EARTH

THE GEOLOGY OF SOUTH DAKOTA

Description

"South Dakota, the land of infinite variety..." This phrase is especially true when one considers the wealth of geologic diversity that lies beneath our feet. From the glacial sediments underlying most of Eastern South Dakota to the *igneous* and *metamorphic* rocks of the Black Hills area, our state's geological deposits range in age from a few thousand years to over a billion years old! (See cross section below.)

Geologists normally describe the rocks of any area in chronological order, i.e., from the oldest to youngest. However, this fact sheet first will concentrate on surface rocks, examining the geology along the east-west line illustrated by the cross section below, from Sioux Falls to Harney Peak. Then, the older rocks beneath will be discussed. By coincidence this east-west transect starts with some of the youngest rocks, in Eastern South Dakota, and ends up with some of the oldest rocks, in the Black Hills area.

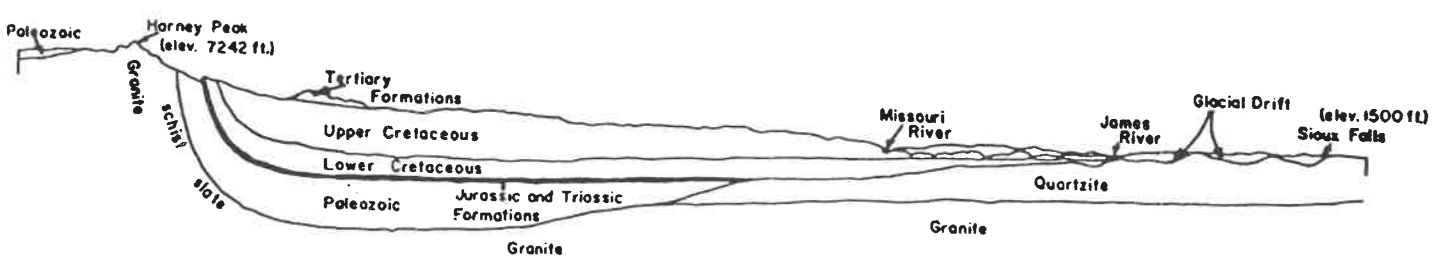


Fig. 1: Idealized Cross-Section of South Dakota
(Cross-section runs from A to A' shown in Fig. 2)

Eastern South Dakota - The Pleistocene Epoch

The Glaciers Advance

The *unconsolidated* rocks making up most of the surface east of the Missouri River are of glacial origin. Evidence suggests that these sediments were laid down through numerous glacial advances and retreats beginning some 1.5 million years ago, and ending 10 thousand years ago. Rock particles of many types, shapes, and sizes were left behind by the glaciers, and this material is collectively called *drift*. Many of these rock fragments originated from Canada and other points north and east of their present positions. The average thickness of the glacial sediments in Eastern South Dakota is about 100 feet (30.5 meters), although in the northeastern part of the state thicknesses can sometimes exceed 900 feet (274.3 meters).

Two of the most noticeable land forms left behind from this glacial activity are moraines and kettles. Moraines are often long, rounded ridges that create rugged, boulder-strewn upland areas. Kettles are usually small, concentric lowlands, commonly called sloughs. Some of the largest kettles form lakes, the best known probably being Lake Poinsett.

Central South Dakota - The Cretaceous Period

The Great Interior Seaway

Beneath most of the glacial drift east of the Missouri River, and forming the land surface of large tracts of Central and Western South Dakota (see Figure 2), are Cretaceous age shales, sandstones, and limestones. These *sedimentary* rocks were deposited over 65 million years ago in a vast inland sea that covered most of this state. Many fossils of giant marine reptiles that swam in those seas have been found, although other marine fossils, such as fish and sea shells, are generally easier to locate. (The future *Marine Vertebrate Fossils of South Dakota* fact sheet will have more information).

South Central S. Dakota - The Tertiary Period

Badlands And Sand Dunes

Extreme South Central South Dakota is an area of pine-covered buttes, rolling sand dunes, and badlands topography. The dunes are a northern extension of the Nebraska Sand Hills, resulting from the deposition of fine-grained sediments originating from the mountains to the west. During the Tertiary Period, about 2.5 to 65 million years ago, and on into the Quaternary, sediments that later became the buttes and badlands were deposited. Concurrently, rich and diverse fauna and flora existed in this area, resulting in fossil deposits and scenic vistas today. Anyone visiting the Badlands National Park can attest to this!

Western South Dakota - The Cretaceous Period

The Black Hills Uplifted

Toward the end of the Cretaceous or during earliest Tertiary times, the Black Hills were thrust up during a period of mountain building. At that time the highest elevations were probably over 15,000 feet above *mean* sea level. Over time, this uplifted dome was eroded down to its present elevation. Today, the Black Hills area gives us the most complete geologic record of rock history in South Dakota. The oldest rocks are found in the center of the uplifted, eroded dome. These rocks are metamorphic, mostly slates and quartzites, and are over 2 billion years old. Intruded into these are granites, such as one sees at Harney Peak and Mount Rushmore. Moving out from the central core of the Black Hills, one encounters progressively younger formations encircling one another. Looking at the *stratigraphic column* (Figure 3 fold out), one can see the many formations that are represented in the over 400 million year time interval between the Cambrian Deadwood Formation and the Jurassic Morrison Formation. All of these formations are visible in the Black Hills.

The Precambrian Era

Lying beneath the *sedimentary* rocks of South Dakota are found a variety of very old Precambrian *igneous* and *metamorphic* rocks. Most are over a billion years old. Where the overlying *sedimentary* rocks have been eroded away, as in the core of the Black Hills, and in the Sioux Falls, Dell Rapids, and Milbank areas, rocks such as granite and quartzite can be seen at the surface. Both of these rock types have played significant roles in the economy of this state.

Milbank "mahogany granite" is world renowned as an ornamental stone. From Tokyo to London one can find this beautiful granite used as facia stone on many buildings. The granite in the Black Hills is too fractured to be useful for building.

Many older buildings around the state are built of the incredibly hard and weather resistant pink "Sioux quartzite." Over the years, quartzite has seen many diverse applications. Toothpaste, engine block manufacturing, and road construction are just a few examples.

Why Is Geology Important?

Almost everything we use in our daily lives revolves around earth materials. If we don't grow it, then we probably mine it. In South Dakota, we use our glacial gravels for the building and maintenance of roads. The crushed Sioux quartzite is also used extensively for roads and other construction projects. Much of the *riprap* along our dams is also Sioux quartzite.

Ever since the gold rush days, the Black Hills area has been an important gold and silver mining area. South Dakota has recently ranked second or third among the states in the production of gold. Many semiprecious gem stones can also be found in the area.

Other materials mined in Western South Dakota include limestone and gypsum for cement, *bentonites* for drilling muds, and feldspars and micas for the glass, electrical and ceramics industries. The production of oil in the northwest and natural gas in the southwest are also contributors to our economy. In certain other areas of the state, significant reserves of uranium and low grade manganese ore may also be found.

A thorough understanding of geology also enables a better understanding of our *aquifer* systems. As the majority of our state's population relies on ground water for drinking water, the better the data concerning this critical resource, the better the management and protection of these supplies. (See *S.D. Aquifers* fact sheet.)

The scientific study of South Dakota's geology is ongoing. Just correlating the geology from one part of the state to another is an immense task (see generalized *stratigraphic column*), but the more we understand the history of the rocks beneath us, the more treasures we uncover!

The geology of South Dakota is a truly unique asset. Not only does it help build our homes and roads, run our cars, and create jobs, but its beauty attracts thousands of tourists to our state every year.

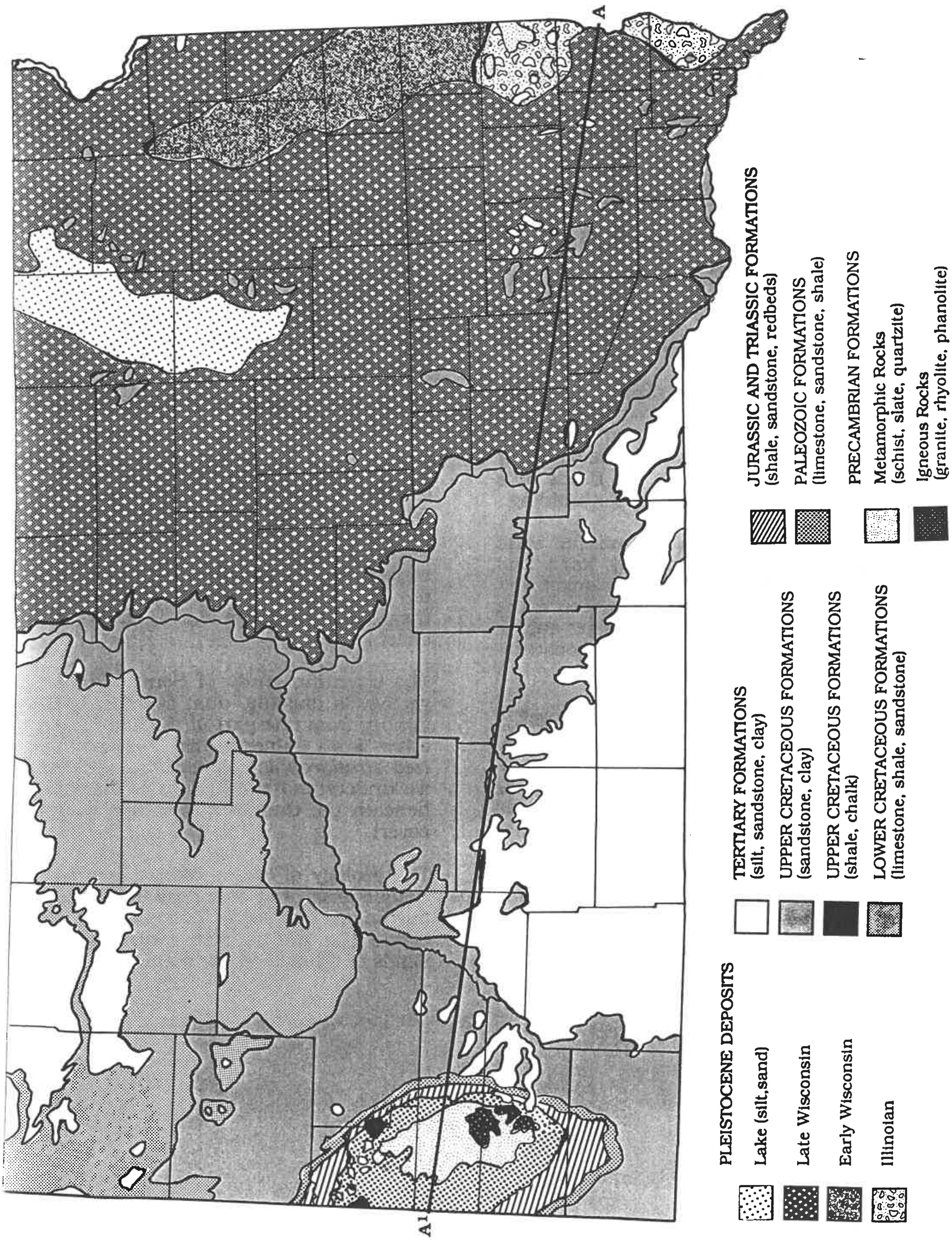


Figure 2. Geologic Map of South Dakota

Department of Natural Resource Development
South Dakota Geological Survey

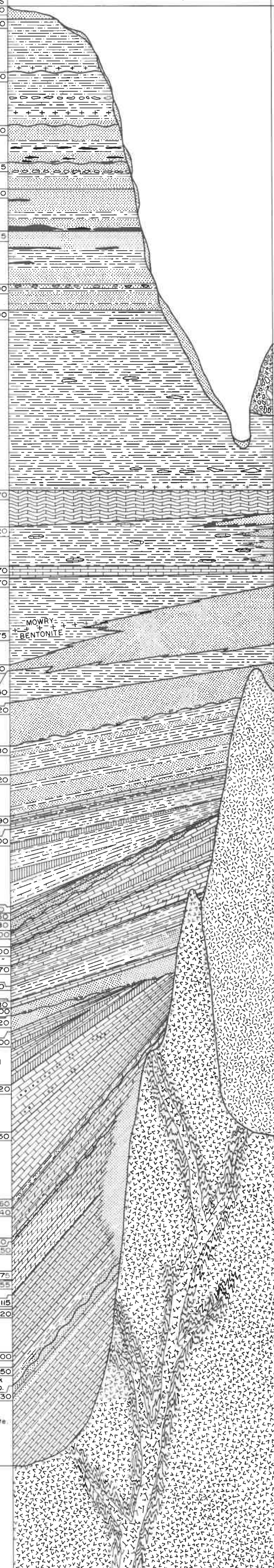
GENERALIZED STRATIGRAPHIC COLUMN OF CENTRAL AND NORTHWESTERN SOUTH DAKOTA—by Robert A. Schoon

Educational Series
Map Six

Northwestern South Dakota

PERIOD / EPOCH	GROUP / FORMATION	DESCRIPTION	THICKNESS
QUATERNARY	PLEISTOCENE	Sand, gravel, boulders.	0-60
TERTIARY – MIOCENE	ARIKAREE GROUP	Clay and silt, light colored, soft to cemented; white ash bed at base.	0-500
TERTIARY – OLIGOCENE	WHITE RIVER GROUP	Clay, pink, sandy and silty, chalcedony veins, massive.	0-600
TERTIARY – PALEOCENE	FORT UNION: TONGUE RIVER	Clay and sand, light colored, minor thin coal beds.	0-400
TERTIARY – PALEOCENE	FORT UNION: CANNONBALL	Shale, greenish gray, sandstone, yellow to buff as concretions and channel filling.	0-225
TERTIARY – PALEOCENE	FORT UNION: LUDLOW	Clay and sandstone, somber gray with some thin lignite beds. Shadehill (?) coal at base.	0-350
CRETACEOUS	HELL CREEK FORMATION	Shale, drab, soft brown (somber beds) and sandstone gray. Sandstone increases toward base. Thin lenses of lignite in upper part.	0-325
CRETACEOUS	FOX HILLS FORMATION	Sandstone, grayish white to carbonaceous gray shale. Ironstone concretions at top.	0-200
CRETACEOUS	PIERRE SHALE	Shale, light gray to dark gray.	2800
CRETACEOUS	NIOBRARA FORMATION	Chalk, light to dark gray, white speckled, microfossiliferous.	270
CRETACEOUS	CARLILE SHALE	Shale, medium to dark gray plastic to fissile - scattered ironstone concretions.	320
CRETACEOUS	GREENHORN LIMESTONE	Limestone, white to light gray, slabby, very fossiliferous with dark gray, white speckled shale at top and at base.	70
CRETACEOUS	BELLE FOURCHE SHALE	Shale, dark gray, dolomite and ironstone concretions.	370
CRETACEOUS	MOWRY SHALE	Shale, medium gray, siliceous, bentonite marker at top.	275
CRETACEOUS	NEWCASTLE SANDSTONE	Sandstone, white to light gray, fine-grained in part, very shaley.	0-100
CRETACEOUS	SKULL CREEK SHALE	Shale, dark gray with thin glauconitic siltstone near middle of interval.	200-250
CRETACEOUS	INYAN KARA GROUP (FALL RIVER AND LAKOTA SANDSTONE)	Sandstone, white to light gray, fine to medium-grained quartz, predominately friable.	320
JURASSIC	MORRISON FORMATION	Shale, medium gray, interbedded with sandstone, white, fine grained, glauconitic.	180
JURASSIC	SUNDANCE FORMATION	Sandstone, white, fine to medium grained, glauconitic, interbedded with shale, gray, green and brown.	320
TRIASSIC	PIPER LIMESTONE	Limestone, white to brown, fine grained, interbedded with shale, green, red and brown.	90
TRIASSIC	SPEARFISH FORMATION	Shale, silty, orange, brick red, green and minor gray. Interbedded with anhydrite, gypsum and salt.	0-600
PERMIAN	MINNEKAHTA LIMESTONE	Limestone, white to lavender, fine, dense.	0-50
PERMIAN	OPECHE SHALE	Shale, brick red, silty.	0-50
PERMIAN	MINNELUSA: CASSA [3]	Sandstone, white, brick red, clayey.	0-80
PERMIAN	MINNELUSA: BROOM CREEK [3]	Anhydrite, white to light brown, limestone and dolomite, white to light gray, silty.	80-300
PENNSYLVANIAN	MINNELUSA: WENDOVER-MEEK [3]	Limestone, dolomite, light gray, fine, silty, anhydrite, light brown and gray. "Red Shale Marker" at top.	175-200
PENNSYLVANIAN	MINNELUSA: HAYDEN [3]	Limestone, light gray to brown interbedded with black radioactive shale.	140-170
PENNSYLVANIAN	MINNELUSA: ROUNDTOP [3]	Shale, green to minor red, plastic, sands up eastward	100-160
PENNSYLVANIAN	MINNELUSA: RECLAMATION [3]	Ls, white to black, lithographic, varicolored shale	0-80
PENNSYLVANIAN	MINNELUSA: FAIRBANK [3]	Sandstone, white to red, in part shaley.	0-100
MISSISSIPPIAN	KIBBEY SANDSTONE	Sandstone, white to gray, medium to coarse grained.	0-120
MISSISSIPPIAN	CHARLES FORMATION	Limestone, white to light tan, lithographic, interbedded with anhydrite, white to light blue and light brown.	0-400
MISSISSIPPIAN	MISSION CANYON FORMATION	Limestone, white to light tan, fine to oolitic, in part anhydritic.	120-320
MISSISSIPPIAN	LODGEPOLE FORMATION	Limestone, light to medium brown, gray, fine to medium grained, in part sucrosic.	120-550
MISSISSIPPIAN	ENGLEWOOD	Dolomitic siltstone and varicolored shale	0-60
DEVONIAN	DUPEROW	Light brown, fine grained limestone and dolomite, interbedded with thin gray shale.	0-240
DEVONIAN	SOURIS RIVER	Varicolored shale and red dolomitic siltstone	0-30
SILURIAN	INTERLAKE	Light tan to brown dolomite, fine grained clastics at base.	0-250
ORDOVICIAN	STONEWALL	Light tan to pale dolomite, locally sandy.	0-75
ORDOVICIAN	STONY MOUNTAIN	Brownish gray fine grained dolomite at top with green waxy shale and siltstone at base.	0-155
ORDOVICIAN	RED RIVER (UNIT A)	Light brown to pale red	0-115
ORDOVICIAN	RED RIVER (UNIT B)	limestone, in part dolomitized, and light colored chert. Threefold subdivision is mainly based	0-320
ORDOVICIAN	RED RIVER (UNIT C)	E-log characteristics.	0-100
ORDOVICIAN	WINNIPEG	Fine grained quartz sandstone at base, green, splintery to subway shale with small vitreous black phosphate nodules interbedded with siltstone at top.	0-150
CAMBRIAN	DEADWOOD	White to reddish-orange, fine to medium grained quartz sandstone and dolomite, contains green shale partings and locally abundant glauconite.	0-630
PRECAMBRIAN		Igneous and metamorphic rock.	

Stratigraphic Section



Central South Dakota

THICKNESS	DESCRIPTION	GROUP / FORMATION	PERIOD / EPOCH
0-500	Clay, sand, pebble and boulder mixture.	PLEISTOCENE	QUATERNARY
1000-1300	Shale, medium to dark gray with limestone and ferruginous concretions. Many thin bentonites. Shale, dark gray, carbonaceous. Bentonite at base.	PIERRE SHALE	CRETACEOUS
120-150	Chalk, light to dark gray, white, speckled, microfossiliferous	NIOBRARA FORMATION	CRETACEOUS
0-70	Sandstone, white to gray, glauconitic.	CODELL SANDSTONE	CRETACEOUS
330	Shale, medium to dark gray, plastic, ironstone concretions and stringers of fine grained sandstone.	CARLILE SHALE	CRETACEOUS
40	Limestone, white to light gray, fossiliferous.	GREENHORN LIMESTONE	CRETACEOUS
110	Shale, dark gray, fissile to blocky, ironstone concretions.	GRANEROS SHALE [1]	CRETACEOUS
450	Sandstone, white, fine to medium grained, friable to well consolidated.	DAKOTA SANDSTONE [2]	CRETACEOUS
0-150	Sandstone, dark gray, glauconitic, siltstone near middle part.	SKULL CREEK SHALE	CRETACEOUS
0-225	Sandstone, white, fine to coarse grained quartz.	INYAN KARA GROUP	CRETACEOUS
0-7000 ?	Sioux Ridge composed of pale maroon to red orthoquartzite.	SIOUX QUARTZITE	PRECAMBRIAN
	Igneous and metamorphic rock.		PRECAMBRIAN

[1] As defined by Hattin, D.E., 1965. Stratigraphy of the Graneros Shale (Upper Cretaceous) in Central Kansas. Kansas Geological Survey, Bull. 178, 83 pp.

[2] As described by Meek, F.B., and Hayden, F.V., 1861. Philadelphia Academy of Natural Resources Proceedings, v. 13, p. 419-20.

[3] Condra, G.E., Reed, E.C., and Scherer, O.S., 1940. Correlations of the Formations of the Laramie Range, Hartville Uplift, Black Hills and western Nebraska, Nebraska Geological Survey Bull. 13, 52 pp.

In view of the equivalency of the Hartville "Formation" and the Minnelusa, the Hartville subdivisions are employed in the Minnelusa in South Dakota.

SOUTH DAKOTA GEOLOGICAL SURVEY

DJ

1,000 copies of this document were printed on recycled, acid-free paper by the South Dakota Geological Survey, Vermillion, at a cost of 10 cents each. WN026 2-93

Glossary

Aquifer - a body of rock or sediment that is sufficiently permeable to conduct ground water and to yield economically significant quantities of water to wells and springs.
Bentonite - soft clay, formed by the weathering of volcanic ash, with the unique characteristic of swelling to several times its original volume when in contact with water.
Drift - collectively, the variously sized and shaped rock particles left behind by glaciers.
Igneous - rocks formed by solidification from a molten or partially molten state. Can either be formed beneath the earth's surface (plutonic), or by volcanic activity (extrusive).
Mean - in statistics, the average of a group of numbers.
Metamorphic - rocks formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.
Riprap - foundation or wall made of broken stones, loosely or irregularly thrown together.
Sedimentary - rocks formed generally in one of three ways, either by accumulation and solidification of eroded rock fragments, i.e., sandstone; by precipitation from a saturated aqueous solution, i.e., rock salt; or by the secretion of organisms, i.e., coral limestone.
Stratigraphic column - the vertical succession of rock and soil layers at a particular location.
Unconsolidated - sediments that are loosely arranged or with particles not cemented together.

Reference Materials

S.D. Geological Survey, 1964. Geologic Map of S.D.: S.D. Geological Survey Education Series Map 1.
Schoon, R.A., 1974. Generalized Stratigraphic Column Of Central And Northwestern South Dakota: South Dakota Geological Survey Educational Series Map 6.

Selected Geological Resources For Teachers

Publications available through the S.D. Geological Survey, USD, Vermillion, SD 57069:
- *Geologic Map of South Dakota*: South Dakota Geological Survey Educational Series Map 1 by South Dakota Geological Survey, 1964.
- *A Geology of South Dakota; Part 1: The Surface* by Rothrock, E.P., 1944, South Dakota Geological Survey Bulletin 13. (Photocopies only).
- *Minerals and Rocks of South Dakota:* South Dakota Geological Survey Educational Series 5 by Petsch, B.C., and McGregor, D.J., 1973.
- *Record of life:* S. D. Geological Survey Educational Series 2. by McGregor and Petsch, 1968.
- *South Dakota's Rock History:* South Dakota Geological Survey Educational Series 3. by Petsch, B.C., and McGregor, D.J., 1969.

The Black Hills: Geological Gem of the West, a video describing the events that created the Black Hills and the Badlands by Gerald Teachout, available through the Petrified Forest, HC-80, Box 766, Piedmont, SD 57769, Grades 6- adult.
Fossiliferous Cenozoic Deposits of Western South Dakota and Northwestern Nebraska edited by J. E. Martin, 1985. Museum of Geology, SD School of Mines and Tech., Dakoterra, vol. 2 no. 2.
Geology of the Black Hills, South Dakota and Wyoming edited by F.J. Rich, 1985. Geological Society of America, Rocky Mountain Section Guidebook, American Geological Institute.

Outreach (Resource Agency Personnel)

Earth Sciences and Physics Department, University of South Dakota, Vermillion, SD 57069.
Geology Department, S.D. School of Mines and Technology, Rapid City, SD 57701.
Museum of Geology, S.D. School of Mines and Technology, 501 E. St. Joseph, Rapid City, SD 57701
South Dakota Geological Survey, Akeley Science Center, USD, Vermillion, SD 57069.
U.S. Geological Survey, Rm. 408 Federal Bldg., 200 4th Street SW, Huron, SD 57350.

Written by:
Martin J. Jarrett, South Dakota Geological Survey, Vermillion, SD 57069.
Reviewed by:
Dr. James E. Martin, S.D. School of Mines and Technology, Rapid City, SD 57701.

Publication of the *Geology of South Dakota* fact sheet was funded through a Natural Resource Conservation Education Grant, USDA, Forest Service.