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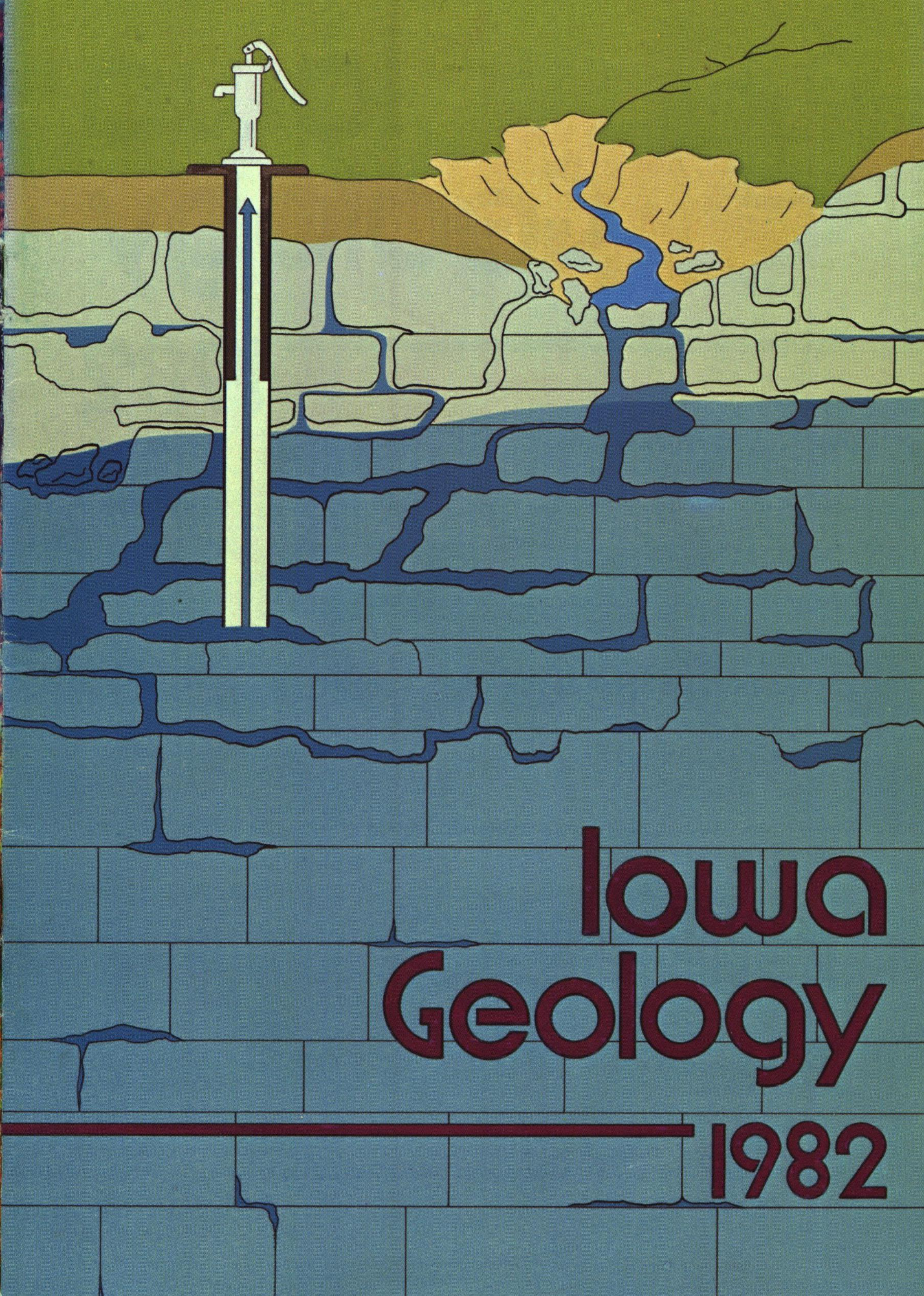

Iowa Geology

1982

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IOWA GEOLOGICAL SURVEY

123 North Capitol Street
Iowa City, Iowa 52242
319-338-1173

Donald L. Koch
State Geologist and Director

Front Cover: Illustration of surface drainage entering a carbonate aquifer through a sinkhole. Design by Patricia Lohmann.

Back Cover: IGS computer-processed, false-color display of a portion of a Landsat scene over Des Moines, Iowa. The image was obtained from a distance of 500 miles out in space on May 27, 1975, before Saylorville Reservoir was filled. Light-colored areas show urban features; dark areas are planted fields of corn or soybeans; red areas are grass, pasture or forests; black areas are water. Photo by Donna McGuire.

Bernard E. Hoyer . . . . Editor
Patricia J. Lohmann . . . . Publication Designer, Artist
Donna A. McGuire . . . . Staff Photography

Editor's note: I would like to express my appreciation to Jean Prior, for her careful reading and helpful comments on the articles, and to Mary Howes, Laurie Kottman and Renee Smith for their help in producing this issue of *Iowa Geology.*

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FROM THE DIRECTOR'S DESK

The Iowa Geological Survey is a research and service agency whose function is to collect, interpret, and report information on the geology and hydrology of the state. The results of practical research are applied to solutions and prevention of environmental problems related to natural resource protection, conservation, and development. As a separate, non-regulatory research and service agency, the Survey is able to provide basic information and analyses of technical data that are not biased as a consequence of any connection with, or obligation to, agencies with regulatory functions. In this way, the Survey is of service to the regulat*or*, as well as to those who are regulat*ed*.

An adequate data base and a staff that can assess and interpret the data base are critical to successful management of our natural resources. For Iowa, the development of an adequate data base on water availability and water quality is a key natural resource issue. An improved data base is essential to address the demands among competing users, and to at least mitigate the burgeoning problems of water quality degradation.

The available data base on regional aquifer systems, such as the Jordan Aquifer, generally is adequate to predict ground-water distribution, yield potential, and water quality available from these systems. However, expansion of the network of wells to monitor water-levels in these regional systems, and the development of mathematical models as a tool to predict changes created by increased water withdrawals are necessary to ensure proper management practices.

In contrast, the available data base on local aquifer systems, such as shallow aquifers in upland areas or along interior streams, generally is poor. These systems are closely associated with surface water, and are extremely sensitive to land-use activities. Nitrate concentrations have increased in many of these local aquifer systems, and in many areas of the state these systems constitute the sole source of water. The magnitude of the problem must be better defined, and water quality degradation must be reduced. The impacts of continued development of local aquifer systems will require closer evaluation of data derived from exploratory drilling and test pumping.

Information on water use is another element of a viable water resources data base. Unfortunately, reliable data on water use is very limited. Records maintained by users with permits provide information on less than half of the water that is used in Iowa each year. An information system that includes data on where water is being used in the state, for what purpose, in what quantities, and from what sources must be fully implemented to ensure prudent water allocation decisions.

Presently, there exists a strong wave of support by Iowa's executive and legislative branches of government for improvement of our data base on water resources. Governor Ray has urged the reorganization of water regulatory agencies to effect improved coordinated management and increased government efficiency. Additionally, he has urged that the state reestablish primacy for the public drinking water program, that agreements be negotiated with the federal government to obtain water storage capability in federal reservoirs, that we maintain the ability to deal with increasing competition for Missouri River water, and that efforts in water data collection be increased.

Similarly, legislative bills that deal with water resource problems have come into prominence. Specific areas addressed include the matter of regulatory agency reorganization, certification and regulation of well-construction and pumping-equipment contractors, compensation to a non-regulated user for well interference, and appropriation of funds for the development and implementation of a water resources data base.

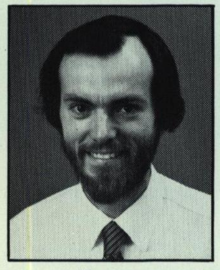
Recognition of the problems and challenges that we face in managing our water resources is only the first step. Active support by the governor, the legislature, state agencies, industry, and the public sector is a positive sign that a revitalized effort to acquire and maintain a viable water resources data base will be realized. Iowa's citizens will be the beneficiaries.

Donald L. Koch

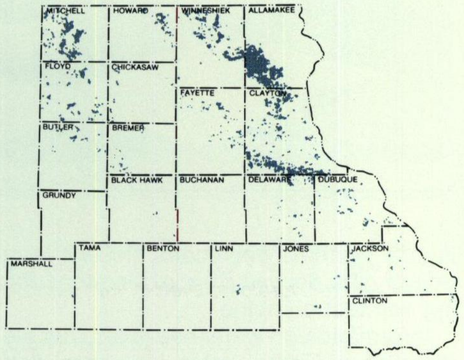
Donald L. Koch
State Geologist and Director

SINKHOLES AND GROUND WATER IN NORTHEAST IOWA

By George R. Hallberg



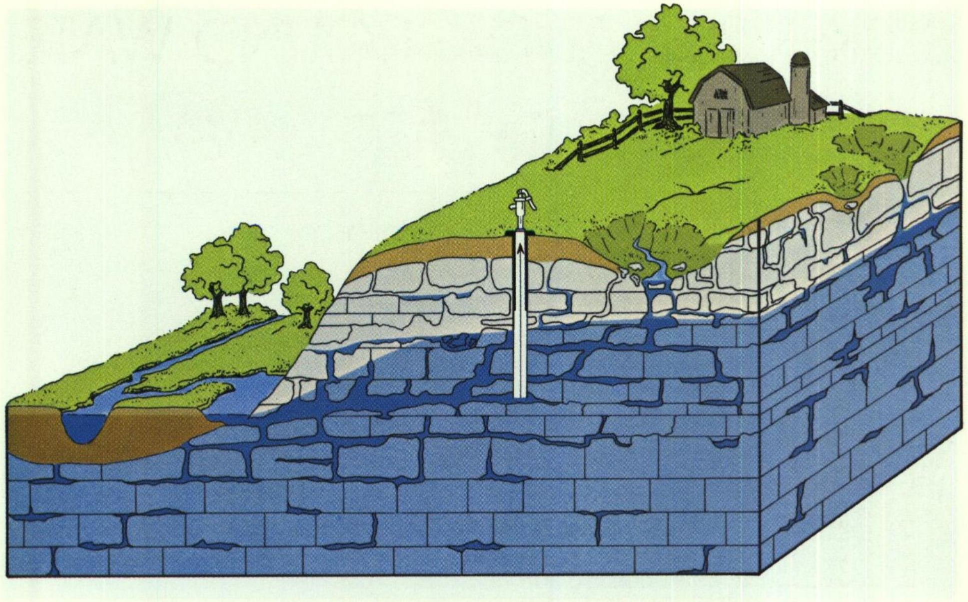
In Northeast Iowa, local residents and public officials have often voiced concern for the quality of their public and private underground water supplies. In this region many of the important water-bearing units, or aquifers, are shallow limestone formations which often are revealed at the land surface by the occurrence of sinkholes. Over the years, many cases of contaminated water have been documented in these areas and well drillers describe increased difficulty in completing wells without high levels of nitrate in the water.



Location of sinkholes in Northeast Iowa.

Many questions naturally are raised about these conditions. Is this water-quality degradation real or apparent? Is it just localized or is it regional? Where are the sinkholes located and are they really related to the water-quality problems? Can anything be done to protect these water sources? The Iowa Geological Survey, through a contract with the Iowa Department of Environmental Quality (IDEQ), is conducting a study designed to answer these questions. Although this work is still in progress, some of the major results can be outlined.

Iowa's bedrock aquifers may be separated into two types: clastic and carbonate. Clastic aquifers are composed of rock formations, such as sandstone, in which the water slowly moves through small, interconnected pores between the grains of sand. In contrast, carbonate aquifers are composed of limestone or dolomite in which water moves through fractures in the rock. In addition these carbonates are subject to chemical solution by the infiltrating ground water. As the water dissolves away the rock, these fractures and other openings are enlarged, and the aquifer eventually becomes a series of inter-connected openings ranging in size from microscopic fractures to large caves. The flow of water in these larger cracks is like that in a pipe. In fact, this is one of the problems associated with carbonate aquifers—the rapid, undiluted flow does not provide the natural filtering that occurs with the slower flow through the small pores in a sandstone aquifer. A second, more obvious difference, is the potential for direct connection of the carbonate aquifer with surface water. The solution of underground carbonate rocks may result in the development of unique land-surface features collectively referred to as karst topography. One of the more important karst features is the sinkhole, a funnel-shaped depression on the land surface. These are generally developed from the collapse of rock and soil material into underlying caverns formed as carbonate rocks are dissolved. Alternately, vertical fractures in the formation may enlarge and soil and rock wash into them also forming sinkholes. The resultant depressions can conduct surface water directly into the aquifer. Any contaminants carried by surface runoff or streams are "swallowed" into the ground-water supply in an unfiltered and undiluted state. This is a major problem in sinkhole regions—the sinkholes provide direct conduits for surface water to enter underground cavities in the limestone and join the ground-water system. As a consequence, carbonate aquifers are highly susceptible to contamination from agricultural or industrial land, effluent from septic tanks, drainage tiles, and other forms of waste disposal. Unfortunately, sinkholes also provide convenient and all too common places to dispose of solid waste materials. Observations in northeast Iowa have shown numerous occurrences where everything from creamery wastes to old chemical containers, car bodies, and dead animals have been dumped into sinkholes. Out-of-sight is not necessarily out-of-mind in these instances, because this dumping can seriously contaminate local water supplies.



A carbonate hydrologic system with sinkholes, fractures, caves and springs.

In the current study, IGS staff and several university graduate students employed through contract, compiled pertinent geological and water-quality records for the 22 northeast Iowa counties. County soil-survey maps, records of quarries and wells, field notes, color-infrared aerial photography, and computer plots of geologic data were used to map the distribution of sinkholes and to assess the geologic controls on their locations, especially the depth below the land surface at which the karst-forming rocks are buried.

More than 12,700 sinkholes were map-

This Clayton County sinkhole opened suddenly last fall. Photo by Greg Ludvigson.

ped in the area. In some localities over 1,000 sinkholes occur in a single township! The actual number of sinkholes is not static, for new sinkholes continue to form every year. The three main areas of sinkhole concentrations are found in southwestern Allamakee County near Waukon, in the outcrop area of the Galena Formation; in southern Clayton County and vicinity, along the upland escarpment adjacent to the Volga River, and underlain by Silurian-age rocks; and in Mitchell and Floyd Counties adjacent to the Cedar River, in the outcrop area of Middle Devonian-age limestones. These sinkhole regions all occur in carbonate rocks which are also ground-water sources, especially the latter two regions which occur in part of the regionally important Silurian-Devonian Aquifer.

Comparison of the mapped sinkhole distributions with the geologic and soil data revealed that sinkholes appear only where the carbonate rock is buried by less than 30 feet of "soil." In some areas, few or no sinkholes developed even though carbonate bedrock is not deeply buried. This allowed comparison of the ground-water quality between those areas with sinkholes and those without. Further, both these areas could be compared with water quality from areas where bedrock is buried more deeply. Water-quality data were compared among three specific geologic conditions: Karst—areas with sinkholes and shallow bedrock; Shallow Bedrock—areas without sinkholes, but bedrock buried less than 50 feet in depth; and Deep Bedrock—areas where bedrock was buried between 50 and 500 feet. The data were also analyzed in relation to well depth.

Existing water-quality data sets were reviewed and all were found to have serious limitations. For example, none were found satisfactory to assess long-term changes in water quality. The most helpful data set was provided by the University Hygienic Laboratory. It consisted of more than 8000 total-coliform bacterial analyses and 6000 nitrate analyses from well samples collected from the study area between 1977-1980. The coliform bacteria and nitrate data were evaluated because they are the most widely available parameters related to health standards, and they are uniquely related to ground-water contamination from surface sources. The presence of coliform bacteria indicates a probable occurrence of other bacteria, such as *salmonella,* which can cause health problems. Also, drinking water standards for nitrate, set at 45 milligrams per liter (mg/L), are needed because high concentrations can cause health problems for infants and livestock.

A clump of trees often marks the location of a sinkhole. Photo by Bernard Hoyer.

Statistical evaluations of the bacterial data were inconclusive. Some data suggested that bacterial contamination was more severe in the Karst areas, but not clearly. As a whole, the differences were not highly significant. The bacteria data were not related to well depth either, suggesting that other factors are causing the problems. These could include the local setting of the well, faulty casing, and contamination of cisterns, among others. Throughout the region, 35% of the analyses had unsatisfactory or unsafe bacterial levels, which suggests that these problems are widespread. The problem, however, cannot be significantly attributed to contamination of an aquifer from runoff into sinkholes.

The analysis of the nitrate data is much clearer and reveals an orderly and significant change from one geologic setting to another and from one well-depth category to another, indicating aquifer contamination on a regional scale. The most common nitrate concentration value for all the geologic regions and different aquifers was zero, clearly indicating there is little naturally occurring nitrate in the ground water. The elevated levels of nitrates that are found in some water supplies, thus, can be attributed primarily to infiltration and runoff from fertilized fields, barnyards, feedlots and waste-disposal systems.

Nitrate levels systematically and significantly increase in shallower wells. The

Well Depth (Feet)	Karst Areas	Shallow Bedrock	Deep Bedrock
50 — 99	34	19	6
100 — 149	23	16	0
150 — 499	3	5	0
>500	0	0	0

Median nitrate values from geologic settings in milligrams per liter.

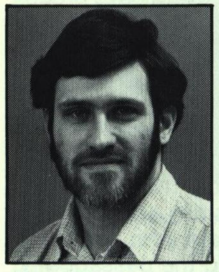
highest nitrate levels occur in wells less than 50 feet deep. Analysis of data from all of Iowa indicates that shallow wells, regardless of the aquifer involved, are exhibiting significantly high levels of nitrate contamination.

It is in the deeper well categories that the problems of the Karst regions become apparent. Ground-water supplies from wells between 50-150 feet deep in the Karst region show significantly higher levels of nitrate contamination. Median nitrate values are shown in the accompanying table to illustrate the systematic changes by geologic region and well depth. Medians are the midpoints of a statistical distribution; 50% of all samples fall below this value and 50% are above. The median value is reported because the data are not suited to using the more typical statistical mean or average. In the 50 to 99 feet well-depth class, the highest nitrate values are found in all three geologic settings, but the value for the Karst region is 1.8 times greater than the Shallow Bedrock region, and nearly 6 times greater than Deep Bedrock regions. Likewise, in the 100 to 149 feet well-depth category, there is a progression of decreasing nitrate from the Karst area, to the Shallow Bedrock area, and to the Deep Bedrock area, which has a median of zero. Note also the decrease in median nitrate value with increasing well depth. All of these data point to surface contamination as the source of the nitrates. The data indicate widespread elevated levels of nitrate in the Karst areas and also widespread moderate levels of nitrate in the Shallow Bedrock regions. This is cause for concern, but not necessarily for alarm. Although 18% of all nitrate analyses exceeded the drinking-water health standard of 45 mg/L, the medians from all well depth classes and all geologic settings were below the standard. Furthermore, 34% of samples in the Karst areas, 39% in the Shallow Bedrock area, and 58% in the Deep Bedrock areas have zero nitrate.

A major question which needs to be answered is whether the significantly higher nitrate values in the Karst region are symptomatic of contamination of ground water with other chemicals widely used in northeast Iowa, especially pesticides. This significant nitrate increase in the Karst region amplifies the previously known examples of local water contamination from wells. Much is still unknown, but a second research effort has begun. This second phase of the project involves a detailed field study of a portion of the Karst region in northern Clayton County. Funded in part by IDEQ and the U.S. Soil Conservation Service, and with the cooperation of the Iowa Conservation Commission and many private citizens, the study will detail the nature of chemicals entering the ground-water system and will also identify what practices might be used to correct these problems. □

THE INSIDE VIEW ON CAVES

By Michael J. Bounk



Carbonate rock formations extend under much of eastern and northeastern Iowa. These formations consist of limestone and dolomite and contain large amounts of ground water, providing valuable supplies to many individuals and communities. They are the same formations which contain most of Iowa's sinkholes and caves. In fact, the map in the previous article displaying the sinkhole distribution could be used to illustrate the distribution of caves in Iowa. While there may be 12,000 sinkholes and only several hundred known caves, most of them occur in the immediate vicinity of sinkhole concentrations.

The association of caves, sinkholes, ground water, limestone and dolomite is not coincidental, of course. They are all parts of what may be called a carbonate hydrologic system. Sinkholes are one possible expression of this system; caves are the most rare and spectacular manifestation. Their rarity, beauty and mystery, however, has made them the best known

Cold Water Cave in Winneshiek County, Iowa's largest cave. Photo by Michael Bounk.

part to most people. To geologists, caves provide a unique "inside view" of the system and can help explain and demonstrate how a carbonate aquifer system works.

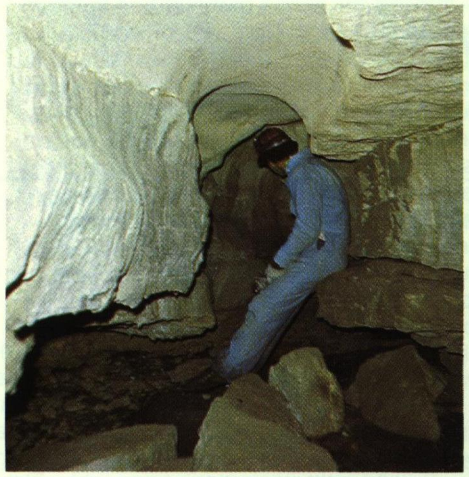
Carbonate rock formations contain many cracks. Vertical cracks, called fractures, consist of planes which intersect at near right angles. The horizontal cracks are called bedding planes and they represent partings between "beds" or layers of rock. The carbonate rock itself does not hold or conduct much water. Rather, the aquifer consists of water moving through and filling many of these cracks.

Rainwater is somewhat acidic, and as it moves through the soil and into the fractured carbonate formations, it reacts with some of the adjacent rock and dissolves it away. As certain fractures and bedding planes are preferentially used by the moving ground water, they become enlarged. This allows even greater volumes of water to flow and further speeds up the rate at which the carbonate rock is dissolved. The largest few of these crevices, those which can be entered, are caves.

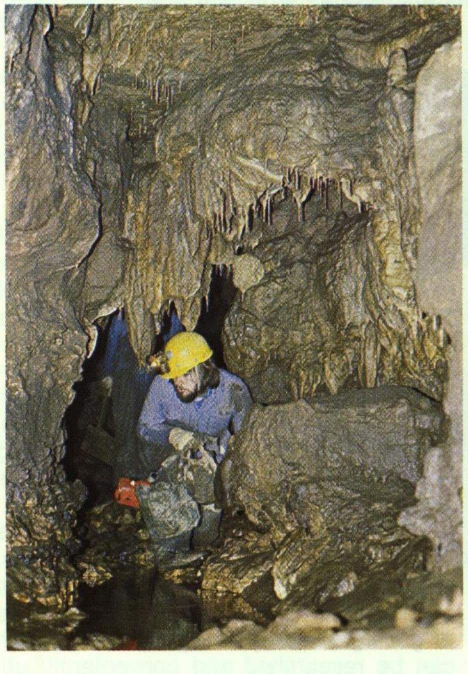
If you ever have an opportunity to visit a cave, you may observe many properties of carbonate rocks, their aquifers, and the processes which are the carbonate hydrologic system. Passageways often consist of straight segments, interrupted by near right-angle turns and intersected by side passageways which join at near right angles. Caves often zig-zag their way along, reflecting the original fracture patterns in the rocks. Corridors frequently have flat ceilings imparted from the original, flat, bedding planes. Fractures may be observed in the ceiling and side walls, often with water percolating out of them. The percolation of water along fractures often produces the most attractive and well known deposits—the stalactites hanging from the ceiling and the stalagmites built up on the floor. As the water, saturated with calcium carbonate dissolved from the rock, enters an air-filled cave passage, calcite or aragonite is precipitated from the solution and slowly builds these unique cave forms. Beautiful colors may be achieved if other materials, especially iron compounds, are dissolved in the water. Often these features are aligned with fractures observable in the ceiling.

Caves are not only the result of solution. In fact, many are also the result of underground erosion. Normally, we can enter caves only after nearby rivers have eroded deeply enough that the local ground-water table is lowered. This empties water from at least part of the passageway. Such a situation can be observed in the schematic block drawing with the previous article. Under most circumstances, a stream continues to flow along the cave floor. This erodes the rock as any stream would and produces a characteristic "keyhole" shaped cross section to the passageway. The top of the keyhole is developed along the original bedding plane, and the lower portion is developed by the cave's stream as it erodes a "canyon." Breakdown, rock fallen from the ceiling, often is found in the stream bed, as are deposits of silt, sand and clay which are brought down from above when surface water drains into sinkholes or fractures. In fact, mud, grass, wood or even cornstalks can sometimes be found high on the cave walls, even on the ceiling, indicating previous high-water levels from rainstorms. These serve as important reminders that caving may be dangerous, and that carbonate hydrologic systems may directly join activities on the land surface with processes deep beneath the ground and within some of our important sources of ground water.

Keyhole-shaped passage in April Cave, Winneshiek County. Photo by Michael Bounk.



Thorson's Cave in Floyd County shows "breakdown" in stream. Photo by Michael Bounk.



Exploring a Clayton County cave. Note stalactites. Photo by Michael Bounk.

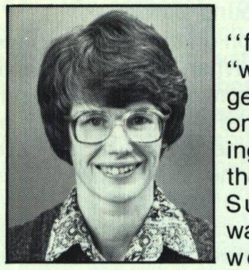
Eventually erosion on the land's surface will destroy caves. When caves are at shallow depths, the downward erosion of surface streams and the eventual collapse of the roof can combine to expose the cave passageways to the sun. The cave's stream becomes a stream like any other, and the dark, wet cave environment becomes a valley alive with flowers and trees. Maquoketa Caves State Park in Jackson County is such an example. Dancehall Cave, the largest one remaining in the park, is but a remnant of the original cave system. Most of the original cave passageway has evolved into the park's beautiful valley.

Caves can be mysterious and beautiful. Their environment is fragile; exploring them can be both rigorous and dangerous. Their study can tell us much about the important natural system of which they are a part. □

Editor's note: Michael Bounk is a research geologist at IGS and an active explorer of Iowa caves. He is currently Chairman of the Iowa Grotto, a chapter of the National Speleological Society.

IOWA'S WATER-WELL FORECASTER

By Jean C. Prior



To most of us, "forecasts" and "water" usually suggest meteorologists on television predicting rain or snow. At the Iowa Geological Survey, however, water forecasts mean well predictions: Where can water be found underground? How much is there? What will the water be like? Will pumping cause any problems? The man most likely to answer these questions is Paul Horick, "Iowa's Water-Well Forecaster."

Paul has been a mainstay of IGS since 1948. A geology graduate of Augustana College in Rock Island, Illinois, with a Master's degree from the University of Iowa, he works at that important interface where data gathering and research pay off in the form of practical information applied to solving problems. The Survey depends heavily on Paul to respond to a steady stream of water-related questions from farmers, engineers, and well-drillers, as well as representatives of industry and all levels of government. About 75% of Iowans depend on ground water to meet their water-supply needs, and every year thousands of new wells are drilled for domestic, commercial, industrial, municipal, or recreational uses. Data acquired from this drilling, as well as from IGS test-drilling programs and research projects, is refined into geologic strip-logs, maps, charts and printouts and then returned to Iowans in the form of assistance, advice, and information about water.

Paul's approach is to provide as complete information as possible, whether the water-supply questions are those of a rural home-owner needing only a few gallons a minute or a large corporation requiring several million gallons per day. His thorough and carefully prepared answers address questions on the availability of ground water at a particular site, the water quantity and quality, the depths at which water may be obtained, and the sequence of glacial deposits and rock formations that will be encountered in drilling. In some places, sand and gravel within valleys, glacial deposits, or buried, pre-glacial river channels are available alternatives. At other locations, deeper, bedrock sources —limestone, sandstone, or dolomite—will provide the most reliable supply of water. Each source, or aquifer, with its own set of geologic and hydrologic characteristics must be matched with the requirements of the individual request. He also provides advice on problems with well construction, contamination, and potential interference effects on other wells, in addition to information on well-development techniques, selection of pump settings, casing needs and the location of monitoring wells if needed.

Responding to these inquiries requires a special "feel" for water-supply problems, an understanding acquired through years of work experience and from a solid base of geologic and hydrologic records which can be researched and conveniently utilized. Paul credits his "first-rate" colleagues—active researchers of the state's geology and talented computer experts—in addition to the invaluable cooperation of water-well drilling contractors, engineers and well owners. Samples collected during drilling, construction records, information on well design, results of pumping tests, and access to wells are instrumental in assembling information on each aquifer —information beneficial to all Iowans, both now and in the future. State and federal agencies, especially the Iowa Natural Resources Council, Department of Environmental Quality and the U.S. Geological Survey also are very important in building the information base necessary to respond to questions.

Paul doesn't rely solely on others to compile this information; some of the best he has prepared himself. His own research efforts have focused on individual groundwater sources. This research has resulted in the publication of comprehensive reports on two of Iowa's most important bedrock aquifers, the Mississippian, serving central and southeastern Iowa, and the Jordan, providing water throughout eastern and central Iowa. He is now working on a third, the Silurian-Devonian aquifer system, which serves primarily northeast and east-central Iowa.

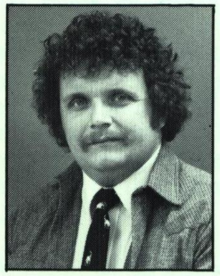
To quote Paul, "This work, both service and research, is geared to help people upgrade the quality of their life in Iowa—to protect, develop, and conserve our water resource, without which life cannot exist. As our population grows, as water demands increase, and competition for water intensifies, this work can only take on more importance, can only become more useful—and interesting." Paul's enthusiasm, dedication and knowledge, both to research and service, is a tribute to him and a great benefit both to IGS and the State of Iowa. □

Editor's note: Jean Prior is a Senior Research Geologist and works with Paul Horick in the Water Resources Divison.

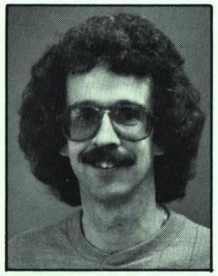
Paul Horick checking data sources in preparation for a water-well forecast. Photo by Donna McGuire.

OIL AND URANIUM POTENTIAL IN IOWA

By Raymond R. Anderson and Bill J. Bunker



Raymond Anderson



Bill Bunker

In an energy-hungry world, exploration for oil and uranium resources has expanded recently into areas not generally considered favorable in the past—areas like Iowa. Because exploration companies have actively sought leases here this past year, and because some companies may hope to attract Iowa investors, it is important for Iowans to understand more about the potential for these resources in their state. An article like this obviously can't go into great detail about these subjects, but at least it can provide some information about the geologic aspects of the search and some facts about drilling success so far. Separating fact from fantasy is a necessary, although sometimes difficult and delicate task.

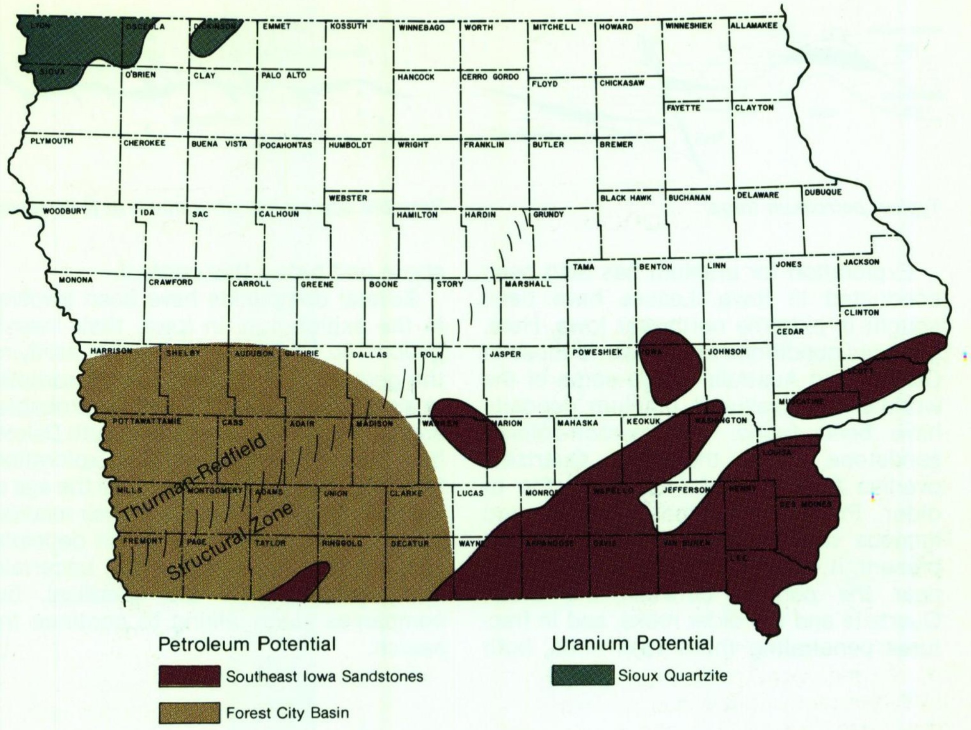
Petroleum, including oil and natural gas, is the product of chemical reactions which occur at great depths underground. During these reactions, fossilized organic materials are slowly converted into petroleum. As either a fluid or gas, the petroleum can flow through porous and fractured rocks, especially sandstones. The petroleum continues to flow until it is trapped by an impermeable barrier, usually a shale. Geological and geophysical studies are conducted during exploration to determine if a source rock for the original formation of oil is present, if a suitable host rock exists to store the oil, and if a suitable trap occurs to stop its migration and create a "pool," the potential oil field.

Do these conditions exist in Iowa? The answer is yes. Both southeastern and southwestern Iowa have geological conditions with potential for commercial petroleum production. In the southeast, two sandstone formations could be potential oil producers. The upper one is called the Hoing Sandstone in Illinois, where it has produced over four million barrels of oil. Traces of oil in these rocks have also been found in Missouri, not far south of Iowa. The lower unit, the Starved Rock Sandstone, has already produced oil in Iowa. A well drilled near Keota in Washington County, provided the only 400 barrels ever produced in Iowa. Both sandstone units are deformed into gentle undulations, called folds, which could trap oil. A potential source rock, the brown, organic-rich Harmony Shale, could have provided oil to either or both units.

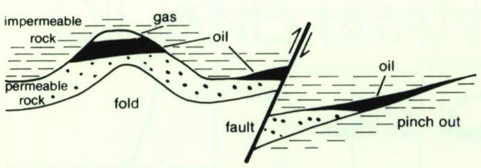
In the southwest, oil could be found in a feature called the Forest City Basin. In the 1860's, the first oil production west of the Mississippi River was found in Kansas and was produced from this basin. It extends from Kansas through Missouri and into Iowa. One producing area at Tarkio, Missouri, is just ten miles south of Iowa's border, and there are no known geological barriers to suggest that similar production is not possible further north. Petroleum could be found in sandstones of Pennsylvanian age or from deeper rocks near the Thurman-Redfield structural zone, a zone along which folds and faults could have developed to trap the petroleum. To date, however, test wells in southwest Iowa have produced only traces of oil.

Successful petroleum exploration generally requires abundant geologic information. This is lacking, especially in southwest Iowa. Few deep holes have been drilled and little geophysical data has been acquired from which to establish or evaluate potential drilling sites. Less than 100 oil or gas test wells have been drilled throughout the state, and many of these are located in highly unlikely areas. Nationally only 19% of the wildcat wells drilled in 1980 produced any oil or gas, and most of these were drilled in major producing parts of the country. Closer to Iowa, success rates were lower: Illinois -5%, Kansas -14%, Missouri -0%, Nebraska -11%. Drilling success increases as more well information is available. Kansas, a major oil and gas producing state, had 4000 wells drilled in 1980 alone. Compare the potential information and control from a history of drilling like that to the 96 test wells drilled in Iowa's entire history!

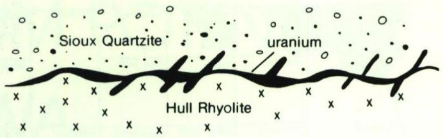
Professional opinions vary considerably, but we feel that oil and gas can be produced in Iowa. The odds, however, are great against any one individual test well becoming a producing well. But as test wells are drilled and other information is acquired, the odds may improve. If petroleum is found, most professionals believe it will be produced from rather small fields.



Location of potential petroleum and uranium resources.



Typical petroleum traps.



Possible occurrence of uranium in N.W. Iowa.

Exploration for uranium has also been conducted in Iowa. Leases have been sought in extreme northwest Iowa. Here, geologic conditions are similar to those in Canada and Australia where some of the world's most valuable uranium deposits have been found. The maroon-colored sandstone, called the Sioux Quartzite, overlies a surface of erosion on top of older Precambrian metamorphic and igneous rock formations. If uranium is present, it is believed to be concentrated near the contact between the Sioux Quartzite and the older rocks, and in fractures penetrating these rock units, both above and below this contact.

Several companies have been involved in the exploration. In Iowa, their investigations so far have consisted of studying the geology and analyzing water samples in an attempt to identify "most probable" areas. Test drilling in nearby South Dakota has proven unsuccessful. Exploration, however, may continue because the age of the rocks, the rock types and their relationships are favorable for uranium deposits. The chances for success are uncertain. Many professionals are skeptical, but companies seem willing to continue the search. ☐

GLACIAL GEOLOGY EXPLAINED

Timothy Kemmis lead the Geological Society of Iowa fall field trip on September 26, 1981. The trip's 47 participants were shown how glacial processes can result in the different types of deposits and landforms present in north-central Iowa. Materials deposited beneath glacial ice result in dense, uniform glacial till which generally covers areas of subdued topography. In contrast, materials deposited as the glaciers melted away are less consolidated, vary widely in their properties and are associated with hilly, irregular terrain. The trip began near Iowa Falls, travelled west to Algona, and followed the Algona Moraine northeast to the Lake Mills area near the Minnesota border. ☐

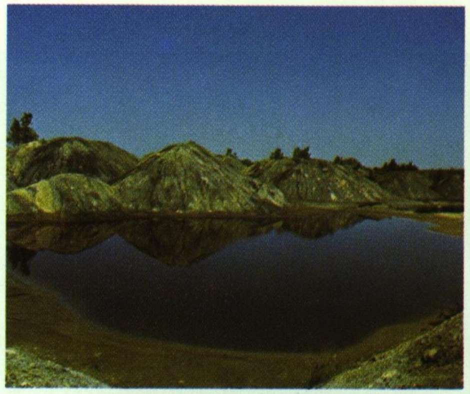
Kemmis discussing glacial deposits at a quarry near Dows. Photo by Bernard Hoyer.

ABANDONED MINE LANDS INVENTORY

By Susan J. Lenker

The Abandoned Mine Lands Inventory for Iowa was recently completed. It was sponsored by the U.S. Department of Interior's Office of Surface Mining and was performed under guidelines established by the sponsoring agency. The inventory identified and evaluated all Iowa land disturbed by coal strip-mining prior to 1977. In addition, several cities in Iowa that overlie underground coal mines were identified for possible future investigation.

Abandoned mine sites were identified from mining records, maps, and aerial photographs. Each site was visited and assessed for public health and safety problems. Some conditions which were investigated included polluted water being used for drinking or watering livestock, dangerous highwalls left standing after mining ceased, and shafts or other openings into which people or livestock could fall. Site-specific data such as dates of mining, adjacent land use and water-quality data also were compiled. Discussions with land owners and nearby residents, as well as state, county, and local officials, further helped to evaluate problems.



Barren mine-spoil piles and acid pond, Mahaska County. Photo by Marsha Miller.

The inventory identified 181 problem areas covering 9,561 acres. The problem areas ranged in size from a single acre to 490 acres, with an average of about 50 acres. The most heavily strip-mined counties, Marion, Mahaska, and Monroe, contain roughly 85% of the problem areas.

Each problem area was assigned a priority for possible future remedial action. By acreage, 4% of the area was defined as having severe problems and assigned priority class 1; 67% was found to have moderate problems (priority 2); and 29% was classified as having minor problems (priority 3). An additional 245 sites (4509 acres) were determined not to be in need of reclamation.

The results of this inventory are being combined with problems identified by the USDA Soil Conservation Service Rural Abandoned Mines Program to assure that remedial funds can be spent on the most hazardous sites. Funding for reclamation comes from a portion of the tax collected on all coal production. Remedial action on high-priority areas is the responsibility of the Division of Mines and Minerals of the Iowa Department of Soil Conservation as funding becomes available. ☐

MINERAL PRODUCTION IN IOWA

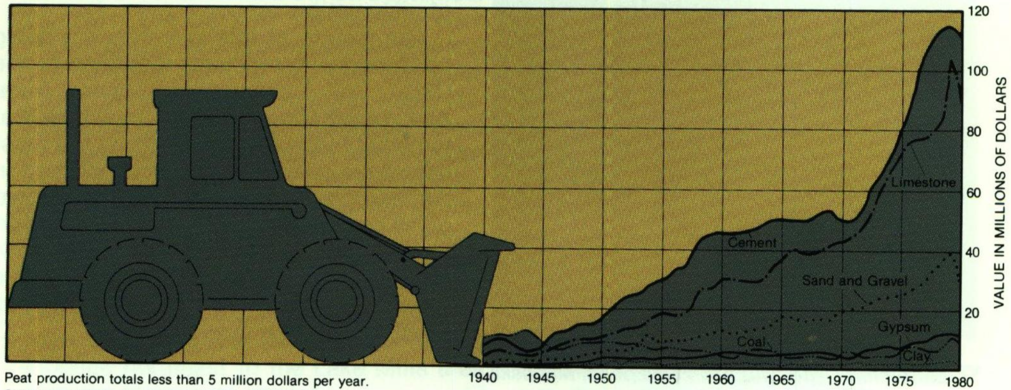
By Raymond R. Anderson

Mineral production has been important to the economy of the land that is now Iowa since the mid-1600's when the French and Indians began mining lead in the Dubuque area. Although the total value of minerals produced in Iowa dropped from 1979 to 1980 by about 11%, the mineral industry still pumped more than a quarter of a billion dollars into the state's economy. The variety of minerals currently produced include cement, limestone, sand and gravel, gypsum, clay, coal, silica sand, and peat.

Cement is the most valuable of the minerals produced in the state. It is produced at Davenport, Des Moines and Mason City by grinding and mixing limestone and clay with other materials and then firing them in large kilns. Clinkers generated from firing are ground to form the final product. In 1980, the production of both portland and masonry cement exceeded a value of $110 million.

The shallow seas which covered Iowa for most of the last 500 million years left our state with abundant limestone resources. Limestone generally is crushed for use as aggregate in concrete or asphalt, as a road surfacing material, or as agricultural lime. Building stone or dimension stone, once quarried rather widely in Iowa, is now produced only at Anamosa and Dubuque. In 1980, limestone production was valued at more than $89 million.

Sand and gravel resources in Iowa are located primarily along major rivers where the deposits were sorted and concentrated by the moving water. These resources are used heavily in the construction industry as fill and as a component of concrete and asphalt. The value of sand and gravel produced in Iowa followed the general trend and dropped a little to just under $33 million in 1980.



Peat production totals less than 5 million dollars per year.
Silica sand production value is confidential.

Iowa gypsum production ranks third among the 50 states and yielded a value of somewhat less than $14 million in 1980. Gypsum is presently being produced from underground mines at Harvey and Sperry, and from surface pits at Ft. Dodge. It is used primarily in the production of wallboard, but is also used in the production of plaster and cement.

Iowa clay has been mined primarily to produce ceramics, bricks, and as a part of cement production. The best year for the clay industry was 1920 when clay products in excess of $10 million were produced. However, as bricks became less popular in building, and with the recent introduction of plastic drainage tile greatly reducing the market for ceramic tile, the industry has been depressed. Production in 1980 was valued at only $2.5 million.

Likewise the coal industry of Iowa was at its peak in 1920 when over a hundred mines produced 7.8 million tons of coal worth almost $30 million. In 1980, only eight mines were operating and production was down under 600 thousand tons, valued at $11 million. With estimated reserves of almost 7 billion tons, Iowa coal could be a valuable resource to both Iowa and the U.S. in future years, and the industry could experience dramatic growth.

Silica sand is produced at only one locality, in Clayton County. It is used as foundry sand by several area industries which cast metals. Similar deposits across the Mississippi River in Wisconsin are used in glass-making. Production figures are confidential because they would reflect the sole Iowa producer.

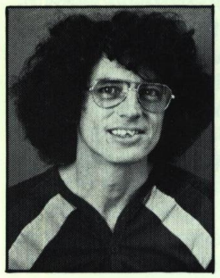
Peat is composed of partially decomposed plants and is mined by several small operators in Iowa. It is used primarily as a soil conditioner by local florists. In 1980 peat production in Iowa bucked the economic trend reaching an all-time high for the commodity, $270 thousand. □

THE MILS PROJECT

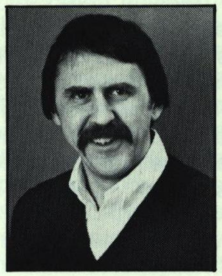
The Iowa Geological Survey is participating in the Mineral Industry Location System (MILS) through a contract with the U.S. Bureau of Mines. MILS is a national computerized directory of locations where mineral resources are extracted. It includes primary processing sites as well. Both active, inactive and historical sites are being inventoried. The ownership of each site is investigated, but emphasis is placed on identifying the specific minerals extracted or processed. In Iowa this would include limestone, sand and gravel, gypsum, coal, peat, silica sand, lead and zinc. Survey staff members are researching the Iowa sites and coding the information for inclusion in the national inventory. The project began last fall. Over 1700 sites have been identified so far, and the number is expected to triple before the contract concludes this next fall. □

BEHIND THE SCENES

By M. Patrick McAdams and Richard L. Talcott



Patrick McAdams

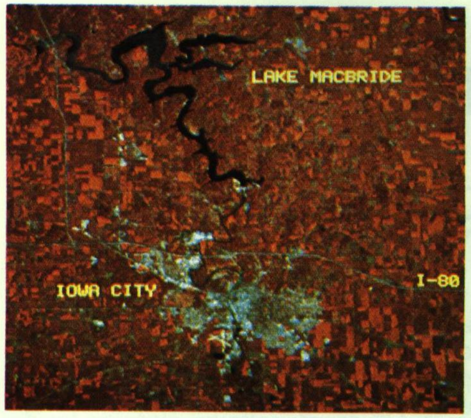


Richard Talcott

Research and information on Iowa's natural resources is the dominant focus of the Iowa Geological Survey. In order to continue providing quality resource information, new data sources must be used to supplement existing ones and new analysis techniques must be applied to all data, making it more readily accessible and useful. A mini-computer, installed in 1980, is proving itself an integral part of both new and old IGS research and information capabilities. It allows us to apply remotely sensed Landsat satellite data to Iowa's resource problems and to interpret the earth's geologic structure beneath Iowa from its seismic, gravity and magnetic properties. Further, it allows much geologic and hydrologic data to be more readily available, offers greatly improved communication of data with other computer centers, and enhances the way we go about much of our routine geologic and hydrologic analysis.

The computer was purchased primarily to process Landsat image data. The Landsat satellites acquire images of Iowa at regular intervals throughout the year. Images record data from 1.1 acre-sized areas in a computer-compatible format. Pictures made from these records contain significant information, but the data's full potential can only be realized through computer processing. One set of computer programs developed by NASA to process Landsat data is now fully operational on our computer. Through these programs, Landsat data can be viewed on a television screen as images. The back cover shows such an image. More importantly, images may be "classified." This means that each 1.1 acre-sized data element is assigned to a separate land-cover class via statistical criteria. Thus the computer discriminates areas of corn, beans, forests, lakes, bare soil, buildings, and other general classes of Iowa's land cover and maps their locations. The process is not easy and requires significant time and precise analyst's judgements—but the task would be nearly impossible without such data-collection tools as Landsat and such analysis tools as computers and applications programs.

A land-cover map by itself can be a valuable aid to resource managers. However, its value as a management tool is enhanced by the ability to merge land-cover information with ancillary resource information such as soils maps, conservation practices, topography, geology or water resources. A digitizer is used to convert existing maps to a format compatible with the land-cover information. Different data sets are "overlaid" in the computer forming a resource data base. The data base can then be analyzed to provide information for resource-management decisions. A demonstration of this capability was done with NASA's help in 1978 concerning the issue of soil erosion in Madison County. Currently, our computer system is being used to evaluate soil erosion and ground-water relationships in Clayton County, and the increased utility of a higher resolution satellite system is being tested for similar soil-erosion management potentials in Johnson County. The application of satellite imagery and various data bases to the management of Iowa's natural resources is still in the early stages of development. It will take considerable time to develop systems capable of providing Iowa's resource agencies with the information needed to make rational management decisions. But we at the Survey feel that our present capabilities are an important step in that direction.



Landsat image of Iowa City area, August 12, 1977. Photo by Donna McGuire.

IGS computer programmers in the computer room. Photo by Donna McGuire.

While image processing was the initial impetus for purchase of our own computer system, other Survey programs are the beneficiaries of the expansion in computer applications. With our own computer and in-house terminals, our staff has direct access to over 12,000 geologic records which are available instantly at most times. These records can be selected by geologic criteria and/or location criteria to help answer questions over the telephone, help visitors find information, or aid our staff's research. In the future, IGS staff will be able to print or plot the data without the aid of a computer programmer. Water-quality data and other well information are also planned to be made available in this format.

Geophysical techniques are becoming increasingly important to our understanding of the geology and resources of the state because they enable subsurface geological interpretations to be made in areas where drill-hole data is lacking. Seismic-data collection, measurement of the earth's gravity and magnetic-field properties, and subsequent computer analysis can be used to evaluate potential sites for ground water as well as for petroleum and mineral resources.

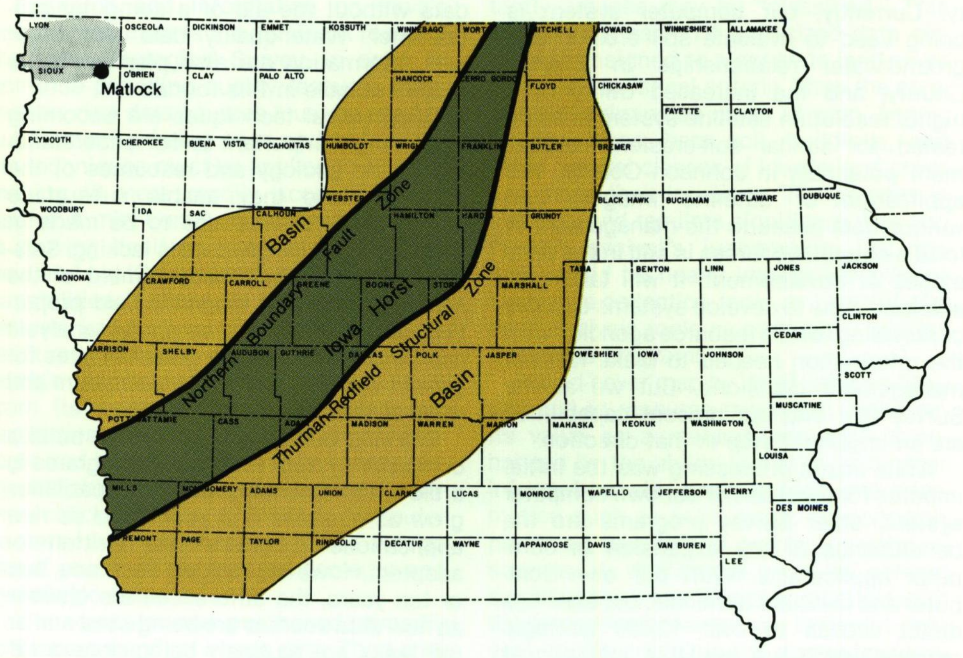
Working behind the scenes to build a computer system for our IGS programs is a slow, incremental process. Capabilities grow as equipment is added and as new applications programs are written or adapted. However, looking back one, two or ten years, the differences are obvious as new data sources are being used and as old tasks are routinely being done a different way—with the computer. ☐

IOWA'S DISTANT PAST

By Raymond R. Anderson

The first seventy-five percent of the earth's history has been lumped together by geologists and called the Precambrian. It represents the period of time from about 4.6 billion years ago (the estimated date of the earth's origin) to 600 million years ago. Rocks dating from this period are exposed in Iowa only in the northwestern-most corner of the state. There, they may be identified easily as a purple sandstone known as the Sioux Quartzite. Little can be said about earth history from these rocks alone. However, by studying other samples from nearly 100 deep wells in Iowa and by utilizing additional information, a few geologic events from the state's most distant past can be pieced together.

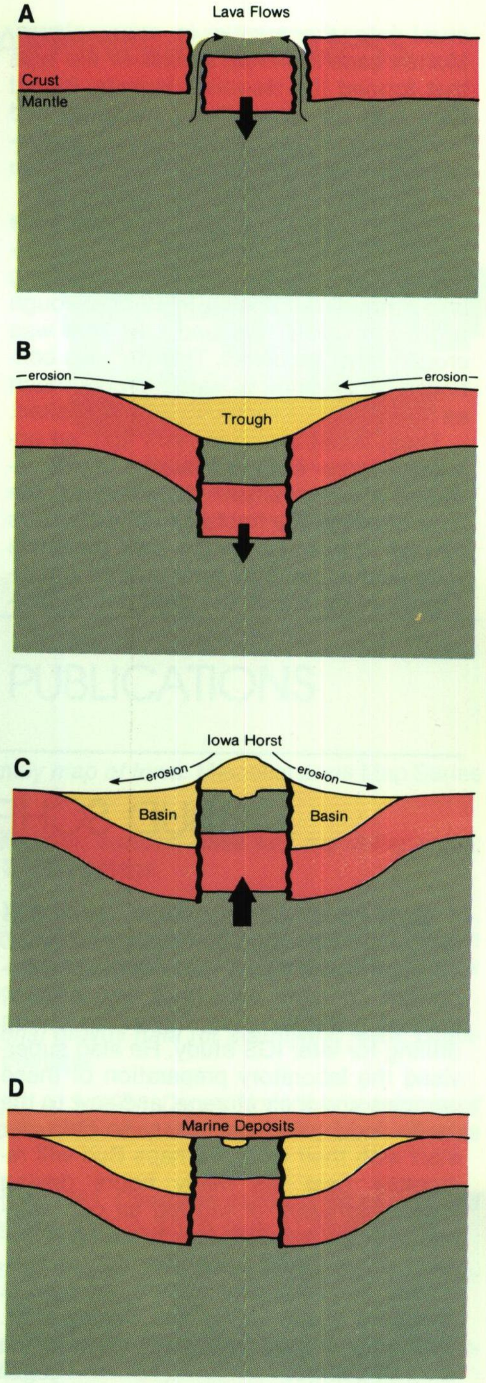
Iowa's Volcano. A geology graduate student, Tim Tvrdik, found evidence of a long-extinct volcano in northwest Iowa. He was studying a series of rock cores drilled by the New Jersey Zinc Company as a part of their exploration of an unexplained change in the earth's magnetic field near the town of Matlock. These cores of rock disclosed evidence of a violent volcanic eruption about 1.7 billion years ago. Upon careful examination, Tvrdik discovered two distinct zones in the rock. The lower zone consisted of a series of lava flows. These flows, identified as rhyolites, were about 200 feet thick in the Matlock cores, a testimony to the nearness of the volcano. The upper zone, also 200 feet thick, was identified as a tuff. Tuff is a rock composed of particles which settled to earth after having been blown into the air from a violent volcanic eruption, much like that recently experienced at Mt. St. Helens. Little more is likely to be learned of those distant events because these rocks are so deeply buried and were severely eroded prior to the deposition of the Sioux Quartzite sandstone 1.6 billion years ago.



Deposits from Iowa's volcano are located near Matlock in northwest Iowa. The Iowa portion of the Central North-American Rift System includes the Iowa Horst and adjoining basins.

Central North-American Rift System. Rifts are linear zones where the earth's crust ruptures, and pieces of the crust move apart. Earthquakes and volcanic activity are commonly associated with them. The Central North-American Rift System is a zone stretching from Lake Superior, across Iowa, and south into central Kansas. Numerous geologists have studied this feature in Michigan, Wisconsin and Minnesota where its rocks are exposed. The rift system in Iowa, Nebraska and Kansas is best known by its strong influence on the earth's gravity and magnetic fields. The events which caused this feature are not well understood, but we think it formed much like illustrations **A** through **D** outline.

About 1.1 billion years ago, tensional forces were exerted on the midcontinent of North America, and the crust responded by fracturing along two parallel trends. In Iowa these trends are called the Thurman-Redfield Structural Zone and the Northern Boundary Fault Zone. The earth's crust between these zones began subsiding. The fractures shown in **A** were deep, extending about 25 miles down through the earth's



crust into the mantle in many places. Molten basaltic lavas, similar to the type that formed the Hawaiian Islands, forced their way up along these fractures and flowed onto the subsiding areas. This process probably continued for less than 100,000 years.

As the vulcanism halted, subsidence continued and pulled down the areas adjoining the fracture zones forming a long broad trough as shown in **B.** The trough filled with sand, silt, and clay that was eroded from its flanks. This process continued for millions of years, and as much as 50,000 feet of sediment was deposited.

Then, about a billion years ago, an unknown force from inside the earth reversed the movement and pushed the zone between the fractures upwards. This can be seen in **C.** As the rock materials were pushed up, they were eroded and redeposited on top of the pre-existing marginal basins. The uplifted area has been named the Iowa Horst, as a horst is a geologic term for such an uplifted block. The uplift and erosion of the Iowa Horst continued until most of the material deposited on the lavas was eroded.

About 500 million years ago, seas moved into the area and erosion stopped. In **D** we see the condition today, as the Iowa Horst and the whole rift zone is buried beneath several thousand feet of marine deposits from the last 500 million years.

Research continues in order to better understand these features, their size and their origins, as well as to determine if there is any potential for economic development. What is already evident, however, is that the Precambrian history of Iowa included events as exciting and dramatic as could be found anywhere on earth. □

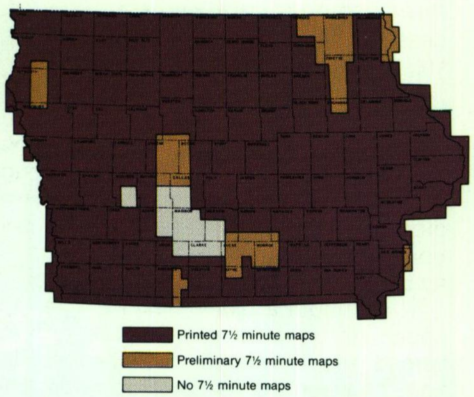
BUD SCHEETZ RETIRES

Earle "Bud" Scheetz retired from IGS after more than eighteen years of service. Through these years, Bud maintained important contacts with Iowa well drillers, collecting the samples they saved during drilling for later IGS study. He also supervised the laboratory preparation of these samples and their storage, and saw to the many "odd jobs" necessary to help our staff with their work. Perhaps Bud will remember best his many hours driving Iowa's highways or moving all our warehoused rock samples four times! A retirement dinner, held December 3rd, was attended by many well drillers, as well as members of his family and Survey staff. Bud remains in the area, still living in the town of Oxford. □

Bud visiting with friends at his retirement dinner. Photo by Paul Van Dorpe.

TOPOGRAPHIC MAPPING PROGRESS

The 7½ minute quadrangle (1:24,000 scale) topographic mapping program in Iowa continues to progress towards its targeted 1984 completion date. In the last year, 93 quadrangle maps were printed along with 10 new preliminary maps. Currently, 96% of this important Iowa map series is available in some form for Iowa. Index maps are available free of charge. Printed maps may be purchased from the Iowa Geological Survey for $2 each; both printed and preliminary maps are available from the U.S.G.S. Mid-continent Mapping Center, Box 133, Rolla, Missouri 65401 for $2 each. □



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Brenner, R. L., Bretz, R. F., Bunker, B. J., Iles, D. L., Ludvigson, G. A., McKay, R. M., Whitley, D. L., and Witzke, B. J., 1981, *Cretaceous stratigraphy and sedimentation in northwest Iowa, northeast Nebraska, and southeast South Dakota:* Guidebook Series No. 4, 172 p. $6.00 plus $1.85 postage.

Cumerlato, C. L., 1981, *Supplementary regional gravity data for southwest Iowa:* Open-File Report 81-1, 35 p. $1.50 plus $ .60 postage.

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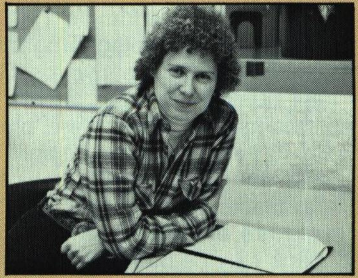
Van Eck, O. J (ed.), 1981, *Regional tectonics and seismicity of southwestern Iowa:* Annual Report to U.S. Nuclear Regulatory Commission, 72 p.

Van Dorpe, P. E., 1980, *A bibliography of Pennsylvanian geology and coal in Iowa:* Open-File Report, 124 p. $2.50 plus $1.40 postage.

NEW STAFF AT IGS

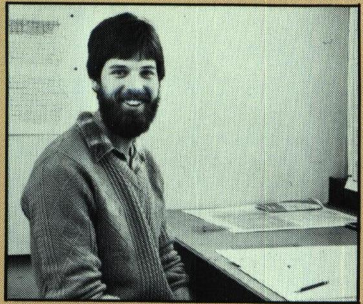


Carol A. Thompson

Renee L. Smith

E. Arthur Bettis

Arletta L. Orelup



David J. Heer

Robert D. Pyle

Donna A. McGuire

E. Arthur Bettis III joined IGS as a research geologist to investigate groundwater quality near the Big Spring fish hatchery. Funding is provided through agreements with the U.S. Soil Conservation Service and the Iowa Department of Environmental Quality. Art is a native of Sioux City and received a B.S. degree in anthropology and his M.S. degree in agronomy (1979) from Iowa State University.

David J. Heer joined our staff as a research geologist after receiving a B.A. degree in geology at the University of Northern Iowa in 1979. Originally hired under the Abandoned Mine Lands Inventory contract, he is now working on the Mineral Industry Location System project which is funded by the U.S. Bureau of Mines. Raised in Dubuque, Dave is interested in environmental geology.

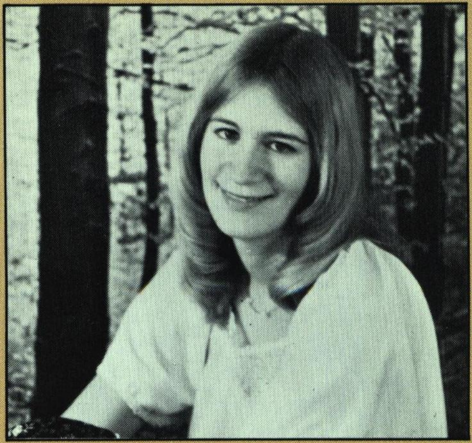
Donna A. McGuire, a native of West Bloomfield, Michigan, earned a Bachelor of Fine Arts degree in graphic design from the University of Michigan in 1980. She became a graphic artist on our staff after having held a similar position with the American College Testing Program.

Arletta L. Orelup joined our staff as Chief of our Administrative and Support Services Division. A native of Rapid City, South Dakota, Arletta has lived in Iowa City for many years and previously served as Executive Secretary to the City Manager of Iowa City and as a manpower specialist with Job Service of Iowa.

Robert D. Pyle is a native of Des Moines with a B.S. degree (1974) in special education from Drake University. Bob taught special education for three years and worked in the building construction and maintenance fields before joining our staff as a geological technician.

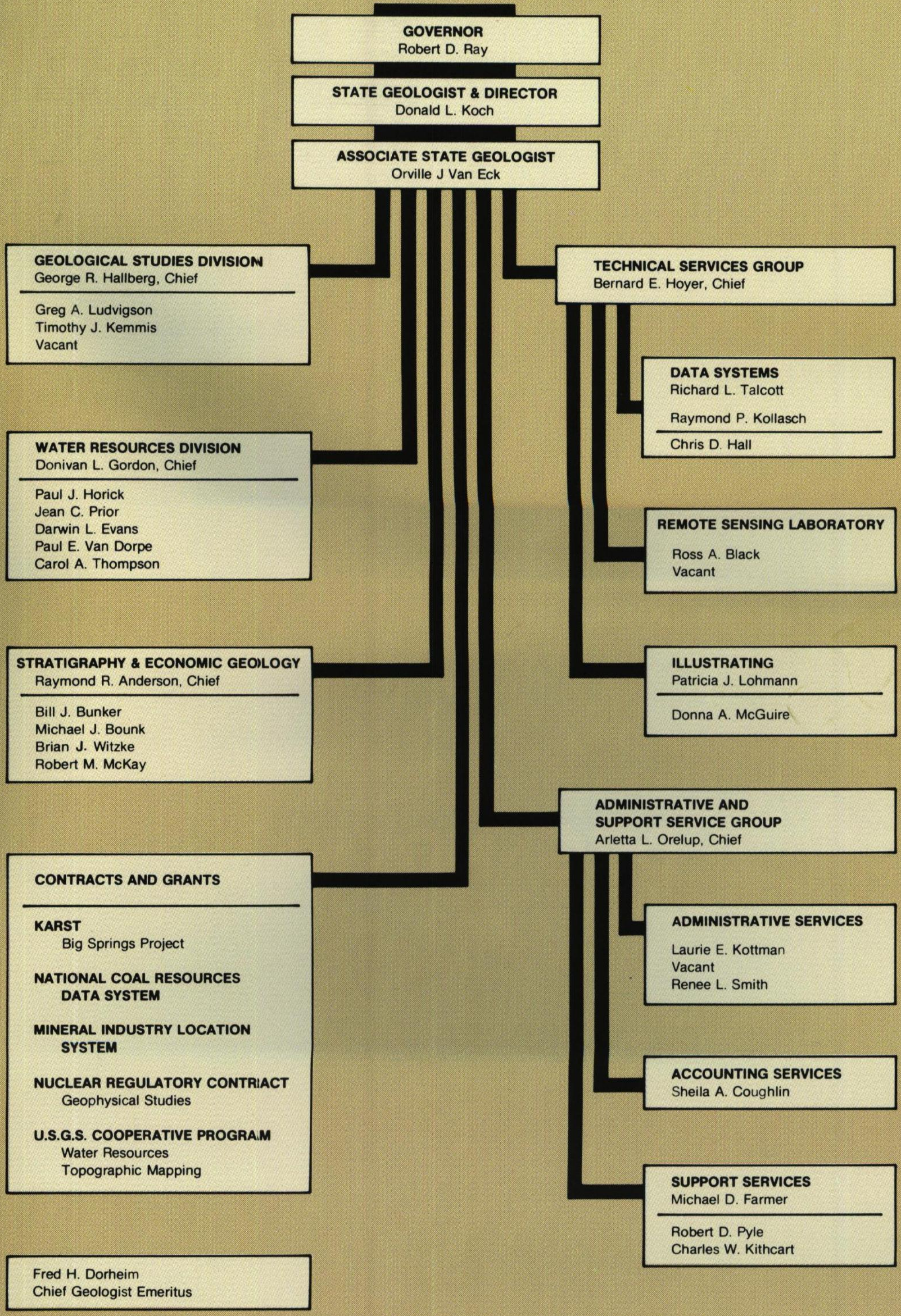
Renee L. Smith became a receptionist at IGS this past August. Raised in Burlington, she graduated from high school in 1980 and attended Southeastern Community College before moving to Iowa City.

Carol A. Thompson, a native of Chicago, Illinois, became a research geologist in our Water Resources Division this past October. Carol received a B.S. degree in geology from the University of Illinois-Chicago Circle in 1978 and expects her M.S. degree this year from the same institution, where she has specialized in experimental geochemistry. □



Susan J. Lenker died in an auto accident this past November while collecting water-quality data near Elkader, Iowa. We regret this tragic event and sympathize with her family, friends and all others involved.

IGS ORGANIZATIONAL STRUCTURE



GOVERNOR
Robert D. Ray

STATE GEOLOGIST & DIRECTOR
Donald L. Koch

ASSOCIATE STATE GEOLOGIST
Orville J Van Eck

GEOLOGICAL STUDIES DIVISION
George R. Hallberg, Chief

Greg A. Ludvigson
Timothy J. Kemmis
Vacant

WATER RESOURCES DIVISION
Donivan L. Gordon, Chief

Paul J. Horick
Jean C. Prior
Darwin L. Evans
Paul E. Van Dorpe
Carol A. Thompson

STRATIGRAPHY & ECONOMIC GEOLOGY
Raymond R. Anderson, Chief

Bill J. Bunker
Michael J. Bounk
Brian J. Witzke
Robert M. McKay

CONTRACTS AND GRANTS

KARST
Big Springs Project

NATIONAL COAL RESOURCES DATA SYSTEM

MINERAL INDUSTRY LOCATION SYSTEM

NUCLEAR REGULATORY CONTRACT
Geophysical Studies

U.S.G.S. COOPERATIVE PROGRAM
Water Resources
Topographic Mapping

Fred H. Dorheim
Chief Geologist Emeritus

TECHNICAL SERVICES GROUP
Bernard E. Hoyer, Chief

DATA SYSTEMS
Richard L. Talcott

Raymond P. Kollasch

Chris D. Hall

REMOTE SENSING LABORATORY

Ross A. Black
Vacant

ILLUSTRATING
Patricia J. Lohmann

Donna A. McGuire

ADMINISTRATIVE AND SUPPORT SERVICE GROUP
Arletta L. Orelup, Chief

ADMINISTRATIVE SERVICES

Laurie E. Kottman
Vacant
Renee L. Smith

ACCOUNTING SERVICES
Sheila A. Coughlin

SUPPORT SERVICES
Michael D. Farmer

Robert D. Pyle
Charles W. Kithcart