water Well Association.

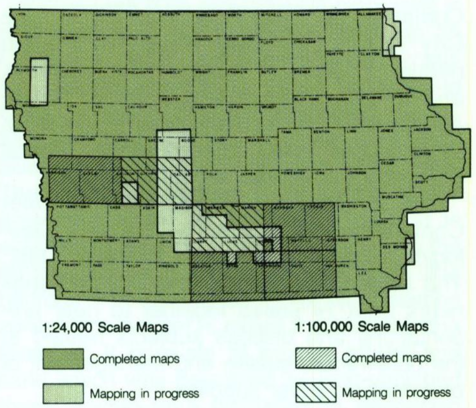
Inquiries concerning display of the exhibit are welcome. □

Patricia Lohmann

Visitors view the geologic model of Iowa at the State Fair.

TOPOGRAPHIC MAPPING

The final group of 1:24,000 scale, topographic maps of Iowa is in preparation. The current standing: 1,008 maps published; 68 maps available in preliminary form; and 16 maps being compiled. Availability of the complete series for the state is now in sight. Also, a new map series is in progress. These maps have a scale of 1:100,000; they are less detailed than the 1:24,000 scale maps, but they have the advantage of covering larger areas. Four are now available and two are in preparation. All these maps may be purchased at IGS for $2 each, and inquiries about maps are always welcome. ☐



SELECTED SURVEY PUBLICATIONS

Hallberg, G. R., and Hoyer, B.E., 1982, *Sinkholes, hydrogeology and groundwater quality in northeast Iowa*: Contract Rept. 6-31-82, 120 p.

Klug, C.R., 1982, *The subsurface Devonian lithostratigraphy of southeastern Iowa*: Open-File Rept. 82-1, 33 p. ($1 plus $.60 postage/handling.)

Klug, C.R., 1982, *Devonian stratigraphy and conodont lithostratigraphy from portions of two cores in central Iowa*: Open-File Rept. 82-2, 53 p. ($1.50 plus $.85 postage/handling.)

Wahl, K.D., Meyer, M.J., and Karsten, R.A., 1982, *Hydrology of the surficial aquifer in the Floyd River basin, Iowa*: Water Supply Bull., No. 12, 53 p. ($3 plus $1.25 postage/handling.)

County Groundwater Resources, Open-File Reports (1982):
Additions to this series include: *Boone, Story*, and *Polk* Counties (Thompson, C.A.). Each report is available at a cost of $.50 plus $.50 postage/handling.

Forest City Basin Map Series, Scale 1:500,000 (1982):
These maps cover the Forest City Basin and adjacent regions of Iowa, Kansas, Missouri, and Nebraska. The individual maps are: *Bouguer Gravity Anomaly Map, Magnetic Map, Precambrian Configuration Map*, (Burchett, R. R., Wilson, F. W., Anderson, R. R., and Satterfield, I. R.), and *Lineament Map* (McCauley, J. R.). Each map is available at a cost of $2 plus $.75 postage/handling.

IGS ORGANIZATIONAL STRUCTURE