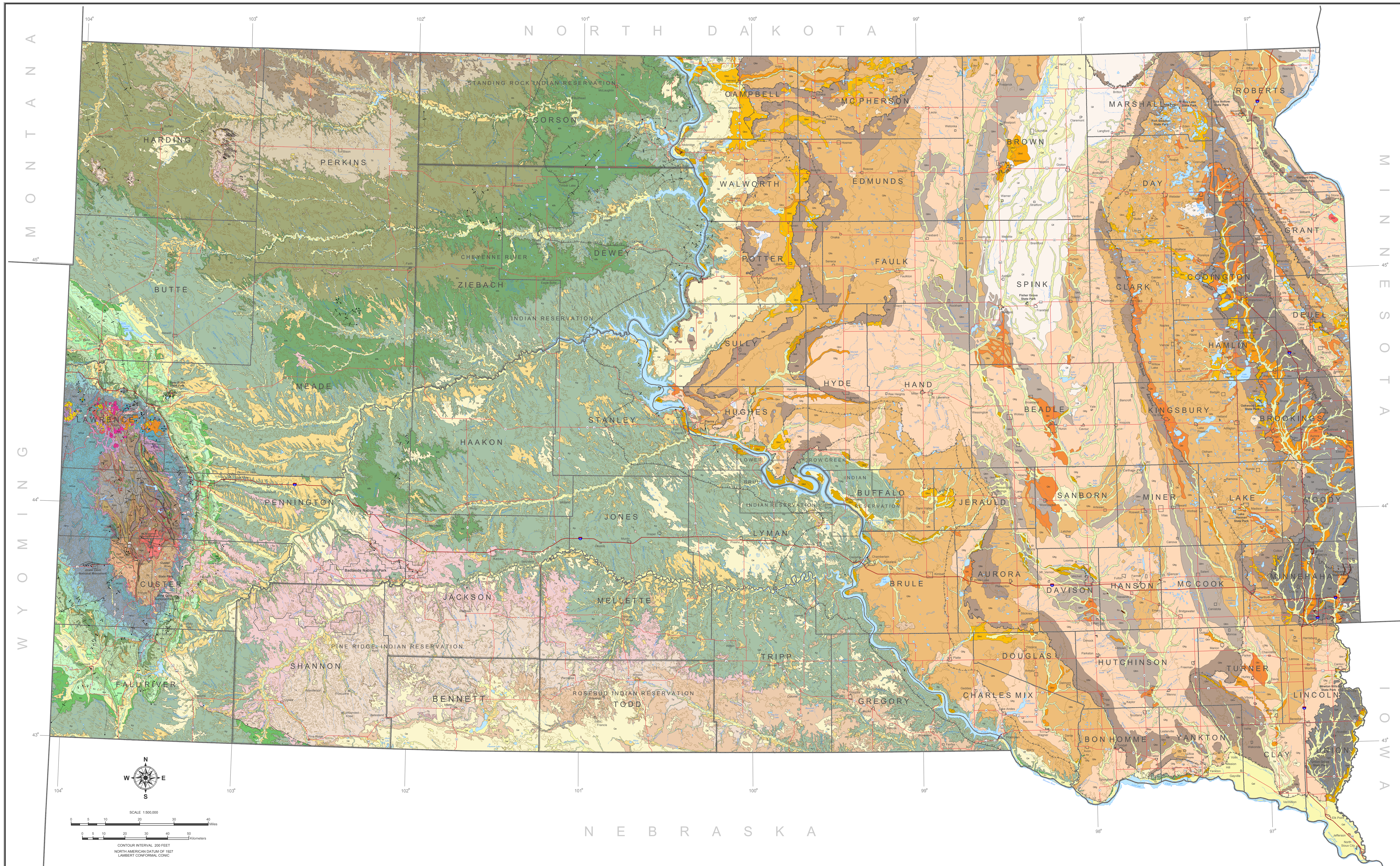


STATE OF SOUTH DAKOTA
M. Michael Rounds, Governor

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Steven M. Pirner, Secretary

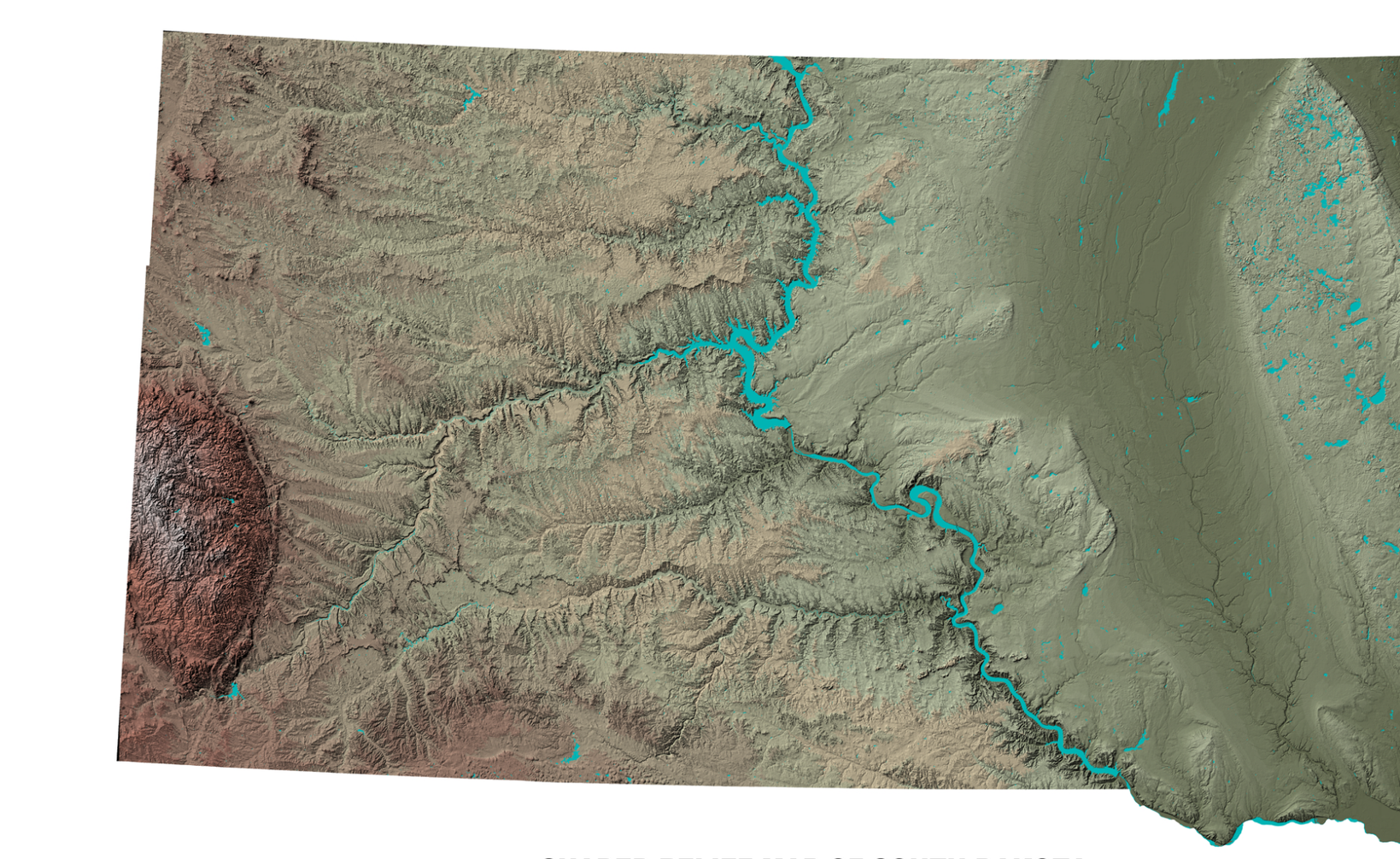
DIVISION OF FINANCIAL AND TECHNICAL ASSISTANCE
David Templeton, Director

GEOLOGICAL SURVEY
Derric L. Iles, State Geologist

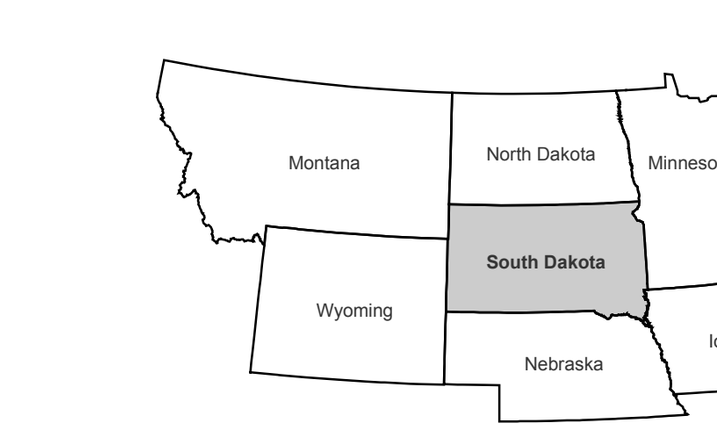
GEOLOGIC MAP OF SOUTH DAKOTA

James E. Martin, J. Foster Sawyer, Mark D. Fahrenbach, Dennis W. Tomhave, Layne D. Schulz

2004



SHADED RELIEF MAP OF SOUTH DAKOTA



MAP AREA

This map was prepared in cooperation with the U.S. Geological Survey

SYMBOLS

CONTACT

FAULT - Location of fault, dashed where approximate, dotted where inferred. Bar and ball shown on downthrown side where space allows.

WESTERN EXTENT OF GLACIATION - Approximate location of the western extent of Pleistocene glaciation in South Dakota. Hachures on side of line from which ice advanced.

GLACIAL ADVANCES - Location of major glacial advances, including Still Lake, Bemis, Altamont/Dakota, Gary/DeSmet, and Big Stone/Oakes. Dashed where approximate. Hachures on side of line from which ice advanced.

IRON FORMATION

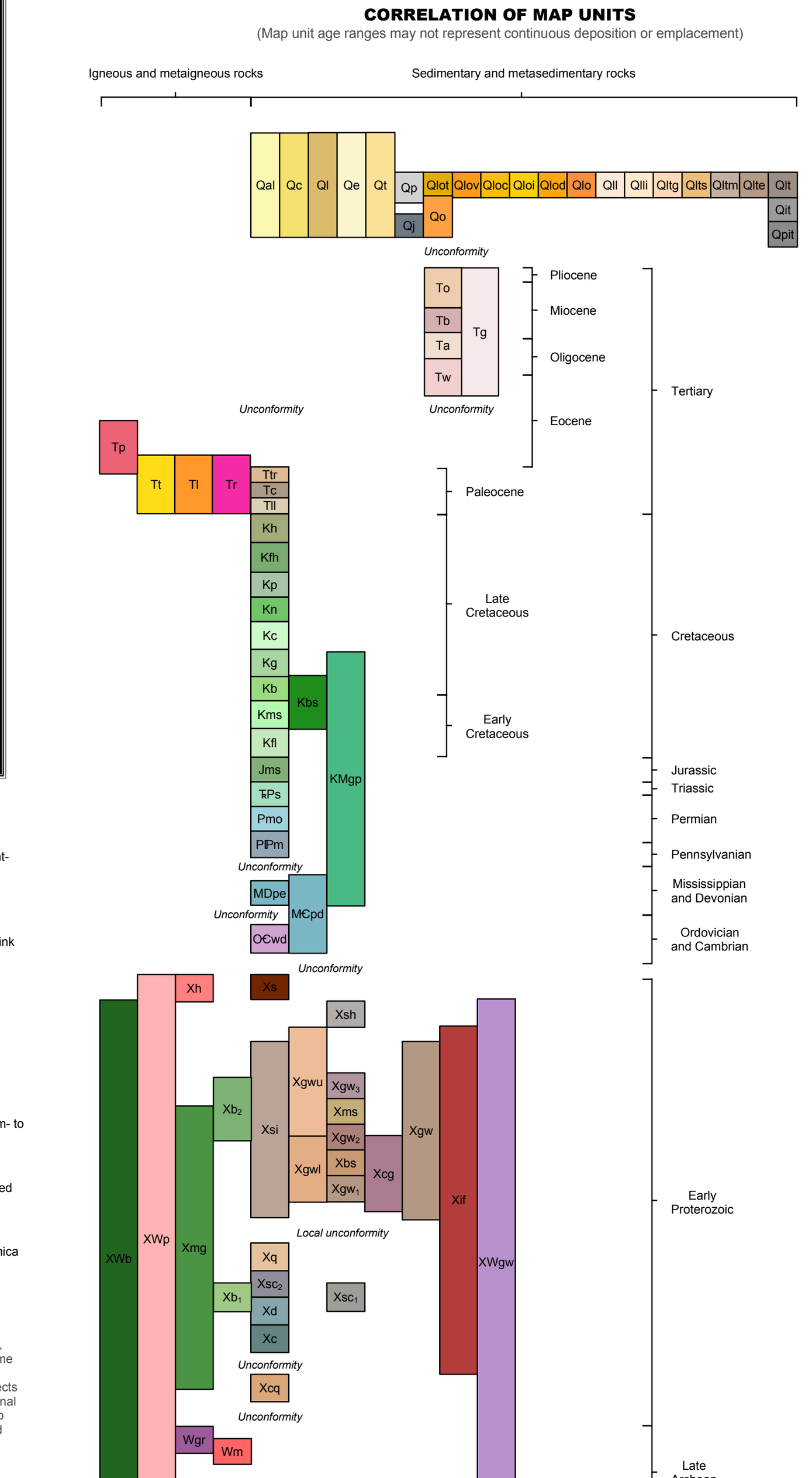
FOLD LINES - Location of fold, dashed where approximate, dotted where inferred. Arrow on fold axis indicates direction of plunge.

ANTICLINE **MONOCLINE**

SYNCLINE **DOME**

CORRELATION OF MAP UNITS

(Map unit age ranges may not represent continuous deposition or emplacement)



DESCRIPTION OF MAP UNITS

(Order of rock description does not always indicate stratigraphic position; refer to correlation chart)

Qal — **Alluvium** (Quaternary) - Clay- to boulder-sized clasts with locally abundant organic material. Thickness up to 75 ft (23 m).

Qc — **Colluvium** (Quaternary) - Clay- to boulder-sized clasts forming rubble residuum and talus. Thickness up to 30 ft (9 m).

Ql — **Landslide deposits** (Quaternary) - Landslide, slump, and collapsed material composed of chaotically mixed boulders and finer grained rock debris. Thickness up to 180 ft (55 m).

Qe — **Eolian deposits** (Quaternary) - Silt to medium-grained sand. Deposited as: sand sheets; barchan, linear, and dome-like dunes; and as a veneer on uplands. Includes the Sand Hills Formation. Thickness up to 300 ft (91 m).

Qt — **Terrace deposits** (Quaternary) - Clay- to boulder-sized clasts deposited as pediments, paleochannels, and terrace fills of former flood plains. Thickness up to 75 ft (23 m).

Qlot — **Outwash, terrace** (Upper Wisconsin) - Heterogeneous clay to gravel of glaciofluvial origin. Thickness up to 60 ft (18 m).

Qlov — **Outwash, valley train** (Upper Wisconsin) - Heterogeneous silt to gravel. Confined to valleys of glaciofluvial origin. Thickness up to 60 ft (18 m).

Qloc — **Outwash, collapsed** (Upper Wisconsin) - Heterogeneous sand and gravel of glaciofluvial origin. Deposited as outwash sediments that collapsed due to melting of buried ice. Thickness up to 90 ft (27 m).

Qloi — **Outwash, ice-walled** (Upper Wisconsin) - Heterogeneous sand and gravel of glaciofluvial origin. Typically forms elevated, level terrain. Thickness up to 90 ft (27 m).

Qlod — **Outwash, delta** (Upper Wisconsin) - Heterogeneous sand and gravel of glaciofluvial origin. Typically forms level terrain at mouths of meltwater streams which flowed into Glacial Lake Dakota. Thickness up to 30 ft (9 m).

Qlo — **Outwash, undifferentiated** (Upper Wisconsin) - Heterogeneous sand and gravel with minor clay and silt, of glaciofluvial origin, including outwash plains, kames, kame terraces, and other undifferentiated deposits. Thickness up to 30 ft (9 m).

Qll — **Lacustrine sediments** (Upper Wisconsin) - Glaciolacustrine clay and silt with minor sand and gravel. Forms flat, low-lying terrain. Includes deposits from Glacial Lake Dakota and Glacial Lake Agassiz. Thickness up to 60 ft (18 m).

Qlli — **Lacustrine sediments, ice-walled** (Upper Wisconsin) - Glaciolacustrine clay and silt with minor sand and gravel. Forms elevated, level terrain. Thickness up to 60 ft (18 m).

Qltg — **Till, ground moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by smooth, rolling terrain. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

Qlts — **Till, stagnation moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by hummocky terrain with abundant sloughs resulting from stagnation of ice sheets. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

Qltm — **Till, minor moraine** (Upper Wisconsin) - Compact, silty clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by elevated linear ridges including minor, washboard, or recessional moraines. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

Qlte — **Till, end moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by elevated linear ridges with hummocky terrain locally at former ice sheet margins. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

Qlt — **Till, moraine** (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. Exhibits a distinctive weathered, dissected surface. Typically overlain by up to 10 ft (3 m) of loess. Thickness up to 150 ft (46 m).

Qp — **Pollock Formation** (Upper Wisconsin) - Glaciolacustrine clay and silty clay with laminae of very fine-grained sand near the middle and base of the formation. Thickness up to 165 ft (50 m).

Qit — **Till, moraine** (Illinoian?) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. Exhibits a distinctive weathered, dissected surface. Contains prominent oxidized joints and fractures with gypsum or calcite. Typically overlain by up to 25 ft (8 m) of loess. Thickness up to 120 ft (37 m).

Qo — **Outwash, undifferentiated** (Illinoian? and pre-Illinoian) - Heterogeneous sand and gravel with minor clay and silt of glaciofluvial origin. Thickness up to 90 ft (27 m).

Qpit — **Till, moraine** (pre-Illinoian) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. Exhibits an extremely weathered, dissected surface. Contains prominent oxidized joints and fractures with calcite or gypsum. Typically overlain by up to 45 ft (14 m) of loess. Composite thickness of all pre-Illinoian till may be up to 1,000 ft (305 m).

Qj — **Java Formation** (Lower Pleistocene) - Silt to gravel of fluvial origin. Upper portion is tan to reddish-brown eolian silt with minor clay and fine-grained sand. Thickness up to 180 ft (55 m).

Tg — **Gravel Deposits** (Tertiary) - Clay- to boulder-sized clasts primarily from igneous and metamorphic rocks of the central Black Hills. Also includes Phanerozoic lithic clasts and rare vertebrate fossils. Thickness up to 60 ft (18 m).

To — **Ogallala Group** (Pliocene and Miocene) - Includes the Ash Hollow, Valentine, and Fort Randall Formations. Also includes the Thin Elk, Bon Homme, Herrick, Medicine Root, and "western derived" gravels.

Ash Hollow Formation (Miocene) - White, tan, and gray, well-cemented, calcareous sandstone and silty limestone often referred to as "mortar beds." Thickness 90-250 ft (27-76 m).

Valentine Formation (Miocene) - Gray, unconsolidated, fine- to coarse-grained, fluvial siltstone, channel sandstone, and gravel derived from western sources. Thickness 175-225 ft (53-69 m).

Fort Randall Formation (Miocene) - Pink and gray claystone with interbedded sandstone. Also includes green to gray orthoquartzite, bentonitic clay, and conglomerate. Thickness up to 130 ft (40 m).

Tb — **Batesland Formation** (Miocene) - Tan to green, calcareous siltstone, claystone, channel sandstone, conglomerate, and arkose. Thickness up to 50 ft (15 m).

Ta — **Arikaree Group** (Miocene and Oligocene) - Includes the Rosebud, Harrison, Turtle Butte, Monroe Creek, and Sharps Formations.

Rosebud Formation (Miocene and Oligocene) - Pink siltstone with channel sandstone and concretions, may be in part equivalent to the Sharps Formation. Thickness up to 250 ft (76 m).

Harrison Formation (Miocene) - Gray, silty sandstone and reworked volcanic ash with calcareous siltstone and marl. Thickness approximately 180 ft (55 m).

Turtle Butte Formation (Miocene) - Light-green to gray siltstone with sandstone channels containing claystone pebbles. Thickness approximately 65 ft (20 m).

Monroe Creek Formation (Oligocene) - Tan to grayish-tan, massive, sandy siltstone and reworked volcanic ash. Thickness approximately 100 ft (30 m).

Sharps Formation (Oligocene) - Pink siltstone and claystone with concretionary layers, paleochannels, and beds of reworked volcanic ash. Thickness approximately 360 ft (110 m).

Tw — **White River Group** (Oligocene and Eocene) - Includes the Brule, Chadron, Chamberlain Pass, and Slim Buttes Formations.

Brule Formation (Oligocene) - White, pink, light-green, and light-brown, massive to thin-bedded, bentonitic claystone, tuffaceous siltstone, and well-bedded, calcareous, tuffaceous quartz sandstone. Thickness up to 150 ft (46 m).

Chadron Formation (Eocene) - Upper beds are gray to light-brown to maroon bentonite, claystone, siltstone, and tuffaceous fine-grained sandstone, with local silicified carbonate lenses. Basal portion consists of poorly cemented, white, coarse-grained arkose and conglomerate. Thickness up to 160 ft (49 m).

Chamberlain Pass Formation (Eocene) - Pale-olive to pale-red, mottled mudstone containing white, cross-bedded channel sandstone with basal conglomerate. Thickness up to 32 ft (10 m).

Slim Buttes Formation (Eocene) - White, grayish- to yellowish-orange, and pale-red to pink siltstone, clayey siltstone, bentonitic claystone, medium- to fine-grained sandstone, and conglomerate. Thickness up to 48 ft (15 m).

Tp — **Phonolitic intrusive rocks** (Eocene and Paleocene) - Gray to greenish-gray sills, laccoliths, and small stocks of phonolite, trachyphonolite, and trachyandesite. Contains phenocrysts of andesine, feldspathoids, aegirine-augite, biotite, and sphene in a fine-grained plagioclase-biotite-feldspathoid groundmass.

Tt — **Trachytic intrusive rocks** (Eocene and Paleocene) - Tan to reddish-brown, iron-stained stocks, laccoliths, sills, and dikes of trachyte, quartz trachyte, and alkalic rhyolite. Contains phenocrysts of sanidine, orthoclase, anorthoclase, aegirine-augite, and biotite in a fine-grained orthoclase-quartz-biotite groundmass.

Tl — **Latitic intrusive rocks** (Eocene and Paleocene) - Dark-gray to greenish-gray laccoliths and sills of latite, latitic andesite, and quartz latite. Contains phenocrysts of andesine, oligoclase, biotite, hornblende, and sphene in a fine-grained andesine-biotite-quartz groundmass.

Tr — **Rhyolitic intrusive rocks** (Eocene and Paleocene) - Light-tan to light-gray stocks and small laccoliths of rhyolite. Contains phenocrysts of oligoclase, quartz, and biotite in a fine-grained orthoclase or sanidine-quartz groundmass.

Ttr — **Tongue River Formation** (Paleocene) - White, gray, and tan, massive, cross-bedded sandstone with interbedded gray, brown, and green claystone, bentonitic claystone, clayey siltstone, carbonate concretions, and lignite. Thickness up to 285 ft (87 m).

Tc — **Cannonball Formation** (Paleocene) - Gray and tan siltstone, sandy to silty claystone, fine-grained, calcareous, clayey to silty sandstone, and abundant round to lenticular carbonate concretions. Thickness up to 180 ft (55 m).

Tll — **Ludlow Formation** (Paleocene) - White, tan, yellow, and gray, cross-bedded, fine- to medium-grained, silty sandstone interbedded with locally bentonitic, gray siltstone, claystone, and sandy to silty claystone. Characterized by uranium-bearing lignite beds and "clinker" beds formed by burning coal seams. Thickness up to 420 ft (128 m).

Kh — **Hell Creek Formation** (Upper Cretaceous) - Tan to brown and light- to dark-gray, "somber beds" of shale. Interbedded with brown to red carbonaceous shale, gray and brown bentonitic silty shale, and gray, brown, and yellow siltstone, sandstone, and claystone-pebble conglomerate. Thickness 260-600 ft (79-183 m).

Kfh — **Fox Hills Sandstone** (Upper Cretaceous) - Bluish-green to green, white to dark-gray, and yellow to tan, carbonaceous and iron-stained, cross-bedded, very fine- to coarse-grained, glauconitic sandstone and siltstone. Interbedded with gray and green to brown shale and silty shale. Thickness 25-400 ft (8-122 m).

Kp — **Pierre Shale** (Upper Cretaceous) - Blue-gray to dark-gray, fissile to blocky shale with persistent beds of bentonite, black organic shale, and light-brown chalky shale. Contains minor sandstone, conglomerate, and abundant carbonate and ferruginous concretions. Thickness up to 2,700 ft (823 m).

Kn — **Niobrara Formation** (Upper Cretaceous) - White to dark-gray argillaceous chalk, marl, and shale. Weathers yellow to orange. Contains thin, laterally continuous bentonite beds, chalky carbonaceous shale, minor sand, and small concretions. Thickness 160-225 ft (49-69 m).

Kc — **Carlile Shale** (Upper Cretaceous) - Dark-gray to black, silty to sandy shale with several zones of septarian, fossiliferous, carbonate concretions. Contains up to three sandstone units near the middle of the formation and sandy calcareous marl at the base. Thickness 345-620 ft (105-189 m).

KMgp — **Greenhorn Formation, Belle Fourche Shale, Mowry Shale, Newcastle Sandstone, Skull Creek Shale, Inyan Kara Group, Morrison Formation, Unkpapa Sandstone, Sundance Formation, Spearfish Formation, Minnekahta Limestone, Opeche Shale, Minnelusa Formation, and Pahasapa Limestone** (Upper Cretaceous to Lower Mississippian)

Kg — **Greenhorn Formation** (Upper Cretaceous) - Gray shale, mudstone, marl, calcarenite, and shaly limestone grading upward into light-gray to tan, alternating marl and thin-bedded, fossiliferous limestone. Thickness 225-315 ft (69-96 m).

Kbs — **Belle Fourche Shale, Mowry Shale, Newcastle Sandstone, and Skull Creek Shale** (Upper and Lower Cretaceous)

Kb — **Belle Fourche Shale** (Upper Cretaceous) - Dark-gray to black bentonitic shale containing minor limestone lenses, bentonite layers, fossiliferous calcarenite, and large, ferruginous, carbonate concretions. Thickness 150-350 ft (46-107 m).

Kms — **Mowry Shale, Newcastle Sandstone, and Skull Creek Shale** (Lower Cretaceous)

Mowry Shale (Lower Cretaceous) - Black to gray, siliceous, fissile shale and siltstone containing bentonite layers and sparse sandstone dikes. Thickness 125-250 ft (38-76 m).

Newcastle Sandstone (Lower Cretaceous) - Gray and light-brown to yellow, discontinuously distributed siltstone, claystone, sandy shale, and fine-grained sandstone. Thickness up to 290 ft (88 m).

Skull Creek Shale (Lower Cretaceous) - Dark-gray to bluish-gray shale containing ferruginous and carbonate concretions. Thickness 150-275 ft (46-84 m).

Kfl — **Inyan Kara Group** (Lower Cretaceous) - Includes the Fall River and Lakota Formations.

Fall River Formation (Lower Cretaceous) - Variegated brown, red, and gray to purple, calcareous, well-sorted, fine-grained sandstone, siltstone, and shale containing mica. Thickness 100-200 ft (30-61 m).

Lakota Formation (Lower Cretaceous) - Yellow, brown, red-brown, and gray to black claystone, silty pebble conglomerate, and massive to thin-bedded, cross-bedded sandstone. Locally interbedded with fresh-water limestone and bituminous coal beds. Thickness 35-500 ft (11-152 m).

Jms — **Morrison Formation, Unkpapa Sandstone, Sundance Formation, and Gypsum Spring Formation** (Upper and Middle Jurassic)

Morrison Formation (Upper Jurassic) - Light-gray to green and variegated red, brown, yellow, or lavender, siliceous claystone, shale, and siltstone containing interbedded sandstone and fresh-water limestone lenses. Thickness up to 150 ft (46 m).

Unkpapa Sandstone (Upper Jurassic) - White, massive to thin-bedded, fine-grained, argillaceous sandstone. May be variegated or banded red, yellow, brown, and lavender. Thickness up to 267 ft (81 m).

Sundance Formation (Upper and Middle Jurassic) - Greenish-gray, yellow, tan, red to orange, and white, variegated, interbedded, fine- to coarse-grained sandstone, siltstone, clay, and limestone. Thickness 250-350 ft (76-107 m).

Gypsum Spring Formation (Middle Jurassic) - Massive white gypsum and minor maroon siltstone and shale. Thickness up to 40 ft (12 m).

TRPs — **Spearfish Formation** (Lower Triassic and Upper Permian) - Red sandy shale, siltstone, sandstone, and minor limestone. Interbedded with abundant gypsum. Thickness 328-559 ft (100-170 m).

Pmo — **Minnekahta Limestone and Opeche Shale** (Permian)

Minnekahta Limestone (Upper and Lower Permian) - Purple to gray, fine-grained, thin- to medium-bedded limestone with varying amounts of red shale. Thickness 30-50 ft (9-15 m).

Opeche Shale (Lower Permian) - Red siltstone, argillaceous sandstone, and shale with interbedded caliche layers. Thickness 85-130 ft (26-40 m).

PIPm — **Minnelusa Formation** (Lower Permian and Upper Pennsylvanian) - Variegated, yellow to red, gray to brown, pink to purple, and black, interbedded sandstone, siltstone, shale, limestone, dolomite, calcarenite, chert, and brecciated beds. Thickness 394-1,175 ft (120-358 m).

M€pd — **Pahasapa Limestone, Englewood Limestone, Whitewood Limestone, Winnipeg Formation, and Deadwood Formation** (Lower Mississippian to Cambrian)

MDpe — **Madison Group** (Lower Mississippian and Upper Devonian)

Pahasapa Limestone (Lower Mississippian) - White, light-gray to tan, fine- to medium-grained limestone and dolomite containing brown to gray chert. Solution features include collapse breccia, sinkholes, and caves. Thickness 300-630 ft (91-192 m).

Englewood Limestone (Lower Mississippian and Upper Devonian) - Pink to lavender to light-gray, thin- to medium-bedded, fine- to medium-grained, argillaceous, dolomitic limestone. Thickness 30-63 ft (9-19 m).

O€wd — **Whitewood Limestone, Winnipeg Formation, and Deadwood Formation** (Upper Ordovician to Middle Cambrian)

Whitewood Limestone (Upper Ordovician) - Mottled tan and gray to lavender, fine- to medium-grained, sparsely fossiliferous limestone and dolomite. Thickness up to 70 ft (21 m).

Winnipeg Formation (Upper Ordovician) - Tan calcareous siltstone and sandy shale with limestone lenses overlying gray and light-green fissile shale. Thickness up to 110 ft (34 m).

Deadwood Formation (Lower Ordovician and Middle Cambrian) - Variegated, yellow to red, brown, gray, and green glauconitic conglomerate, sandstone, shale, dolomitic limestone, and dolomite. Thickness 4-400 ft (1-122 m).

Xs — **Sioux Quartzite** (Lower Proterozoic) - Pink and reddish to tan, siliceous, fine- to coarse-grained, iron-stained orthoquartzite with minor metamorphosed conglomerate and mudstone layers. Estimated thickness greater than 1,000 ft (305 m).

Xh — **Harney Peak Granite** (Lower Proterozoic) - Pink to tan, fine-grained to pegmatitic, peraluminous, muscovite granite and pegmatite containing accessory biotite, garnet, apatite, and tourmaline. Main body is a composite dome-shaped mass consisting of hundreds of separate intrusions; more than 20,000 sills and dikes occur adjacent to the main body.

Xsh — **Metamorphosed shale** (Lower Proterozoic) - Gray to dark-gray phyllite, slate, and mica schist. Estimated thickness at least 5,000 ft (1,524 m).

Xb_2 — **Metabasalt** (Lower Proterozoic) - Alkalic basalt, greenstone, and actinolite schist. Includes metamorphosed volcanoclastic rocks and iron-rich schist.

Xgw — **Metagraywacke** (Lower Proterozoic) - Light- to dark-gray, siliceous mica schist and impure quartzite. Differentiated where possible into three primary tongues or lenses (Xgw_1, Xgw_2, and Xgw_3). Thickness from 1,000 ft (305 m) to over 5,000 ft (1,524 m).

Xgw_3 — **Metagraywacke unit 3** (Lower Proterozoic) - Upper Xgw

Xgw_2 — **Metagraywacke unit 2** (Lower Proterozoic) - Middle Xgw

Xgw_1 — **Metagraywacke unit 1** (Lower Proterozoic) - Lower Xgw

Xgwu — **Upper metagraywacke** (Lower Proterozoic) - Light- to dark-gray, quartz-mica-feldspar schist, quartz-mica schist, staurolite- and garnet-rich schist, metaconglomerate, calc-silicate gneiss, and cummingtonite-quartz schist. Thickness up to 14,000 ft (4,267 m).

Xgwl — **Lower metagraywacke** (Lower Proterozoic) - Light- to dark-gray, medium- to thick-bedded, quartz-mica schist containing calc-silicate lenses and ellipsoidal masses. Thickness up to 7,000 ft (2,134 m).

Xms — **Metamorphosed tuffaceous shale** (Lower Proterozoic) - Light-gray to light-tan, muscovite schist and muscovite phyllite. Laterally equivalent to Xsi. Thickness approximately 1,000-3,000 ft (305-914 m).

Xbs — **Metamorphosed black shale** (Lower Proterozoic) - Dark-gray biotite schist, biotite-muscovite schist, pyritic biotite schist, and locally massive chert beds. Thickness approximately 2,000-4,000 ft (610-1,219 m).

Xsc_2 — **Metamorphosed carbonaceous shale** (Lower Proterozoic) - Dark-gray to gray, siliceous biotite phyllite and schist. Thickness greater than 2,500 ft (762 m).

Xq — **Metaquartzite** (Lower Proterozoic) - Light-tan quartzite, siliceous schist, and minor chert. Thickness 800-5,000 ft (244-1,524 m).

Xcg — **Metamorphosed conglomerate** (Lower Proterozoic) - Gray to grayish-brown, conglomeratic biotite phyllite, siliceous biotite phyllite, mica schist, quartzite, and iron-formation. Thickness up to 2,000 ft (610 m).

Xsi — **Metamorphosed siltstone** (Lower Proterozoic) - Medium-gray to dark-greenish-gray phyllite, slate, and biotite schist containing minor chert and amphibolite. Locally intruded by thin metagabbro sills. Laterally equivalent to Xms. Thickness 1,000-3,000 ft (305-914 m).

Xmg — **Metagabbro** (Lower Proterozoic) - Dark-green sills of amphibolite, actinolite schist, greenstone, and serpentine. Thickness of sills variable; maximum thickness 1,000 ft (305 m).

Xsc_1 — **Metamorphosed carbonaceous shale** (Lower Proterozoic) - Dark-gray to gray, siliceous biotite phyllite, calcareous biotite phyllite, and schist. Minimum thickness 1,500 ft (457 m).

Xb_1 — **Metabasalt** (Lower Proterozoic) - Dark-green amphibolite, actinolite schist, and greenstone, locally with pillow structures. Interflow units consist of graphitic schist, chert, and carbonate- and silicate-facies iron-formation.

Xd — **Metamorphosed dolomite** (Lower Proterozoic) - Light-gray to light-tan marble, phyllite, and calcareous phyllite. Thickness 60-300 ft (18-91 m).

Xif — **Iron-formation** (Lower Proterozoic) - Banded, dark-green, reddish-brown, and white iron-formation, ferruginous chert, and minor mica schist. Includes three or more ages of oxide-, carbonate-, silicate-, and sulfide-facies iron-formation and interbedded tuffaceous rocks. Thickness 20-500 ft (6-152 m).

Xc — **Metaconglomerate** (Lower Proterozoic) - Tan to light-gray, conglomeratic siliceous schist, feldspathic schist, and minor marble. Thickness locally over 6,000 ft (1829 m).

Xcq — **Metaconglomerate and metaquartzite** (Lower Proterozoic) - Light-gray to gray, conglomeratic and feldspathic schist, biotite schist, taconite, and phyllite. Individual conglomerate and fanglomerate tongues from 100-1,500 ft (30-457 m) thick. Total thickness over 10,000 ft (3,048 m).

XWp — **Pegmatite** (Lower Proterozoic or Upper Archean?) - Light-tan to pink pegmatite.

XWb — **Metabasalt** (Lower Proterozoic or Upper Archean?) - Dark-green amphibolite and amphibolite schist. Thickness of individual flows 50-200 ft (15-61 m).

XWgw — **Metagraywacke** (Lower Proterozoic or Upper Archean?) - Gray, siliceous mica schist and impure quartzite.

Wgr — **Granite** (Upper Archean) - Pink and gray, strongly foliated, medium- to coarse-grained, locally pegmatitic, biotite-muscovite granite and gneissic granite.

Wm — **Milbank Granite** (Upper Archean) - Pink to dark-red, coarse-grained granite composed of orthoclase, quartz, and biotite.

Wos — **Older metasedimentary rocks** (Upper Archean) - Gray phyllite, mica schist, and biotite-plagioclase schist. Approximately 500 ft (152 m) exposed.

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DISCUSSION

The Geologic Map of South Dakota has been a continuing project for many years through the auspices of the South Dakota Geological Survey (SDGS). Like all such immense undertakings, the investment of resources, expertise, and time was tremendous. The last geologic maps of the state were published over 50 years ago by Darton (1951) and Petsch (1953). A comparison of these historical maps with the new map illustrates the enormous amount of geologic data that has become available during the past 50 years. The new map is the result of a compilation of published maps, unpublished maps, and original mapping by the authors where resolution of previous information was required or where areas had never been mapped. All maps of this scope represent works in progress, and every geologic problem in the state could not be addressed; therefore, the map should be viewed as a foundation upon which increasing knowledge of the geology of South Dakota may be based. Revisions of the map will continue as new information becomes available. In order to produce the map, the geology of the entire state was compiled at a scale of 1:250,000 and then reduced to the final scale of 1:500,000. Geologic information for most of the area east of the Missouri River has been published by the SDGS in various geologic and hydrologic reports. Geologic data for western South Dakota varies from extremely detailed in some areas to reconnaissance level in others.

The production of this geologic map was initiated by Merlin J. Tipton and Richard F. Bretz of the SDGS. Early in the course of this effort, James E. Martin of the South Dakota School of Mines and Technology was appointed as principal investigator, and his contributions have touched upon numerous aspects of the project. J. Foster Sawyer and Mark D. Fahrenbach devoted many years to research, map, and compile the geology of the area west of the Missouri River. Dennis W. Tomhave and Layne D. Schulz contributed significantly to the portrayal of the glacial geology of the eastern portion of the state.

The glacial geology of eastern South Dakota is exceedingly complex due to the number of glacial advances; therefore, many of the glacial advance lines have not been correlated. Advance lines which are labeled on the map have been studied in detail and much is known of their chronology. The glacial advance lines are based upon the previous work of Flint (1955), Gilbertson (1989), Swinehart and others (1994), Fullerton and others (1995), and recent investigations by the SDGS. Because the ages of the various glacial advances are unknown in many areas of eastern South Dakota, the eastern portion of the map is essentially morphostratigraphic rather than chronostratigraphic.

Since the time of Darton (1951) and Petsch (1953), numerous contributions to the geologic literature have been made regarding the unglaciated portion of the state west of the Missouri River. Care was taken on the new compilation to accurately portray surficial deposits and structural features. Efforts were also made to retain as many formational entities as possible at the 1:500,000 scale. Understanding of the geology of the Black Hills area has been greatly advanced through the efforts of geologists from the South Dakota School of Mines and Technology, particularly with respect to metamorphic and igneous geology. Significant contributions to the Tertiary geology of the state have been made by vertebrate paleontologists also associated with the South Dakota School of Mines and Technology and by J.C. Harksen, formerly of the SDGS.

Finally, many questions remain concerning interpretations of nomenclature and stratigraphy within South Dakota and with adjacent states. Every attempt was made to address such discrepancies; however, some unresolved issues remain. Additional field investigations, along with continued coordination among neighboring states, should ultimately resolve such questions.

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A list of references used in compiling this map is provided in a separate document.