ROCKS & MINERALS

MAY/JUNE 1980 VOLUME 55 NUMBER 3 $2.00

Official Show Issue

American Federation

Lincoln, Nebraska

Nebraska!

THE EASTERN FEDERATION OF MINERALOGICAL AND LAPIDARY SOCIETIES AND THE MIDWEST FEDERATION OF MINERALOGICAL AND GEOLOGICAL SOCIETIES HAVE CHOSEN *ROCKS AND MINERALS* AS THEIR OFFICIAL JOURNAL.

SCOPE OF THE JOURNAL

ROCKS AND MINERALS publishes material of interest to all students of mineralogy, petrology, and the earth sciences. The journal contains articles on new and old collecting sites, research articles by authorities in the earth sciences, review articles on specific minerals and mineral groups, historical treatment of the earth sciences, and other subjects of general interest. Also included are regularly written features on such subjects as minerals, rocks, fossils, micromounts, thumbnails, shows and competition, projects and activities, and collections and displays.

Consideration is given to articles dealing with any of the above subjects. Acceptance is subject to the approval of our editors.

ROCKS & MINERALS

MAY/JUNE 1980, Volume 55 Number 3

Nebraska!

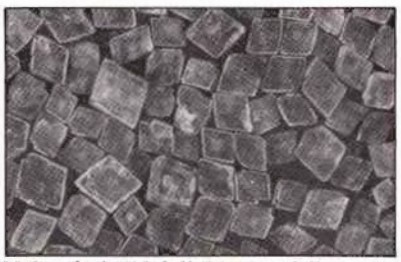
FEATURES

DEPARTMENTS

Nebraska Show Program p. 113

Nebraska Portfolio p. 107

Fossil Collecting in Nebraska p. 118



Nebraska's "Odell Diamonds" p. 132

ON THE COVER:

Lake Superior agate collected from Pleistocene age glacial till exposed near Palmyra, Otoe County, Nebraska. Photo by Roger K. Pabian.

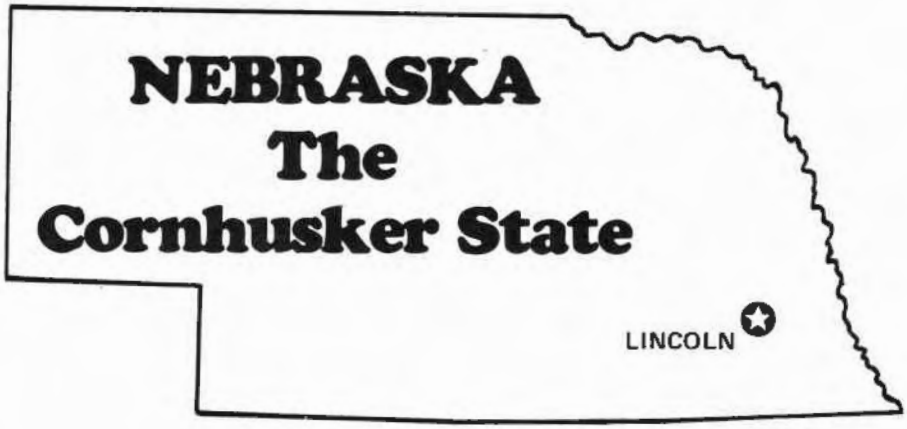
ROCKS AND MINERALS (ISSN 0035-7529) is published bi-monthly by HELDREF PUBLICATIONS at 4000 Albemarle St., N.W., Washington, D. C. 20016. Telephone: (202) 362-6445. Annual subscription rates are $15 for institutions and $10 for individuals. Single copy order price is $2.00, newsstand price $2.00. Add $4.00 for subscriptions outside the United States. Foreign subscriptions must be paid in U.S. dollars. Allow six weeks for shipment of first copy.

All orders by individuals should be paid in advance. Institutions may send purchase orders and will be billed. Claims for missing issues made within six months will be made free of charge.

Second class postage paid, Washington, D.C. POSTMASTER: Send address changes to ROCKS AND MINERALS, Room 500, 4000 Albemarle Street, N.W., Washington, D. C. 20016.

ISSN 0035-7529

NEBRASKA
The Cornhusker State



State Rock
PRAIRIE AGATE

State Gem
BLUE CHALCEDONY

State Fossil
MAMMOTH

NEBRASKA, the Cornhusker State, is also a state of wide geologic significance. Agate Springs National Monument in Sioux County is known throughout the world for its abundant fossils. The world's largest open-pit silica (volcanic ash) mine, now inactive, is in Frontier County. Scenic waterfalls cascade over resistant beds of sandstone and siltstone in Cherry County. Petrified wood can be found throughout the state. The attraction extends even to the State Capitol in Lincoln which is decorated with fine stone from all over the world. The mosaic and tiles should be seen by all lapidaries.

ROCKS AND MINERALS is pleased to present this special issue devoted to Nebraska, host state for the 1980 combined Midwest Federation-American Federation Show and Convention.

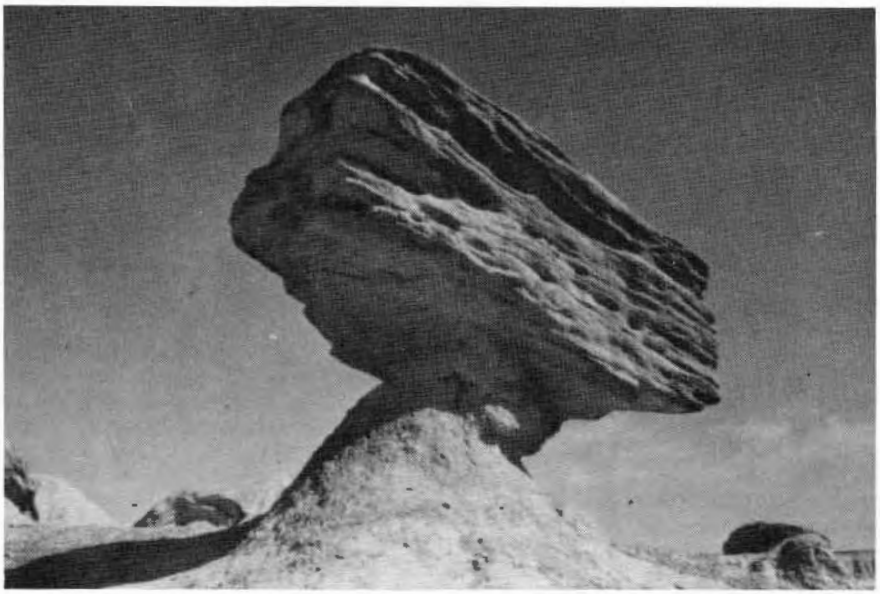
All of the articles in the issue deal with this midwestern state and its minerals, fossils, geology, collections and displays, collecting sites, and related literature. Also included is a special section on the show itself, which will be held June 12, 13, 14, and 15, in Lincoln.

Special acknowledgement is given to Roger K. Pabian of the University of Nebraska, Conservation and Survey Division—IANR, who served as guest editor for this Nebraska issue and to the authors who have provided an indepth picture of the state.

Visitors to the show are invited to look for ROCKS AND MINERALS at the show and to stop by the booth, meet some of the consulting editors, and visit awhile.

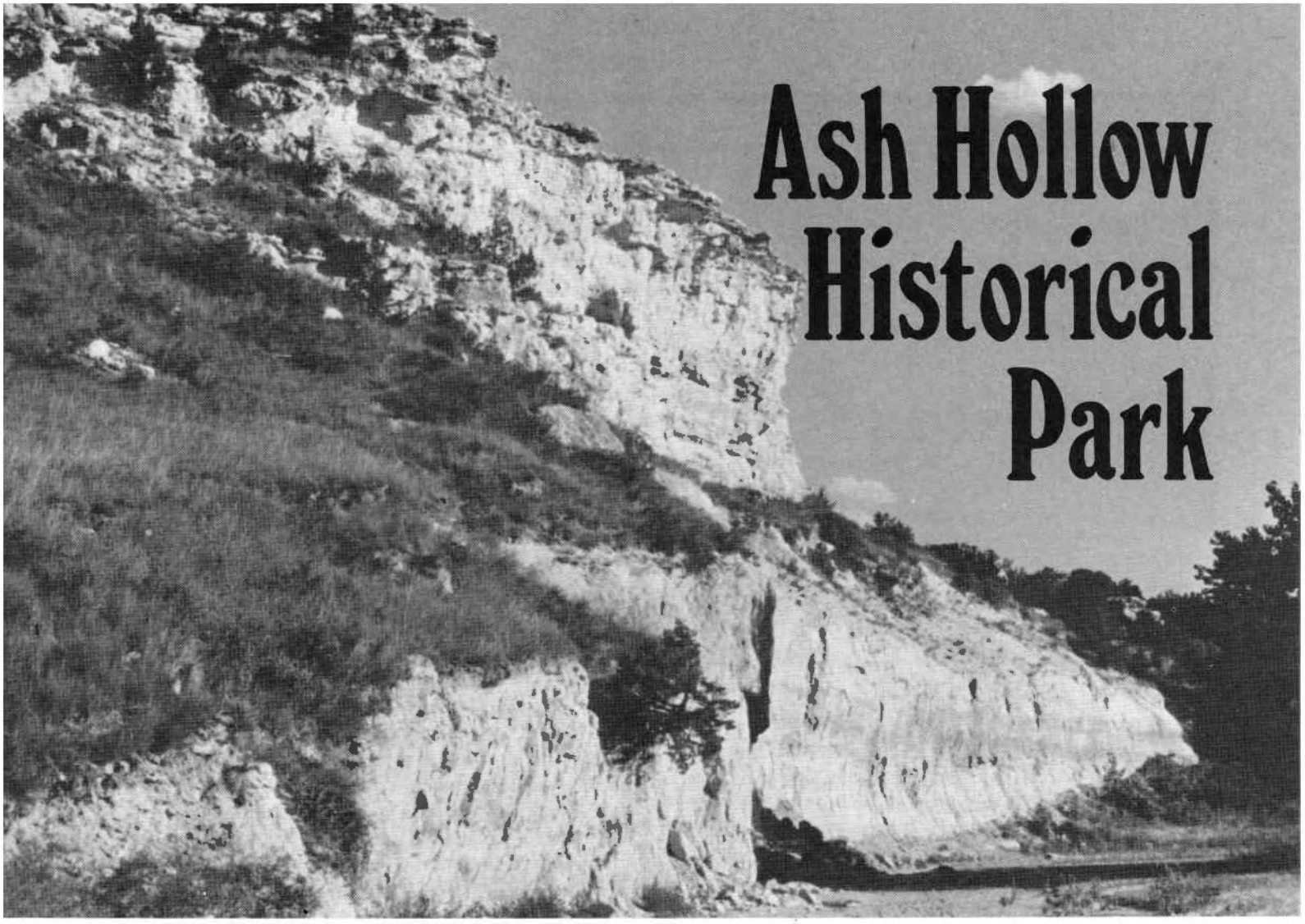
Visitors also will want to explore Nebraska's interesting geologic features. Pictured on the right is Toadstool Park, Sioux County, where erosion has carved badland features from bedded sandstones and clays. The resistant sandstones formed the "toadstool" caps, and the less resistant clays formed the pedestals.

Other attractions include: Scotts Bluff National Monument, a prominent erosional feature, Scotts Bluff County; Agate Springs National Monument, dominated by Carnegie Hill and University Hill fossil quarries, Sioux County; and Ash Hollow Historical Park, Garden County.



Toadstool Park, Sioux County, Nebraska

Ash Hollow Historical Park



Rock exposures, east side of Ash Hollow Creek at the mouth of the valley. The Brule Formation is exposed in the lower half of the photo. The Ash Hollow beds overlie the Brule.

The Ash Hollow State Historical Park, administered by the Nebraska Game and Parks Commission, is located at the mouth of Ash Hollow Creek in southeastern Garden County. It occupies 1,001 acres and has a camping area with picnic tables, drinking water, fireplaces, hiking trails, and sanitary facilities. The park offers an opportunity to study early man and the Tertiary and Quaternary geology of the state.

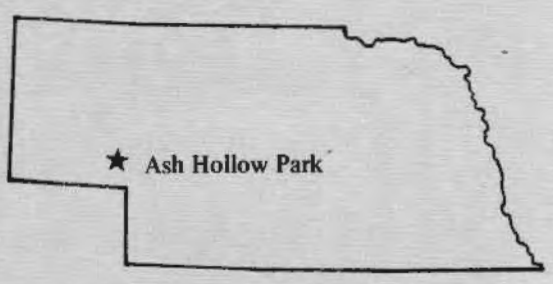
R. F. DIFFENDAL, JR.
University of Nebraska
Lincoln, Nebraska 68588

Ash Hollow Creek is an intermittent stream forming a southern tributary to the North Platte River. The creek flows only in response to precipitation from locally heavy thunderstorms or to heavy runoff from melting snow in the spring. Western Nebraska has a semi-arid climate and receives less than 20 inches of rainfall per year.

Vegetation in the park and surrounding area is typical of the short grass prairie of the Great Plains. Native short grasses grow abundantly on undisturbed tablelands, valley sides, and along principal flood plains of streams and rivers. Prickly pear, barrel cactus, yucca and sagebrush are common but are more abundant in areas underlain by sand or sand and gravel. The dominant tree in the park area is the mountain cedar. The trees on the floor of Ash Hollow Creek valley include white ash, hackberry, and cottonwood, while cottonwood and willow are dominant along the channel of the North Platte.

There is a tremendous variety of animal life in the park; small mammals, many varieties of birds, and reptiles are well represented in the area. Fishing in the North Platte and in nearby lakes and reservoirs is often excellent.

Ash Hollow has a long history of human occupation. Ameri-



COLLECTORS PLEASE NOTE:

FOSSIL, MINERAL, OR ARTIFACT COLLECTING IS NOT ALLOWED IN ASH HOLLOW HISTORICAL PARK. THERE ARE NUMEROUS ROCK OUTCROPS IN ROAD CUTS AND ALONG THE NORTH PLATTE RIVER, AS WELL AS GRAVEL BARS IN THE RIVER BED, WHERE COLLECTING ACTIVITIES MAY BE PURSUED.

can Indians roamed the park area for thousands of years before the arrival of European, African, and Asian settlers. Animal kill sites, camp sites, and shelters reveal that the valley was the home of several distinct cultures of Indians during this period.

After the first European and American explorers worked their way along the North Platte, a flow of settlers moved along the Platte River following the Oregon trail and often crossed the divide between the South and North Platte Rivers at Ash Hollow. While the terrain is rugged in the park area, the valley of Ash Hollow Creek was one of the few spots along the North Platte within a day's travel of the South Platte where wagons could descend to the valley floor with relative safety and where water and shelter were available to travelers and their animals. Along most of the remainder of the south side of the North Platte nearly vertical escarpments of as much as 100 feet made wagon descent virtually impossible.

Today a modern highway allows a traveler to make the journey between the two rivers in a few minutes instead of a long, difficult, day-long wagon trip. The valley of Ash Hollow Creek now has an improved campground offering shelter and rest to visitors.

General Geology

It is always difficult to convey the richness of the human and geologic history of Ash Hollow in a relatively few words. Many people looking for the scenery of the national parks or even of Scottsbluff National Monument to the west only see Ash Hollow from a rapidly moving automobile. But a closer study reveals a part of the interesting saga of Great Plains geologic development.

The oldest rocks in the park are exposed along the valley sides at and near the mouth of Ash Hollow Creek. These light brown siltstones belong to the Brule Formation of Oligocene age and have been dated at about 30 million years. The siltstones are poorly consolidated, vertically jointed, and weathered and eroded to form nearly vertical slopes. To the untrained eye the rocks of the Brule Formation look uniform in appearance, but a closer inspection reveals that in some places there are darker horizontal zones in the formation representing periodic soil development during times when sediment deposition had ceased or slowed appreciably. Near the top of the formation, scattered, hard, lime-cemented nodules occur in zones, probably close to where the former water table of the area was located after Brule deposition.

The rather uniform, fine-grained, and unstratified nature of the Brule siltstone is interpreted by most geologists to indicate deposition of material by wind. Recent studies have produced another unexpected conclusion. Most of the silt grains in the Brule are composed of either volcanic ash (glass) shards or crystals coated with glass. These glass shards and crystals were blown high into the atmosphere during gigantic explosive volcanic eruptions in the Rocky Mountains or Great Basin. The fact that a blanket of volcanic material up to 600 feet thick covers much of western Nebraska is difficult to comprehend. Imagine the magnitude of the eruptions necessary to produce a layer just a few feet thick covering much of the northern Great Plains and the tremendous dust clouds that swept across the plains after these eruptions! The dust bowl days of the 1930s would be insignificant by comparison.

The Brule Formation yields few fossils in the park area. Vertebrate fossils from the Brule include teeth and bones from rhinos and oreodonts (extinct mammals similar in size and life habits to sheep). A few limy pond deposits have yielded snails and ostracods (crustaceans with bean-shaped, bivalved shells).

The next younger deposits at Ash Hollow Park belong to the Ash Hollow Formation of Miocene age. These deposits have been radiometrically dated at 6 to 10 million years old by Boellstorff (1978). The 20-million-year gap between the youngest Brule and the oldest Ash Hollow beds is represented by an erosion surface called an unconformity. It is not known whether beds younger than the Brule and representing part of the missing 20-million-year record were deposited and later eroded or not. But we do know that the thick, basal Ash Hollow conglomerate is composed almost entirely of eroded concretions from the Brule, so it is unlikely that a thick formation of intermediate age was ever deposited in the area.

The Ash Hollow beds, in contrast to the underlying Brule, display a diverse sequence of rocks that vary greatly both vertically and laterally. They include claystones, siltstones, orthoclase-rich sandstones, granitic conglomerates, lithic conglomerates, pebbly sandstones, limestones, diatomaceous

---

R. F. Diffendal is a research geologist at the University of Nebraska, Conservation and Survey Division-Institute of Agriculture and Natural Resources, Lincoln, Nebraska.

marls, volcanic ash beds, and their unconsolidated equivalents. Many of these rock layers show definite stream channel geometries and were deposited in streams or oxbow lakes bordering streams. The pebbly sandstones may represent mudflow or slope deposits.

Because the slope of the stream deposits is not much greater than the slope of the Great Plains surface today, the streams that drained the area in Ash Hollow time were probably sluggish and intermittent. The geometry of the entire formation and the relationship of laterally equivalent layers to one another indicates that elevation differences on the surface of the deposits in any one place during an instant in geologic time were very small and the surface was very flat.

Up to five volcanic ash layers have been found in superposition in the park area. These ash deposits are sandwiched between layers of stream deposited sediments up to tens of feet thick. The ash beds are as much as twenty feet thick and are very pure indicating the ash fell directly from the air. In some places, small, concentrically layered ash pellets have been found that have been interpreted as "fossil hailstones" by some geologists.

Fossils are far more common in the Ash Hollow beds than in the Brule. These fossils include casts of roots, seed husks and coats from grasses and trees, shells of snails, clams, and

Fossils from the vicinity of Ash Hollow Park.

Brule Formation – 5. Oreodont left upper molars; 10. Beaver (*Paleocastor*?) mandible. x1.5.

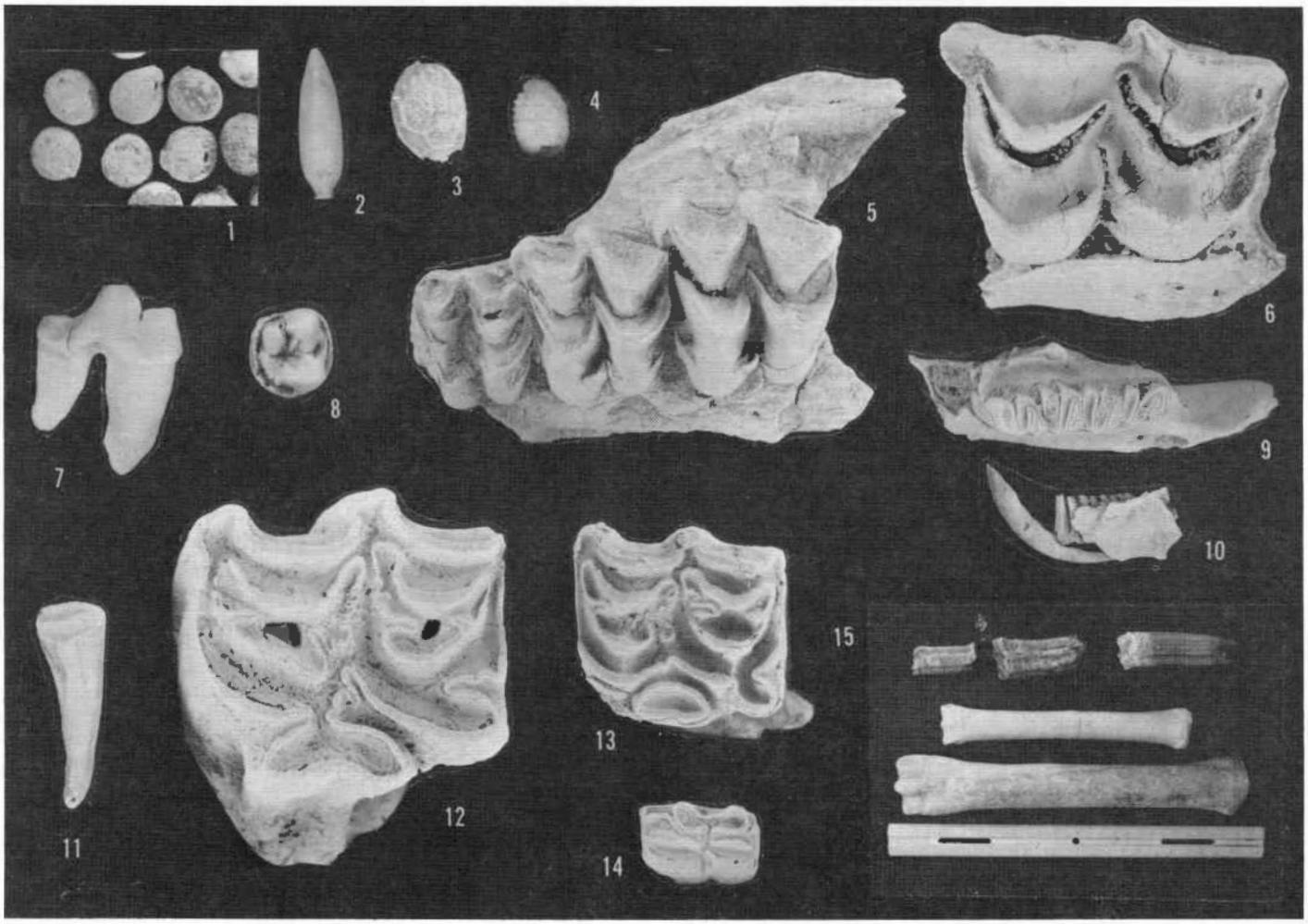
Ash Hollow Formation – Seeds – 1. Hackberry (*Celtis*), x2; 2. Grass (*Stipidium*), x5; 3. Shrub (*Biorbia*), x5.

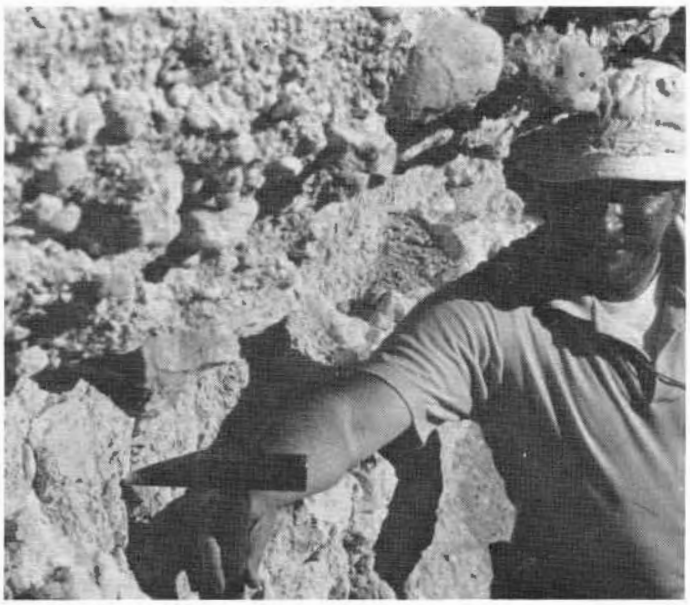
Vertebrates – 6. Camel (*Oxydactylus*?) molar, x1.5; 7. "Dog" (*Borophagus*?) molar, x.75; 9. Beaver (*Dipoides*) mandible, x1.5; 11. Horse incisor, x1; 13. Horse (*Neohipparion*?) upper molar, x1.5; 14. Horse (*Neohipparion*?) lower molar, x1.5.

Pleistocene and Recent Formations – Alga – 4. *Chara*, x6.

Vertebrates – 8. Tapir (*Tapirus*) premolar, x1; 12. Horse (*Equus*) molar, x1.5.

15. Comparison of size of *Neohipparion*? (smaller) and (larger) teeth and limb bones.





Left: **The three darker zones are old soils developed within the Brule.** *Right:* **The Ogallala-Brule contact is shown above the author's hammer and hat brim.**

ostracods, and teeth and bones from a diverse mammalian fauna, including beavers, oreodonts, camels, antilocaprids, horses, rhinos, mastodons, and "dogs." Shells of land turtles as large as washtubs are sometimes found. Since all these fossils have modern representatives living in environments typified by the semi-arid plains climate of today, it can be concluded the fossil forms probably lived in similar environments.

The next youngest deposits at the park are light tan silts called loess which are interpreted as wind deposits. These silts are probably part of the Peorian loess of Pleistocene age dated by Schultz and Hillerud (1978) as about 10,000 to 80,000 years old. The loess rests unconformably on top of the Ash Hollow beds and drapes over much of the terrain like a blanket. The most common fossils in the loess are land snails, root casts, and bison bones and teeth.

The youngest strata at the park are slope debris, stream terrace, and flood plain deposits. According to Schultz and Hillerud (1978) these sediments range in age from 10,000 years before present to debris being transported today. Most of the Indian artifacts, bison kill sites, and village sites are found in this material.

The geological history of Ash Hollow State Historical Park is, of course, much more detailed than this brief sketch indicates. As indicated in the reference list, there is a considerable amount of geological and paleontological literature that will lead you to an understanding of the area's interesting geology.

REFERENCES

Boellstroff, J. 1978. Chronology of some late Cenozoic deposits from the central United States and the Ice Ages. *Transactions of the Nebraska Academy of Sciences* 6:35-50.

Darton, N. H. 1899. *Preliminary report on the geology and water resources of Nebraska west of the one hundred and third median. U.S. Geol. Survey Ann. Rept. 19,* pt. 4:719-785.

Elias, M. K. 1942. *Tertiary prairie grasses and other herbs from the High Plains:* Geol. Soc. America Spec. Paper 41:176 p.

Schultz, C. B. and Hillerud, J. M. 1978. Climatic change and the extinction of large mammals during the Quaternary. *Transactions of the Nebraska Academy of Sciences* 6:95-106.

Schultz, C. B. and Martin, L. D. 1970. Quaternary mammal sequence in the Central Great Plains: *In* Pleistocene and Recent Environments of the Central Great Plains, Dept. Univ. Kansas, Spec. Publ. 3:341-353.

Schultz, C. B.; Martin, L. D.; Tanner, L.G.; and Corner, R. G. 1978. Provincial land mammal ages for the North American Quaternary: *Trans. Neb. Acad. Sci.* 5:59-64.

Stanley, K. O. and Wayne, W. J. 1972. *Epeirogenic and climatic controls of early Pleistocene fluvial sediment dispersal in Nebraska. Geol. Soc. America Bull.* 83: 3675-3690.

Stout, T. M.; Degraw, H. M.; Tanner, L. G.; Stanley, K. O.; Wayne, W. J.; and Swinehart, J. B. 1971. *Guidebook to the late Pliocene and Early Pleistocene of Nebraska.* Conser. and Survey Div., Univ. of Nebraska-Lincoln: 108 p.

Vondra, C. F.; Schultz, C. B.; and Stout, T. M. 1969. *New members of the Gering Formation (Miocene) in western Nebraska, including a geological map of Wildcat Ridge and related outliers.* Neb. Geol. Surv. Paper 18:18 p.

Collecting in Nebraska's Cretaceous Strata

Channel sandstones of the Dakota Group, Jefferson County, Nebraska. *(See Field Trip* #1.)

HAROLD M. DEGRAW
University of Nebraska
Lincoln, Nebraska 68588

ROGER K. PABIAN
University of Nebraska
Lincoln, Nebraska 68588

There is an abundance of collectible materials in Nebraska's Cretaceous rocks. Included are gypsum crystals, marcasite, scenic jasper, flint, plant fossils, ammonite imprints, clams, oysters, and fish and shark remains.

Cretaceous rocks underlie most of Nebraska except in the southeast and an isolated area on the Chadron Arch in the northwest. More than 7,200 feet of Cretaceous rocks occur in the southwest corner of the panhandle.

The Nebraska Cretaceous consists of eight principal rock units which document the most recent marine transgressions across the western interior of the North American Continent and a long period of post-Cretaceous weathering and soil development. The Cretaceous is economically important as a source of water, oil, natural gas, agricultural lime, as well as limestone, clay, and shale for construction materials.

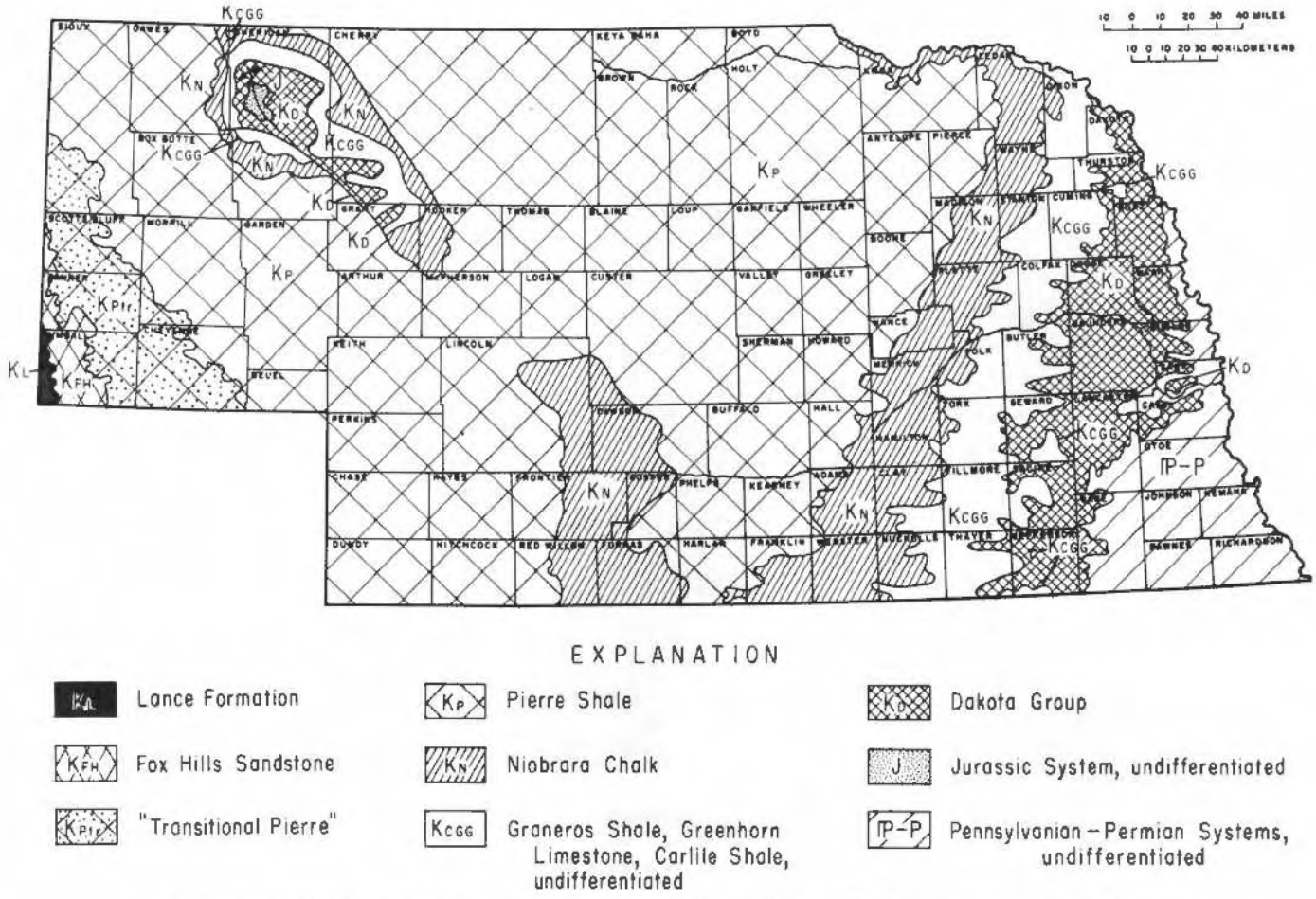
Cretaceous rocks are mostly overlain by Tertiary stream and wind deposits, but in eastern Nebraska they are mantled by younger stream and wind deposits and Pleistocene glacial deposits. Thus, outcrops are not extensive and most data has been derived from cores, cuttings, and geophysical logs of deep wells.

GENERAL STRATIGRAPHY

Dakota Group

The Dakota Group, named for Dakota County, Nebraska, consists mostly of sandstones, shales, and clays, and locally contains thin beds of chalk, limestone, coal, and pyrite. Dakota strata may be light to dark gray (dominant in the west), or oxidized reds, yellows, or browns (typical in southeastern Nebraska), with greens and grays common near the base. The diverse lithology and colors suggest environments of deposition that include streams, tidal flats, and shallow seas. Some coloration may indicate weathering due to later sub-areal exposure.

The Dakota group ranges from about 400 to 600 feet in eastern Nebraska and exceeds 900 feet in the northwest. Much of this variation is due to the paleotopography of the depositional surface. Some Dakota strata has been removed by erosion.



Generalized distribution of Cretaceous and older rocks overlain by Tertiary and younger strata.

In eastern Nebraska, mappable formations of the Dakota Group are not recognized, but in the panhandle three units, the basal Cloverly Formation, the Skull Creek Shale, and the Omadi Formation, comprise the Dakota. The Cloverly is mostly sandstones and clays but varies in lithology and color; the Skull Creek is mostly a shale but contains siltstones and sandstones; and the Omadi, sandstones and shales. Sandstones in the Omadi are important oil and gas reservoirs in Nebraska's panhandle.

In Nebraska the Dakota rests unconformably on rocks which become progressively older to the northeast. They overlie the Jurassic Morrison Formation in the west; northwest trending Pennsylvanian-Permian rocks, and then Mississippian, Devonian, Orodovician, and Precambrian rocks to the northeast.

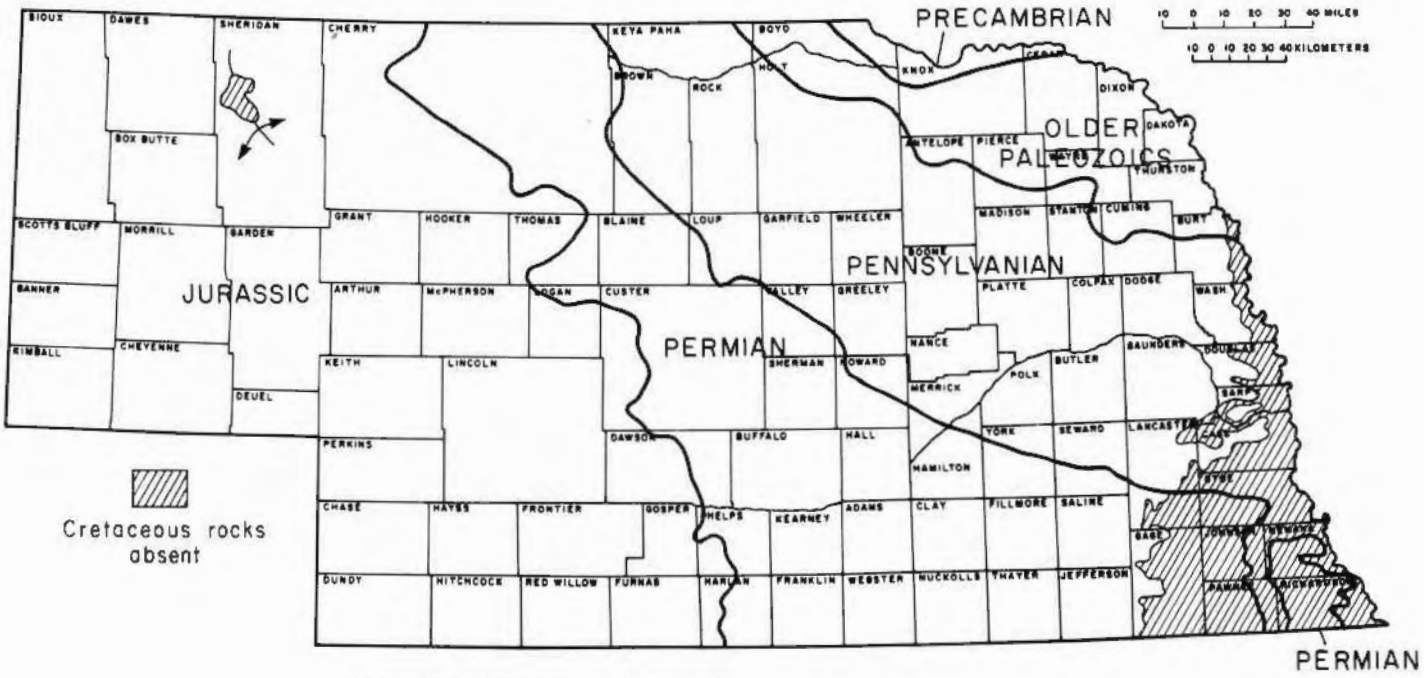
*Some important Dakota outcrops are in Ponca State Park in Dixon County and in the Basswood State Recreational Area in Dakota County. There are numerous, good Dakota exposures in southern Jefferson County (See Trip 1) and along I-80 and nearby county roads near the Platte River in Cass and Sarpy counties. Shales in the Dakota Group may yield plant fossils, and the only dinosaur specimen collected in Nebraska, a bone of a duck-billed dinosaur (*Trachodon*) was collected from the Dakota near the town of Tekamah in Burt County.*

Graneros Shale

In eastern Nebraska the Graneros is a marine shale less than 60 feet thick consisting of a lower, medium to dark gray, clayey shale and an upper, light to medium gray, calcareous shale which some workers include in the overlying Greenhorn Limestone. The Graneros gradually thickens to the west and is about 80 to 120 feet thick in west central Nebraska and over 350 feet in parts of the panhandle. In the panhandle, the Graneros contains several bentonite beds, the lowest of which is easily recognized in well logs.

The contact of the Graneros Shale with the underlying Dakota Group is based on lithology and is somewhat subjective. On a regional perspective, shales in the lower part of the Graneros in the west interfinger with upper Dakota sandstones to the east.

Graneros shale crops out in Dixon County at Ponca State Park and in southern Jefferson County, as well as in Thayer County along the Little Blue River (Trip 2). The Graneros contains many clams of the genus Inoceramus *(*Mytiloides*), some ammonites, shark and fish remains. A small Graneros outcrop in Saunders County yielded the remains of a plesiosaur that*



Generalized distribution of rock units underlying Cretaceous rocks.

were excavated and prepared by members of the Lincoln Gem and Mineral Club. This specimen is one of the most complete plesiosaurs ever found and is now an important display at the University of Nebraska Museum.

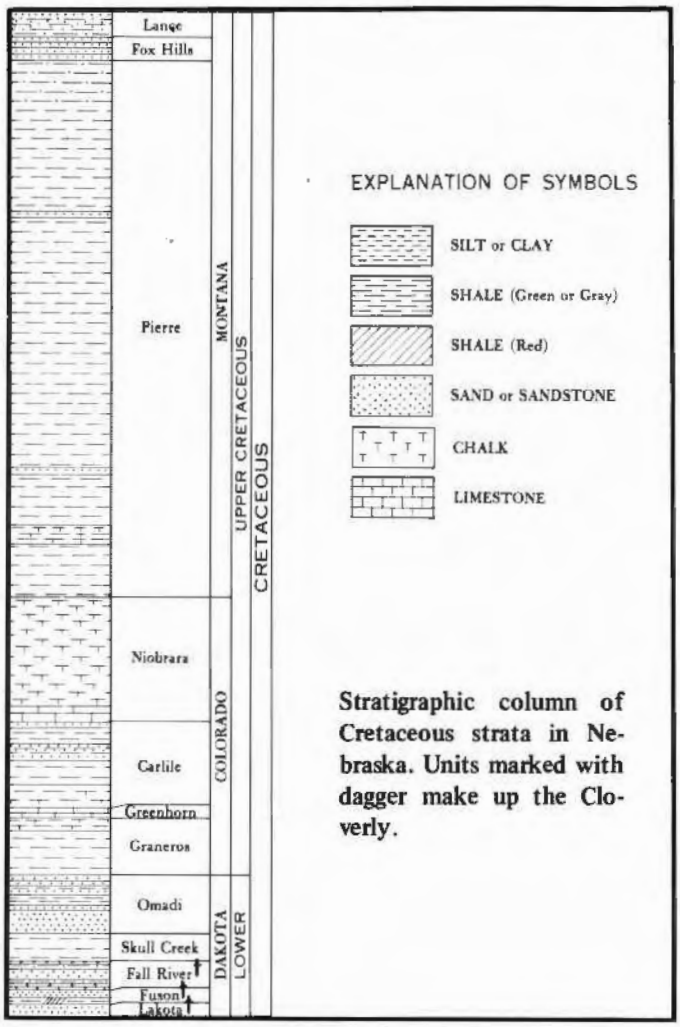
Greenhorn Limestone

The Greenhorn Limestone consists of medium-gray, interbedded limestones and chalks with a few bluish bentonite seams. These weather to yellow and off-white. Over much of Nebraska the Greenhorn is an easily recognized marker formation in both outcrops and on geophysical well logs. The Greenhorn commonly ranges from 25 to 45 feet thick, but in the northern panhandle it can be as thin as 10 feet and in the southern panhandle more than 55 feet. The Greenhorn becomes much less calcareous in the southwestern panhandle and grades into shales similar to those in the Graneros below and Carlile above. In this area, Greenhorn shales lie in contact with the Niobrara, the Carlile Shale having been eroded away before Niobrara deposition.

The Greenhorn was deposited on an eroded surface on the Graneros shale. Some of the variation in thicknesses of both the Graneros and Greenhorn may be due to relief on this surface.

The Greenhorn yields many collectible fossils. The clam Inoceramus *(*Mytiloides*)* labiatus, *ammonites, fish and shark remains can be found on most exposures. See Trips 1 and 2.*

Harold M. DeGraw and Roger K. Pabian are research geologists with the Conservation and Survey Division-Institute of Agriculture and Natural Resources at the University of Nebraska, Lincoln, Nebraska.



Stratigraphic column of Cretaceous strata in Nebraska. Units marked with dagger make up the Cloverly.

CRETACEOUS FIELD TRIPS

The following trips have been designed to familiarize the reader with the Cretaceous geology of Nebraska

Trip Number	Stratigraphic Units	Collectible Materials
1. 4.2 miles south from jct of Highways 8 and 15 south of Fairbury, and continuing south toward the Kansas-Nebraska border.	The first outcrop is a sandstone of the Dakota Group. 1 mile farther south is a shale of the Dakota Group in the abandoned clay pit (private property). The outcrop area continues south to the state line where shales and limestones of the Graneros-Greenhorn intervals are exposed.	The sandstone contains numerous concretions. Gypsum, marcasite, and plant fossils occur in the clay pit. The shale and limestone exposures contain numerous marine fossils including clams and some shark teeth.
2. 3.0 miles south of Alexandria on Highway 53.	Shales and limestones of Graneros and Greenhorn Formations.	Ammonite imprints, including *Prionocyclus*, *Bacculites*. Numerous clams and some fish and shark remains.
3. 1.6 miles south from jct of Highways 136 and 10 in Franklin and 1 mile west on county rd. on south side of Republican River.	Shales and limestones of Niobrara Formation.	Numerous clams, oysters, and some fish and shark remains.
4. 1.7 miles south of Bloomington on County road.	Shales and limestones of Niobrara Formation.	Numerous clams, oysters, some fish remains.
5. 2.0 miles west of jct of Highways 12 and 15 south of Niobrara.	Pierre shale Formation.	Abundant gypsum crystals. Some ammonites including *Bacculites*.
6. Roadcuts on county road on south side of Republican River 1.9 miles south of jct of Highways 136 and 281 in Red Cloud.	Shales and limestones of Niobrara Formation.	Numerous clams, few ammonites and some fish remains.
7. Roadcuts about 1.4 miles south of Gavins Point Dam, Knox County, on Highway 121.	Pierre shale Formation. Limestones and shales of Niobrara Formation.	Gypsum in Pierre shale. Clams and some fish and shark remains in Niobrara Formation.
8. Roadcut 3.5 miles south of Franklin on Highway 10 and 4.6 miles east on county road.	Cherty limestone at top of Niobrara Formation.	Cutting materials-scenic jaspers, flint.

Carlile Shale

The Carlile Shale is a medium to dark gray, marine shale with local sandy and limy zones. The Carlile may be up to 300 feet thick in central Nebraska but is absent in the southwestern panhandle. The thickness differences are mostly due to the eroded depositional surface on the Greenhorn below and an unconformable contact with the Niobrara above.

In eastern Nebraska, the Carlile includes the lower Fairport Shale, the middle Blue Hill Shale, and the upper Codell Sandstone. The Fairport, 60 to 80 feet thick, is bluish gray and calcareous, with thin, limy, fossiliferous layers. The Blue Hill is clayey and ranges from 80 to 100 feet in thickness. The Codell Sandstone is light to medium gray, usually less than 10 feet thick and is discontinuous over much of Nebraska except in the northeast where it may attain 50 feet and is an important aquifer.

Regionally, progressively younger Carlile beds onlap the older Greenhorn to the east. Thin, calcareous shale zones that become much more limy to the east are sometimes confused with the Greenhorn.

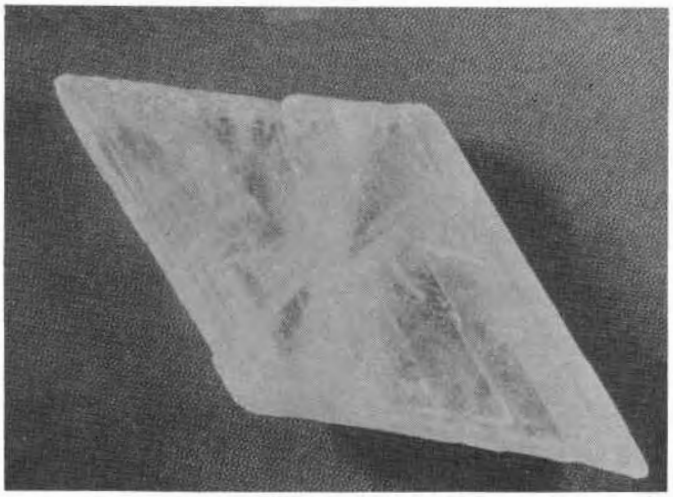
Some large septarians including calcite, barite, and celestine crystals have been collected from Carlile outcrops north of Hay Springs, in northeastern Dawes County. Locally, the Carlile may contain clams and ammonites. The Codell sandstone yields many shark teeth.

Niobrara Chalk

The Niobrara Chalk consists of the basal Fort Hayes Limestone (30 to 50 feet) and the Smoky Hill Chalk to the southeast. In northeastern Nebraska, the Niobrara is about 220 feet thick; it exceeds 500 feet in the southwest near the Kansas border. In the panhandle and north central Nebraska, it consists mostly of alternating chalk and shale and a discontinuous basal sandstone that grades laterally to a sandy siltstone, and an overlying, discontinuous clay shale. This lower shale has been mistaken for the Carlile and the basal sand mistaken for the Codell. In the subsurface the Niobrara is usually medium to dark gray with varying amounts of white speckles, but in some outcrops the grays have oxidized to yellow or orange. Where younger Cretaceous rocks are absent, a hard, cherty limestone sometimes occurs at the top of the Niobrara. Some of this material polishes very well and occurs in a variety of colors including greens, grays, browns, yellows, oranges, and reds. (See Trip no. 8). This horizon occurs in both outcrop and subsurface and is thought to be a paleosol (fossil soil), indicating a long period of exposure and weathering.

The Niobrara can be an important aquifer and gas source. Some irrigation wells have been developed in the eastern subcrop belt, the water possibly coming from a network of solution enlargements of faults and fractures. Where the Pierre overlies the Niobrara a number of shallow wells have proven gas reservoirs.

The Niobrara contains many marine vertebrate and invertebrate fossils including clams, oysters, fish, and shark remains (See Trips 3, 4 and 6). The Niobrara has yielded marine reptiles in Kansas and South Dakota. The lack of these fossils in Nebraska probably reflects the limited outcrops.



Gypsum crystal, Carlile Shale, Newcastle area.

Pierre Shale

The Pierre is a marine shale sequence in Nebraska; its thickness varies greatly, being thinnest or absent on uplifts and thickest in basins. Some of the Pierre may have been eroded from uplifting areas and redeposited in nearby basins simultaneously. The Pierre is a clay shale to the east, becoming more calcareous to the north. In western Nebraska the Pierre becomes sandier and siltier. The Pierre is over 700 feet thick in north central Nebraska, where it contains a 150 to 250 foot thick chalky sequence called the Mobridge. In the southwestern corner of the panhandle, the Pierre exceeds 5,800 feet; the upper 1,200 feet is the transition zone consisting of sandy and silty shales with several sandstone beds. About 3,000 feet below the base of the transition zone is an interbedded sequence of sandstones and shales called the Hygiene.

The Pierre rests on an eroded Niobrara surface throughout Nebraska. In the panhandle, the basal shales and Ardmore Bentonite were deposited on an eroded Niobrara surface, and the thickness configuration of these beds reflect the paleotopography (DeGraw 1973).

The Pierre crops out in the northwestern corner of the panhandle. About 20 miles north of Crawford in Sioux and Dawes counties many outcrops yield large amounts of gypsum and some marine invertebrate fossils including clams and ammonites. A small plesiosaur and diving bird were collected near the South Dakota border.

Good outcrops of Pierre Shale also occur in northeastern Nebraska. An excellent example is found 2.5 miles west of the town of Niobrara and state Highway 12 (See Trip no. 5). This outcrop has yielded some ammonites and many very fine gypsum crystals.

Fox Hills Sandstone

The Fox Hills sandstone occurs in the western part of the

southern panhandle. It consists of a sequence of blue-gray, very fine- to fine-grained sandstones that may exceed 250 feet in thickness. The Fox Hills also contains interbedded silty and clayey shales. The sandstones thin eastward and grade into sandy silts; to the west some of these beds abruptly end near the Wyoming border. These sandstones appear to be shallow, nearshore, marine sand bars. Although not extensively utilized, the Fox Hills appears to be an excellent aquifer.

Lance Formation

The Lance Formation is restricted to the southwestern panhandle where it exceeds 375 feet. The Lance shows a variable lithology ranging from claystones to siltstones to lenticular sandstones, and local beds of lignite and limestone. It varies from black to brownish to bluish gray and can be deeply oxidized, exhibiting brilliant hues of reds, purples, and yellows; mild reduction colors of light blues and greens provide sharp contrasts. Some of this coloring may reflect the original environment but much of it may be attributed to the Interior Paleosol. Remains of the dinosaur *Triceratops* have been found in the Lance a few miles into Wyoming, but none have been found in Nebraska.

Interior Paleosol (Fossil Soil)

Throughout much of western Nebraska and adjacent areas the top of the Cretaceous rocks has been deeply weathered prior to and during early Oligocene of Tertiary time. This resulted in highly oxidized coloration on paleouplands and mildly reduced coloration in paleolowlands in the areas where the Oligocene Chadron Formation was deposited on the Cretaceous. This coloration may be as thick as 75 feet on impervious shales, such as the Pierre, and 300 feet on more permeable beds, such as the Lance and Fox Hills.

SELECTED READINGS

Anon. 1973. *Jefferson County, Fairbury area, field guide.* Lincoln: Conservation and Survey Division, IANR, Univ. Nebraska. 23 p.

Anon. 1973. *Thayer County, Alexandria and Gilead areas, field guide.* Lincoln: Conservation and Survey Division, IANR, Univ. Nebraska. 8 p.

Busch, J. D. 1976. *Geometry, depositional environments, diagenesis, and economic potential of the Codell Sandstone (Upper Cretaceous) in western Nebraska and eastern Wyoming.* Unpublished MS Thesis. Lincoln: Univ. Nebraska. 75 p.

Condra, G. E., and Reed, E. C. 1943. *The geological section of Nebraska.* Nebraska Geol. Surv., Bull. 14 (Reprinted in 1959 as Bull. 14A): 82 p.

DeGraw, H. M. 1969. *Subsurface relations of the Cretaceous and Tertiary in western Nebraska.* Unpublished MS Thesis. Lincoln: Univ. Nebraska: open file report, Nebraska Geol. Surv. 137 p.

DeGraw, H. M. 1971. The pre-Oligocene surface in western Nebraska—its relations to structure and subsequent topography. *Guidebook to the Late Pliocene and Early Pleistocene of Nebraska.* Nebraska Geol. Survey: 12-21.

DeGraw, H. M. 1975. The Pierre-Niobrara unconformity in western Nebraska; *Geol. Assoc. Canada, Spec. Paper 13*: 589-609.

Kellison, L. B. 1979. The Niobrara Formation in the southern part of the Nebraska panhandle. Unpublished MS Thesis. Lincoln: Univ. Nebraska. 100 p.

Miller, R. D.; Van Horn, R.; Dobrovolny, E.; and Buck, L. P. 1964. *Geology of Franklin, Webster, and Nuckolls County.* U.S. Geol. Surv., Bull. 1165. 91 p.

Moore, V. A. 1959. The Cretaceous stratigraphy and structure of northwestern Nebraska with special attention to the Chadron Dome. Unpublished MS Thesis. Lincoln: Univ. of Neb. 68 p.

Pabian, R. K. 1970. *Record in rock, a handbook of Nebraska's invertebrate fossils.* Lincoln: Conservation & Survey Division, Univ. Nebraska. 99 p.

Collecting in Nebraska's Glacial Deposit

JOHN BOELLSTORFF
University of Nebraska
Lincoln, Nebraska 68583

Lake Superior agates are the most sought lapidary material found in glacially derived rocks in Nebraska. Specimen from near Palymra, Nebraska.

The Quaternary deposits of North America have had a long and colorful history. In Nebraska they are of great importance because much of the economy is based on the rich soils developed from these deposits, on water drawn from them, and on construction materials derived from them. In a sense, nearly all who work the land are students of the Quaternary. Farmers note differences in soils and the odd "foreign" stones scattered about the landscape in glaciated eastern Nebraska. Well drillers recognize the stratification of these deposits and the presence of "veins" of water known to be ancient, buried stream channels often filled with water yielding gravels. In addition, studies of Quaternary deposits are important to engineers building dams, highways, and other structures. Much of our culture is based on the Quaternary—we are living in the Quaternary!

Quaternary Defined

The Quaternary is a division of geologic time believed to encompass about the last 2.8 million years. It is divided into two major subdivisions—the Pleistocene, which constitutes the bulk of Quaternary time including all of the Ice Ages, and the post glacial Quaternary which is termed Recent or Holocene and encompasses about the last 10,000 years. Although most geologic time lines are arbitrary and do not relate to global events, it now appears the beginning of the Quaternary is coincident with a global cooling that led to the onset of continental glaciation.

Dating Deposits

Deposits from continental glaciation occur in eastern Nebraska and adjoining areas. Our understanding of these deposits has been greatly facilitated by the dating of lens-shaped deposits of volcanic ash interlayered between glacial deposits at several localities. The volcanic ash consists of fine sand-to-clay-sized particles of obsidian produced during the highly explosive phase of rhyolitic volcanoes located in the Yellowstone National Park area and from those in the Bishop area of Northern California. The ash was probably carried into Nebraska by jet stream winds and may have served as nuclei for rain drops. Although the ash may have once covered large areas, it was preserved as lentils in pond and lake environments where it was rapidly buried and protected from reworking. These lens-shaped deposits can be dated by means of the fission-track technique which is based on the slow but steady rate of natural fission or splitting of the uranium-238 nucleus. The fission fragments produce submicroscopic tubules in the glass shards, much like a bullet-hole in wood. These damaged zones can be enlarged and made visible by etching the shards in hydrofluoric acid and examining them with an optical microscope at 500 magnifications. Dating of ash deposits in Nebraska has shown that many ages of ashes occur rather than just one as previously thought.

Glacial Tills

A detailed study of the minerals and pebbles comprising

the glacial tills of eastern Nebraska and adjoining areas has revealed the presence of three compositionally distinct types of till–here labelled "A", "B", and "C". Fission-track dates on volcanic ashes associated with these tills has permitted placing them in a chronologic framework; the older being the "C" tills and the youngest the "A" tills.

The First Ice Age

The paleotemperature record of the Gulf of Mexico suggests the first late Cenozoic Ice Age in North America commenced about 2.8 million years ago, reached a maximum around 2.4 million years ago, and ended about 2.1 million years ago. The glacial "C" tills in Nebraska probably were deposited during the maximum of this glaciation. Exposures of this type are rare. One exposure, the Elk Creek Till of Reed and Dreeszen (1965) can be seen at its type locality about 2.5 miles west and 5 miles north of Table Rock, Pawnee County. It also occurs on exposure as the lowermost till resting on glacially striated Pennsylvanian age bedrock in the City Wide quarry about 3 miles west of LaPlatte in Sarpy County.

The "C" tills are unique in that nearly 90 percent of the plus 4mm pebbles found in them are locally derived sedimentary rocks including limestones, sandstones, dolomites, and shales of Paleozoic and Cretaceous ages. There are very few pebbles of granitic rocks or Sioux quartzite. Lapidary material is rare in the "C" tills and consists of occasional pieces of petrified wood and chalcedony.

The interglacial period between the first and second Ice Age was possibly as warm or warmer than today. This was a period predominated by soil development on relatively stable divide areas and dissection near stream systems. Volcanic ashes carried in by winds from the Yellowstone National Park area were preserved locally in oxbow lakes and ponds. These ashes are about 2.0 and 2.2 million years old.

The Second Ice Age

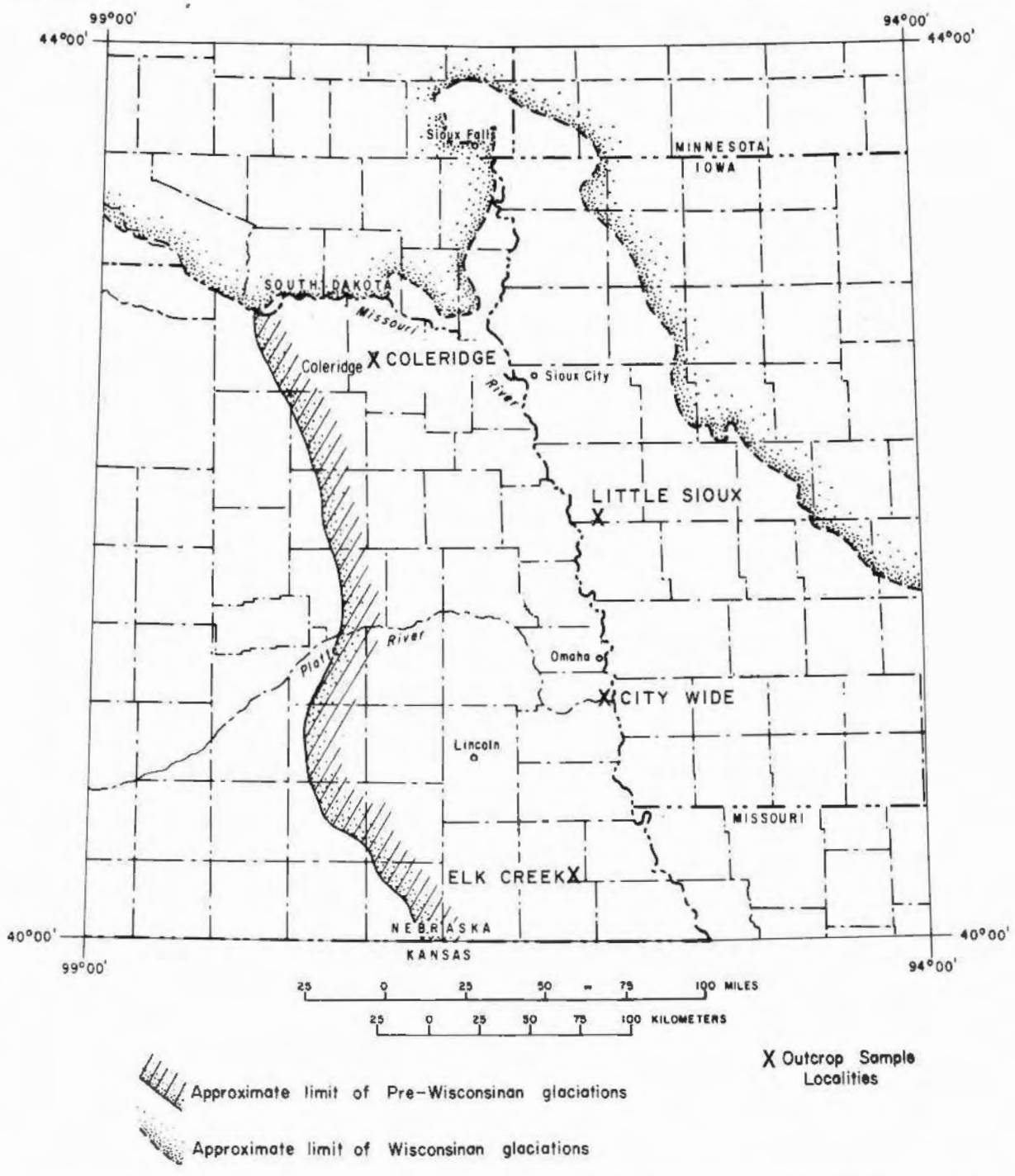
The second Ice Age occurred between about 1.9 and 1.5 million years ago. This Ice Age is represented in Nebraska by alluvial deposits laid down along ancient stream valleys, which are now buried, and by silt and fine sand that was swept from the flood plains by winds and trapped by vegetation in the uplands to form loess deposits. Soil formed in areas where the landscape was relatively stable. Although glaciers didn't reach Nebraska during this time the climate was probably considerably colder than today.

The interglacial period between the second and third Ice Ages again was nearly as warm or warmer than today. Again, fluvial processes, dissection, soil formation, and loess deposition dominated. Volcanic ash (Coleridge Ash) was deposited during this interglacial period and is preserved in lakes and ponds. This ash is best exposed about 3 miles west and about 2 miles north of Orleans, Harlan County.

The Third Ice Age

The third Ice Age occurred between about 1.0 to 0.4 million years ago. Glaciers invaded Nebraska and Iowa at least four times, and periods between these advances were of

Sequence of glacial tills exposed in City Wide quarry near LaPlatte, Nebraska.



LIMIT OF GLACIAL DEPOSITS IN EASTERN NEBRASKA AND ADJACENT AREAS

sufficient duration for the formation of paleosols (fossil soil) and gleys (blue-gray, compact, and often structureless soil layers).

The lowermost of the tills associated with this Ice Age is the "B" till. Its only known exposure is at the City Wide Rock quarry where it is found as the middle till. The "B" till is predominately sedimentary material foreign to Nebraska coming from the James Lowland area of Canada. It is mostly limestone, dolomite, chert, siltstone, shale, and sandstone. Non-sedimentary material consists principally of granites, schists, greenstones, and Sioux quartzite. Occasional pieces of petrified wood, chalcedony, and jasper are present.

QUATERNARY FIELD TRIPS

There are some general rules that can be applied to collecting in Nebraska's glacial deposits. Most good exposures of rock material derived from tills are found in roadcuts or fields along topographic breaks between uplands and streams. Excellent artificial exposures may also occur in pits, construction sites, and feedlots. A day in the field may consist of reconnoitering many ditches along county roads. Gravel and cobble-sized material having a high percentage of green and black rocks are more productive than those rich in pink quartzite. Perseverance is the key to locating agates, chalcedony wood, and other lapidary materials.

Most glacial till outcrops are small and can be examined for lapidary material in a matter of minutes. Thus, looking for Lake Superior agates in eastern Nebraska is a matter of moving from outcrop to outcrop and checking 20 to 30 outcrops in a day.

Gravel bars on the many streams draining southeastern Nebraska are often excellent collecting sites because the relative small percentage of cobbles occuring in the tills is concentrated. Bars on both the Big and Little Nemaha Rivers, and their tributaries have been very productive in agate, petrified wood, jasper, chalcedony, and occasionally Indian artifacts.

Gravel bars on the Platte River in eastern Nebraska consist largely of sand and are not very productive. Tills having high percentages of quartzite or sedimentary rocks are also usually poor producers of lapidary material.

Of the "A" tills, the youngest is not known to occur in Nebraska, but it is widespread in south-central Iowa. The "A" tills, especially the younger ones, are richest in materials of interest to rock collectors. This material includes Lake Superior agates, chalcedony, petrified wood, jasper, and rarely topaz and jade.

There was a period of about 100,000 years duration (between about 0.6 and 0.7 million years ago) during which continental glaciers receded from this area but not so far as to permit a great warming. Pearlette ash (restricted) and the Hartford ash derived from eruptions in the Yellowstone National Park area were deposited and preserved in lakes and ponds during this period.

Excellent exposures of the Hartford Ash can be seen along the road bordering the Little Sioux River between three and four miles north and one mile east of the village of Little Sioux, Iowa. Along this road the ash stands out as a white bed ranging from about one to four feet thick. The Pearlette Ash can be seen about 1.5 miles west and 1 mile south of the village of Elk Creek on the north side of Highway 62, Johnson County.

The interglacial period between the third and last Ice Age is represented in Nebraska by fluvial and loessic sediments with paleosols on divide areas. There appear to be three cycles of coarse sand to silt loess deposition capped by paleosols during this interglacial. These cycles probably relate to advances and retreats of continental glaciers to the north. This interglacial period began about 500,000 years ago and ended about 100,000 years ago when conditions again led to expansion of continental glaciers.

John Boellstorff is a research geologist with Conservation and Survey Division-Institute of Agriculture and Natural Resources at the University of Nebraska, Lincoln, Nebraska.

The Fourth Ice Age

The fourth Ice Age, beginning about 100,000 years ago, resulted in numerous advances and retreats of the ice sheet. Glacial deposits representing the fourth Ice Age are not known in Nebraska but occur in central Iowa. In Nebraska this Ice Age is represented mainly by thick accumulations of loess (Peoria and Bignell). Although many scientists consider the fourth Ice Age to have ended about 10,000 years ago, others believe we are still living in it and that today's temperate climate represents only a lull between advances of the continental ice.

REFERENCES

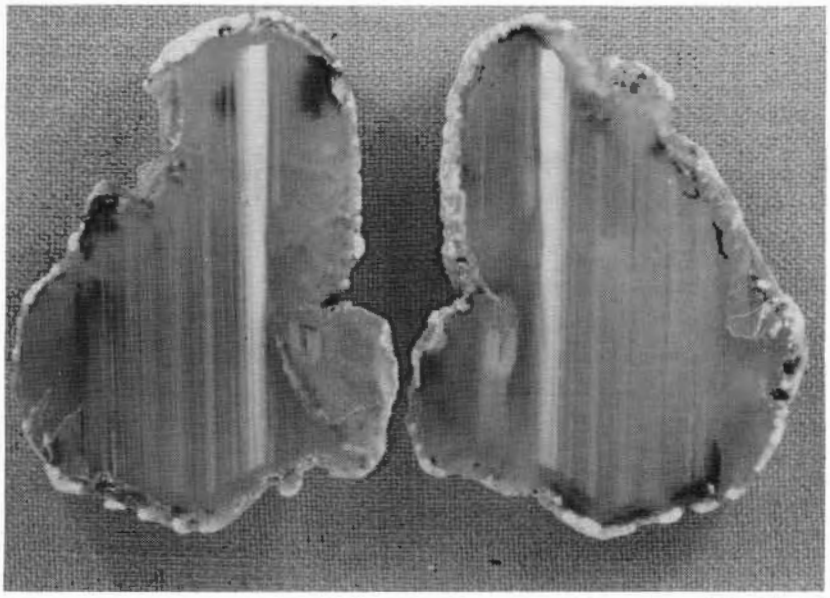
Beard, J. H. 1969. Pleistocene paleotemperature record based on planktonic foraminifers, Gulf of Mexico. *Transactions Gulf Coast Association of Geological Societies* 19: 535-553.

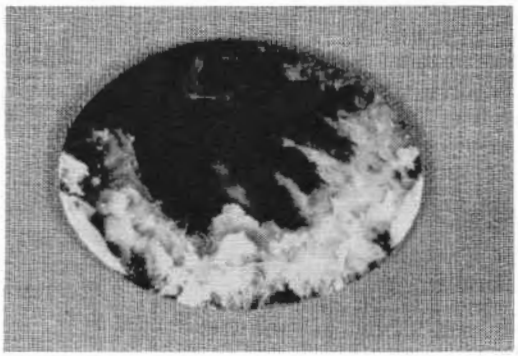
Boellstorff, J. 1978. North American Pleistocene stages reconsidered in light of probable Pleitocene-Pleistocene continental glaciation. *Science* 202-305-307.

___. 1978. Chronology of some late Cenozoic deposits from the central United States and the ice ages. *Transactions Nebraska Academy of Sciences* 6: 35-49.

Reed, E. C. and Dreeszen, V. H. 1965. *Revision of the classification of the Pleistocene deposits of Nebraska. Nebraska Geological Survey Bulletin 23.* 65 pp.

___ et al. 1966. Evidence of multiple glaciation in the glacial-periglacial area of eastern Nebraska. *Guidebook of 17th Ann. Mtg. Midwestern Section Friends of the Pleistocene.* Lincoln: University of Nebraska. 25 pp.





Above: Blue agate, Chadron Formation, U.S. Forest Service pasturelands about ½ mile north and 1½ miles east of Orella Crossing, Sioux County.

Left: Onyx agate, Sidney Gravels, South Platte River terraces, Big Springs, Deuel County.

A Nebraska Portfolio

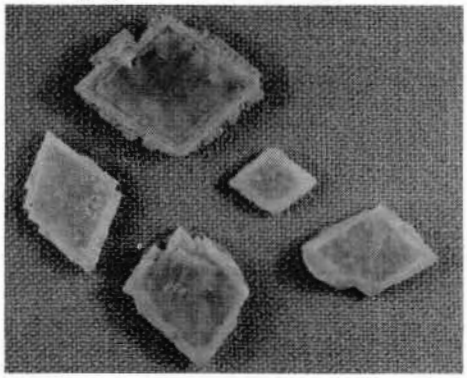
Fairburn agates, petrified wood, quartz concretions, trilobites, corals, jasper, and barite—these are what come to mind when the collector thinks of Nebraska. From the gem fields in Eastern Nebraska to the fossil beds at Weeping Water, the state has much to offer those who enjoy hunting in the field. And there's something for everyone—mineral collector, fossil collector, and lapidary. Pictured here is but a sampling of what awaits the visitor.

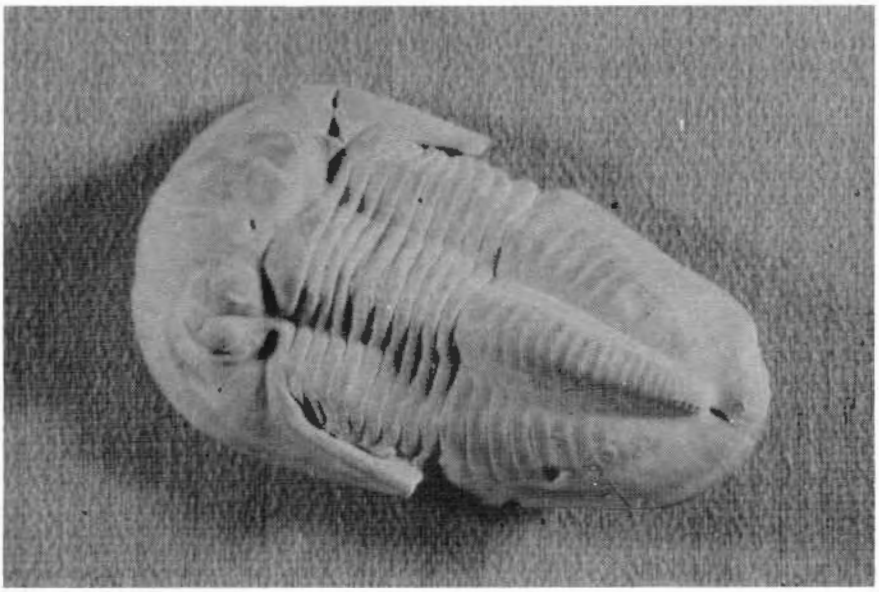
Collectors are reminded to follow the American Federation Code of Collecting Ethics and obtain permission before entering private property. Courtesy is essential if access to some of these sites is to continue.

Photographs provided by Roger K. Pabian

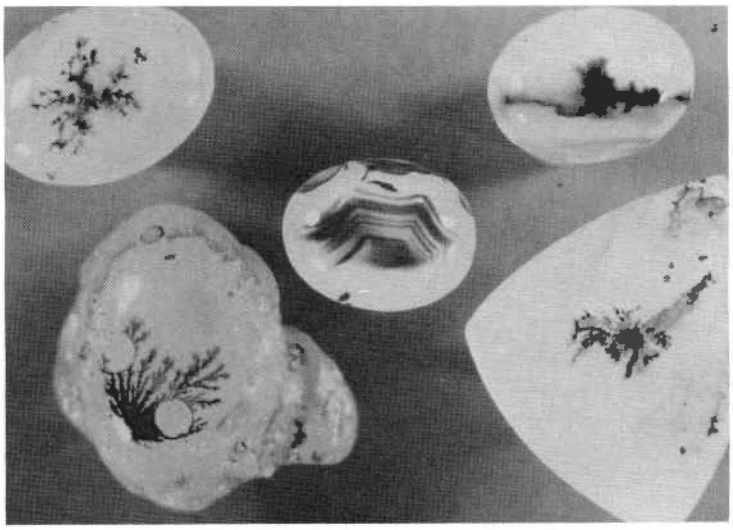
Right: Trilobite, *Ameura missouriensis*, abandoned quarry 1.2 miles west of junction of Highways 31 and 50 near Louisville, Sarpy County.

Below: Tabular barite crystals, abandoned quarry 47 miles east and 1.7 miles south of Weeping Water, Cass County.

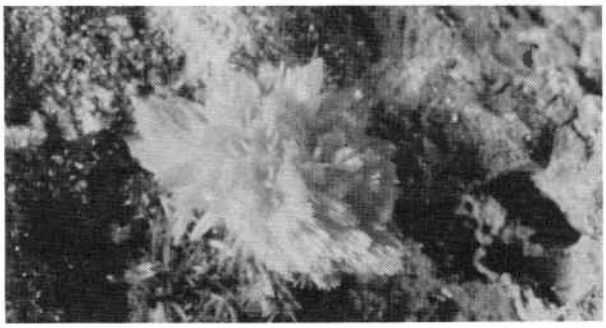


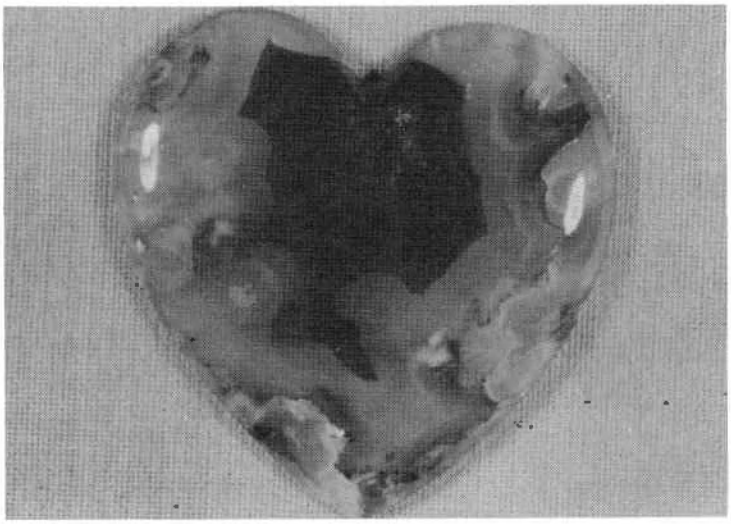


Lake Superior agate, gravel bar, south fork, Big Nemaha River, 5.1 miles south of Humboldt, Richardson County.



Moss agates recovered from gravel bars in the Platte River throughout much of its course in Nebraska.

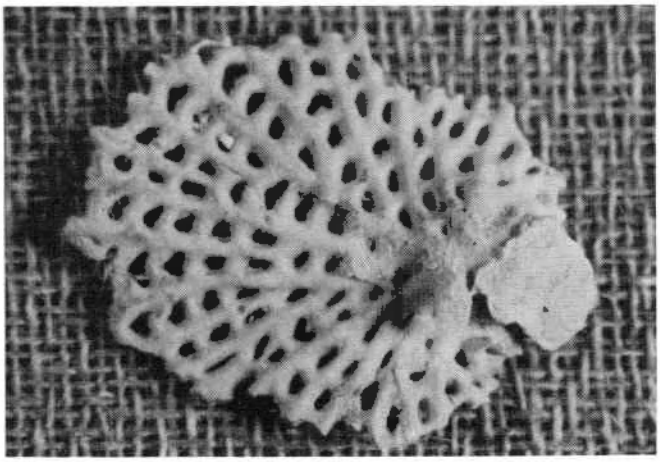


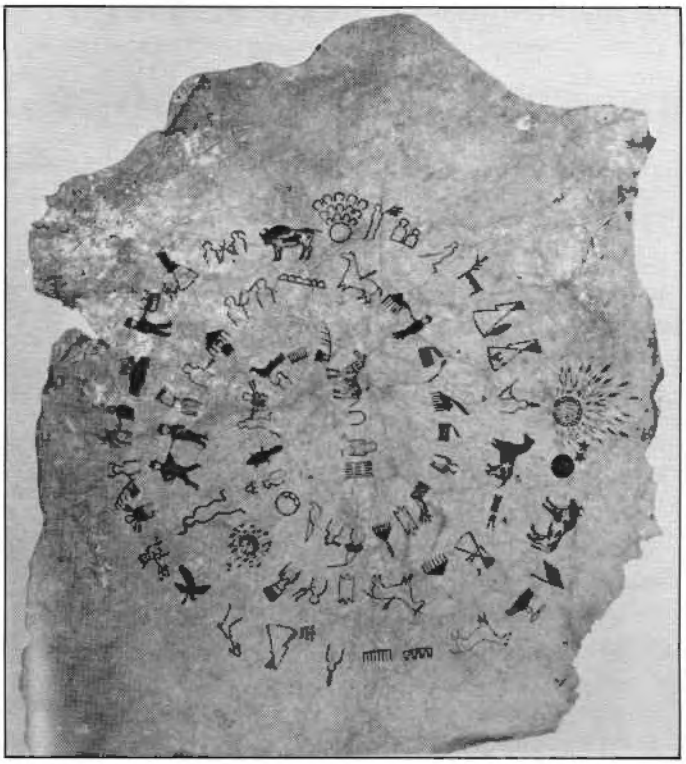


Blue agate, Nebraska's official state gemstone, from Chadron Formation exposed in U. S. Forest Service pasturelands about 18 miles north of Crawford, Sioux County, on Highways 2 and 71.

Above: Barite crystals, quarry 4 miles east and 2.6 miles south from junction of Highways 4 and 77 in Beatrice, Gage County. Additional minerals are in a quarry 1 mile further south.

Right: Pennsylvanian age, fenestrate bryozoan colony, Plattsburg Limestone, abandoned quarry 1.2 miles west of junction of Highways 31 and 50 near Louisville, Sarpy County.





Buffalo hide robe used in the Dakota Sioux Winter Count is displayed in Pierre by the South Dakota State Historical Society. These pictographs are a source of information for interpreting petroglyphs. South Dakota State Historical Society photo.

Nebraska's Petroglyphs

What's on Them Can Tell a Tale

CARL E. WELLS
804 South Glass
Sioux City, Iowa 52242

Introduction

Sometimes the surfaces of rock exposures bear a fascinating, beautiful record—the markings and drawings of people who passed this way before, people who have carved their thoughts and images into rock outcrops—the most enduring surfaces around. These carvings are a part of our connection with the past, its people, what they saw, and what they believed to be significant.

Archeologists call these images petroglyphs or pictographs, petroglyph from the Greek meaning "rock carving," and pictograph meaning "picture-writing." This article deals mostly with petroglyphs, especially those carved in the sandstone outcrops in Eastern Nebraska.

Although these carvings are currently available for us to study, they may not be for long. Many examples of this irreplacable record have already been lost to vandalism and to the continuing encroachment of man's living areas, transportation systems, and recreation areas. Whole cliff faces are blasted and bulldozed away for roads, shopping centers, and housing developments. People in recreation areas still like to leave their mark, carving their names or initials in the rock. Too often these carvings are on top of earlier records, masking them or obliterating them altogether.

The people who decided to carve petroglyphs usually sought a smooth, even expanse of rock on which to rub grooves. It is, therefore, in these kinds of areas where petroglyphs are most likely to be found and where collectors should be increasingly alert for their presence. It should be noted that each carved groove will have the same color as the adjacent rock surface after a number of years, as a surface patina builds up from exposure to the elements. This is one reason why petroglyphs are sometimes overlooked by people on casual outings.

Petroglyphs in Eastern Nebraska

Indian rock carvings in this region are generally associated with sandstone outcroppings in the Late Cretaceous age Dakota Group. Among the first references to these carvings are the publications of the Nebraska State Historical Society Journals, from about 1930, which depict some spectacular examples. One of them—The Birdman of Blackbird Hill—was used as a graphic on the title page of Wedel's (1961) book *Prehistoric Man on the Great Plains.* Another is a four-foot long zoomorphic fantasy figure the writer dubbed The Water Dragon.

Both of these figures are located in Thurston County, Nebraska. The Water Dragon is on a 40 foot high cliff that once faced the meandering Missouri River channel and the Birdman is in a narrow ravine that cuts into the cliff. The site is decidedly off the beaten track, on the Omaha Indian Reservation, and barred from the only casually interested observer by

---

Carl E. Wells is a member of the Board of Directors of the Sioux City Public Museum, Sioux City Iowa.

mosquitos, nettles, and virulent, head-high poison ivy. The entrance to the narrow ravine in which the Birdman is carved is blocked by a huge, fallen tree. The walls of the ravine contain a gallery of other carvings—delicately shaped horses, man figures, smaller versions of the Water Dragon, and a fanciful mask-like dragon head.

In the Lewis and Clark Expedition in 1804, William C. Clark recorded petroglyphs in Nebraska. His journal contains a July entry describing Indian rock carvings near the junction of Nemaha River and the Missouri.

Another petroglyph area is the Round Springs site located in the Basswood Ridge Recreation Area, owned by the State of Nebraska and located near Homer in Dakota County. The visitor to this location will see a classic exposure of Dakota Group Sandstones. The base of the cliff with its interlaced carvings contains the "round spring" which gives the site its name.

There are records of petroglyph locations at several other places in Nebraska. One is at or near Santee, one is near Table Rock, and another at Indian Cave State Park near Auburn. Extensive damage has been reported at the latter site.

Researchers who study petroglyphs are reluctant to reveal locations to those whose professionalism is not firmly established. Experience has shown that many who share their finds with others often later discover irreparable damage. Such damage can take several forms: attempting to chip or saw the carving from the face of the cliff, "inking" the carving to make a print, or "chalking" the carving. Chalking not only targets the area, it also distorts the design and hastens the weathering process by widening lines and exposing new surfaces to the elements.

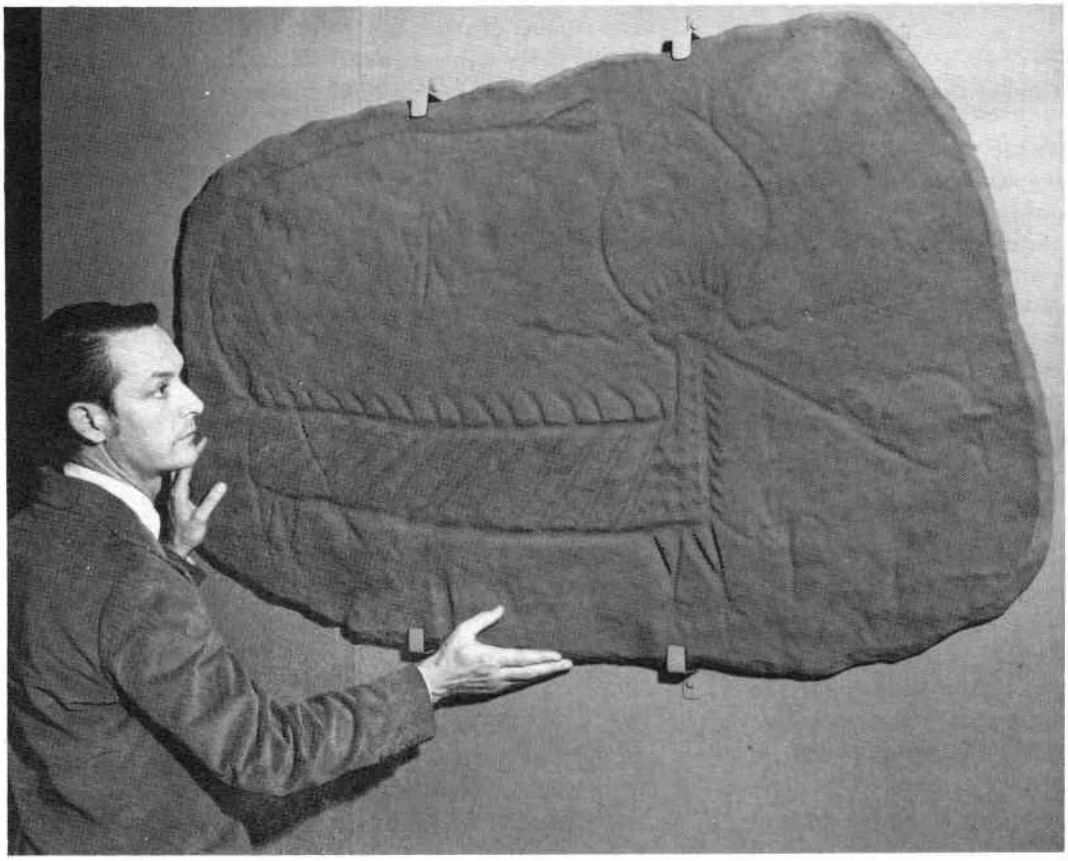
Non-destructive Collecting Techniques

The most useful techniques for the responsible collection of petroglyphs include photographs, tracings, rubbings, and double-casts. Each of these techniques produces a suitable record for study with little, if any, risk to the original artwork.

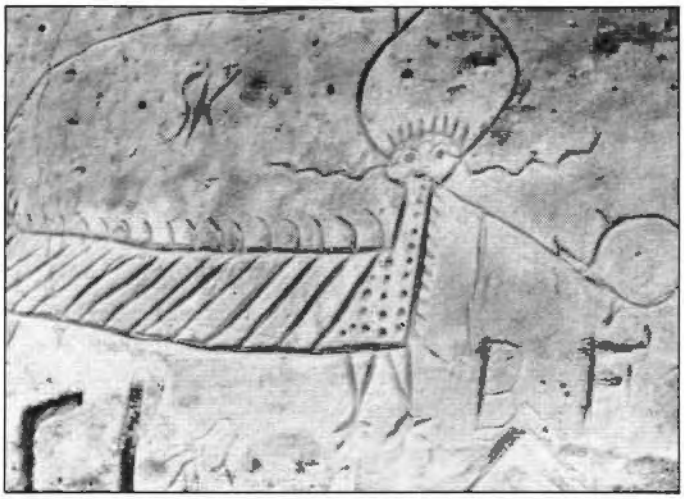
Photos

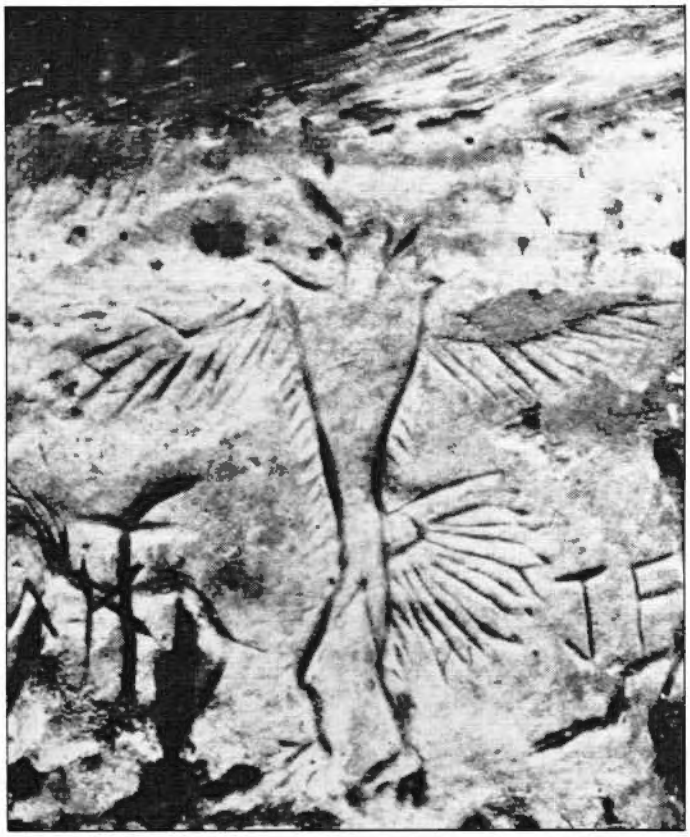
Any good camera can be used to photograph petroglyphs, however the quality of the finished product depends to a large extent on the skill of the photographer. Some suggestions:

1) Use a single-lens reflex camera if possible.
2) Take along adequate means to control both the direction and intensity of light. These two factors determine which grooves in a carving will show in a photo and which will go unnoticed. The older the glyph, the shallower the groove and the more difficult the shot.
3) Use any assistance available (unipod, tripod, tree-stump, or rock) to make certain that the camera is absolutely immobile when the exposure is made.
4) Bracket the shots.
5) Include a ruler or some other object of known size



The author presented a double-cast of the Water Dragon to the Indian collection of the Sioux City Public Museum where it is displayed in the Indian Hall.





Above: **A closeup view of the Water Dragon shows the forked tail and antlers, the lightninglike marks from the eyes, the "talk-mark" from its mouth leading to the turtle figure at the end, the polka dots on its chest, and the spines down its back.**

Right: **Birdman showing handsome feathered bustle, feathers down arms. Figure is carved on sandstone in a ravine in Thurston County, Nebraska.**

to provide scale. This archeological technique makes it possible to make enlargements that are exactly lifesize.

Tracings

Sketches of exposures are perhaps the oldest technique for recording petroglyphs, but tracings are better in some respects. They are exactly the size of the originals and they permit someone with a lower level of artistic skill to make a perfectly useful record. The clear plastic films available today are portable and convenient to store. They can be used in conjunction with a felt-tip marker.

Tracings have a place in photo albums too. Outlines on hinged acetate overlays can isolate the Indian design and then be lifted so the picture of the rock surface itself can be studied.

Rubbings

This technique is an adaptation of that used by people who make tombstone rubbings on rice paper. However, paper never seemed to conform to the undulations of the sandstone exposures in Nebraska, so various alternative fabrics have been tried. Plain muslin is a very satisfactory medium, and commercial block-printing ink is the best coloring agent. Apply it with a narrow (about 1½ inches) rubber brayer.

It must be perfectly clear that the *ink is rolled onto the cloth.* The cloth is taped tightly to the cliff face, completely covering the carving. A positive image results, with the lines of the carving appearing on the rubbing in the same color as the cloth, while the background is the color of the ink used. The technique described here is refined from that described by Hedden (1958).

One dark color usually suffices for an archeological record but a combination of colors can add to the attractiveness of the rubbing for display purposes, and aside from aesthetics, they can be used to color-code rubbings from individual sites.

Rubbings contrast with photographs and field observations in that they do not depend on the angle and direction of light for their reproduction, but depend only on whether or not there is a groove in the rock under the cloth. As a result, rubbings can make the student aware of grooves that might have gone undetected and which may not have shown up in a photo. Another advantage is that fabric can be rolled for storage, and a large number can be conveniently stored in a small space. One disadvantage is that every groove in the rock will show, even natural fractures.

Double Casts

The serious student or collector will probably want to make double-cast reproductions of selected glyphs of particular beauty or significance. For glyphs of modest size, ordinary children's modeling clay is a dependable medium. The clay is pressed into a sheet about a half-inch thick, and then pushed firmly against the surface, covering the carving. Every square inch of the clay must make firm contact with the rock surface to get a good impression.

The clay is then carefully released from the wall and laid on on the ground, impression-side up. This negative impression (the grooves stick UP from the surface of the clay, but go down into the rock) is carefully studied and compared to the carving on the cliff face. Any problems of distortion in handling the clay can now be corrected. A chunk of rock which has fallen from the cliff face can be used to touch up the texture. This step is crucial to the successful execution of the double-cast process. Incidentally, for larger works potter's clay can be used, although it will probably have to be thicker.

A note of caution: on hot days when the sun has been shining on the cliff face, the surface should be cooled before the modeling clay is applied. The best way is to pour cool water on it.

Experiments with more exotic materials should be limited to test areas, not petroglyphs. Tests with liquid latex on sandstone show it peels away the surface.

After the surface of the clay impression is touched up, a clay dike is built up around the design. Plaster is then mixed with the required amount of water and poured into the mold. A plaster product called Hydracal—harder and heavier than plaster of paris—gives good results. The mold can be agitated to encourage air bubbles to rise away from the mold surface. The plaster will set up in about half an hour for moderately sized glyphs so that the cast can be released and the mold recycled for another glyph.

After the cast is thoroughly dry the surface may be painted to suggest the appearance of the original rock wall. This step is usually executed in the lab where conditions can be controlled. Spray paints in flat earth-tones yield a handsome finish.

Another technique used by George Jelinek, educator and legislator from Ellsworth, Kansas, involves coating the surface of the cast with powdered sandstone from broken fragments picked up at the site where the design was found. This technique, using thinned white glue painted on the cast, provides a wonderfully authentic texture, but it still requires painting to achieve the surface color of the patina on the original petroglyph surface. On some delicate carvings, the coating of sand may fill in some of the finer grooves as well.

A good cast can be used for the most effective demonstration of the importance of the direction and intensity of light while photographing or studying petroglyphs. As a cast is turned, an observer will quickly see how shadows change and different lines show up more clearly.

Interpretation

Field excursions with all their excitement and contact with the outdoors are an important part of the fun of petroglyph research, but for many the most satisfying part of the experience is the reflective work at home or in the lab, classifying, dating, and striving to find the meaning of the drawings.

Background information that will give insight into the drawings in the plains area is in Garrick Mallery's exhaustive *Pictographs of the North American Indians* (1860). This report contains photographs of the buffalo robes containing the Dakota Sioux winter count—the method these people used to keep track of the years.

In general, the carvings seem to be related to simple and basic needs of man. One is to record the feeling, "I am here," by making a mark on the cliff wall. The universality of that feeling is underscored by the strength of that same urge today. It is thought to have prompted the stenciled outlines of handprints in the Lascaux cave in France.

Another motivation is an attempt to acquire a degree of magical power over game or foes in battle. Early writers in their travels across North America report that Amerinds had some "superstitions" about the power of pictures. Some writers believe that certain petroglyphs may be a form of map, and some an inventory of game in a region. Some of them undoubtedly were carved to commemorate a specific event. Unfortunately, at present, not every one of them can be fully explained—thus deepening their fascination.

Conclusion

There are still petroglyphs to be discovered, studied, photographed, and interpreted. Since rock hobbyists are apt to be in areas where they may be found, it is hoped this article will help visitors become aware of the Indian rock carvings, appreciative of their significance, and protective of their existence. Important to remember is that petroglyphs—interesting as they are—can be found ON the rocks, not IN them.

Selected Readings

Denney, J. 1976. Petroglyphs: Indian art or graffiti? *Omaha World Hearald,* Oct. 24: 6-8.

Grant C. 1967. *Rock art of the American Indian.* New York: Thomas Y. Crowell Co. 178 p.

Hedden, M. 1958. Surface printing as a means of recording petroglyphs. *Amer. Antiquities.*

Hughes, S. P. 1915. An Indian cave in the wilds of southeast Nebraska. *Omaha World,* Jan. 30, p. 7.

Mallery, G. 1860. Pictographs of the North American Indians, Smithsonian Inst.: *U.S. Bureau of Ethnology. 4th Ann. Rept.*

Miller, E. 1868. Report with accompanying photographs. *Proc. American Philos. Soc.* 10:381-387.

Quick, J. H. 1892. *Pictographs of the North American Indians.* Sci. Assoc. Sioux City, [Unpubl. Paper]. Archives #74, Rumsey Room, Sioux City Public Museum.

Wedel, W. 1961. *Prehistoric man in the great plains.* Univ. Oklahoma Press. 355 pp.

OFFICIAL SHOW PROGRAM

State Capitol, Lincoln, Nebraska. Nebraska Game Commission photo.

1980 Midwest Federation and Convention and Show American Federation June 12, 13, 14, 15, 1980

WELCOME TO LINCOLN !

HOWARD J. TAYLOR

On behalf of the Lincoln Gem & Mineral Club, the members of our Show Committee and the friendly people of Lincoln, we welcome you. We will have many fine exhibits, displays, demonstrations, slide programs, and lectures. The show will feature one hundred dealers. Sixty of these will be retail dealers and forty will be wholesale dealers. They have been selected from across our nation so visitors will have a fine selection of materials and supplies.

One of the best accommodations we have for visitors is an enormous amount of FREE parking. All of our camping facilities are within walking distance of the show site. The show site itself is air-conditioned and our headquarters hotel is just 16 blocks straight east of the show site. We will have an information booth at the entrance to the show. If you have any questions please go to this booth for help.

With a big Welcome we say "I-80 TO LINCOLN IN '80."

Howard J. Taylor
Show Chairman

Consider this your SPECIAL INVITATION from the Midwest Federation of Mineralogical and Geological Societies to attend the combined Midwest Federation and American Federation Convention and Show.

The friendliest folks in the world live in Nebraska, and the welcome mat is out. All roads lead to Lincoln, and that's where you will want to be June 12, 13, 14 and 15th.

This year, 1980, marks the 40th anniversary of the Midwest Federation as well as the 25th anniversary of the Lincoln Gem & Mineral Club. So look for spectacular exhibits, excellent programs, opportunities to increase your knowledge, improve your skills, add to your collection, and make new friends.

The show promises to be comfortable, affordable, and enjoyable. A few days in Lincoln will bring a year of lasting pleasure.

We hope you will join us.

Bernice McCloskey
President—MWF

BERNICE McCLOSKEY

ACTIVITIES SCHEDULE

JUNE 8-15, 1980

HEADQUARTERS HOTEL—Nebraska Center for Continuing Education,
3300 Holdrege Street, Lincoln, Nebraska 68503
SHOW SITE—Bob Devaney Sports Center, 15th and Military Road,
Lincoln, Nebraska 68508

SUNDAY, JUNE 8

2:00 p.m.	Registration (Early Arrivals)	Headquarters Hotel

MONDAY, JUNE 9

8:00 a.m.	Registration	Headquarters Hotel
9:00 a.m.	Uniform Rules Meeting	Headquarters Hotel
12:00 noon	Lunch, no-host	Headquarters Hotel

TUESDAY, JUNE 10

8:00 a.m.	Registration	Headquarters Hotel
9:00 a.m.	Uniform Rules Meeting (Continued)	Headquarters Hotel
12:00 noon	Lunch, no-host	Headquarters Hotel
7:30 p.m.	AFMS Cracker Barrel Session	Headquarters Hotel

WEDNESDAY, JUNE 11

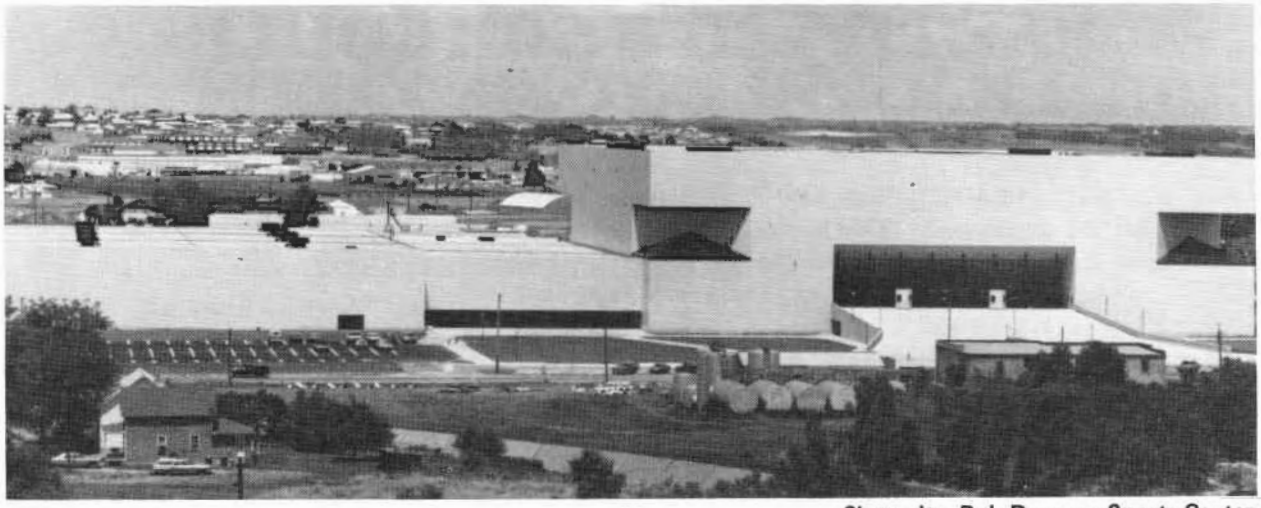
8:00 a.m.	Set up for Retail and Wholesale Dealers, Guest Exhibits Competitive Exhibits, Manufacturers, Demonstrators, and Special Exhibits	Show Site
8:00 a.m.	Registration	Headquarters Hotel
9:00 a.m.	AFMS Officers and Directors Meeting (Visitors welcome); AFMS Scholarship Foundation Meeting - immediately afterward	Headquarters Hotel
10:00 p.m.	Completion of set up	Show Site

Judges Room Open

THURSDAY, JUNE 12

9:00 a.m.	Ribbon Cutting Ceremonies	Show Site
9:00 a.m.	Show Officially Opens	Show Site
	Printed program at the show will detail daily lecture program.	
12:00 noon	Judges Luncheon	Show Site
6:00 p.m.	Fried Chicken Picnic	Show Site
9:00 p.m.	Show Closes	Show Site

LOOK FOR *ROCKS AND MINERALS* AT THE NEBRASKA SHOW. STOP BY THE BOOTH AND VISIT AWHILE.



Show site, Bob Devaney Sports Center.

FRIDAY, JUNE 13

8:00 a.m.	Editors Breakfast	Headquarters Hotel
9:00 a.m.	Midwest Federation State Directors Meeting	Headquarters Hotel
9:00 a.m.	Show Opens	Show Site
10:00 a.m.	Midwest Federation Executive Meeting	Headquarters Hotel
12:00 noon	All Past Presidents Luncheon	Headquarters Hotel
1:30 p.m.	Midwest Federation Executive Meeting (Continued)	Headquarters Hotel
1:30 p.m.	American Federation of Mineralogical Societies Past Presidents Meeting	Headquarters Hotel
9:00 p.m.	Show Closes	Show Site

SATURDAY, JUNE 14

9:00 a.m.	Show Opens	Show Site
9:00 a.m.	Delegates Registration	Headquarters Hotel
10:00 a.m.	Midwest Federation Council Meeting	Headquarters Hotel
12:00 noon	Midwest Federation Council Luncheon	Headquarters Hotel
1:30 p.m.	Midwest Federation Council Meeting (Continued)	Headquarters Hotel
6:00 p.m.	Social Time	Headquarters Hotel
6:30 p.m.	Awards Banquet	Headquarters Hotel
9:00 p.m.	Show Closes	Show Site

SUNDAY, JUNE 15

8:00 a.m.	Photographers Hour	Show Site
8:00 a.m.	Ye Olde Timers Breakfast	Headquarters Hotel
9:00 a.m.	Show Opens	Show Site
9:00 a.m.	Rollin' Rock Club	Headquarters Hotel
10:30 a.m.	Worship Service	Show Site
5:00 p.m.	Show Closes	Show Site

ATTENTION ALL VISITORS WITH C.B. RADIOS: The Show Committee has arranged for Channel 13 to be monitored at all times from June 8 through June 15. While you are traveling in and around the Lincoln area all information about the show may be obtained by asking for GEM SHOW CONTROL.

FIELD TRIPS: Although there will be no collecting trips planned in conjunction with the show, information for self-guided trips will be available at the information booth.

1979 - 80 Federation Officers

MIDWEST FEDERATION

President . . . . . Bernice McCloskey
P.O. Box 527
Elm Grove, Wisconsin
53122

First Vice President . . . . . Milford J. Sharp
3901 West 210th Street
Fairview Park, Ohio 44126

Second Vice President . . . Larry Nawojski
22757 Redwood Drive
Richton Park, Illinois
60471

Secretary . . . . . Jean Reynolds
107 Tuttle Avenue
Clarendon Hills, Illinois
60514

Treasurer . . . . . William Parch
Oakdale, Wisconsin 54649

Meetings of both the Midwest and American Federations will be held in conjunction with the show. See preceding page for time and place. Additional information can be obtained at the information booth or by writing the federation presidents.

AMERICAN FEDERATION

President . . . . . Ellwood T. Rees, M.D.
806 El Monte Street
Twin Falls, Idaho 83301

Executive Vice President . Dan Caudle
1248 Prince Road
Tucson, Arizona 85719

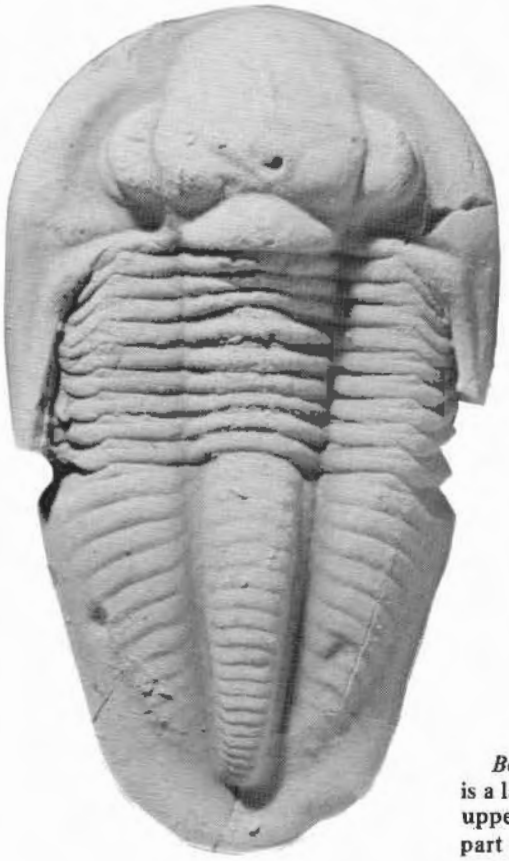
Treasurer . . . . . Barbara Goss
2037 Fremont Street
Sarasota, Florida 33583

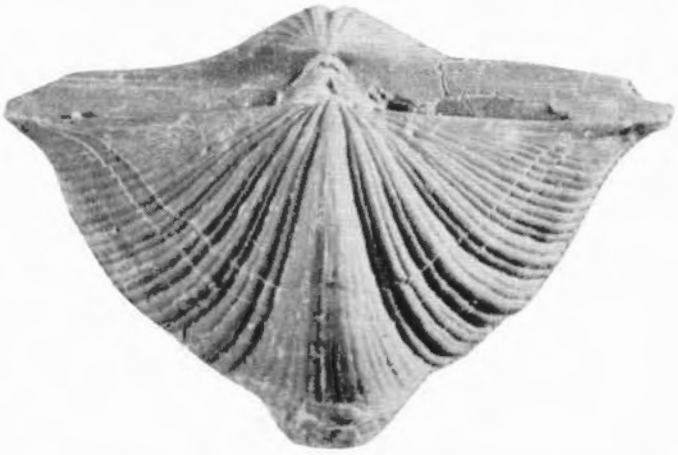
Secrerary . . . . . Henry Bonar
231 McGlamery , Rt. 1
Odessa, Florida 33556

Sr. Reg. Vice President . . . Bill Cox
9039 Katy Freeway, #230
Houston, Texas 77024

Jr. Reg. Vice President . . . Betty Crawford
1119 Seminole Avenue
Mansfield, Ohio 44906

Executive Secretary . . . . . Mignon Wagner
611 Clifford Drive
Austin, Texas 78745





Above: Neospirifer kansasensis (Swallow), a large, ornate brachiopod characteristic of fossils found in the upper parts of nearshore shales and the middle to upper parts of regressive limestones.

Left: The trilobite, *Amerura missouriensis* (Shumard), is an ornate species that characterizes the nature of fossils from the transgressive limestone or lower part of the regressive limestone.

Below right: Graffhamicrinus magnificus (Strimple) is a large, ornate crinoid typical of fossils found in the upper part of a nearshore shale or middle to upper part of a regressive limestone.

Below left: A conodont fossil, *Ozarkodina* sp. aff. *O, kansasensis* von Bitter, X139. Conodonts are useful microfossils for stratigraphic and paleoecological studies. After von Bitter, 1972.

Collecting in Nebraska's Pennsylvanian-Permian Strata

ROGER K. PABIAN
University of Nebraska
Lincoln, Nebraska 68588

Pennsylvanian-Permian age rocks in Nebraska contain fossil assemblages similar to those found in rocks of the same age in Iowa, Kansas, Oklahoma, and Texas.

In late Pennsylvanian time the area now occupying the Great Plains and much of the Midwest was located about 2 to 10 degrees north of the equator, which roughly approximated the axis of the Appalachian Mountains. Northern Oklahoma, Kansas, Missouri, Nebraska, Iowa, Illinois, and Indiana were periodically covered by extensive seaways. With the exception of periods of submergence and emergence of land areas, the above region was characterized by relatively stable environments that covered much of the western interior and persisted for relatively long time spans. Thus, the sediments and ensuing sedimentary rocks that cover this area can be traced laterally over hundreds of square miles. This observation is especially true regarding some of the thin limestone beds and overlying black shales. It is, therefore, no surprise that Pennsylvanian-Permian age rocks in Nebraska contain fossil assemblages similar to those found in rocks of the same age in Iowa, Kansas, Oklahoma and Texas.

Cyclic Sedimentation

In the late 1920s and early 1930s, geologists recognized that bedded sedimentary rocks in Kansas and Nebraska occurred in similar, repeating, vertical sequences. For example, a thick shale would be followed upward by a thin, dense, highly fossiliferous limestone, another shale bed, usually containing a slate-like black shale, and a thick, massive limestone. Such repetitive beds were termed *cyclothems* by Wanless and Weller (1932). Various models of cyclic deposition have subsequently been described (Moore 1929, 1930, 1931; Weller 1930; Elias 1934, 1937; Heckel and Baesemann 1975; Heckel 1977; Merrill and Von Bitter 1976 and others). For the purposes of this article the cyclic model prepared by Heckel and Baesemann (1975) and Heckel (1977) is being used, since it seems to be applicable to Pennsylvanian-Permian rocks over the greatest geographical area.

Nearshore Shales

These beds may contain sandstones, sandy shales and, locally, coal. The nearshore shale may contain continential deposits and fossil plant remains in the lower parts and marine deposits with warm, shallow water fossils in the sandy upper parts. The geological importance of nearshore shales is that they mark the onset of a marine invasion of an existing land mass.

A typical example of a nearshore shale is the Stull Shale Member of the Kanwaka Formation. This unit is exposed in an abondoned quarry one mile north and 1.7 miles east of Weeping Water in Cass County. (See Trip #1.) The Stull Shale at Weeping Water contains numerous, large shelled, ornate invertebrate fossils, including corals, bryozoans, brachiopods, mollusks, crinoids, and trilobites.

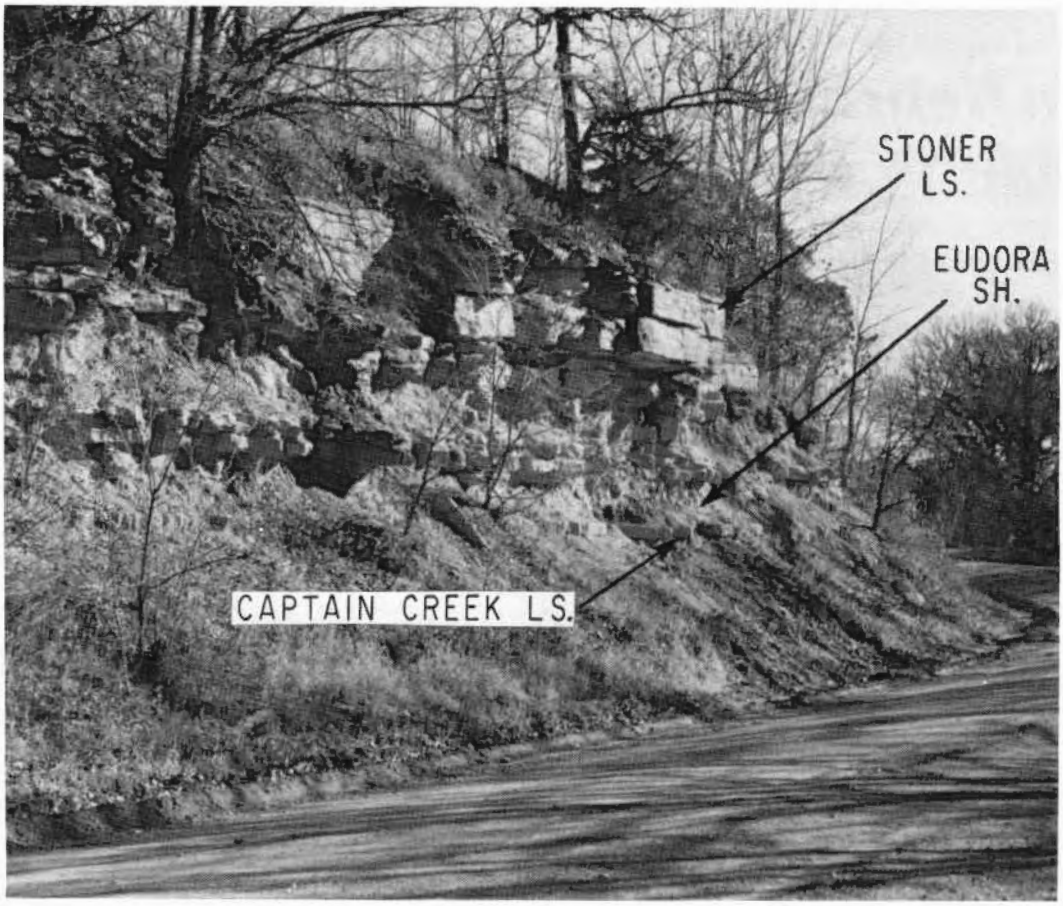
Transgressive Limestone

Lying above the nearshore shales are thin (0.3 to 1.5 m), dense, dark, extremely fossiliferous limestone beds. The fossils in these rocks are difficult to see in rough, hand specimens, since the rock is so dense. Polished samples or thin sections easily show the fine grain and abundant fossils which indicate the rock was deposited in an open marine environment below effective wave action. (Some lapidaries consider the transgressive limestones a good medium for making carvings and ornaments because of the dense nature of the rock and the color contrast between the matrix and fossils.)

The contact between the transgressive limestone and overlying offshore shale marks a point of near maximum transgression (advance) of the sea. This period was characterized by long-term stability of physical factors allowing for delicate ecosystems to become established (Sanders 1971). Here one finds the greatest abundance and diversity of marine fossils, including foraminifers, corals, bryozoans, brachiopods, clams, nautiloids, trilobites, crinoids, and fish teeth.

Collectors desiring to sample a contact between a transgressive limestone and an offshore shale may do so at an abandoned quarry near Louisville. (See Trip #2.) The section at this quarry is given in Burchett and Reed (1967, p. 54, stop 5) and Heckel et al. (1979, p. 54, stop 20). The fossils occur

Roger Pabian is a research geologist at the University of Nebraska, Conservation and Survey Division–IANR, in Lincoln, Nebraska.



Cyclothemic sequence of Pennsylvanian sedimentary rocks near Gretna, Nebraska. Note "paired" transgressive limestones, the Captain Creek Member of the Stoner Limestone and limestone above Eudora Shale. The Eduora is a black shale here, and this bed can be laterally traced to almost the Kansas-Oklahoma border.

at the top of the Captain Creek limestone. The fossils are small and inornate and are thought to have lived in cold, deep water.

Offshore Shales

Beds of thin (0.3 to 2.0 m), black, fissile, laterally persistent shales lie immediately above the transgressive limestone. These shales are characterized by the absence of sandy material and by abundant phosphate nodules, all of which suggests that they were deposited in very deep, oxygen-starved water. Most fossils are uncommon in the offshore shales, but occasionally exceptional fossils such as complete fishes, sharks, and nautiloids have been found in them. One group of fossils that is both abundant and diverse in the offshore shales is the conodonts. Conodonts are animals of unknown affinities, but these fossils have been very useful in developing a cyclic deposition model as well as for correlation of Pennsylvanian strata in the mid-continent.

Regressive Limestones

Above the offshore shales are beds of limestones which are generally thicker (up to 9 m) than the underlying transgressive limestones and which show a greater variation. The fossils in the lower part of the regressive limestone are very similar to those found at the top of the transgressive limestone. Sometimes a shaly bed appears at about 0.3 m above the lower bed of the regressive limestone, creating the image that the transgressive limestones and offshore shales are paired. This condition suggests a minor period of deepening in a general period of sea withdrawal.

As the sea regression continued, water depths decreased and temperatures increased. Large, ornate invertbrate fossils, found in the middle parts of the regressive limestone, suggest this relationship. The greatest variety of limestone facies occurs in the regressive limestones. This is due to the shallow water and differences in sea bottom topography that did not exist during deposition of earlier transgressive limestones. In southeastern Kansas, the regressive limestones thicken and grade upward into phylloid algal mounds. In northeastern Kansas these limestones grade upward into skeletal limestones with some abraded algal and fossil fragments. Northward in Nebraska, the regressive limestones grade upward into unfossiliferous, dolomitic limestones with locally abundant mud cracks, recording a tidal flat. Regressive limestones may display conspicuous shoal water facies such as oolite near their tops, and, in some instances, cherty horizons representing caliche soil formations can be seen.

A good example of a regressive limestone is in the roadcut 0.1 mile west of Weeping Water, Nebraska, on spur road 13K (Trip # 3). Numerous, large, ornate horned corals and other invertebrate fossils can be found here. A second outcrop is in a roadcut 0.7 mile west and 0.1 mile south from the junction

of spur road 13K and State Highway 50 (Trip #4). Here one sees the regressive Ervine Creek Limestone Member of the Deer Creek Formation and its relationship to the transgressive Larsh Shale and Rock Bluff Limestone below.

The regressive limestones are covered by a new nearshore shale that is a green to red, sandy shale with siltstones and few fossils. Such shales are often non-marine and have been subjected to subareal weathering.

Predicting Collecting Sites

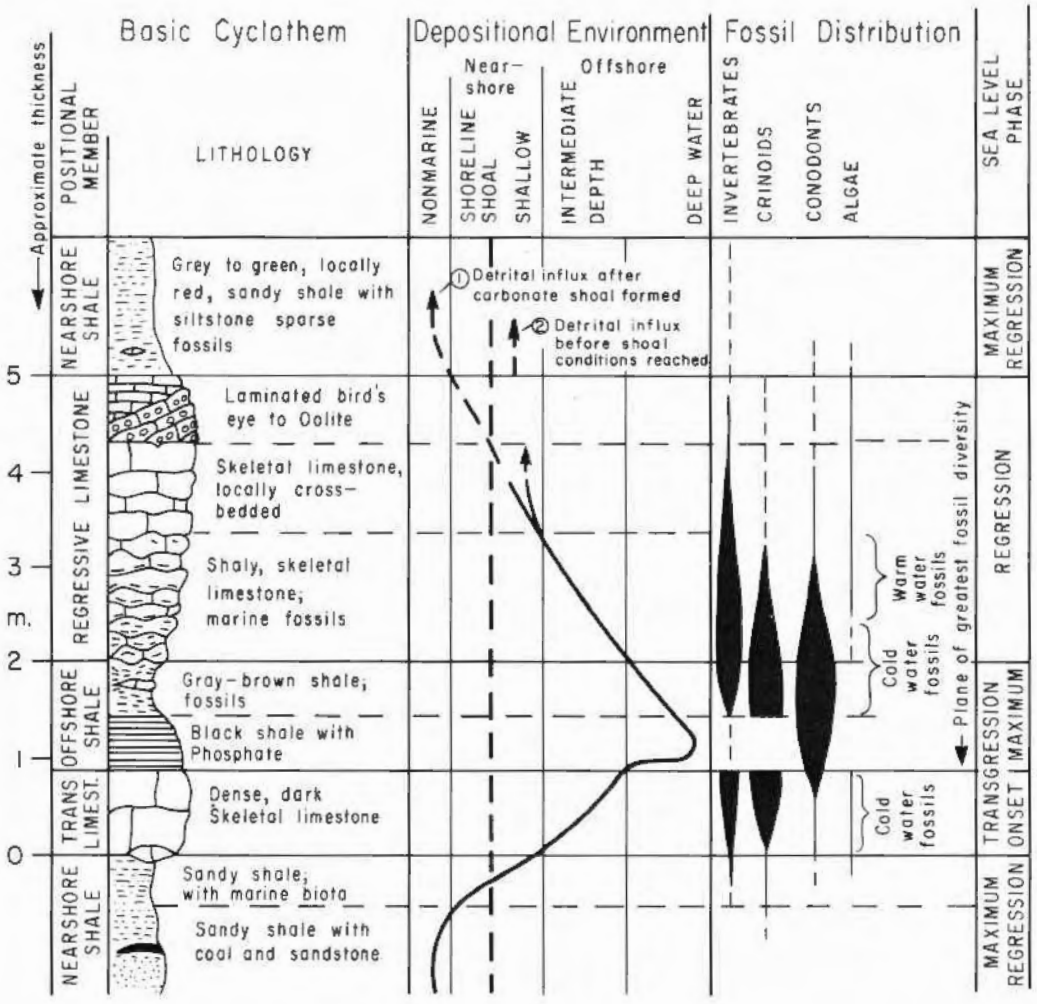
The cyclic deposits of Pennsylvanian and Permian ages in Nebraska and adjoining states can be of great importance and interest to the hobbyist not only in an academic sense but also in predictability of field trip yields.

Nearshore shales may yield plant remains in their lower portions and marine invertebrate fossils (especially mollusks) near the top.

Transgressive limestones are extremely dense and some are suitable for lapidary work. Sulfide minerals such as pyrite and sphalerite can be found in these beds, since they were deposited in oxygen deficient water. The contact between the transgressive limestone and the offshore shale above is usually a very crumbly, thin shale (about 50 mm thick) that yields a diverse fossil assemblage of usually small, thin-shelled, inornate animals that lived in deep, cold water. The ideal way to collect this material is to scoop up a small sackful of the shaly contact material and soak it in soda water for a day or so. The mud can be washed in a sieve, and the residue contains numerous fossils.

Offshore shales contain numerous microfossils but only a few macro fossils. The black, fissile shale may yield occasional fish fossils.

Regressive limestones contain many fossils. The fossil assemblage near the bottom of the regressive limestone is usually similar to that at the top of the transgressive limestone. Nearer the top of the regressive limestone, large, ornate fossils characteristic of warm, shallow water are found. Oolite and colorful cherts may occur at the top of regressive limestone beds. Most mineral crystals occur in regressive limestone beds. In these beds one may find geodes lined with quartz and calcite and containing accessory minerals such as barite, celestite, chalcopyrite, and sphalerite.



Basic vertical sequence of an individual cyclothem, the basic transgressive-regressive depositional unit. This model, with only minor variations, characterizes most of the rocks deposited in the North-American mid-Continent during late Pennsylvanian time. (Modified after Heckel 1977.)

SUGGESTED FIELD TRIPS

The following trips are designed to acquaint the novice with the cyclic nature of Pennsylvanian-Permian sedimentary rocks and their great lateral extent in the central United States.

	TRIP NUMBER AND LOCATION	STRATIGRAPHIC AND CYCLOTHEMIC DESIGNATION	COLLECTIBLE MATERIAL, REMARKS
1.	Abandoned quarry 1 mile north and 1.7 miles east of Weeping Water. (Private property-obtain permission.)	Doniphan Shale, Nearshore Shale? Spring Branch Limestone, Transgressive Limestone at base? Stull Shale, Nearshore Shale. Clay Creek Limestone. Jackson Park Shale. Kereford Limestone Shoal Facies, Regressive Limestone. Hermader Shale. Plattsmouth Limestone, Regressive Limestone.	Numerous, warm-water invertebrate fossils throughout Stull Shale and Doniphan Shale. Note abundant fusulines in Kereford Limestone. Compare Stull Shale biota to Captain Creek and Basal Stoner Limestone biotas.
2.	Abandoned quarry 1.2 mile, west of jct. of state Hwys. 50 & 31, north of Platte River. (Private. Permission needed.)	Southbend Limestone, Transgressive at Base? Rock Lake Shale, Nearshore Shale. Stoner Limestone, Regressive Limestone. Eudora Shale, Offshore Shale. Captain Creek Limestone, Transgressive Limestone. Vilas Shale, Nearshore Shale. Spring Hill Limestone, Regressive Limestone. Hickory Creek Shale, Offshore Shale. Merriam Limestone, Transgressive Limestone.	Marine invertebrate fossils from basal Stoner Limestone. Most beds below Merriam Limestone now covered. Outcrop belt continues along Platte River about 2.8 miles west of quarry along Hwy. 31.
3.	Roadcut, 0.1 mile west of Weeping Water on Spur Road 13K.	Rakes Creek Shale, Nearshore Shale. Ost Limestone, Regressive Limestone? Kenosha Shale, Offshore? Avoca Limestone, Transgressive Limestone. King Hill Shale, Nearshore Shale. Beil Limestone, Regressive Limestone.	Marine invertebrate fossils, especially many corals. Note size differences in fossils from this outcrop and above outcrop.
4.	Roadcut and abandoned quarry (private property) 0.7 mile west & o.1 mile south of jct. of Hwy. 50 and Spur 13K near Weeping Water.	Ervine Creek Limestone, Regressive Limestone. Larsh Shale, Offshore Shale. Rock Bluff Limestone, Transgressive Limestone. Rakes Creek Shale, Nearshore Shale.	Diverse fauna, especially in shale about 1 foot above base of Ervine Creek Limestone.
5.	Roadcut 2.7 miles south of Humboldt, NE on State Hwy. 109.	Howe Limestone. Bennett Shale. Glenrock Limestone. Johnson Shale. Long Creek Limestone. Hughes Creek Shale, contains regressive Limestone above, black Shale below. Americus Limestone, Transgressive Limestone. Many units below covered.	Howe Limestone contains calcite crystals. Long Creek Limestone contains calcite geodes. Hughes Creek Shale exposed at jct. of county road and Hwy. 109 contains numerous fossils. Note 17 degree NE dip on on beds due to Humboldt fault. Excellent Permian fauna.

TRIP NUMBER AND LOCATION		STRATIGRAPHIC AND CYCLOTHEMIC DESIGNATION	COLLECTIBLE MATERIAL, REMARKS
6.	Roadcut 1 mile south and 1.1 miles east of jct. of Hwys. 109 and 8 near Humboldt. Junction is 7.6 miles south of Humboldt.	Cottonwood Limestone, (caps hills nearby). Eskridge Shale, Nearshore-Fresh water? Neva Limestone, Regressive Limestone. Salem Point Shale. Burr Limestone, Regressive Limestone. Legion Shale, Offshore Shale. Sallyards Limestone, Transgressive Limestone? Roca Shale, Nearshore?	Invertebrate fossils common-sponges abundant in Neva Limestone. Many geodes near top of Eskridge Shale. Note numerous glacial erratics covering hills to north of outcrop.
7.	Roadcut 1.5 miles east of Odell on Hwy. 8.	Odell Shale, Outside Shale? Cresswell Limestone. Grant Shale, Regressive?	Numerous marine fossils and geodes with quartz, calcite, and barite.

REMINDER TO COLLECTORS

When collecting, it is important that the following guidelines, taken from the American Federation Code of Ethics, be observed: Do not collect on privately owned land without the owner's permission; use no blasting material in collecting areas; cause no willful damage to property; leave all gates as found; fill all excavation holes which may be dangerous to livestock; cause no willful damage to collecting material and take home only what can be reasonably used; discard no burning material; build fires in designated or safe places only and be certain that they are completely extinguished before leaving; and ascertain the boundary lines on property on which collecting is planned.

Selected Readings

Burchett, R.R. 1970. *Guidebook to the geology along the Missouri River bluffs of southeastern Nebraska and adjacent areas.* Conservation and Survey Division, University of Nebraska-Lincoln, 23 p.

——— 1971. *Guidebook to the Geology along portions of the lower Platte River Valley and Weeping Water Valley of eastern Nebraska.* Conservation and Survey Division, University of Nebraska-Lincoln, 38 p.

———, and Reed, E.C. 1967. *Centennial guidebook to the geology of southeastern Nebraska.* Conservation and Survey Division, University of Nebraska-Lincoln, 83 p.

Heckel, P.H. 1977. *Origin of phosphatic black shale facies in Pennsylvanian cyclothems of Mid-continent North America.* American Assoc. Petrol. Geol., Bull. 61:1045-1068.

——— and Baesemann, J.F. 1975. *Environmental interpretation of conodont distribution in Upper Pennsylvanian (Missourian) megacyclothems in Eastern Kansas.* American Assoc. Petrol. Geol., Bull. 59:486-509.

———, Brady, L.L.; Ebanks, W.J.; and Pabian, R.K. 1979. *Pennsylvanian cyclic platform deposits of Kansas and Nebraska.* Ninth International Congress of Carboniferous Stratigraphy and Geology. Field Trip. No. 10. Guidebook, Ser. 4, Kansas Geol. Surv.

———, et al. 1978. *Field guide to Upper Pennsylvanian cyclothems limestone facies in eastern Kansas.* Society of economic Paleontologist and Mineralogists, 52nd Ann. Mtg. and American Association Petroleum Geologists, 63rd Ann. Mtg., SEPM Field Trip #2, Guidebook. 77 p.

Meriam, D. F., ed. 1964. *Symposium on cyclic sedimentation, Kansas.* Geol. Surv., Bull. 169, 1:380 p., v. 2.

Moore, R.C. 1931. *Pennsylvanian cycles in the Northern Mid-continent Region.* Illinois Geol. Surv., Bull. 60: 247-257.

——— 1964. "Paleoecological aspects of Kansas Pensylvanian and Permian cyclothems". *Merriam,* D.F., ed. Symposium on Cyclic Sedimentation. Kans. Geol. Surv., Bull. 169, 1:287-372.

Pabian, R. K. and Strimple, H. L. 1979. "Notes on biometrics, paleoecology, and biostratigraphy of *Cibolocrinus conicus.* Strimple from Oklahoma, Kansas, and Nebraska." *Jour. Paleont.* 53:421-437.

Reed, E.C. and Burchett, R.R. 1964. "Stratigraphic sequences in the Pennsylvanian of Nebraska and their relationships to cyclic sedimentation" *in* Merriam, D.F., *ed.* Symposium on Cyclic Sedimentation. Kansas Geol. Survey Bull. 169, (2): 441-447.

Sanders, H.L. 1971. *Benthic marine diversity and the stability-time hypothesis.* Brookhaven Symp. Biol. 22: 71-81.

Stout, T.M. 1970. *Re-exploring the Missouri.* Guidebook, 2nd Field Conf., Nebraska Geol. Soc., May 22, 1970. An excursion aboard Corps of Engineers Inspection Boat, "The Sergent Floyd," from Omaha to Rulo, Nebraska.

To motorists traveling on Interstate 80 the geology of western Nebraska probably looks quite simple. The few visible outcrops appear to contain horizontal, rather unexciting strata, certainly nothing to write home about. Fortunately the pioneers traveled the Great Platte River Road past interesting outcrops like Ash Hollow, Courthouse and Jail rocks, Chimney Rock, and Scotts Bluff, all of which provided some inspiration for diaries and letters home.

Introduction

Exposures along the North Platte and Niobrara river valleys and on Pine Ridge allow a glimpse of the fascinating and complex geologic history of western Nebraska during the last 35 million years. Geologists and paleontologists have been studying the sequence of Cenozoic strata in this area since the late 1800s. Prior to the 1950s the Cenozoic geologic framework was established on outcrop data. Since that time a considerable amount of information on the subsurface geology of Nebraska has been obtained by drilling holes for geohydrologic information, oil and gas tests, and irrigation wells. This data has provided a more complete picture of Cenozoic geology.

Stratigraphy

Formations are the fundamental lithostratigraphic units for classification of rocks and sediments. They are defined solely on lithologic features (grain size, composition, structure, etc), and their boundaries generally reflect significant changes in lithology. A formation may contain a variety of rock types, and its thickness is not an important consideration. It must, however, be mappable from outcrop to outcrop or correlatable in the subsurface. Formations may be subdivided into members or beds, and two or more formations having certain unifying characteristics can be combined to constitute a group. Group ranking provides a very handy means of generalizing and simplifying the complexities of regional lithostratigraphy, since formation nomenclature, particularly for continental deposits, can be as confusing to the professional as to the amateur geologist.

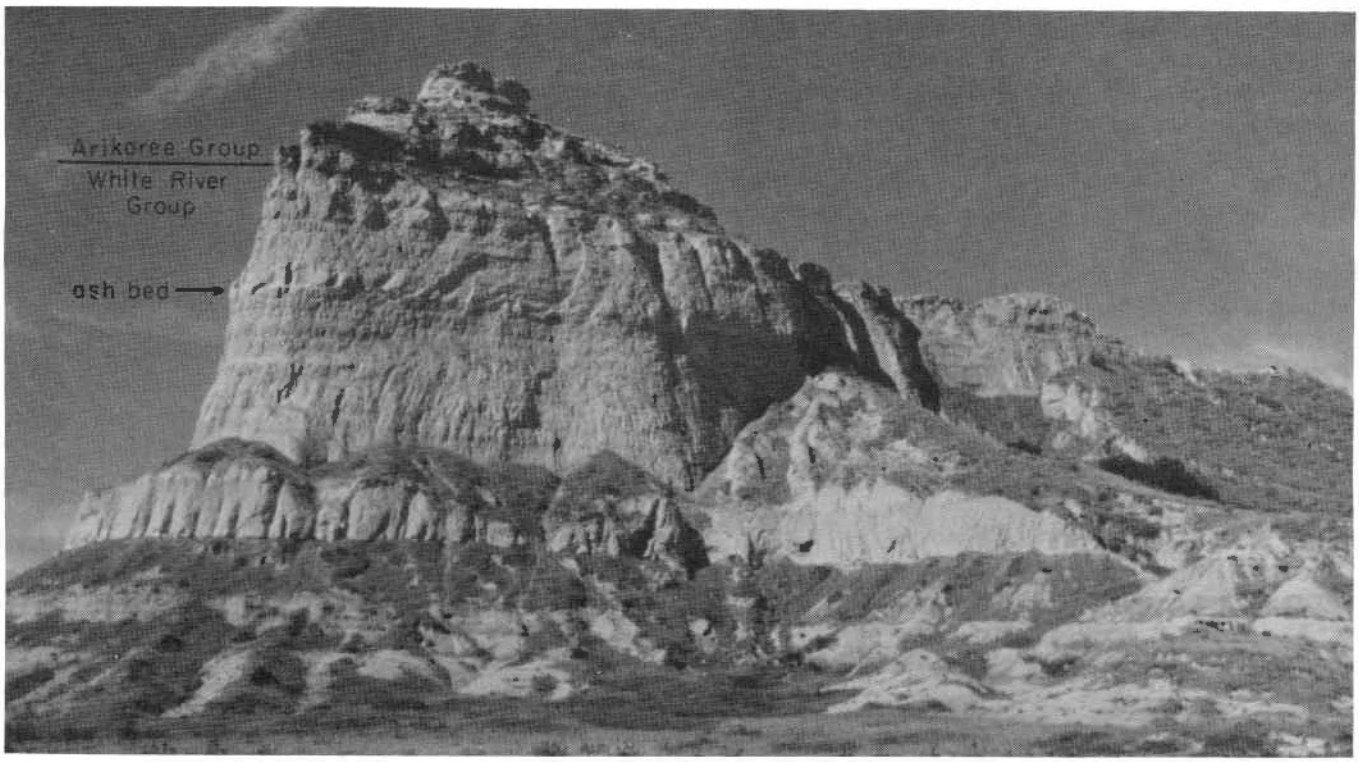
Difficulties in correlating Cenozoic strata of western Nebraska and adjoining areas arise because many formations contain similar lithologies or "look-alikes." Moreover, major outcrops may be widely separated and have only parts of some formations exposed. Also, contacts between formations or groups are not necessarily horizontal because many formations were deposited in ancient river valleys that have been eroded deep into underlying formations. Because of these problems, the establishment and correlation of valid lithostratigraphic units often requires detailed geologic mapping combined with subsurface, petrologic, and paleontologic data.

The Cenozoic (Tertiary plus Quaternary) sedimentary strata of western Nebraska are part of an extensive sequence of continental deposits extending eastward from the Laramie, Front Range, and Hartville uplifts. The geologic history of this region during the last 35 million years is largely a story of the interactions among the following: (1) Agents of deposition—rivers and streams (fluvial sedimentation) versus wind (eolian sedimentation); (2) sources of sediment—igneous, metamorphic, and sedimentary rocks in the Rocky Mountain uplifts of Colorado and Wyoming versus debris from volcanoes in Colorado, Wyoming, and the Great Basin; and (3) erosion. In turn, these factors are controlled to a large part by tectonics and climate.

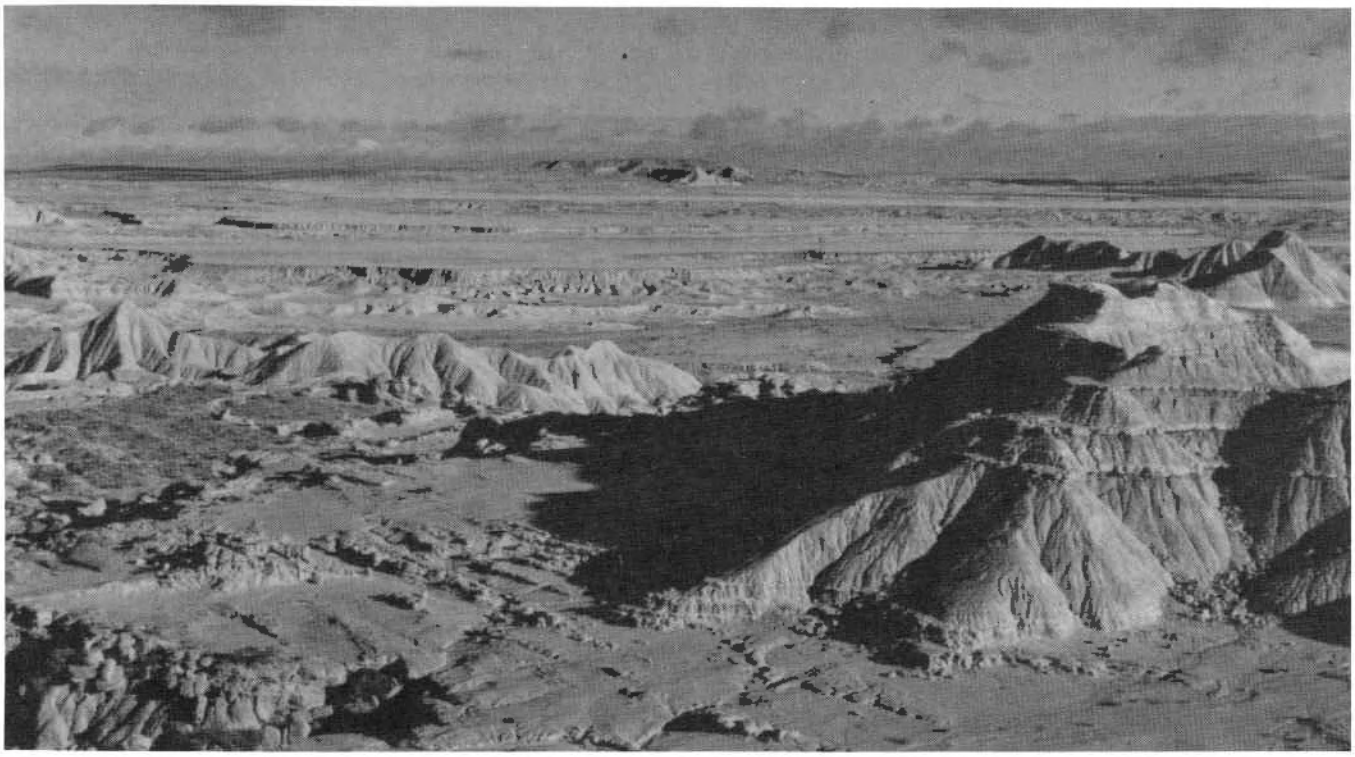
Strata of Cenozoic age in western Nebraska can be divided into one of the following four groups of rocks and sediment: Three formal groups—White River, Arikaree, and Ogallala—and one informal group comprising unconsolidated silt, sand, and gravel deposited during the latest Cenozoic. The many gaps or unconformities in this rock record are the result of erosion or nondeposition. The largest unconformity or missing interval of time and rock is at the base of the White River Group where approximately 30 million years of Cenozoic history is not represented by any strata in western Nebraska.

Collecting in Western Nebraska's Cenozoic Strata

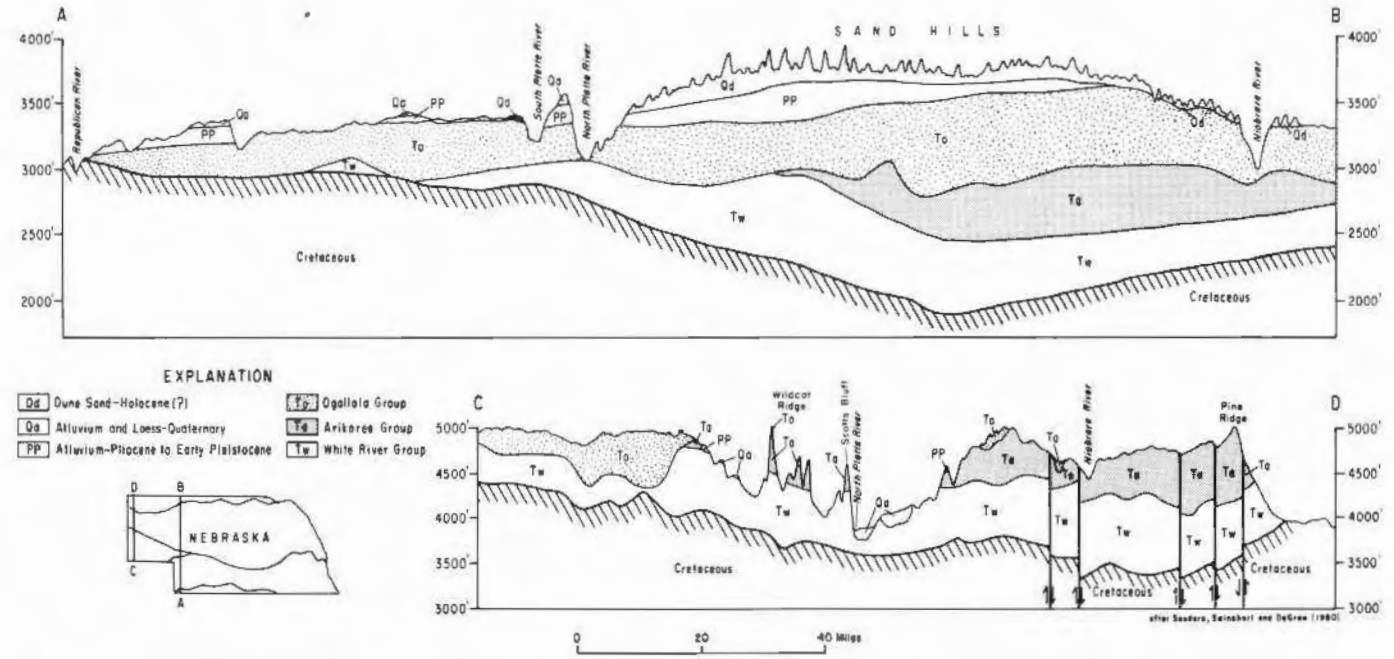
JAMES B. SWINEHART
University of Nebraska
Lincoln, Nebraska 68588

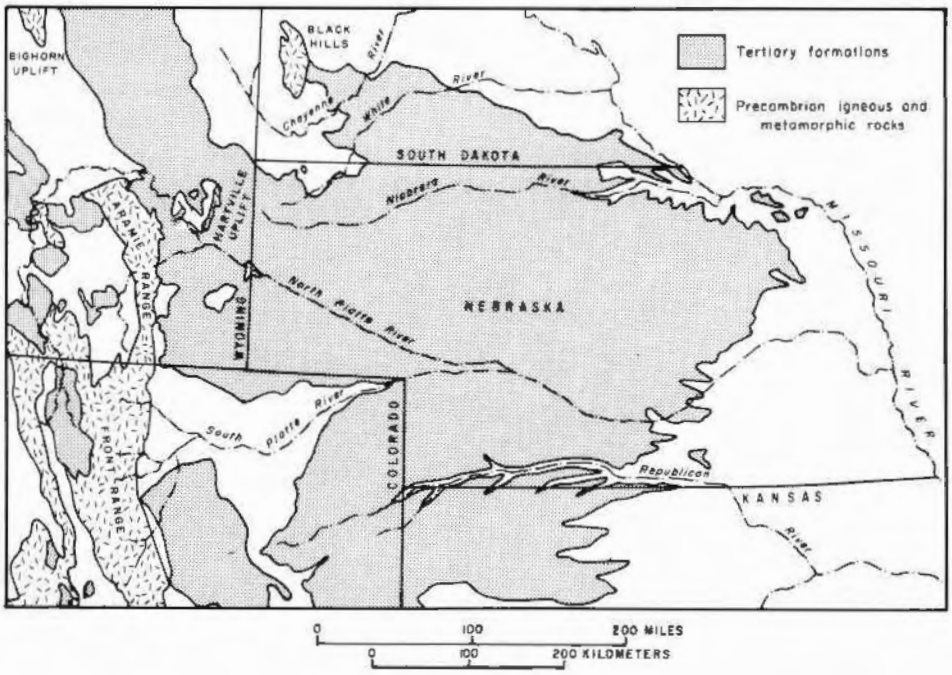


Eagle Rock at Scotts Bluff National Monument. The contact between the siltstones of the White River Group and the sandstones of the Arikaree Group is easily recognized in this area.



The little badlands of the White River Group at Toadstool Park, northwest of Crawford, Nebraska. Thin sandstone beds are sandwiched between thick, fine-grained clayey siltstone beds. Excellent exposures of channel-form fluvial sandstones also occur here.





Above: **Geologic cross-sections through western Nebraska. Cross-section AB follows State Highway 61, and cross-section CD generally follows State Highways 71 and 29.**

Left: **Extent of Tertiary rocks in Nebraska and adjacent areas. Areas of Quaternary sediments have been omitted.**

White River Group—The oldest Cenozoic strata of western Nebraska overlie the truncated surface of Cretaceous rocks and consist predominantly of siltstone and claystone belonging to the White River Group. These rocks are very interesting because they are composed primarily of volcanic dust or ash and contain only a small amount of nonvolcanic material. Microscopic, angular shards of volcanic glass and fragments of volcanic plagioclase are the most common grains. The location of the volcanic centers that produced this ash are not well known but may have been as far away as Nevada or as close as central Colorado. Wherever they were located, tremendous eruptions threw huge quantities of volcanic dust into the atmosphere throughout deposition of the White River Group. This material was carried eastward by high altitude winds and slowly deposited as a succession of blankets over western Nebraska and adjacent areas. Distinct beds, composed almost entirely of glass shards, also were deposited and probably represent very rapid accumulation of material from a single eruption. One such ash bed occurs in the upper part of the White River Group and is known to extend throughout an area of 7,000 square miles in western Nebraska. The maximum thickness of the White River Group is about 1,100 feet.

The clay-rich rocks of the White River Group commonly erode to a "badlands" topography. This fascinating land form is best seen in exposures north of the Pine Ridge between Chadron and the Toadstool Park area.

Sandstones and siltstones deposited as stream channel and floodplain sediments make up only a small part of the White River Group. The basal part of the Chadron Formation locally contains coarse river gravels. These are well exposed north of Crawford and contain "fortification" agates and petrified wood transported from the Hartville Uplift and Laramie Range.

Arikaree Group—Most of the Arikaree Group consists of gray to buff, well sorted, very fine-grained sandstones and sandy siltstones. Like the White River Group, most of these are interpreted to have been wind deposited. They generally contain 25 to 50 percent glass shards and other volcanic grains—not as high a percentage as usually found in the White River Group. A period of erosion preceded deposition of the Arikaree, and several major valley systems were eroded into the underlying White River Group. The oldest formation of the Arikaree, the Gering, fills these valleys. It consists of gray, fine to medium-grained sandstones, along with some coarse sand and gravel beds deposited by rivers draining the Laramie and Front ranges. Fluvial deposits occur throughout the Arikaree but are common only in the Gering Formation. The Harrison and Monroe Creek Formations are very similar in lithology and extremely difficult to differentiate. The maximum thickness of the Arikaree Group is about 850 feet.

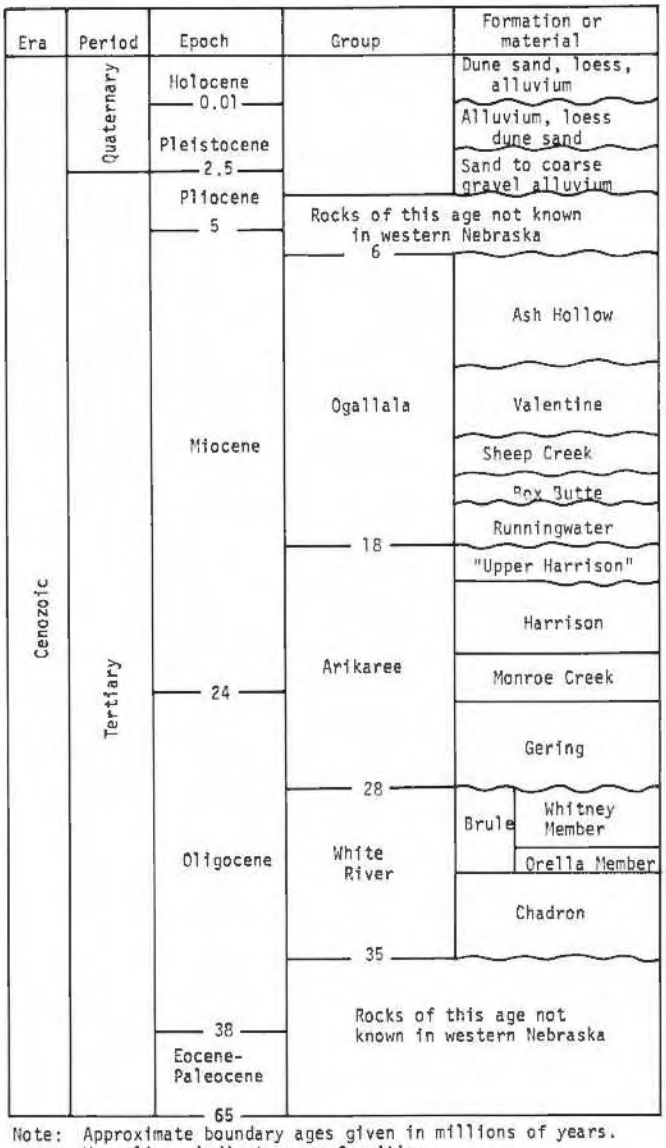
Hard ledges of carbonate-cemented sandstone called pipy concretions are a characteristic feature of many Arikaree outcrops. These concretions probably formed soon after deposition and burial of the sand when calcium carbonate was precipitated out of the groundwater and into the pore spaces around individual sand grains.

Like the White River Group, the greater part of Arikaree sediment was supplied by western volcanoes. However the Arikaree is over a smaller area in western Nebraska than the White River Group. Together these two groups form most of the outcrops of the Wildcat and Pine Ridge.

Ogallala Group—The rocks of the Ogallala Group consist of a wide variety of lithologies ranging from claystones to poorly sorted sandstones to coarse gravel. Moderately well sorted, medium-grained sandstone is probably the most common lithology in western Nebraska. South of the North Platte River coarse sand and gravel is very common in the Ogallala Group. All of these lithologies occur in a bewildering assortment of fluvial deposits, many of which fill deep cuts into underlying strata. For example, in an area of a few square miles on the high divide between the Niobrara and North Platte Rivers at least three separate stratigraphic units within the Ogallala are successively cut into and deposited over one another. These cycles of deposition and erosion span 10 million years. In the southwestern part of the Panhandle only the upper part of the Ogallala is known to be present, yet it fills a valley eroded 500 feet into the White River Group. The Ogallala Group has a maximum thickness of about 700 feet.

In contrast to the Arikaree and White River groups the Ogallala contains only small amounts of glass shards and other fine-grained volcanic debris. However, discontinuous volcanic ash beds occur in most of the formations comprising the group.

The Ogallala is the most widespread Tertiary group in Nebraska. It has been recognized throughout most of the Great Plains from Texas to South Dakota and is one of the major aquifers of the United States.



Note: Approximate boundary ages given in millions of years. Wavy lines indicate unconformities.

Generalized lithostratigraphic classification of Cenozoic rocks in Western Nebraska. This is not a complete list of named formations; current research indicates additional units need to be defined.

James Swinehart is a research geologist with the Conservation and Survey Division–Institute of Agriculture and Natural Resources at the University of Nebraska, Lincoln, Nebraska.

Youngest Cenozoic—An unconformity encompassing several million years occurs between the Ogallala Group and unconsolidated deposits of late Pliocene and Quaternary age. The oldest of these deposits is a complex and extensive body of river-deposited sand and coarse gravels derived from the Laramie and Front ranges. The coarsest material occurs in narrow channels eroded 200 feet deep into Tertiary age rocks. The most extensive outcrops border the north side of the North Platte River valley, where they have been called the Broadwater Formation. This unit also underlies most of the central and southern Sand Hills. Younger and less extensive episodes of fluvial deposition that occurred between periods of erosion are preserved as terraces throughout western Nebraska. Many of these are probably related to periods of glaciation in the Rockies.

During the late Quaternary wind-deposited silt, called loess, was laid down in many parts of Nebraska. Magnificent exposures of this loess can be found on the south side of Lake McConaughy along State Highway 26. Unlike wind deposited silt of the White River Group, this Quaternary loess contains very little volcanic material.

The youngest and most impressive area of wind-deposited sediment in Nebraska is the Sand Hills. Sand dunes, some over 300 feet high and 20 miles long, cover 20,000 square miles of central Nebraska. Now stabilized by vegetation, the Sand Hills are the largest single area of sand dunes in the Western Hemisphere. Recent evidence suggests that a majority of the dunes in the Sand Hills formed between 3,000 and 7,000 years ago during a dry period that affected the entire Midwest. In what recently was a desert, the grass-frozen dunes are now one of the great cattle producing areas of the world.

Fossil Collecting

The Cenozoic strata of Nebraska and adjoining areas have yielded an almost incredible variety of vertebrate fossils—from elephants, mice, and sabre tooth cats to crocodiles, frogs, and birds. The widespread and locally abundant occurrences of these fossils have drawn a steady flow of "bone diggers" into the area. Their findings have gone to museums around the world. In Nebraska, the State Museum in Lincoln and Trailside Museum in Ft. Robinson have displays featuring Cenozoic fossils. At Agate National Monument north of Scottsbluff, visitors can see bones in place at an actual fossil quarry.

Mineral Collecting Areas

White River Group gravels crop out in the grasslands about 20 miles north of Crawford and contain agate, jasper, wood, and other cuttable materials. Chalcedony of very high quality can be found in the fine-grained White River rocks in this same area.

Terraces along the South Platte and North Platte Rivers and their tributaries yield a variety of quartz materials including agate, jasper, and wood. Older gravel deposits occur in the uplands adjacent to these rivers and contain similar materials. Gravel bars on all streams in the southern part of the Panhandle are excellent collecting areas.

Structure

The most prominent structural feature in western Nebraska is the Chadron Arch. It is a broad asymmetrical flexure trending northwest-southeast across west-central Nebraska. While most movement on the arch dates from the Cretaceous or before, sporadic movements probably occurred through the Cenozoic. Several small earthquakes have been associated with the arch in modern times.

Field mapping and test drilling by geologists at the University of Nebraska have documented faulting with up to 250 feet of displacement in Arikaree and White River group rocks in northwest Nebraska. Further research likely will discover additional and younger faulting.

Summary

Cenozoic rocks of western Nebraska are a record of the fascinating history of erosion, deposition, tectonism, and climate during the last 35 million years. It is not, as might first be thought, simply a story of rivers transporting material eroded from the Rocky Mountains and depositing it on the plains. A surprisingly tremendous volume of fine volcanic debris was blown into Nebraska from the west during the middle Cenozoic. This glass-rich material slowly blanketed and built up the landscape during deposition of the White River and Arikaree groups. During late Cenozoic times, fluvial deposition and erosion was the order of the day. The development of a great sea of sand dunes adds a final twist to this intriguing story.

Suggested Readings

Keech, C. F., and Bentall, R. 1971. *Dunes on the plains: Conservation and Survey Div., Univ. of Neb., Resource Rept. no. 4*, 18 p.

Pabian, R. K. 1971. *Minerals and gemstones of Nebraska: Conservation and Survey Div., Univ. of Neb., Ed. Circ. no. 2*, 80 p.

Pabian, R. K., and Swinehart, J. B. 1979. *Geologic history of Scotts Bluff National Monument: Conservation and Survey Div., Univ. of Neb., Ed. Circ. no. 3*, 26 p.

Robinson, P. 1972. *Tertiary history: in geologic atlas of the Rocky Mountain region, U.S.A.* Rocky Mtn. Assoc. Geol., p. 233-242.

Souders, V. L., Swinehart, J. B., and DeGraw, H. M. in press. *Lithostratigraphy of Cenozoic and Upper Mesozoic rocks: western Nebraska, Conservation and Survey Div., Univ. of Neb., Neb. Geol. Survey Paper 20.*

Stout, T. M., and others. 1971. *Guidebook to the Late Pliocene and Early Pleistocene of Nebraska: Conservation and Survey Div., Univ. of Neb.* 108 p.

Museums and Exhibits

A Compilation of Earth Science Exhibits and Displays
Submitted by Roger K. Pabian

CHADRON—Chadron State College Museum, Maine Street, Chadron, Nebraska 69337. Telephone: 308-432-5571. Founded: 1939. Paleontology, natural history, archaeology, mineralogy, anthropology, geology.
Open Monday-Friday, 8:00 a.m.-5:00 p.m. No charge.

CRAWFORD—Fort Robinson Museum, Box 304, Crawford, Nebraska 69339. Telephone: 308-665-2852. Founded 1956. Artifacts, anthropology, ethnology, archaeology, pioneer.
April 1-November 15 open Monday-Saturday, 8:00 a.m.-5:00 p.m.; Sunday, 1:00-5:00 p.m. No charge. Closed November 16-March 31 except by appointment.

GERING—Scotts Bluff National Monument, P.O. Box 427, Gering, Nebraska 69341. Telephone: 308-436-4340. Founded: 1919. Historical artifacts, geology, paleontology, vegetation.
Summer: daily 8:00 a.m.-8:00 p.m.: Winter: daily 8:00 a.m.-4:30 p.m. No charge. Memorial Day-Labor Day, $1.00.

HARRISON—Agate Fossil Beds National Monument, Rural Route, Harrison, Nebraska 69346. Telephone: 308-668-2211. Founded: 1965. Paleontology Museum located on the pre-historic site of 20-million-year-old mammal fossil remains. Collections: fossils, artifacts.
June-August, daily 8:30 a.m.-5:30 p.m.; September-May, Saturday and Sunday, 8:00 a.m.-5:00 p.m. No charge.

HASTINGS—Hastings Museum, 1330 North Burlington, Hastings, Nebraska 68901. Telephone: 402-463-7126. Founded: 1926. Many displays in addition to rocks, minerals, pioneer items, and Indian lore.
Monday-Saturday, 8:00 a.m.-5:00 p.m.; Holidays, 1:00-5:00 p.m. Adults 75¢, children (6-11) 25¢, children under 6 no charge.

KEARNEY—Fort Kearney Museum, 311 S. Central Avenue, Kearney, Nebraska 68847. Telephone: 308-234-5200. Founded: 1950. Many displays in addition to natural history, archaeology, mineralogy, and geology.
Memorial Day-Labor Day, daily 10:30 a.m.-6:00 p.m. Adults $1.25, children no charge.

LEWELLEN—Ash Hollow State Historical Park, Box A, Lewellen, Nebraska 69147. Telephone: 308-778-5651. Founded: 1967. Museum located on the site of Ash Hollow. Archaeology, artifacts, pioneer trail history.
Summer 8:00 a.m.-8:00 p.m. No charge. Closed winter.

LINCOLN—Nebraska State Capitol, 1445 K. Street, Lincoln, Nebraska 68509. Telephone: 402-471-2311. Founded: 1867. Stone and lapidary decorative arts, sculpture.
Monday-Friday 9:00 a.m.-4:00 p.m.; Saturdays and holidays 10:00 a.m.-4:00 p.m. No charge. Closed Christmas.

LINCOLN—Nebraska State Historical Society, 1500 "R" Street, Lincoln, Nebraska 68508. Telephone: 402-471-3270. Founded: 1878. Earth Science exhibits, anthropology, archaeology, ethnology.
Monday-Saturday 8:00 a.m.-5:00 p.m.; Sundays and holidays 1:30-5:00 p.m. No charge. Closed New Year's, Thanksgiving, Christmas.

LINCOLN—University of Nebraska State Museum, 212 Morril Hall, 14th and U Streets, Lincoln, Nebraska 68588. Telephone: 402-472-3779. Founded: 1871. Anthropology, archaeology, geology, mineralogy, invertebrate and vertebrate paleontology.
Monday-Saturday 8:00 a.m.-5:00 p.m.; Sundays and holidays 1:30 p.m.-5:00 p.m. No charge. Closed New Year's, Thanksgiving, December 24-25, 31.

OSHKOSH—Historical Society of Garden County, West 1st and Avenue E, Oshkosh, Nebraska 69154. Telephone: 308-772-4555. Founded: 1969. Dioramas, fossils of the area.
Monday-Saturday 9:00 a.m.-5:00 p.m., Sunday 1:00-5:00 p.m. No charge.

WEEPING WATER—Heritage House Museum, Weeping Water, Nebraska 68463. Telephone: 402-267-5215. Founded: 1969. Prehistoric Indian artifacts from 20,000 years ago to Plains Indians, fossils.
May-October, Saturday-Sunday 2:00-5:00 p.m.; other times to groups by appointment. No charge. Closed November-April.

In addition to the above, most counties in Nebraska have an historical museum which has some sort of state mineral and fossil displays.

Collections and Displays

UNIVERSITY OF NEBRASKA STATE MUSEUM
Paleobiology Gallery
Lincoln,Nebraska

ALLAN D. GRIESEMER
University of Nebraska State Museum
Lincoln, Nebraska 68588

Most museums regardless of locality or discipline have displays or at least miscellaneous specimens of invertebrate fossils tucked away in the corner of a case, more often than not shared with artifacts or photographs of pioneers. The reason is quite simple. Human beings are inquisitive with a desire to hold and examine interesting objects that they encounter. And certainly the discovery of shells of marine animals existing far from any known ocean strongly qualified for such an examination. Continued handling of these fossils further adds to the curiosity level, for the specimen's unexpected weight and hardness are an additional surprise. It can easily be understood how the desire to preserve these unusual objects became overwhelming–and thus how the collection, care, and presentation of objects for other than practical reasons began. Today, museum collections are well stocked with the results of this inclination to preserve such "curiosities."

University of Nebraska State Museum.

Although the University of Nebraska State Museum has an invertebrate fossil collection of over 75,000 specimens and has had prominent displays for many years, the Museum only recently has been able to commit suitable space to tell the story of this immense segment of the animal kingdom and give them deserved emphasis. The new Paleobiology Gallery provides 1,100 square feet of exhibit area and, though not complete, was opened to the public in early 1979. The gallery houses a variety of displays in invertebrate paleontology as well as in paleobotany and is intended to meet varying educational needs and interests.

Planning of the Gallery

As the design of the gallery was being planned, it was decided an attempt should be made to identify the audience in order to better understand their needs and backgrounds. To accomplish this, a survery was conducted during the summer of 1977 to determine the level of visitors' background in the area of geologic history and animal and plant taxonomy, areas felt to be basic to the gallery's emphasis.

The results of the survey revealed clearly that casual visitors, both adults and children, do not have a basic store of knowledge concerning geologic time or animal classification and relationships. Therefore it clearly became the Museum's responsibility to assist them in gaining this basic knowledge by providing effective and stimulating exhibits and programs.

The goals the gallery hoped to meet for its audience included:

1. Helping people become aware of the vastness of geologic time and of the apparent environmental changes the earth experienced through this immense span of our history.
2. Giving the visitor a feeling for the degree and variety of invertebrate and plant changes that have taken place through geologic time.
3. Facilitating an understanding of invertebrate morphology and classification.
4. Augmenting class study of invertebrate paleontology by exhibiting representative specimens.

Left: **Museum artist working on background for the Pennsylvanian coal swamp diorama. The diorama will include models of various extinct plant fossils.** *Right:* **View toward entrance of the University of Nebraska State Museum Paleobiology Gallery. Wall cases will house dioramas. Center cases will house taxonomic displays. The bubble case now contains 3.5 square foot slab covered with trilobites and a 15 foot square foot slab of Cretaceous crinoids now occupies the spot from which the photo was taken.**

The visitor survey indicated that if these goals were to be met, the Gallery must acquaint visitors with basic, as well as more advanced, information. Therefore, the new Paleobiology Gallery is designed to provide self-directed teaching exhibits to which visitors can return often.

The plan for the new gallery directs visitors initially to a series of impressive full scale dioramas which will highlight invertebrates that lived in the Great Plains area 700 to 70 million years ago and can now be found as fossils from the Dakotas to Texas. The feature attractions of this series include a strikingly elaborate peninsular diorama of a small segment of a Permian age reef teeming with thousands of animals as they lived in the area of west Texas 225 million years ago, and a large full-scale habitat view of a coastal swamp as it appeared in the midcontinent region 275 million years ago during the period of geologic history when such swamps were common environments in many parts of the world.

For those wishing to make comparisons between dioramas and actual fossil specimens, a second series of eighteen exhibits dealing with various invertebrate animal groups arranged in a taxonomic format is being installed down the middle of the gallery. These displays not only indicate scientific order and group relationships, but also provide diagrams and descriptions of major organism groups, which will aid collectors interested in understanding and identifying their own specimens. Eventually slide tape presentations may also be used to extend the educational experience even further.

Considering the relative wealth and ease of collection of invertebrate and plant fossils in the Pennsylvanian, Permian, and Cretaceous rocks of eastern Nebraska, the University of Nebraska is very pleased to make this study of the earth's history more prominent in the exhibition-education program.

Alan Griesemer is Coordinator of Educational Activities at the University of Nebraska State Museum.

MUSEUM DIRECTORY

Second Floor
Vertebrate and Invertebrate Fossils
New Paleobiology Gallery

Third Floor
Hall of Dinosaurs
Archeology Exhibits
Mineralogical Displays

The Museum is located in Morrill Hall,
14th and U Streets, Lincoln, Nebraska 68588

SECOND EDITION

"ODELL DIAMONDS"

Barite Crystals from Gage County, Nebraska

Second Edition *is a feature which reruns pertinent articles published during the fifty-four years of* ROCKS AND MINERALS' *history. This article on "Odell Diamonds" originally appeared in the September 1977 issue.*

RICHARD S. MITCHELL
University of Virginia
Charlottesville, Virginia 22903

Small barite crystals occur in sediments near Odell, Gage County, Nebraska. Because of their tabular rhomboid habit, these have often been referred to as "Odell diamonds." The purpose of this article is to describe the crystals and their associated minerals. Although not studied before, the locality has been noted in the literature (Schramm 1943; Priest 1957; Everett 1962; Trump 1963; Pabian 1971). Also a photograph on the cover of *Rocks and Minerals* showed the crystals in November-December, 1963 (vol. 38).

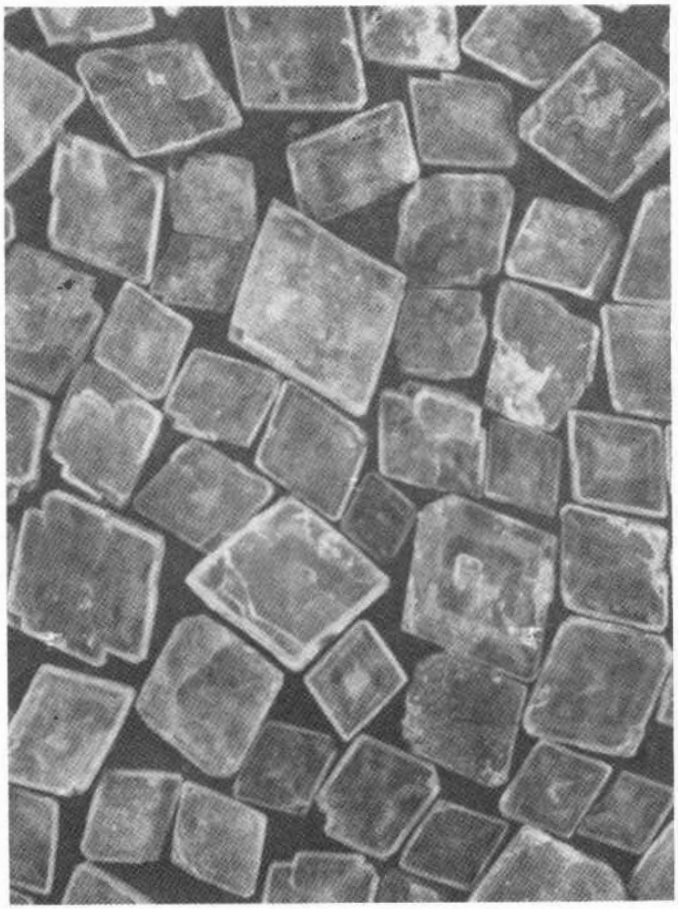
Description of Crystals

The morphology of the barite was studied with an optical goniometer. Because most of the crystals are etched and give poor reflections, a mixture of water and glue was brushed on some of the faces to enhance their reflectivity. The crystals are tabular parallel to the orthorhombic basal pinacoid *c* (001). This is the largest and most reflective face on the crystals. The rhomboid outline of the crystals is due to the four prism, *m* (210), faces. Although these are prominent faces, they are very etched and give exceedingly poor reflections. Rarely the brachypinacoid, *b* (010), is observed. The brachydome, *o* (011), was also noted, but is rare and poorly developed.

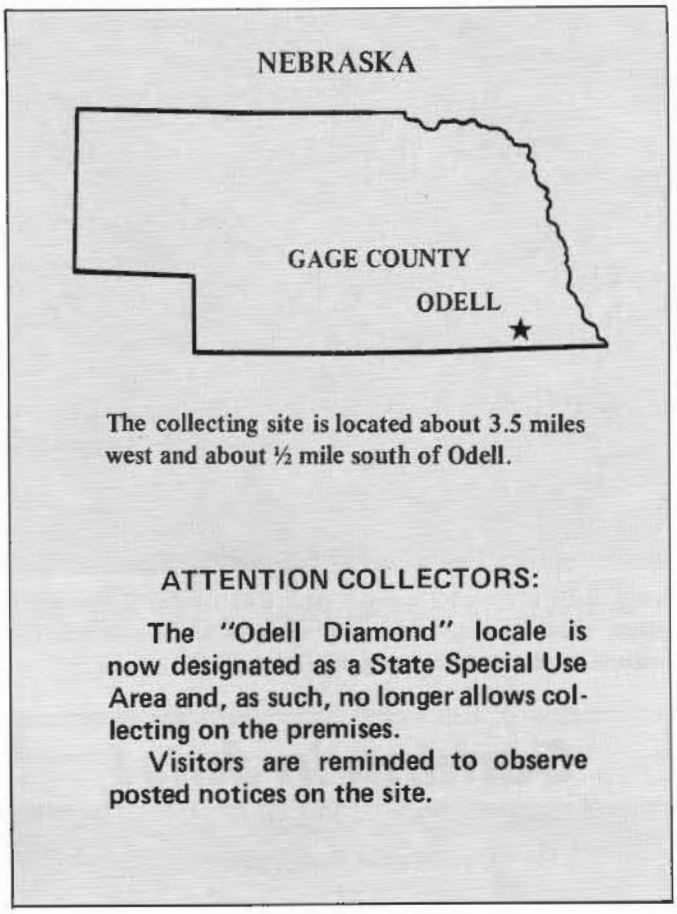
The crystals are always small. They vary in thickness from less than 1 to about 3 mm, with the longest dimension of the rhomboid varying from less than 4 to over 10 mm. The specimens are pink, although sometimes they are stained yellow by iron oxide. They are transparent to translucent, with a thin opaque chalky border-zone parallel to the *m* (210) and *b* (010) faces. Many of the crystals have additional growth zones ("phantoms"), shown by color variations within the crystals parallel to the *m* (210) planes. Faint and poorly developed four- or eight-pointed stars can be seen on some of the tabular rhomboid faces, especially with transmitted light. In these, the major rays bisect the angles between the *m* (210) faces, and the minor rays are parallel to these faces. Imperfections in growth have caused some crystals to resemble intergrowths of two or more individuals with nearly parallel orientations. These are slightly separated as shown by re-entrant angles at the acute corners of the rhomboids. The specimens show the typical cleavage for barite, one plane parallel to the *c* (001) and two planes parallel to the *m* (210) faces.

Associated Minerals

The shale, with which the barite is associated, consists of white to grayish clay composed of kaolinite and minor traces of illite and quartz (x-ray diffraction analyses). Porous masses and clods, as well as loose clay fragments, make up most of the material at the site. The porous masses and fragments consist of angular clay pieces, usually from less than 5 to 10 mm across. Apparently the angularity of these results from desiccation of the clay as it dries after rain or snow. Generally the clay frag-



Odell barite crystals. Largest crystals about 10 mm across.

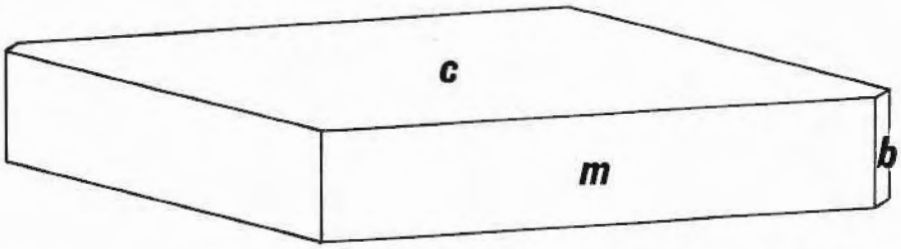


The collecting site is located about 3.5 miles west and about ½ mile south of Odell.

ATTENTION COLLECTORS:

The "Odell Diamond" locale is now designated as a State Special Use Area and, as such, no longer allows collecting on the premises.

Visitors are reminded to observe posted notices on the site.



Crystal habit usually exhibited by the Odell barite.

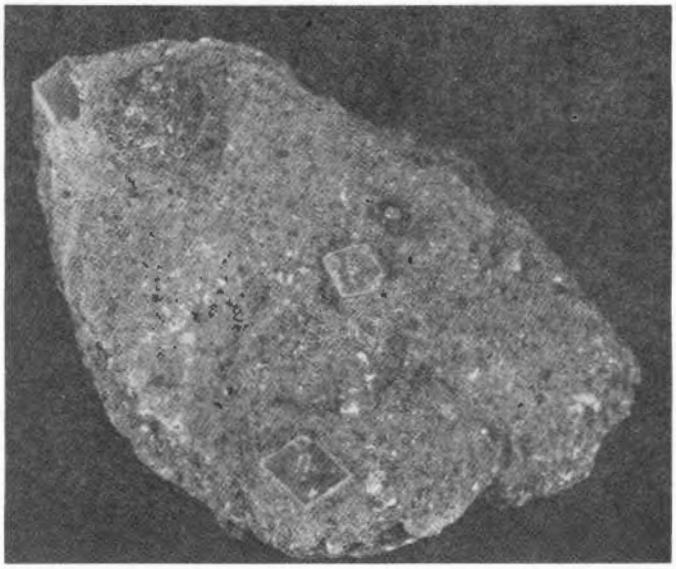
ments are coated with pink to red hematite dust and stains. Occasionally the hematite impregnates and discolors the clay. Earthy to spongy hematite zones and small rounded smooth hematite pellets (to 2 mm across) occur with the clay. Very rarely the otherwise white clay also shows minor staining which is gray to black, presumably due to a manganese oxide mineral. According to Pabian (1971) this material is in Cretaceous shale in the Dakota group.

Richard S. Mitchell is an Executive Editor and also a regular columnist (Who's Who in Mineral Names) for ROCKS AND MINERALS. *Many years before assuming either position, he wrote another Nebraska article for* ROCKS AND MINERALS *entitled "A Description of the Quartz Minerals Found at Bayard, Nebraska" (January-February 1950).*

Within the shale are zones which also contain foreign detrital and other materials. Mixed with small angular clay fragments are spherical goethite-quartz concretions (to slightly over 1 cm in diameter), platy fragments consisting of quartz grains mixed with goethite (up to 2.5 cm long), quartz grains (a fraction of a mm across), and rarely tiny white mica flakes. Also calcite-rich pellets, and an irregular fragment of green amphibole, 1 by 2 cm, were noticed. Barite crystals occur at the surface and throughout both the relatively pure clay as well as with these detrital materials, and can be obtained by screening them.

Locality

The site is located about 3.5 miles west and about 1/2 mile south of Odell, in T. 1 N., R. 5 E., section 21. The crystals are



Odell barite in matrix (largest crystal, 6 mm); spherical goethite-quartz concretion (8 mm) near sharpest corner; matrix is a mixture of clay (white) and hematite (black).

especially abundant in the reddish outcrops on "Diamond Hill" which lies on the northwestern side of the Burlington Northern Railway track, which runs southwest through the area.

Acknowledgements

The writer would like to express his appreciation to Mr. Amel Priest, of Peru, Iowa, who collected and made available the materials used in this study.

REFERENCES

Everett, I. 1962. World news on mineral occurrences–Nebraska. *Rocks and Minerals* 37:592.

Pabian, K. 1971. The Minerals and Gemstones of Nebraska. *Educational Circ. No. 2, Univ. of Nebraska, Conservation and Survey Division*, Lincoln, 80 pp.

Priest, A. 1957. Geode hunting in Nebraska. *Rocks and Minerals* 32:348-349.

Schramm, E.F. 1943. Some minerals of Nebraska. *Rocks and Minerals* 18:323-326.

Trump, E. 1963. Photo on front cover. *Rocks and Minerals* 38:562.

Classified Advertisements

Classified Advertising rates are 20¢ a word; minimum of $5.00. REMITTANCE MUST ACCOMPANY COPY IN ALL CASES. No Advertisement will be inserted until payment is received. Forms close the 20th of the second preceding month.

BOOKS

NEWLY RELEASED FOURTH EDITION–Standard Mineralogical Catalogue. Approximately 20,000 reference prices evaluating mineral specimens. Extraordinary specimen coverage included. Evaluate collections, individual specimens. Most prices changed from earlier editions. Biggest, best book yet. $5.25 postpaid. MINERALOGICAL STUDIES, 7808 Division Drive, Battle Creek, Michigan, 49017.

EQUIPMENT

DELUXE GEM MAKING UNIT–Must sell. New, unused. Superior quality by Star Diamond. Includes such quality components as 10" grinding wheels and more. All mounted on large steel cabinet. MAKE OFFER. Paul A. Kendall, 4615 Saul Road, Kensington, MD. Call 301-942-5305.

WHAT SIMPLER WAY TO IDENTIFY MINERALS–Computer cards with built in memory, identify numerous gems and minerals on the spot. Illustrated and informative. No other equipment necessary. Mineral Sort-$9.95 postpaid, free literature. SORT-CARD CO., Box 901, Boulder, Colorado 80306.

THREE DIMENSIONAL MODELS of the Basic Crystal forms. Great for teachers, students, mathematicians, rockhounds! Construction kit for 111 crystal models–$8.50. 15 models, –$3.50. A. J. GUDE, 845 Dudley St., Lakewood, Colorado 80215.

ULTRAVIOLET lamps and kits for beautiful fluorescence from $18.25. Accessories, filters, tubes. Free brochures. RADIANT ULTRA VIOLET, Box 131, Jamesburg, New Jersey 08831.

FOSSILS

FOSSIL FERNS in split nodules, 2-3", $2.50; Fossil worm 1-2", $2.50; Trilobitomorph ½", $1.50. Plus postage. Fossil list free with purchase. THE THURSTON'S, 395 Central St., Boylston, Mass. 01505.

FOSSILS–Shark teeth, fish, trilobites, mammal teeth, starfish, mollusks, insects, plants and much more available. Send stamped addressed envelope for price list to: J. F. RAY'S FOSSILS, POB 1364, Ocala, Florida 32670. Mail orders only please. Dealer inquiries invited. Also buy fossils.

FOSSILS: BUYING, EXCHANGING, SELLING. Large inventory of 11,000 species. Artifacts also available. Catalog 23 with plates: $3.00 net. MALICKS FOSSILS, 5514 Plymouth Road, Baltimore, Maryland 21214. Telephone (301) 426-2969.

SHARK TEETH–$6.00 pound, delivered. (Wholesale jewelry supply catalog .25¢) ROUSSELS, 107-1875 Dow Ave., Arlington, MA 02174.

GEMSTONES

NEW OFFER! "GRAB BAG" TUMBLING PACKAGE–Top grade Mexican agate; all colorful material ($12.00 value) 12 lbs. for $10.50 ppd. GORIN'S Gemarts & Rocks, 4108 N. Piedras, El Paso, Texas 79930.

1980 CATALOG SENT ON REQUEST–These list over 3,000 cut gems. Stones of all types available on 10-day approval and satisfaction is absolutely guaranteed. INTERNATIONAL IMPORT CO., P. O. Box 747, Stone Mountain, Ga. 30086 (Tel. 938-0173).

GOLD & PLATINUM jewelry mounting custom designed and manufactured in our own workshop for your finest Gems. Quotations gladly given upon approval of design for one or one thousand pieces. Our expert staff and seventeen years of experience assures you of cautious and secure treatment of your most valued gems. Send inquiries for prompt attention to: BELL JEWELERS, 1661 Estero Blvd., Fort Myers Beach, Florida 33931. Visit our showroom and shop. Our Catalog is available at slight cost. BELL JEWELERS Goldsmiths, Diamond setters, Jewelers.

"GRAB BAG" CUTTING PACKAGE OFFER–Mixed colorful Mexican agate. Top grade only. 10 lbs., $12.50 postpaid. GORIN'S Gemarts & Rocks, 4108 N. Piedras, El Paso, Texas 79930.

WHOLESALE JEWELRY SUPPLIES–Neckchains .07¢, earwire 1¢, 2 x 3 bags, $3/1000. (Wholesale catalog .25¢) ROUSSELS, 107-1875 Dow Ave., Arlington, MA 02174.

MICROMOUNTS

FINE MICROMOUNTS–Zunyite, Africa 75¢, Spinel, Burma 75¢, Silver, Mexico 50¢, Perovskite, Arkansas 75¢, Emerald, Columbia $2.00, Brookite, Arkansas 75¢, Barite, Missouri 50¢. List free. ROBERT EATON, 54 Heberle, Rochester, N. Y. 14609.

QUALITY MICROMOUNT BOXES–1 x 1 x ¾" deep, black or clear, $12.00 per 100, plus $1.50 shipping. Quantity discounts available. Send 50¢ for samples. Showroom open by appointment. MINERALOGICAL RESEARCH COMPANY, 704 Charcot Avenue, San Jose, CA 95131, U.S.A.

FINEST QUALITY MICROMOUNTS from Tsumeb, St. Hilaire, Francon, Sterling and other classic localities. List SIMKEV MINERALS, Box 956, Port Perry, Ontario L0B 1N0.

NEW MEXICO MICROMINERALS–Mounted suites, 50 different New Mexico species. Write for quote. ZUNI Mining and Minerals, 9012 Hilton Ave. NE, Albuquerque, New Mexico 87111

MICRO ZEOLITE PACKAGE, 9 rare zeolites including paulingite, cowlesite, ferrierite, dachiardite, clinoptilolite, erionite brewsterite, stellerite, and edingtonite, only $15.00. Other zeolite packages and individual specimens available. Write for listing. ZEOLITE RESEARCH AND EXPLORATION, P.O. Box 5101, Everett, Washington 98206.

MINERALS

PYROMORPHITE ON quartzite. 2" pieces, Phoenixville, Pa. $2.00; Herkimer diamonds ¼", 50¢, ½", 75¢. Fluorite crystal groups. Approx. 2 x 2" Illinois, $2.50. Mineral list free with purchase. Postage extra. THE THURSTON'S, 385 Central St., Boylston, Mass. 01505.

FLUORITE OCTAHEDRAL CRYSTALS, Arizona, miniature size $2.50; Wulfenite, Finch Mine, $1.85; Bixbyite, Utah, TN 45¢; Scorazalite, California, $1.75. Over 300 minerals at reasonable prices. Send two stamps for list. DAVID SHANNON, 1727 W. Drake Cricle. Mesa, AZ 85202.

CRYSTAL SPECIMEN–quality thumbnail to small cabinet from world-wide localities. Material for novice to competitive exhibitors. Satisfaction guaranteed. Send 30¢ stamps for mailing list. OLSON ORIGINALS, P. O. Box 1532, Homewood, Illinois 60430.

CANADIAN MINERAL SPECIMENS–Silver ores, also Canadian Cutting Materials. For other newly available materials or specimens, jewelry, books and other lapidary equipment, write for our free liest. CANADIAN GEMS AND MINERALS LTD., Drawer 730, Kirkland Lake, Ontario, Canada.

FINE MINERAL SPECIMENS from world-wide localities. Rare species, and well crystallized specimens for collections and competitive display. Send 30¢ postage for lists of thumbnail, miniature and cabinet specimens. Showroom open by appointment. MINERALOGICAL RESEARCH CO., 704 Charcot Avenue, San Jose, CA 95131, U.S.A.

RARE SPECIES? BASIC MINERALS? ROCKS? Send 26¢ stamps for lists. Our customers say: "Quality material, accuracy in labels, excellent wrapping." Find out why. MINERALS UNLIMITED, Box 877, Department RM, Ridgecrest, California 93555.

TYPE LOCALITY MINERALS and rare species our specialty. Over 15,000 specimens on hand from TN to cabinet sizes. New species offered upon publication. Get on our mailing list for 30¢ stamps. Mail order only; dealer inquiries invited. EXCALIBUR, 7 Grover Road, Dover, New Jersey 07801.

RARE FLUORESCENTS SET: Malayaite-England; Wollastonite- Mexico; Hemimorphite-U.S.A.; Fluorite- South West Africa; Colemanite- Turkey; Petrified Wood-U.S.A. One inch size. $7.00 Postpaid U.S.A. BI-COLOR FLUORESCENTS SET: Calcite-Willemite; Chalcedony- Calcite; Cleiophane-Willemite; Manganapatite- Autunite; Calcite-Fluorite; Diopside- Phlogopite. $5.00 Postpaid. Both for $11.50. Send 75¢ (refundable) for CATALOG of Fluorescents, U-V Lights, Minerals. HORN MINERALS 263C North Country Road, Smithtown, New York 11787. OUR SEVENTEENTH YEAR SERVING THE COLLECTOR.

BRITISH, EUROPEAN AND SCANDINAVIAN MINERALS–200 species available in free descriptive catalogue from R. TAYLER MINERALS, Byways, Burstead Close, Cobham, Surrey, England.

SMALL GOLD SPECIMENS panned from New Hampshire streams. Several pieces in glass vial. $2 plus 25¢ postage. E. FOLEY, Route 2, Woodsville, NH 03785

SPECIAL–20 Black Hills specimens, 1". Each wrapped with identification. $4.85 Postpaid. R & I GEMS & MINERALS, Box 275, Keystone, South Dakota 57751.

SEVERAL NICE AND EDUCATIONAL SETS AVAILABLE. We pay half of the postage on all orders. Write for set list. CONTINENTAL MINERALS, 4737 E. Adams, Tucson, AZ. 85712.

JOIN WORLDWIDE MINERAL CLUB!! Receive one or more different and interesting Mineral Specimens each month with descriptive Fact Sheets, plus Monthly Bulletin listing members interested in exchanging or corresponding. Free mineral identification service for members. FREE Ruby Crystal given to each new member. Write today for free details! MINERAL OF THE MONTH CLUB, Box 487-RC, Yucaipa, California 92399.

WE HAVE AN IMMENSE STOCK OF MINERALS (massives and crystals) in petrographic material all suitable for schools, collectors, prospectors, for display or study purposes. Inquire by name, size and quality of minerals or rock types you need. We gladly give information about availability and price. Sorry, no list at the present. CONTINENTAL MINERALS, 4737 E. Adams, Tucson, AZ 85712.

TOP QUALITY ONLY–We deal in only the finest aesthetic thumbnails, miniatures, and cabinet specimens for competition and display. Write for list. Special requests invited. Mountain Gems and Minerals, 6455 Kline, Arvada, Colo. 80004.

SOUTH AMERICAN MINERALS–Peruvian sulfides, huebnerite, Bolivian vivianites, phosphates. Benitoite and neptunite from California. Spanish pyrite cubes and clusters. Dealers write for wholesale list or call CALIFORNIA ROCK AND MINERAL, 9447 E. La Rosa Drive, Temple City, California 91780, (213) 286-8905.

GUSSEN'S MINERALS offers a variety of crystallized, reference, and fluorescent sepcimens in T/N to museum size from worldwide locations. Specific requests invited. P. O. Box 449, Lynden, Washington 98264.

MINERALS–U.S. and Mexico, 5 different minerals–2" by 3" average size. Some xls $15.00 (postpaid in U.S.) Send stamp for free minerals list. "THE PROSPECTOR." P.O. Box 180, Dept. RM, River Grove, Illinois 60171.

CHOOSE from one of the largest collections of minerals in this country including minerals from all the famous Mexican locations. Write for list or give us your wants. McGREGOR & WATKINS, Route 8, Box 487, Hot Springs, Arkansas 71901–7 miles west on US 70.

PRICE LIST OF MINERALS FOR STAMP. No lapidary material or wholesale. SOUTHEASTERN MINERAL CO., 826 S. Ingraham Ave., Lakeland, FL 33801.

NATURE'S OWN SCULPTURE from Wildlife Limited. Write for free mineral specimen list. New display and showroom. WILDLIFE LIMITED INC., 432 North Virginia Street, Reno, Nevada 89502. AGMSA Member.

MISCELLANEOUS

SEE COLLISON OF NORTH AFRICA AND AMERICA–at BURGUNDY HILLS QUARRIES and Garnet Mines and Tunnels. Plus tour and observing of specimens. Junction Routes 74 and 30. Mt. Spring Road, Tolland, Connecticut. Tel. 875-5339 in Rockville, Connecticut for appointment. Mrs. Bruce Cramer, Tolland.

MICROMOUNT BOXES
THUMBNAIL BOXES
PLASTIC
For visible storing, handling and displaying of specimens. Ideal for GEMOLOGISTS, MINERALOGISTS, GEOLOGISTS and LAPIDARIES.
WRITE FOR FREE LIST RM
ALTHOR PRODUCTS
Box 1236 Weston, Conn. 06883

24 KARAT GOLD PLATED REAL FLORIDA sand dollars, starfish and sea horses. As low as $2.50 each. White and light pink coral necklaces, $6.00 (minimum 6); oxblood coral, $14.00. Butterfly and heart pendants (cloisonne) $18.00 dozen. ROBERT LEE GALVIN COMPANY, Box 15695, Dept. RM, Sarasota, Florida 33579.

ROCK SHOPS

WEYMOUTH, MASS.–Machinery, rough, specimens, findings, polished stones, sterling silver and supplies. No catalog. LUSCOMBE'S ROCK SHOP, 126 Main St., Rt. 18, Weymouth, MAss 02188

WANTED

MINERAL COLLECTIONS WANTED–Especially old collections. Will also buy museum surplus and your duplicates. Send details to THE THURSTON'S, 385 Central St., Boylston, Mass. 01505.

WANTED TO BUY OR EXCHANGE–METEORITES. Correspondence invited. JIM DUPONT, 391 Valley Road, Watchung, N.J. 07060.

WANTED–METEORITES–METALLIC ONLY. One of a kind, or lots from one fall. All sizes are of interest. Send offers and prices to: MINERALOGICAL RESEARCH COMPANY, 704 Charcot Avenue, San Jose, CA 95131 USA.

This Publication is Available in MICROFORM

FOR INFORMATION WRITE:

University Microfilms International

Dept. F.A.
300 North Zeeb Road
Ann Arbor, MI 48106
U.S.A.

Dept. F.A.
18 Bedford Row
London, WC1R 4EJ
England

Collectors & Cutters

Don't Delay!

We have a limited quantity of

Russian Emerald Roughs

available to you for only

$1.00 Per Carat

Minimum orders $300 (300 carats); check, money order, Visa or Mastercharge accepted.

Excellent for:

Faceting, Cabbing
Carving
&
Specimen Crystals

Many large crystals available

Call Toll Free
800-327-2413

or write Dept. R

DIAMOND SALES COMPANY
Ainsley Building
14 N.E. 1st Avenue
Miami, Florida 33132

In Florida, CALL COLLECT 379-2438

ADVERTISERS INDEX

j. r. rodgers, ltd.

P.O. Box 829, Tualatin, Oregon 97062
Cable Address: Rodgersltd, Portland
Local Phone: (503) 638-8419
Order Desk: (800) 547-9674 (toll free)

WOW!!! WHAT WE HAVE FOUND FOR YOU on our recent world-wide trips . . .THE BEST SELECTION of AGATE EVER FROM BRAZIL. Plus the . . .

"RODGERS COLLECTION"

of fine Brazilian Agate will be for sale. These hundred of slabs are duplicates and are from the personal collection of Jim and Mary Rodgers, and represent probably the best collection of Brazilian Agate in the world.

PLUS - - personally selected:

MARBLE . . . Fancy marble items from Taiwan—many one of a kind.

WOOD . . . Stands and boxes of wood—exciting new designs.

AMETHYST . . . Amethyst specimens from Brazil and Uruguay.

BOXES . . . New designs of boxes from around the world.

LUCITE . . . Stands of all types, many new designs.

AGATE ARTICLES . . . Letter openers, bottle openers, paper weights—new designs.

"When you buy from J. R. Rodgers, Ltd., you are buying from the source."

We stock the following in our Oregon warehouse:

over 200,000 slabs
over 75,000 ashtrays
Book ends
Paperweights
Amethyst and other
Fine Agate products.

See us in the wholesale section of the National Show June 12-15, at Lincoln, Nebraska.

Introducing the MANUAL MINI-SONICS Compact Electronic Vibratory Tumblers with NEW LOW PRICES!

MT-4 "S"

New models "S" (single speed) and "SD" (dual speed) Mini-Sonic Tomblers polish baroques, pre-forms, cabs, sea shells and metals. Intensity and speed of rotation are adjusted manually. "S" Models feature an On/Off switch, while "SD" Models have High/Low/Off switch positions.

All models feature sturdy A.B.S. housings in a brilliant blue color. Hoppers are solid vinyl with capacities from 4 to 15 pounds. Mini-Sonics are constructed of solid steel and aluminum with no sheet metal, gears, pulleys, belts or eccentric weights.

MT–4 S Model $79.50
MT–4 SD Model $89.50

MT-10 "SD" Double

UNDERWRITERS LABORATORIES LISTED . . . Mini-Sonic Tumblers are manufactured to strict U. L. Standards assuring safe construction and operation.

MT–10 S Models $139.50
MT–10 SD Models $149.50
(MT–10 Tumblers are available in single hopper or double hopper models.)

Save energy, too! Mini-Sonic Tumblers use less than 25 Watts (per hopper) at full power and less than half that at low speeds.

MT-14 "S" Triple

See the new Mini-Sonics and other quality Geo-Sonics products displayed and demonstrated at these up-coming shows:

June 12, 13, 14, 15	American National Gem & Mineral Show (Bob Devaney Sports Center) Lincoln, Nebraska
June 20, 21, 22	"Showers of Gems and Minerals" (The Civic Center) Charleston, West Virginia

MT–14 S Models $199.50
MT–14 SD Models $209.50
(MT–14 Tumblers are available in single, double or triple hopper models.)

GEODE industries

(319) 367-2256 108 W. Main, Highway 34, New London, Iowa 52645

SEND FOR OUR NEW 100 PAGE CATALOG TODAY–ONLY $2.00 POSTPAID

ROCKS AND MINERALS
Helen Dwight Reid
Educational Foundation
Suite 504, 4000 Albemarle St., N.W.
Washington, D.C. 20016
RETURN POSTAGE GUARANTEED

Second Class
Postage Paid at
Washington, D.C.