SOUTH DAKOTA DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
DIVISION OF FINANCIAL AND TECHNICAL ASSISTANCE
GEOLOGICAL SURVEY PROGRAM
1° x 2° SERIES GEOLOGICAL QUADRANGLE MAP 3

GEOLOGIC MAP OF THE McINTOSH 1° x 2° QUADRANGLE, SOUTH DAKOTA AND NORTH DAKOTA

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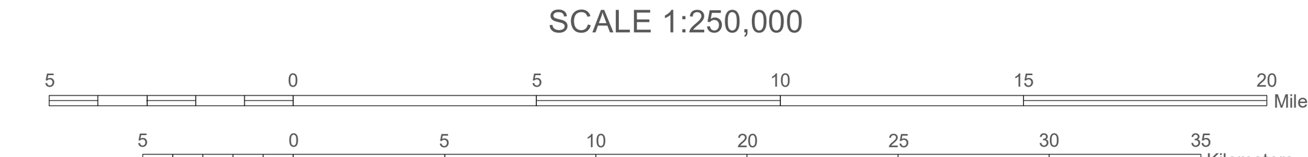
2022

State of South Dakota
Kristi Noem, Governor

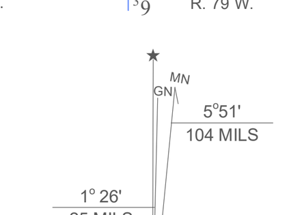
South Dakota Geological Survey
Timothy C. Cowman, State Geologist

Map base digitized from U.S. Geological Survey 1:250,000 McIntosh quadrangle 1953 (Revised 1976) Digital Raster Graphic.
South Dakota road base modified from South Dakota Department of Transportation data.
North Dakota road base modified from North Dakota Department of Transportation data.
Projection is Universal Transverse Mercator, Zone 14N.
Datum is 1983 North American.

SCALE 1:250,000



CONTOUR INTERVAL 100 FEET



UTM GRID AND 2022 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

Digital Cartography by Jonathan N. Luczak

QUADRANGLE LOCATION

CORRELATION OF MAP UNITS

- Holocene / Pleistocene — QUATERNARY: Qal, Ql, Qt, Qe, Qll, Qloc, Qlot, Qlov, Qltg, Qlte, Qlts
- Paleocene — TERTIARY: Ttr, Tcb, Tll
- Late Cretaceous — CRETACEOUS: Kh, Kfh, Kp

DESCRIPTION OF MAP UNITS

QUATERNARY

Qal — **Alluvium** (Holocene-Pleistocene) – Sandy clay with lenses of sand and gravel. Poorly consolidated to unconsolidated, poorly- to well-sorted, angular to rounded, clay to boulder-size clasts. Typically stratified, and having a high clay content. Deposited in present-day drainages. May include associated terrace deposits. Estimated maximum thickness 50 ft (15.2 m)

Qe — **Eolian deposit** (Holocene-Pleistocene) – Silt and clayey silt, fine-grained, unconsolidated to consolidated, wind transported and deposited loess. A thin veneer of loess covers some terraces and upland areas east of the Missouri River, and adjacent to larger streams and rivers west of the Missouri River. Exposures are completely oxidized. Thickness typically several inches to 6 ft (1.8 m), to as much as 15 ft (4.6 m). Localized areas of dunes of fine- to medium-grained, well-sorted sand with up to 25 ft (7.6 m) of relief occur along some major drainages. Blowouts may expose 15-20 ft (4.6-6.1 m) of sand, with a maximum thickness of 25 ft (7.6 m)

Ql — **Landslide deposit** (Holocene-Pleistocene) – Slumps of local lithologies with displacements of over 30 ft (9.1 m), producing a hummocky topography. Prevalent in the Fox Hills Sandstone, Hell Creek Formation, and Pierre Shale along major drainages. Identification may be difficult because most slopes are covered with vegetation and the orientation of the beds is usually not visible

Qt — **Terrace deposit** (Holocene-Pleistocene) – Terrace deposits associated with small streams and tributaries are up to 6 ft (1.8 m) thick and contain over 90% subrounded to angular, locally derived material with abundant sandstone and calcareous and ironstone concretion fragments. Terrace deposits associated with major drainages are as much as 21 ft (6.4 m) thick and contain lenses and interbeds of fine to coarse sand and sandy gravel with angular, cobble-size clasts of 50-70% locally derived material including abundant fragments of ironstone and claystone concretions, silicified wood and orthoquartzite from the Tongue River Formation, and western derived feldspar and quartz. Terraces on the eastern side of the quadrangle contain 20-50% rounded glacial clasts of granite and arkosic material, quartz, greenstone, sandstone, chalcedony, and limestone. Most terrace deposits have a high clay and silt content. Some terraces have a cover of loess as much as 10 ft (3.0 m) thick. Lag deposits of residual boulders of orthoquartzite and pieces of silicified wood from the Tongue River Formation, or local greenish-gray conglomeratic boulders possibly from the Chadron Formation, are scattered widely across the quadrangle and diminish to the east. Residual glacial boulders occur locally in the north central portion of the quadrangle and are dominantly of igneous and metamorphic lithologies. Multiple terrace levels and ages may be included within a single mapped deposit. Includes the Moreau gravel. Deposits occur as much as 300 ft (91.4 m) above present-day streams

Qlot — **Outwash, terrace** (Upper Wisconsin) – Heterogeneous clay to gravel of glaciofluvial origin, typically unconsolidated and stratified. Includes tan subgraywacke sand, coarse- to fine-grained and cross bedded, with lenses and interbeds of coarse gravel consisting of 2-40% local non-glacial material, and 50-67% igneous, 7-13% metamorphic, and 3-17% sedimentary clasts of glacial origin. In North Dakota, includes sediments of the Coleharbor Group. Thickness up to 20 ft (6.1 m)

Qlov — **Outwash, valley train** (Upper Wisconsin) – Primarily unconsolidated, stratified, heterogeneous silt to gravel. The upper portion of deposits often contains coarser material. Confined to valleys of glaciofluvial origin. Forms flat to slightly sloping topography along present streams and is partially overlain by Recent alluvium. In North Dakota, includes sediments of the Coleharbor Group. Thickness up to 60 ft (18 m)

Qloc — **Outwash, collapsed** (Upper Wisconsin) – Unconsolidated to poorly consolidated, stratified, heterogeneous sand and gravel of glaciofluvial origin. Generally fine-grained, consisting mainly of clayey silt and silty fine sand mixed with lenses and layers of coarse gravelly sand to medium-size gravel. Deposited as outwash sediments that collapsed due to melting of buried ice. Characterized by undulating topography with low to high local relief. Thickness as much as 150 ft. (45.7 m)

Qll — **Lacustrine deposit** (Upper Wisconsin) – Glaciolacustrine clay, silty clay, and silt with minor sand and gravel layers and lenses, calcareous to noncalcareous. Medium- to thick-bedded; may be laminated or varved. Medium- to dark-gray, weathers to yellowish-gray. Forms flat, low-lying terrain or terraces. Includes the Pollock Formation. In North Dakota, includes sediments of the Coleharbor Group and Oahe Formation. Thickness approximately 6-150 ft (1.8-45.7 m)

Qlts — **Till, stagnation moraine** (Upper Wisconsin) – Heterogeneous clay with silt- to boulder-size clasts of glacial origin. Geomorphology is characterized by hummocky terrain having topography with 10-50 ft (3.0-15.2 m), to as much as 100 ft (30.5 m) of relief, and abundant sloughs resulting from stagnation of ice sheets. In North Dakota, includes sediments of the Coleharbor Group. Thickness approximately 40-200 ft (12.2-61.0 m), locally as much as 290 ft (88.4 m)

Qlte — **Till, end moraine** (Upper Wisconsin) – Heterogeneous clay with silt- to boulder-size clasts of glacial origin. Geomorphology is characterized by elevated linear ridges with hummocky terrain locally at former ice sheet margins. In North Dakota, includes sediments of the Coleharbor Group. Thickness approximately 50-200 ft (15.2-61.0 m)

Qltg — **Boulder residuum** (Pre-Wisconsin) – Includes concentrations of angular orthoquartzite gravel to boulders possibly from the Tongue River Formation mixed with approximately 87% igneous, 10% metamorphic, and 3% non-carbonate sedimentary cobbles of glacial origin over 2.4 in (6.1 cm) to boulder-size in a matrix of loess. Thickness 0-6 ft (0-1.8 m)

Disconformity

TERTIARY

Fort Union Group (Paleocene) – Includes the Ludlow, Cannonball, and Tongue River formations

Ttr — **Tongue River Formation** – Graywacke sandstone, siltstone, claystone, shale, carbonaceous shale, and lignite. Tan to rose. Medium- to very fine-grained with abundant irregular calcareous concretions and cementation. Limestone layers to 4 in (10.2 cm) thick occur within the claystone and siltstone beds. Some sandstone beds contain abundant petrified wood and plant fragments, especially near the base. Thickness approximately 0-25 ft (0-7.6 m)

Tcb — **Cannonball Formation** – Interbedded and lensing clay, silty clay, and very fine- to medium-grained graywacke sand. Dark-gray, tan to yellow. Poorly consolidated, with small lenses of gray, friable, calcareous glauconitic sandstone. Contains abundant, characteristic irregular gray limestone concretions to several feet across that weather to an erosional lag of angular fragments. The more limy beds have a marine molluscan fauna dominated by the gastropods *Fasciolaria* sp. and *Epitonium* sp. Typically poorly exposed. The lower Cannonball Formation interfingers laterally with the Ludlow Formation. Thickness approximately 60-200 ft (18.3-61.0 m)

Tll — **Ludlow Formation** – Interbedded and lensing arkosic and graywacke sandstone, poorly consolidated, medium- to fine-grained, cross bedded and ripple marked, and silt to silty sand, claystone and shale. White, tan, to gray. Locally with numerous calcareously cemented slabby lenses and orange-brown limonitic concretionary layers. Associated with gray, brown, to pinkish, fissile to massive clay and bentonitic clay, silty to sandy clay, and peat clays having plant fragments. Typically poorly exposed. The upper Ludlow Formation interfingers laterally with the Cannonball Formation. Includes the Shadehill lignite facies and the Hillen lignite facies. Thickness approximately 35-200 ft (10.7-61.0 m)

Shadehill lignite facies – Occurs locally at the base of the Ludlow Formation, and consists of gray to brown clay, peat clays, and tan to rusty sand and silty sand with interbedded thin seams of coal, and brown to black fissile lignite and peat clay from 0.5-30 in (1.3-76.2 cm) thick. Has associated limonite staining, melanterite nodules, and selenite crystals. Thickness 10-20 ft (3.0-6.1 m)

Hillen lignite facies – Occurs approximately 25-80 ft (7.6-24.4 m) above the Shadehill lignite facies, and consists of one or more black, fissile to blocky, lignitic coal seams 0.5-34 in (1.3-86.4 cm) thick interbedded with gray to dark-gray clay, brown peat clay, and gray to tan clayey graywacke sands. Thickness 8-40 ft (2.4-12.2 m)

CRETACEOUS

Kh — **Hell Creek Formation** (Upper Cretaceous) – Includes upper and lower units that lose identity to the west. Undifferentiated on this quadrangle. Total thickness of formation as much as 440 ft (134.1 m)

Lower unit – Interbedded and lensing arkosic and graywacke sand and silt. Tan, medium-gray, brown, to white. Locally with angular, very fine- to medium-grained, calcareous, cross bedded white bentonitic sand, gray clayey sand, and brown to dark-gray lenses and beds of clay, bentonitic clay, and silty clay. Bentonitic clays and silts have plant and fusain fragments, brown to black peat clay, and local lenses and seams of black, blocky lignite up to 12 in (30.5 cm) thick. Fossil resin pellets are present locally in the carbonaceous beds with sparse pyrite and marcasite nodules. Resistant sandstone beds occur locally near the base. Calcareously cemented lenses and layers of orange to rusty-brown limonitic ironstone, and black to purple-black ferromanganese concretions are locally abundant. The Lower unit is characterized by white sand blowouts, abundant ferromanganese concretion fragments, beds of brown peat-clay, and has more sandy and silty beds than the Upper unit. Contains discontinuous beds of *Ostrea glabra* and dinosaur remains. Weathered bentonitic clays have a popcorn-like surface. Gradational with the underlying Fox Hills Sandstone, with the contact placed at the first appearance of red carbonaceous shale. Includes the Isabel-Firesteel lignite facies. Thickness approximately 20-80 ft (6.1-24.4 m)

Isabel-Firesteel lignite facies – Occurs locally near the top of the Lower Hell Creek unit and is a discontinuous zone 0-25 ft (0-7.6 m) thick consisting of white sand, tan to beige siltstone, and brown carbonaceous and peat-clay and gray clay with fragments of carbonized wood. Includes as many as three local seams of black, fissile clayey and silty lignite to subbituminous coal up to 7 ft (2.1 m) thick. Coal beds may split into several beds or grade laterally into brown peat-clay or carbonaceous siltstone. Intervals between coal beds are approximately 11-19 ft (3.4-5.8 m) thick. Inclusions of melanterite, marcasite, gypsum crystals, fossil resin pellets, and limonite staining occur. Tan to brick-red beds of clinker or pseudoscoria, with some underlain by whitish ash, were produced from peat-clay beds overlying burning coal seams, and locally form resistant hills

Upper unit – Graywacke and arkosic sand and silt, fine- to coarse-grained, locally cross bedded. Light-gray to gray, tan to white. Contains numerous interbeds and lenses of dark-gray to tan bentonitic to sandy clay, and gray to tan bentonitic graywacke, sand, and sandy silt. Brown peat-clay and black carbonaceous shale beds are more abundant and thicker than in the Lower unit. Some beds contain abundant plant fragments. Has numerous discontinuous, calcareously cemented, ledge-forming sandstone layers. Locally abundant orange-brown limonitic and black to purple-black ferromanganese concretions form an erosional veneer of weathered fragments typical of the Upper unit. Pseudoscoria or clinker beds are absent. Weathered bentonitic clays have a popcorn-like surface. Originally referred to as the “somber beds.” Thickness approximately 60-360 ft (18.3-109.7 m)

Kfh — **Fox Hills Sandstone** (Upper Cretaceous) – Includes the Trail City, Timber Lake, and Iron Lightning members. Undifferentiated on this quadrangle. Contacts between members and lithofacies are gradational. Depositional environments grade from marine to brackish, to freshwater and continental from east to west, with the members becoming less discernable. Gradational with the underlying Pierre Shale and the overlying Hell Creek Formation

Iron Lightning Member – Includes the Bullhead and Colgate lithofacies (Waage, 1968). Named after exposures near Iron Lightning, Ziebach County, South Dakota

Colgate lithofacies – Subgraywacke and graywacke sand. Gray to light-gray, tan to white, weathering light-brown. Laminated to thick-bedded, subrounded to subangular, very fine- to medium-grained with 1.5-4 ft (0.46-1.2 m) thick interbeds of slabby, ledge-forming siliceous and calcareous sandstone. Sandstone and graywacke beds and lenses increase in abundance upward, but occur at various levels throughout the Iron Lightning Member. Characterized by a “salt and pepper” appearance, cross bedding, clay pebble layers and clay partings, current and oscillation ripple marks, carbonaceous seams, and scattered petrified wood and plant fragments. Locally with calcareous and siliceous cement, and small brownish limonitic claystone concretions. Differential weathering and removal of cement produces a brownish, irregular to spheroidal surface. Contains scattered *Ostrea subtrigonalis, Corbicula subelliptica, C. occidentalis, Mytaloides* sp., *Anchura* sp. and *Melania* sp. A 1-10 ft (0.3-3.0 m) thick bed of *Ostrea glabra* having tan silt and fine calcarenite matrix occurs at the base. The Colgate lithofacies thickens from east to west, thins to the north, and interfingers with the Bullhead lithofacies. Thickness 1-60 ft (0.3-18.3 m)

Bullhead lithofacies – Alternating beds of graywacke to subgraywacke sand, clayey sand, and silt 1-14 in (2.5-35.6 cm) thick, tan to light-gray, and medium-gray, coarse- to very fine-grained, locally cross bedded sand. Occurs with 1-12 in (2.5-30.5 cm) thick beds of tan, brown, to dark-gray fissile clay, and brown to olive-green bentonitic silty clay. Orange-brown limonitic staining and concretions occur in local beds as well as scattered throughout. Thin partings of brown plant material are present. Originally referred to as the “Banded Beds.” The lower 25 ft (7.6 m) of the Bullhead lithofacies has the same fauna as the Timber Lake Member. The upper portion of the Bullhead lithofacies is sparsely fossiliferous, with scattered layers of *Ostrea glabra*. Upper and lower contacts are slightly gradational, with the Bullhead lithofacies having a higher clay content than adjacent units. Scattered outcrops occur, however the Bullhead lithofacies is typically poorly exposed. Thickness variation is due to facies changes and interfingering with the overlying Colgate lithofacies and underlying Timber Lake Member. Named for exposures near Bullhead, Dewey County, South Dakota. Thickness 20-130 ft (6.1-38.1 m)

Timber Lake Member – Subgraywacke to slightly glauconitic subquartzose sand. Tan, gray, to greenish-gray, weathering yellowish-tan to yellowish-brown. Laminated to thick-bedded, medium- to very fine-grained, subrounded to subangular, and cross bedded. Becomes more silty to clayey at the base. Contains discontinuous orange-brown, 5-14 in (12.7-35.6 cm) thick calcareous and ferruginous cemented ledge-forming layers, masses of orange limonitic to gray sandy claystone, and carbonate and ironstone concretions. Gray clay pebbles, gypsum crystals, and plant fragments are present. Fossil invertebrates occur as scattered individuals and in coquina-like concretions. The lower Timber Lake Member has a brackish water fauna dominated by local accumulations of *Tancredia americana*. About 5-20 ft (1.5-6.1 m) above the Tancredia zone is a fauna characterized by *Pteria linguiformis* associated with *Dosinopsis nebrascensis, Callista* sp., *Ostrea pellucida, Pteria nebrascana, Limopsis parvula, Mactra* sp., *Panopea occidentalis, Dosinopsis nebrascensis, Anchura americana, Discoscaphites cf. D. nebrascensis,* and *Sphenodiscus lenticularis*. Burrow casts of the form genus *Halymenites major* occur throughout, increasing in abundance upward. The Timber Lake Member thins to the south and from east to west, pinching out along a north-south line west of the town of McIntosh, Corson County, South Dakota. Named for exposures near Timber Lake, Dewey County, South Dakota. Thickness 14-240 ft (4.3-73.1 m)

Trail City Member – The lower Trail City Member is fissile bentonitic clay, silty clay, and silt, medium- to dark-gray, with interbedded tan, brown, to light-gray, fine- to medium-grained, locally glauconitic subgraywacke sand, siltstone, and silty clay. The clay content decreases upward, and grades into thin beds of tan to light-gray sand and silt with interbedded limonitic sand and clay of the upper Trail City Member. Locally with discontinuous layers having fossiliferous limonitic and gray limestone concretions, and gypsum crystals. Weathers light- to medium-gray with a popcorn-like surface. Concretions in the lower 25 ft (7.6 m) of the Trail City Member are characterized by *Discoscaphites nicoletti,* and are overlain by accumulations of *Gervilla recta* and *Limopsis parvula*. Approximately 35-75 ft (10.7-22.9 m) above the base of the member the fauna is dominated by *Protocardia subquadrata, Pteria nebrascana,* and *Limopsis parvula*. Other fossils include *Tellina scitula, Yolda evansi, Y. scitula, Pteria linguiformis, Ostrea cf. O. pellucida, Mytaloides* sp., *Goniomya americana, Cucullaea* sp., *Gervillia* sp., *Limopsis* sp., *Fusis* sp., *Nucula cancellata, N. planimarginata, Corbula cf. C. inornate, Anchura americana, Fasciolaria culbertsoni, F. buccinoides, Spironema tenuilineata, Trachytriton vinculum, Lunatia concinna, Closteriscus tenuilineatus, Discoscaphites nebrascensis, D. mandanensis, D. abyssinius, Sphenodiscus lenticularis*, and *Eutrephoceras dekayi.* Sphenodiscids are absent in the lower fossil assemblages. Concretions and fossils decrease in abundance to the west. Named for exposures near Trail City, Dewey County, South Dakota. Thickens from east to west, thins to the northeast. Thickness 48-200 ft (14.6-42.7 m)

Kp — **Pierre Shale** (Upper Cretaceous) – Includes the DeGrey, Verendrye, Virgin Creek, Mobridge, and Elk Butte members based on Searight’s (1937) subdivision along the Missouri River valley, and a generalized Upper Pierre Shale unit that likely includes the Mobridge and Elk Butte members. Undifferentiated on this quadrangle. Gradational into the Fox Hills Sandstone with increasing silt content and a color change from gray to light-gray or tan

Upper Pierre Shale unit – Clay shale to bentonitic clay shale, blocky to fissile. Gray, dark-gray, to dark bluish-gray. Few silty beds are present in the upper portion. Gypsum crystals and partings, limonite staining, thin bentonite layers, and light-gray limestone and black to orange-brown limonitic claystone concretions occur throughout. Fossils include *Baculites* sp. and *Mytaloides* sp. Exposed thickness 160-280 ft (48.8-85.3 m)

Elk Butte Member – Bentonitic clay and silty bentonitic clay, fissile. Dark-gray to bluish-gray, weathering light- to medium-gray. Weathered surfaces have a popcorn-like appearance. Thin beds of silt, sand, and silty bentonitic clay occur near the top, with thin partings of bentonite throughout. Contains cone-in-cone concretions, gypsum crystals, limonite, melanterite, and orange to black limonitic and calcareous ironstone concretions. Gradational into the Fox Hills Sandstone, with the contact placed above the highest bentonite bed in the Elk Butte Member. Erosion produces a characteristic complex drainage pattern and blowouts. Named after Elk Butte, Corson County, South Dakota. Exposed thickness up to 162 ft (49.4 m)

Mobridge Member – Interbedded shale, clay, and foraminiferal bentonitic clay, gray to bluish-gray, and tan marl. Bentonite increases in abundance toward the base. Marl having a banded appearance is prevalent near the middle of the unit. Very calcareous to noncalcareous, with abundant limestone concretions. The fossil *Baculites* sp. occurs in the lower portion. Named for exposures west of Mobridge, Corson County, South Dakota. Exposed thickness 140 ft (42.7 m)

Virgin Creek Member – Shale, siliceous shale, clay, and bentonitic clay. Light- to dark-gray. Noncalcareous, fissile, weathers to small, silvery-gray flakes. Contains thin siliceous and bentonite layers that increase in abundance toward the base. Iron-stained limestone concretions occur locally in the upper portion. Named after Virgin Creek, Dewey County, South Dakota. Thickness 120-150 ft (36.6-45.7 m)

DeGray and Verendrye members (undifferentiated) – Clayey shale, bentonitic shale, fissile, becoming siliceous toward the base. Gray, light-gray, to brown. Contains thin bentonite layers. Initially mapped as the Sully Member. Exposed thickness approximately 122 ft (37.2 m)

CONTACT

FOLDS

Anticline — Arrow indicates direction of plunge. Dashed where approximately located; dotted where concealed

Syncline — Arrow indicates direction of plunge. Dotted where concealed

Monocline, anticlinal bend — Dotted where concealed. Shorter arrow on steeper limb

GLACIAL

Western extent of pre-Wisconsin glaciation — Location inferred. Hachures on side of line from which ice advanced

Late Wisconsin glaciation advance lines — Dashed where approximately located. Hachures on side of line from which ice advanced

Meltwater channel — May be partially collapsed drift

Ice contact face — Arrows point down slope of contact

OTHER FEATURES

- Open Pit Mine
- Gravel Pit
- Oil Test

REFERENCES

(Numbers indicate mapped areas shown on index map; unnumbered sources are general references)

1) Baker, C.L., 1952a, *Areal geology of the Akaska quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

2) _____1952b, *Areal geology of the Mobridge quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

3) Baldwin, B., 1951a, *Areal geology of the Mahto quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.p., scale

4) _____1951b, *Areal geology of the Pollock quadrangle [South Dakota]*: South Dakota Geological Survey Quadrangle Map, scale 1:62,500.

5) Baldwin, B., and Glass, M.G. 1950, *Areal geology of the Wakpala quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

6) Bluemle, J.P., 1984, *Geology of Emmons County, North Dakota*: North Dakota Geological Survey Bulletin 66- Part 1 and North Dakota State Water Commission County Groundwater Studies 23, 69 p., scale 1:125,000.

7) Carlson, C.G., 1982, *Geology of Grant and Sioux counties, North Dakota*: North Dakota Geological Survey Bulletin 67- Part 1 and North Dakota State Water Commission County Groundwater Studies 24, 32 p., scale 1:125,000.

8) Curtiss, R.E., 1952, *Areal geology of the Isabel quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

9) _____1954a, *Areal geology of the Black Horse Butte quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

10) _____1954b, *Areal geology of the Gopher quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

Fullerton, D.S., Bluemle, J.P., Clayton, L., Steece, F.V., Tipton, M.J., Bretz, R., and Goebel, J.E., 1995, *Quaternary geologic map of the Dakotas 4° x 6° quadrangle, United States*: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NL-14).

11) _____1954c, *Areal geology of the Firesteel Creek quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

12) _____1954d, *Areal geology of the Glad Valley quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

13) _____1954e, *Areal geology of the Worthless Creek quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

14) Fournier, R.E., 1969, *Geology of the Red Elm quadrangle, South Dakota*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

15) Hedges, L.S., 1972, *Geology and water resources of Campbell County, South Dakota*; Pt. I - Geology: South Dakota Geological Survey Bulletin 20-1, 39 p., scale 1:125,000.

16) _____1987, *Geology of Walworth County, South Dakota*: South Dakota Geological Survey Bulletin 30, 33 p., scale 1:190,080.

17) Howells, L.W., 1979, *Geohydrology of the Cheyenne River Indian Reservation, South Dakota*: U.S. Geological Survey Hydrologic Investigations Atlas HA-585, scale 1:250,000, 1:500,000.

18) _____1982, *Geohydrology of the Standing Rock Indian Reservation, North and South Dakota*: U.S. Geological Survey Hydrologic Investigations Atlas HA-644, scale 1:250,000, 1:500,000.

19) Mickelson, J.C., 1952a, *Areal geology of the Cheyenne Agency quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

20) _____1952b, *Areal geology of the Little Cheyenne quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

21) Mickelson, J.C. and Baker, C.L., 1950, *Areal geology of the Mouth of Moreau quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

22) Osterwald, F.W. and Dean, B.G., 1957, *Preliminary tectonic map of western South Dakota, showing the distribution of uranium deposits*: U.S. Geological Survey Mineral Inv. Field Studies Map MF 128, scale 1:500,000.

23) Pettyjohn, W.A., 1961, *Geology of the Glencross quadrangle, South Dakota*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

24) Searight, W.V., 1931, *The Isabel-Firesteel coal area*: South Dakota Geological Survey Report of Investigations No. 10, 34 p., scale 1:95,040.

_____1937, *Lithologic stratigraphy of the Pierre Formation of the Missouri Valley in South Dakota*: South Dakota Geological Survey Report of Investigations No. 27, 63 p., scale 1:1,125,000.

25) Stevenson, R.E., 1954a, *Areal geology of the Thunder Hawk quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

26) _____1954b, *Areal geology of the Morristown quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

27) _____1956, *Areal geology of the Bullhead quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

28) _____1957a, *Areal geology of the McIntosh quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

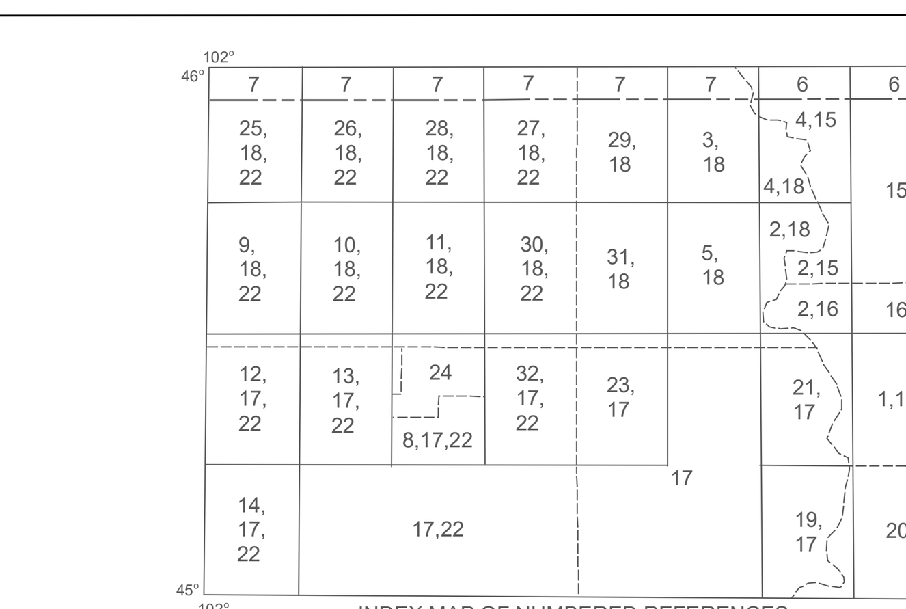
29) _____1957b, *Areal geology of the McLaughlin quadrangle [South Dakota]*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

30) _____1959, *Geology of the Miscol quadrangle, South Dakota*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

31) _____1960a, *Geology of the Little Eagle quadrangle, South Dakota*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

32) _____1960b, *Geology of the Timber Lake quadrangle, South Dakota*: South Dakota Geological Survey Geologic Quadrangle Map, scale 1:62,500.

Waage, K.M., 1968, *The type Fox Hills Formation, Cretaceous (Maastrichtian), South Dakota- Pt. I, Stratigraphy and paleoenvironments*: Yale University, Peabody Museum of Natural History Bulletin 27, 175 p.



INDEX MAP OF NUMBERED REFERENCES