NEWSLETTER NDGS

Industrial Commission of North Dakota, North Dakota Geological Survey

Vol. 20, No. 1, Spring 1993

Silcrete-covered hillside near Hettinger in Adams County. Silcrete is a weather-resistant, silica-rich rock that forms a lag (an armor) after enclosing softer sediments have been eroded. Often, hollow plant stem molds occur in the silcrete, suggesting that it formed in a swamp environment; other silcrete beds may represent old weathering horizons (paleosols). This photo is from "Landforms of North Dakota", one of many earth science videos available through a new VCR Tape Library developed by the North Dakota Geological Society (see p. 10). *Photo by John Bluemle*.

NEW NDGS PUBLICATIONS

The Occurrence of Picloram (Tordon) and 2,4-D in Groundwater in the Denbigh Sand Hills, McHenry County, North Dakota, by Edward C. Murphy and Earl A. Greene, NDGS Report of Investigation 95, (1992), 40 pages, $7.00.

The Denbigh Sand Hills are stabilized sand dunes heavily infested with leafy spurge (*Euphorbia esula*). Tordon and 2,4-D are widely used to control leafy spurge, and in this area of highly permeable sandy soils and shallow water table, the risk of groundwater contamination by these chemicals is significantly increased. The U.S. Bureau of Land Management (BLM), which owns several tracts of land in the Denbigh Sand Hills, was concerned that the herbicides might be reaching the shallow groundwater.

The purpose of this cooperative project between the NDGS, BLM, and the North Dakota State Department of Health, was to monitor fluctuations of the water table, analyze the shallow groundwater beneath four selected BLM tracts for the presence of the herbicides, and recommend, as appropriate, means of preventing these chemicals from reaching the water table.

Tordon and 2,4-D were detected in groundwater and sediment beneath the BLM tracts, but at concentrations below the Maximum Contaminant Levels (MCL) set by the U.S. Environmental Protection Agency. Interestingly, 2,4-D was detected in the no-spray control tract, suggesting that drift during application and/or migration of groundwater works to spread these chemicals beyond areas where they are applied.

Geologic Postcard of North Dakota. This postcard shows a computer-generated simplified geologic map of the state. The postcard measures 5x7 inches and is printed in full color. Limited copies of the postcard are available free upon request.

Oil and Gas Pool Maps of North Dakota. This set of 11 Diazo prints is updated annually and shows all producing wells from a pool or combination of related pools. Individual pool maps are available for the Tyler and Heath; Madison; Bakken, Sanish, and Three Forks; Birdbear; Devonian and Duperow; Dawson Bay; Winnipegosis; Silurian and Interlake; Stonewall and Gunton; Red River/Ordovician; Ordovician, Winnipeg, and Deadwood. The map scale is approximately 1:500,000 and each map measures approximately 30" x 42". Price is $5.00 per map or $50.00 for the entire set.

NDGS publications and USGS topographic maps are available at our sales office (1022 E. Divide Ave, Bismarck), by telephone (701-224-4109), by FAX (701-224-3682), or by mail (see address below). Cash, money order, or check, payable to the North Dakota Geological Survey, will be accepted. Minimum charge per order is $1.00. Reasonable requests for items for which no price is quoted are sent free of charge. Customers will be invoiced for materials plus shipping costs, if applicable. A free copy of *NDGS List of Publications* will be sent upon request.

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FEATURES

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Your comments - and contributed articles, photographs, meeting announcements, and news items - are welcome. Correspondence, subscription requests, and address changes should be addressed to Editor, *NDGS Newsletter*, North Dakota Geological Survey, 600 E. Boulevard Ave., Bismarck, ND 58505-0840; (Tel. 701-224-4109).

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FROM THE STATE GEOLOGIST

by John P. Bluemle

The NDGS and the Environment

In the last issue of the *NDGS Newsletter*, we announced the publication of two reports, one dealing with the potential for groundwater pollution near the wastewater impoundments at Devils Lake and the other a report on groundwater conditions at six municipal landfills in North Dakota. This issue of the newsletter includes an announcement of a recently released report on the occurrence of Tordon and 2,4-D in groundwater in the Denbigh Sand Hills area, McHenry County.

The fate of pesticides in groundwater has been of great concern in recent years. Since the late 1980's, more than 74 pesticides have been found in groundwater in the United States. Pesticides applied to sandy soils, like those in the Denbigh area, are especially susceptible to leaching and subsequent contamination of the groundwater.

Geologists at the North Dakota Geological Survey have been concerned about a variety of environmental issues for many years. The siting of landfills and municipal waste water lagoons, the safe disposal of oilfield brines, and geology-for-planning studies have been core issues for NDGS geologists since the late 1960's. Since then, we have studied these and other environmental problems, and published a variety of reports explaining how best to deal with them.

We are currently working closely with the State Department of Agriculture on a project to regulate the application of pesticides in and near areas where they might impact endangered species habitat. Our cooperation with the State Health Department includes several water-related projects: the Wellhead Protection Program, Nonpoint Source Pollution Program, and Uranium in Groundwater Study. All of these joint projects and programs rely heavily on application of our new Geographic Information System (GIS).

Concern about the whole solid waste problem reached a kind of crescendo during the Legislative session in 1991 and it continues to be a major issue during the current session. I haven't counted the number of bills that have been introduced during the current session to deal with various aspects of the waste problem, but I am sure it is at least several dozen. How to best handle solid waste; whether to declare any of various kinds of moratoria, ways to prevent and/or control the transport, importation, storage, or disposal of such things as medical waste, high-level nuclear waste, radioactive waste, hazardous waste, incinerator ash, and other materials throughout, into, and out of North Dakota; issues relating to recycling--all of these questions have been in the news lately. In almost every case, an understanding of the geology and hydrology is vital before the state can deal effectively with these issues.

We are making a considerable effort to deal with the problem of municipal landfills in North Dakota. Two years ago the Legislative Assembly instructed the State Engineer and State Geologist to conduct site-suitability reviews of all the municipal landfills in the state. These reviews are to be completed by July 1, 1995. The purpose of the landfill evaluations is to determine the suitability of each landfill for disposal of solid waste. We are concerned, particularly, about the geologic and hydrologic characteristics at the landfill sites. Our joint reports will be provided to the Health Department for use in site improvement, remediation, or landfill closure. We expect to evaluate between 45 and 50 landfills during the course of the four-year study. Twice before, first in 1977 and then in 1983, the North Dakota Geological Survey evaluated existing landfills in the State, although neither time in nearly the detail as now.

The original mission of the Geological Survey, assigned in 1895, was to study and map the geology of the State. Certainly, thoroughly understanding North Dakota's geology and using our knowledge to further the State's economy remains our main goal. I think, though, we have to be carefully focused, concentrating on studies that clearly may benefit the development of economic resources while, at the same time insuring that any development is done in an environmentally safe manner. Sustainable economic development requires rigorous environmental protection. The price to be paid later to remedy environmental damage will be many times the cost of sound development today.

NDGS Newsletter

With this issue, we are very pleased to begin quarterly publication of the *NDGS Newsletter*. We intend to bring to you more timely news, information about resources available from the Survey, and of course both technical and non-technical articles on the geology and mineral resources of North Dakota. With free subscriptions, this deal is hard to beat.

National Geologic Mapping Act Update

The National Geologic Mapping Act of 1992 has, justly, received considerable attention since it was signed into law by former President Bush on May 18, 1992 (see, for example, *GSA Today*, September, November, and December 1992 issues). The Act has four main components - federal, support, state, and educational - designed to reverse the decline in geologic mapping activities in the United States and to develop a plan to map approximately 80% of the country that is still unmapped at intermediate to detailed scales. The Act authorizes up to $219.5 million over four years in support of these four mapping components.

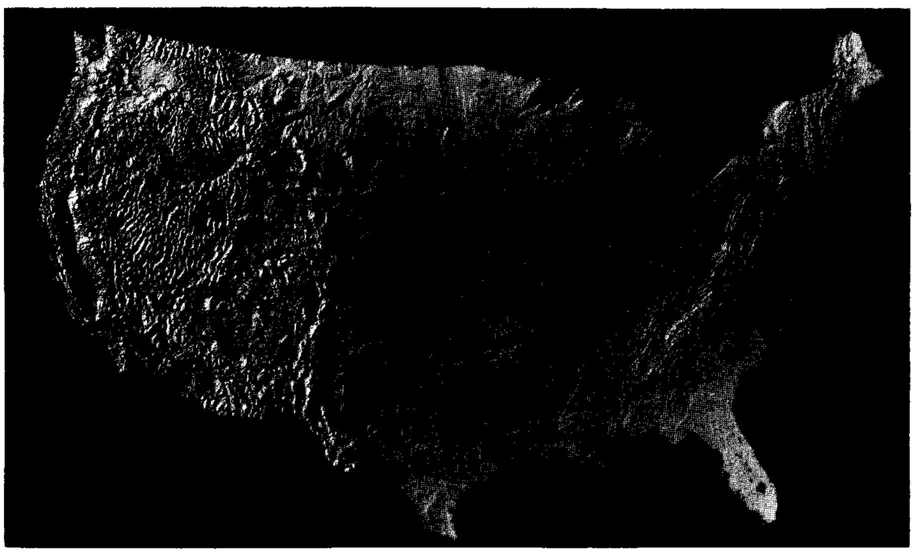
According to *Resource News* (the Nebraska Conservation and Survey Division bimonthly newsletter), for federal fiscal year 1993, the federal and support components are funded at nearly 100% of authorized levels. However, the state component, authorized for funding at $15 million, is funded at only $1.3 million, and the educational component, authorized for $500,000, is currently not funded.

According to the recently released "Program Announcement" for the state geologic mapping component, 1993 is a transition year for the National Geologic Mapping Act program. This year, funds will be directed toward completion of mapping projects already underway as part of the U.S. Geological Survey's COGEOMAP program; a few modest new projects may be funded.

The state component directly affects North Dakota because it provides for federal funds to state geologic surveys for geologic mapping and requires 50% state matching funds. While appropriation and distribution of state component funds is uncertain, the NDGS is working to establish mapping priorities and will agressively pursue funding when it becomes available.

Available Again

The U.S. Geological Survey's tremendously popular *Landforms of the Conterminous United States: A Digital Shaded-Relief Portrayal* by G.P. Thelin and R.J. Pike is once again available from the NDGS (see ordering instructions on p. 13). USGS Map I-2206. 1991 (reprinted 1992). Scale 1:3,500,000 (1 inch = about 55 miles). Sheet 55 by 35.5 inches. Accompanied by a 16-page explanatory text. Price = $6.00 plus shipping.



The Geology of Radon

In the Winter 1992 *NDGS Newsletter* we reported on a new U.S. Geological Survey booklet - *The Geology of Radon*, by J. K. Otton - indicating that it was available free through the North Dakota Geological Survey. Single copies are still free while the supply lasts, but thereafter the booklet will cost $1.50 per copy. It may still be ordered through the North Dakota Geological Survey. Copies may also be obtained directly from the USGS Book and Open-File Report Sales, Box 25286, Denver, CO 80225.

U.S. Bureau of Mines *1990 Annual Report* Available

The *1990 Annual Report*, published by the U.S. Bureau of Mines, summarizes nonfuel mineral industry activity in North Dakota for the 1990 calendar year. Included are discussions on trends and developments, legislation and government programs, and a review by mineral commodity. The report is available free of charge from the North Dakota Geological Survey, or from Eileen Peterson, U.S. Bureau of Mines, Intermountain Filed Operations Center, Denver Federal Center, P.O. Box 25086, Denver, CO 80225 (Tel. 303-236-0451).

Nonfuel Mineral Industry Statistics

The U.S. Bureau of Mines (USBM) recently released 1992 estimates of nonfuel mineral production in North Dakota. According to USBM estimates, the value of nonfuel minerals produced in North Dakota in 1992 was about $17.7 million, up slightly from the $17.4 million reported in 1991. Construction sand and gravel accounted for more than 70% of the value of North Dakota's nonfuel mineral production. Elemental sulfur was recovered from natural gas processing at five plants in the western part of the state, but is not included in the bureau's estimates. In terms of value, elemental sulfur is the second most important nonfuel mineral produced in North Dakota.

Table 1.
Nonfuel mineral production in North Dakota1/

12/ 4/1992
S92P-ND

Mineral	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)	1992e/ Quantity	1992e/ Value (thousands)
Clays ------------------ metric tons --	50,485	W	27,825	W	25,948	W
Gem stones ----------------------------	NA	$10	NA	$6	NA	W
Lime ------------ thousand short tons --	82	4,623	98	5,360	75	$4,102
Sand and gravel (construction) --- do.--	7,644	17,219	e/5,000	e/12,000	5,300	13,000
Stone (crushed) --------- short tons --	e/1,000	e/4,600	11	W	10	W
Combined value of other industrial minerals and values indicated by symbol W ----------------------------	XX	116	XX	(2/)	XX	628
Total ------------------------------	XX	26,568	XX	3/17,366	XX	17,730

e/Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
1/Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2/Value excluded to avoid disclosing company proprietary data.
3/Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

STATE ROCKS, MINERALS, AND FOSSILS: A STATE ROCK FOR NORTH DAKOTA?

by John Bluemle

Introduction

North Dakota has a state flower (wild prairie rose), a state tree (American elm), a state bird (meadowlark), a state grass (western wheatgrass), a state beverage (milk), and a state fossil (Teredo petrified wood). A number of other states also have state gems, stones, minerals or rocks and twenty-eight states have designated state fossils (see list at the end of this article). Arizona even has a state cravat, the bola tie, which is usually adorned with their state mineral, turquoise, and a state symbol, the saguaro cactus. In fact, Arizona even had a "state fungus" at one time. It seems that one of their legislators had been quoted as saying that "politicians in Arizona are bought and sold." In response, his fellow legislators designated him as their official state fungus, a "commercial type of fungus that can be bought and sold."

We often get letters asking for a sample of our state rock and I will comment on some possibilities later. The requests come mainly from students doing science projects, but also from individuals all over the country and from other countries. Although North Dakota has no official state gem or state rock, we do, as I said, have a state fossil, Teredo (bored) petrified wood (see sidebar).

A State Rock for North Dakota?

It has been suggested that the state designate an official State Rock and, although several possibilities exist, I think I'd favor either the rock known as Knife River Flint or, perhaps, clinker (the baked, brick-like rock formed when lignite beds burn and fuse adjacent sediments). Neither of these materials is in short supply, although clinker is certainly more abundant than flint. I've written about clinker in previous newsletter articles and this time I'd like to comment on the kinds of siliceous, quartz-rich rocks found in North Dakota and why I think the rock known as Knife River Flint would be a logical choice for a state rock.

Most of the flint in North Dakota comes from rock that formed during early and mid Tertiary time, between about 60 and 30 million years ago. It is "petrified" swamp debris--a silicified lignite bed. The expression "silicified" means the filling of pores and/or the substitution of silica (the chemical compound SiO_2) for another substance. Flint forms when silica-carrying waters pass through a peat or lignite layer, gradually replacing the organic matter and filling the pores with silica. The process is the same as that for forming certain kinds of petrified wood, but the parent material is swamp debris, not an individual tree. Examination of some samples of flint will reveal elongate leaves, flattened stems, and other fragments of organic debris. Silicification is a common process in many areas, especially below the water table.

Flint is often strewn around on the surface in southwestern North Dakota. Most of the material originated not where it is found, but in older beds now eroded away. It persists as a coarse lag material because of its extreme physical toughness and chemical insolubility.

The term "flint" or "flintstone" is applied to any dark-colored rock nearly completely siliceous in composition. It could also be referred to as "chert," though that term is not commonly used in North Dakota. Rock hounds have numerous names for this kind of material, the names varying with person, locality, source, and polishing qualities of the rock. The names vary greatly in usage and can be very confusing.

A closely related material, similar to flint, known as quartzite or silcrete occurs in two types in North Dakota. A dull, buff-colored, very hard siliceous rock commonly pierced by small diameter (a half inch or less) tubular holes and a dull white material also commonly full of "holes." This rock is also derived by silicification, but the original material prior to silicification was more commonly a clay or sandstone, and the resulting rock typically lacks the dark color found in flint. Flint and silcrete are commonly found mixed at the same locality, though most commonly one kind will dominate. The white variety is common in the Bowman area and along some parts of the Little Missouri River badlands.

North Dakota's State Fossil

North Dakota's state fossil was designated in 1967, when State Representative W. G. Sanstead of Minot proposed the state fossil in House Bill 933. Representative Sanstead acted at the request of R. W. Carlson, formerly of Bismarck and former president of the Central Dakota Gem and Mineral Club. Promotion of "Teredo Wood" as the state fossil was largely due to the efforts of H. A. Brady of Mandan, who presented a plea before the Legislature. (Most of the information below came from a paper by Dr. Alan M. Cvancara, a Professor of Geology at the University of North Dakota, which appeared in the Spring, 1970 issue of the *North Dakota Quarterly*.)

Teredo petrified wood is a fossil wood that is riddled with irregular, very elongate borings (Fig. 1). The fossil wood is variably preserved. It may be compact, with good preservation of wood structure, or it may be somewhat splintery. Borings in the fossil wood are the result of action by worm-like, bivalve mollusks (clams), which are common in modern seas. Commonly known as "shipworms" because of their riddling of wooden ships, the creatures are infamous because of damage they do to pilings and other wood structures; the mollusks are exclusively woodborers.

Since living shipworms inhabit seas, one logically searches for Teredo petrified wood in rock formations of marine origin. In North Dakota, three exclusively marine formations are extensively exposed at the surface: Pierre Formation shale, Fox Hills Formation sandstone, and Cannonball Formation shale and sand. Most of the Teredo Wood has been collected from the Cannonball Formation (Paleocene age, about 60 million years old), which was deposited in the last sea that covered North Dakota. This formation is best exposed in the Bismarck-Mandan area and southwest of these two cities. I've also found a few small pieces of Teredo Wood in younger gravel deposits in glacial sediment, but these are the result of reworking of Cannonball, or older, sediment and such specimens are usually quite worn.

The phrase "Teredo petrified wood" is somewhat misleading because one might assume that it means a type of wood, such as oak or elm. The term "Teredo" actually refers to the animal that bored the wood; the term "Teredo-bored petrified wood" might be better. Also, since several types of shipworms (not just the Teredo) may have bored the wood, it might be even better to call the fossil "clam-bored fossil wood" or "shipworm-bored fossil wood."

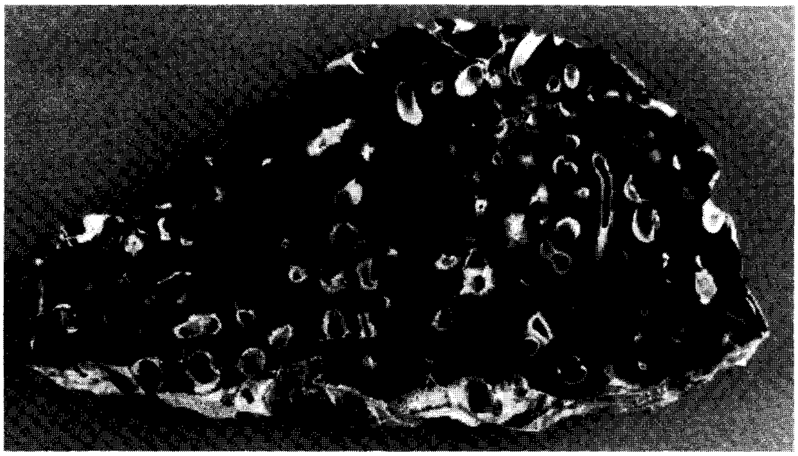


Figure 1. *Polished section of Teredo petrified wood. This specimen is about 7 inches long and was cut perpendicular to most of the elongate tubes. The tubes, or borings, were made by marine mollusks commonly known as shipworms because of the damage they still do to wooden ships, pilings and other wooden structures.* Photo by Todd Strand, Photo Archivist, State Historical Society of North Dakota.

Silcrete commonly has a high sheen (a wavy, polished appearance) on some weathered surfaces, which contrasts with the dull surface of a fresh break. This sheen is due to both minor amounts of solution and/or to abrasion by wind-blown particles.

Knife River Flint is a fairly uniform, non-porous, dark-brown rock, a form of equidimensional, microcrystalline quartz. Apparently the dark brown color is caused by extremely fine-grained organic particles dispersed through the material. The flint has a conchoidal fracture, like glass, making it an excellent material for tools (Fig. 2). Knife River Flint fluoresces in a characteristic manner in long-wave and short-wave ultraviolet light (Mark Luther, personal communication).

Knife River Flint is a distinctive rock that was used extensively as raw material for tools by the prehistoric Native Americans of the Northern Plains and Midwest. Most of the flint was probably quarried from deposits along the Knife River valley in Dunn and Mercer Counties, North Dakota. "Knife River" is the translation of an Indian name, which is said to have been given because flint for knives was quarried along the river.

At least twenty-four Knife River Flint quarries have been found in Dunn County and five in Mercer County. They occur on hill tops or on hill slopes, generally a few tens of feet above the adjacent valley bottoms. The quarries range in size from 2 to 80 acres and they have a total combined area of about 250 acres. Each quarry consists of numerous pits spaced about 20 feet apart. The pits are round depressions that today are about 20 feet in diameter and 3 to 4 feet deep; they were likely considerably deeper when the Native Americans were excavating them, but they have since caved and sediment has washed into them. About 30 pits may be found on an acre of land. Approximately one million cubic feet of Knife River Flint was removed from the pits during prehistoric times, though probably less than half of this was high-quality material.

The exact age of the flint quarries is not known. Knife River Flint is common in projectile points made during the Woodland and Plains Village Periods (from about 2,000 to 100 years ago) and during the Paleo-Indian Period (from at least 11,000 to about 6,000 years ago). The flint was used throughout North Dakota and it was traded in adjacent states and provinces and in areas as far apart as Alberta, Missouri, and Ohio. This suggests that the Knife River Flint quarries in North Dakota were worked for several thousand years.

References

Milici, Robert C., editor, 1991, State gems, minerals, rocks, stones, metals, and fossils: State Geologists Journal, p. 93-97.

Clayton, Lee, Bickley, W. B., Jr., and Stone, W. J., 1970, Knife River Flint: Plains Anthropoligist, v. 15-50, p. 282-290.

Cvancara, Alan M., 1970, North Dakota's state fossil: North Dakota Quarterly, v. 38, no. 2, p.31-35.

Figure 2. Knife River Flint. Note characteristic conchoidal fracture and white rind on weathered surface. Knife River Flint is a distinctive dark brown rock that formed from a silicified lignite bed. It was used for projectile points and tools throughout North Dakota and widely traded in areas as far apart as Alberta, Missouri and Ohio. These projectile points were made by Jim Regan of Minnesota.

LIST OF STATE ROCKS

Here is a listing of state rocks, etc. from most of the states. I have no information on five states: Hawaii, Kansas, New Hampshire, Vermont, and Virginia.

ALABAMA:
- Mineral - Hematite
- Rock - Marble
- Fossil - Eocene Whale, *Basilosaurus cetoides*

ALASKA:
- Gemstone - Jade
- Mineral - Gold
- Fossil - Pleistocene Mammoth, *Mammuthus primigenius*

ARIZONA:
- Gem - Turquoise
- Fossil - Triassic Petrified Wood, *Araucarioxylon arizonicum*

ARKANSAS:
- Gem - Diamond
- Mineral - Quartz Crystal
- Rock - Bauxite

CALIFORNIA:
- Gem - Benitoite
- Mineral - Gold
- Rock - Serpentine
- Fossil - Pleistocene Saber-Tooth Cat, *Smilodon californicus*

COLORADO:
- Gem - Aquamarine
- Fossil - Upper Jurassic Dinosaur, *Stegosaurus*

CONNECTICUT:
- Gem - Garnet

DELAWARE:
- Mineral - Sillimanite

FLORIDA:
- Gem - Moonstone
- Stone - Agatized Coral
- Fossil - Eocene sea urchin, *Eupatagus antillarum* (unofficial)

GEORGIA:
- Gemstone - Quartz Crystal
- Mineral - Staurolite
- Fossil - Shark's Teeth (no genus or species specified)

IDAHO:
- Gemstone - Star Garnet

ILLINOIS:
- Mineral - Fluorite

INDIANA:
- Fossil - Crinoid (proposed)

IOWA:
- Rock - Geode

KENTUCKY:
- Fossil - Brachiopod (no genus or species specified)

LOUISIANA:
- Gemstone - Agate
- Fossil - Petrified Palm Wood

MAINE:
- Mineral - Tourmaline
- Fossil - Devonian Plant, *Pertica quadrifaria*

MARYLAND:
- Fossil - Miocene Marine Snail, *Ecphora quadricostata*

MASSACHUSETTS:
- Gem - Rhodonite
- Mineral - Babingtonite
- Rock - Conglomerate
- Fossil - Dinosaur Tracks

MICHIGAN:
- Stone - Petoskey Stone (Devonian Coral), *Hexagonaria percarinata*
- Gem - Chlorastrolite

MINNESOTA:
- Stone - Lake Superior Agate

MISSISSIPPI:
- Stone - Petrified Wood
- Fossil - Eocene Whale, *Zygorhiza koochii*

MISSOURI:

Mineral - Galena
Rock - Mozarkite
Fossil - Crinoid

MONTANA:

Gem - Yogo Sapphire
Gemstone - Moss Agate
Fossil - Upper Jurassic Dinosaur, *Maiasaurus*

NEBRASKA:

Gem - Blue Chalcedony
Rock - Prairie Agate
Fossil - Pleistocene Mammoth, *Mammuthus (Archidiskodon)*

NEVADA:

Metal - Silver
Fossil - Marine Reptile, *Ichthyosaurus*

NEW JERSEY:

Rock - Stockton Sandstone (unofficial)
Fossil - Dinosaur, *Hadrosaurus foulkii* (unofficial)

NEW MEXICO:

Gem - Turquoise
Fossil - Upper Triassic Dinosaur, *Coelophysis*

NEW YORK:

Gem - Garnet
Fossil - Late Silurian Sea Scorpion (Eurypterid), *Eurypteris remipes*

NORTH CAROLINA:

Precious Stone - Emerald
Rock - Granite
Shell - Scotch Bonnet

NORTH DAKOTA:

Fossil - Teredo (bored) Petrified Wood

OHIO:

Gemstone - Flint
Fossil - Ordovician Trilobite, *Isotelus*

OKLAHOMA:

Rock - Rose Rock (Barite Rose)

OREGON:

Gemstone - Sunstone (gem feldspar)
Rock - Thunderegg (agate-filled nodule)

PENNSYLVANIA:

Fossil - Devonian Trilobite, *Phacops rana*

RHODE ISLAND:

Mineral - Bowenite
Rock - Cumberlandite

SOUTH CAROLINA:

Gemstone - Amythyst
Stone - Blue Granite
Shell - Snail, *Oliva sagana*

SOUTH DAKOTA:

Gemstone - Fairburn Agate
Mineral - Rose Quartz
Fossil - Upper Cretaceous Dinosaur, *Triceratops prorsus*

TENNESSEE:

Gemstone - River Pearl
Rocks - Limestone and Agate

TEXAS:

Gemstone - Topaz
Rock - Fossilized Palm Wood

UTAH:

Gem - Topaz
Fossil - Upper Jurassic Dinosaur, *Allosaurus fragilis*

WASHINGTON:

Gem - Petrified Wood

WEST VIRGINIA:

Gem - Mississippian Coral, *Lithostrotionella*

WISCONSIN:

Mineral - Galena
Rock - Wausau Red Granite
Fossil - Trilobite, *Calymene celebra*

WYOMING:

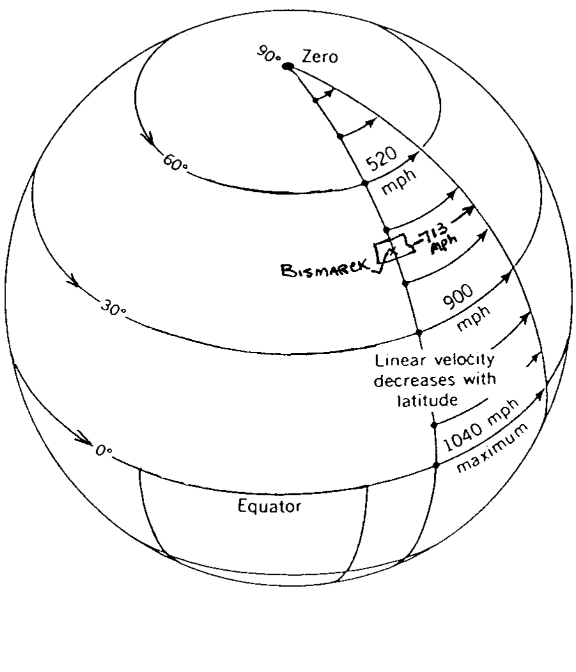
Gem - Jade
Fossil - Eocene Fish, *Knightia*

ROCKY CLAVEN CORNER

by
Paul Diehl

Have you ever heard someone say so-and-so is so busy that it seems like they are constantly in motion? Guess what; they are! In fact, unless you live directly on the north or south pole you are continuously in motion. Even when we think we are sitting still we are moving; moving at speeds fast enough to more than double the land speed records. Depending on how far from the equator you live, you are moving at a velocity greater than the speed of sound. For instance if you are in Bismarck, you - and everything and everyone else around you - are moving with a linear velocity of approximately 713 miles per hour. But if you live in Maida along the northern border or in Forbes along the southern border of North Dakota, you are traveling at about 683 mph or 724 mph respectively. How is this possible?

Since we all live on the surface of the earth, we are actually moving along with the earth as it rotates on its axis. The instantaneous linear velocity of a point on the surface of the earth resulting from the earth's rotation varies from approximately 1,040 mph at the equator to zero at the poles (Figure 1). As you know, the earth makes one complete rotation in each 24 hour mean solar day. Solar time is the time by which we set our watches and clocks. The eastward rotation of the earth is what makes the sun, moon, and stars seem to rise in the east, travel across the sky, and set in the west.



The linear velocity of a point on the earth's surface varies with the point's distance from the equator (Table 1). Since each point makes one rotation each day, the linear velocity can be calculated if we know how far the point travels in one day's time. The distance traveled is equal to the earth's circumference at a particular distance from the equator, i.e., at a given latitude. Standing on the equator you would travel a distance equal to the earth's equatorial circumference in one day. Velocity is equal to the distance traveled divided by the time to travel that distance. Thus, the linear velocity of someone standing on the equator would be equal to the number of miles around the earth at the equator divided by the number of hours in a day*.

Table 2 shows the length of one degree of latitude and longitude for various latitudes from 0° to 90°. Data from this table may be used to calculate the distance around the earth along each of the parallels of latitude by multiplying the number of miles for 1° of longitude at a given latitude by 360°, the distance the earth rotates in a day. The calculated distance can then be divided by the number of hours in a day to arrive at the linear velocity for a point at that latitude.

*This calculation involves the use of a particular kind of time - the number of mean solar hours in a sidereal day. There are 23.934 mean solar hours in a sidereal day.

Figure 1. Instantaneous linear velocity of selected points on the surface of the earth. Because of the spherical shape of the earth, linear velocity decreases toward the poles. At successively higher latitudes, a point on the earth has a shorter distance to travel in a given length of time. Modified from: Strahler, 1971, The Earth Sciences, *Hasper & Ron, NY.*

Latitude	Linear Velocity: Miles per hour	Linear Velocity: Meters per second
0°	1,041.41	465.06
10°	1,024.72	458.05
20°	978.05	437.19
30°	901.79	403.10
40°	798.11	356.75
50°	670.10	299.53
60°	521.53	233.12
70°	356.90	159.53
80°	181.25	81.02
90°	0.000	0.000

Table 1. Linear velocity of rotation at various latitudes. Source: from Strahler, 1971, The Earth Sciences, *Hasper & Ron, NY, p. 23.*

Latitude, degrees	Length of 1° of Latitude: statute miles	Length of 1° of Latitude: kilometers	Length of 1° of Longitude: statute miles	Length of 1° of Longitude: kilometers
0	68.704	110.569	69.172	111.322
5	68.710	110.578	68.911	110.902
10	68.725	110.603	68.129	109.643
15	68.751	110.644	66.830	107.553
20	68.786	110.701	65.026	104.650
25	68.829	110.770	62.729	100.953
30	68.879	110.850	59.956	96.490
35	68.935	110.941	56.725	91.290
40	68.993	111.034	53.063	85.397
45	69.054	111.132	48.995	78.850
50	69.115	111.230	44.552	71.700
55	69.175	111.327	39.766	63.997
60	69.230	111.415	34.674	55.803
65	69.281	111.497	29.315	47.178
70	69.324	111.567	23.729	38.188
75	69.360	111.625	17.960	28.904
80	69.386	111.666	12.051	19.394
85	69.402	111.692	6.049	9.735
90	69.407	111.700	0.000	0.000

Source: From S. S. Gannett, "Geographic Tables and Formulas," *U.S. Geological Survey Bulletin* 650, 1916, pp. 36–37. Based on Clarke ellipsoid of 1866.

Table 2. Lengths of degrees of latitude and longitude.

EARTH SCIENCE EDUCATION

In this edition of "Earth Science Education" we would like to bring to your attention educational materials available from a different organization, the North Dakota Geological Society. (While we share acronyms, the North Dakota Geological SURVEY and the North Dakota Geological SOCIETY are different; the former is a state agency whereas the latter is a non-profit organization of persons interested in the geology of North Dakota.)

The North Dakota Geological Society recently established a VCR Tape Library with a $1,000 grant from the Rocky Mountain Section Foundation of AAPG (American Association of Petroleum Geologists). The tapes, listed below, are available for use by schools, colleges, service clubs, or groups interested in earth science or the solar system. The Society has one copy of each geology and paleontology tape and two copies of each NASA tape.

Terms:

* Loan period is 14 days.
* Tapes may be picked up and returned to the Tapes Librarian at the North Dakota Geological Survey, 1022 E. Divide Ave., Bismarck, ND at no charge.
* One or two tapes will be mailed for a fee of $2.50 to cover postage and handling, plus return postage.
* Checks must be made out to the **North Dakota Geological Society**, not to the North Dakota Geological Survey or NDGS.

GEOLOGY

(Viewing time, in minutes and seconds is shown in brackets).

AAPG 1 - Before the Mountains [28:48]. A broad introduction to the sedimentary sequences laid down before compressional tectonics formed the Rocky Mountains; this video uses the western Canada sedimentary basin as a study model.

AAPG 2 - Birth of the Rockies [28:05]. The extremely complex system of eastward-directed thrust faults in the Canadian Rockies is documented in this video. The three main components of the Rockies, all composed of thrust sheets, are reviewed.

AAPG 3 - Modern Carbonates [17:00]. Using the outline of Abu Dhabi and the Bahama Platform as examples, this video compares and contrasts environments of carbonate deposition.

AAPG 4 - Arid Carbonate Coastlines [31:00]. Shows modern processes on today's arid carbonate tidal flats along the southern Arabian Gulf and explains how the model translates into producing formations in West Texas.

AAPG 5 - Stratigraphic Traps: The Tidal Flat Model [13:00]. Shows tidal flat depositional processes in the field and explains their implications by comparing them with rock samples from ancient tidal flats.

AAPG 6 - Carbonate Petrography [28:10]. An excellent guide to classification of carbonate strata through light- and electron-microscopic study of grains, cements, fabrics, etc.

AAPG 7 - Development Geology [46:00]. AAPG distinguished lecturer presentation focusing on the numerous problems and solutions to successful development of petroleum reservoirs. Numerous field examples plus relationship of geological engineering and geophysical technologies to reservoir development.

AAPG 8 - Sample Examination [26:00]. Staff at the Shell Exploration Training Center cooperated in demonstrating proper wellsite sample collection and preparation practices; office examination, identification and logging techniques; and lab preparation of thin sections, acetate peels, etc.

GSA 1 - The Earth Has a History [19:50]. This film uses two principles to demonstrate that the earth has a history far vaster than human history: original horizontality of sedimentary layers and superposition (i.e., the bottom layer was deposited first). Teacher's guide included.

RCV 1 - Life in the Balance: The Study of Extinctions [28:00]. Highlights the research of two geologists concerned with mass extinctions in the geological record and draws parallels between ancient and modern environmental crises.

DK 1 - The Beaches are Moving [60:00]. Describes geologic processes of beach accumulations and erosion along the Atlantic Coast of North Carolina. Examines consequences and environmental costs of human development of the Atlantic shoreline.

SM 1 - Gems and Minerals [45:00]. Shares the beauty and mystery of gems and minerals from the collections of the Smithsonian Institution.

SM 2 - Gemstones of America [60:00]. Describes how crystals are formed, how gems are mined and crafted into jewelry; illustrated with gem specimens from collections at the Smithsonian Institution.

AMOCO 1 - Blowout at Lodgepole [61:00]. Deals with a sour gas blowout that occurred in 1982 at Lodgepole, Alberta. Explains the reason for the blowout, how it was brought under control and studies the effects of hydrogen sulfide gas on the area.

NDGS 1 - Landforms of North Dakota [23:00]. This is a slide presentation adapted to video. It describes the geology of North Dakota in general terms. The video was intended mainly for teachers of earth science in North Dakota schools, but it should be useful to anyone interested in learning more about the surface geology of the state.

PALEONTOLOGY

AAE 10101 - Dinosaur! The First Clue: Tale of a Tooth: [:48] 1991. The discovery, less than 200 years ago, of the dinosaurs, those amazing beasts who towered over the earth for 150 million years.

AAE 10102 - Dinosaur! The Fossil Rush: Tale of a Bone: [:48] 1991. Follow the dinosaur trail out west to the wide open spaces of America. From the 1870's "bone rush" to today's scientific discoveries.

AAE 10103 - Dinosaur! Birth of a Legend: Tale of an Egg: [:48] 1991. Enter the fascinating world of the baby dinosaur. In 1922, a chance discovery in the deserts of Mongolia heralded a new understanding of dinosaur behavior.

AAE 10104 - Dinosaur! Giant Birds of the Air: Tale of a Feather: [:48] 1991. The dinosaurs were one of the most successful groups ever to inhabit the earth. What caused their extinction? Are modern birds their decendents?

NASA TAPES

NASA 1AB - Planet Mars: [28:30] 1979. Story of planet from telescopic investigations to landing of the Viking robot.

NASA 1AB - Voyager 2: Neptune Encounter [29:00] 1989. Segments progress from computer animation of the Voyager mission to actual photographs of Neptune and Triton.

NASA 2AB - Earth Views from Shuttle Flights [26:00] 1986. Variety of video footage includes parts of North America, South America and Africa.

NASA 2AB - Comet Halley Returns [29:00] 1988. Features a narrated history of Halley's Comet and a discussion about its value in studying the origin of the solar system.

NASA 3AB - New Look at the Old Moon [28:30] 1980. Reviews geophysical and sample investigations from Apollo missions 1969-1979. Interprets lunar history based on these investigations.

NASA 3AB - Assignment: Shoot the Moon [28:00] 1967. Summarizes the exploration of the moon conducted by the unmanned ranger, surveyor, and lunar orbiter spacecraft. Shows how such detailed data and photography contributed to the first manned flight.

NASA 3AB - Moon: An Emerging Planet [13:00] 1973. Briefly compares the geology of the moon with that of the earth and other terrestrial planets.

NASA 4AB - Our Star the Sun [28:30] 1988. The sun as revealed by thousands of pictures taken by Skylab astronauts during 3 Skylab flights.

NASA 4AB - Earth, the Planet [28:30] 1988. This program explains a region of the earth's atmosphere, the magnetosphere. Includes a description of how the magnetosphere works, how its energy releases and an explanation of solar wind and aurora.

NASA 5AB - Veil of Venus [28:30] 1988. Features facts about the atmosphere of Venus.

NASA 5AB - Apollo 12: Pinpoint for Science [28:00] 1970. Reviews the EVA activities during mans' second journey to the moon; includes recording of a solar eclipse.

NASA 6AB - Eagle has Landed: The Flight of Apollo 11 [28:00] 1969. The story of the historic first landing of men on the moon in July 1969. Highlights from launch through post-recovery activities.

NASA 6AB - Four Rooms: Earth View [28:00] 1975. Skylab was the first U.S. manned space station. This is the story of the 3 missions and 9 astronauts who manned the laboratories for 171 days.

NASA 7AB - Fourth Planet: Mars [28:30] 1988. This program shows how facts gleaned from space missions began to separate fact from science fiction.

NASA 7AB - Mercury: Exploration of a Planet [28:00] 1976. The flight of the Mariner 10 spacecraft to Venus and Mercury is detailed in animation and photography.

NASA 8ABC - I Will See Such Things [28:30] 1986. Images of the atmosphere, moon and rings of Uranus from the Voyager 2 flyby of January 1986.

NASA 8ABC - 19 Minutes to Earth [14:30] 1978. Examines scientific findings of Viking missions to Mars. Difficulties in interpretation of data are discussed.

NASA 8ABC - Picture the Solar System [14:30] 1979. Reviews theories about how the solar system evolved and challenges to theories based on data from Voyager and Pioneer flights.

NASA 8ABC - Earth-Sun Relationship [5:30]. Animated depiction of how the sun and planets formed.

NASA 9AC - Life on the Moon [28:30] 1988. Explains importance and function of the NASA JSC's Lunar Receiving Laboratory. Geological and botanical experiments are performed on rock and soil samples.

NASA 9AC - Mars: Is There Life [14:30] 1976. Introduces the possible past history of Mars as well as its present topography. The Viking lander and its biology experiments are discussed in relationship to the search for life on Mars.

NASA 9AC - Life [14:30] 1976. General characteristics of life; illustrations of how life adapted to earth conditions. The habitat of Mars is described and questions of life on Mars are raised.