NEWSLETTER
NDGS

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Among collectors, North Dakota is perhaps best known for its petrified wood, agates, and flint. Yet a much greater variety of rocks and minerals, many suitable for lapidary work, can be found in the state. Some of the best places to look for interesting rocks and minerals are in gravel deposits of modern and Ice Age rivers and beaches, such as along this creek in the Turtle Mountains. See page 6 for a glimpse of what rockhounds commonly find in North Dakota. *North Dakota Tourism Department photo by Dawn Charging.*

FEATURES

DEPARTMENTS

NDGS Newsletter (ISSN: 0889-3594) is published quarterly by the North Dakota Geological Survey, a division of the Industrial Commission of North Dakota. *NDGS Newsletter* is designed to reach a wide spectrum of readers interested in the geology and mineral resources of North Dakota. Single copies of *NDGS Newsletter* are distributed free upon request. Please share the *NDGS Newsletter*; we encourage its reproduction if recognition is given.

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NEWSLETTER

NDGS

NORTH DAKOTA GEOLOGICAL SURVEY 1895

NDGS NEWSLETTER
Editor**Bob Biek
Word Processing**LaRae Fey

FROM THE STATE GEOLOGIST

by John P. Bluemle

New Oil Drilling Techniques Pay Off

The North Dakota Geological Survey and the Saskatchewan Energy and Mines recently co-sponsored the Third International Williston Basin Horizontal Well Workshop in Regina, Saskatchewan. This year's workshop featured twenty-two talks and five posters (see list on page 2) on horizontal drilling and production activity in North Dakota, Montana, Saskatchewan, Alberta, and Manitoba, the states and provinces underlain by the various Williston Basin oil-producing reservoirs. The workshop was held from April 30 - May 2.

As with our past two workshops, the format this year was intentionally kept informal to allow for easy communication. The three workshops we have co-sponsored with Saskatchewan Energy and Mines have served as a forum for the exchange of information on the latest new technology and geologic concepts in the Williston Basin. The first two workshops, which were held in Minot, were very successful in encouraging effective horizontal drilling in both North Dakota and Saskatchewan. A number of horizontal wells were drilled over the past two years because of information oil company operators gained from the workshops and we expect additional wells to be drilled as a result of this year's workshop.

Higher oil production — higher production rates and higher total volumes— are made possible by horizontal drilling. Horizontal wells help to cut the operating costs of companies by spreading them over more barrels of oil. In addition, horizontal wells can produce more oil than vertical wells because the higher production rates can significantly reduce operating costs. It's doubtful whether vertical wells, operating over a longer period of time, would recover as much oil as horizontal wells because when equipment wears out on a low-productivity well, it's time to shut down.

The success of a horizontal well is not a given. We were told that, to be successful, it's necessary to have good geological control and to understand the reservoir mechanics, including such factors as the rock strength and the possibility of drilling damage to the reservoir.

The speakers at this year's workshop in Regina dealt with geologic and engineering topics in both Canada and the US. In addition, oil-field service companies displayed their latest horizontal drilling technology. Presentations included horizontal drilling in gas, light oil and heavy oil reservoirs in the North Sea and on geosteering in the Gulf of Mexico, as well as other presentations on topics in North Dakota, Saskatchewan, and Manitoba.

Information and ideas gained from the last two horizontal-drilling workshops have translated quickly into drilling and development activity in North Dakota. For example, a talk last year on the Spearfish pool at Manor Field in Saskatchewan sparked exploration and leasing on a similar play in North Dakota. New data presented during the workshop by the North Dakota Geological Survey on the geology of the Lodgepole Formation has helped maintain activity around Dickinson Field, where oil companies have recently had exceptional exploration and development success (also see the article by Randy Burke and Paul Diehl in the last issue of the *NDGS Newsletter*).

When this series of workshops with the Saskatchewan Energy and Mines was initiated, we intended to invite a few companies from each side of the border to attend a meeting to informally discuss the technology of horizontal wells and business opportunities stemming from this new technology. The concept has obviously been successful beyond our best expectations; attendance at this year's Horizontal Drilling Workshop was about 450, compared to last year's 325 participants in Minot. We expect to return to North Dakota for next year's workshop.

NEWS IN BRIEF

compiled by Bob Biek

HORIZONTAL-WELL WORKSHOP
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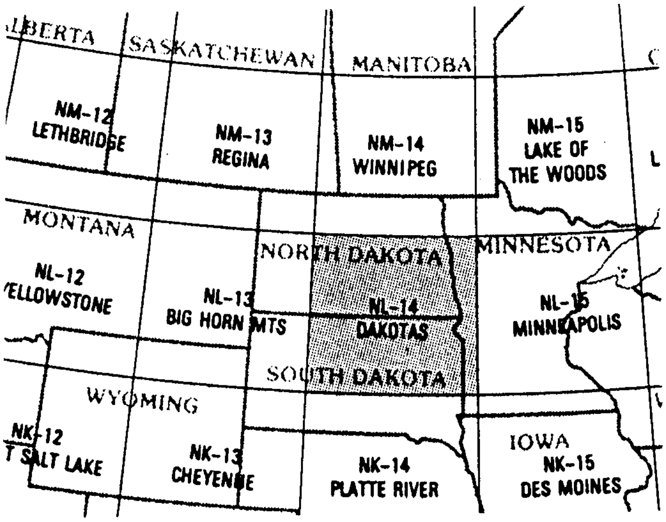
Quaternary Geologic Map of the Dakotas $4^o x 6^o$ Quadrangle

A geologic map that shows Quaternary deposits of the Dakotas $4^o x 6^o$ Quadrangle was recently published by the U.S. Geological Survey. This 1:1,000,000-scale map, USGS Map I-1420 (NL-14), is part of the Quaternary Geologic Atlas of the United States. The map was edited and integrated by David Fullerton of the USGS in cooperation with the Geological Surveys of North Dakota, South Dakota, and Minnesota. Similar maps for the Big Horn Mountains, Regina, and Winnipeg quadrangles are in progress. The map will soon be available through the USGS Information Center, Box 25286 Federal Center, Denver, CO 80225.



NDGS Updating the Bibliography and Index of North Dakota Geology

The NDGS is updating the Bibliography of North Dakota Geology to cover the period 1980 through 1994. Larry Greenwood, Library Director at Minot State University, has done a commendable job of compiling a draft version of the bibliography, culling references from the *Georef, Geobase*, and *Geoarchive* databases.

It appears, however, that *Georef* and the other databases are incomplete. In an effort to track down missing references, we sent researchers who have worked in North Dakota a list of their publications for this period that appear on one of these databases. If you have not received such a list, please call Tom Heck or Bob Biek at the NDGS. We want you to have the opportunity to review, and add to if necessary, your publications list.

Survey Loses Assistant State Geologist

During the last Legislative session, the Geological Survey lost one full-time equivalent (FTE) position, along with funding for that position. As a result of the loss of an FTE position, the NDGS was forced to undergo a reduction in force that called for the elimination of the position of Assistant State Geologist.

The loss of Bill McClellan is an especially severe blow to the Survey because, even though he was in a management position, he was also involved in studies of North Dakota's petroleum-producing formations. His loss leaves the NDGS with only three subsurface geologists in Bismarck and one in Grand Forks.

State Historical Society and North Dakota Geological Survey Celebrate Centennials

A joint celebration will be held on Friday, June 23 from 11:30 to 1:00 to "officially" celebrate the 100th birthday of both the NDGS and the State Historical Society. The informal gathering will be held at the Heritage Center Plaza. A cake will be served, but bring your own lunch. The two agencies will also plant a tree in the Centennial Grove on the capitol grounds. The gathering is open to all — come help us celebrate!!

USBM Donates Library Materials

The U.S. Bureau of Mines (USBM) recently donated 59 volumes of the *Minerals Yearbook* to the NDGS library. The *Minerals Yearbook* is an annual, three-volume review of the mineral industry. Volume I, "Metals and Minerals," contains chapters on virtually all metallic and industrial mineral commodities important to the U.S. economy. Volume II, "Area Reports — Domestic," contains chapters on the mineral industry of each of the 50 States and possessions. Volume III, "Area Reports — International," contains mineral data on more than 150 foreign countries.

The USBM donation includes most *Minerals Yearbook* reports from 1965 to 1990. The *Minerals Yearbook* series began in 1932, and builds on an annual review of mineral information statistics that reaches back to the 1880s. The donations came about because of restructuring taking place at the USBM.

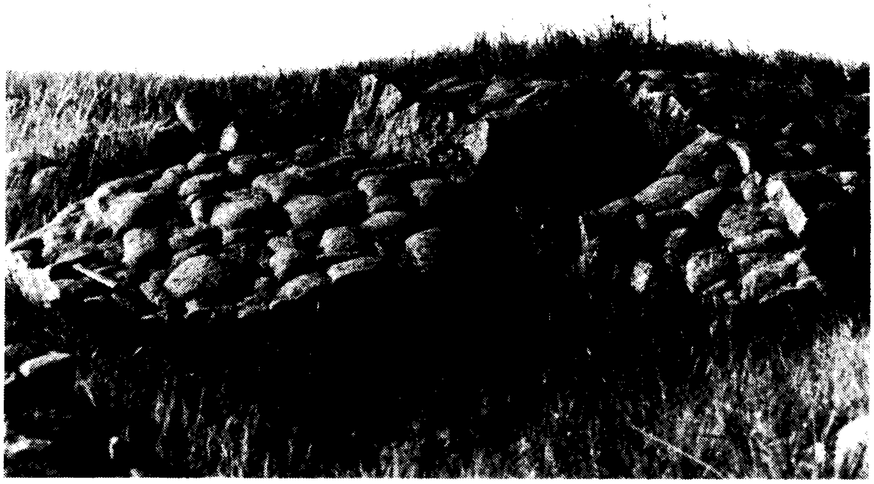
7th International Williston Basin Symposium

The 7th International Williston Basin Symposium will be held July 23-25, 1995 in Billings, Montana. This two-day symposium will feature talks and poster presentations on tectonics and exploration methods; regional sedimentation and stratigraphy; field studies; and oil sources, reserves, and hydrodynamics. Two field trips are scheduled prior to the meeting, and a core workshop will be held on the afternoon of Sunday, July 23. For further information, contact W. Kipp Carroll, General Chairman, at 406-245-2367.

An Unusual Example of the Taylor Bed Silcrete

by Bob Biek

I've often thought to compare the science of geology to a foreign language. In order to converse in the native language of a foreign country, one must develop a vocabulary and understand the rules of grammer and diction. The more adept you are at the language, the better you can understand the culture, the more questions you can ask, the more you can learn.



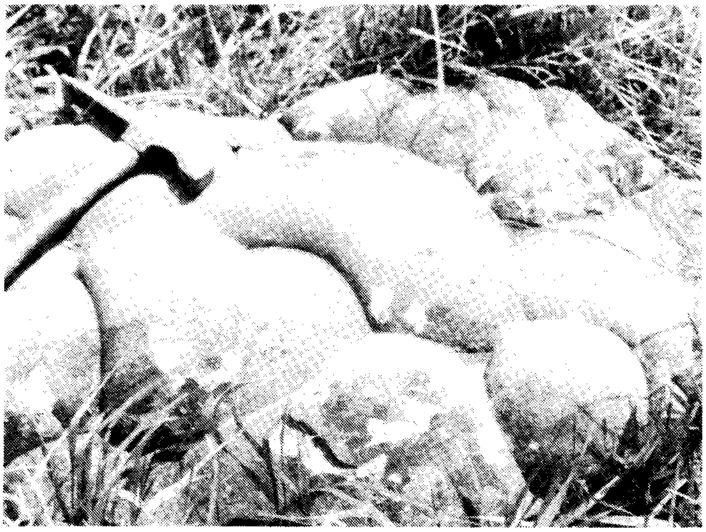
So it is with geology. With an understanding of terminology, classification schemes, and rocks, fossils, and structures themselves — the "vocabulary" of geology — and a grasp of geologic history and processes — the "rules" of geology — one can go forth and analyze and interpret the geology about them. You are only as good, however, as your preparation and experience have made you, and I fear here that I have come up short. I have come across something unusual, which I have never before seen, and which I cannot explain. Perhaps one of you, reading this plea of ignorance, will write or give me a call with your idea of how it may have formed and if you have seen similar examples elsewhere.

The "it" is an unusual form of the Taylor bed silcrete, found while I was working on a geologic map of the greater Dickinson area[1]. I have seen it at just one location, where it forms a pavement of large, extremely hard blocks that are about 2 feet thick and up to 10 feet long. The silcrete is a light gray, massive silicified siltstone that contains comparatively few plant stem molds. No obvious bedding, laminations, or other internal structures were seen in the silcrete. Thin sections show the rock to be composed of very well-sorted, angular, coarse silt to very fine sand size quartz (and rare chert) grains. It is completely cemented by quartz overgrowths, which being optically continuous with adjacent grains, make the grains appear very tightly packed in thin section.

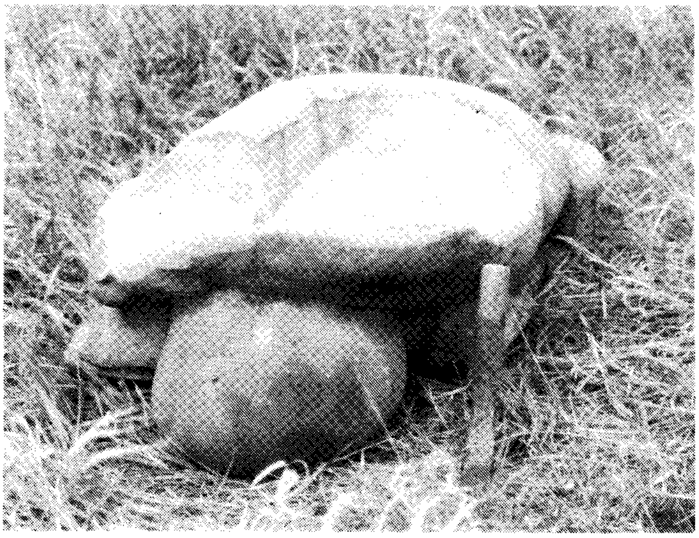
The puzzling thing about this particular outcrop are the pillow-like structures on the upper surfaces of each block. There seems to be no preferred orientation or shape to the structures; no obvious symmetry or asymmetry, no regular polygonal pattern. They are closely spaced "blobs" up to two feet in length, although most are 3-10 inches long and of comparable width. The undersides of some blocks have what appear to be well-developed load casts.

In her 1978 M.S. Thesis, Barbara Wehrfritz notes that the upper surface of the Rhame bed rarely forms botryoidal "globs" that range from about 2 inches to one foot in diameter. She notes that this botryoidal surface appears more often on boulders than in outcrop, suggesting that it may be a result of weathering.

These two photos show the unusual, upper surface of the Taylor bed. The origin of these randomly oriented "blob-like" structures is as yet a mystery.



Close-up of the upper surface of the Taylor bed, showing irregular pillow-like structures.



Bulbous protrusion from the underside of the Taylor bed appears to be a load cast. Note hammer handle for scale.

The presence of plant stems and molds in the silcrete suggest that it was deposited in shallow water, such as a swamp or marsh. The presence of hollow, vertical plant stem molds themselves seems to require that the silcrete be silicified prior to decay of the plant material.

Have you any ideas on how these structures formed? Have you seen similar examples elsewhere?

1 The Taylor bed, or its lateral equivalent the Alamo Bluff lignite, marks the top of the Bear Den Member (Paleocene) of the Golden Valley Formation (Hickey, 1977). Like the Rhame bed at the top of the Slope Formation, the Bear Den Member is believed to represent a weathering horizon that developed on top of the Sentinel Butte Formation (Karner et al., 1978; Clayton et al., 1980; Prichard, 1980). The member thus marks an unconformity, a hiatus in deposition between the Sentinel Butte Formation (Paleocene) and the Camels Butte Member (Eocene) of the Golden Valley Formation.

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Prichard, Gordon H., 1980, Authigenic kaolinite in the Bear Den Member (Paleocene) of the Golden Valley Formation, in southwestern North Dakota: Unpublished UND M.S. Thesis, 174 p.

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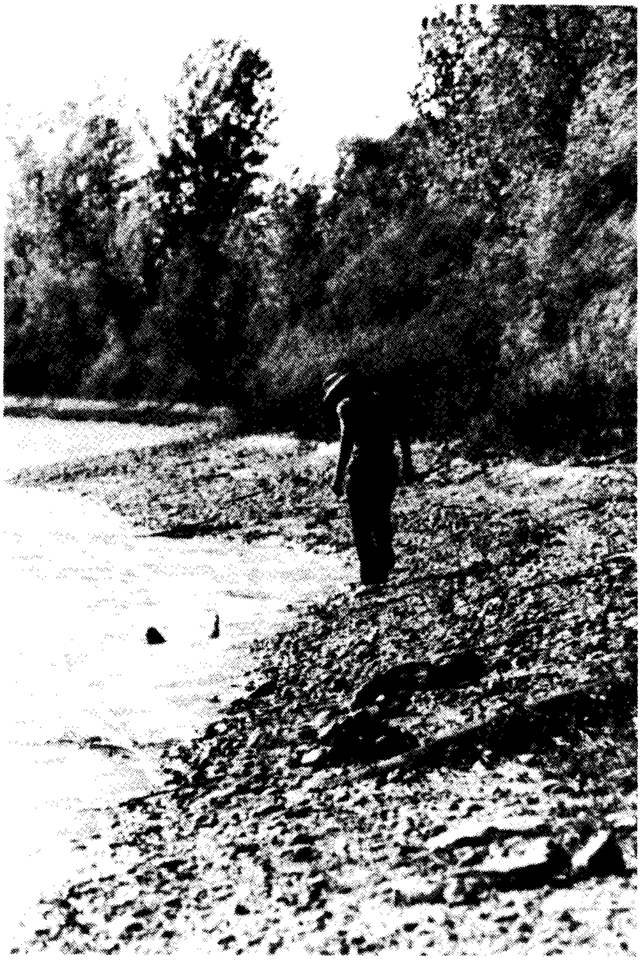
North Dakota's Rocks and Minerals

by Bob Biek

Among collectors, North Dakota is perhaps best known for its "quartz family" minerals. Rocks and minerals formed by the precipitation of silica from cold water solutions — such as petrified wood, agates, jasper, and flint — are common in North Dakota, so much so that they are locally used as a building stone for foundations and retaining walls and as rip rap. Yet a much greater variety of materials, many suitable for lapidary work, are found in the state. Sulfates, such as transparent nodules and rhombohedral crystals of gypsum; oxides of iron and manganese that form oddly shaped nodules and concretions; sulfides such as brassy colored pyrite and marcasite; and carbonates, including common limestone and more exotic nodules — all of these and more await the collector. North Dakota's palette of rocks and minerals may lack the great diversity of our neighboring states, but a remarkable amount of material suitable for display and lapidary purposes is found right here at home.

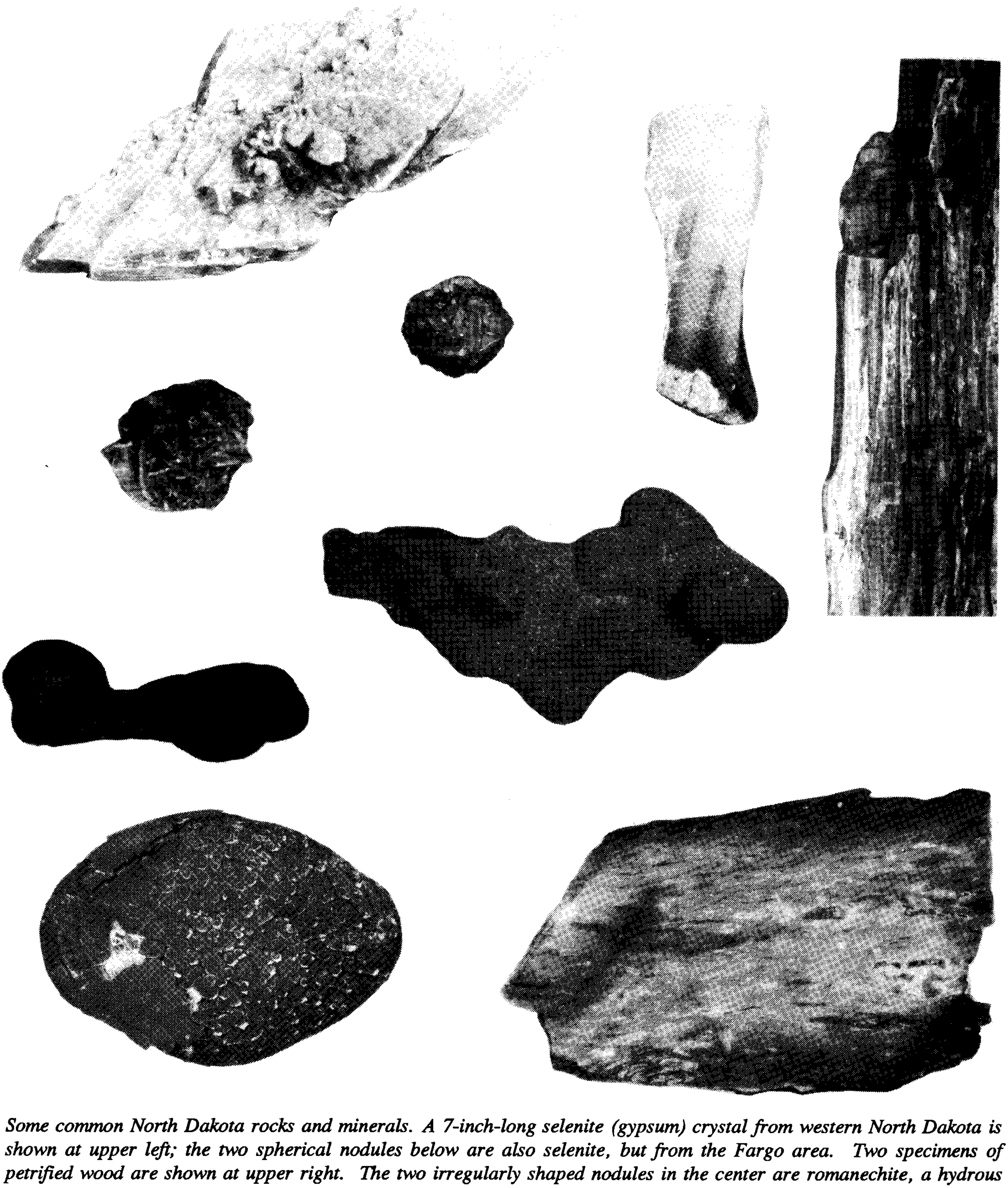


Some of the most productive areas for rock and mineral collecting are in badlands areas and in gravel deposits of Ice Age and modern rivers. Many such areas are shown in the guidebooks listed at the end of this article, but for me "the X marks the spot" is the wrong approach to rock hunting. First, such a strategy tends to concentrate collecting in small areas, which can be played out or abused. Second, such directions give little hint of where else to look. And third, one cannot possibly list all localities in which to collect a given mineral. A better way, perhaps, is to use a geologic map, have an idea of what rocks and minerals might be found in a given geologic unit, and apply a little intuition and map reading skills to locate productive areas — areas that quite possibly have not been looked at in any detail before.

Only sedimentary bedrock is exposed at the surface in North Dakota; igneous and metamorphic rocks are deeply buried under the Williston Basin of western North Dakota, and at the basin's margin in eastern North Dakota, they are buried by up to several hundred feet of glacial sediments. Ice Age glaciers, however, have scattered a wide variety of igneous and metamorphic rocks across glaciated portions of the state, and Late Tertiary/Pleistocene gravels derived from the Black Hills or Rocky Mountains are found in the southwestern portion of the state. There is, thus, still greater diversity of rock types than one might expect here on the northern plains.

The following descriptions refer to geologic units shown on the *Geologic Map of North Dakota*, compiled by Lee Clayton and others in 1980. Once a region for collecting has been chosen, more detailed geologic and topographic maps can be used to better define potential collecting areas.

Some of the best places to look for interesting rocks and minerals are in gravel deposits of modern and Ice Age rivers and beaches. Hard, resistant rocks are concentrated in such deposits and, while worn, many are suitable for slabbing while smaller specimens can be used for tumbling. In North Dakota, gravel deposits fall into four main groups and you can find display- and lapidary-quality stones in each major group.



Some common North Dakota rocks and minerals. A 7-inch-long selenite (gypsum) crystal from western North Dakota is shown at upper left; the two spherical nodules below are also selenite, but from the Fargo area. Two specimens of petrified wood are shown at upper right. The two irregularly shaped nodules in the center are romanechite, a hydrous barium manganese oxide, found near Dickinson. At the lower left is an 8-inch-long siderite (iron carbonate) nodule with characteristic "alligator skin" surface. Silicified peat is shown at lower right. Silicified peat is locally so abundant it is used as rip rap and in construction, such as for the old house pictured at the end of this article.

Quaternary and Late Tertiary sediment

This unit includes mostly Late Tertiary or Quaternary river sediments composed of locally derived material, as well as quartzite and porphyry derived from the Black Hills or Rocky Mountains. It is restricted to the southwestern part of the state, principally south and west of the Missouri River. Much of the material is pebble to cobble size, but small boulders are also present. Often, these deposits form esker-like ridges. The ridges are former river channels that stand in topographic relief because they are more resistant to erosion than the surrounding finer grained, poorly consolidated bedrock.

Petrified wood, flint, agates, and concretions are very common in these gravels. Much of the wood is well silicified and has a beautiful figure to it. Moss agates and less commonly Montana agates are found, as is locally derived chalcedony. Many of these agates have a whitish patina or weathering rind, and so are easy to spot. Montana agate, one of that state's official gemstones, is prized for its brown bands and black dendritic (tree-like) patterns set in clear to amber-colored chalcedony. The moss agate tends to be dark in color and often riddled with fine fractures, but some specimens can be thinly slabbed and used for cabochons.

Holocene river sediment

This unit consists of all sediments found in modern channels and floodplains and in adjacent terrace deposits (the terraces may be located quite high above the present floodplain). Many specific sites are mentioned in the guidebooks listed at the end of this article, but they can only hint at the number of productive localities to be found. Highly prized Montana agates are common in terrace gravels along the Yellowstone River southwest of Williston. These gravels contain astounding amounts of petrified wood and moss agate as well.

Teredo-bored petrified wood — North Dakota's State Fossil — can be found in gravel deposits derived at least in part from the marine Cannonball Formation. Such deposits are found in the southcentral part of the state, especially south and west of the Bismarck-Mandan area. Teredo petrified wood is a fossil wood that is riddled with irregular, very elongate borings made by "shipworms."

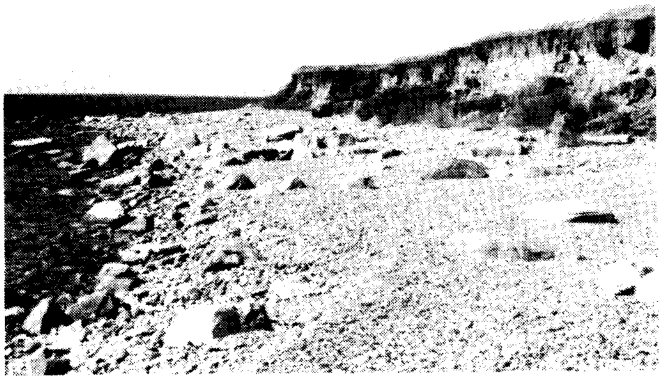
Elsewhere in the state, gravels associated with modern river channels may yield anything from reworked shaly bedrock to a variety of quartz-family minerals and erratics.

Freshwater pearls have also been recovered from North Dakota waters. Most are gathered from the Missouri River and its tributaries. The U.S. Bureau of Mines reports that in 1992, gemstone production in North Dakota was valued at $643,000, one hundred times the normal amount reported. The reason for this sharp increase was because independent divers, who normally harvest pearls from the southeastern United States, moved farther north in search of better mussel beds.

Montana agates are often found in gravel deposits in western North Dakota. They are prized for their black tree-like patterns and layers. Agates, like these, often have a white weathering rind and so are easy to spot.

Beach sediment

Gravels found around the margins of some Ice Age lakes also provide for good rock collecting. Lake Superior-type agates have been found in beach deposits of glacial Lake Agassiz, but are understandably rare as they have been transported great distances by glacial ice. Other siliceous rocks, such as flint, jasper, and petrified wood — all suitable for tumbling — are more common.



Gravelly beaches of modern lakes provide a similar concentrated deposit through which to glean specimens for display and lapidary work. Beaches are especially productive where they erode glacial till; wave action removes the fines, in effect concentrating erratics. Some of the more interesting erratics that I have found include a schist with porphyroblasts or large crystals of andalusite(?), a gneiss studded with garnets, concretionary graywackes known as "omars", and "granites" colored green by an unidentified mineral. Where waves erode bedrock, such as the Sentinel Butte Formation along the shores of Lake Sakakawea, entire logs of petrified wood have been exposed; one such 80-foot-long petrified log, collected in 1990 in Beulah Bay, is now displayed on the North Dakota State Capitol Grounds.

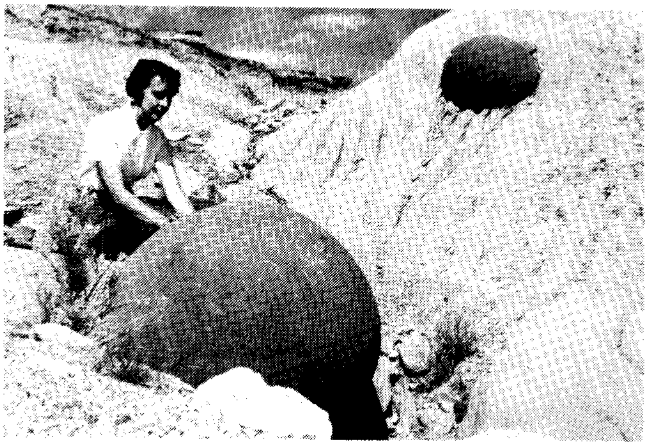
Glacial outwash sediment

On the *Geologic Map of North Dakota*, glacial outwash is mapped as uncollapsed river sediment and collapsed river sediment. These units mark the locations of Ice Age rivers and outwash plains. Collapsed glacial sediments were originally deposited over ice that later melted, resulting in an often hilly surface that may look very much unlike the level floodplains and terraces of modern river valleys. In addition to locally derived sandstone and shale, these deposits contain reworked igneous and metamorphic clasts from the Canadian Shield and Minnesota. Granitic and gneissic rocks in particular are useful for some lapidary work.

Some of the best places to look for rocks and minerals are along the shores of modern and Ice Age beaches and rivers. Our native agates and petrified wood, and glacial erratics from the Canadian Shield, are concentrated in such deposits. The glacial erratic pictured above is a schist with large, one-inch-long crystals of what may be the aluminum silicate mineral, andalusite. Photos at left by John Bluemle.

Bedrock

Bedrock exposed in North Dakota was deposited in a wide variety of marine, fluvial, and lacustrine environments. These sedimentary rocks range in age from the Late Cretaceous Niobrara and Carlile Formations (exposed principally in the Pembina Hills and lower Sheyenne River Valley) to the fluvial and lacustrine sediments of the late Tertiary White River Group and overlying Arikaree Formation (exposed in the many buttes of southwestern North Dakota). Each unit contains a distinctive sequence of sedimentary rocks that distinguish it from other map units, and all contain rocks and minerals of interest to collectors. The units of Tertiary age are especially noted for their fantastic variety of nodules and concretions.



Gypsum is common as prismatic or less often rhombohedral crystals in clays and mudstones in many bedrock units. Gypsum is common in shale of the Carlile Formation, which is exposed in the Pembina Hills. Flat crystals of gypsum, commonly 1 to 3 inches long, are scattered about some exposures of Hell Creek, Ludlow, Slope, Sentinel Butte, and Golden Valley Formations. On sunny days, some slopes sparkle as if they were covered with broken glass. (Spherical gypsum nodules are found in glacial lake clays, and smaller flat crystals are found in till throughout the state, especially in moist areas where groundwater seeps to the surface.)

Nodules or "rosettes" of marcasite or pyrite, both brassy colored iron sulfides, are sometimes found in Tertiary lignite beds. While of interest to collectors, these nodules (as well as other sandy or limy concretions) are a nuisance to the state's lignite industry as they are in effect impurities in the lignite.

In North Dakota, perhaps no other material commonly sought by rockhounds is as abundant as petrified wood. Some is splintery and carbonized, but much of North Dakota's fossil wood is well silicified and highly suited for lapidary use. Entire stumps six or more feet in diameter, still in the upright position in which they grew, are known from many parts of southwestern North Dakota. Trunks many tens-of-feet long have also been found.

Other materials of interest to rockhounds in the state include glassy clinker. Clinker, a natural brick-like material formed when burning lignite beds bake and fuse adjacent sediments, is especially common in the Sentinel Butte and Bullion Creek Formations. In places, temperatures were hot enough to partially melt the sediments, turning them into a glassy mass similar to obsidian or pitchstone. Silcrete, high quality pottery clays, a variety of chert and chalcedony, and a fantastic variety of nodules and concretions are also found in North Dakota.

A fantastic variety of concretions and nodules can be found in North Dakota, particularly in areas of badlands topography. Photo at left from North Dakota Tourism Department by Jim Nayes. The ball-like concretions above are in the North Unit of Theodore Roosevelt National Park. Photo courtesy of the State Historical Society of North Dakota.

Sodium sulfate occurs virtually without other salts in saline lakes or former lake basins that occupy undrained depressions in glacial till. Although not commercially exploited, significant deposits are found in Divide, Williams, Mountrail, and Ward Counties in northwestern North Dakota. Also known as Glauber salt, sodium sulfate is used in the kraft paper industry, and in the manufacture of glass, paints, detergents, and other chemicals.

All rock and mineral collecting requires patient searching, often spending fruitless hours looking for but not finding that which catches your eye. It is all to easy to remember the great specimens you've seen or the embellished stories of success of fellow rockhounds, and it can be hard to acknowledge that such finds, while not uncommon, do not happen every day. Still, if you like the outdoors, you will enjoy browsing among nature's gardens, regardless of what you find.

Your chances of success, however, can be greatly improved by using geologic and topographic maps, the fundamental tools that can point the way to potential rock and mineral collecting areas. If you are new to rockhunting, the guidebooks below offer more detailed advice on specific collecting areas.

Midwest Gem Trails: A Field Guide for the Gem Hunter, the Mineral Collector, and the Tourist, by June Culp Zeitner, 1964, 80p.

Western Gem Hunters Atlas, by Cy Johnson & Son, 1973, 79p.

Earth Treasures Volume 3: The Northwestern Quadrant, by Allan W. Eckert, 1987, 632p.

Rock and mineral clubs also have a wealth of information to offer. The two clubs in North Dakota encourage responsible collecting and the knowledge and fun it brings.

Central Dakota Gem and Mineral Society
P.O. Box 2445
Bismarck, ND 58502
Contact: Ray Oliger, President (701) 223-4986

Lake Agassiz Rock Club
P.O. Box 10314
Fargo, ND 58106
Contact: Wil DeGraff (701) 293-3582

Rules for Collecting

Common sense and courtesy will go a long way toward ensuring that rock and mineral collecting remains open to everyone. One must know not only where to collect, but on who's land the collecting is done. North Dakota's lands are managed by private owners (including local governments), state government (North Dakota Land Department), and the federal government (Bureau of Land Management, U.S. Forest Service, Bureau of Reclamation, U.S. Army Corps of Engineers, National Park Service, U.S. Fish and Wildlife Service, and Bureau of Indian Affairs). Permission is required to collect on private lands, and certain rules must be followed when collecting on government lands; some government lands are off limits to collecting of any kind.

The rules summarized below apply to the collecting of rocks and minerals for personal hobby use only. The use of explosives or power equipment is forbidden. In all cases, commercial collecting (with the intent to resell material collected) and large-scale personal collecting (such as material for patios, chimneys, or other stonework) requires special permission. Note also that the rules below do not apply to fossil collecting. For rules governing fossil collecting, contact the NDGS, 600 E Boulevard Avenue, Bismarck, ND 58505-0840 (701-328-4109).

In addition, there are many sites in North Dakota of historical, archaeological, or paleontological importance. Such areas on state and federal lands (and occasionally private lands) are protected though seldom marked in the field (to protect them from looting). Collecting on such protected areas is prohibited. The best way to avoid such areas is to ask the owner or land manager.

The Bureau of Land Management (BLM) has published land status maps of North Dakota (at scales of 1:100,000, 1:500,000, and 1:1,000,000) that show general ownership status. These maps are available from the BLM and the North Dakota Geological Survey. The maps are useful to locate prospective collecting areas, but of course they cannot show recent changes in land ownership. County plat maps provide even more detail for specific collecting areas.

PRIVATE LANDS

Most land in North Dakota is privately owned. Some is posted, some is not, and much of it appears as empty, wide open rangeland. Regardless, collectors must receive permission from the owner prior to entering the property.

STATE LANDS

Most state land managed by the Board of University and School Lands has been leased by various ranchers and farmers. Most lands are open to walking access without notification of the lessee (but it is of course a good idea to notify them). Some lands may be posted and persons wishing access should contact the North Dakota State Land Department. No permit is required to collect rocks and minerals for personal, not-for-profit hobby purposes, but the surface must not be disturbed when doing so.

FEDERAL LANDS

National Parks and National Historic Sites: Collecting on National Park Service lands is prohibited.

Indian Reservations: Collecting on Native American lands is prohibited.

U.S. Army Corps of Engineers: Collecting on USACE land is prohibited.

U.S. Fish and Wildlife Service: Collecting on USFWS lands is prohibited.

Bureau of Land Management: BLM lands are located mostly in northwestern Dunn County and western Bowman County, with scattered holdings elsewhere in North Dakota. The BLM generally allows, with certain exceptions, the collecting of rocks and minerals on BLM lands without a permit. Exceptions include collecting specimens of particular scientific importance and collecting in protected areas. The rules regarding petrified wood are slightly different. Collecting of petrified wood for personal use has a maximum limit of 25 pounds per day and cannot exceed 250 pounds per year.

U.S. Forest Service: Most USFS lands are contained within the Little Missouri National Grasslands in western North Dakota and the Sheyenne River National Grasslands in southeastern North Dakota. General recreational or hobby collecting of small amounts of rocks and minerals on USFS land is allowed without a permit. Most USFS land in North Dakota has been leased by various ranchers and private enterprises. Such lands are open to walking access without notification of the lessee (but it is of course a good idea to notify them).

Bureau of Reclamation: The USBR handles requests for rock and mineral collecting using a categorical exclusion checklist. It is important to ensure that collecting is not done in protected areas and that significant or scientifically important specimens are not collected.

Geologic Projects in North Dakota 1995

Compiled by Bob Biek

In the last issue of the *NDGS Newsletter*, we requested information about areas in North Dakota — and nearby areas of adjoining States and Provinces — currently being studied by government, university, and industry geoscientists. In addition to its inclusion in the newsletter, the request for information was sent directly to 86 individuals known to have worked on geologic projects in North Dakota in the recent past. The reasons for the request were simple: To help keep one another appprised of current geologic projects, and to stimulate interaction among geologic researchers in North Dakota.

To that end, this list (and that of last year) has done a commendable job. I have talked with numerous researchers who were pleased to learn of other projects underway in "their" area. Some collaborative research projects have been sparked. The list has also proven useful as we — with the help of Larry Greenwood, Library Director at Minot State University, and Doris Dougherty and Brian Erickson, both with the State Library — update the *Bibliography and Index of North Dakota Geology*.

Still, this list of geologic projects is incomplete. Many other projects can be found in *Water Quality Projects in North Dakota*, published by the NDSU Extension Service in March 1994. Doubtless still others could be uncovered by talking directly with researchers at universities in North Dakota.

I owe a great deal of thanks to all those who responded to the survey. A total of 53 responses were received, identifying 90 geologic projects.

We intend to solicit (in the Spring) and publish (in the Summer) this information on an annual basis. Thanks again to those of you who responded.

County Codes

County	Code
Adams	AD
Barnes	BA
Benson	BE
Billings	BI
Bottineau	BO
Bowman	BW
Burke	BU
Burleigh	BL
Cass	CA
Cavalier	CV
Dickey	DI
Divide	DV
Dunn	DU
Eddy	ED
Emmons	EM
Foster	FO
Golden Valley	GV
Grand Forks	GF
Grant	GR
Griggs	GG
Hettinger	HE
Kidder	KI
LaMoure	LM
Logan	LO
McHenry	MH
McIntosh	MI
Mckenzie	MK
McLean	ML
Mercer	ME
Morton	MO
Mountrail	MR
Nelson	NE
Oliver	OL
Pembina	PE
Pierce	PI
Ramsey	RA
Ransom	RN
Renville	RE
Richland	RI
Rolette	RO
Sargent	SA
Sheridan	SH
Sioux	SI
Slope	SL
Stark	SR
Steele	ST
Stutsman	SM
Towner	TO
Traill	TR
Walsh	WA
Ward	WD
Wells	WE
Williams	WI
Statewide	SW
Minnesota	MN
Montana	MT
South Dakota	SD
Manitoba	MB
Saskatchewan	SK

Type of Study Codes

Type of Study	Code
Economic Geology:	
a. General	EC
b. Coal	CG
c. Nonfuel minerals	NF
d. Petroleum	PG
Educational geology	GE
Engineering Geology	EG
Environmental Geology	EV
Geoarchaeology	GA
Geochemistry	GC
Geochronology	GR
Geographic Information Systems	GS
Geologic Hazards	GH
Geologic Mapping	GM
Geomorphology	GO
Geophysics	GP
Hydrogeology	HG
Mineralogy	MN
Paleomagnetism	PM
Paleontology	PA
Palynology/Paleobotany	PY
Petrology	PT
Quaternary Geology	QG
Sedimentology	SD
Soils	SO
Stratigraphy	ST
Structural Geology/Tectonics	SG

GEOLOGIC PROJECTS IN NORTH DAKOTA

Investigator(s)	Organization(s)	County(s)	Location	Type of Study	Title/Subject	Scale of Map
Alme, K., Reid, J.R.	UND	SW	southwestern ND	GO,QG	Ice-wedge casts	- 0 -
Ashworth, A., Biek, R., Murphy, E., Shurr, G.	NDSU, NDGS, St. Cloud State Univ.	SR	Little Badlands, Dickinson	SG	Neogene tectonism	1:24,000
Basinger, J., McIver, E.	Univ of Saskatchewan	SK	southern Saskatchewan	PY	E Tertiary flora of Ravenscrag Fm	- 0 -
Bickel, D.	ND PSC	DU,ML,ME, OL,SR	active surface mining areas	EC,CG,HG	Characterization and modelling of water resources	- 0 -
Biek, R.F.	NDGS	BI,MK	Theodore Roosevelt National Park	GM	Geologic maps	1:24000
Biek, R.F.	NDGS	BL	State capitol	GE	Building stones	- 0 -
Biek, R.F., Bluemle, J.P.	NDGS	SW	statewide	GE	Profiles of North Dakota geology	- 0 -
Biek, R.F., Murphy, E.C.	NDGS	SR,DU	Dickinson N + S, Lehigh, Davis Buttes quads	GM	Geologic maps	1:24000
Bluemle, J.P.	NDGS	SW	statewide	GE	History of the NDGS	- 0 -
Boleneus, D.E. McHugh, E.L.	USBM	BI,GR,GV, MK, RI,SL, MT,SD	Custer National Forest	CG,PG	Mineral resources appraisal	various
Burke, R.B., Diehl, P.E., Heck, T.J.	NDGS	SR,SW	Dickinson area/statewide	PG,PT,SD	Lodgepole reservoir characterization and core workshop	- 0 -
Burke, R.B., Haidl, F.	NDGS/SEM	SW,SK	Williston Basin	ST	Silurian stratigraphic problems	- 0 -
Burke, R.B., Lasemi, Z.	NDGS/ISGS	SW,MT	Williston and Illinois Basins	PT,SD,ST	Comparison of Waulsortian mounds	- 0 -
Burke, R.B.	NDGS	ML	western McLean Co	PG	Lucky Mound field study	- 0 -
Cates, S.W.	USGS-WRD	DU	Fort Berthold Indian Reservation	HG	Mandaree area groundwater	- 0 -
Cowdery, T., Stoner, J.	USGS-WRD	many	Red River basin	HG	National Water Quality Assessment	1:750,000
Diehl, P.E.	NDGS	SW	western ND	ST,PT,PG	Tyler Fm/petroleum production	- 0 -
Diehl, P.E.	NDGS	SW	western ND	PG	Rocky Ridge - Tracy Mtn field study	- 0 -
Erickson, B., Melchior, R.	Science Museum of MN	BI, GV	Wannagan Creek quarry	PA,PY	Paleocene flora and fauna	- 0 -
Fritz, S.	Lehigh Univ	BA, MH, MI, WD	Moon, Coldwater, Round, Rice Lakes	HG,PY	Paleohydrology, paleoclimate of the northern Great Plains	- 0 -
Fullerton, D.S.	USGS	SW,MN,MT, MB,SK	Dakotas, Big Horn Mtns, Regina, Winnipeg 1:1M quads	QG,GM	Quaternary geologic maps	1:1000000
Gent, M., Swanson, F.	SEM	SK	Williston Basin	GP	Digital gravity data compilation	- 0 -
Goebel, D., Stepan, D., Mayer, G.	EERC	BE	Devils Lake Sioux Reservation	EV,GC,HG	Phase I environmental assessment	- 0 -
Greer, P.L.	NDGS	SW	western North Dakota	GO	Drainage development	- 0 -
Guillet, R.	SEM	SK	southern Saskatchewan	NF	Clay studies	- 0 -
Halvorson, G., Sharma, P., Carter, S.	NDSU-Land Reclamation	ME,ML,OL	west-central North Dakota	EV,GC,SO	Coal mine reclamation	- 0 -
Hammond, R.	SDGS	SD	eastern one-half of state	NF	Geochemistry of Cretaceous black shales	- 0 -
Harju, J.A., Solc, J., Sharma, R.K., Carter, F.S., Richardson, J.C.	EERC	ME,ML,WD	west-central North Dakota	HG,GC	Wetland hydrology of mined lands	- 0 -
Harris, K.L., West, S.A., Lusardi, B.A., Tipping, R.G.	MGS	MN	southern Red River Valley	GM,QG,ST HG,GO	Regional Hydrogeologic Assessment	1:200000
Harris, K.L., Falteisek, J.	MGS/MNDNR-DW	MN	southern Red River Valley	EV,GC,GM, HG,QG	Regional Hydrogeologic Assessment	1:200000
Harris, K.L., Luther, M.R.	MGS/NDGS	BA,CA,GF,NE, RN,RI,ST,TR,MN	southern Red River Valley	GM,QG,ST GO	Quaternary geology of southern RRV	1:500000
Hartman, J.H.	EERC	SW,MT,SD,SK	Williston Basin	PA,PY,SD,ST	Paleontology and stratigraphy of Cretaceous and Paleogene strata	- 0 -
Haskell, B., Engstrom, D.	Univ of Minnesota	BE,MI,RA	Devils Lake, Coldwater Lake	PA,QG	Late Quaternary paleohydology	- 0 -
Heaton, T.	USD	BW,SK,SL,SD, MT,SK	Eocene/Oligocene badlands	PA	*Ischyromys* (rodent) and *Leptomeryx* (deer) fossils	- 0 -
Heck, T.J.	NDGS	BO	western Bottineau Co	PG	South Antler Creek field study	- 0 -

Investigator(s)	Organization(s)	County(s)	Location	Type of Study	Title/Subject	Scale of Map
Heck, T.J., LeFever, J.A.	NDGS	SW	Williston Basin	PG	Central-basin gas	- 0 -
Heck, T.J., LeFever, R.	NDGS/UND	SW	western ND	PG	Oil-potential assessment	- 0 -
Hoganson, J.W.	NDGS	EM,SI,MI,LO, BW,MO	sw + south-central ND	PA	Fox Hills Fm vertebrate paleontology	- 0 -
Hoganson, J.W.	NDGS	EM,BL,SI MO,BW	sw + south-central ND	PA	Breien Mbr of Hell Creek Fm	- 0 -
Hoganson, J.W.	NDGS	MO	Stumpf site	PA,ST	Hell Creek Fm	- 0 -
Hoganson, J.W.	NDGS	BI,MK	Theodore Roosevelt National Park	PA	Paleontological assessment	- 0 -
Hoganson, J.W.	NDGS	BW	Medicine Pole Hills	PA	Chadron Fm	- 0 -
Hoganson, J.W.	NDGS	PA	Cooperstown area	PA	Pierre Fm paleontology	- 0 -
Hoganson, J., Murphy, E., Schwert, D.	NDGS/NDSU	SW	Statewide	GE	Roadside geology of ND	- 0 -
Johnson, K.R.	Denver Museum NH	BW,SL,MT	Marmarth area	PY	L Cret/E Tertiary paleobotany	- 0 -
Kreis, L. K., Haidl, F.M.	SEM	SK	Williston Basin	GM	Regional isopach and structure maps of L. Paleozoic strata	1:2000000
Langer, W.H. Throckmorton, C.K. Schilling, S.P.	USGS	SW,SD,MT	Missouri River Basin	EV,GH,GO	Earth Science issues in the Missouri River Basin	1:2000000
Loeffler, P.	Durango Petroleum Co.	BO,BI,RE,WD	Proprietary	PG	Prospect generation, play analysis	variable
LeFever, J.A.	NDGS	BO	central Bottineau Co	PG	Landa field study	- 0 -
LeFever, J.A.	NDGS	SW	western ND	PG	Bakken Fm	- 0 -
LeFever, J., Fischer, D., Halabura, S., Martiniuk C.,	NDGS, Fisher Oil and Gas, North Rim Explor., MEM	SR	Dickinson	PG	Lodgepole discovery exploration model	- 0 -
LeFever, J., LeFever, R.	NDGS/UND	SW	Williston Basin	PG	Salt patterns and hydrocarbons	- 0 -
LeFever, J.A., Price, L. Pitman, J.	NDGS/USGS	SW	western ND	PG	Bakken + Madison oil migration	- 0 -
Luther, M.R., Christensen, R.	NDGS/NDDOT	SW	North Dakota	GA,MN	Flakable lithic resources	1:1000000
Luther, M.R.	NDGS	WD	central Ward County	ST	Geology of Wiley Field	- 0 -
Luther, M.R.	NDGS	GF	west-central GF County	GS,GM	GIS prototype project	- 0 -
Luther, M., Brekke, D.	NDGS/EERC	SW	eastern ND	NF,GH,GC, ST	Trace elements in Cretaceous shales	1:1000000
Luther, M.R., Cluer, J.K.	NDGS/Blue Lead Explor.	DU,SR,BI,MK	western ND	NF,MN	Near-surface metaliferous deposits	1:1000000 1:24,000
Martin, J.E., Sawyer, J.F. Hedges, L.S.	SDGS	SD	statewide	GM	Geologic map of South Dakota	1:500000
Martiniuk, C., Young, H., LeFever, J.A.	MEM/Brandon Univ/ NDGS	BO,MB	sw Manitoba, north central ND	PG,ST	Birdbear Fm	- 0 -
Mayer, G., Goebel, D., Steadman, E., Groenewold, G.	EERC	CV,GF,ME,MH	McCanna, Thompson, Anamoose, Hazen, Sarles	EV,GC,HG, SO	Impact of ag chemicals on groundwater	- 0 -
McKenna, D., Smith, L., LaFave, J., Patton, T.	MBMG	MT	Richland, Wibaux, Fallon Counties	HG	Groundwater monitoring/characterization of the Lower Yellowstone	- 0 -
Murphy, E.C.	NDGS	BL	Bismarck-Mandan	GH	Landslides	- 0 -
Murphy, E.C.	NDGS	BL	Bismarck quadrangle	GM	Geologic map	1:24,000
Murphy, E.C.	NDGS	BL	Bismarck	GE,GH	NP railroad bridge,landslide	- 0 -
Murphy, E.C.	NDGS	DU	county wide	GM	Geologic map	1:125,000
Murphy, E.C.	NDGS	SW	western ND	CG	Coal in North Dakota	- 0 -
Murphy, E.C.	NDGS	SW	western ND	EV	Uranium in sw ND	- 0 -
Murphy, E., Hoganson, J., Nichols, D., Forsman, N.	NDGS/USGS/UND	BL,MO,EM GR,SI	south-central ND	ST,PA,PY MN	K/T boundary	- 0 -
Oglesby, C.	CO School of Mines	many	western North Dakota	PG,ST	Prairie Fm	- 0 -
Redly, P., Hajnal, Z.	Univ of Saskatchewan	SW,MT,MB,SK	Williston Basin	GP,ST,SG	Tectono-stratigraphic evolution of the Williston Basin	- 0 -
Reid, J.R.	UND	ML,ME	Lake Sakakawea	EG,GO	Shoreline erosion, mechanisms, rates	- 0 -

Investigator(s)	Organization(s)	County(s)	Location	Type of Study	Title/Subject	Scale of Map
Reid, J.R.	UND	ML	north shore, Lake Sakakawea	EG,SO	Interpretation of 16 paleosol sites	- 0 -
Reiten, J.C.	MBMG	MT	eastern Sheriden County	HG	Water quality of selected lakes	- 0 -
Richardson, J.L.	NDSU	BO,CA,CV,DV RN,RA,SM,TR WA,FO	eastern North Dakota, South Dakota, Minnesota	GO,SO,HG GC,	Wetland soils, saline soils	- 0 -
Schwert, D.P.	NDSU	CA	Fargo-Moorhead	GH	Geotechnical implications of land use	- 0 -
Shurr, G.W.	St Cloud St Univ	SW,SD	southwestern North Dakota and northwestern South Dakota	SG	Structural geology of southern margin of the Williston Basin	1:250000 1:1000000
Shurr, G.W.	St Cloud St Univ	SW	western ND	PG,ST,SG	Shallow gas potential	- 0 -
Shurr, G., Ashworth, A. Burke, R., Diehl, P.	St Cloud St Univ/NDSU/ NDGS	SR	Dickinson area	SG,ST	Tectonic/stratigraphic setting of Waulsortian-like mounds	- 0 -
Soil Survey Staff	USDA-SCS	BI,ED,MK,RI, SA	county wide	SO	Soil survey	1:24000 1:12000
Starr, E.	Valley City State Univ	BA,RN	Sheyenne Valley	PA	Fossils of the Pierre Shale	- 0 -
Strobel, M.L.	USGS-WRD	GF,WA	Red River Valley	HG	Saline seeps	- 0 -
Strobel, M.L.	USGS-WRD	RO	Shell Valley aquifer	HG	Hydrogeology of Shell Valley aquifer	- 0 -
Strobel, M.L.	USGS-WRD	RN,RI	Sheyene Delta aquifer	HG	Groundwater-surface water interaction	- 0 -
Swanson, F. Gent, M.	SEM	SK	southern Saskatchewan	MN,GC	Kimberlite indicator mineral sampling	- 0 -
Teller, J.T.	Univ of Manitoba	MB,SK	southern Manitoba and Saskatchewan	QG,SD,ST, GO	Lake Agassiz, Lake Hind history, Campbell Beach age and paleoecology	- 0 -
Terry, D.	Univ of Nebraska	SD	northwestern South Dakota, Nebraska	SD,SO,ST	Lithostratigraphy, paleopedology, and correlation of White River Group	- 0 -
Tomhave, D., Carter, J.	SDGS/USGS	SD	Roberts County	GM, HG	Geology and water resources	1:24,000
Valero-Garces, B.L., Kelts, K.R.	Univ of Minnesota	BA	Moon Lake	QG,SD	Sedimentary facies, environmental change	- 0 -

Abbreviations

EERC	Energy and Environmental Research Center, Grand Forks	NDSU	North Dakota State University, Fargo
ISGS	Illinois State Geological Survey	SDGS	South Dakota Geological Survey
MBMG	Montana Bureau of Mines and Geology	SEM	Saskatchewan Energy & Mines
MEM	Manitoba Energy and Mines	UND	University of North Dakota
MGS	Minnesota Geological Survey	USBM	US Bureau of Mines
MNDNR-DW	Minnesota Dept of Natural Resources, Division of Waters	USDA-SCS	US Dept of Agriculture, Soil Conservation Service
NDDOT	ND Dept of Transportation	USGS	US Geological Survey
NDPSC	ND Public Service Commission	USGS-WRD	US Geological Survey, Water Resources Division

NDGS Newsletter Index

Editor's note: The following index includes most articles that have appeared in the *NDGS Newsletter* from its inception in 1974 through 1994. Meeting announcements and other lesser news items, including reviews of new survey publications, have not been listed. The annual summaries of survey activities, found in most December or Winter issues, have also been ommitted. While most back issues are out of print, reprints are available for $0.50 each, with a minimum order of $1.00. A collection of about 50 of the most popular articles is being revised and assembled into book form and should be available this Fall.

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Compiled by Phil Greer

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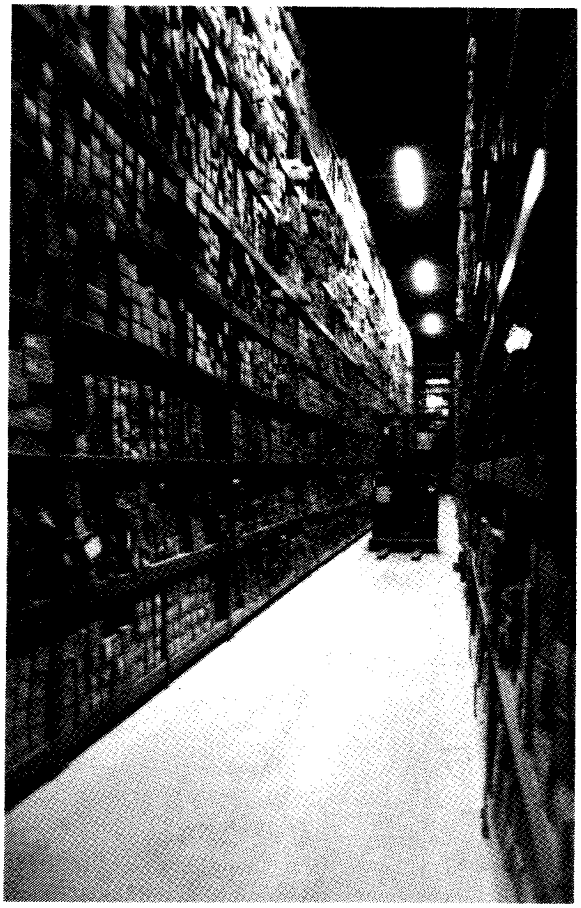
WHAT are they and WHY do we use them?

by
Tom Heck

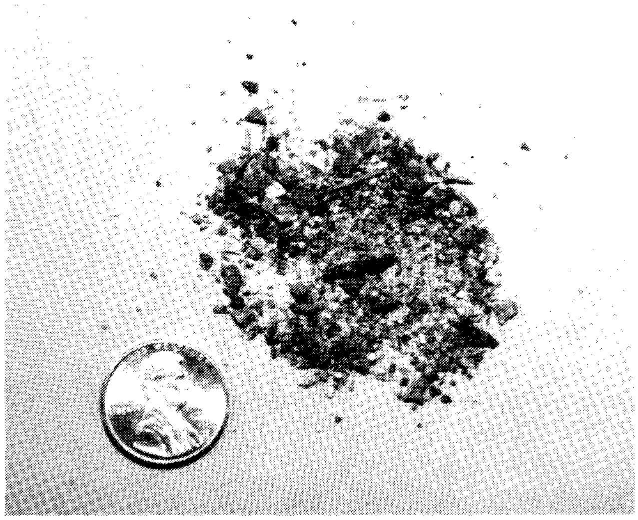


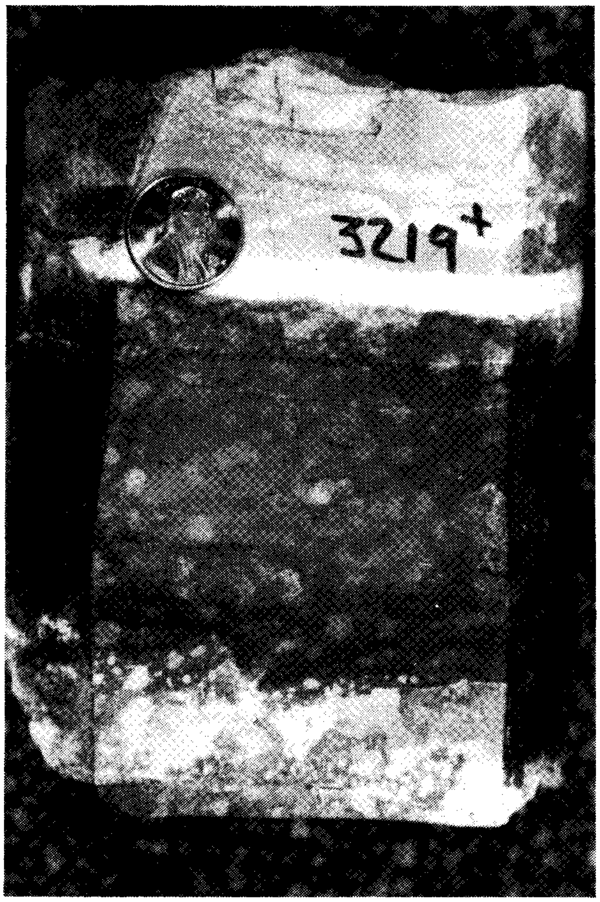
Field geology brings to many a geologist's mind a mountain setting with trees and boulder-filled streams in a valley where every outcrop yields information about the forces that built the mountains. Or maybe the terrain is not so rugged, with gentle hills and scattered gullies and the story there is about glaciers, how they plowed over the earth's surface, mixing together rock fragments from far off places with rocks that may be exposed only meters away. For the modern petroleum geologist, field work may mean a short drive from the office to a core and sample library where envelopes of drill cuttings or boxes of core from oil tests, often drilled more than a mile deep and hundreds or more miles away, are examined. Drill cuttings and cores provide the only direct physical evidence that we have of the geologic history of the oil producing rocks in the North Dakota Williston Basin. Without such evidence, only indirect evidence can be used to explore for oil. All too often, a dry hole is drilled because of an incorrect interpretation based upon incomplete data. Some dry holes can be avoided when data gained from cores and samples are integrated with data gathered from other sources.

What are drill cuttings? They are small chips of rock cut by a drill bit at the bottom of a well and carried (circulated) to the surface in drilling fluid, similar to a wood drill bit bringing pieces of wood to the surface of a board. Instead of a simple arrangement like a drill bit inserted in an electric drill, a drilling rig requires drill pipe, drilling fluid ("mud"), and "mud" pumps working together to carry the rock fragments up the borehole. The drill bit is placed in contact with rocks by pressing the bit against the bottom of the borehole where teeth on the bit cut the rock. The bit is kept in contact with the rock by a portion of the weight of the drill pipe above the bit. The drill pipe is narrower than the drill bit and is hollow. Drilling "mud" is pumped under pressure down the drill pipe by the mud pumps and then out of the drill bit through small holes, or nozzles, in the drill bit. The mud is pumped hard enough to push through the bit nozzles at a high velocity. Much of the mud's velocity comes from the size of the nozzles in the bit. Drill pipe is several inches in diameter but bit nozzles are generally less than one inch in diameter. The mud is pumped down the drill pipe at a constant number of gallons each minute. The only way that the constant volume of mud pumped each minute can get through the narrower nozzles of the drill-bit is to move faster. Therefore, the mud exits the nozzles near the drill-bit's teeth with great force and at a high velocity, washing the rock chips away from the bit and up the annulus or the space between the drill pipe and the sides of the borehole. The mixture of drilling mud and drill cuttings slows down once they move away from the drill bit but the rock chips are carried to the surface because the mud is viscous, or thick, and will not let them fall back down the hole. The deeper the borehole is drilled, the greater the time required for the rock chips to reach the surface. The time delay between when a rock chip is cut by the drill bit and when it reaches the surface is called the "lag time." The lag time from a borehole drilled more than two miles deep in western North Dakota can exceed two hours.

Why do we care about drilling and lag time? Simply because that knowledge helps the geologist recreate the vertical succession of rocks encountered by the drill bit. Portions of the drill cuttings are sampled at the surface at uniform intervals, generally every ten feet drilled. When properly collected, each sample contains a mixture of all the rocks drilled in those ten feet. Drill cuttings are small, usually less than 1/4 inch in diameter. The small size of the rock chips requires a microscope to see the chips clearly. Besides being difficult to see, the amount of geologic information that can be obtained from drill cuttings is also limited. For example, the types and numbers of fossils contained in a formation can be important information. It is often impossible to identify the genus or species of a fossil from microscopic samples nor can the number and variety of fossils in a given rock unit be determined.

What can be observed from cuttings, and is of great importance to the petroleum geologist, is whether a rock unit is porous and whether there is any evidence of hydrocarbons in the rock. Porosity is the volume of open space in a rock. Although an accumulation of hydrocarbons is often called a "pool," in reality the oil is contained within tiny holes in the rock and not within in a giant underground cavern or pool. (For a more detailed discussion of porosity and pools see the Summer 1994 *NDGS Newsletter* article by Paul Diehl, Vol. 21, No. 2, p.5.) To get hydrocarbons out of the rock and to the surface, a percentage of the rock, usually more than 10%, must be porous and those pores must be connected. The size of both the pores and of the openings between connecting pores is also important. In general, the bigger the pores the faster and easier it is for fluids to flow through them. By examining the drill cuttings through a microscope a geologist can often see and estimate the percentage of the rock chip that is porous.





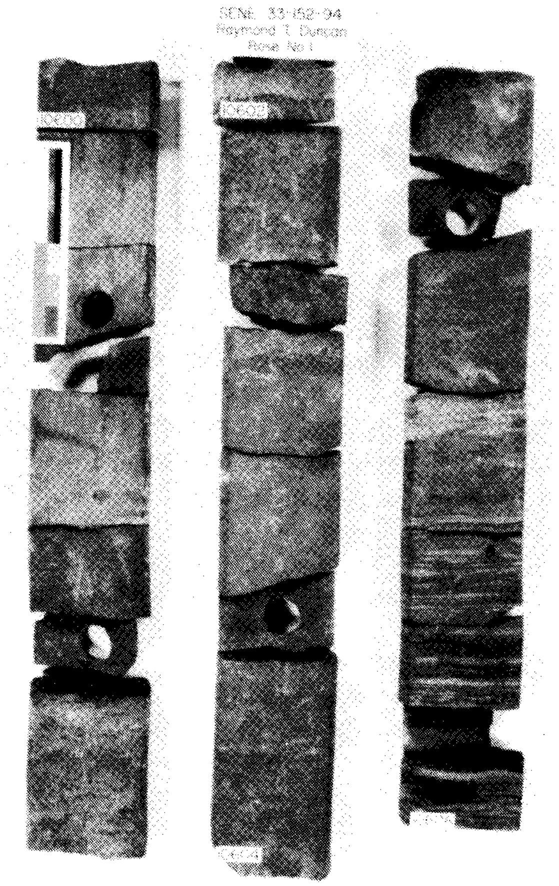
The geologist also looks for other evidence of hydrocarbons, such as oil stain, odor, and fluorescence. Stain and odor are just what you would imagine, a light to dark brown discoloration of the rock chip and the smell of oil, especially when warm. Fluorescence is a property of many materials that when a "black," or ultraviolet, light is shown on them, the material, including crude oil, will emit a bright light. North Dakota oils typically appear bright yellow to yellowish-white under the black light. Unfortunately, anhydrite and calcite are common minerals found in the subsurface of North Dakota that also display yellow fluorescence.

A geologist, while a well is being drilled or later in a core and sample library, examines drill cuttings for the combination of porosity, stain, fluorescence, and other evidence that may indicate the presence or absence of oil. While there are other tools available to the geologist to aid in this search for oil, such as well logs, too often they are either missing or inconclusive and the only direct physical evidence of an oil "pool" are the drill cuttings. Maintaining a collection of drill cuttings as we have done here in North Dakota at the Wilson M. Laird Core and Sample Library in Grand Forks, where more than 90% of all the oil tests drilled in the state have had a set of cuttings collected by the state, is a very cost-effective way of providing important and basic geologic data.

If drill cuttings are so useful, why keep cores too? Cores are more useful than drill cuttings mainly because they are a bigger sample. Cores are cut by a special drill bit. As the core bit cuts deeper, a continuous cylindrical rock sample fills a hollow core barrel. In contrast with a typical rock chip requiring a microscope to study, the geologic data in a core is often visible to the naked eye. At a minimum, the same information obtained from cuttings — porosity and oil shows — can be obtained from a core. But, because a core is a large continuous sample instead of a mixture of everything drilled in the last 10 feet, the relationships between different rock layers or strata are preserved; the core provides more geologic information. For example, while it is nearly impossible to do much fossil research from cuttings, it is easier to do so from cores. The genus and species of a fossil can often be determined, as can the number and variety of fossils in a bed, and the vertical succession of fossils between strata.

Cores contain so much data that by studying closely spaced cores from the same geologic horizon, a three-dimensional model or picture of what the earth's surface was like when the rocks were deposited can be reconstructed. It is often possible from core data for example, to determine whether a sandstone was deposited on a beach, in an offshore sand bar, or in a river. If a core study determines that an oil pool, like the recent discovery near Dickinson, was deposited in a certain geologic setting, then this information can be extremely important in the search for similar oil pools; it helps identify the geographic and geologic limits where such a field can be found. If one dry hole is prevented or a new producing field is discovered because of a core study then the oil company that funded the study has benefitted economically. With a new discovery, an oil company can produce and sell oil whereas if a company can avoid drilling a dry hole, they have saved their limited drilling budget to instead drill a more promising location.

North Dakota's collection of cores and samples from oil tests drilled within it's borders is probably the most complete collection of any of the 50 states. The collecting and preservation of these cores by the North Dakota Geological Survey has provided, and continues to provide, invaluable data to piece together the geologic history of North Dakota. Our understanding of the state's geologic history is vital not only because of the scientific advances it contributes to, but also because it has improved the economic status of the state by helping to maintain a viable oil industry. The dollars spent in the careful maintenance of the core and sample library in Grand Forks is one of the very best investments the state has ever made.



Over the years, the U.S. Geological Survey has produced a number of informative, handsomely illustrated, non-technical reports on topics of widespread geologic interest. Most are published as "Circulars" and are available free in limited quantities; others are "Professional Papers" for which there is a nominal charge. The publications below are just a few of the many that can be ordered from the U.S. Geological Survey, Map Distribution, Box 25286, MS 306, Federal Center, Denver, CO 80225. To be placed on a free subscription list of the monthly catalog *New Publications of the U.S. Geological Survey*, apply in writing to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Floods in the Upper Mississippi River Basin, 1993

U.S.G.S. Circular 1120, *Floods in the Upper Mississippi River Basin*, 1993, consists of individually published chapters that document the effects of the 1993 flooding. The series includes data and findings on the magnitude and frequency of peak discharges; precipitation; water-quality characteristics, including nutrients and man-made contaminants; sediment transport; assessment of sediment deposited on flood plains; effects of inundation on groundwater quality; flood-discharge volume; effects of reservoir storage on flood peaks; stream channel scour at selected bridges; extent of flood-plain inundation; and documentation of geomorphic changes.

Societal Value of Geologic Maps

USGS Circular 1111, by R.L. Bernknopf, D.S. Brookshire, D.R. Soller, M.J. McKee, J.F. Sutter, J.C. Matti, and R.H. Campbell. 1993. 53 p. A study developed to evaluate the benefits and costs of geologic maps. The report provides an overview of the issues addressed in the economic analysis, describes geologic maps and their use as a fundamental data base and in regulatory applications, and discusses the provision of geologic maps and the demand for geologic map information. A large portion of the report is devoted to developing a cost-benefit model designed to evaluate the social value of geologic map information.

Natural Aggregate - Building America's Future

USGS Circular 1110, by William H. Langer and V.M. Glanzman. 1993. 39 p. Natural aggregate (principally crushed stone and sand and gravel) is used in nearly all residential, commercial, and industrial building construction, and in most public-works projects such as roads and highways, bridges, railroad beds, dams, airports, water and sewer systems, and tunnels, yet it remains one of our poorly understood — and even less appreciated — resources. This report describes natural aggregate and its geological occurrence, as well as supply and demand, the aggregate industry, and planning and regulation.

Facing Geologic and Hydrologic Hazards: Earth Science Considerations

USGS Professional Paper 1240-B, edited by W.W. Hays. 1981 (Reprinted 1992). 108 p. $11.00. This collection of papers provides basic information on the hazards from earthquakes, floods, ground failures, and volcanic eruptions. It describes their physical characteristics; identifies locations in the United States where they tend to happen; specifies their impact on the Nation's population, infrastructure, and economy; and discusses actions that can reduce losses. The many examples given tend to be of classic, large events, but the principles discussed are just as applicable to the much more frequent and widespread smaller floods, landslides, subsidence, etc. that occur every year.

Understanding Our Fragile Environment: Lessons form Geochemical Studies

USGS Circular 1105, compiled by L.P. Gough and others. 1993. 34 p. Describes the importance of geochemistry and the earth sciences in investigating environmental problems. Sources of contamination, contaminant detection, and the stresses contaminants place on the environment are explained, with particular reference to acid precipitation, the greenhouse effect, oil spills, and the release of radon, uranium, and heavy metals into the environment.

NEW PUBLICATIONS

Third International Williston Basin Horizontal-Well Workshop, Ken Stalwick, compiler, 1995, approx. 260 pages in a 3-ring binder, $10.00.

This volume contains 22 papers and 5 poster abstracts presented at the Third International Williston Basin Horizontal-Well Workshop co-sponsored by Saskatchewan Energy and Mines and the NDGS. See pages and 1 and 2 for further information.

Outside Publications

Ashworth, A.C., Biek, R.F., Murphy, E.C., and Shurr, G.W., 1995, *Little Faults and Folds on the Prairie — Evidence for Neogene Tectonism in North Dakota*: Geological Society of America Abstracts with Programs, v. 27, no. 3, p. 35.

Biek, R.F., 1995, *Urban Outcrops — Building Stones of the North Dakota Capitol Grounds*: North Dakota Academy of Science, v. 49, p.66.

Biek, R.F., 1995, *Urban Outcrops — Building Stone as an Educational Resource*: Geological Society of America Abstracts with Programs, v. 27, no. 3, p. 40.

Bluemle, J.P., 1995, *1895-1995 — North Dakota Geological Survey's First Century*: North Dakota Academy of Science, v. 49, p. 52.

Burke, R.B., and Diehl, P.D., 1995, *Diversity and Distribution of Lodgepole Buildups in the Williston Basin and Central Montana*: North Dakota Academy of Science, v. 49, p. 58.

Campbell, J.M., and Hoganson, J.W., 1995, Champsosaurus gigas *Erickson — A Restored and Mounted Skeleton (ND94-225.1) in the North Dakota State Fossil Collection*: North Dakota Academy of Science, v. 49, p. 64.

Hoganson, J.W. (editor), 1995, *A Symposium on North Dakota Geology*: North Dakota Academy of Science, v. 49, p. 49-71.

Hoganson, J.W., Erickson, J.M., and Holland, F.D., Jr., 1995, *Cartilaginous Fishes from the Fox Hills Formation (Cretaceous:Maastrichtian), North Dakota*: North Dakota Academy of Science, v. 49, p. 60.

Hoganson, J.W., Murphy, E.C., and Forsman, N.F., 1995, *Lithostratigraphy and Biochronology of the Chadron and Brule Formations in Southwestern North Dakota*: Geological Society of America Abstracts with Programs, v. 27, no. 3, p. 59.

Hoganson, J.W., Murphy, E.C., and Forsman, N.F., 1995, *Stratigraphy, Vertebrate Fossil Record, and Age of the Arikaree Formation in North Dakota*: Geological Society of America Abstracts with Programs, v. 27, no. 3, p. 59.

Luther, M.R., and Christensen, R.C., 1995, *Flakable Lithic resources in North Dakota*: North Dakota Academy of Science, v. 49, p. 71.

Murphy, E.C., 1995, *Slope Stability in the Bismarck-Mandan Area*: North Dakota Academy of Science, v. 49, p. 69.

Pearson, D.A., and Hoganson, J.W., 1995, *The Medicine Pole Hills Local Fauna — A Chadron Formation (Eocene) Vertebrate Assemblage from Bowman County, southwestern North Dakota*: Geological Society of America Abstracts with Programs, v. 27, no. 3, p. 79.

Pearson, D.A., and Hoganson, J.W., 1995, *The Medicine Pole Hills Local Fauna — Chadron Formation (Eocene:Chadronian), Bowman County, North Dakota*: North Dakota Academy of Science, v. 49, p. 65.

Reid, J.R., and Bluemle, J.P., 1995, *History of Glacial research in North Dakota*: North Dakota Academy of Science, v. 49, p. 55.

Warwick, P.D., Flores, R.M., Murphy, E.C., and Obradovich, J.D., 1995, *Parasequences in the Paleocene Ludlow and Cannonball Members of the Fort Union Formation, Williston Basin, North Dakota*: Geological Society of America Abstracts with Programs, v. 27, no. 4, p. 60.