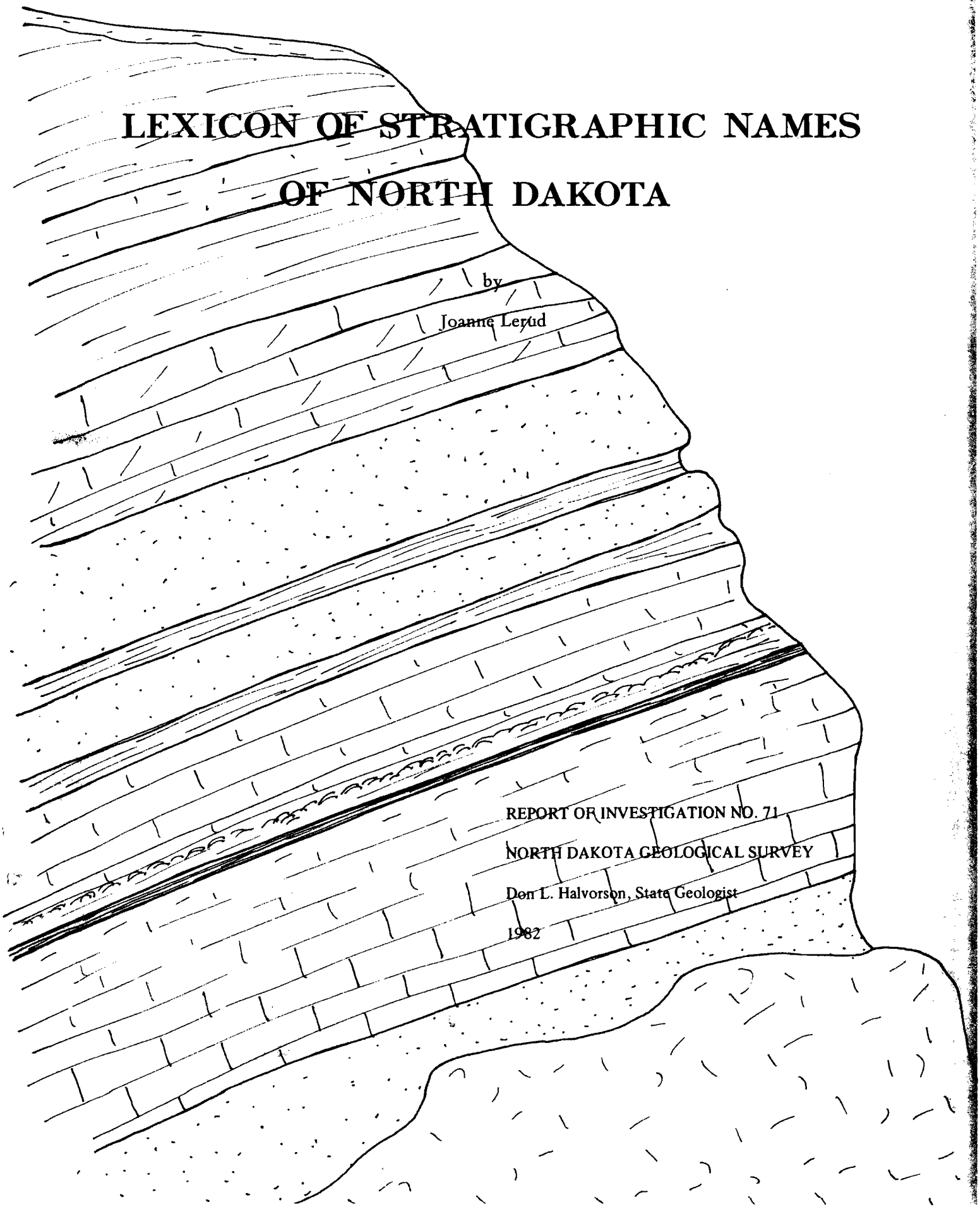
LEXICON OF STRATIGRAPHIC NAMES OF NORTH DAKOTA

by

Joanne Lerud



REPORT OF INVESTIGATION NO. 71

NORTH DAKOTA GEOLOGICAL SURVEY

Don L. Halvorson, State Geologist

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Plate
1. North Dakota Stratigraphic Column . . . . . (in pocket)

INTRODUCTION

This lexicon is a modified version of a master's thesis completed at the University of North Dakota entitled, "Lexicon of Bedrock Stratigraphic Names of North Dakota" by Joanne Van Ornum Groenewold (now Joanne V. Lerud). In the thesis she attempted to include all terms previously applied to these strata in North Dakota together with a history of the unit, age, area of extent, lithology, thickness, relationships to other units, characteristic fossils, economic significance, depositional environment, and references to type sections. An attempt to show accepted North Dakota usage was presented by a system of capitalization and underlining.

The thesis was entirely a literature search with the information provided for each entry being an edited sum of available information for that term. The lexicons of geologic names of the United States by M. Grace Wilmarth (USGS Bulletin 896) and G. C. Keroher (USGS Bulletins 1200 and 1350) were used extensively for the historical summaries. South Dakota Geological Survey Bulletin 14, entitled, "A guide to the Stratigraphy of South Dakota," by Allen F. Agnew and Paul C. Tychsen was also used as a source of information for this section. The "Geologic Atlas of the Rocky Mountain Region," edited by W. W. Mallory, was used extensively for areal extent and age designations. Montana Bureau of Mines and Geology Special Publications 54, entitled, "Catalog of Stratigraphic Names for Montana," edited by C. P. Balster, was also used as a source of information. Other primary sources are included in the list of references.

The thesis was edited for completeness, accuracy, and consistency by the staff of the North Dakota Geological Survey. The North Dakota Geological Survey has, for several years, been reviewing stratigraphic nomenclature in use in North Dakota, and, even though differences of opinion do exist regarding various units, a consensus of current "accepted" usage is provided by the "North Dakota Stratigraphic Column," by John P. Bluemle, Sidney B. Anderson, and Clarence G. Carlson, and by the "Williston Basin Stratigraphic Nomenclature Chart" (North Dakota Geological Survey Miscellaneous Series 61) by John P. Bluemle, Sidney B. Anderson, and Clarence G. Carlson. It should be stressed, however, that the Survey does not enforce a standard usage by its staff.

Editing of the thesis by North Dakota Geological Survey staff resulted in numerous changes from the thesis. These included the addition of some units and the addition of certain pertinent references to some units. Two appendices were added to the Lexicon; one lists named lignite beds and the other lists Pleistocene and Holocene stratigraphic names.

Certain information on general lithologic descriptions, maximum thickness, mineral resources, and relationships to other units, was deleted from the original thesis text because this information is included in the Stratigraphic Column, a copy of which is enclosed in the pocket at the end of the Lexicon. For purposes of this Lexicon, a system of capitalization and underlining was used to distinguish stratigraphic names as to their current status. Each unit in the Lexicon was given a ranking so that one not familiar with the stratigraphy of North Dakota would be able to understand the relative importance of each name. If the name is capitalized, the stratigraphic unit has been formally proposed and is a name accepted by the North Dakota Geological Survey (e.g., MADISON GROUP). If the name is in upper and lower case and underlined, the stratigraphic unit has been formally proposed, but is not used by the North Dakota Geological Survey (e.g., Boissevain Formation). If the name is in upper and lower case, but not underlined, the stratigraphic unit has been informally introduced, but is being used in the state by the North Dakota Geological Survey (e.g., Poplar interval). The lowest ranking involves upper and lower case in quotation marks and indicates that a unit has been informally introduced and is no longer used in the state (e.g., "Muddy sandstone").

LEXICON

ALASKA BENCH MEMBER, FORMATION,
Limestone Member (of AMSDEN FORMATION)

Age: Pennsylvanian (Morrowan to Atokan).

Area of extent: Southern and central Montana, southwestern North Dakota. Probably equivalent to Ranchester Limestone of Amsden Formation in central Wyoming.

Reported fossils: Brachiopods, corals, rare fusilinids, including Millerella inflecta, Paramillerella pinguis, P. circuli, P. ampla, and P. advena. Chonetes pseudoliratus, Linoproductus nodosus, Pugnoides quinqueplecis, and Composita subquadrata are restricted to and characteristic of strata of Amsden Group.

Depositional environment: Marine.

Remarks: Type locality on Alaska Bench, east of Big Snowy Range, Fergus County, Montana.

History of stratigraphic nomenclature:

Freeman, O. W., 1922 (Eng. Min. J., v. 113, no. 19, p. 826-827): Alaska Bench Limestone is well indurated, gray, fossiliferous limestone that weathers red; forms series of hogbacks and sloping benches around Big Snowy Mountains. Well exposed on top of Alaska Bench, east of Big Snowy Mountains where thickness is 100-150 feet. Underlain by 300 feet of white to red sandstones, interbedded with varicolored shale named Tyler Sandstone. Overlain by 100 feet of non-fossiliferous black shale usually classified as part of Quadrant but may, in part, belong to Ellis Formation. In generalized section, 100 feet of black shale above Alaska Bench Limestone are all included in Quadrant Formation.

Mundt, P. A., 1956 (Am. Assoc. Pet. Geol. Bull. 40, p. 1925-1929): Limestone is light to dark brown and gray, with dull purplish-red mottlings. Where exposed, commonly weathers to pink, red, and gray; weathered Alaska Bench Limestone superficially resembles unweathered carbonate rocks of Amsden Formation. Underlies Amsden Formation, overlies and is gradational with Tyler Formation.

Hadley, H. D., and Lewis, P. J., 1956 (Billings Geol. Soc. Gdbk. 7th Ann. Field Conf., p. 142-143): Overlies Cameron Creek and underlies Devils Pocket Formation (both new).

Gardner, L. S., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 332, 334, 338-339, and 347): Alaska Bench Limestone includes massive limestone sequence recognized by O. W. Freeman (1922) and is similar and closely related to overlying beds of limestone and dolomite that are missing from type area but are exposed on south flank of Big Snowy Mountains. Only known complete surface sections are in vicinity of Stonehouse Ranch on south slope of Big Snowy Mountains and at Durfee Creek.

Willis, R. P., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 1942, 1963): Reallocated to member status in Amsden Formation (restricted). Underlies unnamed dolomite member; overlies Cameron Creek Member of Tyler Formation.

Ziebarth, H. C., 1962 (Univ. N.D. Ph.D. Dissert., 414 p.): Alaska Bench Formation of North Dakota includes limestone interbedded with red and gray shale. Is distributed fairly uniformly throughout southwestern North Dakota; is absent from northern part of Nesson anticline because of erosional truncation or facies change to shale so that unit is similar to the underlying Tyler Formation. Thickness is 0-68 feet.

Almont sandstone (of BULLION CREEK FORMATION)

Age: Paleocene (Tiffanian).

Area of extent: Local area near Almont, North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Hennen, R. V., 1943 (Am. Assoc. Pet. Geol. Bull. 27, p. 1573, 1580): Almont Sandstone lies 35 feet above base of Tongue River Member. Section measured along south margin of T138N, R86 and 87W; sandstone forms high cliffs just above drainage, 1 mile south of Almont Railway Station, Morton County, North Dakota.

"Amaranth Formation"

Age: Jurassic (?)Triassic.

Area of extent: Southern Manitoba.

Depositional environment: Marine.

Remarks: Term used in Manitoba for equivalent of Spearfish Formation and perhaps a part of the Piper Formation of North Dakota.

History of stratigraphic nomenclature:
Laird, W. M., and Towse, D. F., 1949 (N.D. Geol. Surv. Rept. Invest. 2, pl. II): Amaranth Formation is 75 feet of calcareous red shale at top of Devonian.

Amidon Member (of CHADRON FORMATION)

Age: Oligocene (Chadronian).

Area of extent: Western North Dakota. Stratigraphic position similar to Ahearn Member of Chadron in South Dakota and "A" Member in Nebraska.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 124): Amidon Member consists of 7 to 16 feet of bentonite and bentonitic claystone in Chadron Formation; lies unconformably above Interior Formation and lies unconformably beneath Chalky Buttes Member. Type section is south-facing exposure near head of deep, unnamed gully at NE NE sec 15, T134N, R101W, Slope County, about 4¼ miles southwest of Amidon and about 18 miles north of Bowman, Bowman County, North Dakota.

AMSDEN FORMATION, GROUP

Age: Early to middle Pennsylvanian (Morrowan to Virgillian).

Area of extent: Wyoming (excluding southern part), Montana, northwestern South Dakota, and western North Dakota. Equivalent strata in the Black Hills are included in the Minnelusa Formation.

Reported fossils: Chonetes pseudoliratus, Linoproductus nodosus, Pugnoides quinqueplecis, and Composita subquadrata.

Depositional environment: Marine.

Remarks: Type locality along Amsden Branch of Tongue River, west of Dayton, Wyoming.

History of stratigraphic nomenclature:

Darton, N. H., 1904 (Geol. Soc. Am. Bull. 15, p. 394-401): Amsden Formation consists of red shale, white limestone, and cherty and sandy limestone. Underlies Tensleep Sandstone and overlies, without apparent unconformity, Little Horn Limestone. [Now replaced by Madison Limestone.] Named for Amsden Branch of Tongue River, west of Dayton, Wyoming. Total thickness, 150-350 feet.

Scott, H. W., 1935 (J. Geol., v. 43, pt. 2, p. 1017, 1020-1023): In type locality, Amsden consists of all beds between top of Madison Limestone and base of Tensleep Formation. Originally considered Pennsylvanian; Wind River area Amsden is Mississippian. In south-central Montana, Amsden rests on erosional surface developed on Madison Limestone. Between Three Forks and Townsend, Big Snowy Group (1200 feet of fossiliferous sandstone, shale and limestone) separates Madison and Amsden Formations. In central Montana, Amsden underlies Ellis Formation (Late Jurassic). Section measured on southeast side of Quadrant Mountain (type section of Quadrant) shows Amsden Formation (beds 1-7) 109 feet thick; underlies Quadrant Formation (beds 8-21); overlies Madison Limestone.

Perry, E. S., and Sloss, L. L., 1943 (Am. Assoc. Pet. Geol. Bull. 27, p. 1293-1295): Between redefined Tensleep (Quadrant) and Sacajawea (lower beds of Ste. Genevieve fauna) are unnamed beds with Chesterian fauna traceable throughout central Montana and much of Williston Basin, overlapping truncated edges of Big Snowy strata, and transgressing over peninsula area with no Big Snowy or Sacajawea sediments along Montana-Wyoming border. Term Amsden should be retained in these strata of Montana and Williston or new term coined.

Sloss, L. L., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 69): Amsden of Williston Basin probably represented by Minnelusa Formation as suggested on cross section.

Mundt, P. A., 1956 (Am. Assoc. Pet. Geol. Bull. 40, p. 1918-1919, 1928-1929): Amsden Formation of central Montana divided into three lithologic units (descending): 1) upper dolomite, 2) brownish limestone, and 3) lower sequence of red shale and sandstone beds. Dolomite unit is lithologically, stratigraphically, and paleontologically equivalent to carbonate of Amsden at type locality. Amsden dolomite overlaps underlying brown limestone and red shale beds and Big Snowy Group toward south. Unconformably(?) underlying Amsden dolomite of Atokan age is brown ostracodal limestone, probably of Chesterian age but may be all or part early Pennsylvanian; named Alaska Bench Formation. Total thickness 33 feet; top of section eroded.

Gardner, L. S., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 344-346): Big Snowy Group revised to include (ascending) Kibbey sandstone, Otter, Heath, Cameron Creek, and Devils Pocket Formations. Parts of Big Snowy Group (revised) have been correlated with Amsden Formation of northern Wyoming and southern Montana. These two sequences represent same general interval of time (end of Madison to beginning of Tensleep) but occupy distinct basins separated by divide. Amsden rocks thin from south and Big Snowy thins from north toward divide. Scott (1935) used term Amsden for rocks (Cameron Creek Formation and Alaska Bench Limestone) overlying Heath. Few dependable correlative data found between Big Snowy rocks of central Montana and Amsden rocks 50 miles away in southern Montana. Mundt (1956) shifted name to different rocks of Atokan age. Suggested to give these rocks separate formational names and discontinue term Amsden in central Montana.

Willis, R. P., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 1942-1966): Sacajawea applies to persistent red shale unit (including Darwin Sand) formerly called lower Amsden. Term Amsden restricted to overlying cherty carbonate sequence;

restricted usage in central Montana for carbonate sequence underlain by Tyler or older rocks. Unit overlain by Tensleep, Minnelusa formation of Williston Basin, or Ellis Group. Maximum thickness 400 feet in southern end of Judith Basin. Divisible into two units (ascending): 1) Alaska Bench Limestone Member and 2) unnamed dolomite member. Pennsylvanian (Morrowan-Atokan). Names Tyler-Heath (below) and Amsden (restricted) extended eastward from Montana into Williston Basin of North Dakota.

Sandberg, C. A., 1962 (U.S. Geol. Surv. Rept. TEI-809, p. 68): Recognized term Amsden in North Dakota, but not South Dakota, where it is apparently included in lower part of Minnelusa.

Maughan, E. K., and Roberts, A. E., 1967 (U.S. Geol. Surv. Prof. Paper 554-B, p. 1-27): Amsden raised to group status with following formations (descending): Devils Pocket, Alaska Bench, and Tyler. Amsden assigned to Pennsylvanian.

Ziebarth, H. C., 1962 (Univ. N.D. Ph.D. Dissert., 414 p.): Amsden Formation ranges in thickness from 0-380 feet in North Dakota; marked thinning occurs on western flank of Nesson anticline. Amsden is unconformably(?) underlain by Alaska Bench Formation and unconformably overlain by Broom Creek Formation.

Arikaree Formation

Age: Miocene (Arikareean).

Area of extent: Western South Dakota and Nebraska, northwestern Colorado and southeastern Wyoming.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Darton, N. H., 1899 (U.S. Geol. Surv. 19th Ann. Rept., p. 732): Arikaree Formation consists of gray sands characterized by layers of dark-gray concretions; overlies Gering Formation (Miocene) and underlies Ogallala Formation (Pliocene) in western Nebraska.

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 123): Arikaree Formation term rejected for strata overlying White River Formation in North Dakota because deposits are lithologically distinct from type Arikaree in Nebraska and Arikaree of badlands of South Dakota. Killdeer Formation proposed for 25-200 feet of green concretionary, calcareous sandstone, siltstone, silty claystone, and dolostone.

Ashern Formation

Age: Middle Devonian (Erian).

Area of extent: Williston Basin; southern Manitoba.

Depositional environment: Marine.

Remarks: Type locality near Ashern, Manitoba. Ashern has been misapplied to many erosional and residual deposits within Devonian and Late Silurian. Where basal Middle Devonian red beds occur, they are generally erratic and discontinuous. Sandberg, C. A., and Hammond, C. R. (1958) included Ashern in Winnipegosis Formation.

History of stratigraphic nomenclature:
Baillie, A. D., 1950 (Man. Dep. Mines Nat. Resour. Mines Br. Pub. 49-2, p. 9-12): Ashern is 5-125 feet of red to pink to orange, dolomite and dolomitic, red to green shales, often silty and sandy. May be brecciated at base and

appears to fill holes in "karst-like" topography of underlying Silurian. May represent "fossil laterite" or soil profile developed on Silurian strata in interval between Silurian and Devonian deposition. Equivalent to "3rd red" of Saskatchewan.

Baillie, A. D., 1953 (Am. Assoc. Pet. Geol. Bull. 37, no. 2, p. 444-447): The report proposes nomenclature for the Devonian in the Williston Basin area of Saskatchewan, Manitoba, North Dakota, and eastern Montana.

Harris, S. H., and Mallin, J. W., 1957 (Williston Basin Oil Rev., v. 6, no. 5, p. 15-16): In Williston Basin, Ashern is up to 50 feet of fine-red to pink clastics and carbonates. Fossils north of Winnipeg are Middle Devonian. Represents initial stage of deposition of pre-Devonian karst topography of low relief; transgresses time boundaries.

North Dakota Geological Society, 1961 (Stratigraphy of the Williston Basin Devonian System: Conrad, Bismarck, p. 9): Ashern overlain by Winnipegosis Formation over most of Williston Basin. Similar basal red shales were deposited by Dawson Bay, Souris River, and Duperow seas of later Devonian time and locally rest unconformably on "true" Ashern, but are nearly impossible to differentiate. Society recommended that "Ashern" be mapped "together with the basal red shales of . . . whatever the identifiable Devonian Formation onlapping the truncated Silurian or older beds may be" (p. 9).

Ashville beds, Formation

Age: Early to Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota. Equivalent to Skull Creek through Greenhorn strata of current North Dakota usage.

History of stratigraphic nomenclature:
Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Rept., 1929, pt. B, p. 117): Used term Ashville beds for shale overlying Dakota beds in Manitoba; probably equivalent to Graneros Shale.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, no. 10, p. 993-1010): Ashville Formation of Cenomanian age is found on Pembina escarpment, Manitoba and North Dakota.

Assiniboine beds, Member

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota; equivalent to part of the Greenhorn Formation of current North Dakota usage.

History of stratigraphic nomenclature:
Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, no. 10, p. 993-1010): Assiniboine Member of Favel Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota.

BACON CREEK MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Southwestern North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 33): Bacon Creek Member is varicolored bentonites, bentonitic shales, and lignitic shales. Type section is west of Bacon Creek in SE¼ of sec 23, T133N, R106W, Slope County, North Dakota. Overlies Marmarth Member; underlies Huff Member. Outcrops in Little Missouri valley around Marmarth and south into Bowman County. Top of unit is bentonite bed which indicates time horizon. Fossil remains (Triceratops, rare invertebrates) and nature of sediments indicate nonmarine origin.

Bakken Formation, "shale"

Age: Late Devonian and Early Mississippian (Conewangoan to Kinderhookian).

Area of extent: Williston Basin; middle and upper members equivalent to Colville in Manitoba.

Reported fossils: Rare conodonts.

Depositional environment: Marine.

Remarks: Named from Amerada No. 1 Bakken test hole located in SW NW sec 12, T157N, R95W, Williams County, North Dakota. Type section designated as the interval between 9, 615 and 9, 720 feet.

History of stratigraphic nomenclature:
Nordquist, J. W., 1953 (Billings Geol. Soc. Gdbk. 4th Ann. Field Conf., p. 72-74): Consists of two, black, fissile shales separated by light-gray to gray-brown, fine-grained calcareous sandstone interbedded with minor amounts of gray-brown cryptocrystalline limestone. Overlies Three Forks Formation. May be equivalent to lower beds of Lodgepole Formation.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2328): Bakken is present in central part of Williston Basin and parts of Montana. Where Bakken not deposited, lowermost Mississippian beds are correlated with Englewood Limestone of South Dakota.

Sandberg, C. A., 1962 (U.S. Geol. Surv. Rept. TEI-809, p. 55): Relationships of Bakken and Englewood described in detail.

Kume, Jack, 1963 (N.D. Geol. Surv. Bull. 39, p. 38): Bakken ranges in thickness from 42 feet in Perkins County to erosional edge in northern Butte and Meade Counties, South Dakota. Overlain by Englewood in Butte County.

"Banded beds"

Remarks: See BULLHEAD LITHOFACIES, MEMBER OF FOX HILLS FORMATION.

BEAR DEN MEMBER (of GOLDEN VALLEY FORMATION)

Age: Late Paleocene (Clarkforkian).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Hickey, L. J., 1977 (Geol. Soc. Am. Mem. 150, p. 17-22): Bear Den is lower member of Golden Valley Formation; is 5-65 feet of light-gray or brightly

colored kaolinitic strata. Is conformable on Fort Union Formation and underlies Camels Butte Member (new). In weathered outcrop, member develops three color zonations (ascending): basal gray zone, middle orange zone, and somber-colored calcareous zone. Thin bed of lignite (Alamo Bluff lignite) or its lateral equivalent, silicified silt or freshwater limestone (Taylor bed) mark upper boundary. Is Late Paleocene in age based on megaflora of 41 species mostly of lowland forest community. Is fluvial in origin. Is equivalent to Hebron Member of Golden Valley Formation.

"Beaverhill Lake equivalent"

Remarks: See Souris River Formation.

History of stratigraphic nomenclature:
Towse, D., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Beaverhill Lake equivalent is shaly and anhydritic limestone and dolomite unit above Manitoban Formation and below "Woodbend equivalent."

BEAVERHILL LAKE GROUP, Formation

Age: Middle to Late Devonian (Erian to Senecan).

Area of extent: Alberta, Saskatchewan, and North Dakota; equivalent to Souris River and Dawson Bay Formations of current usage.

Reported fossils: Brachiopods and other fragmental fossil debris, possibly charophytes.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Layer, D. B., et al., 1950 (Am. Assoc. Pet. Geol. Bull. 34, no. 9, p. 1823-1825): Beaverhill Lake Formation named from Beaverhill Lake near Edmonton. Type section: interval between 4325-5047 feet in Anglo-Canadia #2 Beaverhill Lake, ls 11, sec 11, T50, R17, 4 M., Alberta, Canada.

Stanton, M. S., 1953 (Billings Geol. Soc. Gdbk. 4th Ann. Field Conf., p. 61): Beaverhill Lake Group includes dominantly normal marine carbonates with intermittent evaporites overlying Elk Point Group and extending upward into prominent gamma-ray "kick" marking top of widespread argillaceous carbonate zone. Thickness is 300-750 feet in Saskatchewan. Divided into two formations (ascending), Dawson Bay and Souris River. "The term 'Beaverhill Lake' is here used in quotation marks since this gamma-ray marker . . . occurs some 70-150 feet below the stratigraphic point frequently considered equivalent to the top of the Beaverhill Lake Formation in Alberta. For this reason it would be preferable to introduce a new group name" (p. 61).

Laird, W. M., 1953 (Interstate Oil Compact Quart. Bull., v. 12, no. 2, p. 74): Beaverhill Lake Group consists of Dawson Bay and Souris River Formations in Williston Basin.

Baillie, A. D., 1955 (Am. Assoc. Pet. Geol. Bull. 39, no. 5, p. 579): Beaverhill Lake Formation is equivalent to nearly all of Manitoba Group.

Walker, C. T., 1956 (N.D. Geol. Soc. 1st International Williston Basin Sym., p. 131): Beaverhill Lake Formation equivalent to upper part of Souris River Formation.

"Bed Q"

Remarks: see LINTON MEMBER of FOX HILLS FORMATION.

BELFIELD MEMBER (of SPEARFISH FORMATION)

Age: Permian (Guadalupian).

Area of extent: Western North Dakota; equivalent strata are included in Spearfish Formation in South Dakota and eastern Montana.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Dow, W. G., 1967 (N.D. Geol. Surv. Bull. 52, p. 6-8): Belfield Member (formerly restricted Spearfish) is up to 232 feet thick in northwestern Dunn County; consists of fissile, gray shale interbedded with reddish-orange siltstone and mudstone; few anhydrite and dolomite beds present. Conformably overlies Minnekahta Limestone where Minnekahta present but does not extend beyond limits of Minnekahta; conformably underlies Pine Salt or Saude Members of Spearfish. Type interval is at 7228-7431 feet in Amerada R. E. Newton No. 1 well, NW SW sec 31, T140N, R99W, Stark County, North Dakota.

BELLE FOURCHE FORMATION, SHALE

Age: Late Cretaceous (Cenomanian).

Area of extent: Northeastern Wyoming, eastern and central Montana, and North Dakota, and western South Dakota.

Reported fossils: Inoceramus, Exogyra, Mantelliceras.

Depositional environment: Marine.

Remarks: Type locality at Belle Fourche Creek in neighborhood of Wind Creek, Crook County, Wyoming.

History of stratigraphic nomenclature:
Collier, A. J., 1920 (U.S. Geol. Surv. Press Bull. 9065): Belle Fourche Shale, of Late Cretaceous age, underlies Greenhorn Limestone and overlies Mowry Shale.

_____, 1922 (U.S. Geol. Surv. Bull. 736, p. 83): Belle Fourche Shale Member is top member of Graneros Shale. Consists of greater than 560 feet of dark-gray shale that varies in hardness but is softer than underlying Mowry. Contains calcareous concretions near top, ironstone concretions in lower part, and thick bentonite bed near base.

Moore, R. C., 1949 (Geol. Soc. Am. Mem. 39, fig. 18): Calcareous shale and thin limestones of Greenhorn facies occur lower in stratigraphic column and at expense of dark, noncalcareous shale of Belle Fourche facies southeasterly toward Black Hills. Contact between Belle Fourche and Greenhorn is at base of lowest limestone (Bull Creek Limestone).

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2197): Formations in Black Hills equivalent to Colorado Shale are Fall River Sandstone, Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, and Niobrara Formation. Belle Fourche Shale of northern Black Hills consists of 565 feet of dark-bluish shale with many beds of bentonite and ferruginous concretions. In central Montana Belle Fourche is represented by 240-315 feet of similar beds in middle of Colorado Shale. Is Cenomanian in age.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, pl. 1): Boundary between Lower Cretaceous and Upper Cretaceous at base of Belle Fourche Shale. Bull Creek Limestone equivalent to Orman Lake which is term that should be used.

Knechtel, M. M., and Patterson, S. H., 1962 (U.S. Geol. Surv. Bull. 1082-M, p. 914-919): Belle Fourche in northern part of Black Hills divided into: upper member--6-32 feet of soft, dark-gray shale with calcareous concretions and bentonite beds, base of unit rests on Bentonite Bed F, lateral facies changes cause Belle Fourche-Greenhorn contact to occur lower in section; lower member--consists of three units, upper part is soft dark-gray shale with many bentonite beds and calcareous concretions and cone-in-cone concretions near top and is 200 feet thick near Belle Fourche but thickens to west as Greenhorn contact rises in section, middle part is sandy shale with thin lenses of soft, gray sandstone and thick layers of dark-gray, soft, fissile shale, bentonite beds common, probably equivalent to Frontier sands farther west, lower part is dark shale that is harder and less fissile than overlying units; abundant, oblate, spheroidal, corrugated or pitted concretions of siderite; is 30-45 feet thick, includes Bentonite Beds D and E, rests on Clay Spur Bentonite Bed of Mowry.

Benton Shale

Age: Cretaceous.

Remarks: Term "Benton" now obsolete in North Dakota. Equivalent to Newcastle, Carlile, Greenhorn, Belle Fourche, and Mowry of present usage. Term "Fort" (Fort Benton) was deleted.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 419-421). Introduced the term Fort Benton shale for dark-gray laminated clays. Overlies Dakota Group and underlies Niobrara.

Leonard, A. G., 1906 (N.D. Geol. Surv. 4th Bienn. Rept., p. 67): Benton is oldest member of Colorado Formation exposed in North Dakota. Shales used for manufacture of brick. Is not likely that these beds belong to Pierre Formation.

Laird, W. M., and Towse, D. F., 1949 (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Graneros and Carlile Shales are subdivisions of Benton Shale. Graneros divided into Skull Creek, Newcastle, Mowry, and Belle Fourche.

BIGHORN GROUP, DOLOMITE

Age: Middle to Late Ordovician.

Area of extent: Williston Basin; used as Formation in Wyoming, central and southern Montana.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Darton, N. H., 1904 (Geol. Soc. Am. Bull. 15, p. 394-401): Bighorn limestone consists of 250-300 feet of hard, massive limestone on east side of Bighorn Mountains. Top member is thinly bedded, impure limestone with Late Ordovician Richmond fauna. Middle member somewhat massive and is locally fine-grained, light-colored limestone containing corals. Lower member is hard, massive, impure, light-gray or faint buff limestone with network of silica veinlets that weather to honeycomb appearance; fossils are Middle Ordovician (Trenton) in age. Underlies Madison Limestone; overlies Deadwood Formation.

Ross, R. J., Jr., 1957 (U.S. Geol. Surv. Bull. 1021-M, p. 446-448): Term Bighorn Group used to include (ascending) Red River and Stony Mountain Formations in subsurface. Overlies Winnipeg Formation. Ordovician fossils present.

Caramanica, F. P., 1973 (Univ. N.D. Ph.D. Dissert.): Williston Basin of Wyoming, Manitoba, and eastern North Dakota. Red River, Stony Mountain, Stonewall, and Bighorn Formation corals are present.

BIG SNOWY GROUP

Age: Mississippian (Chesterian).

Area of extent: Montana, western North Dakota, and northwestern South Dakota.

Depositional environment: Marine.

Remarks: Named from Big Snowy Mountains, Montana. Standard section is composite of Stonehouse Ranch and State Road No. 25 section. See also Heath, Kibbey, and Otter Formations.

History of stratigraphic nomenclature:
Scott, H. W., 1935 (Geol. Soc. Am. Proc. 1934, p. 367): Big Snowy Group consists of Kibbey, Otter, and Heath Formations. Is variegated with intercalated limestones and sandstones. Overlies Madison.

_____, 1935 (J. Geol., v. 43, p. 1011-1032): Big Snowy Group is new name for lower part of beds previously assigned to Quadrant Formation in central Montana. "True" Quadrant is absent in central Montana where rocks are all Mississippian--older than Quadrant Formation of Quadrant Mountain. Yellowstone National Park which is early Pennsylvanian and westward extension of Tensleep Sandstone--also older than Mississippian Amsden that underlies Quadrant of Quadrant Mountain as well as Quadrant of southern Montana and overlies Big Snowy Group in central Montana. Group has maximum thickness of 1200 feet and rests on Madison limestone. Divided into three conformable formations (descending): Heath (new), Otter, and Kibbey.

Seager, O. A., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 863): In subsurface in Cedar Creek anticline, southeastern Montana. Big Snowy includes (ascending): Charles (new), Kibbey, Otter, and Heath; underlies Amsden; overlies Madison.

Perry, E. S., and Sloss, L. L., 1943 (Am. Assoc. Pet. Geol. Bull. 27, p. 1287-1304): Big Snowy Group of northern Great Plains described only lower formation (Charles) present in North and South Dakota. Kibbey and Otter pinch out within the Dakotas and Heath is present only in Montana and North Dakota.

Sloss, L. L., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 65, 67-68): Excluded from Big Snowy Group is Charles Formation which is assigned to Madison Group. As restricted includes (ascending): Kibbey, Otter, and Heath Formations.

Gardner, L. S., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 329-349): Big Snowy Group expanded and redefined to include (ascending): Kibbey Sandstone, Otter Formation, Heath Formation. Cameron Creek Formation, Alaska Bench Limestone, and Devils Pocket Formation. Upper three units were previously Scott's (1935) Amsden. Underlies Triassic (?) or Permian (?) and Pennsylvanian undifferentiated, or locally, Ellis Group; overlies Madison Group. Thickness 1509 feet at standard section. Mississippian and Pennsylvanian.

Maughan, E. K., and Roberts, A. E., 1967 (U.S. Geol. Surv. Prof. Paper 554B, p. 27): Redefined Big Snowy Group; restricted it to strata below the Late Mississippian-Early Pennsylvanian unconformity, i.e., to Heath, Otter, and Kibbey Formations.

BIRDBEAR FORMATION (of JEFFERSON GROUP)

Age: Late Devonian (Senecan).

Area of extent: Williston Basin.

Reported fossils: Amphipora.

Depositional environment: Marine.

Remarks: Type locality between 10,310 and 10,400 feet in Mobile No. 1 Birdbear, sec 22, T149N, R91W, Dunn County, North Dakota. Commonly referred to as "Nisku" but H. R. Belyea (1955, Can. Geol. Surv. Paper 55-3, p. 29) indicated no depositional relationship between Nisku Formation of Alberta and Birdbear Formation of Williston Basin.

History of stratigraphic nomenclature:
Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2292, 2302-2303, and 2318-2322): Birdbear Formation proposed for widespread belts of light-colored finely crystalline dolomite and limestone that overlie Duperow and underlie Three Forks in Williston Basin and central Montana. Thickness to 125 feet. Replaces term Nisku Formation now restricted to type area in central Alberta. Type locality given. Birdbear and underlying Duperow constitute Jefferson Group.

North Dakota Geological Society, 1961 (Stratigraphy of the Williston Basin Devonian System: Conrad, Bismarck, p. 27-29): Birdbear is conformable with underlying Duperow Formation and overlying Three Forks Formation in Williston Basin of North Dakota. Probably equivalent in part to Delia Formation which underlies Nisku Formation in central Alberta. Thickness 70-140 feet; over much of Williston Basin thickness is constant at 90-100 feet. Oil productive.

"Blackhorse shales"

Age: Late Cretaceous.

Remarks: Term obsolete; equivalent to Hell Creek of current usage.

Keyes, C. R., 1922 (Pan-Am. Geol., v. 37, p. 63-64): Blackhorse shales are 500 feet thick, underlie Ludlow lignites and overlie Fox Hills Sandstones. Is basal shale of Lance Formation in North and South Dakota. Named from Blackhorse Butte of South Dakota.

BLACK ISLAND MEMBER, FORMATION (of WINNIPEG FORMATION, GROUP)

Age: Middle Ordovician (Blackriverian).

Area of extent: North Dakota, western South Dakota, and southern Manitoba; equivalent strata referred to as Winnipeg Sandstone in eastern Montana, and southern Saskatchewan.

Depositional environment: Marine.

Remarks: Named from Black Island, Lake Winnipeg, Manitoba.

History of stratigraphic nomenclature:
Genik, G. J., 1954 (Alberta Soc. Pet. Geol. J., v. 2, p. 1): Black Island term applied to basal sandstone unit of Winnipeg Formation in surface and subsurface of Manitoba and subsurface of Williston Basin.

Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 55-57): Black Island term used for lower sandstone of Winnipeg Formation in Williston Basin. Black Island consists of mottled light-gray, very fine to medium grained, round to subangular, poorly sorted silty to argillaceous sandstone, cemented with silica or pyrite.

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1341): Black Island of Carlson (1960) in North Dakota not the same as Black Island in Manitoba (Genik, 1954). Replaced name with Burgen Sandstone from mid-continent area. (This usage not followed by North Dakota Geological Survey.)

Boissevain Formation, Sandstone

Age: Late Cretaceous (Maestrichtian).

Area of extent: Pembina escarpment (?) area of southern Manitoba; equivalent to Fox Hills and Hell Creek of current North Dakota usage.

Depositional environment: Marine to nonmarine.

History of stratigraphic nomenclature:
Johnston, W. A., 1934 (Can. Geol. Surv. Mem. 174, p. 11) Used Boissevain Sandstone in column of bedrock formations in Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 993-1010): Boissevain Formation of Maestrichtian age is found on Pembina escarpment, Manitoba and North Dakota.

"Bottineau interval"

Age: Mississippian (Kinderhookian).

Area of extent: North Dakota; equivalent strata in southern Manitoba and Saskatchewan are referred to as Souris Valley; in eastern Montana and South Dakota as Lodgepole.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Smith, M. H., 1960 (AAPG, Rocky Mtn. Sect. Mtg. Billings, Abst.): Proposed Lodgepole, Mission Canyon and Charles as magnafacies of Madison; subdivided Madison into five para-time rock units.

Ballard, F. V., 1963 (N.D. Geol. Surv. Bull. 40, p. 19, fig. 6): Used Bottineau interval for the lowest of Smith's para-time rock units of the Madison; Bottineau interval is essentially equivalent to Lodgepole Formation of previous usage in eastern North Dakota.

Heck, T., 1978 (Mont. Geol. Soc. Williston Basin Sym. 24th Ann. Field Conf., p. 196-197): Bottineau interval divided into four subintervals (ascending): 1) Scallion subinterval, normal marine conditions; 2) lower and upper Virden subinterval, gradual marine regression of cyclical nature with variable clastic influx; 3) lower and upper Whitewater Lake subinterval, gradual marine regression of cyclical nature with variable clastic influx; and 4) Flossie Lake subinterval; gradual marine regression. Kinderhookian in age and is interval of Madison Formation.

BOWES MEMBER (of PIPER FORMATION)

Age: Middle Jurassic (Bathonian).

Area of extent: Central and eastern Montana and western North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 97, and 102-103): Bowes Member displays varying lithologies, represented in Williston Basin by red to varicolored shale facies that grades westward into sandstone and sandy oolitic limestone on east flank of Sweetgrass Arch. The type section is the interval from 3,360-3,417 feet in Northern Ordinance no. 1 Guertzgen well, SW NW NE sec 2, T31N, R19E, Blaine County, Montana, where it consists of (ascending): 18 feet of light-brown, finely crystalline to fragmental limestone, very sandy to argillaceous in part with few thin stringers of light-gray calcareous sandstone; 7 feet of light-gray, fine- to coarse-grained, very calcareous sandstone; 20 feet of light-gray, oolitic to sandy limestone with thin beds of calcareous sandstone; and 12 feet of light-brown, fine-grained calcareous sandstone grading downward into light-gray, sandy and partly oolitic, limestone. Becomes increasingly sandy and somewhat variable in thickness west of type well; eastward becomes interbedded with shale and eventually grades into varicolored shale with uniform thickness. Conformably overlies Firemoon Limestone Member (new) in Williston Basin and most of north-central Montana; southward overlaps Firemoon Member and unconformably overlies Madison Limestone. Underlies Rierdon Formation.

Boyne Beds, Member (of Vermilion River Formation)

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota; equivalent to part of Niobrara of current usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Kirk, S. A., 1930 (Can. Geol. Surv. Summ. Rept. 1929, pt. B, p. 129): Used term Boyne Beds for speckled calcareous shales overlying Morden beds in Pembina Valley area of Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 993-1010): Boyne Member of Vermilion River Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota.

BREIEN MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Central North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 14-15): Thin, fossiliferous, marine member interfingering with lower part of nonmarine Hell Creek; named Breien Member of Hell Creek Formation. Occurs 20 feet above base of Hell Creek; consists of two gray sand beds separated by gray bentonite. Upper sand is greenish and contains marine fossils. Breien is 31 feet thick in Morton County, North Dakota, and has been reported farther south, west of Fort Yates, North Dakota. Type locality near village of Breien, T134N, R82W, Morton County, North Dakota.

Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 30-39): Hell Creek Formation divided into 8 members in North Dakota (ascending): Crowghost Member (new), Breien Member, Fort Rice Member (new), Huff Member (new), and Pretty Butte Member in central North Dakota and ascending Little Beaver Creek Member (new), Marmarth Member (new), Bacon Creek (new), Huff and Pretty Butte Members (new) in southwestern North Dakota. Unnamed ninth member may be present in Montana.

BROOM CREEK GROUP, Formation

Age: Permian (Wolfcampian).

Area of extent: Hartville Uplift area of eastern Wyoming, southwestern South Dakota, and North Dakota; equivalent to part of Minnelusa of Black Hills area.

Reported fossils: Fusulinids.

Depositional environment: Marine.

Remarks: Type locality in Broom Creek valley, sec 10, T28N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13, p. 2, 5, 18-19, 37, and 45): Broom Creek Group consists of interbedded limestones and sandstones. Comprises interval between top of Wendover Group (new) and base of Cassa Group (new). Age is uncertain but is Pennsylvanian or Permian. Thickness of 14-75 feet.

Condra, G. E., and Reed, E. C., 1943 (Neb. Geol. Surv. Bull. 14A, p. 37-38): Broom Creek Group stratigraphically expanded to include few higher beds than included in original definition, placing top on unconformity in overlying Cassa Group. Thickness is 85-101 feet. Is Permian in age.

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Broom Creek comprises lower part of Division I of Hartville "Formation" (Condra, G. E., and Reed, E. C., Neb. Geol. Surv. Paper no. 9, 46 p.). Consists of two distinct facies divided by structural high along North Dakota-South Dakota border. Southern facies is anhydritic dolomite (up to 350 feet thick); northern facies is sandstone with lesser amounts of dolomite (up to 100 feet thick). Erosional unconformity separates Broom Creek Group from overlying Cassa Group.

Ziebarth, H. C., 1962 (Univ. N.D. Ph.D. Dissert., 414 p.): Broom Creek Formation in North Dakota is of interbedded sandstones and dolomites. Subsurface reference section is from 7391-7630 feet in Cardinal Petroleum No. 16-5 N.P.R.R. SE SE sec 5, T139N, R98W, Stark County, North Dakota.

Brule Formation, Member

Age: Oligocene (Orellan).

Area of extent: Southwestern North Dakota, western South Dakota and Nebraska.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Hayden, F. V., 1857 (Phila. Acad. Nat. Sci. Proc., v. 9, p. 151-158): Brule Formation had originally been termed Turtle and Oreodon beds by Hayden, F. V., 1867 (Rept. of F. V. Hayden, U.S. Geol. Surv. Terr., 1st Ann. Rept.).

Darton, N. H., 1899 (U.S. Geol. Surv. 19th Ann. Rept., pt. 4, p. 736): Brule clay separated from underlying Chadron Formation (equivalent to Titanotherium beds) for use in South Dakota.

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 127): Two new members proposed for Brule Formation in North Dakota (ascending): Dickinson Member and Schefield Member. Dickinson Member includes Fitterer bed (new) consisting of sandstone.

BULLHEAD LITHOFACIES, Member (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota and western South Dakota.

Reported fossils: Plant remains and shell fragments.

Depositional environment: Marine.

Principal reference section: NE-facing bluff of badland rim, center of west line, W½ sec 33, T14N, R19E, Redelm NE quad., Ziebach County, South Dakota.

Remarks: See Iron Lightning Member. Bullhead Member named for Indian Village in north-central South Dakota.

History of stratigraphic nomenclature:
Searight, W. V., 1931 (S.D. Geol. Surv. Rept. Invest. 10, p. 1-35): Upper Fox Hills divided into two members: lower banded shale and sandstone and upper sandstone.

Morgan, R. E., and Petsch, B. C., 1945 (S.D. Geol. Surv. Rept. Invest. 49, p. 17): Thin series of banded beds occur stratigraphically higher than Timber Lake Member and stratigraphically lower than butte-capping sandstone.

Stevenson, R. E., 1956 (S.D. Geol. Surv. Bullhead Quad. 1:62,500): Scattered outcrops occur on uplands and high valley-sides in southern half of quadrangle. Consists of alternating thin (1-14 inches) beds of light-gray, medium- to fine-grained, locally cross-laminated, subgraywacke sand, and thin, fissile, clay limonitic concretions throughout member and along some bedding planes. Varigradational contact with overlying and underlying members. Lower 25 feet characterized by fauna of Timber Lake Member; Ostrea glabra occurs in few scattered layers in upper part. Total thickness 135 feet.

Waage, K. M., 1961 (Wyo. Geol. Assoc. 16th Ann. Field Conf., p. 237): Bullhead Member is 15-75 feet of banded, gray clay-shale and light-gray siltstone or fine-grained sandstone. Colgate and upper part of banded beds are lateral facies. Lenses of Colgate-like sand occur in lowest part and top of Bullhead in north-central South Dakota.

_____, 1968 (Yale Univ., Peabody Mus. Nat. Hist. Bull. 27, p. 119-122): Bullhead lithofacies consists of thinly interbedded sand, silt, and clay with abundant plant fragments and some marine fauna. Local zones of contorted bedding associated with intercalated lenses of sand of Colgate lithofacies are evidence of delta-front sediments. Principal reference section selected to show fossiliferous phase.

Feldmann, R. M., 1972 (N.D. Geol. Surv. Bull. 61, p. 28): Bullhead Member in North Dakota, consists of interbedded sandstone, siltstone and shale. Represents brackish-water deposition.

Erickson, J. M., 1974 (Bull. Am. Paleo., p. 145-146): Accepted Waage's (1968) Bullhead lithofacies for south-central North Dakota.

Cvancara, A. M., 1976 (N.D. Geol. Surv. Rept. Invest. 55, p. 8): Used Bullhead as lithofacies within the Iron Lightning Member.

BULLION CREEK FORMATION (of FORT UNION GROUP)

Age: Paleocene (Tiffanian).

Area of extent: Western North Dakota; equivalent strata are included in Tongue River Formation of South Dakota and Montana, Ravenscrag in Saskatchewan and Turtle Mountain Formation in Manitoba.

Depositional environment: Nonmarine.

Remarks: See also Tongue River Formation.

History of stratigraphic nomenclature:
Clayton, L., et al., 1977 (N.D. Geol. Surv. Rept. Invest. 59, p. 10-12): Bullion Creek Formation consists of alternating beds of clay, silt, sand, and lignite. Named from Bullion Creek; type section is SW¼ sec 27, SE¼ sec 28, NE¼ sec 33, and SW¼ sec 34, T137N, R103W, Golden Valley County, North Dakota. Conformably overlain by Sentinel Butte Formation; unconformably underlain by Slope Formation (new). Is 50-200 metres thick and occurs in western North Dakota, northwestern South Dakota, and westward to Cedar Creek anticline of Montana; is equivalent to part of Ravenscrag Formation of Saskatchewan. Is Paleocene in age and is of fluvial-plain origin including overbank, flood basin, and point-bar sediments. Consists of strata considered to be equivalent to entire Tongue River Formation or lower, middle, or upper part of Tongue River Formation.

Burgen Sandstone

Age: Middle Ordovician.

Area of extent: Eastern Oklahoma.

Depositional environment: Marine.

Remarks: See Black Island Member (of Winnipeg Formation).

History of stratigraphic nomenclature:
Taff, J. A., 1905 (U.S. Geol. Surv. Tahlequah Folio 122): Massive, moderately fine-grained, light-brown sandstone, 5 to 100 feet thick in eastern Oklahoma.

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1341): Replaced term "Black Island Formation" of North Dakota, South Dakota, and Montana with Burgen Sandstone. (Usage not followed by N.D. Geol. Surv.)

"Cambro-Ordovician"

Remarks: Term used for all pre-Winnipeg Formation (Deadwood) sedimentary rocks during early stages of oil exploration in Williston Basin.

CAMELS BUTTE MEMBER (of GOLDEN VALLEY FORMATION)

Age: Eocene (Wasatchian).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Hickey, L. J., 1977 (Geol. Soc. Am. Mem. 150, p. 28-34): Camels Butte is upper member of Golden Valley Formation; consists of up to 150 feet of yellow to tan illitic to montmorillonitic strata. Unconformably underlies White River Group and may contain up to 75 feet of weathering or leaching zone; overlies Bears Den Member (new). Is early Wasatchian in age, based on megaflora of 37 species, including Salvinia. Is fluvial in origin.

CANNONBALL FORMATION, MEMBER (of FORT UNION GROUP, FORMATION)

Age: Paleocene (Midway).

Area of extent: North Dakota, South Dakota.

Reported fossils: Foraminiferids, molluscs, and crustacean burrow Ophiomorpha.

Depositional environment: Marine.

Remarks: Type area is along Cannonball River in T132 and 133N, R87 and 88W, Grant County, North Dakota.

History of stratigraphic nomenclature:
Lloyd, E. R., 1914 (U.S. Geol. Surv. Bull. 541, p. 248-249): Cannonball Marine Member comprises upper 250-300 feet of Lance Formation. Consists of 144.5 feet of (descending): 1) calcareous sandstone, 6 inches; 2) gray, partly consolidated sandstone containing numerous layers cemented with iron, 10.5 feet; 3) yellow consolidated sandstone, 5 feet; 4) hard, red sandstone, 6 inches; 5) dark-gray shale with "cannonball" concretions, 25 feet; 6) very dark-gray shale, very sandy, with layer of marine shells 20 feet from base and with "cannonball" concretions, 103 feet; base concealed. Marine invertebrates belong to modified Fox Hills fauna.

Lloyd, E. R., and Hares, C. J., 1915 (J. Geol., v. 23, p. 523-547): In large area west of Missouri River in North and South Dakota, Lance Formation consists of lower nonmarine part containing flora similar to Fort Union and upper marine member containing fauna resembling Fox Hills. Upper part, because of peculiar fauna, has been mapped separately and named Cannonball Marine Member of Lance Formation. Farther west, nonmarine beds with lignite and occupying similar stratigraphic position have been named Ludlow Lignitic Member of Lance Formation. Cannonball Member mapped from Mandan to 4 miles west of Haley, North Dakota, distance of 130 miles. Presence of Ostrea glabra near Yule in Slope County, North Dakota, shows sea extended some distance farther than its sediments mapped. Cannonball Member becomes thinner to west; oyster beds near Yule may represent western limit of Cannonball sea which probably advanced into western North and South Dakota from east or northeast. Is contemporaneous with Ludlow Lignitic Member and overlies 400-525 feet of somber-colored shale, yellow sandstone, and thin lignite beds composing lower, nonmarine member of Lance. Consists of dark, sandy shale or shaly sandstone with lesser amounts of dark-yellow and gray sandstone and thin limestone; strata is lenticular and can be followed only for short distances. Sections show Cannonball Member overlying or grading laterally into Ludlow. "Cannonball" concretions are formed by cementation of sandy shale by deposition of calcium carbonate. No definite boundary could be determined between nonmarine and marine beds of Lance.

Dorf, E., 1940 (Geol. Soc. Am. Bull. 51, p. 213-236): Paleobotanical evidence supports known vertebrate evidence in placing boundary between true Lance and Fort Union at base of nondinosaur-bearing Tullock, Ludlow, or Bear Formations or their equivalents (at top of Triceratops-bearing Hell Creek or Lance Formations as originally defined).

Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 18-20): Cannonball of Fort Union Group comprises upper 250-300 feet of old Lance Formation. Is typically exposed along Cannonball River. To west, intergrades with underlying Ludlow Formation and southern Morton County, underlies and is gradational with Ludlow. Conformably underlies Tongue River Formation.

Fox, S. K., Jr., and Ross, R. J., Jr., 1942 (J. Paleo., v. 16, p. 660-673): Analyses of foraminifera from Cannonball beds of North Dakota indicates Midway (Paleocene) age.

Seager, O. A., et al., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 1414-1415, 1417): Fort Union in North Dakota is represented by three members: Tongue River, Cannonball, and Ludlow. Cannonball and Ludlow are interfingering contemporaneous sediments of early Paleocene age.

Cvancara, A. M., 1976 (N.D. Rept. Invest. 57, 22 p.): Poorly consolidated, very fine to fine-grained, light to medium brownish yellow-weathering sandstone and light gray-weathering, sandy mudstone are the principal types of lithology. Mudstone generally predominates in North Dakota whereas sandstone predominates in South Dakota. Sequence is 385 feet thick in southeastern Hettinger County, North Dakota; thinning occurs away from here, except for another thickening in Dunn County and possibly Ward County.

CARLILE SHALE (of COLORADO GROUP)

Age: Late Cretaceous (Turonian).

Area of extent: Central and eastern Montana, eastern Colorado, Wyoming, New Mexico, North Dakota, South Dakota, Kansas, and Nebraska.

Reported fossils: Scaphites and other cephalopods.

Depositional environment: Marine.

Remarks: Named for outcrops around Carlile Spring and Carlile Station, 21 miles west of Pueblo, Colorado. See also Niobrara Formation.

History of stratigraphic nomenclature:
Gilbert, G. K., 1896 (U.S. Geol. Surv. 17th Ann. Rept., pt. 2, p. 565): Carlile Shale is medium-gray shale with thin, purplish limestone or thicker, yellow sandstone at top. Is top formation of Benton Group.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 1, p. 348): Niobrara and Benton are not now considered groups but are included in Colorado Group. Referred to as Niobrara Limestone and Benton Shale where not subdivided.

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2187-2190): Carlile of northern Black Hills consists of basal unnamed dark-gray shale, 75-155 feet thick; middle, gray, sandy member (Turner), 185-260 feet thick; and upper dark-gray shale (Sage Breaks), 195-305 feet thick.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 77): Carlile is 370-440 feet thick in western South Dakota; underlies almost entirely North Dakota and South Dakota, and is much thinner on eastern side of Williston Basin. Lower half of formation consists of dark-gray, fissile shale and very finely interbedded shale and glauconitic siltstone with thin sandstones and large limestone concretions. In upper half of formation, three definite but thin sandstones are present.

Knechtel, M. M., and Patterson, S. H., 1962 (U.S. Geol. Surv. Bull. 1082-M, p. 920-925): Carlile in northern Black Hills consists of three members (descending): Sage Breaks Shale Member--195-300 feet of dark-gray noncalcareous shale with

many limestone concretions; Turner Sandy Member--210-260 feet of dark shale with many limestone concretions and lenses of light-gray sandstone and sandy shale; and Pool Creek Shale Member--upper unit of 81 feet of black-gray shale that contain in lower part, two bentonite layers, and in upper 37 feet, many clay-ironstone concretions; and lower unit of 13 feet of dark-gray soft papery shale, with limestone concretions at top.

Carrington shale facies

Age: Mississippian (Kinderhookian).

Area of extent: Eastern North Dakota; probably equivalent to Routledge shale in Manitoba and Englewood Formation in South Dakota.

Type section: Interval of 2,362 to 2,425 feet mechanical log depth in Pure Oil Company J. M. Carr 1 well, sec 15, T146N, R66W, Foster County, North Dakota (Ballard, 1963, p. 19). Named for Carrington, North Dakota.

History of stratigraphic nomenclature:
Ballard, F. V., 1963 (N.D. Geol. Surv. Bull. 40, p. 19-24): Carrington shale facies proposed to be part of Bottineau interval instead of equivalent to Three Forks Formation.

Bjorlie, P. F., 1979 (N.D. Geol. Surv. Rept. Invest. 67, p. 10-11): Carrington shale facies is a part of Scallion subinterval of the Bottineau interval.

Cassa Group

Age: Permian (Leonardian).

Area of extent: Hartville Uplift area of eastern Wyoming, northeastern Colorado, southwestern South Dakota. Cassa (?) of Macauley is included in Opeche of North Dakota current usage.

Depositional environment: Marine.

Remarks: Type locality is Buckshot Canyon (also called Ragan Canyon), T29N, R67W, 3 miles northeast of Cassa, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2, 5, 19, and 45): Cassa Group is upper 180 feet of Division I of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, 46 p.). Thickness is 175-328 feet. Underlies Phosphoria Group; overlies Broom Creek Group (new). Consists of Owl Canyon Formation (new) below, Lyons Sandstone above.

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, p. 150-164): No Cassa Group deposits along eastern flank of Permo-Pennsylvanian basin of South Dakota or in North Dakota. In restricted basin in west-central North Dakota, Cassa (?) sediments are 400 feet thick. Consists of red to pink, soft, lumpy, clayey, locally silty and sandy, shale that may be calcareous or dolomitic with anhydrite inclusions and salt beds (up to 100 feet thick).

CHADRON FORMATION (of WHITE RIVER GROUP)

Age: Oligocene (Chadronian).

Area of extent: Western North Dakota and western South Dakota, Nebraska, and northeastern Colorado.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Darton, N. H., 1899 (U.S. Geol. Surv. 19th Ann. Rept., pt. 4, p. 736): Chadron Formation is thin sheet of light-greenish sandy clay, underlying Brule clay. Forms basal member of White River Group; rests unconformably on Pierre Shale. Formerly called "Titanotherium beds."

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 124): Three new members proposed for Chadron Formation in North Dakota (ascending): Amidon, Chalky Buttes, and South Heart Members.

Chalky Buttes Member (of CHADRON FORMATION)

Age: Oligocene.

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 124): Chalky Buttes Member proposed for middle of Chadron Formation. Consists of "dazzling white," fine- to coarse-grained, cross-bedded, cobbly arkoses unconformably overlying Amidon Member and conformably underlying South Heart Member. Type section is south-facing exposure near head of deep, unnamed gully at NE NE sec 15, T134N, R101W, Slope County, about 4¼ miles southwest of Amidon.

CHARLES FORMATION, Magnafacies (of MADISON GROUP)

Age: Late Mississippian (Meramecian).

Area of extent: Williston Basin.

Reported fossils: Algae and ostracods.

Depositional environment: Marine.

Type section: Interval from 3200 to 3800 feet in Argo-California 4 Charles oil test in sec 21, T15N, R30E, Garfield County, Montana (Andrichuk, 1955, p. 2176). Named from Charles lease.

History of stratigraphic nomenclature:
Seager, O. A., 1942 (Am. Assoc. Pet. Geol., v. 26, p. 861-864): Charles includes shale, salt, anhydrite, and earthy limestone beds (810 feet). Represents post-Madison, pre-Kibbey sedimentation and placed in Big Snowy Group.

Sloss, L. L., 1952 (Billings Geol. Soc. 3rd Ann. Field Conf., p. 66-67): Charles assigned to Madison Group and overlies Mission Canyon Limestone. Charles is recognizable in many outcrops of Montana.

Andrichuk, J. M., 1955 (Am. Assoc. Pet. Geol. Bull. 39, p. 2170-2210): Charles equivalent mapped as upper unit of Madison Group, plus upper (second) evaporite zone of middle unit. Recognized north of Black Hills, reaching greater than 300 feet at South Dakota-North Dakota border. Type section suggested in sec. 21, T15N, R30E, Garfield County, Montana.

Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Mississippian Charles Formation contains seven salt beds. In descending order, "A" through "F" Mississippian Salts and seventh salt named "X" Salt. In north-central North Dakota, seventh salt is two separate salts (descending): "X" Salt and "XY" Salt. "A" through "F" Salts are located in deepest part of Williston Basin (western one-third of North Dakota and eastern Montana) and are equivalent to Poplar beds. "D" and "F" Salts extend into Canada and are 60 feet and 90 feet, respectively. "X" Salt equivalent to Frobisher-Alida beds. "A" Salt is 150 feet thick.

Gardner, L. S., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 330-332): Charles Formation transitional laterally in subsurface into upper beds of Mission Canyon Limestone (middle unit of Madison Group).

Smith, M. H., 1960 (Am. Assoc. Pet. Geol. Bull. 44, p. 959): Changes in nomenclature of Mississippian Madison Group reported by Committee of Mississippian Madison Group of North Dakota Geological Society. Five marker-determined intervals and two subintervals defined by log deflection.

Carlson, C. G., and Anderson, S. B., 1970 (N.D. Geol. Surv. Misc. Ser. 28, p. 1842): Charles facies shown to include all of Poplar interval where present and parts of Ratcliffe interval, Midale subinterval, and Frobisher-Alida interval where present.

Sando, W. J., and Dutro, J. T., Jr., 1974 (U.S. Geol. Surv. Prof. Paper 842, 22 p.): Geographically and stratigraphically restricted to subsurface Williston Basin of central and eastern Montana and western part of Dakotas; name was formerly extended to surface rocks in part of central and western Montana and included beds considered to be part of underlying Mission Canyon Limestone.

"Charles Salt," "lower" or "last"

Age: Mississippian.

Area of extent: Central part of Williston Basin.

Depositional environment: Marine.

Remarks: Informally named in Charles Formation. See also "Ratcliffe beds" and Madison Formation. See also Charles Salt.

History of stratigraphic nomenclature:
North Dakota Geological Society, 1959 (Nesson anticline of North Dakota: Conrad, Bismarck, p. 9): Base of "last Charles salt" in stratigraphic section.

"Charles Salts" ("A," "B," "C," "D," "E," "F," "X," and "XY")

Age: Mississippian.

Area of extent: Central part of Williston Basin.

Depositional environment: Marine.

Remarks: See Charles Formation of Madison Group and "Charles Salt."

History of stratigraphic nomenclature:
Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Mississippian Charles Formation contains seven salt beds. In descending order, "A" through "F" Mississippian salts and seventh salt named "X" Salt. In north-central North Dakota, seventh salt is two separate salts (descending): "X" Salt and "XY" Salt. "A" through "F" Salts are in deepest part of Williston

Basin (western one-third of North Dakota and eastern Montana) and are equivalent to Poplar beds. "D" and "F" Salts extend into Canada and are 60 and 90 feet thick. "X" Salt equivalent to Frobisher-Alida beds. "A" Salt is 150 feet thick.

Cloverly Group

Age: Early Cretaceous (Aptian to Albian).

Area of extent: Central, eastern, and northern Wyoming, and central-southern Montana; equivalent to Inyan Kara of current usage in North Dakota and South Dakota.

Reported fossils: Gastropods and plant fossils.

Depositional environment: Marine to nonmarine.

Remarks: Named for exposures near Cloverly post office on east side of Big Horn basin, Wyoming.

History of stratigraphic nomenclature:
Darton, N. H., 1904 (Geol. Soc. Am. Bull. 15, p. 394-401): Cloverly Group is varicolored claystone of red-purple-green and gray with basal, coarse-grained, massive sandstone in Bighorn Mountain area.

North Dakota Geological Society, 1954 (Stratigraphy of the Williston Basin: Conrad , Bismarck): Cloverly Group consists of Lakota, Fuson, and Dakota Formations in Williston Basin of North Dakota.

COLGATE LITHOFACIES, Member (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Eastern Montana, southwestern North Dakota, and northwestern South Dakota.

Reported fossils: Plant remains.

Depositional environment: Brackish to marine.

Remarks: Type locality is near Colgate Station on Northern Pacific Railway, Dawson County, Montana. See also Iron Lightning Member.

History of stratigraphic nomenclature:
Calvert, W. R., 1912 (U.S. Geol. Surv. Bull. 471, p. 189-198): Basal Colgate Sandstone Member of Lance Formation is 185 feet of white and yellowish sandstone. Exposed on both sides of Cedar Creek anticline, Dawson County, Montana. Near Iron Bluff (NE part of T14N, R55E), consists of (descending): 1) 35 feet of massive white sandstone, 2) 75 feet of brown sandstone forming summit of Iron Bluff, with fossil leaves at base, and 3) 75 feet of shale and sandstone with fossil leaves in upper 20 feet. Overlies Pierre Shale; underlies, with local unconformity, 500 feet of somber-colored clay and lenticular sandstone with few lignite beds of Lance Formation. Appearance of transition between Colgate and Pierre, suggesting that Colgate occupies same stratigraphic position of Fox Hills, but fossil leaves indicate late age, placing it in Lance Formation.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484-497): Colgate Sandstone Member redefined as upper white sandstone of Fox Hills, typically developed between Colgate Station and Glendive, Montana and exposed along Cedar Creek anticline and elsewhere in eastern Montana. Colgate is 35 feet of white sandstone and forms top of lower 75 feet of sandstone of

Iron Bluff; ferruginous matter leached from Lance masked usual white color. Halymenites major casts and fossil leaves in exposure along Cedar Creek anticline. Colgate is gradational, into underlying marine strata on Little Beaver Creek, south of Baker, Montana; is strikingly developed along Missouri River between Hell Creek and Musselshell River. Fluvatile basal sandstone of Lance in central Montana is probably equivalent to Colgate Sandstone and upper white sandstone of Fox Hills but has not been traced.

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, 110 p.): 17-40 feet of Colgate Sandstone Member at top of Fox Hills Sandstone in Marmarth lignite field, North Dakota.

Waage, K. M., 1961 (Wyo. Geol. Assoc. 16th Ann. Field Conf., p. 237): Facies relationships between Bullhead and Colgate are source of mapping confusion, as lenses of Colgate-like sand occur in lower Bullhead, as well as at top, in north-central South Dakota. Colgate and upper part of banded beds are lateral facies.

_____, 1968 (Yale Univ., Peabody Mus. Nat. Hist. Bull. 27, p. 122-124): Upper part of Iron Lightning Member is clayey, grayish-white sand with brackish-water fauna named Colgate lithofacies (reduced from member rank). Lateral transition to Bullhead lithofacies.

Feldmann, R. M., 1972 (N.D. Geol. Surv. Bull. 61, p. 31): In North Dakota, Colgate is light graywacke sandstone or white to cream-colored flaggy sandstone. Colgate represents strandline deposition.

Erickson, J. M., 1974 (Bull. of Am. Paleo., p. 145): Colgate lithofacies recognized in south-central North Dakota.

COLORADO GROUP, Shale, Formation

Age: Late Cretaceous (Cenomanian to Santonian).

Area of extent: Montana, North Dakota, South Dakota, Wyoming, Colorado, Nebraska, Kansas, southern Alberta and Saskatchewan.

Reported fossils: Inoceramus, Scaphites.

Depositional environment: Marine.

Remarks: Type locality along eastern base of Front Range, Colorado. North Dakota usage follows Cobban and Reeside, Montana and Canadian usage follows White.

History of stratigraphic nomenclature:
Hayden, F. V., 1876 (U.S. Geol. and Geog. Surv. of the Terr. 8th Ann. Rept., p. 45): Nos. 2, 3, and 4 of Cretaceous (Fort Union, Niobrara, and Fort Pierre divisions) may be regarded as one group, under name of Colorado Group as adopted by Clarence King, 1876 (U.S. Geol. Expl. 40th Paral. Atlas, map 1). Underlain by Dakota Group and overlain by Fox Hills Group. Exposed along eastern base of front of Colorado range.

White, C. A., 1878 (U.S. Geol. and Geog. Surv. of the Terr. 10th Ann. Rept., p. 21-22, 30): Colorado Group includes equivalents of No. 2 (Fort Benton) and 3 (Niobrara) of Meek and Hayden's original section, leaving No. 4 (Fort Pierre Group) to be included with strata of Fox Hills Group.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, pl. 1): Base of Colorado Group is contact between Mowry and Belle Fourche Shale.

CROWGHOST MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: South-central North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 33-34): Crowghost Member consists of lignitic, bentonitic sediments, mostly shales, with few sandstones, siderite nodules weathered to limonite common. Overlies Colgate or Bullhead Member of Fox Hills Formation, underlies Breien Member. Named from Crowghost Cemetery; type section is center sec 33, T134N, R82W, Sioux County, North Dakota. Can interfinger with Bullhead Member of Fox Hills and probably also interfingers with Breien Member. Ranges from 6 feet thick in central Emmons County to 31 feet thick at type section in Sioux County.

DAKOTA GROUP, Sandstone, Formation

Age: Early Cretaceous (Aptian to Albian).

Area of extent: North Dakota, South Dakota, Nebraska, Kansas, eastern Colorado, northwestern Oklahoma. Equivalents of Inyan Kara part of Dakota Group of North Dakota are termed Dakota Sandstone in parts of Wyoming and northeastern New Mexico.

Reported fossils: Plant fossils, pelecypods in marine facies.

Depositional environment: Marine to Nonmarine.

Remarks: Type locality near town of Dakota, Dakota County, Nebraska. Other reference sections given by G. E. Condra and E. C. Reed, 1943 (Neb. Geol. Surv. Bull. 14) and W. T. Lee, 1923 (U.S. Geol. Surv. Bull. 751-A).

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1861 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 419-420): Dakota Group (Formation No. 1 of Cretaceous) consists of yellowish, reddish, and occasionally white sandstone, locally with alternations or varicolored clays and lignite beds. Thickness is 400 feet. Occurs in hills near town of Dakota, and is extensively developed in Dakota County (Nebraska) below mouth of Big Sioux River, and extends into Kansas. Underlies Fort Benton Group, of which it may probably be only of member status.

Newton, H., and Jenney, W. P., 1880 (U.S. Geol. and Geog. Surv., Rocky Mountain Region, p. 151-180): Dakota Group includes equivalents of Lakota, Fuson, and Fall River. Forms capping rock on foothills. Coaly plant fossils present. Is Early Cretaceous in age.

Jenney, W. P., 1899, 1901 (U.S. Geol. Surv. 19th Ann. Rept., pt. 2-3, p. 568-593): Dakota usage restricted to upper sandstone of former Dakota Group in northern Black Hills.

Russell, W. L., 1927 (Am. J. Sci. 5th ser., v. 14, p. 402): Dakota Sandstone of Black Hills region is older than true Dakota as is Fall River Formation. Overlies Fuson Formation and underlies Graneros Shale.

Rubey, W. W., 1931 (U.S. Geol. Surv. Prof. Paper 165-A, p. 5): Fall River Sandstone is Dakota Sandstone of previous reports in Black Hills region. Is top formation of Inyan Kara Group, of Early Cretaceous age. Conformably underlies Graneros Shale and overlies Fuson. Is continental deposit except upper 20 feet, which contains marine fossils.

Ballard, N., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 1562): Strata of Dakota Group crop out as hogbacks surrounding Black Hills and are present throughout Dakotas in subsurface. Dakota Group consists of upper unnamed sandstone member, middle or Fuson Shale Member, and lower or Lakota Sandstone Member. Maximum thickness is 725 feet.

Gries, J. P., 1954 (Am. Assoc. Pet. Geol., v. 38, p. 446-449): Term "Dakota" used for thick sandstone sequence in central South Dakota, where called "true Dakota," and where it overlies Skull Creek Shale, "true Dakota" is age-equivalent of Newcastle-Mowry interval and what is called Dakota in Williston Basin to north is actually Fall River Sandstone.

Hansen, D. E., 1955 (N.D. Geol. Surv. Bull. 29, p. 17): Revised Dakota Group to include Mowry, Newcastle, Skull Creek, Fall River, Fuson, and Lakota Formations in North Dakota.

Waage, K. M., 1955 (U.S. Geol. Surv. Prof. Paper 274-B, p. 15-49): Dakota Group applied to pre-Benton sandstone and shale sequence in northern Front Range of Colorado can be correlated with strata including Lakota (below) and Newcastle (above). Dakota Group is strictly a rock term and age should be irrelevant to usage.

Pettyjohn, W. A., 1960 (S.D. Acad. Sci. Proc., v. 38, p. 34-38): Dakota Group includes Lakota, Fuson, Fall River, Skull Creek, and Newcastle Formations.

Sandberg, C. A., 1962 (U.S. Geol. Surv. TEI-809, p. 94-95): Dakota Group of Williston Basin includes only what Inyan Kara Group comprises in Black Hills--Lakota and Fall River.

"Dakota silt"

Age: Early Cretaceous.

Remarks: Informal term applied in subsurface to uppermost, silty part of Fall River Formation. Wulf, G. R., 1962 (Am. Assoc. of Pet. Geol. Bull. 46, no. 8, p. 1370) noted that "Dakota silt" should be abandoned because Dakota had been used in different sense previously.

DAWSON BAY FORMATION (of MANITOBA GROUP)

Age: Middle Devonian (Erian).

Area of extent: Williston Basin.

Reported fossils: Rare chitinozoans, brachiopods, ostracods, and stromatoporoids.

Depositional environment: Marine.

Remarks: Type locality near Dawson Bay at north end of Lake Winnipegosis.

History of stratigraphic nomenclature:
Baillie, A. D., 1953 (Am. Assoc. Pet. Geol. Bull. 37, p. 444-452): Dawson Bay Formation is lowest sequence of strata of Manitoba Group. Lower boundary is at base of "second red" and green argillaceous zone that overlies Elk Point Group. Upper boundary marked by top of widespread reefoid and stromatoporoid zone. Thickness is 100-200 feet. In outcrop overlies Winnipegosis Formation; underlies unnamed strata of Beaverhill Lake Group.

Laird, W. M., 1953 (Interstate Oil Compact Quart. Bull., v. 12, p. 74): Underlies Souris River Formation (new). Included in Beaverhill Lake Group.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2302-2309): Baillie (1953) placed Dawson Bay Formation and overlying unnamed beds approximately equivalent to Souris River Formation, to Manitoba Group. This grouping not recommended for Williston Basin of United States because Dawson Bay and Souris River Formations are readily separable. Dawson Bay Formation is less than 1 foot to 185 feet; thickest along international boundary and in north-central North Dakota. Underlies approximately same area as Elk Point Group in Williston Basin and northeastern Montana but extends slightly beyond limit of Winnipegosis Formation. Overlies Prairie Formation of Elk Point Group; underlies Souris River Formation. Does not outcrop in United States.

DEADWOOD FORMATION

Age: Late Cambrian to Early Ordovician (Albertan to Canadian).

Area of extent: North Dakota, South Dakota, northeast Wyoming, southeast Montana, southern Saskatchewan.

Reported fossils: Faunizones of Late Cambrian; Crepicephalus, Aphelaspis, Elvinia, Conaspis, and Ptychaspis-Prosaukia faunizones are known. Distacodid conodonts are present.

Depositional environment: Marine.

Remarks: Type locality is Whitewood Canyon at Deadwood, South Dakota.

History of stratigraphic nomenclature:
Darton, N. H., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 505): Deadwood Formation consists of red-brown quartzite and sandstone, locally conglomeritic and partly massive. Upper part is thinner bedded, softer sandstone, interbedded with shale in places. Basal member is usually hard, massive, reddish-brown quartzite; portions of basal beds are conglomeritic. Rests unconformably on Precambrian granites and schists and underlies Englewood Limestone (Mississippian); in northern Hills underlies Whitewood Limestone (Ordovician).

McCoy, M. R., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 45-47): Changed Scolithus Sandstone to Aladdin Sandstone and took it out of Deadwood Formation. Thickness of revised Deadwood is 350 feet.

Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 49-50): Deadwood Formation of North Dakota includes all pre-Winnipeg sedimentary rocks. Consists of sandstone, shale, and carbonates of Late Cambrian to Early Ordovician age. McCoy's (1952) correlation of Aladdin with lower sand member of Winnipeg is erroneous.

Sandberg, C. A., 1962 (U.S. Geol. Surv. TEI-809, p. 23-27): Deadwood consists of basal, grayish-red, conglomeritic, quartzitic, sandstone and remainder is interbedded greenish-gray and gray shale, gray limestone and limestone-pebble conglomerate, and light-gray, grayish-red, and brownish-red sandstone and siltstone, which grades eastward into mainly sandstone. Is Late Cambrian in age.

DEGREY MEMBER (of PIERRE FORMATION, SHALE)

Age: Late Cretaceous (Campanian).

Area of extent: Central South Dakota, eastern North Dakota.

Depositional environment: Marine.

Type section: Cutbank of Missouri River, 2 miles south of DeGrey in western edge of NW¼ sec 8, T109N, R75W, Hughes County, South Dakota. Named after DeGrey Post Office.

History of stratigraphic nomenclature:

Crandell, D. R., 1950 (Am. Assoc. Pet. Geol. Bull. 34, p. 2341-2346): No representative type section of Agency-oacoma zone: DeGrey Member proposed for unit. Verendrye and Crow Creek raised to member rank. Sully no longer used. DeGrey is 82 feet of shale, clay, and bentonite. Top placed on horizon between "gumbo-forming" shale of overlying Verendrye Member and "step-forming" shale of DeGrey Member. Base of member is between noncalcareous shale of DeGrey Member and calcareous beds of underlying Crow Creek Member.

Wilson, E. E., 1958 (Univ. N.D. Master's Thesis, 134 p.): Pierre Shale along northern Sheyenne River and in Stutsman County may be equivalent to Verendrye and DeGrey Members of South Dakota.

Robinson, C. S., Mapel, W. J., and Cobban, W. J., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 101-123): Monument Hill Bentonitic Member fossils found in DeGrey Member of Pierre of central South Dakota.

Gill, J. R., and Cobban, W. A., 1965 (U.S. Geol. Surv. Prof. Paper 392A, 20 p.): DeGrey Member exposed along Sheyenne River Valley in North Dakota and along South Branch of Park River.

"Devonian 'A', 'B', 'C', and 'F'"

Remarks: Towse, D. F., 1952 (N.D. Geol. Surv. Circ. 7): These terms were intended as temporary informal units to be used until correlation of subsurface units could be established. The approximate current equivalents are "Nisku" Formation-'A', Duperow Formation-'B', Souris River Formation-'C', and 'F'-lower Winnipegosis.

DICKINSON MEMBER (of BRULE FORMATION)

Age: Oligocene (Orellan).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 127): Dickinson Member is lowest member of Brule Formation. Consists of 60-130 feet of clay, cross-bedded sandstone, and pitted-weathering, silty claystone. Conformably lies above South Heart Member of Chadron Formation; conformably underlies Schefield Member of Brule Formation or younger deposits. Contains 5-9 feet of fossiliferous, cross-bedded sandstone named Fitterer bed. Type section is small butte about ¼ mile northeast of Fitterer Ranch house in NW SE sec 7, T137N, R97W, Stark County, North Dakota.

Dunham Salt

Age: Middle Jurassic (?).

Area of extent: North Dakota, northeastern Montana.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Zieglar, D. L., 1955 (N.D. Geol. Soc. South Dakota Black Hills Field Conf. Gdbk., p. 53): Dunham Salt consists of evaporites overlying Saude Formation conformably. 0-100 feet thick. Slight erosion of upper part of Saude occurs locally.

Dow, W. G., 1964 (N.D. Geol. Soc. 3rd Internat. Williston Basin Sym., Conrad, Bismarck, p. 127-131): Dunham Salt, formerly of Spearfish Formation, is considered to be facies of lower evaporite unit of Piper Formation and is Jurassic in age.

DUPEROW FORMATION

Age: Late Devonian (Senecan).

Area of extent: Williston Basin; equivalent strata termed Jefferson in central and western Montana.

Reported fossils: Algae, brachiopods, and corals. Amphipora locally common.

Depositional environment: Marine.

Type section: Hunt No. 1 Olsen log, sec 18, T163N, R77W, Bottineau County, North Dakota. Standard subsurface section is at depth of 10,400 to 10,743 in Mobil No. 1 Birdbear oil test in sec 22, T149N, R91W, Dunn County, North Dakota.

History of stratigraphic nomenclature:
Powley, D., 1951 (Univ. Sask. M.S. Thesis): Duperow defined from Tidewater No. 1 Duperow Crown well in southwest Saskatchewan. Is equivalent to all but lower part of Beaverhill Lake Formation.

Stanton, M. S., 1953 (Billings Geol. Soc. Gdbk. 4th Ann. Field Conf., p. 62): Duperow is thick series of carbonates, normal marine to fossil-fragmental limestone, dolomitized limestone, and dolomite, with anhydrite and minor shale; argillaceous phases are common and minor silty carbonates present. Limestone is characteristically light gray to gray brown, microcrystalline to fine crystalline, and dense. Duperow Formation includes strata above well-defined gamma-ray "kick" marking upper limit of Souris River Formation to top of gamma-ray marker at base of "Nesker" (Nisku) Formation. Thickness is 50-500 feet.

Towse, D., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Devonian "B" of earlier N.D. Geol. Surv. reports is equivalent to Duperow Formation or "Woodbend equivalent" of this report. North Dakota Geological Society, 1954, recognized that Powley's original definition included part of Souris River Formation, but used name Duperow and the Hunt No. 1 Olsen log, sec 18, T163N, R77W, Bottineau County, North Dakota, to define the typical development of this unit in North Dakota.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2315-2318): Through misunderstanding of Powley's (1951, unpub.) definition, Duperow was considered to be equivalent to Woodbend Formation of Late Devonian age which overlies Beaverhill Lake Formation of Alberta. In 1953, Williston Basin Nomenclature Committee of Am. Assoc. Pet. Geol. abandoned usage of Duperow Formation according to Powley and applied name to overlying lithologic unit. Consists of medium- to brownish-gray, dense to microcrystalline limestone, brownish-gray, finely crystalline dolomite, and white to brownish-gray anhydrite, interbedded with thinner beds of greenish-gray dolomitic shale, very fine grained siltstone, and sandy argillaceous dolomite. Maximum thickness is 600 feet in north-central and northeastern Montana. Standard subsurface section designated. Overlies Souris River Formation; underlies Birdbear Formation (new); is in Jefferson Group. Contains Late Devonian fossils.

"Dynneson sand" (of MOWRY FORMATION, SHALE)

Age: Early Cretaceous (Albian).

Area of extent: Usually considered as equivalent to Newcastle in North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Wulf, G. R., 1962 (Am. Assoc. Pet. Geol. Bull. 46, p. 1396-1402): Mowry Shale of Williston Basin divided into two units separated by bentonite bed. Lower unit (Dynneson unit) is shale with two prominent sandstone lithofacies, Dynneson (of Williston Basin) and Bow Island (of northwest Montana). Dynneson unit marked by unconformity at top of Skull Creek. Where Dynneson sand absent, unit is called "lower Mowry." Dynneson Sandstone Member is blanket-type sandstone with shoe-string sandstone bodies at top. Grains are light gray and fine in size.

EAGLE SANDSTONE (of MONTANA GROUP)

Age: Late Cretaceous (Campanian).

Area of extent: Central and eastern Montana, northeastern Wyoming, and westernmost North Dakota.

Reported fossils: Scaphites hippocrepis, pelecypods, plant fossils.

Depositional environment: Marine to brackish.

Remarks: Type locality is along Missouri River near confluence with Eagle Creek, 40 miles east of Fort Benton.

History of stratigraphic nomenclature:
Weed, W. H., 1899 (U.S. Geol. Surv. Folio 55): Eagle Sandstone consists of sandstone, shale with interbedded lignite and coal seams.

Laird, W. M., and Towse, D. F., 1949 (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Eagle Sand shown to produce gas at several localities in North Dakota.

ELK BUTTE MEMBER (of PIERRE FORMATION, SHALE)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Eastern North Dakota and eastern South Dakota.

Depositional environment: Marine.

Type section: Along U.S. Highway 12, between 1-5 miles west of Wakpala, Corson County, South Dakota. Type location is actually on Rattlesnake Butte (Agnew and Tychsen, 1965). See also Pierre Formation.

History of stratigraphic nomenclature:
Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 50-55): Elk Butte Member is 60-310 feet of fine-textured, medium-gray shale that weathers to fine, thin, flat, polygonal chips with submetallic luster. Gradational contact with overlying Fox Hills Sandstone; basal beds are noncalcareous shale that overlie buff, calcareous shale of Mobridge Member.

Fisher, S. P., 1952 (N.D. Geol. Surv. Bull. 26, p. 8-10): Most of Pierre Shale in Emmons County is Elk Butte Member.

Wilson, E. E., 1958 (Univ. N.D. Master's Thesis, 134 p.): Emmons County has equivalent strata of Elk Butte Member.

ELK POINT GROUP, Formation

Age: Middle Devonian (Erian).

Area of extent: Alberta Basin; Williston Basin strata included in this Group are equivalent to upper part of Elk Point Group of Alberta.

Reported fossils: Algae, stromatoporoids, Amphipora.

Depositional environment: Marine.

Remarks: Type locality at Elk Point area of east-central Alberta. See also Ashern, Elm Point, Winnipegosis, and Prairie Formations.

History of stratigraphic nomenclature:

McGehee, J. R., 1949 (Am. Assoc. Pet. Geol. Bull. 33, p. 603, 606-611): Elk Point Formation underlies thick section of Late Devonian strata and overlies Ordovician, Cambrian, or Precambrian rocks. Consists of two conspicuous red shales, anhydritic dolomites, and thin, slightly fossiliferous, argillaceous, silty limestones, and one to three shale members. Maximum thickness is 1550 feet. Formation is probably Silurian in age but upper part of formation is Middle Devonian.

_____, 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 64): Recent wells in southern Saskatchewan, southwestern Manitoba, eastern Montana, and North Dakota show sequence of strata believed to be equivalent to Elk Point Formation of Alberta Plains. Dominant lithology is evaporite; underlies thick section of Late Devonian and late Middle Devonian carbonate rocks. Similarity in lithology and position indicates Elk Point age for evaporite portion of deposits.

Belyea, H. R., 1952 (Can. Geol. Surv. Paper 52-27, p. 7-12): Rank raised to Group but subdivisions are not named.

Baillie, A. D., 1953 (Am. Assoc. Pet. Geol. Bull. 37, p. 444-452): Term "Elk Point Group" applied to basal major Devonian unit in Williston Basin. Group approximately equivalent to Elk Point Formation in Alberta. In Williston Basin, Elk Point Group includes (ascending) Ashern, Elm Point, and Winnipegosis Formations of outcrop area and subsurface equivalents and also Middle Devonian salt and anhydrite section named Prairie Evaporite (new). Upper limit is top of evaporite section or top of Winnipegosis Formation where evaporite not present; underlies Manitoba Group. Is Middle Devonian in age.

Williston Basin Correlation Committee, unpublished, February 18, 1953. Elk Point Group consists of marine carbonates and evaporite beds. Of four groups of strata of Devonian age, Elk Point Group exhibits greatest degree of shelf and basin differentiation. Divided into three formations (ascending): Ashern, Winnipegosis, and Prairie. Maximum thickness is 800 feet near Saskatoon.

Baillie, A. D., 1955 (Am. Assoc. Pet. Geol. Bull. 39, p. 590): Middle Devonian evaporitic section of Williston Basin is part of sequence divided into several lithologic units of formation rank, is proposed to designate strata that include such formations as Elk Point Group. Formations included are (ascending): Ashern Formation, Elk Point Limestone, Winnipegosis Formation, and Prairie Evaporite.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2302-2307): In United States portion of Williston Basin and adjacent areas, Elk Point Group consists of Winnipegosis Formation and overlying Prairie Formation. Underlies Dawson Bay.

ELLIS GROUP

Age: Middle and Late Jurassic (Callovian to Oxfordian).

Area of extent: Western Montana, southern Alberta; equivalent to Swift, Reirdon, and upper part of Piper of current North Dakota usage.

Reported fossils: Ostrea strigilecula, Eumicrotis curta, Cardioceras (?) sp., Gryphaea nebrascensis, Camptonectes sp., Pentacrinus sp., Pholadomya sp., Arctica (?) sp., Kepplerites sp., and others.

Depositional environment: Marine.

Type section: North side of highway, in Rocky Canyon about 3.7 miles southeast of site of Fort Ellis, or 7 miles southeast of Bozeman Court House, sec 19, T2S, R7E, Gallatin County, Montana.

History of stratigraphic nomenclature:
Peale, A. C., 1893 (U.S. Geol. Surv. Bull. 110, map): Ellis Formation overlies Quadrant Formation and underlies Cretaceous strata in vicinity of Three Forks, Montana.

Iddings, J. P., and Weed, W. H., 1894 (U.S. Geol. Surv. Folio 1, Livingston): Ellis limestone consists of sandy limestone underlain by Myacites beds (impure fossiliferous limestones or soft, earthy, dark-gray calcareous rocks, with sandstones at base). Thickness 400 feet. At Cinnabar Mountain, Myacites beds rest upon massive cross-bedded, ripple-marked sandstone, underlain by bright-red sandstone that may be equivalent to Red-bed sandstones of more southern localities. Underlies Dakota Formation and overlies Quadrant quartzite.

Peale, A. C., 1896 (U.S. Geol. Surv. Folio 24, Three Forks): Basal part of Ellis Formation (Juratriassic) consists of 40-60 feet of nonfossiliferous quartzitic sandstone which may be Juratriassic or possibly Carboniferous. Above basal quartzite is argillaceous limestone, many beds crowded with Jurassic fossils. Middle and upper parts of formation are more arenaceous and devoid of fossils. Total thickness 300-500 feet. Overlies Quadrant Formation and underlies Dakota Formation.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 1, p. 676): Commonly accepted definition of Ellis Formation applies to Late Jurassic marine strata and excludes any older beds that may inadvertently have been included in earlier mapping.

Cobban, W. A., Imlay, R. W., and Reeside, J. B., Jr., 1945 (Am. Assoc. Pet. Geol. Bull. 29, p. 451-453): Thickness 297 feet at type section. Underlies Morrison Formation; overlies Tensleep (?).

Cobban, W. A., 1945 (Am. Assoc. Pet. Geol. Bull. 29, p. 1262-1303): Rank raised to Group and subdivided into (ascending): Sawtooth, Rierdon, and Swift Formations (all new). Name restricted to marine Jurassic beds. In Sweetgrass Arch area, north-central Montana, unconformably overlies marine Mississippian beds and underlies Upper Jurassic continental deposits (Morrison) or Lower Cretaceous continental deposits (Kootenai). Middle and Upper Jurassic (Bathonian-Argovian).

Imlay, R. W., Gardner, L. S., Rogers, C. P., Jr., and Hadley, H. D., 1948 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 32, 1 sheet): Group, in south-central Montana, comprises (ascending) Piper (new), Rierdon, and Swift Formations.

Vine, J. D., and Hail, W. J., Jr., 1950 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 108): Group, in Hobson area of central Montana, consists of (ascending): Piper, Rierdon, and Swift Formations. Entire group is less than

100 feet thick; Swift is only formation represented. Overlies Amsden Formation; underlies Morrison Formation.

ELM POINT FORMATION

Age: Middle Devonian (Erian).

Area of extent: Southern Manitoba; equivalent strata in Saskatchewan and North Dakota are now included in the Winnipegosis Formation.

Reported fossils: Atrypa arctica.

Depositional environment: Marine.

Remarks: Type locality is cliffs near Elm Point on eastern shore of Lake Manitoba.

History of stratigraphic nomenclature:
Kindle, E. M., 1914 (Can. Geol. Surv. Summ. Rept. 1912, p. 251): Elm Point Formation is beds that crop out in cliffs near Elm Point on eastern shores of Lake Manitoba.

Baillie, A. D., 1950 (Man. Dep. Mines Nat. Resour., Mines Br. Pub. 49-2, 72 p.): Elm Point Formation is 50 feet of yellowish-gray, finely granular, thin-bedded limestone with yellowish brown, dolomitic mottles. Most common fossil is Atrypa arctica. Basal part of formation contains iron sulphide nodules and greenish-gray, dolomitic shales with dark, reddish-brown mottling. Elm Point conformable with overlying Winnipegosis but difficult to differentiate. Winnipegosis redefined to include Elm Point.

Towse, D., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Devonian "F" of earlier N.D. Geol. Surv. Repts. is equivalent to Elm Point Formation. Consists of dark-colored, finely crystalline, shaly mixture of limestone and dolomite lying below Winnipegosis and above Ashern.

FAIRBANK FORMATION, Member (of HARTVILLE GROUP, FORMATION)

Age: Pennsylvanian (Morrowan).

Area of extent: Hartville Uplift area of eastern Wyoming, southwestern South Dakota; equivalent strata in North Dakota are included in the Tyler Formation in current usage.

Depositional environment: Marine to nonmarine.

Remarks: Type locality is North Platte River, bluffs immediately north and northwest of site of abandoned village known as Fairbank, sec 27, T27N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2-3, 32, 35, and 44): Fairbank Formation, or lower tongue of Fountain Formation, consists of 30-100 feet of red sandstone or quartzite, locally calcareous. Underlies Reclamation Group (new); overlies Pahasapa Limestone. Comprises Division VI of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, p. 11).

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Fairbank Formation is basal Pennsylvanian deposit consisting of sand or sand and red shale. Thickness is 10-20 feet over most of North and South Dakota but reaches 100 feet locally. In Morton County, North

Dakota, sands reach thickness of 80 feet and thin, becoming slightly silty and shaly to west, north, and east.

FALL RIVER FORMATION, SANDSTONE (of DAKOTA GROUP)

Age: Early Cretaceous (Albian).

Area of extent: Northeastern Wyoming, western South Dakota, and southeastern Montana; equivalent strata in North Dakota are included in upper part of the Inyan Kara; in Blairmore in Saskatchewan and in Swan River in Manitoba.

Reported fossils: Pelecypods and plant remains.

Depositional environment: Marine.

Remarks: Type locality is Evan's Quarry on Fall River, below Hot Springs, South Dakota. See also Dakota Group.

History of stratigraphic nomenclature:

Russell, W. L., 1927 (Am. J. Sci. 5th Ser., v. 14, p. 402): Dakota Sandstone of Black Hills region is older than true Dakota and is named Fall River Formation. Overlies Fuson Formation; underlies Graneros Shale.

_____, 1928 (Econ. Geol., v. 23, no. 2, p. 136-137): Dakota Sandstone of Black Hills is renamed Fall River Formation as fossil plants indicate older age than typical Dakota Sandstone of eastern Nebraska. Consists of 75 feet of sandstones and interbedded shales underlying Graneros Shale and overlying Fuson Shale. Type locality is at Evan's Quarry on Fall River, below Hot Springs, Fall River County, South Dakota.

Rubey, W. W., 1931 (U.S. Geol. Surv. Prof. Paper 165-A, p. 5): Fall River Sandstone is top formation of Inyan Kara Group of Early Cretaceous age. Consists of continental deposits except for upper 20 feet, which contain marine fossils.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 75): Fall River and Dakota (?) are continuous blanket of sand but lack of subsurface data makes Dakota-Fall River relationship uncertain. Well at Kadoka, South Dakota, suggests that artesian sand there and to west is part of sand wedge coming in from east of about same age as siliceous Mowry Shale farther west. Beneath this sand, Newcastle Sandstone and 180 feet of shale occur beneath Fall River-Fuson-Lakota sequence. Is postulated that true Dakota of Missouri River is Mowry in age and black shale and perhaps Fall River-Fuson-Lakota sequence have wedged out to east. Thickness of Fall River is 54-196 feet.

Waage, K. M., 1958 (Wyo. Geol. Assoc. Gdbk. 13th Ann. Field Conf., p. 71-76): Fall River Sandstone (of Inyan Kara Group) overlies Fuson-Lakota sequence and underlies Skull Creek Sandstone.

_____, 1959 (U.S. Geol. Surv. Bull. 1081-B, p. 26-33): Fall River Formation is redefined so that basal contact conforms to transgressive disconformity and formation becomes upper part of twofold division of Inyan Kara Group here redefined. Type locality redefined to exposures in bluffs in Fall River in area of falls and Evan's quarries that lie on opposite sides of river just above falls. All exposures are in N½ sec 33, T7S, R6E, Hot Springs quadrangle, Fall River County, South Dakota. Thickness at type locality is 158 feet where it overlies Lakota and underlies Skull Creek. Thickness range is 110-160 feet. Upper conformable contact is abrupt change from sandstone to gray, sandy shale to black shale typical of Skull Creek.

Pettyjohn, W. A., 1960 (S.D. Acad. Sci. Proc., v. 38, p. 34-38): Dakota Group includes Lakota, Fuson, Fall River, Skull Creek, and Newcastle Formations.

Gries, J. P., 1962 (Wyo. Geol. Assoc. Gdbk. 17th Ann. Field Conf., p. 167): Fall River should be recognized eastward from Black Hills as far as overlying marine Skull Creek can be recognized.

Favel Formation

Age: Late Cretaceous (Cenomanian to Turonian).

Area of extent: Pembina escarpment area of Manitoba and North Dakota; equivalent to Carlile and Greenhorn of current North Dakota usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 993-1010): Favel Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Overlies Ashville Formation; underlies Keld Member of Vermilion River Formation.

FIREMOON LIMESTONE MEMBER (of PIPER FORMATION)

Age: Middle Jurassic (Bathonian).

Area of extent: Central and eastern Montana and western North Dakota.

Depositional environment: Marine.

Type section: Interval from 4,618-4,687 feet in Murphy Corp. no. 1 Firemoon well, Center SE SE sec 12, T30N, R41E, Valley County, Montana.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 97, and 101-102): Firemoon Limestone Member consists of 69 feet of buff to brown, dense to earthy limestone in type section. Locally becomes sandy and oolitic. On east flank of Sweetgrass Arch, member is dolomitic and cherty. In south-central Montana, unit is thinly bedded with varicolored claystone and locally gypsum. Pebbly, oolitic and coquinoid limestones are common. Is uniform in thickness. In outcrop, member appears transitional with underlying Tampico Shale Member (new) and overlying Bowes Member (new). In subsurface of northern Montana boundaries are generally sharp. West and south of Bearpaw Mountains, overlaps Tampico Member and unconformably rests on Madison Limestone. Occasionally in contact with Amsden Formation on Big Snowy platform. Unit correlative with middle limestone member of Piper.

"'First red' bed"

Age: Late Devonian.

Remarks: Marker horizon at top of Dawson Bay Formation.

"First white specks" zone

Age: Late Cretaceous.

Remarks: Marker horizon at top of Niobrara Formation or Colorado Group.

Fitterer bed, sandstone

Age: Oligocene (Orellan).

Area of extent: Western North Dakota and western South Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Skinner, M. F., 1951 (in Bump, J. D., Ed., Soc. Vertebrate Paleont. Gdbk. 5th Ann. Field Conf., Western South Dakota, Aug., Sept., 1951, p. 54): Fitterer channel is 5-9 feet of fossiliferous, cross-bedded sandstone named for exposures on Fitterer Ranch in Stark County, North Dakota.

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 127): Fitterer bed is 5-9 feet of fossiliferous cross-bedded sandstone contained within Dickinson Member of Brule Formation in western Stark County. Lower contact unconformable; upper contact conformable. Is Middle Oligocene (Orellan) in age.

"Flossie lake subinterval" (of Bottineau interval)

Age: Mississippian (Kinderhookian).

Area of extent: Southern Manitoba, eastern North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
McCabe, H. R., 1963 (Man. Mines Br. Pub. 60-5): Introduced Flossie Lake as uppermost member of Lodgepole Formation in Virden area. Type well is Fosca-Flossie Lake 10-21-1-23 well, interval from 3392 to 3608.

Heck, T., 1978 (Mont. Geol. Soc. Williston Basin Sym. 24th Ann. Field Conf., p. 197-198): Flossie Lake subinterval is cyclical in nature like Virden and Whitewater Lake subintervals but cycle does not include oolites. Oolites thought to be absent because of progradation of oolites by marine regression. Is Kinderhookian in age.

FORT PIERRE GROUP

Remarks: See Pierre Formation.

FORT RICE MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: South-central North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 36-37): Fort Rice Member consists of lignitic and bentonitic shales, thin sandstones and siderite nodules that weather to limonite and may be concentrated in zones. Overlies Breien Member and underlies Huff Member. Named from site of previous Army fort 25 miles south of Bismarck; type section is 1 mile north of Huff, in N½ sec 1, T136N, R80W, Morton County, North Dakota. Fort Rice Member is recognizable only where underlain by Breien Member (Missouri River Valley and tributaries). Dentalium, Discoscaphites, Ostrea, and Corbicula indicate marine, fresh- and brackish-water conditions, probably estuaries.

FORT UNION GROUP, FORMATION

Age: Paleocene (Puercan to Clarkforkian).

Area of extent: Western North Dakota, eastern Montana, Wyoming, northwestern South Dakota, and Colorado; equivalent strata in Saskatchewan are included in Ravenscrag Formation, and in Manitoba in the Turtle Mountain Formation.

Reported fossils: Plant fossils.

Depositional environment: Nonmarine to marine.

Remarks: Named for Fort Union, near mouth of Yellowstone River, Williams County, North Dakota.

History of stratigraphic nomenclature:

Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 433): Fort Union or Great Lignite Group consists of clay and sand, with round, ferruginous concretions, numerous beds, seams, and local deposits of lignite, and great numbers of dicotyledonous leaves and stems of many genera. Thickness is 200 plus feet. Overlies Fox Hills beds (Cretaceous) and underlies Wind River deposits. Occupies area around Fort Union and north into British possessions and south to Fort Clark. Seen under White River Group on North Platte River above Fort Laramie, and on west side of Wind River Mountains.

Meek, F. B., 1876 (U.S. Geol. and Geog. Surv. Terr. Mon. 9, p. lix): Fort Union Group at Fort Union, consists of (descending): 1) 20-30 feet of ferruginous marl, with arenaceous concretions, upper part may contain concretionary sandstone ledges several feet thick; 2) 20 feet of drab, indurated, arenaceous clay; 3) 1 foot of impure lignite, with numerous selenite crystals; 4) 50-70 feet of gray and drab, indurated clay, with locally numerous leaf impressions; 5) 1.5 feet of impure lignite with much silicified wood; 6) 30 feet of gray, indurated sand with clay, numerous fossil beds and many fragments of entire stumps of trees (silicified); 7) 0.33 feet of impure lignite; and 8) 2 feet of yellowish-gray, indurated clay.

Hayden, F. V., 1878 (U.S. Geol. and Geog. Surv. Terr. Mon. 7, pt. 2, p. iv): "Lignitic Group" included Laramie and Fort Union. Fort Union probably identical with whole, or at least part, of Wasatch Group.

Weed, W. H., 1893 (U.S. Geol. Surv. Bull. 105, 68 p.): Fort Union of Livingston, Montana, divided into (descending): 1) Fort Union Formation (Eocene), 4000-8000 feet of massive, cross-bedded sandstone with gray, silty shales and local lenses of impure limestone. Rests unconformably on Livingston beds, 7000 feet of assorted and water-worn volcanic material, somber-colored sandstone, shales and grits, which rest unconformably on 1000 feet of massive, light-colored, coal-bearing sandstone and intercalated shales with leaf remains and invertebrates corresponding to Cretaceous Laramie Formation.

Stone, R. W., and Calvert, W. R., 1910 (Econ. Geol., v. 5, p. 551-557, 652-669, 741-764): In Crazy Mountain region, Montana, strata consist of following formations (descending): 1) Fort Union Formation, 4000 feet of massive sandstones and shales, with Lebo Andesitic Member at base; 2) Lance Formation ("Ceratops beds"), 1000-2400 feet of light-gray sandstone and variegated shale; 3) Lennep Sandstone, 250-400 feet of sandstone with intercalated shales that may correspond to Fox Hills Sandstone; 4) Bearpaw Shale; 5) Judith River Formation; 6) Claggett Formation; 7) Eagle Sandstone; 8) Colorado Shale; and 9) Kootenai Formation. Lebo Andesitic Member is 450-2200 feet thick and contains Fort Union (Eocene) fossils.

Dorf, E., 1940 (Geol. Soc. Am. Bull. 51, p. 213-236): Paleobotanical evidence supports known vertebrate evidence in placing boundary between true Lance and "Fort Union" at base of nondinosaur-bearing Tullock, Ludlow, or Bear

Formations or their equivalents, at top of Triceratops-bearing Hell Creek or Lance Formations. Table of proposed revision shows Fort Union Group comprises Tullock Formation (equivalent to Ludlow Formation and Cannonball Marine Member) in lower part and several formations (not discussed) in upper part. Overlies Lance Formation (equivalent to Hell Creek Formation). Is Paleocene in age.

Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 16-23): Fort Union Group of southern Morton County consists of Ludlow, Cannonball, and Tongue River Formations. Overlies Hell Creek Formation. Is Paleocene in age.

Benson, W. E., and Laird, W. M., 1947 (Geol. Soc. Am. Bull. 58, pt. 2, p. 1166-1167): Fort Union Formation of North Dakota underlies Golden Valley Formation (new).

May, P. R., 1954 (U.S. Geol. Surv. Bull. 995-G, p. 267-268): Fort Union Group of Wibaux area, Montana and North Dakota, consists of Ludlow, Tongue River, and Sentinel Butte Members. Conformably overlies Late Cretaceous Hell Creek Formation.

Cvancara, A. M., 1976 (N.D. Rept. Invest. 57, 22 p.): The Paleocene Cannonball Formation is a marine, non-lignitic-bearing clastic sequence in the lower part of the Fort Union Group. It is overlain by the lignite-bearing Tongue River Formation in places and both overlain and underlain by the lignite-bearing Ludlow Formation in places.

Clayton, L., et al., 1977 (N.D. Geol. Surv. Rept. Invest. 59, p. 7-12): Two formations added to Fort Union Group of North Dakota. Slope Formation consists of strata previously considered to be upper part of Ludlow Formation or part of Tongue River Formation. Bullion Creek Formation consists of strata previously considered to be equivalent to either entire Tongue River Formation or lower, middle, or upper part of Tongue River Formation.

FOX HILLS FORMATION, Sandstone

Age: Late Cretaceous (Maestrichtian).

Area of extent: Eastern Montana, North Dakota, South Dakota, Wyoming, and eastern Colorado.

Reported fossils: Pelecypods, gastropods, cephalopods, Ophiomorpha, and plant remains.

Depositional environment: Marine.

Remarks: Type area on Fox Ridge, northwestern Armstrong and southwestern Dewey Counties, South Dakota. See also Linton Member, Colgate lithofacies, Bullhead lithofacies, Trail City Member, Timber Lake Member, and Iron Lightning Member.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 419, 427): Fox Hills beds (Formation No. 5 of Cretaceous) are 500 feet of gray, ferruginous and yellow sandstone and arenaceous clays. Outcrops at Fox Hills near Moreau River, along base of Bighorn Mountains, and on North and South Platte Rivers. Fox Hills is top formation of Upper Cretaceous in Nebraska (including Wyoming, Montana, and Dakotas). Underlies Tertiary Fort Union or Great Lignite Group; overlies Fort Pierre Group (Pierre Shale of present usage).

White, C. A., 1878 (U.S. Geol. and Geog. Surv. Terr. 10th Ann. Rept., p. 21, 22, 30): Fort Pierre Group (Pierre Shale) transferred from Colorado Group to overlying Fox Hills Group.

_____, 1879 (U.S. Geol. and Geog. Surv. Terr. 11th Ann. Rept., p. 186-187): Fox Hills Group, consolidation of Fort Pierre Group (Cretaceous No. 4) and Fox Hills Group (Cretaceous No. 5), proposed for Colorado and adjacent territories, but because lithologic and paleontological characteristics cannot delineate separation, Fox Hills will continue to be used in restricted sense according to original authors in Upper Missouri River region.

Eldridge, G. H., 1888 (Colo. Sci. Soc. Proc., v. 3, pt. 1, p. 93 footnote): Montana Group, with approval of C. A. White, introduced to replace Fox Hills broad definition. Original restricted definition of Fox Hills will continue to be used.

Todd, J. E., 1896 (U.S. Geol. Surv. Bull. 144, 71 p.): Fox Hills sandstone in Kidder, Burleigh, and Emmons Counties, North Dakota.

Babcock, E. J., 1901 (N.D. Geol. Surv. 1st Bienn. Rept., p. 23): Fox Hills found adjacent to Missouri River, in Turtle Mountains, and west of Rugby, North Dakota.

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 234): Fox Hills represents last advance of Cretaceous sea into North Dakota. Erosional surface at top of Fox Hills along Little Beaver Creek.

Stanton, T. W., 1910 (Am. J. Sci. 4th Ser., v. 30, p. 172-188): Top of Fox Hills contains marine and, in places, brackish fauna (oysters, Anomia and Corbicula). Beds indicate transition between marine unit below and fresh-water unit above. Change in character and thickness of Fox Hills from Colorado to North Dakota may be function of distance from source and variation in topographic expression of source.

Calvert, W. R., 1912 (U.S. Geol. Surv. Bull. 471, p. 187-201): Colgate sandstone member of Lance Formation occupies same stratigraphic position as Fox Hills Formation, but plant fossils indicate Tertiary age. As no other sandstone is present in Bowman County, Fox Hills must not be in Bowman County.

Knowlton, F. H., 1916 (U.S. Geol. Surv. Prof. Paper 98, p. 87): Flora indicates distinct Upper Cretaceous age and warm, temperate climate.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484-495): Fox Hills includes Colgate Member defined as white upper sandstone, formerly placed as basal member of Lance Formation.

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, 110 p.): 17-40 feet of Colgate Sandstone Member at top of Fox Hills Sandstone at Marmarth lignite field, North Dakota.

Dobbin, C. E., and Reeside, J. B., Jr., 1929 (U.S. Geol. Surv. Prof. Paper 158, p. 9-25): No evidence of unconformity between Fox Hills and overlying Lance Formation. Discordant bedding relationships represent minor, erosional scour features or cross bedding or small, local fault structures. Similarity of fauna of Cannonball Marine Member of Lance Formation and Fox Hills further indicates no major break in deposition.

Rocky Mtn. Assoc. Pet. Geol., by its committee, composed of T. S. Lovering, H. A. Aurand, C. S. Lavington, and J. H. Wilson, 1932 (Am. Assoc. Pet. Geol. Bull. 16, p. 702-703): Base of Fox Hills Formation considered as horizon below which section is predominantly gray, marine, clay shales and sandy shales of Pierre age, and above which section changes abruptly to buff or brown sandstone and sandy shale. Top of Fox Hills is horizon above which is predominantly

fresh- and brackish-water deposits accompanied by coals and lignitic shales, and below which is predominantly marine.

Morgan, R. E., and Petsch, B. C., 1945 (S.D. Geol. Surv. Rept. Invest. 49, p. 11-18): Fox Hills Formation of Dewey and Corson Counties, South Dakota contains two identifiable units of almost pure sandstone and two other units that are less sandy. Sandstone members are (descending): 90 feet of Timber Lake and 50-90 feet of Trail City. Total thickness of section is 120-250 feet. Overlies Pierre; underlies Hell Creek Formation.

Gries, J. P., 1952 (Billings Geol. Soc. 3rd Ann. Field Conf., p. 78): Fox Hills cannot be same age everywhere as retreating Cretaceous sea deposited formation.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 1026): Fox Hills is Late Maestrichtian in age.

Fischer, S. P., 1952 (N.D. Geol. Surv. Bull. 26, p. 10-17): Fox Hills is most extensive of formations cropping out in Emmons County, North Dakota. Trail City and Timber Lake Members pinch out eastward and disappear between southwestern corner and center of county. Upper 160-230 feet is gray to brown sands with thin, gray shales; capped by sandstone bed.

Stevenson, R. E., 1957 (S.D. Geol. Surv. McIntosh Quad.): Formation includes (descending): 1) 15 feet of Colgate Member, 2) Bullhead Member (new), 3) 20-25 feet of Timber Lake Member, and 4) 65 feet of Trail City Member.

Robinson, C. S., Mapel, W. J., and Cobban, W. A., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 101-123): Along west and north flanks of Black Hills, typical Fox Hills lithology appears stratigraphically lower; upper four Baculites zones of Pierre in central South Dakota are in Fox Hills in Black Hills.

Waage, K. M., 1961 (Wyo. Geol. Assoc. 16th Ann. Field Conf., p. 229-240): Four members defined (descending): 1) Colgate; fine- to medium-grained sandstone; 2) Bullhead, banded gray clay shale and light-gray siltstone or fine-grained sandstone; 3) Timber Lake, fine- to medium-grained greenish-gray sand; and 4) Trail City, light-gray to brownish-gray clayey silt and silty to sandy clay. Members vary in stratigraphic detail over large area but remain uniform in Corson, Dewey, and Ziebach Counties, South Dakota. Each member is lateral facies of members above and below.

_____, 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, 175 p.): Fox Hills is 300-350 feet of sandy, fossiliferous, marine, and brackish-water strata divisible into two distinctive parts gradational into marine Pierre below and nonmarine Hell Creek above; equivalent to lower part of nonmarine Lance Formation in eastern Wyoming. Lower part is Trail City Member, basal clayey silt, grading upward and laterally into Timber Lake Member, wedge-like sand body that pinches out westward. Trail City Member contains Little Eagle lithofacies, biogenically-assemblage zones in lower part in eastern two-thirds of type area; westward is Irish Creek lithofacies, thinly bedded silt and shale with concretions. Upper part is Iron Lightning Member (new) of (ascending) thinly bedded sand, silt and shale with few marine fauna named Bullhead lithofacies and clayey, grayish-white sand with brackish-water fauna named Colgate lithofacies. Bullhead and Colgate formerly classed as members but cannot be consistently separated in type area. Sharp contact between upper and lower parts of Fox Hills is product of different depositional regimes.

Feldmann, R. M., 1972 (N.D. Geol. Surv. Bull. 61, p. 22): In North Dakota, Trail City Member cannot be recognized. Timber Lake Member is unconsolidated medium- to fine-grained sandstone becoming cross bedded near top. Bullhead Member is interbedded sandstone and shale. Colgate is light graywacke sandstone. Members were deposited penecontemporaneously with Timber Lake sediment. Bullhead deposition represents brackish conditions; Colgate represents

strandlike deposition, and Timber Lake deposition represents normal marine deposition.

Erickson, J. M., 1974 (Bull. Am. Paleo., p. 145): In south-central North Dakota, four members of Fox Hills recognized (descending): 1) unnamed member, very fine to fine-grained siliceous sandstone; 2) Iron Lightning, interbedded, poorly consolidated sandstone or siltstone (Bullhead lithofacies and medium-grained, poorly consolidated, sandstone (Colgate lithofacies); 3) Timber Lake, fine- to medium-grained, poorly consolidated sandstone; and 4) Trail City, poorly consolidated sandy shale and siltstone. Trail City and Timber Lake Members represent lower to upper shoreface of barrier bar environment; Iron Lightning Member and unnamed member deposited within deltaic complex. Bullhead lithofacies may represent lagoonal facies behind barrier bar or baymouth bar.

Klett, M. C., and Erickson, J. M., 1976 (N.D. Acad. Sci. Proc. 28, pt. 2, p. 3-21): Linton Member named; previously placed in Colgate lithofacies (or member). Consists of 0.64-22.4 feet of light-olive-gray to grayish-brown, fine-grained, subangular, moderately to poorly sorted, indurated, siliceous sandstone with volcanic shards; interpreted as channel sand deposit. Is probably Meek and Hayden's Bed Q, resistant sandstone that caps Fox Ridge. Type section in N½ sec 8 and 9, T132N, R76W, 1 mile east of Linton, North Dakota.

Cvancara, A. M., 1976 (N.D. Geol. Surv. Rept. Invest. 55, 16 p.): Considerable lithologic variation occurs in subsurface away from main outcrop area in the south-central part of the state; members are difficult to trace. Thickest recognized sequence is 391 feet in Hettinger County; nearly 300 feet of Fox Hills has been reported as far east as Pierce County. Principal macrofossils are bivalve and gastropod mollusks that occur primarily in limestone and sandstone concretions and indurated sandstone. A barrier bar--deltaic model is followed for the deposition of Fox Hills sediments.

Fox Hills Group (broad sense)

Remarks: See 1878, 1879, and 1888 entries under Fox Hills Formation, Sandstone, Group.

"Frobisher evaporite," "anhydrite"

Age: Mississippian.

Area of extent: Southeastern Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Frobisher Oilfield, southeastern Saskatchewan. See also Rival subinterval and Madison Group.

History of stratigraphic nomenclature:
Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 34): "Frobisher evaporite" is bedded primary anhydrite and caps oil pools in Saskatchewan and North Dakota.

Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 4): "Frobisher evaporite" part of Rival subinterval at top of Frobisher-Alida interval; overlies "Frobisher-Alida beds" and equivalent to Rival subinterval of present usage.

Frobisher-Alida interval, "beds"

Age: Mississippian.

Area of extent: Southeastern Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Frobisher and Alida Oilfields, southeastern Saskatchewan. See also Rival subinterval and Madison Formation.

History of stratigraphic nomenclature:

Porter, J. W. (Chm.), 1956 (Sask. Geol. Soc. Report of the Mississippian Names and Correlation Committee, p. 1-4): "Frobisher-Alida beds" bounded above by "Midale beds" or "Frobisher anhydrite" and bounded below by "Tilston beds." Boundaries of "beds" well-defined horizons of silty or evaporitic beds. Boundary between Charles Formation and Mission Canyon Limestone may be at top of "Frobisher-Alida beds."

Smith, M. H., 1960 (AAPG, Rocky Mtn. Sect. Mtg. Billings, Abst.): Subdivided the Madison Group into 5 para-time rock units.

Anderson, S. B., Hansen, D. E., and Eastwood, W. P., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 5): Frobisher-Alida interval includes Rival subinterval (Frobisher anhydrite of Porter) at top.

Eastwood, W. P., 1961 (N.D. Geol. Surv. Rept. Invest. 37, pl. 1): The Frobisher-Alida interval overlies the Tilston interval and is overlain by the Ratcliffe interval.

FUSON FORMATION, Shale (of DAKOTA, or INYAN KARA GROUP)

Age: Early Cretaceous (Aptian).

Area of extent: Black Hills area, central and eastern Wyoming, and southeastern Montana; equivalent strata included in Inyan Kara of current North Dakota usage.

Reported fossils: Gastropods, some plant remains.

Depositional environment: Nonmarine to marine.

Remarks: Type locality is Fuson Creek Canyon, east side of Black Hills near Buffalo Gap, Wyoming.

History of stratigraphic nomenclature:

Darton, N. H., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 530): Fuson Formation is very fine grained sandstone and massive shale and clay of varying colors. Thickness is 30-100 feet. Underlies Dakota Sandstone and overlies Minnewaste Limestone. Included in Dakota Sandstone of previous reports.

Rubey, W. W., 1930 (U.S. Geol. Surv. Prof. Paper 165-A, 54 p.): Fuson Formation is middle formation of Inyan Kara Group.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 75): Fuson should not be considered as separate formation but shaly closing phase of Lakota deposition. Similar pink, gray and buff clays may be traced in subsurface east of Missouri River. There is tendency to lump Lakota-Fuson-Fall River divisions of Dakota(?) into Dakota or Cloverly Group.

Waage, K., 1959 (U.S. Geol. Surv. Bull. 1081-B, p. 33): Fuson term should be dropped from usage because of its close facies relationship with Lakota Formation and its miscorrelations elsewhere. Where local Minnewaste Limestone is present, Fuson term may be helpful but needs new type section because base of Fuson not present at Darton's (1901) type section.

GAMMON FERRUGINOUS MEMBER (of PIERRE FORMATION)

Age: Late Cretaceous.

Area of extent: Northeastern Wyoming, central and southeastern Montana, Black Hills of South Dakota, and North Dakota.

Reported fossils: Scaphites hippocrepis, Baculites, Inoceramus, fish remains.

Depositional environment: Marine.

Remarks: Named for exposures along Gammon Creek, T57N, R67W, and R68W, Crook County, Wyoming. See also Pierre Shale.

History of stratigraphic nomenclature:

Rubey, W. W., 1930 (U.S. Geol. Surv. Prof. Paper 165-A, p. 4): Gammon Ferruginous Member, basal member of Pierre Shale in northeastern Wyoming and southeastern Montana, consists of 800-1000 feet of light-gray mudstone and shale with concretions and thin beds of siderite. Includes Groat Sandstone, 150 feet, near top, and Pedro bentonite bed at base. Overlies Niobrara; commonly forms bare buttes. Possible unconformity at or near base.

Cobban, W. A., 1952 (Billings Geol. Soc. 3rd Ann. Field Conf., p. 87): Gammon Member, lower half of Pierre Formation, thins eastward across north flank of Black Hills. In common corner of Montana, Wyoming, and South Dakota; 800 feet of Gammon Member divided into three units. Upper unit is 150 feet of gray mudstone with numerous ferruginous and calcareous concretions; middle unit is 50 feet of Groat Sandstone; lower unit is 600 feet of gray mudstone, slightly calcareous in basal 150 feet, with numerous red-weathering ferruginous concretions and thin, shaly ferruginous layers.

Robinson, C. W., Mapel, W. J., and Cobban, W. J., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 101-123): Gammon Ferruginous Member along west and north flanks of Black Hills, consists of (descending): 1) upper unit, dark-gray mudstone and shale with dark-gray, iron-cemented, septarian concretions, 2) Groat Sandstone bed, 75-100 feet, light-gray glauconitic iron-stained sandstone, and 3) lower unit, same as upper except concretions are not septarian. Groat fossils are same as those in Telegraph Creek Shale and Eagle Sandstone of Montana, and same as in Shannon Sandstone of Powder River Basin, Wyoming.

Tourtelot, H. A., 1962 (U.S. Geol. Surv. Prof. Paper 390, p. 8): Gammon not present south of Newcastle, Wyoming. From Newcastle, Wyoming, southward, overlying Mitten becomes Sharon Springs of southern part of Black Hills.

Gill, J. R., and Cobban, W. A., 1973 (U.S. Geol. Surv. Prof. Paper 776, p. 16-19): Assigned as formation of Montana Group (newly restricted) only in central Montana; no longer assigned as member or formation to any named group elsewhere. Remains in good usage as Gammon Ferruginous Member of Pierre Shale or Cody Shale in southeastern Montana and northeastern Wyoming.

GOLDEN VALLEY FORMATION

Age: Late Paleocene and Early Eocene (Clarkforkian to Wasatchian).

Area of extent: Western North Dakota and northwestern South Dakota(?).

Depositional environment: Nonmarine.

Reported fossils: Salvinia preauriculata and other plant remains.

Remarks: Named from exposures in secs 2 and 5, T143N, R90W, and secs 32 and 33, T144N, R90W, near town of Golden Valley, Mercer County, North Dakota.

History of stratigraphic nomenclature:

Benson, W. E., and Laird, W. M., 1947 (Geol. Soc. Am. Bull. 58, p. 1166-1167): Golden Valley Formation consists of series of fine-grained, micaceous sands with minor amounts of light-colored clays and shale (upper unit), which rest on hard, white to dark-gray clay and locally lignite (lower unit). Near middle of lower unit is reddish-yellow mottled "marker bed." Beds were formerly known as "unnamed formation" of Wasatch Group. Overlies Paleocene Sentinel Butte Shale Member of Fort Union Formation; unconformably overlain by Oligocene White River Group.

Benson, W. E., 1949 (Geol. Soc. Am. Bull. 60, p. 1873-1874): Upper member of Golden Valley Formation is fine- to coarse-grained, micaceous sands and silts with small clay lenses; lower member is purplish-gray, carbonaceous shales interbedded with white, sandy, bentonitic clays commonly stained bright yellow-orange. Golden Valley Formation is conformable with underlying Tongue River Formation and unconformable with overlying White River Group. In places, pre-Oligocene erosion removed entire Golden Valley Formation before White River sediments were deposited.

Hickey, L. J., 1977 (Geol. Soc. Am. Mem. 150, 181 p.): Golden Valley Formation consists of up to 180 feet of claystone, mudstone, siltstone, micaceous sandstone, and lignite deposited under fluvial conditions during late Paleocene and early Eocene in Williston Basin. Divided into (ascending): 5-65 feet of light gray or brightly colored kaolinitic strata named Bear Den Member, and up to 150 feet of yellow to tan illitic to montmorillonitic strata named Camels Butte Member. Bear Den is Paleocene in age; Camels Butte is Wasatchian, based on megaflora.

Graneros Shale (of COLORADO GROUP)

Age: Early to Late Cretaceous.

Area of extent: Eastern Colorado, Kansas, Nebraska, South Dakota; equivalent to Skull Creek, Newcastle, Mowry, and Belle Fourche of current North Dakota usage. Used in Montana as equivalent to Mowry and Belle Fourche of North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:

Gilbert, G. K., 1896 (U.S. Geol. Surv. 17th Ann. Rept., pt. 2, p. 564): Is gray shales; is bottom formation of Benton Group in Colorado, underlies Greenhorn limestone and overlies Dakota Group.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 1011-1044): Graneros Formation considered to be in Ward County, North Dakota.

Laird, W. M., and Towse, D. F., 1953 (rev.) (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Graneros Shale is subdivision of Benton. Benton divided into two subdivisions: Graneros and Carlile. Graneros divided into Skull Creek, Newcastle, Mowry, and Belle Fourche Formations.

GREAT LIGNITE GROUP

Age: Paleocene.

Remarks: Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 433): Referred to Fort Union or Great Lignitic Group.

GREENHORN FORMATION (of COLORADO GROUP)

Age: Late Cretaceous (Cenomanian to Turonian).

Area of extent: Eastern Montana, North Dakota, South Dakota, eastern Wyoming, San Juan Basin, Nebraska, Kansas, eastern Colorado; equivalent strata are referred to as Favel Formation in Manitoba.

Reported fossils: Inoceramus labiatus, Dunveganoceras, Globigerina, fish remains.

Depositional environment: Marine.

Remarks: Type locality on Greenhorn Creek near Pueblo, Colorado. "Second white specks" zone used extensively by subsurface petroleum geologists. Top of Greenhorn usually indicated as readily identifiable "kick" on electric logs.

History of stratigraphic nomenclature:
Gilbert, G. K., 1896 (U.S. Geol. Surv. 17th Ann. Rept., pt. 2, p. 564): Greenhorn Limestone consists of limestone beds, 3-12 inches thick, separated by somewhat thicker shale beds. Total thickness is 25-40 feet. Middle formation of Benton Group in Arkansas Valley region, Colorado.

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2183): Greenhorn on north flank of Black Hills may be divided into four lithologic units (descending): 1) 60 feet of bluish- to whitish- weathering marl with limestone lenses and concretions; 2) 22 feet of dark-bluish-gray, noncalcareous, very fissile shale with numerous, soft, yellow, limonitic nodules; 3) 33-80 feet of calcareous shale and impure calcareous marl with calcareous, ferruginous concretions and buff-weathering, thin, shaly limestone beds; and 4) 125-250 feet of light-gray, calcareous mudstone with interbedded marl, shaly limestone, and black-gray, noncalcareous shale. Base may be marked by 1 foot of buff, shaly limestone called Orman Lake Limestone. Greenhorn is Cenomanian and Turonian in age.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 76): Greenhorn consists of 35-65 feet of thin limestones with thick partings of calcareous shale. Contains Inoceramus labiatus. Often referred to in subsurface of Williston Basin as "Second white specks" zone.

Knechtel, M. M., and Patterson, S. H., 1962 (U.S. Geol. Surv. Bull. 1082-M, p. 918-920): Facies relationships of Greenhorn and underlying Belle Fourche causes contact to migrate down-section 45-60 feet from position above Bentonite bed G from west to east across northern Black Hills. Thinned upper member of Belle Fourche is replaced by thickened lower part of Greenhorn.

Gregory Marl

Remarks: See Gregory Member of Pierre Shale.

GREGORY MEMBER (of PIERRE FORMATION)

Age: Late Cretaceous (Campanian).

Area of extent: Eastern North Dakota and eastern South Dakota.

Depositional environment: Marine.

Type section: in Gregory County, South Dakota, at south end of Rosebud Bridge, south of Wheeler. See also Pierre Shale and Crow Creek Member.

History of stratigraphic nomenclature:

Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 10-20): Gregory Member of Pierre Shale is divided into two lithologically and faunally distinct parts. Upper Gregory is chalk, argillaceous chalk, or marl. Lower Gregory is dark, bentonitic bituminous shale with fish scales. Basal member of Pierre includes all beds from top of Niobrara to Oacoma beds south of Great Bend of Missouri River, and northward from this locality, all beds below Agency Shale zone, which lies between Gregory Member and Sully Member.

Moxon, A. L., Olson, O. E., Searight, W. V., and Sandals, K. M., 1938 (Am. J. Botany, v. 25, p. 795-796): Upper Gregory referred to as Gregory Marl and Gregory is subdivision of Sully Member, not Pierre Formation. Lower Gregory changes to Sharon Springs Member of Pierre Formation.

Gries, J. P., and Rothrock, E. P., 1941 (S.D. Geol. Surv. Rept. Invest. 38, p. 5): Beds comprising upper unit of Searight's (1937) Sharon Springs Member lie above marl; thus, original Gregory Member of Searight contained two marls. Upper part of Sharon Springs changed to Gregory Member and Crow Creek marl and sand is name for Searight's upper Gregory marl and thin sandstone directly beneath it.

Gill, J. R., and Cobban, W. A., 1965 (U.S. Geol. Surv. Prof. Paper 392A, 20 p.): In eastern North Dakota Gregory Member is light-colored calcareous rocks best exposed in valley of Sheyenne River at Valley City and southward. Overlies Pembina Member, underlies DeGrey Member.

Rice, D. D., 1977 (U.S. Geol. Surv. Misc. Invest. Map OC-70, 1 sheet): Gregory Member is in eastern North Dakota on correlation chart.

GUNTON MEMBER (of STONY MOUNTAIN FORMATION)

Age: Late Ordovician (Richmondian).

Area of extent: Southern Manitoba, Williston Basin.

Depositional environment: Marine.

Remarks: Type locality is Stony Mountain area, Manitoba. See also Stony Mountain Formation.

History of stratigraphic nomenclature:

Okulitch, V. J., 1943 (Roy. Soc. Can. Trans. 3rd Ser., v. 37, sec 4, p. 60, and 62-63): Gunton beds consist of thick-bedded, dense, hard, massive dolomite, commonly buff with occasional red or maroon bands. Thickness is 15-19 feet. Overlies Penitentiary Member (new) and underlies Birse Member (new).

Baillie, A. D., 1952 (Man. Dep. Mines Nat. Res. Mines Br., Pub. 51-G, p. 34-35): Gunton Member and Birse Member combined as the upper member of Stony Mountain Formation in Manitoba.

Stearn, C. W., 1956 (Can. Geol. Surv. Mem. 281, 162 p.): Gunton of Ordovician age because Ordovician fossils found in overlying Stonewall.

Saskatchewan Geological Society, 1958 (Rept. of the Lower Palaeozoic Names and Correlations Committee: Regina, Sask., Sask. Geol. Soc., p. 8): In subsurface, Gunton beds comprise fossiliferous, fragmental, dolomitized limestone and dolomite with maximum thickness of 60 feet, overlain by 1-5 feet of anhydrite and 1-5 feet of arenaceous dolomitic shale. Overlies Stoughton beds (new). In outcrop Gunton beds are equivalent to Gunton Member.

Carlson, C. G., and Eastwood, W. P., 1962 (N.D. Geol. Surv. Bull. 38, p. 6 and 7): Gunton is upper member of Stony Mountain Formation found in subsurface of North Dakota; overlies Stoughton Member, underlies Stonewall Formation.

GYPSUM SPRING FORMATION, MEMBER

Age: Middle Jurassic (Bajocian to Bathonian).

Area of extent: Wyoming, southern Montana, western South Dakota, northern Utah, southeast Idaho; equivalent strata in North Dakota are included in Piper Formation of current usage.

Reported fossils: Defonticeras, Stematoceras, and many other molluscs.

Depositional environment: Marine.

Remarks: Type locality is on east side of Red Creek, sec 6, T6N, R3W, 18 miles southeast of Dubois, Fremont County, Wyoming.

History of stratigraphic nomenclature:

Love, J. D., 1939 (Geol. Soc. Am. Spec. Paper 20, p. 42-43, 45-46): Gypsum Spring Member of Chugwater Formation consists of white, cliff-forming gypsum (lower half) and variegated shale, sandstone, and limestone. Thickness is 182 feet where exposed on Red Creek, 250 feet in Maverick Springs oil field. Unconformably overlain by Sundance Formation and underlain by Popo Agie Member of Chugwater. Triassic(?).

Branson, E. B., and Branson, C. C., 1941 (Am. Assoc. Pet. Geol. Bull. 25, p. 124, 126, and 136): Rank raised to uppermost formation of Chugwater Group.

Love, J. D., et al., 1945 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 14): Gypsum Spring classed as formation and member of Chugwater. Consists of basal, red, blocky, sandy, siltstone overlain by 50-125 feet of massive, white gypsum on surface and white anhydrite in subsurface. Gypsum overlain by sequence of thin gypsum beds, red shale, gray dolomites, and limestone. Maximum thickness is 250 feet in northwest part of Wind River Basin. Unconformable above Nugget Sandstone. Overlain by Lower Sundance. Contains Middle Jurassic fossils.

Imlay, R. W., 1947 (Am. Assoc. Pet. Geol. Bull. 31, p. 231, 236-247): Sequence of gypsiferous beds underlying Sundance Formation in part of Black Hills region, previously considered part of Spearfish Formation, are correlative with Gypsum Spring Formation of central Wyoming. Lowest marine Jurassic beds included in Gypsum Spring comprise two laterally intergrading facies. One facies consists of gypsum, generally interbedded with soft, maroon, siltstone and shale, and is locally 15 feet thick; occurs on western side of Black Hills from Elk Mountain to Sundance and on northeastern side from 10 miles south of Sturgis to Spearfish. Second facies consists of interbedded gray shale, limestone, and dolomite and is 21 feet thick; occurs at northwestern end of Black Hills. Gypsum Springs Formation represents first widespread invasion and withdrawal of marine water during Jurassic in Western Interior region. Middle Jurassic, representing Late Bajocian and Bathonian ages. Underlies Stockade Beaver Shale Member or Canyon Springs Sandstone Members of Sundance Formation. Overlies Nugget(?); locally overlies Spearfish Formation.

_____, et al., 1948 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 32): Basal part of Piper Formation (new) locally includes equivalents of type Gypsum Spring of Central Wyoming.

_____, 1952 (Geol. Soc. Am. Bull. 63, p. 967-968): Gypsum Spring Formation represents basal deposits of transgressive sea; may not be same age throughout, and may represent more time at one locality than at another. Gypsum

Spring in Big Horn Basin of Wyoming is correlative with Piper Formation of eastern Montana and includes more than type Gypsum Spring. Gypsum Spring of type area in central Wyoming represents only early Middle Jurassic and is correlative with lower member of Gypsum Spring. Gypsum Spring usage in Montana arose because of mapping ease and term Gypsum Spring was assumed to include all beds of Middle Jurassic older than type Sundance. Piper now used for Gypsum Spring in Montana.

Mapel, W. J., and Bergendahl, M. H., 1956 (Am. Assoc. Pet. Geol. Bull. 40, p. 84-93): Gypsum and redbed sequence known as Gypsum Spring Formation in Elk Mountain-Sundance region and Sturgis-Spearfish region is also near Hulett, Wyoming, where it is from 0-125 feet thick. It is absent along southern and eastern sides of Black Hills. Lithologic character and stratigraphic position suggest representation of eastward extension of Gypsum Spring Formation of central and northern Wyoming, and lower and middle Piper Formation (Middle Jurassic) of south-central Montana.

Storey, T. P., 1958 (Alberta Soc. Pet. Geol. J., v. 6, p. 90-104): Late and Middle Jurassic of Williston Basin comprises nine stratigraphic units or regional intervals and two regional unconformities. Faunal, environmental, and tectonic evidence groups units into four major depositional sequences or stage-like intervals; Gypsum Spring (or Piper), Sawtooth, Rierdon, and Swift Formations. Miscorrelation of type sections of formations is result of variations in stratigraphic succession caused by sub-Swift and sub-Rierdon unconformities that correspond, respectively, to Early Callovian and late Callovian-Early Oxfordian marine transgressions. Lower Swift (Stockade Beaver-Hulett of lower Sundance) is older than type Swift and younger than type Rierdon Formations; Sawtooth is discrete stratigraphic unit younger than Piper or Gypsum Spring.

Hayden Group

Age: Pennsylvanian (Desmoinesian).

Area of extent: Hartville Uplift area of eastern Wyoming, southwestern South Dakota; equivalent strata are included in Amsden Formation of current North Dakota usage.

Reported fossils: Mesolobus.

Depositional environment: Marine.

Remarks: Type locality is Hayden Cliff, sec 22, T27N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:

Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2, 3, 22 and 45): Hayden Group consists of dark-gray to black sandstone, shale, and dolomite with red sandstone. Comprises Division III of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, 46 p.). Thickness is 120 feet. Underlies Meek Group (new); overlies Roundtop Group (new).

McCauley, V. T., 1956 (N.D. Geol. Soc. Williston Basin Sym. 1st Internat., Bismarck, N.D., p. 150-164): Hayden Group is transitional with underlying Roundtop and is difficult to distinguish. Lower part of section contains several shale or argillaceous zones that do not show up well in samples but exhibit high radioactivity on gamma ray logs. Gamma ray radioactive zone is at contact with overlying Broom Creek Group over most of North Dakota, but does not occur along western flank of Williston Basin, in western North and South Dakota and eastern Montana. Hayden probably consists of basal sandy zone and radioactive sequence in North Dakota but contacts not chosen.

HEATH FORMATION (of BIG SNOWY GROUP)

Age: Late Mississippian (Chesterian).

Area of extent: Montana, possibly westernmost North Dakota.

Reported fossils: Spirifers, corals.

Depositional environment: Marine.

Remarks: Type locality is north flank of Big Snowy Mountains, sec 6, T12N, R20E, near Heath, Montana.

History of stratigraphic nomenclature:
Scott, H. W., 1935 (Geol. Soc. Am. Proc. 1934, p. 367): Big Snowy Group includes Kibbey, Otter, and Heath Formations.

_____, 1935 (J. Geol., v. 43, p. 1016-1032): Heath formation consists of primarily black petroliferous shales with sandstone, forming upper formation of Big Snowy Group. Thickness may reach 500 feet. In most sections, three sandstone beds occur in upper half. On southeastern flank of Big Snowy Mountains, sandstone beds have been grouped as Van Dusen sand, which should be considered as member at top of Heath Formation. On northeastern flank of Big Snowy Mountains, sandstone beds occupying same stratigraphic zone are Tyler sand which should be considered as member at top of Heath. Heath conformably underlies Amsden and conformably overlies Otter. Fossils are closely related to fauna of Brazer limestone of Idaho and Moorefield formation of Arkansas and are not older than Warsaw nor younger than Upper Chester.

Anderson, S. B., 1954 (N.D. Geol. Surv. Rept. Invest. 16, 2 sheets): Heath Formation is sequence of sandstones and black shales confined to subsurface of western North Dakota. Maximum thickness is 130 feet in North Dakota.

Mundt, P. A., 1956 (Billings Geol. Soc. Gdbk. 7th Ann. Field Conf., p. 46-47): Upper limit of Heath Formation (Scott, 1935), is not acceptable since upper part includes prolific oil sands (Tyler sandstone), and unit is separated from lower non-sandy part of Heath by angular unconformity. Heath should be restricted to beds below the unconformity, and beds above, formerly included in Heath, should be separate unit (Tyler).

Willis, R. P., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 1940-1966): Tyler-Heath interval extends eastward from central Montana into Williston Basin of North Dakota. Tyler-Heath is overlain by Amsden (restricted), and is early Pennsylvanian (Morrowan-Atokan). Heath considered uppermost unit of Big Snowy Group.

Foster, F. W., 1961 (World Oil, v. 152, p. 89-93): Representation of Heath Formation (restricted) is in form of erosional remnants and particles of Heath Shale in basal Tyler conglomerate. Alaska Bench Formation overlies "Heath."

Hecla beds, facies (of RED RIVER FORMATION)

Age: Middle Ordovician (Trentonian).

Area of extent: Williston Basin; approximately equivalent to Roughlock of current North Dakota usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1345-1348): Hecla beds are 10-40 feet thick and are in Red River Formation. Named from Hecla

Island near Grindstone Point on west shore of Lake Winnipeg. Hecla beds (transition zone) are typically calcareous, variably sandy and argillaceous, and sporadically glauconitic.

Sandberg, C. E., 1962 (U.S. Geol. Surv. TEI-809, p. 28): Hecla beds are part of underlying Winnipeg Formation.

HELL CREEK FORMATION

Age: Late Cretaceous (Maestrichtian).

Area of extent: Central and eastern Montana, North Dakota, South Dakota, northern Wyoming; equivalent strata referred to as Frenchman Formation in Saskatchewan.

Reported fossils: Triceratops, plant fossils, occasional pelecypods, and small mammal remains.

Depositional environment: Nonmarine.

Remarks: Named from exposure on Hell Creek, Garfield County, Montana.

History of stratigraphic nomenclature:

Brown, B., 1907 (Am. Mus. Nat. Hist. Bull. 23, Art. 33, p. 329-835): Hell Creek beds are 560 feet of fossil-bearing, fresh-water deposits of alternating sandstone and clay in western half of Dawson County, Montana. Most constant member of series is massive basal sandstone up to 160 feet thick. Hell Creek beds are probably continuous with dinosaur-bearing beds of Little Missouri, Grand, and Moreau Rivers. Is Late Cretaceous in age. Is separated from overlying Fort Union Formation by 100 feet of lignite beds named Fort Union (?). Unconformably overlies Fox Hills Formation. Is lithologically similar to Ceratops beds of Converse County, Wyoming.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484-499): Hell Creek Member of Lance Formation defined as "Hell Creek beds" plus "lignite beds" Brown (1907) between Fox Hills Sandstone below and Tullock Member of Lance above. In southwestern North Dakota is overlain by either Ludlow Lignitic Member of Lance Formation or equivalent Cannonball Marine Member of Lance; overlies Fox Hills Sandstone. Consists of somber badlands clays, probably accumulated in topset swamps of large delta, and fluvatile sandstones; sandstones being more numerous and conspicuous toward southwest. Remains of small mammals found in sandstones; dinosaurs (including Triceratops) are numerous below "A" lignite, which marks base of Brown's (1907) "lignite beds," but have not been found above that horizon. Hell Creek and overlying strata are much more calcareous than Brown Member of Fox Hills and older strata. In Cedar Creek anticline, North Dakota and Montana, Hell Creek Member overlies Colgate Sandstone Member of Fox Hills.

Simpson, G. G., 1937 (U.S. Nat. Mus. Bull. 169, p. 15-20): Fort Union of Crazy Mountain field, Montana; consists of beds up to and including true dinosaur-bearing Lance and Hell Creek and their equivalents belong to Cretaceous and that overlying beds without dinosaurs (except by redeposition) and with mammals of Tertiary type (including carnivores, condylarths, and others) from Puerco and its equivalents upward, are to be placed in Tertiary. Hell Creek Formation underlies Bear Formation (new).

Collier, A. J., and Knechtel, M. M., 1939 (U.S. Geol. Surv. Bull. 905, p. 10-11): In McCone County, Montana, Hell Creek beds mapped as member of Lance Formation, overlie Colgate Sandstone Member of Fox Hills Formation and underlie Tullock Member of Lance. Since present report was written (footnote, p. 10), Hell Creek and Tullock Members have been raised to rank of formation. Hell

Creek is considered to be Cretaceous, and Tullock to be Cretaceous or Eocene. Lance is assigned to Eocene(?).

Dorf, E., 1940 (Geol. Soc. Am. Bull. 51, p. 213-236): Study of floras of type Lance and Fort Union Formations show that Lance Formation (equivalent to Hell Creek Formation) is placed in Late Cretaceous; Tullock Formation (equivalent to Ludlow Formation and Cannonball Marine Member) is placed at base of Paleocene Fort Union Group.

Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 9-15): Hell Creek Formation described in Morton County where it reaches 250 feet in complete exposures. Includes Breien Member (new). Overlies Fox Hills Formation; underlies Ludlow Formation of Fort Union Group.

Seager, O. A., et al., 1942 (Am. Assoc. Pet. Geol. Bull. 26, no. 8, p. 1415-1418): Hell Creek is youngest Cretaceous Formation of North Dakota. Consists of gray bentonitic sands and shales with lenticular beds of lavender-brown, lignitic shale and rusty-brown to purplish-black, ferruginous concretions. Thickness varies from 575 feet near Marmarth to less than 100 feet in Souris River area. Underlies Cannonball Member-Ludlow Member of Fort Union.

Colton, R. B., and Bateman, A. F., Jr., 1956 (U.S. Geol. Surv. Misc. Geol. Invest. Map I-225): Hell Creek Formation returned to original definition of Brown (1907) and "lignitic beds" included within Fort Union Formation.

Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 30-39): Hell Creek Formation divided into 8 members in North Dakota (ascending): Crowghost Member (new), Breien Member, Fort Rice Member (new), Huff Member (new), and Pretty Butte Member in central North Dakota and ascending Little Beaver Creek Member (new), Marmarth Member (new), Bacon Creek (new), Huff and Pretty Butte Members (new) in southwestern North Dakota. Unnamed ninth member may be present in Montana.

HUFF MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 37-38): Huff Member consists of thick sandstone bodies separated vertically and laterally by bentonites and bentonitic shales. Overlies Fort Rice Member; underlies Pretty Butte Member. Named from Huff, North Dakota; type section is 1 mile southwest of Huff, SW¼ sec 8, T136N, R79W, Morton County, North Dakota. Is very extensive member of Hell Creek Formation. Fossils are marine, brackish-water, and fresh water forms. Huff Member is considered to be channel deposits of large rivers.

ICEBOX SHALE MEMBER, Formation (of WINNIPEG FORMATION, GROUP)

Age: Middle Ordovician (Trentonian).

Area of extent: South Dakota and North Dakota; equivalent strata referred to as Winnipeg Shale in Manitoba, Saskatchewan, and eastern Montana.

Reported fossils: Scolecodonts, conodonts, fish remains, pelecypods, gastropods, and linguloid brachiopods.

Depositional environment: Marine.

Type section: Secs 14 and 23, T5N, R3E, Butte County, South Dakota.

Remarks: Named from Icebox Gulch. See also Winnipeg Formation.

History of stratigraphic nomenclature:

McCoy, M. R., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 45-46): Icebox Shale Member is 30-40 feet of silty, fissile, greenish-gray to olive shale; soft, noncalcareous, occasionally platy to splintery, with black phosphate nodules several millimeters in diameter in upper part. Overlies Aladdin Sandstone (new) and underlies Roughlock Siltstone (new). Type section given.

Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 58-59): Icebox Member of Winnipeg Formation consists of 90-145 feet of greenish-gray to dark-greenish-gray, splintery to fissile, waxy, non-calcareous shale. Locally, in eastern North Dakota, shale may be pale brown or grayish red. Gradational contact with underlying Black Island and overlying Roughlock Members.

Interior Member (Formation)

Age: Proposed as Late Cretaceous.

Area of extent: Western South Dakota, southwestern North Dakota, and northwestern Nebraska.

Depositional environment: Nonmarine.

Remarks: Type locality is a few miles west of Interior, Jackson County, South Dakota.

History of stratigraphic nomenclature:

Ward, F., 1922 (S.D. Geol. Nat. Hist. Surv. Bull. 11, p. 18-20): Top 35 feet of Pierre in southeastern Pennington County and southwestern Jackson County is Interior phase. Thin beds of yellow-brown shale become darker brown and darker purple in upper part. Fossils are those of Pierre; field studies place it as Fox Hills. Grades into underlying "typical" Pierre. Unconformably underlies Chadron Formation (Oligocene).

Toepelman, W. C., 1922 (S.D. Geol. Nat. Hist. Surv. Bull. 11, p. 64): Interior may be slightly sandy phase of Pierre formed by weathering and leaching. Nebraska Geological Survey calls these beds Rusty Member of Pierre.

Wanless, H. R., 1923 (Am. Philos. Soc. Proc., v. 62, p. 194): Interior is 0-45 feet of lavender and blue clays weathering to rusty brown. Contains calcareous nodules with cone-in-cone structure and concentrically banded pink or red nodules. Rests on Pierre with irregular surface.

Ward, F., 1926 (Am. J. Sci. 5th Ser., v. 11, p. 350-352): Type locality is few miles west of Interior, Jackson County, South Dakota. Is 30 feet thick at type locality, 45 feet thick 21 miles north of type locality. Interior is part of Fox Hills Formation.

Moxon, A. L, Olson, O. E., and Searight, W. V., 1939 (S.D. Agr. Exp. Sta. Tech. Bull. 2, p. 20): Mobridge Member replaced by Interior as Interior has precedence.

Gries, J. P., and Rothrock, E. P., 1941 (S.D. Geol. Surv. Rept. Invest. 38, p. 9-30): Since incomplete equivalence of all Interior beds to Mobridge beds, Mobridge retained. Interior usage dropped.

Dunham, P. J., 1961 (U.S. Geol. Surv. Open-File Rept., p. 55-98): Weathered zone formed on rocks of Pierre Shale down to Niobrara and Carlile studied. Weathered zone is Eocene in age; has been called Interior Formation.

Pettyjohn, W. A., 1966 (U.S. Geol. Surv. Prof. Paper 550-C, p. 61-65): Eocene paleosol, which has been termed Interior Phase of Pierre, Interior Formation, or Interior period of weathering; is exposed at several widely separated localities in western North Dakota.

INTERLAKE FORMATION, GROUP

Age: Silurian (Alexandrian to Niagaran).

Area of extent: Southern Manitoba, Williston Basin.

Reported fossils: Leperditia hisingeri, Virgiana decussata, Fletcheria guelphensis, Palaeofavosites sp., Brachyprion sp., "Amplexus" severnensis.

Depositional environment: Marine.

Remarks: Type locality is Interlake area of Manitoba. See also Stonewall Formation.

History of stratigraphic nomenclature:

Baillie, A. D., 1951 (Man. Dep. Mines Nat. Resour., Div. Mines Pub. 50-1, p. 6): Interlake Group consists of cream to white, earthy to lithographic limestone and dolomite with local zones of reefy porosity and permeability. Contains pyrite and thin, irregular laminae of green shale, and scattered sand grains. Interlake Group is divided into five formations (referred to by letters), but only basal formation (Stonewall) named. Thickness is 200-800 feet. Top and base of unit is under discussion.

Stearn, C. W., 1953 (Geol. Soc. Am. Bull., v. 64, p. 1477-1478): Stonewall fauna is late Ordovician. As rest of Interlake is Middle Silurian, Stonewall should be removed from Interlake. Interlake divided into six formations.

Porter, J. W., and Fuller, J. G. C. M., 1958 (N.D. Geol. Soc. 2nd Internat. Williston Basin Sym., Conrad, Bismarck, p. 33-39): Interlake Group divided into lower, middle, and upper beds.

Andrichuk, J. M., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 2381): Stonewall Formation retained in Interlake Group, as most recognizable unconformity occurs at base of Stonewall.

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1350-1351): Interlake is succession of pale-colored dolomite, anhydrite, and calcareous sandstone. Interlake divided into three unnamed units.

Carlson, C. G., and Eastwood, W. P., 1962 (N.D. Geol. Surv. Bull. 38, p. 10): Interlake Formation of Silurian age is divided into three intervals (upper, middle, and lower) on basis of fine-grained clastic marker horizons that mark interruptions in predominantly carbonate deposits. Stonewall Formation is separate distinct formation of possible Ordovician age, and is not included with Interlake Formation.

INYAN KARA FORMATION, Group

Age: Early Cretaceous (Aptian to Albian).

Area of extent: Western South Dakota, North Dakota, and southeastern Montana; equivalent to Cloverly Group of southern Montana, Swan River Formation of Manitoba and Blairmore Formation of southern Saskatchewan.

Depositional environment: Nonmarine to marine.

History of stratigraphic nomenclature:
Rubey, W. W., 1930 (U.S. Geol. Surv. Prof. Paper 165A, p. 5): Is extremely variable group, consisting of discontinuous beds of sandstone, shale, lignite, conglomerate, and siltstone. Includes Fall River sandstone, Fuson Formation, and Lakota sandstone. Named for exposures along Inyan Kara Creek, Moorcraft Quadrangle, Wyoming.

Waage, Karl, 1959 (U.S. Geol. Surv. Bull. 1081-B, p. 32-33): Redefined the Inyan Kara Group, dividing into 2 units, upper marginal marine unit-Fall River, and lower continental unit-Lakota.

Irish Creek Lithofacies (of TIMBER LAKE MEMBER of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western South Dakota and western North Dakota.

Reported fossils: Rare molluscs.

Depositional environment: Marine.

Type section: South-facing cutbank and bluff north of Moreau River about 0.8 miles southwest of its confluence with Irish (formerly Worthless) Creek, in the center, sec 32, T15N, R21E, U.S. Geol. Surv. Dupree NE quad., Ziebach County, South Dakota.

Remarks: See Timber Lake Member.

History of stratigraphic nomenclature:
Waage, K. M., 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, p. 60-73): West of study area, Irish Creek lithofacies is thinly bedded silt and shale with mostly barren concretions. Upper part of Irish Creek occurs along northwestern part of Grand River and tributaries, west side of Moreau River valley, and on south and east end of Cheyenne-Moreau divide in South Dakota.

IRON LIGHTNING MEMBER (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota and western South Dakota.

Reported fossils: Molluscs, fish, reptiles, birds, mammals, and plants.

Depositional environment: Marine.

Type section: Pieced from partial sections in W½, sec 33, T14N, R19E, U.S. Geol. Surv. Redelm NE quad., Ziebach County, South Dakota.

Remarks: See also Bullhead and Colgate lithofacies.

History of stratigraphic nomenclature:
Waage, K. M., 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, p. 116-138): Iron Lightning Member is upper Fox Hills and consists of thinly bedded sand, silt, and shale with sparse marine fauna (Bullhead lithofacies and bodies of clayey grayish-white sand with brackish-water fauna (Colgate lithofacies). Iron Lightning rests on planed surfaces at several levels on lower Fox Hills, rising steplike eastward. Conformable with Hell Creek Formation in South Dakota. Sediments are of deltaic front advancing from west. Some fluctuations in sea levels are indicated.

Erickson, J. M., 1974 (Bull. Am. Paleo., p. 145): Iron Lightning Member found in south-central North Dakota; consists of interbedded, poorly consolidated sandstone or siltstone (Bullhead lithofacies) and medium-grained, poorly consolidated sandstone (Colgate lithofacies). Iron Lightning deposited in marine deltaic sequence; Bullhead lithofacies may be lagoonal deposit behind barrier or bay-mouth bar.

JEFFERSON GROUP, Formation

Age: Late Devonian (Senecan).

Area of extent: Montana, northern Wyoming, Idaho, North Dakota, and South Dakota.

Reported fossils: Corals, stromatoporoids, and bryozoans.

Depositional environment: Marine.

Remarks: Named after Jefferson River, Montana.

History of stratigraphic nomenclature:
Peale, A. C., 1893 (U.S. Geol. Surv. Bull. 110, p. 27-28): Jefferson Formation consists of 640 feet of brown and black crystalline limestone; underlies Three Forks Shale and conformably overlies Gallatin Formation. Is well exposed on bluffs on both sides of Missouri River just below junction of Three Forks of Missouri River, and on both sides of Jefferson a few miles above mouth, in Three Forks quadrangle, southwestern Montana. Probably can be correlated with part of Beaver Hill Lake Formation of Saskatchewan and Manitoba Formation of North Dakota and Manitoba.

Sloss, L. L., and Laird, W. M., 1946 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 25): Jefferson Formation divided into upper dolomite member and lower limestone member. Basal limestone member transitional with underlying shales.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2315): Jefferson Group divided into Duperow (below) and Birdbear (above) Formations. Definition of Jefferson Group is original definition of Peale (1893); as redefined by Sloss and Laird (1946) includes bottom part of Three Forks Formation.

JUDITH RIVER FORMATION (of MONTANA GROUP)

Age: Late Cretaceous (Campanian).

Area of extent: Central and eastern Montana, westernmost North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1856 (Phila. Acad. Nat. Sci. Proc., v. 8, v. 9, v. 12, v. 13): Allude to Judith deposit, Judith beds and Judith River beds in description of fresh water and brackish water beds near mouth of Judith River, Montana.

Hatcher, J. B., and Stanton, T. W., 1903 (Sci. N.S., v. 18, p. 211-212): Divided the Montana Group of Montana and adjoining areas of Canada into descending: (1) Bearpaw shale, (2) Judith River beds-500 to 600 feet of light-colored, mostly nonmarine beds, (3) Claggett Formation, and (4) Eagle Formation.

Laird, W. M., and Towse, D. F., 1949 (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Judith River Formation shown to produce gas at several locations in North Dakota.

Jura-Triassic red beds

Age: Triassic(?) and Early(?) Jurassic.

Remarks: Term used for strata now termed Watrous in Saskatchewan and Manitoba; Spearfish in North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Francis, D. R., 1956 (Sask. Dep. Min. Resour. Rept. 18, p. 18-22): Jura-Triassic red beds consist of reddish-brown silty and non-silty dolomitic shales. One or more unconformities may exist within unit. Lower boundary difficult to determine where red beds in contact with Big Snowy Group or Minnekahta and Opeche Formations in Montana and North Dakota, but readily apparent where red beds rest on Paleozoic carbonates. Upper boundary placed at lowest occurrence of massive nonclastics in Jurassic; overlying beds are evaporites in eastern half of Williston Basin and carbonates over western half.

_____, 1957 (Am. Assoc. Pet. Geol. Bull. 41, p. 376): Jura-Triassic red beds underlie Gypsum Spring or Sundance Formations in Williston Basin. Consist of red silty shales grading into argillaceous siltstone near base and becoming progressively less silty upward. Lower part or all Jura-Triassic red beds is considered to be equivalent to Spearfish Formation of Black Hills.

Keld Member (of Favel Formation)

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota; equivalent to Greenhorn of current usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Repts. 1929, pt. B, p. 118): Used term Keld beds for calcareous shales and impure limestones overlying Ashville beds; well exposed along Vermilion River near Keld, Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 993-1010): Keld Member of Favel Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Overlies Ashville Formation; underlies Assiniboine Member of Favel Formation.

KIBBEY FORMATION, Sandstone (of BIG SNOWY GROUP)

Age: Late Mississippian (Chesterian).

Area of extent: Montana, western North Dakota, northwestern South Dakota.

Depositional environment: Marine.

Remarks: Type locality near Kibbey Post Office, Fort Benton region, central Montana. See also Big Snowy Group.

History of stratigraphic nomenclature:
Weed, W. H., 1899 (U.S. Geol. Surv. Geol. Atlas Folio 55): Kibbey Sandstone constitutes lowest beds of Quadrant Formation.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 1, p. 1091): U.S. Geol. Surv. adopted Kibbey Sandstone Member of Quadrant Formation in 1907.

Scott, H. W., 1935 (J. Geol., v. 43, p. 1011-1032): Big Snowy Group is new name for lower part of beds formerly assigned to Quadrant Formation. Divided into three conformable formations (descending): 1) Heath (new), 2) Otter, and 3) Kibbey Formation. Kibbey is red to grayish-yellow sand and red shale, with occasional gypsum or anhydrite. Few limestones. Thickness 50-300 feet.

Seager, O. A., 1942 (Am. Assoc. Pet. Geol. Bull. 26, no. 5, p. 863): In Cedar Creek anticline area, southeastern Montana, Kibbey Formation overlies Charles Formation (new).

Anderson, S. B., 1954 (N.D. Geol. Surv. Rept. Invest. 16, 2 sheets): Kibbey Formation is sequence of shales, sandstone, and limestone in subsurface of western North Dakota and eastern Montana. Overlies Charles in deeper part of Williston Basin; underlies Otter and Heath where not eroded. Kibbey is reddish or occasionally light-gray, medium- to fine-grained, rounded sandstone with limestone or occasional dolomite below sandstone and variegated shale at base. Total thickness 225 feet. Resistivity curve "kick" selected as top of Kibbey.

Laudon, L. R., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 210): Kibbey, Heath, Otter, and Amsden are believed to represent shore facies of various parts of early Pennsylvanian seas.

Gardner, L. S., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 333-334, 341-342, 346-347): Kibbey Formation is 220 feet thick in composite section of revised Big Snowy Group. Underlies Otter Formation; unconformably overlies Mission Canyon Limestone of Madison Group.

Anderson, S. B., 1974 (N.D. Geol. Surv. Misc. Map 17, 1 sheet): Kibbey Formation of North Dakota divided into three mappable units (descending): sandstone, limestone, and silt.

Killdeer Formation

Age: Oligocene (Arikareean).

Area of extent: Killdeer Mountains, Dunn County, North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 131): Killdeer Formation proposed for strata overlying White River Group in North Dakota and below unconsolidated deposits whose source and age are unknown (formerly considered Arikaree Formation). Consists of 25-200 feet of green-colored, concretionary, calcareous sandstone, siltstone, silty claystone, and dolostone. Fossil evidence (Paleocastor sp., Hypertragulus minor, and Amphicaenopus(?)) suggests Arikareean (early Miocene) age.

Kinderhook Formation, Group

Age: Mississippian.

History of stratigraphic nomenclature:
Meek, F. B., and Worthen, A. H., 1861 (Am. J. Sci. 2nd Ser., v. 32, p. 288): Kinderhook Group proposed to include the beds lying between black shale below and Burlington limestone above in Illinois.

Laird, W. M., and Towse, D. F., 1949 (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Kinderhook term used in stratigraphic column of North Dakota; equivalent strata now referred to as Bakken.

KLINE MEMBER (of Nesson Formation)

Age: Middle Jurassic (Bajocian).

Area of extent: Western North Dakota and eastern Montana.

Depositional environment: Marine.

Type section: Interval of 4,386-4,533 feet in Price Drilling Co. No. 1, Kline well, center SE SE SE sec 16, T157N, R85W, Ward County, North Dakota.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 104 and 105-106): Kline Member is uppermost member of Nesson Formation (new); overlies Picard Member (new); underlies Piper Formation. At type section, consists of (descending): 34 feet of light-gray to white earthy dolomite and fine-grained sandstone; 13 feet of gray-green to purple calcareous shale containing white gypsum; 37 feet of light- to dark-brown finely crystalline limestone, oolitic in part, and becoming shaly toward base; 63 feet of light-gray to buff, fine- to medium-crystalline limestone, earthy, gypsiferous and fossiliferous in part. Pinches out by nondeposition short distance east of Big Snowy uplift and wedges out in like manner on west flank of Bowdoin dome. On west margin of Williston Basin, unconformably overlies either Mississippian, Pennsylvanian, or Triassic beds.

LAKOTA FORMATION, SANDSTONE (of DAKOTA or INYAN KARA GROUP)

Age: Early Cretaceous (Aptian).

Area of extent: Southeastern Montana, northeastern Wyoming, and South Dakota; equivalent to lower part of Inyan Kara of current North Dakota usage; equivalent to Cantaur Formation in Saskatchewan; included in Swan River Formation in Manitoba.

Reported fossils: Plant fossils.

Depositional environment: Nonmarine to (?) marine.

Remarks: Type locality is Lakota Peak, summit on Hogback Range, 4 miles northwest of Hermosa, South Dakota. Named from tribal division of Sioux Indians. Standard reference section in valley of Fall River in center W½ NW sec 33, NE NE sec 32, and adjacent part sec 29, T7S, R6E, Fall River County. Hot Springs quadrangle, South Dakota.

History of stratigraphic nomenclature:
Darton, N. H., 1899 (Geol. Soc. Am. Bull. 10, p. 387): Lakota sandstone is coarse, buff sandstone with fire clay and local coal. Overlies Beulah Shale (Morrison Formation) in Black Hills, South Dakota.

_____, 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 526): Lakota Formation consists of massive, buff, coarse, cross-bedded sandstone with shale and local coal beds. Uppermost member is dull yellow sandstone. Thickness is

200-300 feet. Contains local unconformities and if not Jurassic, it represents earliest deposit of Cretaceous. Underlies Minnewaste Limestone and unconformably overlies Jurassic Beulah Shales. Included in Dakota Sandstone of earlier reports and name is derived from tribal division of Sioux Indians.

Darton, N. H., and O'Hara, C. C., 1909 (U.S. Geol. Surv. Belle Fourche Folio 164, p. 4): Type locality of Lakota Sandstone is Lakota Peak, 4 miles northwest of Hermosa, South Dakota.

Rubey, W. W., 1931 (U.S. Geol. Surv. Prof. Paper 165-A, 54 p.): Lakota Sandstone included in Inyan Kara Group.

Condra, G. E., and Reed, E. C., 1943 (Neb. Geol. Surv. Bull. 14, p. 15): Lakota shown on columnar section as basal formation of Dakota Group. Underlies Fuson Shale.

Davis, R. E., and Izett, G. A., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2745-2756): A sequence of lensing and interfingering continental deposits of claystone, siltstone, and sandstone that seem genetically related to underlying Morrison Formation has been referred to as Lakota and Fuson Formations undifferentiated, or Lakota Formation. Separated from underlying rocks by nearly planar surface of transgressive disconformity; overlain by Fall River Formation.

Waage, K., 1959 (U.S. Geol. Surv. Bull. 1081-B, p. 26-33): Inyan Kara Group redefined to show change in environment of deposition from continental (Lakota) to marginal marine (Fall River). Upper one-third of Inyan Kara is well-bedded, fine-grained, brown-weathering sandstone with intercalated gray to black shale and siltstone; lower two-thirds is more variable with varicolored and variegated claystone and siltstone, and massive, locally poorly sorted sandstone, carbonaceous shale and coal, and shale and limestone. Two units are separated by transgressive disconformity. Lakota comprises Minnewaste Limestone Member and Fuson Shale Member. Name Lakota should not be used outside Black Hills region; type locality at Lakota Peak should not be considered adequate for reference or comparison--standard reference section designated. Base of Lakota is arbitrary, indefinite, and inconsistent, generally drawn at base of first appreciable sandstone bed above Sundance Formation.

Pettyjohn, W. A., 1960 (S.D. Acad. Sci. Proc., v. 38, p. 34-38): Dakota controversy discussed. Suggested term Dakota Group be used to include Lakota, Fuson, Fall River, Skull Creek, and Newcastle Formations.

Gries, J. P., 1962 (Wyo. Geol. Assoc. Gdbk. 17th Ann. Field Conf., p. 163): Lakota should be recognized eastward from Black Hills as far as overlying marine Fall River and Skull Creek Formations can be identified.

Lance Formation

Age: Late Cretaceous (Maestrichtian).

Area of extent: Wyoming, Montana, northern Colorado; equivalent strata in eastern Montana, North Dakota, and South Dakota are referred to as Hell Creek Formation.

Reported fossils: Plant fossils, dinosaurs.

Depositional environment: Nonmarine.

Remarks: Type locality and exposures on Lance Creek, Niobrara County, Wyoming.

History of stratigraphic nomenclature:
Hatcher, J. B., 1903 (Am. Geol., v. 31, p. 369-375): Lance Creek (Ceratops) beds--name Ceratops beds cannot be used for Wyoming deposits. Conformably overlies Fox Hills; underlies Fort Union.

Stanton, T. W., 1910 (Am. J. Sci. 4th Ser., v. 30, p. 172-188): Name Lance Formation has been adopted by U.S. Geological Survey for "Ceratops beds" of eastern Wyoming and adjacent areas. It is abbreviated form of "Lance Creek beds." Lance Formation is considered to be transition from marine Cretaceous Fox Hills Sandstone into Lance Formation; sedimentation continuous from one to the other and probably on through overlying Fort Union.

Lloyd, E. R., and Hares, C. J., 1915 (J. Geol., v. 23, p. 523-547): In region west of Missouri River in North Dakota and South Dakota, Lance Formation consists of two distinct parts: lower nonmarine part that contains fauna resembling that of Fox Hills Sandstone and upper part, because of peculiar fauna, has been mapped separately and named Cannonball Marine Member of Lance Formation. Farther west, non-marine beds bearing lignite and occupying similar stratigraphic position have been named Ludlow Lignitic Member of Lance.

"Lance Creek beds"

Remarks: See Lance Formation.

Laramie Formation, Group

Age: Late Cretaceous.

Remarks: Mapped by King, Hayden, and other early workers; covered large areas in Rocky Mountains. Now it is restricted to Denver Basin.

History of stratigraphic nomenclature:
King, C., 1876 (U.S. Geol. Surv. Expl. 40th Par. Atlas Maps 1 and 2): Laramie is shown as overlying Fox Hills and underlying Vermilion Creek (Eocene) in northwestern Colorado and southern Wyoming.

Lebo Shale Member

Age: Paleocene.

Area of extent: Central and eastern Montana.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Stone, R. W., and Calvert, W. R., 1910 (Econ. Geol., v. 5, p. 746): Lebo Andesitic Member of Fort Union consists of 450-2200 feet of dark-colored beds of volcanic material lying between Lance Formation and sandstone of Fort Union Formation.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 492): Ludlow Member of Lance is equivalent to Lebo Member of Fort Union of Montana plus Tullock Member of Lance and "lignitic beds" which are part of Hell Creek Member of Lance lying above "A" lignite zone.

Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 19): Lebo Member is tongue of shale near top of Ludlow in southwestern North Dakota.

LINTON MEMBER (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Emmons and Sioux Counties, North Dakota, and eastern Corson County, South Dakota.

Reported fossils: Plant remains (Equisetum) and Ophiomorpha.

Depositional environment: Marine.

Type section: N½ sec 8 and 9, T132N, R76W, 1 mile east of Linton, North Dakota.

Remarks: Probably equivalent of "Bed Q" of Meek, R. B., and Hayden, F. V., 1857 (Phila. Acad. Nat. Sci. Proc. 9, p. 117-148).

History of stratigraphic nomenclature:
Meek, R. B., and Hayden, F. V., 1857 (Phila. Acad. Nat. Sci. Proc., v. 9, p. 117-148): "Bed Q" is gray, indurated to slightly friable sandstone and is basal unit of "Great Lignite Group." Total thickness 30 feet.

Klett, M. C., and Erickson, J. M., 1976 (N.D. Acad. Sci. Proc. 28, pt. 2, p. 3-21): Linton Member named; strata previously placed in Colgate lithofacies (or member). Consists of 0.6-22.4 feet of light-olive-gray to grayish-brown, fine-grained, subangular, moderately to poorly sorted, indurated, siliceous sandstone with volcanic shards. Interpreted as channel sand, deposited in and along major, wide, shallow, southward-flowing estuarine tidal river. Is probably Hayden's Bed Q, resistant sandstone that caps Fox Ridge and other buttes in Missouri valley north of Grand River in South Dakota. Type section given.

LITTLE BEAVER CREEK MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Southwestern North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 30-31): Little Beaver Creek is lowest member of Hell Creek Formation in Little Missouri valley. Consists of lignitic sandstones and shales. Named after Little Beaver Creek; type section is SW¼ sec 7, T132N, R106W, Bowman County, North Dakota. Conformably and unconformably overlies Fox Hills Formation; underlies Marmarth Member. Member is largely continental (cones of Sequoia dakotensis found) but probably has marine beds near base.

Little Eagle Lithofacies (of TIMBER LAKE MEMBER of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota and western South Dakota.

Reported fossils: Ammonites and other molluscs.

Depositional environment: Marine.

Type section: Southwest-facing bluffs along narrow end of southeast-trending spur in SW¼ sec 26, T20N, R26E, U.S. Geol. Surv. Little Eagle NW quadrangle, Corson County, South Dakota.

Remarks: See Timber Lake Member.

History of stratigraphic nomenclature:
Waage, K. M., 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, p. 60-73): Little Eagle lithofacies is clayey silt with several richly fossiliferous concretion layers on south side of Moreau River valley, on Cheyenne-Moreau divide and Grand River valley. Bedding in lower half of sediment is obliterated due to burrowing organisms. Principal assemblage zones are (ascending): 1) Lower nicolleti, 2) Limopsis-Gervilla, and 3) Protocardia-Oxytoma. Two lower assemblage zones extend to Linton, North Dakota. Upper concretionary layers of Little Eagle lithofacies contain few fossils. Little Eagle lithofacies assemblage zones formed off down-current end of Timber Lake sand body.

LODGEPOLE FORMATION, Limestone (of MADISON GROUP)

Age: Early Mississippian (Kinderhookian).

Area of extent: Montana, South Dakota, North Dakota, and southern Manitoba and Saskatchewan.

Reported fossils: Spirifers, crinoids, bryozoans, and corals.

Depositional environment: Marine.

Type section: Bed of tributary of Lodgepole Creek in Little Chief Canyon in NE NW sec 30, T26N, R25E, Blaine County, Montana, and extends across SE¼ sec 19 into SW NW sec 20 (Sando, W. J., and Dutro, J. T., Jr., 1974), p. 17. Named for Lodgepole Canyon, Little Rocky Mountains, Montana.

History of stratigraphic nomenclature:
Collier, A. J., and Cathcart, S. H., 1922 (U.S. Geol. Surv. Bull. 736F, p. 171-178): Madison ranked as group when subdivided into two formations in Little Rocky Mountains of Montana. Formations named (descending) Mission Canyon Limestone (500 feet of thickly bedded limestone) and Lodgepole Limestone (800 feet of thinly bedded limestone) from exposures in Mission and Lodgepole Canyons. Lodgepole Limestone overlies Jefferson Formation in this area.

Sloss, L. L., and Hamblin, R. H., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 305-335): Lodgepole Limestone divided into two members (descending): Woodhurst Member and Paine Member. Fossils listed. Lodgepole Limestone overlies Three Forks Formation.

Smith, M. H., 1960 (Am. Assoc. Pet. Geol. Bull. 44, p. 959): Changes in nomenclature of Mississippian Madison Group reported by Committee of the Mississippian Madison Group of North Dakota Geological Society. Five marker-determined intervals and two subintervals defined by log deflection.

Ballard, F. V., 1963 (N.D. Geol. Surv. Bull. 40, p. 18-26): Bottineau interval equivalent to Lodgepole Limestone.

Sando, W. J., and Dutro, J. T., Jr., 1974 (U.S. Geol. Surv. Prof. Paper 842, p. 17-21): Type section for Lodgepole Limestone described. Lowermost member, Little Chief Canyon, abandoned. Paine Shale Member and Woodhurst Limestone Member changed to Paine Member and Woodhurst Member, respectively.

LUDLOW FORMATION, Lignitic Member (of FORT UNION GROUP, FORMATION)

Age: Paleocene.

Area of extent: Northeastern Montana, western North Dakota, South Dakota.

Reported fossils: Plant fossils.

Depositional environment: Nonmarine.

Remarks: Named from exposures in vicinity of Ludlow, Harding County, South Dakota.

History of stratigraphic nomenclature:

Lloyd, E. R., and Hares, C. J., 1915 (J. Geol., v. 23, p. 523-547): Ludlow Lignitic Member of Lance Formation occupies large area in Harding County, South Dakota, and has been mapped northward into Bowman and Billings Counties, North Dakota, and eastward to Perkins County, South Dakota, where it merges with Cannonball Marine Member. In vicinity of Ludlow, South Dakota, consists of 350 feet of loosely consolidated buff and cream-colored, calcareous sandstone and shale with interbedded lignite. Contains most of the lignite of South Dakota and presence of this lignite is criterion for considering it as distinct member of Lance Formation. In South Dakota, its lithologic character is like Fort Union Formation but different than lower part of Lance Formation, and fossil flora is identical with that of Fort Union or lower part of Lance. In North Dakota, flora is same as in South Dakota, but lithology resembles lower part of Lance except for presence of numerous lignite beds. All of Triceratops collected in Little Missouri area came from below T Cross lignite bed (in lower part of Ludlow) and oysters came from above it.

Dorf, E., 1940 (Geol. Soc. Am. Bull. 51, p. 213-236): Paleobotanical evidence supports known vertebrate evidence in placing boundary between true Lance and Fort Union at base of nondinosaur-bearing Tullock, Ludlow, or Bear Formations or their equivalents, which is at top of Triceratops-bearing Hell Creek or Lance Formations as originally defined. Marine invertebrates of Cannonball Formation, which interfingers with Ludlow, do not contradict this position.

Brown, R. W., 1952 (Billings Geol. Surv. Gdbk. 3rd Ann. Field Conf., p. 91): Fort Union in eastern Montana is divided into (ascending): Tullock Sandstone, Lebo Shale, Tongue River Sandstone, and Sentinel Butte Shale. East of Miles City, Montana, two lower members merge in facies so that they are combined as Ludlow in North and South Dakota.

Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 16-18): Ludlow of southern Morton County is 17-49 feet thick, overlies Hell Creek Formation; underlies and is in gradational contact with Cannonball Formation which it replaces westward. Is of Fort Union Group, and is Paleocene in age.

Brant, R. A., 1953 (U.S. Geol. Surv. Circ. 226, p. 1, 11-12): Ludlow is basal member of Fort Union Formation in North Dakota. Is equivalent to Tullock Member and Lebo Shale Member in lignite fields of southeastern Montana. Underlies Tongue River Member. In Marmarth lignite field, consists of 250 feet of alternating shale, sandstone, and lignite beds. Thins to east and interfingers with Cannonball Formation. Overlies Hell Creek Formation. Is Paleocene in age.

Denson, N. M., et al., 1955 (U.S. Geol. Surv. Map C-33): Ludlow, Cannonball, and Tongue River, all members of Fort Union Formation, considered to be Paleocene in age.

"Lyleton Formation"

Age: Late Devonian.

Area of extent: Williston Basin. Lyleton equivalent to Three Forks Formation of current North Dakota usage.

Depositional environment: Marine.

Remarks: Type locality at Souris Valley Oil Company No. 1 Gordon White well near Lyleton in southwestern Manitoba.

History of stratigraphic nomenclature:
Allan, J. D., and Kerr, L. B., 1950 (The Precambrian, v. 23, no. 10, p. 8-10): Lyleton Shale is name given to 90 feet of red shale marking top of Devonian.

Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Lyleton Formation consists of reddish-brown, fine- to medium-crystalline, shaly dolomite and dolomitic limestone. Underlies Mississippian Englewood; overlies "Nisku equivalent."

MADISON GROUP, FORMATION, or Limestone

Age: Early to Late Mississippian.

Area of extent: Montana, Wyoming, Utah, South Dakota, North Dakota, Saskatchewan, and Manitoba.

Reported fossils: Crinoid debris, spirifers, bryozoans, and corals.

Depositional environment: Marine.

Type section: North side of Gallatin River, north of Logan in SE SW sec 25, T2N, R2E, Gallatin County, Montana (Sando, W. J., and Dutro, J. T., Jr., 1974, p. 4): Named for Madison Range, central part of Three Forks quadrangle, Montana.

History of stratigraphic nomenclature:
Peale, A. C., 1893 (U.S. Geol. Surv. Bull. 110, p. 32): Madison Limestones consist of (descending): 575 feet of massive, jaspery limestone; 350 feet of light-bluish-gray, massive limestone; and 325 feet of dark, compact, laminated limestone. Overlain by Quadrant Formation and underlain by Three Forks Shale.

Collier, A. J., and Cathcart, S. H., 1922 (U.S. Geol. Surv. Bull. 736F, p. 171-178): Madison ranked as group where subdivided into two formations in Little Rocky Mountains of Montana. Formations named (descending) Mission Canyon Limestone (500 feet of thickly bedded limestone) and Lodgepole Limestone (800 feet of thinly bedded limestone) because of exposure in Mission and Lodgepole Canyons.

Sloss, L. L., and Hamblin, R. H., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 305-335): Lodgepole Limestone divided into two members (descending): Woodhurst Member and Paine Member. Fossils listed. Madison Group overlies Three Forks Formation and underlies Kibbey Sandstone, Ellis Formation, or Amsden Formation.

Sloss, L. L., 1952 (Billings Geol. Soc. 3rd Ann. Field Conf., p. 65-69): Charles Formation, previously included in Big Snowy Group, added to Madison Group of Williston Basin. Descending order for section: Charles Formation (thick succession of limestone, dolomite, and evaporite); Mission Canyon Limestone (massive, fine-grained limestone with dolomite toward top of formation); and Lodgepole Limestone (massive limestone with crinoidal fragments); beds of dark limestone, cherty limestone, and thin shale beds; and black shale marks bottom of section).

Andrichuk, J. M., 1955 (Am. Assoc. Pet. Geol. Bull. 39, p. 2170-2210): Madison Group of three units, boundaries redefined on interpretation of depositional environments of entire Mississippian carbonate sequence in Wyoming and southern Montana. Upper unit approximately upper three-fourths of Charles Formation, middle unit of remainder of Charles and most of Mission Canyon Limestone, and lower unit of remainder of Mission Canyon and entire Lodgepole Limestone. Type section for Charles Formation suggested.

Porter, J. W., 1955 (Alberta Soc. Pet. Geol. J. 3, p. 126-130): Charles, Mission Canyon, and Lodgepole Formations interfinger and exhibit facies relationships in subsurface of Williston Basin of Manitoba and Saskatchewan. Facies interpreted to be time transgressive as changes in lithology lateral and vertical.

Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 1-72): Basal Bakken Formation placed in Madison Group. Lodgepole and Mission Canyon Limestones combined into Madison Limestone. This usage not followed by later writers.

Porter, J. W. (Chm.), 1956 (Sask. Geol. Soc. Rept. of the Mississippian Names and Correlations Committee, p. 1-4): "Beds" were chosen for subdivisions of limestone sequence of Madison Limestone because no adequate correlation exists between rocks of northeastern Williston Basin and Mission Canyon or Lodgepole Limestone of Montana. "Beds" may include several contrasting lithologies and have lateral and vertical facies changes. "Beds" named Poplar, Ratcliffe, Midale, Frobisher-Alida, Tilston, and Souris Valley from oil fields of southeastern Saskatchewan.

Anderson, S. B., 1958 (N.D. Geol. Surv. Rept. Invest. 31, p. 1-9): Madison is group of intergrading belts of lithologies that cross time lines in subsurface of North Dakota. Charles magnafacies proposed for evaporitic facies and Mission Canyon magnafacies proposed for massive marine facies of Williston Basin to eliminate confusion caused by time connotation of original definition of formations within Madison Group. Lodgepole Limestone used for sequence below Mission Canyon (MC-1) and above Englewood (Bakken) Formation.

Smith, M. H., 1960 (Am. Assoc. Pet. Geol. Bull. 44, p. 959-960): Changes in nomenclature of Mississippian Madison Group reported by Committee of the Mississippian Madison Group of North Dakota Geological Society. Five marker-determined intervals and two subintervals defined by log deflection.

Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 1-25): Mississippian Madison Group Committee of North Dakota Geological Society proposed following units (descending): Poplar, Ratcliffe, and Frobisher-Alida intervals; Midale subinterval substituted for "Midale beds" at base of Ratcliffe interval; Rival subinterval substituted for "Frobisher evaporite" at top of Frobisher-Alida interval. Interval and subinterval boundaries defined by prominent deflection on gamma ray and spontaneous potential logs; these markers define intervals of laterally varying lithology and assumed to be para-time-rock units (nearly time parallel).

Ballard, F. V., 1963 (N.D. Geol. Surv. Bull. 40, p. 18-26): Bottineau interval equivalent to Lodgepole Limestone. Tilston interval conformably overlies Bottineau interval and conformably underlies Frobisher-Alida interval. Poplar interval, Midale subinterval, Ratcliffe interval, Rival subinterval, and Ratcliffe interval follow usage by earlier authors and followed by North Dakota Geological Survey presently. Carrington shale facies proposed as part of Bottineau interval instead of equivalent to Three Forks Formation.

Sando, W. J., and Dutro, J. T., Jr., 1974 (U.S. Geol. Surv. Prof. Paper 842, p. 1-22): Descriptions of precisely located type sections for Madison Group, Lodgepole Limestone, Mission Canyon Limestone, and Paine and Woodhurst Members of Lodgepole Limestone.

MANITOBA GROUP (also Manitoban Formation)

Age: Middle to Late Devonian.

Area of extent: Used in North Dakota for Dawson Bay and Souris River Formations.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Tyrrell, J. B., 1892 (Can. Geol. Surv. Ann. Rept., pt. E, p. 1890-1891): Manitoban Formation is of shales and limestones that overlie Winnipegosan Formation.

Baillie, A. D., 1953 (Man. Dep. Mines Nat. Resour. Pub. 52-5, p. 25-26): Manitoba Group proposed for carbonate and argillaceous strata overlying Elk Point Group in Williston Basin. Manitoba Group has same areal extent as Elk Point Group. Thickness is generally less than 300 feet. Consists of repetitive sequences of carbonates with thin, shaly beds. Sequences consist of shale and argillaceous limestone that grade upward to light-colored, bedded limestone overlain by fragmental and reefoid zone; evaporites commonly mark upper member of sequence. Basal sequence of group exposed in outcrop area is named Dawson Bay.

Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): In North Dakota, Manitoban Formation consists of light-olive to yellowish-gray, fine- to medium-grained sugary dolomite and limestone. Makes distinctive gamma ray "kick." Is Middle Devonian in age.

MARMARTH MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Southwestern North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 30-31): Marmarth Member consists of two thick sandstone bodies separated by thin sequence of bentonites, bentonitic shales, and lignitic shales. Named for town of Marmarth, North Dakota and type section is just west of Marmarth in SW¼ sec 26, T133N, R106W, Slope County, North Dakota. Overlies Little Beaver Creek Member; underlies Bacon Creek Member. Sandstones appear to have been deposited in large river although no aquatic animal fossils found.

Medora Member (of BULLION CREEK FORMATION)

Age: Paleocene.

Area of extent: Local area of Billings County.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Jacob, A. F., 1973 (Am. Assoc. Pet. Geol. Bull., v. 57, p. 1047): Name proposed for tabular body in the upper part of the Tongue River Formation (Bullion Creek Formation) at Medora, North Dakota.

Meek Group

Age: Pennsylvanian (Missourian).

Area of extent: Hartville Uplift area of eastern Wyoming, southwestern South Dakota; equivalent strata in North Dakota are included in Amsden Formation of current usage.

Reported fossils: Fusulinids.

Depositional environment: Marine.

Remarks: Type locality is Meek Cliff, sec 22, T27N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2, 22, and 28): Meek Group consists of limestones and silty limestones with sandstone. Comprises lower 130 feet of Division II of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, 46 p.). Thickness is 119-130 feet. Underlies Wendover Group (new); overlies Hayden Group (new).

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., 46 p.): Wendover-Meek Group is poorly represented in North Dakota. All beds from base of overlying Broom Creek to below radioactive markers are missing in broad areas of southeastern and eastern Montana, southwestern North Dakota, and northwestern South Dakota. Over rest of basin in North Dakota, Broom Creek rests directly on radioactive zones or is separated by few feet. Sandstone or sandy dolomite are most common lithologies of Wendover-Meek Group.

"Midale beds," subinterval

Age: Mississippian.

Area of extent: Southeastern Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Midale Oilfield, southeastern Saskatchewan. See also Rival subinterval, Midale subinterval, Frobisher-Alida interval, Ratcliffe interval, and Madison Group.

History of stratigraphic nomenclature:
Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 34-35): "Midale beds" of 80 feet of uniformly dolomitized, oolitic limestone and argillaceous dolomite, bounded below by "Frobisher-Alida beds" and above by "Midale evaporite." "Midale beds" most prolific of Mississippian oil-producing rocks in southeastern Saskatchewan.

Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 15): "Midale beds" of Fuller termed Midale subinterval of Ratcliffe interval in North Dakota.

Midale, "evaporite," "anhydrite"

Age: Mississippian.

Area of extent: Southeastern Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Midale Oilfield, southeastern Saskatchewan. See also Ratcliffe interval and Madison Formation.

History of stratigraphic nomenclature:
Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 35): "Midale evaporite" is anhydrite capping oil pools in several southeastern Saskatchewan oil fields.

MINNEKAHTA LIMESTONE

Age: Permian (Guadalupian).

Area of extent: Northeastern Wyoming, southeastern Montana, western South Dakota, and western North Dakota.

Reported fossils: Few molluscs, ostracods, and stromatolites.

Depositional environment: Marine.

Remarks: Type locality near Hot Springs, Black Hills, South Dakota. Is prominent carbonate tongue over sandstone in eastern Wyoming to Black Hills area.

History of stratigraphic nomenclature:
Darton, N. H., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 514): Minnekahta Limestone is thinly bedded gray limestone, 30-50 feet thick; underlies Spearfish Formation and overlies Opeche Formation in Black Hills. Referred to as "Purple limestone" in previous reports. Type locality is region near Hot Springs, South Dakota, originally known as "Minnekahta" by Indians.

Laird, W. M., and Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 2, sheet 1): Permian System of North Dakota includes Minnekahta Formation, 40 feet of pink to purple dolomite and limestone; underlain by Opeche Formation.

Burk, C. A., and Thomas, H. D., 1956 (Wyo. Geol. Surv. Rept. Invest. 6, 11 p.): Goose Egg Formation of eastern Wyoming is sequence of interbedded red shales and siltstones, thin limestones, gypsum, and limestone breccias. Overlies Minnelusa and equivalents (Tensleep, Casper, and Hartville); underlies Spearfish and equivalent (Chugwater). Minnekahta is limestone with farthest easterly extent, is underlain by Opeche Shale; less extensive limestones are overlying Forelle and Ervay, all of Phosphoria Group.

Goldsmith, J. W., 1959 (U.S. Geol. Surv. Misc. Inv. Map I-300, p. 4): Minnekahta is Permian (possibly Leonardian) in age.

MINNELUSA FORMATION, Sandstone, Group

Age: Pennsylvanian to Lower Permian.

Area of extent: Eastern and southeastern Montana, western North Dakota, western South Dakota, and northeastern Wyoming.

Reported fossils: Fusilinids, ostracods, and brachiopods (Mesolobus mesolobus), and Chaetetes milliporaceous.

Depositional environment: Marine.

Type section: Sundance Canyon, SW¼ sec 10, T52N, R61W, Crook County, Wyoming.

Remarks: See also Amsden Formation and Tyler Formation.

History of stratigraphic nomenclature:
Winchell, N. H., 1895 (in Ludlow, W., U.S. Eng. Dep., U.S. Army, Black Hills of Dakota, p. 38 and 65): Minnelusa Sandstone or upper sandstone consists of nearly white, crystalline, subsaccharoidal sandstone, coarsely granular when weathered and hard. Locally iron-stained. Thickness 75 feet in Black Hills. Underlies Upper Limestone and overlies Lower Limestone. Is Indian name of valley where exposed.

Jagger, T. A., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 3, p. 178-181): In northern Black Hills Minnelusa limestones and sandstones consist of (descend-

ing): 1) Minnelusa saccharoidal sandstone, 200 feet, 2) Minnelusa "alternate" series, 300 feet; and 3) Minnelusa white sandstone, 100 feet. Separated from overlying Minnekahta Limestone by 90 feet of red sandstone. Overlies 200-700 feet of gray limestone equivalent to Madison Limestone.

Darton, N. H., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 510): Minnelusa Formation consists of buff and red calcareous sandstones with thin limestones. 400-450 feet thick. Term Minnelusa used to designate all sandstones and limestones in Black Hills lying between Pahasapa Limestone below and red sandstones and shales of Opeche Formation above. Minnelusa is Dakota Indian name for Rapid Creek.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 2, p. 1382): Minnelusa Formation probably includes Permian strata at top and Mississippian strata at base.

Gries, J. P., and Tullis, E. L., 1955 (N.D. Geol. Soc. Gdbk. Black Hills Field Conf., p. 34): Lithologic correlation of upper Minnelusa beds with those in western Nebraska--Hartville, Wyoming area suggests uppermost Minnelusa in Black Hills may be Early Permian in age. No fossil evidence.

Reed, E. C., 1955 (N.D. Geol. Soc. Gdbk. Black Hills Field Conf., p. 46): Pennsylvanian-Permian boundary placed in eastern Wyoming and southwestern South Dakota in Hartville and Minnelusa Formations at top of Wendover Group and 150 feet below top of Minnelusa Formation in Black Hills.

Bates, R. L., 1955 (Am. Assoc. Pet. Geol. Bull. 39, p. 1991-1995): Term Minnelusa Sandstone is misnomer as type area contains 58 percent sandstone and subsurface sections contain lower proportion. Brecciated upper Minnelusa in southern Black Hills is correlative lithologically with upper evaporite zone of subsurface Minnelusa. Black Hills Minnelusa represents leached, thinner counterpart of more completely developed formation toward southwest (Hartville). Upper evaporite zone of subsurface Minnelusa appears contemporaneous with Upper Hartville (Wolfcampian(?)). No paleontologic evidence to refute or support this correlation.

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Permian-Pennsylvanian strata correlated with Hartville Formation of Hartville Formation of Wyoming and Minnelusa of Black Hills. Minnelusa is divided into (ascending): 1) Fairbank Formation, basal sandstone and shale; 2) Reclamation Group, limestone and dolomite sequence, 3) Hayden Group, dolomite and sandstone, and 4) Wendover-Meek Group, sands and shales. Unconformity truncates Hayden and Wendover-Meek Groups, separating strata from overlying dolomites, anhydrites, and sandstones of Broom Creek Group. In North Dakota, salt and silty shale section previously assigned to Opeche is thought to be time equivalent of Cassa. Unconformity separates Broom Creek and Cassa Groups in North Dakota. Fairbank, Reclamation, Roundtop, Hayden, and Wendover-Meek Groups are Pennsylvanian and Broom Creek and Cassa Groups are Permian.

Jennings, T. V., 1959 (J. Paleo, v. 33, no. 6, p. 986-1000): "Red marker bed" separates Pennsylvanian from Permian part of Minnelusa. Pennsylvanian part of Minnelusa correlated with Missourian-Virgilian, Desmoinesian, and Atokan stages based on fossil fusulinid evidence.

Sandberg, C. A., 1962 (U.S. Geol. Surv. TEI-809, p. 68): Amsden Formation included in lower part of Minnelusa in South Dakota.

Ziebarth, H. C., 1962 (Univ. N.D. Ph.D. Dissert., 414 p.): Minnelusa Group includes strata above unconformity on Madison and Big Snowy Groups and below Opeche Formation. Contains Tyler, Alaska Bench, Amsden, and Broom Creek Formations.

MISSION CANYON FORMATION, Limestone (of MADISON GROUP)

Age: Mississippian (Osagian to Meramecian).

Area of extent: Montana, South Dakota, North Dakota, southern Manitoba, and southeastern Saskatchewan.

Reported fossils: Crinoid debris, bryozoans, and few brachiopods.

Depositional environment: Marine.

Type section: Road cut on east side of U.S. Highway 89, 1.8 highway miles north of road intersection at Monarch and about 100 yards north of sign marking boundary of national forest, SW NE sec 27, T16N, R7E, Cascade County, Montana, and continues northward across SE¼ sec 22 into NE¼ sec 22 (Sando, W. J., and Dutro, J. T., Jr., 1974, p. 9). Named for Mission Canyon, Little Rocky Mountains, Montana.

History of stratigraphic nomenclature:

Collier, A. J., and Cathcart, S. H., 1922 (U.S. Geol. Surv. Bull. 736F, p. 173): Madison ranked as group where subdivided into two formations in Little Rocky Mountains of Montana. Formations named (descending) Mission Canyon Limestone (500 feet of thickly bedded limestone) and Lodgepole Limestone (800 feet of thinly bedded limestone) because of exposure in Mission and Lodgepole Canyons. Mission Canyon Limestone is not as fossiliferous as Lodgepole Limestone.

Sloss, L. L., and Hamblin, R. H., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 315): Mission Canyon Limestone lithologically and faunally identical with Castle Limestone whose usage has been discarded. Proposed that Mission Canyon be applied throughout Montana and northern Wyoming. Overlies Woodhurst Member of Lodgepole Limestone; underlies Amsden Formation, Ellis Formation, or Kibbey Sandstone.

Porter, J. W., 1955 (Alberta Soc. Pet. Geol. J. 3, p. 126-136): Charles, Mission Canyon, and Lodgepole Formations interfinger and exhibit facies relationships in subsurface of Williston Basin of Manitoba and Saskatchewan. Facies interpreted to be time transgressive as changes in lithology were lateral and vertical.

Anderson, S. B., 1958 (N.D. Geol. Surv. Rept. Invest. 31, p. 1-9): Madison is Group of intergrading belts of lithologies that cross time lines in subsurface of North Dakota. Charles magnafacies proposed for evaporitic facies and Mission Canyon magnafacies proposed for massive marine facies of Williston Basin to eliminate confusion caused by time connotation of original definition of formations within Madison Group.

Smith, M. H., 1960 (Am. Assoc. Pet. Geol. Bull. 44, no. 6, p. 959): Changes of nomenclature of Mississippian Madison Group reported by Committee of the Mississippian Madison Group of North Dakota Geological Society. Five marker-determined intervals and two subintervals defined by log deflection.

Carlson, C. G., and Anderson, S. B., 1970 (N.D. Geol. Surv. Misc. Ser. 28, p. 1842): Mission Canyon facies shown to include all of Tilston interval and parts of Frobisher-Alida interval, Midale subinterval, and Ratcliffe interval.

Sando, W. J., and Dutro, J. T., Jr., 1974 (U.S. Geol. Surv. Prof. Paper 842, p. 9): Type section for Mission Canyon Limestone described.

MOBRIDGE MEMBER (of PIERRE FORMATION, SHALE)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Eastern North Dakota and eastern South Dakota.

Depositional environment: Marine.

Remarks: Typical exposure above west end of old highway bridge across Missouri River at Mobridge, Walworth County, South Dakota. Named from Mobridge, South Dakota.

History of stratigraphic nomenclature:
Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 44-49): Thinly laminated, calcareous, medium-bluish-gray to dark-gray shale, marl, and chalk. Weathers to light or brownish buff; lighter shades of buff generally predominate in upper and lower parts of section. Beds uniform; total thickness 90-230 feet. Overlies gumbo-forming shale of Virgin Creek Member and underlies noncalcareous shale of Elk Butte Member.

Fisher, S. P., 1952 (N.D. Geol. Surv. Bull. 26, p. 8-10): Mobridge Member may be present in Emmons County, North Dakota.

MONTANA GROUP

Age: Late Cretaceous (Santonian to Maestrichtian).

Area of extent: Montana, Wyoming, Colorado, North Dakota, South Dakota, Kansas.

Reported fossils: Baculites, other cephalopods, and Inoceramus.

Depositional environment: Marine to nonmarine.

Remarks: Named from exposures along Upper Missouri River, north-central Montana.

History of stratigraphic nomenclature:
Eldridge, G. H., 1888 (Colo. Sci. Soc. Proc., v. 3, pt. 1, p. 93 footnote): With approval of C. A. White, Montana Group introduced to replace Fox Hills Group; includes Fox Hills Sandstone and Pierre Shale.

_____, 1889 (Am. J. Sci. 3rd Ser., v. 38, p. 313-321): Original subdivisions of Fox Hills Sandstone and Pierre Shale are recognized in Dakotas, eastern Montana, eastern Wyoming, and eastern Colorado. Group divided into (descending) Bearpaw Shale, Judith River Formation, Claggett Shale and Eagle Sandstone in southern Montana; divided into Horsethief Sandstone, Bearpaw Shale, Two Medicine Formation, and Eagle Sandstone in northwestern Montana; divided into Lewis Shale, Mesaverde Formation, and Steele Shale in central and southern Wyoming. Group is overlain by Laramie Formation (Upper Cretaceous) in eastern Colorado; overlain by Medicine Bow Formation (Upper Cretaceous) in central southern Wyoming; and by Lance Formation (Upper Cretaceous elsewhere in Wyoming and Montana).

Laird, W. M., and Towse, D. F., 1958 (rev.) (N.D. Geol. Surv. Rept. Invest. 2, 2 sheets): Stratigraphy of North Dakota includes Montana stage consisting of Fox Hills and Pierre Formations.

Gill, J. R., Cobban, W. A., and Schultz, L. G., 1972 (Mont. Geol. Soc. 21st Ann. Field Conf., p. 91-97): Rocks of type Montana Group are cyclic Upper Cretaceous transgressive and regressive deposits. Marine shale of Colorado, Claggett, and Bearpaw represent periods of transgression and local westward expansion of sea; Telegraph Creek-Eagle, Parkman-Judith River, and Fox Hills-Hell Creek Formations record episodes of regression and eastward movements of strand.

Gill, J. R., and Cobban, W. A., 1973 (U.S. Geol. Surv. Prof. Paper 776, 37 p): Rocks of type Montana Group in Montana and equivalent rocks in adjacent states

consist of eastward-pointing wedges of shallow-water marine and nonmarine strata that enclose westward-pointing wedges of fine-grained marine strata. Beds of bentonite occur in transgressive part of Claggett and Bearpaw Shales. Strandline movement more rapid during transgressions. Final phase of Fox Hills regression produced Sheridan delta. Twenty-nine ammonite zones characterize marine strata of Montana Group; suggested that Hell Creek Formation be included in Montana Group.

Montana series

Remarks: Proposed by G. H. Ashley, 1923 (Eng. Min. J.--Press, v. 115, p. 1106-1108) to include Montana Group and overlying Laramie Formation.

MORDEN MEMBER (of Vermilion River Formation)

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota; equivalent to Carlile of current usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Repts., pt. B, p. 128): Used term Morden beds for dark-gray, almost black shales underlying Boyne beds in Pembina valley area of Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 1011-1043): Morden Member of Vermilion River Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Overlies Assiniboine Member of Favel Formation; underlies Boyne Member of Vermilion River Formation.

Wosick, F. D., 1977 (Univ. of N.D. M.S. Thesis, 152 p.): Morden Member of Vermilion River Formation crops out in eastern Cavalier County, North Dakota. Canadian Morden Member used instead of Carlile Formation because of lithologic similarity and proximity to Morden type area. Is dark-gray to black, noncalcareous, organic-rich shale. Is 225 feet thick, thins toward outer edge of Williston Basin.

MORRISON FORMATION

Age: Late Jurassic.

Area of extent: Widespread, southern and northern Rocky Mountains and adjacent plains.

Reported fossils: Dinosaurs, fossil wood, "gastroliths," rare molluscs, and microfossils.

Depositional environment: Marine to nonmarine.

Remarks: Type locality near Morrison, Jefferson County, Colorado.

History of stratigraphic nomenclature:
Cross, W., 1894 (U.S. Geol. Surv. Folio 7, 8 p., 5 maps): Morrison Formation described.

Eldridge, G. H., 1896 (U.S. Geol. Surv. Mon. 27, p. 51-62): Morrison Formation is fresh-water marls 200±feet thick throughout Denver region and along east base

of Rocky Mountains. Overlain by Dakota sandstone, underlain by brown and pink sandstone of Triassic. Marls are green, drab or gray and have lenticular, drab-colored limestone in lower two-thirds. At 20 feet above base occurs persistent band of alternating limestone and sandstone or all sandstone, 10-15 feet thick. Clays of lower two-thirds contain reptilian remains and are called Atlantosaurus clays from dominant form. Upper one-third of Morrison is succession of sandstones and marls. Saurian sandstone occurs just above Atlantosaurus clays; 5-35 feet thick; and is 10-125 feet below Dakota Sandstone. Morrison is unconformable with underlying Wyoming Formation.

Darton, N. H., 1904 (Geol. Soc. Am. Bull. 15, p. 388): Thickness of Morrison is up to 150 feet in Black Hills region. Absent to southeast where unconformity shows erosion on surface of Unkpapa Sandstone. Unconformably underlies Lakota Sandstone. Formation has been known as Atlantosaurus beds and Beulah Shale.

Lee, W. T., 1920 (Am. J. Sci. 4th Ser., v. 291, p. 183-188): Type section of Morrison redefined. Strata originally assigned to Morrison include those equivalent to Sundance Formation and those that contain fossil plants of Upper Cretaceous type. Section at Morrison comprised 10 units (numbered in descending order 1-10). Units 1-5 are Dakota Group (265 feet thick); units 6-7 are Morrison Formation (160 feet thick); and units 8-10 are Sundance Formation (17 feet thick). Units 1-3 regarded as two sandstones of Dakota and shale is "Dakota fire clay." Unit 4 is part of Morrison as originally defined, yet contains fossil plants described as belonging to "Dakota flora" (100 feet thick). Unit 5 (10 feet thick) is conglomeratic sandstone--Saurian conglomerate--containing dinosaur bones and pebbles of quartz and jasper; is sharply separated from underlying shale.

_____, 1927 (U.S. Geol. Surv. Prof. Paper 149, p. 17): At Morrison, Colorado, type locality of Morrison Formation, rocks were once assigned to this formation that do not belong; at base is 17 feet or more of orange sandstone now known to be unconformable with overlying Morrison and underlying Lykins, and at top is nearly 200 feet of beds younger than Morrison. Thicknesses given in this paper should replace thicknesses previously published (1920). Cretaceous (?).

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 2, p. 1424): In western South Dakota, Wyoming, and eastern Colorado, Morrison Formation is underlain by marine Sundance Formation of Late Jurassic age. U.S. Geological Survey classifies Morrison as Upper Jurassic although for many years it was considered Lower Cretaceous (?).

Waldschmidt, W. A., and LeRoy, L. W., 1944 (Geol. Soc. Am. Bull. 55, p. 1097-1114): Revised type section proposed. Subdivided into six lithologic units. Basal sandstone unit is of 7 feet of buff, massive, locally cross-bedded, coarse- to medium-grained, calcareous sandstone, conglomeratic in lower part; north from type locality unit thickens to 30 feet. Gray and red shale unit represents lower 55 feet of Morrison. Gray clay and limestone unit of interbedded gray clay and gray lithographic fresh-water limestones is 49.75 feet thick. Gray shale and sandstone unit is 51.5 feet thick. Red shale unit is 36.75 feet thick and most highly colored interval in formation. Sandstone and shale unit is 76.5 feet thick; variegated sandy shales, maroon most prevalent, constitutes about 30 percent interval. Formation, as herein described, is mappable unit between Dakota Sandstone as originally defined by Eldridge (1896) and strata assigned to probable Sundance by Lee (1920) which have, in part, been assigned to Ralston Formation (new). Age is Jurassic. As herein defined, Morrison lies with apparent disconformity below conglomeratic phase of Dakota as defined by Eldridge (1896) and Lee (1927), and overlies disconformably red, sandy shales assigned to Lykins Formation. At some localities, basal sandstone of Morrison is in juxtaposition with strata that have been correlated with Sundance (Jurassic) and that have been included in Ralston Formation.

Peterson, J. A., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 464): Morrison is Kimmeridgian (Late Jurassic) in age.

Francis, D. R., 1957 (Am. Assoc. Pet. Geol. Bull. 41, p. 393): Morrison of Williston Basin is complex series of shales and sandstones with abrupt facies changes. In North Dakota, Morrison is light- and dark-gray shale interbedded with light-gray fine-grained sandstone.

Waage, K. M., 1959 (U.S. Geol. Surv. Bull. 1081-B, p. 38-40, 50-52): In Black Hills region, Morrison underlies Lakota Formation. Thickness is 21.5-111 feet. Position of Morrison-Lakota contact is problem, because of lack of persistent well-defined lithic change. Beds called Morrison in Black Hills may be equivalent to only part of sequence of beds of type Morrison. In area of type Morrison, conglomeratic lenses occur at two horizons, suggesting hiatuses; one is at base of Lytle Formation, other is at base of upper third of Morrison. Top of Lytle is marked by transgressive disconformity that also marks top of Lakota. Matching breaks in Front Range and Black Hills sequences leads to matching Lytle with upper Lakota and upper third of Morrison with lower Dakota.

Sandberg, C. A., 1962 (U.S. Geol. Surv. TEI-809, p. 90-91): In parts of Williston Basin, sandstone in upper part of Morrison is indistinguishable from sandstone at base of overlying Dakota Group of Early Cretaceous age.

MOWRY FORMATION, SHALE (of COLORADO GROUP)

Age: Early Cretaceous (Albian).

Area of extent: Montana, North Dakota, South Dakota, Colorado, and Wyoming.

Reported fossils: Fish remains, shark teeth.

Depositional environment: Marine.

Remarks: Type locality along Mowry Creek, northwest of Buffalo, Johnson County, Wyoming.

History of stratigraphic nomenclature:
Darton, N. H., 1904 (Geol. Soc. Am. Bull. 15, p. 394-401): Mowrie beds consist of hard, light-gray shale and thin-bedded sandstone that weathers to light gray and forms ridges. Contains large number of fish scales and occasional fish teeth and bones.

Rubey, W. W., 1931 (U.S. Geol. Surv. Prof. Paper 165-A, p. 4): Nefsy Shale Member of Graneros Shale now included in base of Mowry Shale into which it grades; Nefsy usage has been abandoned.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 2, p. 1575): Mowry has been approved spelling of this name since 1906.

Reeside, J. B., Jr., 1944 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 10): Mowry Shale overlies Newcastle Sandstone; underlies Belle Fourche Shale. Is Late Cretaceous in age.

Cobban, W. A., and Reeside, J. B., Jr., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 1892-1893): Uncrushed ammonites collected from Mowry Shale belong to Early Cretaceous genera Gastroplites and Neogastroplites.

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2179-2181): Formations equivalent to Colorado Shale are Fall River Sandstone, Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, and Niobrara Formation. Mowry, in northern Black Hills, consists of 235 feet of light-gray weathering, siliceous shale with abundant marine fish

scales, and interbedded with creamy white layers of bentonite (Clay Spur Bentonite at top). In central Montana, beds are less siliceous and more sandy. Farther west, rocks of Mowry age thicken and become more sandy; lower part passes into nonmarine sediments with tuff, bentonite, and bentonitic mudstone. Mowry considered formation in Black Hills and member of Colorado Shale in central Montana. Is Early Cretaceous in age.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, pl. 1): Boundary between Early and Late Cretaceous placed at top of Mowry Shale. Mowry considered Aptian in age.

Gries, J. P., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 446-449): Term Dakota Group applied to thick sandstone sequence in central South Dakota where called "true Dakota" and overlies Skull Creek Shale. "True Dakota" is age equivalent of Newcastle-Mowry interval, and what is called Dakota in Williston Basin to north is actually Fall River Sandstone.

_____, 1962 (Wyo. Geol. Assoc. Gdbk. 17th Ann. Field Conf., p. 170): East of Black Hills, Mowry Shale interval only irregularly silicified and much of it resembles underlying Skull Creek Shale. Mowry merges with Dakota of central South Dakota.

Wulf, G. R., 1962 (Am. Assoc. Pet. Geol. Bull. 46, p. 1396-1402): Mowry Shale in Williston Basin subdivided into two units, separated by marker bentonite bed. Dynneson (lower) unit is shale with two prominent sandstone lithofacies named Dynneson (of Williston Basin) and Bow Island (of northwest Montana). Base of Dynneson unit is marked by disconformity at top of Skull Creek. Where Dynneson is absent, unit called "lower Mowry." Dynneson Sandstone Member is blanket-type sandstone with shoestring sandstone bodies on top. Grains are light gray and fine.

"Muddy Sandstone"

Age: Early Cretaceous (Albian).

Area of extent: Wyoming, southern Montana and South Dakota; equivalent strata referred to as Newcastle in North Dakota.

Reported fossils: Occasional plant fossils and pelecypods.

Depositional environment: Marine.

Remarks: Subsurface term originally used in Big Horn Basin oil fields by drillers because sand mixed with interbedded shale to form "muddy" mixture.

Nesson Formation

Age: Middle Jurassic (Bajocian).

Area of extent: Central and eastern Montana; equivalent to part of Piper Formation of current North Dakota usage; equivalent strata in Saskatchewan are referred to upper part of Watrous Formation.

Depositional environment: Marine.

Type section: Interval of 5,730-5,990 feet in Amerada No. 1 Clarence Iverson well, center SW SW sec 6, T155N, R95W, Williams County, North Dakota.

Remarks: Named for Nesson anticline. See also Poe Evaporite, Picard Shale, and Kline Member.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 104-106): Nesson Formation proposed for sequence of carbonates and evaporites with Tempico Shale Member (new) of Piper Formation in Williston Basin area; unconformably overlies Triassic(?) Spearfish Formation. Thickness is 260 feet. Includes (ascending): Poe Evaporite, Picard Shale, and Kline Members. Formation pinches out by nondeposition on west side of Bowdoin Dome; wedges out northeast of Big Snowy Platform and has no equivalent in Piper type section on north flank of Big Snowy Mountains.

NEWCASTLE FORMATION, SANDSTONE (of DAKOTA GROUP)

Age: Early Cretaceous (Albian).

Area of extent: Southeastern Montana, North Dakota, South Dakota, and eastern Wyoming; equivalent to Viking Formation in Saskatchewan.

Reported fossils: Occasional plant fossils and pelecypods.

Depositional environment: Marine.

Type section: NW NW sec 28, T45N, R61W, exposed on northwest side of cut on Highway 85, 0.4 miles northeast of junction with U.S. Highway 16, 1 mile east of Newcastle, Weston County, Wyoming.

Remarks: Also called Muddy Sandstone.

History of stratigraphic nomenclature:
Hancock, E. T., 1920 (U.S. Geol. Surv. Bull. 716, p. 39, 42, 96): Newcastle Sandstone Member of Graneros Shale consists of reddish to light-yellow sandstone associated with black carbonaceous shale. Named for exposures at Newcastle, Wyoming.

Reeside, J. B., Jr., 1944 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 10): Rank raised to formation and Newcastle is basal Late Cretaceous sand of Black Hills. Underlies Mowry; overlies Skull Creek.

Crowley, A. J., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 83-107): Suggested that Black Hills were uplifted during closing stage of Early Cretaceous time, and that Precambrian core supplied sand for Newcastle. Newcastle is interpreted to be closing phase of Early Cretaceous deposition and overlying Mowry is introductory phase of Upper Cretaceous.

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2196-2197): Formations in Black Hills that are equivalent to Colorado Shale are Fall River Sandstone, Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, and Niobrara Formation. Newcastle of northern Black Hills consists of 40 feet of lenticular sandstone, dark-gray shale, bentonite, and lignite. In central and northwestern Montana, equivalent rocks, 300-430 feet thick, are largely gray-weathering sandy shale, with thin layers of bentonite.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 76): Crowley's 1951 hypothesis not tenable as faunal collections near Rapid City contain Early and Late Cretaceous species.

Grace, R. M., 1952 (Wyo. Geol. Surv. Bull. 44, p. 5): Newcastle Formation has shale and siltstone facies with distribution of equal magnitude to that of sandstone facies. Newcastle Formation is preferred usage. Two phases of formation are indicated--carbonaceous one on west and northwest flanks of Black Hills and noncarbonaceous one on east flank.

Gries, J. P., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 446-449): Dakota not used in Black Hills but applied to thick sequence in central South Dakota where it is called "true Dakota" and overlies Skull Creek Shale. "True Dakota" is age equivalent of Newcastle-Mowry interval, and what is called Dakota in Williston Basin to north is actually Fall River Sandstone.

Skolnick, H., 1958 (Am. Assoc. Pet. Geol., Bull. 42, p. 787-815): Newcastle is member of Skull Creek Formation and is Early Cretaceous. Faunal and mineralogical evidence indicates that physically and spatially Skull Creek Shale, Newcastle Sandstone, and lower Mowry Shale are sufficiently related to be considered one unit. Type section given.

Pettyjohn, W. A., 1960 (S.D. Acad. Sci. Proc., v. 38, p. 34-38): Suggested term Dakota Group be used to include Lakota, Fuson, Fall River, Skull Creek, and Newcastle Formations.

Gries, J. P., 1962 (Wyo. Geol. Assoc. Gdbk. 17th Ann. Field Conf., p. 170): Newcastle described as series of bars along constantly changing shoreline, rather than deposits due to uplift of Black Hills.

Wulf, G. R., 1962 (Am. Assoc. Pet. Geol. Bull. 46, p. 1378): Described new unit Dynneson Sand in northwestern South Dakota and adjoining parts of Wyoming, Montana, and North Dakota which has been called Newcastle in previous reports of Williston Basin. Newcastle considered to be lenticular sand member at top of Skull Creek Shale. Newcastle is channel sandstone, and Newcastle delta extended westward from western South Dakota into northeastern Wyoming and southeastern Montana.

NIOBRARA FORMATION, SHALE (of COLORADO GROUP)

Age: Late Cretaceous (Coniacian to Campanian).

Area of extent: Montana, eastern Wyoming, North Dakota, South Dakota, Nebraska, Kansas, northeastern New Mexico and eastern Colorado; top of Niobrara Formation equivalent to "first white specks" zone in Saskatchewan and Manitoba.

Reported fossils: Inoceramus deformis, Ostrea congesta, Scaphites, and other cephalopods.

Depositional environment: Marine.

Remarks: Named from exposures near mouth of Niobrara River, Knox County, Nebraska.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 419, 422): Niobrara division (Formation No. 3 of Cretaceous) consists of upper part of lead-gray calcareous marl, weathering to yellowish or whitish chalky appearance; lower part is light-yellowish and whitish limestone. Total thickness is 200 feet and occurs in bluffs along Missouri River below Great Bend to vicinity of Big Sioux River. Overlies Fort Benton Group (now Benton Shale) and underlies Fort Pierre Group (now Pierre Shale).

Leonard, A. G., 1906 (N.D. Geol. Surv. 4th Bienn. Rept., p. 67-71): Niobrara is upper member of Colorado Formation in North Dakota. Is exposed along Little Pembina and Sheyenne Rivers. Contains more calcareous clays than Benton.

Wilmarth, M. G., 1938 (U.S. Geol. Surv. Bull. 896, pt. 2, p. 1500): Niobrara is upper formation of Colorado Group. In places, deposits are chiefly or wholly shale and are called Niobrara Shale.

Cobban, W. A., 1951 (Am. Assoc. Pet. Geol. Bull. 35, p. 2170, 2187, 2192-2198): Formations in Black Hills that are equivalent to Colorado Shale of central and northwestern Montana are (ascending): Fall River Sandstone, Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Shale, and Niobrara Formation. In northern Black Hills, Niobrara consists of gray chalk marl that weathers creamy, pale yellow or orange; thin layers of bentonite abundant, dark-gray noncalcareous shale partings present near base and top of formation. Sage Breaks Shale reallocated to member of Carlile Shale.

"'Nisku' Formation"

Age: Late Devonian (Senecan).

Area of extent: Central Alberta; equivalent strata in North Dakota are Birdbear of current usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Layer, D. B., 1950 (Am. Assoc. Pet. Geol. Bull. 34, p. 1815): Nisku Member of Winterburn Formation; buff dolomite; type section interval from 4909 to 5065 in the B. A.-Pyrcz No. 1 ls 12-25-50-4W.

Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): "Nisku equivalent" is Devonian "A" (previous usage of North Dakota Geological Survey).

ODANAH MEMBER, "Series" (of PIERRE FORMATION, SHALE; of Riding Mountain Formation)

Age: Late Cretaceous (Campanian).

Area of extent: Southern Manitoba and eastern North Dakota; equivalent to Verendrye Member in South Dakota.

Reported fossils: Only Inoceramus and radiolarians reported from North Dakota.

Depositional environment: Marine.

Remarks: Named from locality near Minnedosa, Manitoba, 85 miles north of International Boundary.

History of stratigraphic nomenclature:
Tyrrell, J. B., 1893 (Can. Geol. Surv. New Ser., v. 5, pt. 1, p. 83E-85E, 199E, 212E-215E): Odanah series of Pierre Shale is light-gray, hard, fissile shale occurring on upper portion of Riding Mountain in Manitoba and southward to International Boundary. Very few fossils.

MacLean, A., 1916 (Can. Geol. Surv. Summ. Rept. 1915, p. 131-133): Odanah is hard, light-colored shale above soft Millwood beds in Pembina Mountain area.

Williams, M. Y., 1932 (J. Geol., v. 40, p. 561): Odanah of Manitoba is correlated with Bearpaw of Montana, Wyoming, and Alberta.

Wickenden, R. T. D., 1945 (Can. Geol. Surv. Mem. 239, p. 48): Odanah is poorly defined hard facies of Riding Mountain Formation.

Tovell, W. M., 1948 (Man. Dep. Mines Nat. Resour., Mines Br. Prelim. Rept. 47-7, p. 6): Odanah treated as distinct member of Riding Mountain Formation.

Gill, J. R., and Cobban, W. A., 1965 (U.S. Geol. Surv. Prof. Paper 392-A, p. A15-A16, A18): Odanah Member of Pierre Shale is hard, siliceous shale that

overlies DeGrey Member. Thickness of Odanah in Pembina Mountains is unknown. Lower 65 feet crops out along North Dakota Highway 5 near Tongue River. 200 feet crops out in Pembina Mountains of Manitoba. Outcrops of Odanah are scarce in rest of North Dakota and with little thickness. Part of Odanah grades southwest to Virgin Creek Member of Pierre Shale in South Dakota.

Bluemle, J. P., 1973 (N.D. Geol. Surv. Bull. 57, pt. 1, p. 12): Odanah Member crops out in Walsh and Nelson Counties, North Dakota; is hard, siliceous, gray shale with reddish-brown and purple stains on joint faces and concretions. Appears to be jointed along north-south zone that may be result of glacial movement or loading.

Arndt, B. M., 1957 (N.D. Geol. Surv. Bull. 62, pt. 1, p. 7): Odanah Member in Cavalier and Pembina Counties, North Dakota; weathers into distinct plates or flakes.

OPECHE FORMATION, Salt

Age: Permian (Leonardian).

Area of extent: Western North Dakota and western South Dakota, northeastern Wyoming, eastern Montana, and northwestern Nebraska.

Depositional environment: Marine.

Remarks: Type locality on Battle Creek; Opeche is Indian name for Battle Creek.

History of stratigraphic nomenclature:
Darton, N. H., 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 513): Red, soft, sandstone and sandy shale; deep-purple shale at top, basal beds usually red sandstone, 4-15 inches thick. Underlies Minnekahta Limestone and overlies Minnelusa Formation. Typically developed on Battle Creek; Indian name of which is Opeche.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 72): In southern Black Hills, between typical Minnelusa and typical Opeche beds is up to 120 feet of "transitional beds" of fine, brick-red sandstone in outcrop and orange or mottled red and orange sandstone in subsurface. These beds included with Cassa Group of Minnelusa or in Opeche Formation. No fossils in Opeche but usually considered to be Permian.

Laird, W. M., and Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 2, 1 sheet): Permian System in North Dakota includes Opeche, 88 feet of red shale and anhydrite, overlain by Minnekahta Formation.

Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Opeche Formation, reddish sandstone, siltstone, and red shale sequence in North Dakota, contains Permian "A" Salt. Opeche overlain conformably by Permian Minnekahta and unconformably overlies Pennsylvanian Minnelusa. Permian "B" Salt occurs below "A" Salt but not extensive.

OTTER FORMATION (of BIG SNOWY GROUP)

Age: Mississippian (Chesterian).

Area of extent: Central and eastern Montana and western North Dakota.

Reported fossils: Algae and ostracods.

Depositional environment: Marine.

Remarks: Type locality is Otter Creek, Fort Benton quadrangle, Montana.

History of stratigraphic nomenclature:

Weed, W. H., 1892 (Geol. Soc. Am. Bull. 3, p. 307): Detailed section at Belt Creek, Montana consists of following succession in lower part: 1) conglomerate and sandstone with Jurassic fossils, 215 feet; 2) white limestone, red earthy patches, Paleozoic facies, 90 feet; 3) Otter Creek Shale, alternating gray, purple, green, and black shales and earthy limestones yielding carboniferous fossils, 212 feet; 4) black chert, 8 feet; 5) limestone and shale, 80 feet; and 6) gypsum, 3 feet.

_____, 1899 (U.S. Geol. Surv. Geol. Atlas Folio No. 55): In Fort Benton quadrangle, lowest beds of Quadrant Formation are gypsiferous Kibbey Sandstone, overlain by Otter Shale. Otter is upper member of Quadrant Formation, 303 feet of dark-gray or purple basal shales, becoming bright coppery green higher up, and interbedded with limestone (1 or 2 feet thick, oolitic, with lower carboniferous fossils). Otter assigned to Carboniferous. Otter Shale overlain by Ellis Formation.

Scott, H. W., 1935 (Geol. Soc. Am. Proc., 1934, p. 367): Big Snowy Group consists of Kibbey, Otter, and Heath Formations. Otter is variegated shale with intercalated limestones and sandstones. Overlies Madison Limestone.

Anderson, S. B., 1954 (N.D. Geol. Surv. Rept. Invest. 16, 2 sheets): Otter Formation present over western half of North Dakota in subsurface. Consists mainly of variegated shales and little limestone.

PEMBINA MEMBER (of PIERRE FORMATION, SHALE, Vermilion River Formation)

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and eastern North Dakota; equivalent strata termed Sharon Springs Member in South Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:

Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Rept., 1929, pt. B, p. 112-B-135B): The name Pembina applies to the group of beds overlying the Boyne in all localities where the top of the Boyne is exposed in the Pembina Mountain area.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, no. 10, p. 1011-1043): Pembina Member of Vermilion River Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Conformably underlies Riding Mountain Formation, unconformably overlies Boyne Member of Vermilion River Formation.

Gill, J. R., and Cobban, W. A., 1965 (U.S. Geol. Surv. Prof. Paper 392A, p. 6-7): Pembina Member of Pierre Shale found in Pembina Mountain area of North Dakota is 80 feet of dark noncalcareous shale resting on Boyne Member of Vermilion River Formation or Niobrara Formation of North Dakota.

Permian "A" and "B" salts.

Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Permian "A" salt is sequence of salt in Opeche Formation. Section difficult to pick because of associated impurities. Occupies most of Williston Basin, but lateral extent not as far as Mississippian salt. Greatest thickness is 181 feet. Permian "B" salt lies below Permian "A" salt but is not extensive.

PICARD SHALE MEMBER (of Nesson Formation, PIPER FORMATION)

Age: Middle Jurassic (Bajocian).

Area of extent: Eastern Montana, western North Dakota; equivalent strata included in upper part of Watrous Formation in Saskatchewan.

Depositional environment: Marine.

Type section: Interval of 6,610-6,650 feet in Deep Rock Oil Corp. No. 1 Picard well, center NW NE sec 6, T29N, R52E, Roosevelt County, Montana.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 104-105): Picard Shale Member is shale unit that conformably overlies Poe Evaporite Member (new) and underlies Kline Member (new). In type section, consists of 40 feet of dark-red shale that is slightly silty in part and contains masses or thin interbeds of white, earthy gypsum in lower half of unit. Thins toward margins of Williston Basin.

PIERRE FORMATION, SHALE

Age: Late Cretaceous (Campanian to Maestrichtian).

Area of extent: North Dakota, South Dakota, eastern Montana, eastern Wyoming, eastern Colorado, Nebraska, and Kansas.

Reported fossils: Numerous species of Baculites, Scaphites, and other cephalopods, Inoceramus, and foraminiferans.

Depositional environment: Marine.

Type section: Exposure at Fort Pierre in either Stanley or Hughes County, South Dakota. Exact location of Fort Pierre not known.

Remarks: Equivalent to total section of Bearpaw, Judith River, Claggett, Eagle, and Telegraph Creek Formations of central and northern Montana.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 419, 424): Named Fort Pierre Group (Formation No. 4 of Cretaceous). Thickness 700 feet in Nebraska [then included Wyoming, Montana, and Dakotas]. Underlies Fox Hills beds and overlies Niobrara. Fort Pierre Group consists of (descending): 1) dark-gray and blue fossiliferous plastic clays exposed on Sage Creek, Cheyenne River, and White River; 2) middle zone, barren of fossils exposed at Fort Pierre and in Badlands and down Missouri River or high country to Great Bend of Missouri River, 3) lower fossiliferous zone exposed at Great Bend of Missouri, and 4) dark bed of very fine clay containing much carbonaceous matter with veins and seams of gypsum, masses of sulphuret of iron, and fish scales exposed near Bijou Hills on Missouri River.

White, C. A., 1878 (U.S. Geol. and Geog. Surv. Terr. 10th Ann. Rept., p. 21, 22, 30): Fort Pierre Group [Pierre Shale of present usage] transferred from Colorado Group to overlying Fox Hills Group.

Darton, N. H., 1896 (U.S. Geol. Surv. Ann. Rept. 17, p. 609-694): Previous descriptions repeated but name shortened to Pierre. Pierre is extended to Yankton and under Turkey Ridge of South Dakota.

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 42): Pierre found in northwestern Bowman County, North Dakota, and into eastern Montana on an anticlinal fold. Pierre Shale is bluish-gray shale, jointed, weathers to small

flaky fragments with iron-oxide staining. Numerous concretions of impure lime carbonate, and marine fossil shells occur in the formation.

Barry, J. G., and Melsted, V. J., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 171-184): Described as conformably overlying the Niobrara Shale with actual contact perhaps at base of series of black and yellow bands that are uniform over large distance. Pierre reaches a thickness of 1000 feet in central part of North Dakota and thins toward eastern edge due to erosion. Pierre is gray to black shale with clay ironstone in lower 40-50 feet.

Rubey, W. W., 1931 (U.S. Geol. Surv. Prof. Paper 165-A, p. 3-4): Pierre Shale of Black Hills, South Dakota, includes (descending) 150-200 feet of unnamed, dark-gray fissile shale and mudstone, 150 feet of Monument Hill Bentonitic Member, 500-800 feet of unnamed mudstone shale, 150-200 feet of Mitten Black Shale Member, and 800-1000 feet of Gammon Ferruginous Member with Groat Sandstone bed (150 feet in northern part). Overlies Niobrara Formation; underlies Fox Hills Sandstone.

Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 5-63): Along Missouri River of South Dakota, Pierre includes (descending): 1) Elk Butte, of fine, medium-gray shale; 2) Mobridge, of buff, calcareous shale, marl, and chalk beds; 3) Virgin Creek, of light- to medium-gray hard shale with thin bentonite beds and concretions; 4) Sully, of clay and shale with concretions of clay ironstone (Verendrye shale zone), bentonite clays and shales with manganiferous iron concretions (Oacoma zone), and hard, gray, siliceous shale (Agency shale zone); and 5) Gregory Member, of dark bentonite-bearing, bituminous shale with chalk beds at top. Total thickness 361-1204 feet. Overlies Niobrara Formation; underlies Fox Hills Formation.

Moxon, A. L., Olson, O. E., Searight, W. V., and Sandals, K. M., 1938 (Am. J. Botany, v. 25, p. 795-796): Lower Gregory changed to Sharon Springs Member. Mobridge replaced by Interior, as Interior has precedence.

Moxon, A. L., Olson, O. E., and Searight, W. V., 1939 (S.D. Agr. Exp. Sta. Tech. Bull. 2, p. 20): Sharon Springs is considered to be all beds above Niobrara and below Gregory marl (Crow Creek Member). Sharon Springs is divided into upper and lower unit.

Gries, J. P., and Rothrock, E. P., 1941 (S.D. Geol. Surv. Rept. Invest. 38, p. 9-30): Pierre redefined in South Dakota as follows (descending): 1) Elk Butte, of dark, gray shales, 2) Mobridge, of chalk, chalky shale, and sandy shale, 3) Virgin Creek, of upper zone of gray shale, lower zone of gray shale with bentonite beds, 4) Sully, 5) Gregory, of upper thick shale zone and lower chalk beds, and 6) Sharon Springs Members, of upper shale zone and lower fish scale zone in dark-gray shale. Sully Member further subdivided (descending): 1) Verendrye zone, of light- to medium-dark shale, with iron-manganese carbonate concretions, 2) Oacoma zone, of upper beds contain abundant iron-manganese concretions and numerous bentonites, lower beds contain fewer concretions, 3) Agency zone, of hard, light gray, siliceous shale, and 4) Crow Creek zone, of marl or impure chalk over basal sandstone.

Gries, J. P., 1942 (S.D. Geol. Surv. Rept. Invest. 43, p. 5-29): Same usage followed as above with following exceptions: 1) Oacoma zone and Agency zone of Sully Member combined to Agency-Oacoma zone, 2) Gregory Member not divided into shale zone and marl, and 3) Sharon Springs Member not divided into upper and lower zones.

Crandell, D. R., 1950 (Am. Assoc. Pet. Geol. Bull. 34, p. 2337-2346): DeGrey Member proposed for Agency-Oacoma zone. All zones of Sully Member raised to member status, Sully no longer used. Pierre Shale of central South Dakota includes (descending): Elk Butte, Mobridge, Virgin Creek, Verendrye, DeGrey, Crow Creek, Gregory, and Sharon Springs Members.

Fisher, S. P., 1952 (N.D. Geol. Surv. Bull. 26, p. 8-10): Pierre is oldest formation exposed in Emmons County. Most of Pierre is Elk Butte Member; Mobridge Member may be present. Total thickness 135 feet; underlies Fox Hills Formation.

Wilson, E. E., 1958 (Univ. N. D. Master's Thesis, 134 p.): Lowest unit of Pierre Shale of Cavalier County, North Dakota, probably equivalent to Sharon Springs Member of South Dakota and Pembina Member of Vermilion River Formation of Manitoba and Saskatchewan. Stratigraphically higher unit may be equivalent to southern Sheyenne River section. Highest unit may be equivalent to "Odanah" beds of Manitoba. Pierre of northern Sheyenne River and Stutsman County may be equivalent to Verendrye and DeGrey Members of South Dakota. Emmons County has equivalent of Elk Butte Member; Bowman County strata, similar to Emmons County strata, are older and may be equivalent to Mobridge Member.

Gill, J. R., and Cobban, W. A., 1962 (U.S. Geol. Surv. Prof. Paper 450-B, p. 21-24): 200-725 feet of gray, marine, silty shale, named Red Bird Silty Member and is lowest of two unnamed shales above Mitten Member and below Monument Hill in eastern Montana and Wyoming, and western South Dakota. Traceable into Gregory and Crow Creek Members of Pierre Shale in central South Dakota, westward into Parkman Sandstone of Mesaverde in Powder River basin, and northwestward into Judith River Formation of eastern Montana.

_____, 1965 (U.S. Geol. Surv. Prof. Paper 392A, 20 p.): Five units related by lithology and fossil content to equivalent units in type Pierre Shale of central South Dakota and units in Vermilion River and Riding Mountain Formations of Manitoba. They are (ascending): Pembina, Gregory, DeGrey, Odanah, and the fifth (youngest) is unnamed.

_____, 1973 (U.S. Geol. Surv. Prof. Paper 776, p. 16-19): Assigned to Montana Group (newly restricted) only in southeastern Montana; no longer assigned to any named group elsewhere.

PINE MEMBER, SALT (of SPEARFISH FORMATION)

Age: Permian(?) Triassic.

Area of extent: Western North Dakota and eastern Montana.

Depositional environment: Marine.

Remarks: See also Spearfish Formation, Saude Formation, and Triassic "B" Salt.

History of stratigraphic nomenclature:
Zieglar, D. L., 1955 (N.D. Geol. Soc. Gdbk. Black Hills Field Conf., p. 51): Pine Salt is anhydrite and reddish-brown mudstone. Nonmarine evaporitic environment of deposition probable. Conformably underlies Saude Formation erosional unconformity between Pine Salt and Spearfish Formation.

Dow, W. G., 1964 (N.D. Geol. Soc. 3rd Internat. Williston Basin Sym., Conrad, Bismarck, p. 127-131): Pine Salt considered to be member of Spearfish Formation. Grades laterally into anhydrites and shales of lower Spearfish and is considered to be Permian.

PIPER FORMATION

Age: Middle Jurassic (Bajocian to Bathonian).

Area of extent: East of 111° meridian in Montana, and eastward into North Dakota.

Reported fossils: Chondroceras (Defonticeras), numerous pelecypods; locally Astrocoenia hyatti (coral).

Depositional environment: Marine.

Remarks: Type locality about 1 mile southwest of Piper, Montana, on northern margin of Big Snowy Mountains. See also Ellis Group, Tampico Shale, Firemoon Limestone, and Bowes Member.

History of stratigraphic nomenclature:

Imlay, R. W., Gardner, L. S., Rogers, C. P., Jr., and Hadley, H. D., 1948 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 32, 1 sheet): Piper includes all Middle Jurassic red beds, gypsum, and associated normal marine beds underlying Rierdon Formation in eastern Montana east of Sweetgrass-Big Belt line of uplift. Basal part locally includes equivalents of type Gypsum Spring Formation of central Wyoming; upper part includes beds that have been placed in lower part of lower Sundance in Wind River Basin and central Wyoming. In Montana, consists of lower red bed and gypsum member, middle member of gray shale, limestone, and dolomite, and upper red-bed gypsum member. Members grade into each other vertically, and, to some extent, red beds grade laterally into middle marine member; upper member grades laterally into yellowish, calcareous, marine siltstone and sandstone. At type section, consists of (ascending) about 12 feet of massive white gypsum, 6 feet of brittle, chocolate-gray limestone, 57 feet of maroon and green siltstone and shale, 5 feet of gray, silty limestone, 9 feet of gray papery to chunky shale, and 4 feet of yellowish-gray, sandy limestone. Thickness 0-300 feet and varies considerably within short distances. Grades laterally into Sawtooth Formation.

Imlay, R. W., 1952 (Geol. Soc. Am. Bull. 63, p. 967-968): Piper includes all Middle Jurassic beds underlying Rierdon Formation in eastern Montana east of Sweetgrass-Big Belt line of uplift. First identified as Gypsum Spring Formation; later fieldwork showed that Gypsum Spring of type area in central Wyoming represents only basal Middle Jurassic; correlates with lower member of Gypsum Spring in Montana and part of Big Horn Basin of Wyoming. Because beds equivalent to type Gypsum Spring in Montana are not mappable, name Piper is used for beds formerly called Gypsum Spring. Middle member of Piper has ammonites such as Defonticeras and Teloceras, which are of middle or late Bajocian age; upper red-bed member grades laterally in western Montana into yellowish siltstone, sandstone, and limestone that contains Arctocephalites and Procerites and is considered Late Bathonian.

_____, 1954 (Billings Geol. Soc. Gdbk. 5th Ann. Field Conf., p. 56): Piper Formation is conformably overlain by Rierdon Formation in most areas, but in south-central Montana contact may be disconformable.

Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 99-104): Piper subdivided to include (ascending): Tampico Shale, Firemoon Limestone, and Bowes Members (all new). Units are recognizable in subsurface and surface sections. In subsurface of Williston Basin overlies Kline Member of Nesson Formation (both new).

Peterson, J. A., 1957 (Am. Assoc. Pet. Geol. Bull. v. 41, p. 435): Piper Formation divided into three units which in ascending order were the "A", "B", and "C" units. "A" unit considered equivalent of Poe evaporite and Picard shale; "B" unit equivalent of Firemoon, Tampico, and Kline Members; "C" unit equivalent to Bowes Member of Nordquist's (1955) Nesson and Piper Formations.

Dow, W. G., 1964 (N.D. Geol. Soc. 3rd Internat. Williston Basin Sym., p. 127-131): Dunham salt, formerly of Spearfish Formation, is considered to be facies of lower evaporite unit (Poe) of Piper Formation and is Jurassic in age.

POE EVAPORITE MEMBER (of Nesson Formation, PIPER FORMATION)

Age: Middle Jurassic (Bajocian).

Area of extent: Western North Dakota, eastern Montana.

Depositional environment: Marine.

Type section: Interval of 6,947-7,065 feet in Phillips-Skelly-Gulf No. 1 Hoehn (Poe Unit) well, center NE SE sec 13, T152N, R102W, McKenzie County, North Dakota.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. Gdbk. 6th Ann. Field Conf., p. 64-105): Poe Evaporite Member is basal unit of Nesson Formation (new). Underlies Picard Shale Member (new); unconformably overlies Triassic(?) Spearfish Formation. In type section, consists of 65 feet of basal bed of massive salt, overlain by 53 feet of white to pink gypsum and anhydrite and dark-red shale with few thin interbeds of gray to red, dense dolomite; thin bed of buff to brown, very finely crystalline to earthy limestone present at top. Thins eastward from type well and appears to merge in Bowdoin Dome area with younger members of formation. Unit exhibits abrupt facies changes on east flank of Williston Basin where member overlaps Spearfish Formation and Madison Limestone and rests on pre-Mississippian rocks.

Poplar interval, "beds"

Age: Mississippian (Meramecian).

Area of extent: Southeastern Saskatchewan, northeastern Montana, and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Poplar Oilfield, Montana. See also Madison Group.

History of stratigraphic nomenclature:
Porter, J. W., (Chm.), 1956 (Sask. Geol. Soc. Rept. of the Mississippi Names and Correlations Committee, p. 1-4): "Poplar beds" bounded below by "Ratcliffe beds" and above by Kibbey Limestone or Big Snowy Group.

Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 1-25): Poplar interval is uppermost interval in Madison bounded below by Ratcliffe interval and above by Kibbey Formation; base marked by prominent gamma ray deflection at base of "last salt" of Madison.

PRAIRIE EVAPORITE, FORMATION (of ELK POINT GROUP)

Age: Middle Devonian (Erian).

Area of extent: Elk Point Basin, Alberta and Williston Basin.

Depositional environment: Marine.

Type section: Depths of 4,350 and 4,990 feet in Imperial Oil Co., No. 1 Davidson, ls 16, sec 8, T27N, R1W, 3rd Meridian, Saskatchewan.

History of stratigraphic nomenclature:
Baillie, A. D., 1953 (Am. Assoc. Pet. Geol. Bull. 37, p. 444-446): Prairie Evaporite Formation proposed for salt and anhydrite beds of upper unit of Elk Point Group throughout most of Elk Point Basin. Beds are 50-600 feet thick. Overlies Winnipegosis Formation; underlies Dawson Bay Formation of Manitoba Group.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2306-2307): Prairie Formation underlies deepest part of Williston Basin in north-

western North Dakota and northeastern Montana. Thickness 0-500 feet. In center of basin Prairie divided into two members: Lower member is anhydrite and dolomite interbedded with shale and thin beds of halite; upper member is halite and is termed Salt Member.

PRETTY BUTTE MEMBER (of HELL CREEK FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, p. 38-39): Pretty Butte Member consists of bentonites and bentonitic shales with sandstone; siderite nodules are common. Named from Pretty Butte, butte in Slope County, North Dakota; type section is 12 miles north of Marmarth on southeast-facing slope on northeast end of butte on west side of "West Marmarth Road" in SW NE sec 26, T134N, R106W, Slope County, North Dakota. Interfingers with Huff Member below; top of member coincides with top of Hell Creek Formation. Member found everywhere in western and central North Dakota. Fauna and sediments suggest coastal plain with swampy conditions, small meandering streams, and covered at times by volcanic ash.

Qu'Appelle Group

Age: Late Devonian.

Remarks: Group generally regarded as approximately equivalent to Three Forks Formation.

History of stratigraphic nomenclature:
Baillie, A. D., 1953 (Man. Dep. Mines Nat. Resour. Pub. 52-5): Introduced the term "Qu'Appelle" for strata overlying the Nisku and underlying the Lodgepole.

Ratcliffe interval, "beds"

Age: Mississippian.

Area of extent: Subsurface in Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Ratcliffe Oilfield, southeastern Saskatchewan. See also "Poplar beds," "Midale beds," "Midale anhydrite," Midale subinterval, and Madison Group.

History of stratigraphic nomenclature:
Porter, J. W., 1956 (Sask. Geol. Soc. Rept. Mississippian Names and Correlations Committee): Ratcliffe beds bounded above by Poplar beds and below by Frobisher-Alida beds.

Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 36): "Ratcliffe beds" of 75 feet of Upper Madison limestone of southeastern Saskatchewan contain anhydrite, dolomite, and mudstone, bounded below by "Midale beds." Oil productive where capped by "Charles lower salt" in Ratcliffe Oilfield.

Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 12): Base of Ratcliffe interval at lower boundary of Midale subinterval and top at prominent gamma-ray marker overlying lowest Madison salt bed. Ratcliffe interval includes (descending) bottom one-third of "Poplar beds," "Ratcliffe beds," "Midale anhydrite," and top two-thirds of "Midale beds" of Saskatchewan definitions.

Ray Member (of KIBBEY FORMATION)

Age: Mississippian (Chesterian).

Area of extent: Equivalent to Kibbey limestone of Central and eastern Montana, North Dakota, and northern South Dakota.

Environment of deposition: Marine.

History of stratigraphic nomenclature:
Rawson, R. R., 1969 (Mont. Geol. Soc. 1969 Sym., p. 165): Introduced the term Ray Member for limestone unit within the Kibbey Formation.

Reclamation Group

Age: Pennsylvanian (Atokan)

Area of extent: Hartville Uplift area of Wyoming, southwestern South Dakota; in North Dakota, equivalent strata are included in upper part of Tyler Formation or lower part of Amsden Formation of current usage.

Depositional environment: Marine.

Remarks: Type locality is Reclamation Hill, sec 27, T27N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2-3, 28, and 32): Reclamation Group consists of red, gray, and green limestones and shales. Comprises Division V of Hartville "Formation" (Condra, G. E., and Reed, E. C., Neb. Geol. Surv. Paper 9, 46 p.): Thickness is 72-87 feet. Underlies Roundtop Group (new); overlies Fairbank Formation (new).

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Reclamation Group is light-colored, argillaceous limestone interbedded with thin, red and green shales. On electric logs, Reclamation is resistant unit overlying shales and porous sands of Fairbank and underlying more argillaceous Roundtop Group. Transition zone is frequently developed at top; contact between Reclamation and Roundtop is difficult to pick.

RED RIVER FORMATION (of BIGHORN GROUP)

Age: Upper Ordovician (Trentonian to Edenian)..

Area of extent: Southern Manitoba, southeastern Saskatchewan, North Dakota, northern South Dakota, and eastern Montana.

Reported fossils: Climacograptus typicalis crassimarginalis and Diplograptus amplexicaulis, crinoids, brachiopods, and ostracods.

Depositional environment: Marine.

Remarks: Type area at quarries near Winnipeg, Manitoba.

History of stratigraphic nomenclature:

Foerste, A. F., 1929 (Denison Univ. Bull., J. Sci. Lab., v. 29, no. 2, p. 35, 37): Red River Formation is thick-bedded, crystalline to fragmental limestones and dolomites, very uniform and widespread near Lake Winnipeg. Some shale in basal unit and often sandy to cherty in middle unit. In outcrop, is divided into three units (descending): Selkirk, limestone; Cat Head, dolomite and chert; and Dog Head, dolomitic limestone. In subsurface, formation has distinctive three-fold aspect known as Units A, B, and C. Red River equivalent to Whitewood of Black Hills and Bighorn Dolomite of Montana. Thickness is 250-1100 feet.

Kline, V. H., 1942 (Am. Assoc. Pet. Geol. Bull. 26, no. 3, p. 345): Red River Formation extended into subsurface of North Dakota.

Ross, R. J., Jr., 1957 (U.S. Geol. Surv. Bull. 1021-M, p. 446-448): Red River Formation is basal unit of Bighorn Group; overlies Winnipeg Formation; underlies Stony Mountain Formation. Members not differentiated. Is Late Ordovician in age.

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1343-1349): Red River divided into two general lithologic units: lower, marine, fossiliferous limestone, variably dolomitized; and upper evaporitic, thinly bedded, carbonate sequence. "Transition" beds at base (called Hecla beds) are part of Red River Formation. Top of Red River marks end of Middle Ordovician time.

Sandberg, C. A., 1961 (U.S. Geol. Surv. TEI-809, p. 28): "Transition zone beds" are placed in underlying Winnipeg Formation.

Caramanica, F. P., 1973 (Univ. N.D. Ph.D. Dissert.): Williston Basin of Wyoming, Manitoba, and eastern North Dakota. Red River, Stony Mountain, Stonewall, and Bighorn Formation corals are present.

Riding Mountain Formation

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of southern Manitoba and northeastern North Dakota; equivalent strata included in Pierre Formation of current usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:

Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Repts. 1929, pt. B, p. 124): Used term Riding Mountain Beds for light-gray to greenish-gray, noncalcareous shales overlying Vermilion River beds in vicinity of Vermilion River, Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 1011-1043): Riding Mountain Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Underlies Boissevain Formation; overlies Pembina Member of Vermilion River Formation. Includes Odanah facies.

RIERDON FORMATION (of ELLIS GROUP)

Age: Late Jurassic (Callovian).

Area of extent: Montana, western North Dakota, and western South Dakota.

Reported fossils: Cadoceras muelleri, Kepplerites tychonis, Gryphaea nebrascensis, Arctocephalites, Pachyteuthis, and other molluscs.

Depositional environment: Marine.

Remarks: Type locality is Rierdon Gulch, sec 23, T24N, R9W, Teton County, Montana, about 25 miles west of Choteau, Montana. See also Ellis Group.

History of stratigraphic nomenclature:

Cobban, W. A., 1945 (Am. Assoc. Pet. Geol. Bull. 29, p. 1277-1281): Rierdon is group of alternating, gray, limy shales and limestones overlying Sawtooth Formation (new). At type locality, consists of (ascending) 20.5 feet of medium-gray limy shale containing few, dense, gray, modular limestones; 33.5 feet of dark-medium-gray, fissile, calcareous to almost noncalcareous shale containing thin beds of gray, dense, nodular limestone; 43.5 feet of medium-gray shale containing few, thin beds of limestone in lower part; and 39 feet of alternating 4- to 6-inch limestone layers and thicker beds of medium-gray, limy shale. At type locality, lower part of formation is of Late Bathonian age and rest is Early Callovian. Basal beds are younger on flanks of South arch than along Rocky Mountain front.

Imlay, R. W., Gardner, L. S., Rogers, C. P., Jr., and Hadley, H. D., 1948 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 32, 1 sheet): In south-central Montana, overlies Piper Formation (new).

Peterson, J. A., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 466, 475-477, 482): Swift-Rierdon nomenclature of Ellis Group in Montana is applied in eastern Wyoming to formations of Sundance Group. Names are applicable to marine Upper Jurassic throughout most of Wyoming and western South Dakota, but term Sundance should be retained because of historical use. Section of Rierdon, measured northeast of Newcastle, Wyoming, is 212 feet thick; includes (ascending) Stockade Beaver Shale, Hulett Sandstone, and Lak Member. Overlies Gypsum Springs Formation; underlies Swift Formation. In places in the Black Hills Formation includes fourth member, Canyon Springs, at base.

_____, 1957 (Am. Assoc. Pet. Geol. Bull. 41, p. 413, 417): Although five Sundance subdivisions and names of Black Hills are useful there, in Williston and Powder River Basins more continuous sedimentation makes nomenclature of Ellis Group more useful. Redwater abandoned in favor of Swift; Lak, Hulett, Stockade Beaver, and Canyon Springs retained as local members of Rierdon. Sundance includes Rierdon and Swift. Rierdon seas deposited three main lithologic units in Williston Basin (ascending): Rierdon "A" is calcareous and gives good electric log "kick"; Rierdon "B" is shale; and Rierdon "C" is sandstone. Thickness 350 feet in central part of Williston Basin.

Storey, T. P., 1958 (Alberta Soc. Pet. Geol. J. 6, p. 90-104): On basis of regional extent and significance of sub-Swift and sub-Rierdon unconformities of Williston Basin and adjacent areas, Swift is divided into Lower, Middle, and Upper units. Lower Swift in Williston Basin is equivalent to Stockade Beaver and Hulett Members of Sundance and unconformably overlies Rierdon, which has been considered equivalent to Stockade Beaver and Hulett. Rierdon corresponds essentially to type Rierdon of Sweetgrass arch where it occurs with notable unconformity, both below Middle and Upper Swift and above Sawtooth and older Gypsum Spring beds. Lower Swift of Williston Basin is absent over Sweetgrass arch and over most of western Montana, where it is overlapped by Swift Formation of Cobban (1945).

Rival subinterval

Age: Mississippian.

Area of extent: Southeastern Saskatchewan and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Rival Oilfield, Burke County, North Dakota. See also "Midale beds," Frobisher-Alida interval, and Madison Formation.

History of stratigraphic nomenclature:
Anderson, S. B., Hansen, D. E., and Eastwood, W. D., 1960 (N.D. Geol. Surv. Rept. Invest. 36, p. 5): Rival subinterval is upper unit of Frobisher-Alida interval and equivalent to lower part of "Midale beds" or "Frobisher evaporite" of Saskatchewan terminology.

ROUGHLOCK MEMBER, FORMATION, Siltstone (of WINNIPEG FORMATION, GROUP)

Age: Middle Ordovician (Trentonian).

Area of extent: Western South Dakota, North Dakota, and northeastern Wyoming; approximately equivalent to Hecla Beds of Fuller in Williston Basin.

Reported fossils: Conodonts.

Depositional environment: Marine.

Remarks: Type locality is 2.4 miles north of Maurice in Spearfish Canyon, Lawrence County, South Dakota. Agnew and Tychsen (1965) indicate 6.5(?) miles southwest(?) of Maurice. Named from Roughlock Falls, South Dakota.

History of stratigraphic nomenclature:
McCoy, M. R., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 44-46): Roughlock Siltstone consists of 25-30 feet of pale-gray-green to cream siltstone. Conformably underlies Whitewood dolomite; conformably overlies Icebox Formation (new). Unit disappears by nondeposition 10 miles south of Deadwood, South Dakota.

Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 59-61): Roughlock accepted as upper member of Winnipeg in Williston Basin. Consists of 0-90 feet of very light gray, very fine grained, calcareous sandstone and siltstone in south-central North Dakota. Siltstone grades laterally into greenish-gray, calcareous, silty shale and greenish-gray, calcareous shale to north and northeast. Roughlock becomes difficult to trace in northern part of state. Interval referred to as "Winnipeg transition zone" is included in Roughlock Member. Is probably Trentonian in age.

Roundtop Group

Age: Pennsylvanian (Atokan).

Area of extent: Hartville Uplift area of Wyoming, southwestern South Dakota; in North Dakota appears to be equivalent to Alaska Bench of current usage.

Depositional environment: Marine.

Remarks: Type locality is Roundtop Mountain, sec 22, T27N, R66W, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2-3, 33-34, and 44): Roundtop Group consists mostly of shale, mudstone, and red, green, and gray thin limestone. Comprises Division IV of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, 46 p.). Thickness is 149 feet. Underlies Hayden Group (new): overlies Reclamation Group (new).

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Roundtop Group consists of red, green, and brown, waxy to subwaxy shales, interbedded with very thin beds of dolomite. Dolomitic content increases toward top of group.

"Sanish sandstone"

Age: Late Devonian.

Area of extent: Central part of Williston Basin.

Depositional environment: Marine.

History of stratigraphic nomenclature:
North Dakota Geological Society, 1954 (Guide to the Stratigraphy of Williston Basin, p. 56): Introduced term Sanish for fine-grained clastics at base of Bakken Shale, believed to be unconformity sand; since has generally been included at top of Three Forks Formation.

Saskatchewan Group

Age: Late Devonian.

Area of extent: Saskatchewan, Manitoba, North Dakota; equivalent to Jefferson Group in Montana and South Dakota.

Depositional environment: Marine.

Remarks: Named after Saskatchewan, Canada. Includes Duperow and Birdbear Formations.

History of stratigraphic nomenclature:
Baillie, A. D., 1953 (Man. Dep. Mines Nat. Resour. Mines Br. Pub. 52-5, p. 30-32): Saskatchewan Group consists of a thick series of strata directly overlying Souris River Formation of Beaverhill Lake Group and underlying carbonate-clastic-evaporite units of Qu'Appelle Group. Predominant lithologies are dolomite, anhydrite, limestone, and shale. Divided into two units (ascending): Duperow and Nisku (Birdbear).

Agnew, A. F., and Tychsen, P. C., 1965 (S.D. Geol. Surv. Bull. 14, p. 163): Saskatchewan Group represents same interval as Jefferson Group of South Dakota.

SAUDE MEMBER (of SPEARFISH FORMATION)

Age: Triassic-Jurassic(?)

Area of extent: North Dakota and eastern Montana; equivalent to part of Watrous Formation in Saskatchewan and Manitoba, to part of Spearfish Formation in South Dakota.

Depositional environment: Marine.

Remarks: See also Dunham Salt, Pine Salt, and Spearfish Formation.

History of stratigraphic nomenclature:
Zieglar, D. L., 1955 (N.D. Geol. Soc. Gdbk., S.D. Black Hills Field Conf., p. 52): Saude is reddish-orange siltstone and fine-grained sandstone with medium- to coarse-grained sandstone interbeds. Anhydrite present as inclusions in finer grained matrix; nearly spherical, frosted quartz grains are common. Saude

conformably overlies Pine Salt and conformably underlies Dunham Salt. Where Pine Salt absent, Saude rests unconformably on Permian(?) to Devonian rocks.

Dow, W. G., 1964 (N.D. Geol. Soc. 3rd Internat. Williston Basin Sym., Conrad, Bismarck, p. 127-131): Saude Formation considered to be member of Spearfish Formation; is stratigraphically equivalent to lower two units of Watrous Formation of Saskatchewan, and upper evaporite unit of Watrous is correlative with lower member of Piper Formation; therefore, Triassic-Jurassic time boundary may lie within upper part of Saude in northern North Dakota. Majority of Saude in North Dakota is Triassic.

Scallion Member, subinterval

Age: Mississippian (Kinderhookian).

Area of extent: Eastern North Dakota, southern Manitoba.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Stanton, M. S., 1956 (Alberta Soc. Pet. Geol. J., v. 4); 1958 (AAPG Allen Mem., v. p. 378): Introduced Scallion member of the Lodgepole Formation; type section is Cal Standard-Scallion-Prov. 5-11 (ls 5-11-11-26 WPM) interval from 2030 to 2228; overlies Routledge Shale or Bakken Formation, overlain by Virden Member. Limestone or argillaceous limestone, cherty.

Heck, T., 1978 (Mont. Geol. Soc., Williston Basin Sym. 24th Ann. Field Conf., p. 196-197): Scallion subinterval is equivalent to lower Bottineau interval and consists of sediments of normal marine circulation. Five major facies developed: 1) dark-gray to black, irregularly laminated, crinoidal, mudstone-wackestone (central basin), 2) medium- to light-gray, argillaceous, crinoid, brachiopod, wackestone to packstone (basin slope), 3) light-colored, cherty, skeletal wackestone to packstone (open shelf), 4) crinoidal mudstone (at or near shelf break) and 5) gray shale (restricted environment shoreward). Is Kinderhookian in age.

Schefield Member (of BRULE FORMATION)

Age: Oligocene (Orellan).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 128): Schefield Member is 25-77 feet of silty claystone and clay that forms vertical cliff-forming strata of uppermost part of Brule Formation in North Dakota. Lies above Dickinson Member of Brule and below Killdeer Formation. Contains calcareous concretions. Age is late Orellan through Whitneyan.

"'Second red' bed"

Age: Middle Devonian.

Remarks: Term used to refer to red zone at base of Dawson Bay Formation.

"Second white specks" zone

Remarks: Term used to refer to uppermost beds of the Greenhorn Formation.

SENTINEL BUTTE FORMATION, Member (of FORT UNION GROUP, FORMATION)

Age: Late Paleocene (Clarkforkian).

Area of extent: North Dakota; equivalent strata in Montana and Wyoming are probably included in their Tongue River or Fort Union strata.

Reported fossils: Fresh-water molluscs, and plant remains including petrified wood.

Depositional environment: Nonmarine.

Type section: Sentinel Butte; top of butte is in west-central sec 8, T139N, R104W, Golden Valley County, North Dakota.

History of stratigraphic nomenclature:

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 105-113): Sentinel Butte Coal Group of southwestern North Dakota is in upper part of Fort Union Formation and includes coals Q, R, S, T, and U. Underlying Beaver Creek Coal Group included coals N, O, and P.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484, 495-497): Sentinel Butte Shale Member of Fort Union(?) Formation is typically developed at Sentinel Butte (Billings County, North Dakota). Consists of dark clay shales resembling Hell Creek Member of Lance Formation and Lebo Shale Member of Fort Union Formation. Overlies Tongue River Member of Fort Union Formation and underlies Ulm Coal Group of Wasatch Formation. Is essentially equivalent to intermediate coal group of northern Wyoming and also Roland coal bed.

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, 110 p.): Sentinel Butte Member of Fort Union(?) Formation is 325 feet thick in Marmarth field of southwestern North Dakota. Consists of dark, somber, sandy shale, gray sandstone, and lignite interbedded. Overlies Tongue River and unconformably underlies White River(?) Formation. Bullion Creek lignite bed lies near top, HT lignite bed at base.

Benson, W. E., and Laird, W. M., 1947 (Geol. Soc. Am. Bull. 58, pt. 2, p. 1166-1167): Golden Valley Formation (new) overlies Sentinel Butte Shale Member of Fort Union Formation now considered to be of Paleocene age.

Fisher, S. P., 1953 (N.D. Geol. Surv. Rept. Invest. 11, 2 pl.): Sentinel Butte considered facies of Tongue River in central McKenzie County.

May, P. R., 1954 (U.S. Geol. Surv. Bull. 995-G, p. 267-268): About 200 feet of Sentinel Butte Shale, uppermost member of Fort Union, is exposed at top of Blue Mountain in northern Wibaux area, Montana and North Dakota. Composed of gray and brown sandstone and shale and thin lignite beds. Overlies Tongue River Member. Is Paleocene in age.

Hanson, B. M., 1955 (N.D. Geol. Surv. Rept. Invest. 18, 1 pl.): Sentinel Butte reallocated to member of Tongue River Formation. In Elkhorn ranch area of Billings and Golden Valley Counties, only lower 250 feet present. Contact of Sentinel Butte and underlying part of Tongue River Formation is locally picked at base of most persistent and prominent clinker bed or on basis of characteristic lithologies--Tongue River light-tan to gray sand and clay and Sentinel Butte of brown sand and clay.

Royse, C. F., Jr., 1967 (N.D. Geol. Surv. Rept. Invest. 45, p. 1): Separated Sentinel Butte and Tongue River as Formations in the Fort Union Group.

SKULL CREEK FORMATION, SHALE (of DAKOTA GROUP)

Age: Early Cretaceous (Albian).

Area of extent: Southeastern Montana, southwestern North Dakota, western South Dakota, eastern Wyoming, and eastern Colorado; equivalent to Joli Fou Formation of Saskatchewan.

Reported fossils: Inoceramus bellevuensis.

Depositional environment: Marine.

Remarks: Type locality along Skull Creek, southeast of Osage, Weston County, Wyoming.

History of stratigraphic nomenclature:
Collier, A. J., 1922 (U.S. Geol. Surv. Bull. 736, p. 79): Skull Creek Shale is basal member of Graneros Shale in Osage oil field, Weston County, Wyoming. Is dark bluish-gray shale, about 200 feet thick with few calcareous concretions and some siliceous shale near base. Contains few fossils. Is called Thermopolis Shale by drillers but represents only basal part of true Thermopolis Shale. Is well exposed along Skull Creek southeast of Osage; lies between Dakota Sandstone below and Newcastle Sandstone above.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 76): Contact with underlying Fall River is usually sharp, but top is difficult to locate where lower sands of Newcastle Formation are not well developed. Microfossils indicate Early Cretaceous age. Is equivalent to lower part of Thermopolis Shale of Wyoming.

_____, 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 446-449): Dakota not used in Black Hills but applied to thick sandstone sequence in central South Dakota where it was termed "true Dakota" and where it overlies Skull Creek Shale.

Pettyjohn, J. A., 1960 (S.D. Acad. Sci. Proc., v. 38, p. 34-38): Dakota Group to be used to include Lakota, Fuson, Fall River, Skull Creek, and Newcastle Formations.

SLOPE FORMATION (of FORT UNION GROUP)

Age: Paleocene.

Area of extent: Western North Dakota; equivalent strata are included in Ludlow and Tongue River Formations in Montana and South Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Clayton, L., et al., 1977 (N.D. Geol. Surv. Rept. Invest. 59, p. 7-9): Slope Formation consists of alternating beds of clay, silt, sand, and lignite. Named for Slope County, North Dakota, and type section is south-facing exposure in NW¼ sec 15 and SW¼ sec 10, R105N, R135W, Slope County, North Dakota. Overlies Cannonball Formation in western North Dakota and Ludlow Formation in westernmost North Dakota; is unconformably overlain by Bullion Creek Formation (new). Is 20-90 meters thick. Is Paleocene in age and consists of strata considered by others to be upper part of Ludlow Formation or part of Tongue River Formation.

SOURIS RIVER FORMATION (of MANITOBA GROUP)

Age: Late Devonian (Senecan).

Area of extent: Williston Basin.

Reported fossils: Algae, ostracods.

Depositional environment: Marine.

Remarks: Proposed standard subsurface section is interval between 10,743 and 11,052 feet in Mobile No. 1 Birdbear oil test, SE SW sec 22, T149N, R91W, Dunn County, North Dakota.

History of stratigraphic nomenclature:

Laird, W. M., 1953 (Interstate Oil Compact Quart. Bull., v. 12, no. 2, p. 74): Beaverhill Lake Group has been divided into two formations (ascending) Dawson Bay and Souris River. Souris River Formation is new term for part of Devonian known only in subsurface of north-central North Dakota and adjacent parts of Saskatchewan and Manitoba. Overlies Dawson Bay; underlies Duperow Formation.

Towse, D., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Devonian "C" of earlier North Dakota Geological Survey reports is equivalent to Souris River Formation or "Beaverhill Lake equivalent" of this report.

North Dakota Geological Society, 1954 (Stratigraphy of the Williston Basin: Conrad, Bismarck, p. 14): Base of Souris River Formation is persistent shale or argillaceous dolomite marker (first red bed). Lithology of rest of unit is dull-gray to buff, argillaceous dolomite with interbedded, greenish-gray dolomitic shale. Suggested that the interval between 5912 and 6160 feet in California No. 1 Blanche Thompson, sec. 31, T160N, R81W, Bottineau County, North Dakota, be used as type section.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2310-2311): Report of Williston Basin Correlation Committee not published; Souris River Formation not formerly proposed or adequately described. Proposed standard subsurface section be interval 10,743-11,052 feet in Mobile No. 1 Birdbear oil test, SE SW sec 22, T149N, R91W, Dunn County, North Dakota (adopted by North Dakota Geological Society, 1961, Stratigraphy of Williston Basin Devonian System: Conrad, Bismarck, p. 21). Consists of thin, interbedded gray, greenish-gray, and brownish-gray argillaceous dolomite, argillaceous limestone, shale, siltstone, and anhydrite. Is Late Devonian in age.

South Heart Member (of CHADRON FORMATION)

Age: Oligocene (Chadronian).

Area of extent: Western North Dakota.

Depositional environment: Nonmarine.

Stone, W. J., 1972 (N.D. Geol. Surv. Misc. Ser. 50, p. 124): South Heart member is uppermost member of Chadron Formation; conformably overlies Chalky Buttes Member and conformably underlies Brule Formation. Consists of 8 to 55 feet of green bentonite.

SPEARFISH FORMATION

Age: Permian-Triassic.

Area of extent: Western South Dakota, western North Dakota, eastern Montana, eastern Wyoming, and northwestern Nebraska.

Depositional environment: Marine.

Remarks: Type locality in Black Hills; named for Spearfish, Lawrence County, South Dakota.

History of stratigraphic nomenclature:

Darton, N. H., 1899 (Geol. Soc. Am. Bull. 10, p. 387): Triassic Spearfish Formation (red beds) unconformably underlies Sundance Formation in Black Hills.

_____, 1901 (U.S. Geol. Surv. 21st Ann. Rept., pt. 4, p. 516): Spearfish Formation consists of red, sandy clay or shale with gypsum beds up to 30 feet thick. Thickness is 350-500 feet at type locality in Black Hills. Overlies Minnekahta Limestone and unconformably underlies Sundance Formation.

Imlay, R. W., 1947 (Am. Assoc. Pet. Geol. Bull. 31, no. 2, p. 235, 237-240): Spearfish Formation extended into Black Hills area; unconformably underlies Gypsum Spring Formation. Gypsiferous facies of Gypsum Spring was included by Darton at top of Spearfish, contains marine Jurassic fossils and interfingers laterally with dolomite and limestone containing marine fossils.

Gries, J. P., 1952 (Billings Geol. Soc. Gdbk. 3rd Ann. Field Conf., p. 73): Spearfish red beds extend eastward to Missouri River to subsurface where they pinch out. East of Black Hills, Spearfish is 350 feet thick, thickens to north and west; 1,000 feet thick in North Dakota. Stratigraphic correlation with Wyoming strata indicates Spearfish is Permo-Triassic in age but no fossils recovered.

Reed, E. C., 1955 (N.D. Geol. Soc. Gdbk. S.D. Black Hills Field Conf., p. 46): Lower Spearfish in Black Hills is equivalent to middle and upper Phosphoria, and is Permian, not Triassic in age. No concrete evidence to divide Spearfish into Triassic and Permian.

Zieglar, D. L., 1955 (N.D. Geol. Soc. Gdbk. S.D. Black Hills Field Conf., p. 53, 54): "Red-bed" sequence between top of Minnekahta and base of Piper is divided into (ascending): 1) Triassic Spearfish (Spearfish by this usage limited to western one-third of state), 2) Pine Salt, 3) Saude, and 4) Dunham Salt.

Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Spearfish Formation of North Dakota contains two salts (descending): 1) Triassic "A" Salt, up to 142 feet thick, and 2) Triassic "B" Salt, up to 199 feet thick. Spearfish "A" salt thins over Nesson anticline.

Dow, W. G., 1964 (N.D. Geol. Soc. 3rd Internat. Williston Basin Sym., Conrad, Bismarck, p. 127-131): Spearfish Formation of Williston Basin divided into three members (ascending): 1) lower shale unit, 2) Pine Salt Member, and 3) Saude Member. Lower shale unit is Permian in age; Pine Salt grades laterally into anhydrites and shales of lower Spearfish and is considered to be Permian in age. Saude Member is stratigraphically equivalent to lower two units of Watrous Formation of Saskatchewan, and upper evaporite unit of Watrous is correlative with lower member of Piper Formation; therefore, Triassic-Jurassic time boundary may be within upper part of Saude in northern North Dakota. Majority of Saude is primarily Triassic in age. Spearfish overlain by Piper Formation (Jurassic).

_____, 1967 (N.D. Geol. Surv. Bull. 52, p. 6-8): Restricted Spearfish of Zieglar (1955) named Belfield Member. Consists of fissile gray shale interbedded with reddish-orange siltstone and mudstone, few anhydrite and dolomite beds present. Conformably overlies Minnekahta but does not extend beyond the limits of Minnekahta; conformably underlies Pine Salt or Saude Members of Spearfish.

STONEWALL FORMATION, LIMESTONE (of BIGHORN GROUP)

Age: Late Ordovician to Early Silurian (Richmondian to Alexandrian).

Area of extent: Manitoba, Saskatchewan, North Dakota, South Dakota, and eastern Montana.

Reported fossils: Kochoceras and Antiplectoceras. None found in North Dakota.

Depositional environment: Marine.

Remarks: Named for quarry near Stonewall, Manitoba.

History of stratigraphic nomenclature:
Kindle, E. M., 1914 (Can. Geol. Surv. Summ. Rept. 1912, p. 247-261): Stonewall Formation includes all beds of Silurian age exposed in Manitoba.

Baillie, A. D., 1951 (Man. Dep. Mines Nat. Resour., Mines Br. Pub. 50-1), p. 6): Replaced originally defined Stonewall Formation with term "Interlake Group"; Stonewall restricted to lowest formation of group. Stonewall overlain by series of units, B, C, D, and E (ascending), for which naming is deferred until units can be established in subsurface. Consists of arenaceous shale and dolostone above, and yellowish-gray, finely crystalline dolostone with salt crystals below. Thickness is 40-50 feet. Overlies Stony Mountain Formation; underlies Ashern Shale. Fauna assigned to Silurian, although several Late Ordovician fossils present.

Stearn, C. W., 1953 (Geol. Soc. Am. Bull. 64, p. 1477-1478): Stonewall fauna is Late Ordovician in age and should be removed from Interlake Group.

Andrichuk, J. M., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 2381): Stonewall retained as basal unit of Interlake Group as significant lithologic break occurs at base of Stonewall. Usage, therefore, returned to Baillie's (1951) definition.

Carlson, C. G., and Eastwood, W. P., 1962 (N.D. Geol. Surv. Bull. 38, p. 8-10): Stonewall in North Dakota consists of basal anhydrite overlain by finely crystalline dolomitic limestone. Toward margins of basin, anhydrites pinch out and entire section becomes dolomitic. No fossils noted in Stonewall from cuttings in North Dakota. Ordovician-Silurian boundary tentatively placed within Stonewall Formation in North Dakota.

STONY MOUNTAIN FORMATION (of BIG HORN GROUP)

Age: Late Ordovician (Richmondian).

Area of extent: Manitoba, Saskatchewan, North Dakota, eastern Montana, and northern South Dakota.

Reported fossils: Brachiopods, bryozoans, crinoids, and graptolites (Nematograptus gracilis, Diplograptus amplexicaulis, and Climacograptus typicalis crassimarginalis).

Depositional environment: Marine.

Remarks: Type area is Stony Mountain area, Manitoba.

History of stratigraphic nomenclature:
Dowling, D. B., 1901 (Can. Geol. Surv. Ann. Rept., new ser., v. 11, p. 46F-53F): Stony Mountain Formation divided into three members at outcrop (descending): 1) Gunton Dolomite, Shale, and Sand; 2) Penitentiary Dolomite; and 3) Stony Mountain Shale. In subsurface, Stony Mountain is shale or shaly limestone with dark-brown to black fossil fragments. Exact age of Gunton not

established; may represent transition from Ordovician to Silurian. Fauna from wells in eastern Montana is similar to that of Maquoketa Formation of Iowa. Thickness is 25-200 feet.

Miller, A. K., 1930 (Am. J. Sci. 5th Ser., v. 20, p. 211): Stony Mountain Formation of Manitoba equivalent to upper part of Bighorn Dolomite of Richmond age.

Kline, V. H., 1942 (Am. Assoc. Pet. Geol. Bull. 26, p. 339, 360-361): Stony Mountain Formation extended into subsurface of North Dakota.

Okulitch, V. J., 1943 (Roy. Soc. Can. Trans. 3rd Ser., v. 37, sec. 4, p. 59-74): Stony Mountain Formation divided into four members (ascending): Stony Mountain Shale, Penitentiary, Gunton, and Birse.

Baillie, A. D., 1952 (Man. Dep. Mines Nat. Resour. Pub. 51-6, p. 8): Stony Mountain Formation consists of calcareous shales, argillaceous dolostones, and dolostones. Divided into three members (ascending): Stony Mountain Shale, Penitentiary, and Gunton. Gunton Member includes Birse Member of V. J. Okulitch (1943).

Ross, R. J., Jr., 1957 (U.S. Geol. Surv. Bull. 1021-M, p. 447): In Williston Basin, Stony Mountain Formation consists of two units: 1) lower shale, commonly called Stony Mountain Shale by oil geologists; and 2) upper dolomite. Upper unit includes Penitentiary (below) and Gunton Member of A. D. Baillie (1952) and restricted Stonewall Formation of C. W. Stearn (1953, Geol. Soc. Am. Bull. 64, p. 1477-1478). Overlies Red River Formation.

Sinclair, G. W., and Leith, E. I., 1958 (J. Paleo., v. 32, p. 243-244): Gunn Member proposed for lower member (formerly Stony Mountain Shale) of Stony Mountain Formation to abide by (Code of Stratigraphic Nomenclature, 1970, Art. 16, d) which states same name should not be applied to whole unit and part of same unit.

Porter, J. W., and Fuller, J. G. C. M., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 131): Stony Mountain Formation divided into two units in subsurface (ascending): lower or Stony Mountain Shale Member and upper or Gunton Member. Lower member equivalent to Sinclair and Leith's (1958) Gunn and Penitentiary Members of outcrop section. Gunton Member equivalent to Gunton Member of outcrop section.

Saskatchewan Geological Society, 1958 (Report of the Lower Paleozoic Names and Correlations Committee: Sask. Geol. Soc., Regina, Sask.): Stony Mountain Formation divided into two units (ascending); Stoughton beds (for lower or Stony Mountain Shale Member) and Gunton Member (upper).

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1334-1365): Stony Mountain Formation of Williston Basin consists of lower shale member, 75 feet of dark-gray to brown shelly, argillaceous limestone with few interbedded calcareous shale beds; and upper dolomitic fossiliferous, fragmental limestone (Gunton beds). Is overlain by Stonewall Limestone.

Carlson, C. G., and Eastwood, W. P., 1962 (N.D. Geol. Surv. Bull. 38, p. 5-8): Stoughton Member consists of medium-dark-gray fossiliferous limestone interbedded with dark-gray, calcareous, fossiliferous shale; Gunton Member consists of brownish-gray to yellowish-brown, finely crystalline, limy dolomite and dolomitic, fossiliferous limestone with anhydrite bed in northwestern North Dakota. Stony Mountain Formation is 115-180 feet thick.

Caramanica, F. P., 1973 (Univ. N.D. Ph.D. Dissert.): Williston Basin of Wyoming, Manitoba, and eastern North Dakota. Red River, Stony Mountain, Stonewall, and Bighorn Formation corals are present.

STOUGHTON MEMBER, "beds" (of STONY MOUNTAIN FORMATION)

Age: Late Ordovician (Richmondian).

Area of extent: Manitoba, Saskatchewan, northern South Dakota, North Dakota; equivalent strata referred to as lower Stony Mountain in Montana.

Reported fossils: Brachiopods, bryozoans, and crinoids.

Depositional environment: Marine.

Remarks: Standard reference section is interval of 7,768-7,816 feet in Imperial Canadian Superior Stoughton No. 3-27, ls 3, sec 27, T8, R8W, 2nd meridian Saskatchewan. Type locality is Stony Mountain area, Manitoba. See also Stony Mountain Formation.

History of stratigraphic nomenclature:
Saskatchewan Geological Society, 1958 (Report of the Lower Paleozoic Names and Correlations Committee: Regina, Sask., Sask. Geol. Soc., p. 8): Two facies included in Stoughton beds are: 1) dark-gray calcareous shale and highly fossiliferous shale and limestone sequence confined to southwestern Manitoba, southeastern Saskatchewan, and northern North Dakota; and 2) laterally equivalent dolomite or dolomitic limestone elsewhere. Beyond depositional edge of argillaceous beds (Stony Mountain Shale), Gunton and Stoughton sequences merge into sequence of carbonate (undifferentiated Stony Mountain beds); Stoughton beds reach maximum thickness (100 feet) in eastern North Dakota. Equivalent to Stony Mountain Shale Member as defined by Porter and Fuller (1958, Am. Assoc. Pet. Geol. Bull. 43, no. 1, p. 124-189) in near-outcrop Manitoba subsurface.

Carlson, C. G., and Eastwood, W. P., 1962 (N.D. Geol. Surv. Bull. 38, p. 3 and 7): Stoughton Member is basal unit of Stony Mountain Formation. Underlies Gunton Member.

SUNDANCE GROUP, Formation

Age: Late Jurassic (Callovian to Oxfordian).

Area of extent: Western South Dakota, central Montana, Wyoming, and northwestern Nebraska; equivalent to Swift and Rierdon of current North Dakota usage.

Depositional environment: Marine.

Remarks: Type area southeast [southwest] of Belle Fourche Quadrangle, South Dakota, north of Sundance, Wyoming. Named from Sundance, Wyoming, 15 miles west of South Dakota boundary. Standard reference section is 1 mile north-northeast of center of Spearfish, sec 3, T6N, R2E, Lawrence County, South Dakota. See also Swift and Rierdon Formations.

History of stratigraphic nomenclature:
Darton, N. H., 1899 (Geol. Soc. Am. Bull. 10, p. 387-393): Sundance Formation consists of green shale and thinly bedded sandstones, 60-400 feet thick. Underlies Unkpapa Sandstone; unconformably overlies Spearfish Formation in Black Hills. Contains marine Jurassic fossils.

Darton, N. H., and O'Harra, C. C., 1909 (U.S. Geol. Surv. Folio No. 164, p. 3): Type locality of Sundance is above Sundance, Wyoming, not southeast of Belle Fourche Quadrangle.

Imlay, R. W., 1947 (Am. Assoc. Pet. Geol. Bull. 31, p. 227-273): Members of Sundance Formation in Black Hills area are (ascending): 1) Canyon Springs Sandstone Member, 2) Stockade Beaver Shale Member, 3) Hulett Sandstone

Member, 4) Lak Member and 5) Redwater Shale Member. Thickness is 200-500 feet. Overlies Gypsum Spring; underlies Morrison Formation. Type section named by Darton considered to be inadequate. Standard reference section (1 mile north-northeast of center of Spearfish, sec 3, T6N, R2E, Lawrence County, South Dakota) is 327 feet thick and includes all members except Canyon Springs. Is Callovian and Oxfordian in age.

Peterson, J. A., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 464-500): Sundance ranked as group comprising two formations, which are correlated with Swift and Rierdon Formations of Montana. Because of historical use, term Sundance retained, and despite correlation with upper units of Ellis Group, Sundance Group here applies to marine Late Jurassic rocks of Black Hills, northern Colorado, subsurface of northwestern Nebraska, and Wyoming. Sundance Group may be expanded to include Gypsum Spring Formation; if so, Sundance Group would include Middle Jurassic Bajocian age as well as Callovian to Oxfordian (Late Jurassic).

_____, 1957 (Am. Assoc. Pet. Geol. Bull. 41, p. 413): Although five divisions of Sundance are useful in Black Hills, in Williston and Powder River Basins more continuous sedimentation makes nomenclature of Ellis Group more useful. Term Redwater abandoned for Swift Formation; Lak, Hulett, Stockade Beaver, and Canyon Springs retained as local members of Rierdon Formation. Sundance includes Rierdon and Swift Formations.

Storey, T. P., 1958 (Alberta Soc. Pet. Geol. J., v. 6, p. 90-104): On basis of regional extent and significance of sub-Swift and sub-Rierdon unconformities of Williston Basin and adjacent area, Swift is divided into lower, middle, and upper units. Lower Swift is considered to be lithologically similar to and regionally conformable with Middle and Upper Swift, which corresponds to type Swift of western Montana. Lower Swift of Williston Basin and equivalent Stockade Beaver and Hulett Members of Lower Sundance in Black Hills lie unconformably on Rierdon, and are younger than Rierdon and older than Swift. Lak and Redwater Members are equivalent to type Swift of western Montana.

Agnew, A. F., and Tychsen, P. C., 1965 (S.D. Geol. Surv. Bull. 14, p. 178): South Dakota Geological Survey uses Sundance Group in Black Hills for Jurassic members (except Gypsum Spring), including Canyon Springs at base and Redwater at top. In central South Dakota Sundance Formation used. In Williston Basin, Piper (equivalent to Gypsum Spring), Rierdon, and Swift (equivalent to Redwater) used as formations of Sundance Group. Ellis Group not used.

Love, J. D., and Keefer, W. R., 1975 (U.S. Geol. Surv. Prof. Paper 729-D, p. 17-21): Sundance considered to be Middle to Late Jurassic in age.

Swan River Formation

Age: Early Cretaceous.

Area of extent: Manitoba; equivalent strata included in Inyan Kara of current usage in North Dakota.

Depositional environment: Marine to nonmarine.

History of stratigraphic nomenclature:
Johnston, W. A., 1934 (Can. Geol. Surv. Mem. 174, p. 12): Used term Swan River beds (Dakota Sandstone) for strata between Benton Shale (Upper Cretaceous) and Lower Cretaceous and Jurassic Shale in southern Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, no. 10, p. 1011-1043): Swan River Formation (Early Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Overlain by Ashville Formation.

SWIFT FORMATION

Age: Late Jurassic (Oxfordian).

Area of extent: Montana, western North Dakota, western South Dakota, and eastern Wyoming.

Reported fossils: Quenstedticeras, Pavloviceras, Cardioceras, and other molluscs.

Depositional environment: Marine.

Remarks: Type locality on north shore of Swift Reservoir on Birch Creek NE¼ sec 27, T28N, R10W, Ponderosa County, Montana, about 15 miles west of Dupuyer, Montana. See also Ellis Group.

History of stratigraphic nomenclature:

Cobban, W. A., 1945 (Am. Assoc. Pet. Geol. Bull. 29, p. 1264, 1281-1286, and 1288-1289): At type locality, two members consists of (ascending): 1) dark-gray, non-calcareous shale; 54.5 feet, and 2) flaggy, ripple-marked sandstone with abundant black-gray, shale partings; 80 feet. Lithology at type locality persists along mountain front from south boundary of Glacier National Park southeast to Sun River. From Sun River southeast along mountain front, formation becomes increasingly sandy. On South Arch, formation consists of fine-grained, flaggy sandstone with pebble horizon at base. In Little Belt Mountains, formation is massive, fine-grained sandstone containing prominent basal conglomerate. Thickness 135 feet at type locality; underlies Morrison Formation; overlies Rierdon Formation (new). In areas where Rierdon is absent, unconformably overlies Sawtooth Formation.

Peterson, J. A., 1954 (Am. Assoc. Pet. Geol. Bull. 38, p. 480-486, 491-504): Swift-Rierdon nomenclature of Ellis Group in Montana is applied in eastern Wyoming and western South Dakota to formational units of Sundance Group. Names are applicable to marine Upper Jurassic throughout most of Wyoming and western South Dakota, but term Sundance should be retained because of historical use. Thicknesses in outcrop of Swift vary from 63 feet in Laramie County to 289 in Johnson County. Overlies Rierdon Formation; underlies Morrison Formation.

_____, 1957 (Am. Assoc. Pet. Geol. Bull. 41, p. 413, 417): Although five Sundance subdivisions are useful in Black Hills, in Williston and Powder River Basins more continuous sedimentation makes nomenclature of Ellis Group more useful. Redwater abandoned in favor of Swift; Lak, Hulett, Stockade Beaver, and Canyon Springs retained as local members of Rierdon Formation. Sundance includes Rierdon and Swift. At type locality Swift consists of two units: 55 feet of lower dark-gray shale and 80 feet of upper glauconite sandstone. In Williston Basin these two units are present but lower shale is thicker (up to 400 feet). Lower shale becomes sandier east of Basin's center.

Storey, T. P., 1958 (Alberta Soc. Pet. Geol. J. 6, p. 90-104): On basis of regional extent and significance of sub-Swift and sub-Rierdon unconformities in Williston Basin and adjacent areas, Swift is divided into Lower, Middle, and Upper units. Lower Swift is lithologically similar to and regionally conformable with Middle and Upper Swift that corresponds to type Swift Formation of western Montana. Lower Swift of Williston Basin and equivalent Stockade Beaver and Hulett members of Lower Sundance in Black Hills are considered to lie unconformably on Rierdon, and therefore, are younger than Rierdon and older than Swift of Cobban. Lak and Redwater Members of Sundance are considered equivalent to type Swift Formation.

TAMPICO SHALE MEMBER (of PIPER FORMATION)

Age: Middle Jurassic (Bathonian).

Area of extent: Western North Dakota, central and eastern Montana; equivalent strata in Saskatchewan are termed Gravelbourg Formation.

Depositional environment: Marine.

Type section: Interval of 3,858-3,944 feet in Gulf Oil Corp. No. 1 Cornwell, center SW NE sec 14, T30N, R38E, Valley County, Montana.

History of stratigraphic nomenclature:
Nordquist, J. W., 1955 (Billings Geol. Soc. 6th Ann. Field Conf., p. 101): Tampico Shale Member is lower red bed and gypsum member of Piper Formation. Consists of 86 feet of gray-green calcareous shale; may be interbedded with red shale and less limestone, gypsum, and sandstone. Sandstones well developed in Saskatchewan; red shales more prevalent in central and southern Montana. Maintains uniform thickness. Underlies Firemoon Limestone Member (new); overlies Nesson Formation (new).

"Third red"

Remarks: Term used to refer to beds equivalent to Ashern Formation in subsurface of Williston Basin.

THREE FORKS FORMATION, SHALE

Age: Late Devonian (Cassadagan to Conewangoan).

Area of extent: Williston Basin, Montana, east-central Idaho; equivalent strata called Lyleton in Manitoba and Torquay and Big Valley Formations in Saskatchewan.

Reported fossils: Rare brachiopods.

Depositional environment: Marine.

Remarks: Type "locality" is north side of Gallatin River at Logan, Montana. Named for exposures at junction of Three Forks of Missouri River, near Three Forks, Montana. Standard subsurface section. Williston Basin in Montana east of 111° meridian in interval between depths of 10,076 and 10,310 feet in Mobil Producing Co. Birdbear Well 1, center SE NW sec. 22, T149N, R91W, Dunn County, North Dakota. In some areas, strata becomes so calcareous that it is called Three Forks Limestone.

History of stratigraphic nomenclature:
Peale, A. C., 1893 (U.S. Geol. Surv. Bull. 110, p. 29): Three Forks Shale consists of (descending): 1) yellow, laminated sandstone, 25 feet; 2) dark, bluish-drab or black, argillaceous limestones, 45 feet; 3) highly fossiliferous green, purple, and black, argillaceous and calcareous shale, 70 feet; 4) grayish-brown, compact, limestone, 15-20 feet; and 5) reddish and brownish-yellow, calcareous and argillaceous shales, 65 feet. Rests on Jefferson Limestone and underlies Madison Limestone.

Berry, G. W., 1943 (Geol. Soc. Am. Bull. 54, p. 14-16): Named Peale's unit no. 1 the Sappington Sandstone (considered to be Early Mississippian).

Sloss, L. L., and Laird, W. M., 1946 (U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart-25): Redefined lower contact of Peale's Three Forks to exclude units 4 and 5, which were placed in underlying Jefferson Limestone.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2323): Suggested that lower contact of Three Forks as originally defined be re-established. In Williston Basin, Three Forks Formation is interbedded

greenish-gray, grayish-orange, and grayish-red dolomitic siltstone and shale. Standard subsurface section designated. Overlies Birdbear Formation (new): underlies Bakken Formation.

Tilston interval, "beds"

Age: Mississippian.

Area of extent: Southern Manitoba, southeastern Saskatchewan, and North Dakota.

Depositional environment: Marine.

Remarks: Informally named for Tilston Oilfield, Saskatchewan.

History of stratigraphic nomenclature:
Fuller, J. G. C. M., 1956 (Sask. Dep. Min. Resour. Rept. 19, p. 34): "Tilston beds" are bounded below by "Souris Valley beds" and above by "Frobisher-Alida beds" equivalent to part of Mission Canyon Limestone. "Tilston beds" are oil productive where capped by anhydrite in eastern portion of Saskatchewan.

Ballard, F. V., 1963 (N.D. Geol. Surv. Bull. 40, p. 18-26): Tilston interval overlies Bottineau interval and underlies Frobisher-Alida interval.

TIMBER LAKE MEMBER (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota and western South Dakota.

Reported fossils: Cucullaea and Sphenodiscus.

Depositional environment: Marine.

Principal reference section: NE½ SW¼ sec 27, T15N, R23E, Lantry NE Quad., Dewey County, South Dakota.

History of stratigraphic nomenclature:
Morgan, R. E., and Petsch, B. C., 1945 (S.D. Geol. Surv. Rept. Invest. 49, p. 15-17): Timber Lake Sandstone Member crops out in most of Dewey and Corson Counties, South Dakota. In fresh exposures, lower part is greenish-yellow, medium-grained, soft or uncemented quartz sand. Upper part contains thin bands of fine-grained, orange to brown, well-cemented, limonitic claystone. Limonitic claystone occurs most abundantly at base of series of lens-like masses formed by concretionary cementation of sand.

Stevenson, R. E., 1956 (S.D. Geol. Surv. Geol. Quad. Bullhead, 1:62,500): Name shortened to Timber Lake Member.

Waage, K. M., 1961 (Wyo. Geol. Assoc. 16th Ann. Field Conf., p. 236): In north-central South Dakota, Timber Lake and underlying Trail City Members are lateral facies. Timber Lake overlain conformably by Bullhead.

_____, 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, 175 p.): Timber Lake Member is sand lithofacies of Lower Fox Hills. Numerous, shallow, undrained depressions are topographic evidence of member. Timber Lake is not continuous; in western part of type area, member disappears by facies change; northeast from study area, member encroaches on underlying Trail City Member. Contains Little Eagle lithofacies, biogenically-mixed clayey-silt with several fossiliferous concretionary layers forming assemblage zones in lower part of eastern two-thirds of type area; westward is Irish Creek lithofacies, thinly bedded silt and shale with concretions.

Feldmann, R. M., 1971 (N.D. Geol. Surv. Bull. 61, p. 25): Timber Lake Member is unconsolidated medium- to fine-grained sandstone becoming cross bedded near top. Timber Lake represents normal marine deposition.

Erickson, J. M., 1974 (Bull. Am. Paleo., p. 145): Timber Lake Member present in south-central North Dakota; consists of fine- to medium-grained, poorly consolidated sandstone. May represent "spit-barrier bar" environment of deposition.

TRAIL CITY MEMBER (of FOX HILLS FORMATION)

Age: Late Cretaceous (Maestrichtian).

Area of extent: Western North Dakota and western South Dakota.

Reported fossils: Molluscs.

Depositional environment: Marine.

Principal reference section: East of S.D. Highway 63, in E½ SW¼ sec 32, T15N, R24E, U.S. Geol. Surv. Parade NW Quad., Dewey County, South Dakota.

History of stratigraphic nomenclature:
Morgan, R. E., and Petsch, B. C., 1945 (S.D. Geol. Surv. Rept. Invest. 49, p. 13-14): Trail City Member is lowest member of Fox Hills Formation, extending from Trail City on east end of Grand-Moreau Divide southwest to St. Patrick's Butte, just west of S.D. Highway 65. Consists of brown or buff sandy shale, becoming more sandy toward top. Contains 3-5, locally persistent zones of fossiliferous concretions that have cores of dense limestone and may have sandy jackets that fall off when weathered.

Waage, K. M., 1961 (Wyo. Geol. Assoc. 16th Ann. Field Conf., p. 236): Trail City and Timber Lake Member are lateral facies.

_____, 1968 (Yale Univ. Peabody Mus. Nat. Hist. Bull. 27, 175 p.): In eastern two-thirds of type area, Trail City Member is biogenically mixed clayey silt with several richly fossiliferous concretion layers forming assemblage zones in lower part (Little Eagle lithofacies). Westward in type area, Trail City grades to thinly bedded silt and shale with mostly barren concretions (Irish Creek lithofacies). Trail City grades into Timber Lake Member.

Feldmann, R. M., 1972 (N.D. Geol. Surv. Bull. 61, p. 23): Trail City Member cannot be recognized in North Dakota.

Erickson, J. M., 1974 (Bull. Am. Paleo., p. 145): Trail City Member found in Logan, Emmons, and Sioux Counties, North Dakota. Lithofacies of Trail City Member not recognizable in south-central North Dakota as unit is thin.

Tongue River Formation, Member (of FORT UNION GROUP, FORMATION)

Age: Paleocene.

Area of extent: North Dakota, Montana, and Wyoming.

Reported fossils: Fresh-water molluscs, plant remains, and petrified trees.

Depositional environment: Nonmarine.

Remarks: Named from Tongue River, Wyoming; see also Bullion Creek Formation.

History of stratigraphic nomenclature:

Taff, J. A., 1909 (U.S. Geol. Surv. Bull. 341, p. 129-130): Coal-bearing rocks of Sheridan coal field, Wyoming, are divided into three coal groups (descending): 1) Ulm coal group, 2) intermediate coal group equivalent to at least part of Sentinel Butte Shale Member, exclusive of Roland coal, and 3) Tongue River coal group. Top bed of Tongue River coal group is Roland coal; Tongue River includes also Smith, Dietz, Monarch, Carney, and Masters coals. Is exposed along Tongue River.

Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484-499): Tongue River Member of Fort Union Formation consists of yellow or light-colored strata containing massive sandstones and numerous thick coal beds. Top of member is placed beneath bed K of Sidney field, bed F of Sentinel Butte field, and Roland coal of Sheridan field. Base is placed beneath light-colored, coal-bearing rocks that characteristically form clinker-capped escarpment rising above lowlands or badlands developed from Lebo Shale, with which it intertongues at contact. Fort Union Formation should be restricted to Lebo Andesitic (or Shale) Member and Tongue River Member although overlying Sentinel Butte Shale is considered Fort Union by U.S. Geological Survey. Tongue River Member well exposed on Tongue River between Carneyville, Wyoming, and Brandenburg, Montana; and along Yellowstone River between Burns, Montana, and Buford (Fort Union), North Dakota; and in Missouri valley above Fort Clark, North Dakota.

Laird, W. M., and Mitchell, R. H., 1942 (N.D. Geol. Surv. Bull. 14, p. 21-23): In southern Morton County, North Dakota, Tongue River Formation of Fort Union Group is 180 feet thick. Overlies Cannonball Formation. Is Paleocene in age.

Hennen, R. V., 1943 (Am. Assoc. Pet. Geol. Bull. 27, p. 1573, 1580): In Morton County, Almont Sandstone (new) lies about 35 feet above base of Tongue River Member of Fort Union.

Benson, W. C., 1949 (Geol. Soc. Am. Bull. 60, pt. 2, p. 1873): Tongue River Member of Fort Union Formation conformably underlies Golden Valley Formation.

Fisher, S. P., 1953 (N.D. Geol. Surv. Rept. Invest. 11, 2 pl.): Tongue River Formation includes all strata above Ludlow-Cannonball Formation and below Golden Valley beds. Includes Sentinel Butte Shale facies in upper part. Thickness is 745-1010 feet.

May, P. R., 1954 (U.S. Geol. Surv. Bull. 995-G, p. 268): Tongue River Member of Wibaux area, Montana and North Dakota is composed of light-yellow, tan and gray sandstones and shales; thin lenses of limestones; and numerous beds of lignite. Thickness of 1200 feet in Sidney lignite area and 600 feet in Marmarth field. Overlies Ludlow Member; underlies Butte Member.

Royse, C. F., Jr., 1967 (N.D. Geol. Surv. Rept. Invest. 45, p. 1): Separated Sentinel Butte and Tongue River as Formations in the Fort Union Group.

Clayton, L., et al., 1977 (N.D. Geol. Surv. Rept. Invest. 59, p. 9-12): Suppressed Tongue River Formation, replacing with Bullion Creek Formation.

Triassic "A" salt

Age: Triassic(?) Jurassic.

Area of extent: Western North Dakota, easternmost Montana.

History of stratigraphic nomenclature:

Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Triassic "A" salt is up to 199 feet thick in Spearfish Formation of North Dakota, thins over Nesson anticline. Equivalent to Dunham Salt.

Triassic "B" salt

Age: Triassic.

Area of extent: Western North Dakota, southeastern Montana, northwestern South Dakota.

History of stratigraphic nomenclature:
Anderson, S. B., and Hansen, D. E., 1957 (N.D. Geol. Surv. Rept. Invest. 28, 2 sheets): Triassic "B" salt is in Spearfish Formation of North Dakota. Appears to show salt solution with resulting collapse of overlying formations in Slope County and may create traps for accumulation of oil. Equivalent of Pine Salt.

Tullock Formation, Member

Age: Paleocene.

Area of extent: Montana, northeastern Wyoming; equivalent strata referred to as Ludlow in North and South Dakota.

Depositional environment: Nonmarine.

History of stratigraphic nomenclature:
Thom, W. T., Jr., and Dobbin, C. E., 1924 (Geol. Soc. Am. Bull. 35, p. 484-495): In Montana, Fox Hills Formation is overlain by (ascending): Hell Creek and Tullock Members of Lance.

Frye, C. I., 1969 (N.D. Geol. Surv. Bull. 54, 65 p.): Tullock Formation extended from Montana into southwestern North Dakota. Includes beds below T Cross of C. J. Hares, 1928 (U.S. Geol. Surv. Bull. 775, p. 47) and above lowest persistent coal of R. W. Brown, 1962 (U.S. Geol. Surv. Prof. Paper 375, 119 p.).

TYLER FORMATION, Sandstone Member (of BIG SNOWY GROUP)

Age: Pennsylvanian (Morrowan).

Area of extent: Central and eastern Montana, western North Dakota.

Reported fossils: Cypridopsis fabuline, ostracods, brachiopods, conodonts, spores, and fragments of sharks' teeth.

Depositional environment: Marine to nonmarine.

Type section: 5 miles west of Tyler School (also site of old Tyler Post Office), at southeast end of Middle Bench in S½ sec 5, T12N, R21E, Fergus County, Montana.

History of stratigraphic nomenclature:
Freeman, O. W., 1922 (Eng. Min. J.-Press, v. 113, no. 19, p. 827): Tyler sandstone is white to red sandstone interbedded with varicolored sandy shale. Thickness 300 feet. Overlain by Alaska Bench Limestone (text) or 100 feet of gray shale (generalized section).

Scott, H. W., 1935 (J. Geol., v. 43, p. 1028-1029): Tyler sands of Freeman (1922) occur at same stratigraphic zone as Van Dusen sand on southeast flank of Big Snowy Mountains. Sands are not a lithologic, paleontologic, or mappable unit over broad areas but should be considered member of Heath Formation.

Hadley, H. D., Lewis, P. J., and Larsen, R. B., 1952 (Billings Geol. Soc. Gdbk., 3rd Ann. Field Conf., p. 142): Tyler is member of Heath Formation. Thickness is 5 to 100 feet. Mississippian.

Mundt, P. A., 1956 (Am. Assoc. Pet. Geol. Bull. 40, p. 1920-1925): Tyler defined as formation to include black, gray, and reddish shales within which sandstone bodies (formerly Tyler Sandstone) occur; also includes marine limestone tongue locally present near top. Thickness where typically exposed is 382 feet. Underlies Alaska Bench Formation; unconformably overlies Heath Formation. Unit has been referred to as Amsden, Heath, Heath-Amsden transition zone, and nonmarine Heath, Mississippian. Uncertainty exists as to exact position of Freeman's type locality. Type section restated.

Grenda, J. C., 1978 (Mont. Geol. Soc. 24th Ann. Sym., Billings, p. 249): Studies of oil well cores of the Tyler in western North Dakota resulted in recognition of 44 invertebrate species, 11 conodonts, 3 types of fish, and at least 4 plant genera. Based on these flora and fauna, the Tyler is Morrowan, Atokan, and Desmoinesian in age.

Harris, S. H., 1958 (N.D. Geol. Soc. 2nd Internat. Williston Basin Sym.: Bismarck, p. 42): Lower Amsden carbonate marker bed traced through western North Dakota. "Lower Amsden operational unit" is developed on post-Heath erosion scour zone. As black fossiliferous shale and calcareous sandstone may indicate Tyler, brown limestone Amsden marker might be Alaska Bench Formation.

Willis, R. P., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 1948-1962): Tyler Formation in Montana area is limited to central Montana trough, and overlaps locally underlying Heath Formation. Isopach pattern shows abrupt thinning toward north along Cat Creek trend. Formation divided into two members: lower, predominantly dark, slightly calcareous shale, and upper, predominantly red and maroon calcareous shale with marine fauna. Term Cameron Creek used for upper member. "A" zone denotes both sand facies and limestone equivalent (Bear Gulch member or tongue); at base of "A" zone Tyler becomes marine and trend changes from east-west to southwest-northeast. Pennsylvanian (Morrowan).

Foster, F. W., 1961 (World Oil, v. 152, p. 89-93): Tyler divided into 2 units (ascending): 1) lower unit is black to dark-gray carbonaceous shale with freshwater ostracod, and other fauna, plant remains, and coal; and 2) upper unit is red, yellow, green, and black shale with thinly bedded limestone. Sand lenses occur in lower unit in North Dakota. Tyler is absent in southwestern North Dakota but thickens to 150 feet in west-central North Dakota; is usually dull red shale often called lower Amsden. Intraformational unconformity or diastem separates lower unit from upper unit but author not ready to apply Cameron Creek or Sacajawea to these units. Tyler developed on relatively flat shelf in North Dakota; basin influenced development in South Dakota. Heath represented by basal detritus in Tyler, which unconformably rests on Otter. Pennsylvanian.

Ziebarth, H. C., 1962 (Univ. N.D. Ph.D. Dissert., 414 p.): Tyler Formation in North Dakota is medium- to dark-gray shale and limestone with local sandstone lenses; ranges in thickness from 0-270 feet. Thickening toward periphery of unit may be result of disappearance of identifiable marker beds or facies changes within Alaska Bench and basal Amsden units similar to lithology of Tyler. Hiatus marks top of Tyler.

"Tyler-Heath interval"

Remarks: Willis, R. P., 1959 (Am. Assoc. Pet. Geol. Bull. 43, p. 1956): Used term Tyler-Heath interval in North Dakota; the section he referred to is currently included entirely within the Tyler Formation in North Dakota.

VERENDRYE MEMBER, Shale Zone (of PIERRE FORMATION, SHALE)

Age: Late Cretaceous (Campanian).

Area of extent: Eastern North Dakota and eastern South Dakota.

Depositional environment: Nonmarine.

Remarks: Type locality presumably under Verendrye Monument at Fort Pierre, Stanley County, South Dakota.

History of stratigraphic nomenclature:
Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 25-26, 34): Verendrye zone of light- to medium-gray banded shale. Concretions light-gray to olive-green where fresh, weathers dark brown. Underlies Virgin Creek and overlies manganiferous Oacoma beds. Total thickness 10-200 feet.

Crandell, D. R., 1950 (Am. Assoc. Pet. Geol. Bull. 34, p. 2345): Verendrye and Crow Creek raised to member rank and DeGrey Member (Agency-Oacoma unit) named. Sully no longer used.

Vermilion River Formation

Age: Late Cretaceous.

Area of extent: Pembina escarpment area of Manitoba and northeastern North Dakota; equivalent to Carlile, Niobrara, and lower part of Pierre Formation of current North Dakota usage.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Kirk, S. R., 1930 (Can. Geol. Surv. Summ. Rept. 1929, pt. B, p. 123): Used term Vermilion River Beds for dark, carbonaceous and noncalcareous shales overlying Assiniboine Beds in the Vermilion River area, Manitoba.

Cobban, W. A., and Reeside, J. B., Jr., 1952 (Geol. Soc. Am. Bull. 63, p. 1011-1013): Vermilion River Formation (Late Cretaceous) is found on Pembina escarpment, Manitoba and North Dakota. Overlies Favel Formation; underlies Riding Mountain Formation.

"Virden subinterval"

Age: Mississippian (Kinderhookian).

Area of extent: Southern Manitoba, eastern North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Stanton, M. S., 1956 (Alberta Soc. Pet. Geol. J., v. 4); 1958, (AAPG Allen Mem., v. p. 382): Introduced Virden as Member of the Lodgepole Formation; type section is Cal. Standard-Virden 9-25 (ls 9-25-10-26WPM); interval from 1911 to 1968. Overlies Scallion Member, underlies Whitewater Lake member. Lower part is oolitic and bioclastic limestone, upper part is crinoidal.

Heck, T., 1978 (Mont. Geol. Soc. Williston Basin Sym. 24th Ann. Field Conf., p. 197): Virden subinterval is sequence reflecting gradual marine regression coupled with prograding into basin. Three facies developed: 1) medium- to dark-gray, argillaceous, pelletal, skeletal, muddy grainstone (shallow open-shelf), 2) oolite grainstone (as shoals or near shelf break), and 3) light-colored, argillaceous, cherty, pelletal, skeletal wackestone to packstone interbedded with oxidized skeletal mudstone to wackestone (shoreward of oolite shoals). Lower unit is more argillaceous than upper unit, which is relatively clastic-free. Is cyclical, grading from basal oolite shoal and skeletal grainstones

interbedded with argillaceous limestone and shale, grading upwards to interbedded pelletal limestone and skeletal grainstone. Is Kinderhookian in age.

Virgin Creek Member (of PIERRE FORMATION, SHALE)

Age: Late Cretaceous (Campanian to Maestrichtian).

Area of extent: Eastern North Dakota and eastern South Dakota.

Type section: Valley wall of Virgin Creek, about 1½ miles south of Promise, Dewey County, South Dakota.

History of stratigraphic nomenclature:
Searight, W. V., 1937 (S.D. Geol. Surv. Rept. Invest. 27, p. 35-43): Virgin Creek divided into two zones (descending): Upper zone contains small fossiliferous concretions in lower part and bed of large limestone concretions; lower zone is light- to medium-gray shale with thin bentonite beds. Basal part of lower unit weathers to gray gumbo, tinged rusty brown in places. Overlies Sully Member; underlies calcareous beds of Mobridge Member. Top of zone of limestone concretions contains Sage Creek fauna farther west.

Crandell, D. R., 1950 (Am. Assoc. Pet. Geol. Bull. 34, p. 2340): Overlies Verendrye Member; underlies Mobridge Member.

Rice, D. D., 1977 (U.S. Geol. Surv. Misc. Invest. Map OC-70, 1 sheet): Virgin Creek Member is in eastern North Dakota on correlation chart.

Wendover Group

Age: Pennsylvanian (Virgillian).

Area of extent: Hartville Uplift area of eastern Wyoming, northeastern Colorado, southwestern Dakota; equivalent strata in North Dakota appear to be included in upper part of Amsden Formation of current usage.

Reported fossils: Fusulinids.

Depositional environment: Marine.

Remarks: Type area is in Platte River Valley in vicinity of Wendover, Platte County, Wyoming.

History of stratigraphic nomenclature:
Condra, G. E., Reed, E. C., and Scherer, O. J., 1940 (Neb. Geol. Surv. Bull. 13A, p. 2-3, 5, 22, 23-24, 28, 30, and 45): Wendover Group consists of limestones interbedded with sandstones, mudstones, and shales. At base is sandstone that probably marks unconformity. Comprises upper part of Division II of Hartville "Formation" (Condra, G. E., and Reed, E. C., 1935, Neb. Geol. Surv. Paper 9, 46 p.): Thickness is 104 feet. Underlies Broom Creek beds (new); overlies Meek Group (new).

McCauley, V. T., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., Bismarck, N.D., p. 150-164): Wendover-Meek Group is poorly represented in North Dakota. All beds from base of overlying Broom Creek to below radioactive markers are missing in broad areas of southeastern and eastern Montana, southwestern North Dakota and northwestern South Dakota. Broom Creek rests directly on radioactive zones or is separated by few feet. Sandstone or sandy dolomites are most common lithologies of Wendover-Meek Group.

WHITE RIVER GROUP, Formation

Age: Oligocene (Chadronian to Orellan).

Reported fossils: Fish, mammalian and chelonian remains.

Depositional environment: Nonmarine.

Remarks: Named for exposures along White River in western South Dakota.

History of stratigraphic nomenclature:
Meek, F. B., and Hayden, F. V., 1857 (Phila. Acad. Nat. Sci. Proc., v. 9, p. 119, 133): White River (Miocene) deposits in places crown summits of hills on east side of Missouri River near mouth of White River. Titanotherium bed of White River basin is oldest member. No evidence that any Tertiary deposits known in Nebraska are older than Miocene.

_____, 1862 (Phila. Acad. Nat. Sci. Proc., v. 13, p. 433-434): White and light-drab clay with sandstone beds and local layers of limestone. Is 1000 feet thick. Fossils contain no brackish-water or marine forms. Occurs in Bad Lands of White River, on Niobrara, and across area to Platte River. Overlies Fort Union Group on North Platte River above Fort Laramie; underlies Loup Fork beds (Pliocene).

Meek, F. B., 1876 (U.S. Geol. and Geog. Surv. Terr. Mon. 9, p. lxi-lxiv): Contains great numbers of mammalian and chelonian remains with very fine state of preservation. No marine or brackish water remains found so must be freshwater lacustrine deposit. White River spreads extensively south of Black Hills into Nebraska, Colorado, and Kansas. Unconformably overlies Fort Union Group; underlies Pliocene lake deposit on Loup River and other areas of Nebraska.

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 64-71): Beds of White River Formation confined to White Butte or Chalk Butte of southern Billings County and Sentinel Butte. Conformably overlies Fort Union Formation. Is Oligocene in age.

"Whitewater Lake subinterval"

Age: Mississippian (Kinderhookian).

Area of extent: Southern Manitoba, eastern North Dakota.

Depositional environment: Marine.

History of stratigraphic nomenclature:
Stanton, M. S., 1956 (Alberta Soc. Pet. Geol. J., v. 4); 1958 (AAPG Allen Mem. v. p. 386): Introduced Whitewater Lake Member as upper member of Lodgepole Formation in southern Manitoba. Type sections: Lower part is Cal. Standard-Whitewater 10-17 (ls 10-17-3-21 WPM) interval from 2545 to 2585, upper part is Cal. Standard-Whitewater 16-17 (ls 16-17-3-21 WPM) interval from 2502-2541. Lower part is oolitic, fossiliferous, fragmental limestone; upper part is dolomitized carbonate.

Heck, T., 1978 (Mont. Geol. Soc. Williston Basin Sym. 24th Ann. Field Conf., p. 197): Whitewater Lake subinterval is sequence reflecting gradual marine regression coupled with prograding into basin. Three facies developed: 1) medium- to dark-gray, argillaceous, pelletal, skeletal, muddy grainstone (shallow open-shelf), 2) oolite grainstone (as shoals or near shelf break), and 3) light-colored, argillaceous, cherty, pelletal, skeletal, wackestone to packstone interbedded with oxidized skeletal mudstone to wackestone (shoreward of oolite shoals). Lower unit is more argillaceous than upper unit which is relatively

clastic-free. Is cyclical in nature, grading from basal oolite shoal and skeletal grainstones, interbedded with argillaceous limestone and shale, grading upwards to interbedded pelletal limestone and skeletal grainstone. Is Kinderhookian in age.

WINNIPEG GROUP, FORMATION

Age: Upper Ordovician (Blackriverian to Trentonian).

Area of extent: Manitoba, Saskatchewan, North Dakota, South Dakota, and eastern Montana.

Reported fossils: Conodonts, brachiopods, corals, scolecodonts, pelecypods, and gastropods.

Depositional environment: Marine.

Remarks: Type section exposed on shores and islands in southern part of Lake Winnipeg, Manitoba.

History of stratigraphic nomenclature:
Dowling, D. B., 1896 (Ottawa Field Nat. Club Trans. 1895-1896, v. 11, p. 67-68): Winnipeg Formation is basal sandstone unit and overlies green shale sequence. Sand locally present in upper green shale; formation may contain pyrite and phosphate nodules; thin limestone beds occur locally. Thickness is 60-800 feet.

McCauley, G., and Leith, E. I., 1951 (Geol. Soc. Am. Bull. 62, p. 1461-1462): Winnipeg Formation assigned to Late Ordovician Richmondian age.

Baillie, A. D., 1952 (Man. Dep. Mines Nat. Resour. Pub. 51-6, p. 41): Winnipeg considered to be Trentonian(?) in age.

Erickson, H. D., 1954 (S.D. Geol. Surv. Rept. Invest. 74, p. 43): Winnipeg Formation divided into two lithologic units (descending) in South Dakota: Winnipeg Shale, light-gray to green, mottled bentonitic shale and siltstone with few sandy horizons; and Winnipeg Sandstone, well-sorted, medium-textured, clear quartz sand, few fossils present. Unit has been called Black River and St. Peter in previous reports of South Dakota Geological Survey.

McCauley, G., 1955 (Alberta Soc. Pet. Geol. J., v. 3, p. 49-52): Winnipeg Formation is shale and sandstone section that underlies Red River Formation and overlies Precambrian basement complex in Manitoba. In Saskatchewan and Dakotas, formation is underlain by Cambrian sediments. No type outcrop section can be established because upper and lower contacts are not exposed at any one place. Suggestions given for two type wells.

Ross, R. J., Jr., 1957 (U.S. Geol. Surv. Bull. 1021-M, p. 448-449): In subsurface of Williston Basin, Winnipeg Formation overlies Deadwood Formation and underlies Red River Formation of Bighorn Group.

Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 44-74): Winnipeg Formation consists of sandstone, shale, and siltstone. Lies unconformably on Deadwood Formation except in northwestern North Dakota where it may be conformable on Deadwood and in northeastern North Dakota where it lies nonconformably on Precambrian rocks; overlain conformably by Red River Formation. Is divided into three members (ascending): Black Island, Icebox, and Roughlock. Thickness is 0-357 feet. Age is Middle Ordovician, Blackriverian and Trentonian, based on conodonts.

Fuller, J. G. C. M., 1961 (Am. Assoc. Pet. Geol. Bull. 45, p. 1341): Black Island Member of Carlson (1960) not same as originally defined and thus replaced by

Burgen Sandstone (p. 1339). (This usage not followed by North Dakota Geological Survey.)

"Winnipeg transition zone"

Remarks: Carlson, C. G., 1960 (N.D. Geol. Surv. Bull. 35, p. 61): In northwestern North Dakota, near limit of recognition of Roughlock Member, interval referred to as "Winnipeg transition zone" by some petroleum geologists; is included in Roughlock Formation.

WINNIPEGOSIS FORMATION (of ELK POINT GROUP)

Age: Middle Devonian (Erian).

Area of extent: Williston Basin, Elk Point Basin, Alberta.

Reported fossils: Stromatoporoids, Amphipora corals.

Depositional environment: Marine.

Remarks: Type area at exposures along Lake Winnipegosis in Manitoba.

History of stratigraphic nomenclature:
Tyrrell, J. B., 1893 (Can. Geol. Surv., new ser., v. 5, pt. 1, p. 144E-199E): Winnipegosan Formation of Manitoba is Devonian in age.

Wallace, R. C., 1915 (Can. Geol. Surv. Summ. Rept. 1914, p. 77): Winnipegosan beds are exposed at Graves Point, Lake Winnipegosis. Winnipegosis and Winnipegosan spellings used in report.

Baillie, A. D., 1953 (Am. Assoc. Pet. Geol. Bull. 37, p. 444-447): Formation originally called Winnipegosan by Tyrrell (1893) but, because adjectival suffix has time connotation, term "Winnipegosis" used to conform with usage recommended by Geological Survey of Canada and American Commission on Stratigraphic Nomenclature. In outcrop, overlies Elm Point Formation; underlies Dawson Bay Formation (new). Redefined in subsurface to include Elm Point Limestone. Is member of Elk Point Group.

Check, R., 1956 (N.D. Geol. Soc. 1st Internat. Williston Basin Sym., p. 140): Winnipegosis extends from eastern Alberta to Manitoba and south to its depositional edge in North Dakota and Montana.

Sandberg, C. A., and Hammond, C. R., 1958 (Am. Assoc. Pet. Geol. Bull. 42, p. 2299, 2303-2306): In Williston Basin, Winnipegosis is redefined to include strata previously assigned to Ashern Formation of Baillie (1951, Man. Dep. Mines Nat. Resour. Mines Br. Pub. 49-2). In United States, Winnipegosis restricted to Williston Basin and northeastern Montana. Is less than 1 to 300 feet thick. Lower formation of Elk Point Group; underlies Prairie Formation. In Birdbear well, Dunn County, North Dakota, Winnipegosis lies at 11,438-11,698 feet and rests unconformably on Silurian rocks. Is Middle Devonian.

"Woodbend equivalent"

Remarks: Towse, D. F., 1953 (N.D. Geol. Surv. Rept. Invest. 12, 1 sheet): Used Woodbend equivalent to thick, medium to dark brown, dolomite above "Beaverhill Lake equivalent." (Duperow of current usage.)

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Hares, C. J., 1928, Geology and lignite resources of the Marmarth Field, southwestern North Dakota: U.S. Geological Survey Bulletin 775, 110 p.

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Leonard, A. G., 1908, The geology of southwestern North Dakota, with special reference to the coal: North Dakota Geological Survey 5th Biennial Report, p. 27-114.

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APPENDIX A

NAMED LIGNITE BEDS IN NORTH DAKOTA

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Early studies of the lignite-bearing strata were concerned primarily with the resources of specific areas. The general practice was to establish a stratigraphic column based on lignite beds and the intervals between the beds. The lignite beds were either assigned numbers (e.g., Smith, C. D., 1910; Pischel, M. A., 1912) or they were assigned letters (e.g., Leonard, 1908; Hancock, E. T., 1921). Gradually, names were applied to some of the beds of economic importance (Lloyd, 1914; Leonard, 1925). The practice of naming most of the lignite beds began with Hares (1928), and subsequent workers have generally applied names to most of the lignite beds in their study areas. Except where correlations to adjacent areas were reasonably certain, new names were introduced for each area rather than risk miscorrelations, which would result in the same name being applied to some different beds. A few such miscorrelations can now be recognized as well as some duplicative names, but no effort was made here to arrange any synonymy. The purpose here is to provide a list of previously named lignite beds and the original reference as an aid for those who might wish to create such a synonymy, or for those who might be interested in the derivation of a specific name.

Alamo Bluff bed

Benson, W. E., 1952 (U.S. Geol. Surv. Open-File Rept., p. 252): Lower member of Golden Valley Formation is capped by thin, impure lignite or carbonaceous shale, which locally thickens to coal bed 2-6 feet thick, named Alamo Bluff bed. Named for ruins of adobe house called Alamo on northeast corner of sec 28, T143N, R90W.

Antelope Creek bed

Groenewold, G. H., et al., 1979 (N.D. Geol. Surv. Rept. Invest. 64, p. 24): 4-50 feet thick throughout Knife River basin.

Baker's Ferry bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 109): Baker's Ferry bed is lowest coal seam of Rough Creek area. Considered to be of Fort Union Formation.

Bar-H lignite

King, J. W., 1955 (N.D. Geol. Soc. Gdbk. Black Hills Field Conf., p. 85): Bar-H lignite is 135 feet below top of Ludlow Formation; named from Bar-H Ranch, Harding County, South Dakota.

Beaver Creek bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Uppermost bed of Tongue River Member in Heart Butte Quadrangle, Morton and Grant Counties.

Beaver Creek coal group

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 102-105): Beaver Creek group of coals occurs in northwestern corner of Billings County. Lies above Medora group beds and uppermost bed is 100 feet below Sentinel Butte group. Contains beds N to P.

Berg bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 39): Berg bed is lignite bed of local extent in Square Butte area.

Beta bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 82): The third bed above base of Ludlow was designated the Beta bed in the Marmarth coal field.

Beulah bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 127): Beulah bed is coal bed in vicinity of Beulah; is 190 feet below Beulah-Zap bed.

Beulah-Zap bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N. D. Geol. Surv. Bull. 4, p. 125): Beulah-Zap bed is perhaps most important and extensive lignite bed of

North Dakota. Crops out along Knife River and Spring Creek. Named for towns of Beulah and Zap.

Bonus bed

Pollard, B. C., et al., 1972 (U.S. Bureau Mines Inform. Circ. 8537, p. 11): Occurs above Niobe bed in southwestern portion of deposit in Ward and Burke Counties, North Dakota. Is 8.5 feet thick.

Bowman bed

Leonard, 1925 (N.D. Geol. Surv. Bull. 4, p. 62): Bowman bed varies in thickness from 8 to 38 feet; shown as about 75 feet above Harmon bed in figure 7.

Brazda bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 38): Brazda bed is lignite bed of local extent in Square Butte area.

Buckmann bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 44): Buckmann bed is lignite found on Buckmann Farm in sec 34, T143N, R87W. Is 65-75 feet above Beulah-Zap bed and is exposed in Otter Creek area.

Bullion Butte bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 50): Bullion Butte lignite of Sentinel Butte shale is 16 feet thick and occurs only in Bullion Butte. Occurs above HT Butte lignite.

Burkey bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 63): 3-6.5 feet thick in T137N, R105W, and may be present in other areas of Marmarth field, North Dakota; surface rocks are Tongue River Member of the Fort Union.

Burlington bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 147): Coal bed mined in Des Lacs and Mouse River valleys is Burlington bed.

Byer bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 46): Byer bed lies 65 feet above Otter Creek bed and consists of lignite.

Cannonball bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 47): Cannonball lignite is at base of Ludlow lignitic member of Lance Formation.

Coal Creek bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 256): Coal Creek bed is named for exposures along Coal Creek. Consists of lignite 35-40 feet below Stanton bed; may be equivalent to Hazen B bed.

Coal Lake Coulee bed

Groenewold, G. H., et al., 1979 (N.D. Geol. Surv. Rept. Invest. 64, p. 20): 8 feet in type well but usually is 2-4 feet thick. Can occur as split bed and may merge locally with Tavis Creek bed.

Coalbank bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 91): Coalbank coal bed is exposed along Coalbank Creek and is mappable for a distance of 10 miles along valley of Cannonball River and 15 miles along Coalbank Creek.

Coteau bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 148): Coteau bed is thick bed of coal in extreme southeast corner of Ward County. Named for Missouri Coteau.

Crooked Creek bed

Smith, H. L., 1973 (U.S. Geol. Surv. Coal Invest. Map C-62): Lignite bed in New Salem quadrangle; is equivalent to bed B of Hancock (1921).

Cut Bank Creek

Smith, H. L., 1973 (U.S. Geol. Surv. Coal Invest. Map C-62): Lignite bed in New Salem quadrangle; is equivalent to bed C of Hancock (1921).

Des Lacs bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 146): Des Lacs bed is only coal bed mined in Ward County. Is 4-6 feet thick.

Dickinson bed

Menge, M. L., 1977 (U.S. Geol. Surv. Open-File Rept. 77-482, p. 7): Dickinson bed is pod-shaped uppermost potentially economic bed in Sentinel Butte of Dickinson area.

Discovery bed

Soward, K. S., 1975 (U.S. Geol. Surv. Coal Invest. Map C-69): Lignite bed in White Butte area of Hettinger County; is about 225 feet above base of Sentinel Butte.

Dunn Center bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 83): Dunn Center bed is one of thickest coal beds in Dunn County. Named for town of Dunn Center.

Fairman bed

Smith, C. D., 1908 (U.S. Geol. Surv. Bull. 381, p. 24): Fairman bed is coal seam mined at Satterlund Mine. See also Satterlund-Kugler bed.

Fryburg coal bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 140): Of two coal beds 50-60 feet apart in western Stark County, lower one has burned out extensively in vicinity of Fryburg and is named Fryburg coal bed. See also Heart River bed.

Garner Creek bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 50): Garner Creek bed lies about 180 feet above Harmon bed and consists of lignite.

Garrison Creek bed

Andrews, D. A., 1939 (U.S. Geol. Surv. Bull. 906-B, p. 72): Garrison Creek bed, named from exposures along Garrison Creek, crops out along Missouri River, and in Minot area of North Dakota.

Great Bend coal group

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 80-90): Great Bend coal group occurs along Little Missouri River from Yule to Garner Creek, beds G to I lie in lower 150 feet of middle division of Fort Union.

Gunsch bed

Soward, K. S., 1975 (U.S. Geol. Surv. Coal Invest. Map C-69): Lignite bed in White Butte area of Hettinger County; is about 400 feet below base of Tongue River; is in Ludlow.

Hagel bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 40): Hagel bed named for Hagel Mine, is thickest coal bed in area. Is found along Square Butte Creek and tributaries in Oliver County. Is 25-50 feet above Yeagher bed.

Hancock bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 258): Hancock bed is lignite named for Hancock Mine. Is about 15 feet below Stanton bed. May be equivalent to Wolf Creek bed of Smith, C. D., 1908 (U.S. Geol. Surv. Bull. 381, p. 19, 20).

Hanks bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 157): Hanks bed is burned coal bed in vicinity of Hanks, North Dakota.

Hansen bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 49): The Hansen bed is about 30 feet above the H bed in the Tongue River Member of the Fort Union.

Harmon lignite bed

Leonard, A. G., and Smith, C. D., 1909 (U.S. Geol. Surv. Bull. 341, p. 24): The Harmon lignite, A in the columnar section, is the lowest bed of consequence in the Sentinel Butte Field.

Harnisch bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 71, 83-84): Crops out in northwestern Stark County. Sand of lower member of Golden Valley Formation channels into Harnisch bed. Is 4 feet thick but may vary locally.

Hastings-Frobisher beds

Fuller, J. G. C. M., 1956 (Sask. Dept. Min. Resour. Rept. 19, p. 31): Introduced term to apply to beds.

Haymarsh Creek bed

Barclay, C. S. V., 1974 (U.S. Geol. Surv. Coal Invest. Map C-67, 13 p., 2 pl.): Haymarsh Creek bed is local lignite unit in Dengate Quadrangle, North Dakota.

Haynes bed

Lloyd, E. R., 1914 (U.S. Geol. Surv. Bull. 541G, p. 252): Haynes bed is lowest important lignite in Cannonball River Field except in vicinity of Cannonball River. Reaches thickness of 6 feet.

Hazen A bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 255): Hazen A bed is lowest coal bed that crops out near town of Hazen. Is 4-5 feet thick; occurs 155-160 feet below Beulah-Zap bed.

Hazen B bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 245): Hazen B bed, named for exposures near Hazen, outcrops along Knife River valley to town of Beulah. Hazen B bed is about 110-115 feet below Beulah-Zap bed.

Heart River bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 140): Of two coal beds 50-60 feet apart in western Stark County, upper bed is named Heart River Coal bed.

"Hell Creek lignite"

King, J. W., 1955 (N.D. Geol. Soc. Gdbk. Black Hills Field Conf., p. 85): Illustrated Hell Creek lignite as being 10 feet below top of Hell Creek Formation.

Herman bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 44): Herman bed is lignite found on Herman farm in sec 28, T143N, R87W. Is 25-30 feet above Buckmann bed and crops out along Otter Creek.

HT Butte lignite

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 50): HT Butte lignite is basal bed of Sentinel Butte shale; averages 9 feet in thickness but can reach 16 feet thick. Has been largely eroded or burned out and now only occurs as remnants. Equivalent to bed F of Sentinel Butte Lignite Group of Leonard, A. G., and Smith, C. D., 1909 (U.S. Geol. Surv. Bull. 341, p. 30) and Bed R of

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 90-102) and may correspond to Roland Coal of northern Wyoming.

Hummel bed

Soward, K. S., 1975 (U.S. Geol. Surv. Coal Invest. Map C-69): Lowest lignite bed in Tongue River in White Butte area of Hettinger County.

Ives bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 48): The Ives bed, which averages about 3 feet thick along Bacon Creek is about 100 feet above T Cross bed.

Jim Creek bed

Groenewold, G. H., et al., 1979 (N.D. Geol. Surv. Rept. Invest. 64, p. 25): 4 feet of lignite; can split into two seams locally.

Kaelberer bed

Smith, H. L., 1973 (U.S. Geol. Surv. Coal Invest. Map C-62): Lignite bed in New Salem area; is equivalent to bed D of Hancock (1921).

Kinneman Creek bed

Groenewold, G. H., et al., 1979 (N.D. Geol. Surv. Bull. 4, p. 23): 8 feet of lignite overlain by 4 feet of black carbonaceous clay; is underlain by 2 feet of black carbonaceous clay and associated 4 feet of lignite. Is present throughout Knife River basin.

Kit Fox bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Local bed between Heart Butte and Spring Valley beds in the Heart Butte quadrangles.

Knoop bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 257): Knoop bed is named for exposures on Knoop Ranch on west side of Missouri River in secs 8, 9, 16, and 17, T145N, R85W. Consists of two beds of coal separated by 3-4 feet of clay. Is about 80-120 feet below Stanton bed. May be lateral equivalent of Wolf Creek bed.

Koehler bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Lignite bed about 105 feet below top of Tongue River in the Heart Butte quadrangles.

Kruckenberg bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 260): Kruckenberg bed is coal bed named for Kruckenberg Farm where it is exposed. Is 50 feet above Garrison Creek bed.

Kuether bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 40): Keuther bed is 35-45 feet above Hagel bed and is named for Keuther Mine. Is found in Oliver County, North Dakota.

Lehigh bed

Leonard, A. G., 1925 (N.D. Geol. Surv. Bull. 4, p. 144): Lehigh bed ranges in thickness from 8 to 14 feet in T139N, R95W.

Many Springs bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Lignite bed about 75 feet below top of Tongue River in Heart Butte quadrangles.

Mattson bed

Brant, R. A., 1953 (U.S. Geol. Surv. Circ. 226, p. 19): 12 feet thick; named for Mattson Mine, 2 miles from Tolley, North Dakota in Renville County.

Medora group

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 96-102): Medora group of coal beds crops out along valley of Little Missouri River from Bullion Butte to northern boundary of Billings County. Beds J to M make up this group of coals.

Meyer bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 50): Meyer bed is thin and of poor quality. Crops out in lower part of Bullion Butte.

Minter bed

Andrews, D. A., 1939 (U.S. Geol. Surv. Bull. 906B, p. 73): Minter coal bed, named from Minter Mine, crops out along Douglas Creek near Minot, North Dakota.

Mormon bed

Collier, A. J., 1918 (U.S. Geol. Surv. Bull. 691-G, Plate XXVI): 13 feet of lignite at Mormon Mine in Williams County, North Dakota. Is 300 feet above Williston bed.

Niobe bed

Pollard, B. C., et al., 1972 (U.S. Bur. Mines Inform. Circ. 8537, p. 8-11): Is in Ward and Burke Counties, northwestern North Dakota; is 6 feet thick. Occurs with Bonus bed in southwestern portion.

Nomad bed

Owen, H., 1979 (U.S. Geol. Surv. Open-File Rept. 79-564, p. 9): Is lignite bed up to 12 feet thick; averages 5 feet in thickness. Splits and pinches out in subsurface.

Noonan bed

Leonard, A. G., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 78): Ranges from 7 to 10 feet thick in vicinity of Noonan and Columbus.

Otter Creek bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 45): Otter Creek bed is named for Otter Creek; lies 135-145 feet above Beulah-Zap bed. Consists of two coals about 15 feet apart.

Paulson No. 1 bed

Brant, R. A., 1953 (U.S. Geol. Surv. Circ. 226, p. 13): Lowest lignite in Divide County; is 6 feet thick. Is 100 feet below Paulson No. 2 bed.

Paulson No. 2 bed

Brant, R. A., 1953 (U.S. Geol. Surv. Circ. 226, p. 13): Is 100 feet above Paulson No. 1 bed and is in northeastern Divide County. Is 11 feet thick.

Pittsley lignite bed

Collier, A. J., 1918 (U.S. Geol. Surv. Bull. 691-G, p. 213): 14 feet thick at Pittsley Mine in Williams County, North Dakota.

Ramsland bed

Smith, H. L., 1973 (U.S. Geol. Surv. Coal Invest. Map C-62): Ramsland bed in New Salem area is equivalent to bed E of Hancock (1921).

Red Butte bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 42): Red Butte bed is named for Red Butte. Lignite underlies Knife River, Square Butte Creek, and Sweet Briar Creek.

Red Dog bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Red Dog bed is about 45 feet below top of Tongue River in Heart Butte area.

Reservation bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 81, 104): Reservation bed is lowest coal bed of this area and appears along southern boundary of Fort Berthold Indian Reservation.

Satterlund-Kugler bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 119): Satterlund-Kugler bed is lignite bed mined about 5 miles west of Washburn. Bed is 8-11 feet thick and is named for mines of area.

Schaffner bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 253): Schaffner bed named for exposures near Schaffner Creek is coal occurring about 30 feet

above Alamo Bluff bed. Is in upper member of Golden Valley Formation.

Schank bed

Soward, K. S., 1975 (U.S. Geol. Surv. Coal Invest. Map C-69): Schank bed is about 20 feet above Hummel bed in White Butte area of Hettinger County.

Schoolhouse bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 251): Schoolhouse bed named for exposure in small mine near rural school in southern part of sec 27, T142N, R89W; is 45-100 feet above Beulah-Zap bed.

Scranton bed

Leonard, A. G., Babcock, E. J., and Dove, L. P., 1925 (N.D. Geol. Surv. Bull. 4, p. 59-62): Is 12-21 feet thick; underlies large area of eastern and northeastern Bowman County, North Dakota.

Sentinel Butte group

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 90-96): Sentinel Butte coal group is highest coal group in region. Contains beds Q to U. Beds Q to S occur at Bullion Butte.

Shell bed

Stephans, E. V., 1970 (U.S. Geol. Surv. Coal Invest. Map C-52): Shell bed is about 175 feet below top of Tongue River in Heart Butte area. Named for association with fossil.

Sims Creek bed

Smith, H. L., 1973 (U.S. Geol. Surv. Coal Invest. Map C-62): Sims Creek bed is equivalent to the A bed of Hancock (1921) in the New Salem area.

Spear bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 252): Spear bed occurs about 60 feet below Beulah-Zap bed. Named for exposures at Spear Ranch in northeast corner of sec 12, T143N, R89W.

Spring Valley-Richter lignite zone

Barclay, C. S. V., 1974 (U.S. Geol. Surv. Coal Invest. Map C-67, 13 p., 2 pl.): Zone of locally thick and persistent lignite beds in Glen Ullin and Dengate Quadrangles named Spring Valley-Richter lignite zone. Named from Spring Valley and Richter Mines. Spring Valley and Richter beds are at least partly equivalent.

Stanton bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 256): Stanton bed is named for exposures of coal 4-6 miles south of Stanton. May be equivalent to Garrison Creek bed of Andrews, 1939 (U.S. Geol. Surv. Bull. 906B, p. 43-84).

Star bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 255): Star bed is poorly exposed bed 25-40 feet above Hazen B bed and 75-95 feet below Beulah-Zap bed. Named for Dakota Star Mine where it is 10 feet thick.

Tavis Creek bed

Barclay, C. W. V., 1974 (U.S. Geol. Surv. Coal Invest. Map C-67, p. 3): Tavis Creek lignite bed is 5-11 feet thick; occurs 20-40 feet below top of Tongue River.

T-Cross lignite

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 47): T-Cross bed is extensive and principal lignite bed in Ludlow "Lignitic" Member of Lance, corresponding to Giannonatti bed of northwest South Dakota. Has been traced from T20N, R8E, South Dakota, to vicinity of Yule and westward to Montana; ranges from 3-8 feet thick. At T-Cross Mine, sec 20, T133N, R104W, bed is 24 feet thick. Is "lowest persistent lignite" of eastern Montana.

Twin Buttes bed

Benson, W. E. B., 1952 (U.S. Geol. Surv. Open-File Rept., p. 252): Twin Buttes bed is named for exposures near pair of small conical buttes in sec 28, T134N, R92W. Is 130-150 feet above Beulah-Zap bed.

Weller Slough bed

Groenewold, G. H., et al., 1979 (N.D. Geol. Surv. Rept. Invest. 64, p. 18): 12 feet thick; is lignite of Bullion Creek Formation. Is in southwestern McLean County to southwestern Mercer County.

Williston bed

Collier, A. J., 1918 (U.S. Geol. Surv. Bull. 691-G, p. 213): 5-12 feet thick in Williams County, North Dakota.

Wilton bed

Leonard, A. G., Dove, L. P., and Eaton, H. N., 1925 (N.D. Geol. Surv. Bull. 4, p. 119): Wilton bed is most important lignite bed of district. Named for town of Wilton.

Wolf Creek coal bed

Andrews, D. A., 1939 (U.S. Geol. Surv. Bull. 906-B, p. 70): Named for exposures along Wolf Creek, T147N, R84W; about 80 feet above base of Fort Union.

Yaegher bed

Johnson, W. D., Jr., and Kunkel, R. P., 1959 (U.S. Geol. Surv. Bull. 1076, p. 39): Yeagher bed is coal named for Yeagher Mine. Crops out along Square Butte Creek and is 30 feet above Berg bed, when both found together. Is composed of two beds of lignite separated by 8 feet of sandy shale. Lower bed is 6 feet thick; upper bed is 5 feet thick.

"Yule group"

Leonard, A. G., 1908 (N.D. Geol. Surv. 5th Bienn. Rept., p. 77-80): Coal beds found in vicinity of Yule and farther south on Bacon and Coyote Creeks named Yule coal group. Beds A to F occur in lower member of Fort Union Formation.

Yule bed

Hares, C. J., 1928 (U.S. Geol. Surv. Bull. 775, p. 47): Yule bed is in upper part of Ludlow lignitic member of Lance; equivalent to E bed of Leonard's Yule Group.

APPENDIX B

PLEISTOCENE AND HOLOCENE STRATIGRAPHIC NAMES

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PLEISTOCENE AND HOLOCENE STRATIGRAPHIC NAMES

Research on the glacial and post-glacial stratigraphy in eastern and northern North Dakota, under way since about 1960, has led to recognition of a large number of lithostratigraphic units of Pleistocene and Holocene age. Many of these units have been named in accordance with the Code of Stratigraphic Nomenclature (A. C. S. N., 1970). Others, however, have been named only in theses or dissertations, or were used informally. The listing of these names in this appendix is not meant to indicate approval or disapproval; it is intended, rather, to help researchers find how names have been used by previous workers. We strongly oppose the proliferation of a plethora of short-lived, unnecessary stratigraphic names.

The listing that follows consists of four broad categories of stratigraphic units: 1) units that have been formally named in accordance with the Code of Stratigraphic Nomenclature are shown in capital letters (BRENNA FORMATION); 2) units that have attained wide usage even though they were never formally named are shown underlined in lower case (Flaxville Gravel); 3) units proposed in theses and dissertations are shown as lower case (Braddock Formation); and 4) units used only informally are shown in quotes ("Buchanan Drift").

AGGIE BROWN MEMBER (of OAHE FORMATION)

Clayton, L., Moran, S. R., and Bickley, W. B., Jr., 1976.

ARGUSVILLE FORMATION

Arndt, B. M., 1977.

Barnesville Formation

Anderson, C. A., 1976.
Perkins, R. L., 1977.

"Blue Mountain Drift"

Pettyjohn, W. A., 1967.

Braddock Formation

Bickley, W. B., Jr., 1972.

BRENNA FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.
Arndt, B. M., 1977.

"Buchanan Drift"

Winters, H. A., 1963.

BURNSTAD DRIFT

Lemke, R. W., and Colton, R. B., 1958.
Clayton, L., 1962.

Cando Formation

Hobbs, H., 1975.

Cartwright Gravel

Howard, A. D., 1960.
Freers, T. F., 1970.

CARY DRIFT

Leighton, M. M., 1933.
Leighton, M. M., 1957.
Lemke, R. W., and Colton, R. B., 1958.

CHARGING EAGLE FORMATION

Ulmer, J. H., and Sackreiter, D. K., 1973.

COLEHARBOR GROUP, FORMATION

Bluemle, J. P., 1971.
Clayton, L., 1972.

"Cooperstown Drift"

Bluemle, J. P., 1975.

Coteau Formation

Bickley, W. B., Jr., 1972.

Crane Creek Gravel

Howard, A. D., 1960.
Freers, T. F., 1970.

DAHLEN FORMATION

Salomon, N. L., 1975.
Hobbs, H., 1975.
Bluemle, J. P., 1979a.
Bluemle, J. P., 1979b.

"Dead Man Drift"

Bluemle, J. P., 1971.
Clayton, L., 1972.

Denbigh Formation

Bickley, W. B., Jr., 1972.

Downer Formation

Perkins, R. L., 1977.

"Dunn Drift"

Clayton, L., 1970.

Dunvilla Formation

Anderson, C. A., 1976.
Perkins, R. L., 1977.

"Eldridge Drift"

Winters, H. A., 1963.

Emmons Formation

Bickley, W. B., Jr., 1972.

FALCONER FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

Flaxville Formation (Gravel)

Collier, A. J., and Thom, W. T., Jr., 1918.
Colton, R. B., 1955.
Howard, A. D., 1960.

Four Bears Formation

Bickley, W. B., Jr., 1972.

GARDAR FORMATION

Salomon, N. L., 1975.
Hobbs, H., 1975.
Bluemle, J. P., 1979a.
Bluemle, J. P., 1979b.

"Grace City Drift"

Winters, H. A., 1963.

Hansboro Formation

Hobbs, H., 1975.

HARWOOD MEMBER (of POPLAR RIVER FORMATION)

Arndt, B. M., 1977.

Hawley Formation

Perkins, R. L., 1977.

"Heimdal Drift"

Bluemle, J. P., 1965.

HORSESHOE VALLEY FORMATION

Ulmer, J. H., and Sackreiter, D. K., 1973.

HUOT FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

"Kensal-Oakes Drift"

Hard, H. A., 1929.
Lemke, R. W., and Colton, R. B., 1958.
Bluemle, J. P., 1965.

Long Lake Drift

Todd, J. E., 1896.
Clayton, L., 1962.
Kume, J., and Hansen, D. E., 1965.

LOSTWOOD DRIFT

Clayton, L., 1972.

"Luverne Drift"

Block, D. A., 1965.

"Makoti Drift"

Pettyjohn, W. A., 1967.

MALLARD ISLAND MEMBER (of OAHE FORMATION)

Clayton, L., Moran, S. R., and Bickley, W. B., Jr., 1976.

MANKATO DRIFT

Leighton, M. M., 1931.
Leighton, M. M., 1957.
Lemke, R. W., and Colton, R. B., 1958.

MARCOUX FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

"Martin Drift"

Pettyjohn, W. A., 1967.
Bluemle, J. P., 1967.

MEDICINE HILL FORMATION

Ulmer, J. H., and Sackreiter, D. K., 1973.

"McHenry Drift"

Bluemle, J. P., 1965.

"Mercer Drift"

Bluemle, J. P., 1971.

"Millarton Drift"

Winters, H. A., 1963.

"Minot Drift"

(unknown)

"Morton Drift"

Clayton, L., 1966.

NAPOLEON DRIFT

Bonneville, J. W., 1961.
Clayton, L., 1962.

"Newtown Drift"

Bluemle, J. P., 1971.

OAHE FORMATION

Clayton, L., Moran, S. R., and Bickley, W. B., Jr., 1976.
Clayton, L., and Moran, S. R., 1979.

"Pembina Drift"

Clayton, L., 1966.

PICK CITY MEMBER (of OAHE FORMATION)

Clayton, L., Moran, S. R., and Bickley, W. B., Jr., 1976.

POPLAR RIVER FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.
Arndt, B. M., 1977.

RED LAKE FALLS FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

RIVERDALE MEMBER (of OAHE FORMATION)

Clayton, L., Moran, S. R., and Bickley, W. B., Jr., 1976.

"Ryder Drift"

Pettyjohn, W. A., 1967.

"Sakakawea Sequence"

Bickley, W. B., Jr., 1972.

SHERACK FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

"Sheyenne Valley Drift"

(unknown)

SNOW SCHOOL FORMATION

Ulmer, J. H., and Sackreiter, D. K., 1973.

"Streeter Drift"

Clayton, L., 1962.
Rau, J. L., Bakken, W. E., Chmelik, J., and Williams, B. J., 1962.

ST. HILAIRE FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.

TAZEWELL DRIFT

Leighton, M. M., 1931.
Leighton, M. M., 1957.
Lemke, R. W., and Colton, R. B., 1958.

Tibor Formation

Hobbs, H., 1975.

Vang Formation

Hobbs, H., 1975.

"Walsh Formation"

Bluemle, J. P., 1973.

WEST FARGO MEMBER (of POPLAR RIVER FORMATION)

Arndt, B. M., 1977.

Wiota Gravel

Jensen, F. S., 1952.
Freers, T. F., 1970.

WYLIE FORMATION

Harris, K. L., Moran, S. R., and Clayton, L., 1974.
Arndt, B. M., 1977.

"Zeeland Drift"

Clayton, L., 1962.

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NORTH DAKOTA STRATIGRAPHIC COLUMN

NORTH DAKOTA GEOLOGICAL SURVEY
Lee C. Gerhard, State Geologist

By John P. Bluemle, Sidney B. Anderson, and Clarence G. Carlson

AGE (MILLIONS OF YEARS BEFORE PRESENT)	ERA	PERIOD / EPOCH	SEQUENCE	ROCK UNIT: GROUP	ROCK UNIT: FORMATION	ROCK UNIT: MEMBER	MINERAL RESOURCES	MAXIMUM THICKNESS: FEET (METRES)	LITHOLOGY, DEPOSITIONAL ENVIRONMENTS, AND OTHER CHARACTERISTICS
0.01	CENOZOIC	QUATERNARY: Holocene	TEJAS		OAHE		Water Gravel	50 (15)	Clay, sand, silt, and gravel; dispersed organic material; river, windblown, lake, and slough sediment; found throughout the state; the Oahe Formation includes the complete range in grain sizes found in materials overlying the Coleharbor Group.
		QUATERNARY: Pleistocene		COLEHARBOR	NAMED FORMATIONS: WEST CENTRAL — SHERACK, SNOW SCHOOL, HORSESHOE VALLEY, MEDICINE HILL; EAST — FALCONER, DAHLEN, GARDAR, VANG; RED RIVER VALLEY — SHERACK, POPLAR RIVER, BRENNA, HUOT, WYLIE, RED LAKE FALLS, ST. HILAIRE, MARCOUX; (Numerous named and unnamed units)		Gravel Water Stone Peat Clay	1 000 (300)	Pebbly, sandy, silty clay (till); pebbles of limestone, dolomite, granite, gneiss, and basalt; associated bedded clay, silt, sand, and gravel; glacial, river, lake, and windblown sediment; found throughout the glaciated part of the state. Several subdivisions of the Coleharbor have been recognized and formally named. In the Red River Valley they include: Sherack, Brenna, and Wylie (all offshore lake sediment); Poplar River (river sediment); Huot, Falconer, Red Lake Falls, St. Hilaire, and Marcoux (all glacial sediment). West of the Red River Valley in eastern North Dakota, the Dahlen, Gardar, and Vang (all glacial sediment) have been described. In west-central North Dakota, the Snow School, Horseshoe Valley, and Medicine Hill (all glacial sediment) have been described.
2		QUATERNARY / TERTIARY: Pliocene			(Unnamed Unit)		Gravel Water	300 (90)	Gravel, sand and sandstone, silicified wood, concretions; locally derived river sediment; mainly pebbles and cobbles; terrace, fan, and pediment deposits of Quaternary age. Clay, silt, sand, and gravel; western-derived pebbles and cobbles; valley fills of Paleocene to middle Quaternary age.
		TERTIARY: Miocene			(Unnamed Unit)			400 (120)	Limestone and sandstone, tuffaceous, light-gray, greenish or white; river and lake sediment; found mainly on butte tops. Has been called "Arikaree" and "Killdeer"; Oligocene, Miocene, and Pliocene age.
		TERTIARY: Oligocene		WHITE RIVER	BRULE		Clay	150 (45)	Siltstone and clay, pinkish; offshore lake sediment and some river and shoreline sand; forms steep slopes on hills and buttes in the southwestern part of the state.
54		TERTIARY: Eocene			CHADRON			100 (30)	Sand with quartzite and porphyry pebbles, light-colored; overlain by clay, dark-colored; river and lake sediment; forms rounded slopes on hills and buttes in the southwestern part of the state.
		TERTIARY: Paleocene		GOLDEN VALLEY		CAMELS BUTTE	Clay	215 (65)	Camels Butte Member: upper part is shale and siltstone, gray, montmorillonitic, minor lignite; river and lake sediment; lower part is sandstone, yellowish, micaceous, cross-bedded; river sediment.
						BEAR DEN			Bear Den Member: kaolinitic clay, lignite, and chert; white to yellow with shades of lavender; weathering zone. The Golden Valley Formation is found mainly on drainage divides and buttes.
				FORT UNION	SENTINEL BUTTE		Clinker Uranium Coal Leonardite Water	650 (200)	Silt and clay, brownish-gray, varying amounts of sand, lignite, natural brick, limestone, and sandstone; river, lake, and swamp sediment; forms steep, rilled slopes; found throughout western North Dakota; forms badlands topography.
					TONGUE RIVER: BULLION CREEK		Water Stone Coal Clinker	650 (200)	Silt and clay, yellowish-brown, varying amounts of sand, lignite, natural brick, limestone, and sandstone; gently rounded slopes; most of the rock and sediment included in the Bullion Creek Formation is equivalent to rock and sediment that were previously referred to the Tongue River Formation; found throughout western North Dakota; forms badlands topography.
					TONGUE RIVER: SLOPE		Coal Clinker	650 (200)	Silt, sand, and clay, grayish- to yellowish-brown; some sandstone and minor lignite; river, lake, and swamp sediment and some marine sediment; "Rhame silcrete bed" (weathered zone) at top; has been called Ludlow and Lebo Formations; found along southern flank of Williston Basin in southwestern North Dakota.
					TONGUE RIVER: CANNONBALL				Sand and mudstone, brownish-yellow and light-gray, with lenticular and concretionary sandstone; marine shoreline and offshore sediment; found in approximately the same area as the Slope Formation.
68					LUDLOW		Water Clinker Coal		Silt, sand, and clay, grayish-brown and thin-bedded; some sandstone and minor lignite; river, lake, and swamp sediment; T-Cross lignite bed at top; equivalent to beds formerly known as Tullock.
		CRETACEOUS			HELL CREEK		Water	500 (150)	Sand, somber shades of light-gray to brownish-gray, and cross-bedded sandstone with lignitic shale and dark, purple, manganese-oxide-stained concretions; river sediment and some estuarine sediment; forms rilled slopes except clayey member at the top forms smooth, rounded slopes; forms badlands topography.
					FOX HILLS	COLGATE	Ash	400 (120)	Silt and shale, sandy shale, sandstone, and siltstone, shades of buff to yellowish-brown; interbedded with lignitic shale laminae; some beds fossiliferous; intermittent sandstone at top is grayish-brown to white, fine, siliceous; silt and shale gradational downward with shale of the Pierre Formation; largely marine coastal sediment; forms gentle, rounded slopes.
						BULLHEAD			
						TIMBER LAKE	Water Stone		
						TRAIL CITY			
				MONTANA	PIERRE	ODANAH	Water	2 300 (700)	Shale, light- to medium- or dark-gray, fissile, flaky to blocky, generally noncalcareous; marine offshore sediment. Four members are exposed in the Pembina Hills in the northeastern part of the state; they are: Odanah Member, shale, medium-light-gray, hard, siliceous, noncalcareous; reddish-brown stained joint faces; light-yellowish bentonite bed near the base; forms steep slopes in exposures; DeGrey Member, shale, olive to dark-gray, flaky, noncalcareous; ironstone concretions; Gregory Member, shale, dark-gray to yellowish, soft, thinly bedded, slightly calcareous to marly, pyritic, some claystone; smooth, loose surface that tends to slump; Pembina Member, shale, grayish-brown to brownish-black, soft, noncalcareous; yellowish streaks of jarosite and gypsum-encrusted phosphate nodules; highly organic in the middle portion with abundant fish scales; light-colored, waxy beds of montmorillonitic clay at the base; Gammon Ferruginous Member, gray mudstone with calcareous and ferruginous concretions; Ardmore Bentonite Bed marks the contact between the Gammon Ferruginous and Pembina Members. Two fine-grained, silty tongues are recognized in the subsurface in the westernmost part of the state; the upper of these may be equivalent to the Judith River Formation; the lower is locally referred to as "Eagle sand." Three additional members, the Elk Butte, Mobridge, and Virgin Creek, occur above the Odanah Member, but these members are not generally recognized in North Dakota.
						DEGREY			
						GREGORY			
						PEMBINA	Bentonite		
						GAMMON FERRUGINOUS	Gas		
				COLORADO	NIOBRARA			250 (75)	Shale, medium-light-gray to medium-gray, calcareous with white, limy inclusions (referred to by drillers as "First White Specks"); marly zone near the middle. Upper part is tan to yellowish or golden in weathered exposures; lower part weathers to grayish hues; steep slopes.
					CARLILE			400 (120)	Shale, medium-dark-gray to black, noncalcareous, soft; large ellipsoidal concretions containing abundant gypsum (selenite); zone of fine, secondary gypsum crystals at the top. Rounded slopes in exposures.
					GREENHORN			150 (45)	Shale, dark-gray, calcareous, soft; thin-bedded shaly limestone; good electric and radioactivity log marker; referred to by drillers as "Second White Specks."
					BELLE FOURCHE			350 (105)	Shale, medium- to dark-gray, soft, micaceous, lumpy to massive, spongy; includes beds of light-bluish-gray bentonitic clay; sand and silt facies near base in parts of eastern North Dakota.
				DAKOTA	MOWRY			180 (55)	Shale, medium- to dark-gray, soft, flaky, spongy; traces of light-blue-gray bentonitic clay; top is marked by radioactive zone.
					NEWCASTLE		Water	150 (45)	Sandstone, light-gray, fine- to medium-grained angular quartz grains, some calcareous cement, silty; shale, medium- to dark-gray, soft, lumpy, fissile, micaceous; known also as "Muddy." Probably type "Dakota."
					SKULL CREEK		Water	140 (40)	Shale, medium- to dark-gray, micaceous, soft, flaky to lumpy; sandstone, fine-grained, friable, calcareous, light-gray, glauconitic, limited to east; traces of pyrite and white bentonitic clay.
					INYAN KARA		Water	450 (135)	Upper part is mainly marine sandstone, light-gray, fine to coarse, quartzose; and shale, gray, silty, and lumpy. Lower part is mainly nonmarine sandstone, medium to coarse, angular to subrounded, quartzose; occasional lenses of gray, bentonitic shale commonly contains manganese-siderite spherulites (pellets).
136		JURASSIC			MORRISON			260 (80)	Shale and siltstone, light-gray-green to varicolored, soft, pyritic; small amounts of thin, interbedded calcareous sandstone and sandy limestone.
					SWIFT			500 (150)	Shale, dark-gray to greenish, fissile, waxy, silty, calcareous; local limestone and glauconitic sandstone.
					RIERDON			100 (30)	Shale, varicolored shades of gray, green, and red, calcareous; some limestone. Characteristic log marker at the top is known as the "Rierdon Shoulder."
					PIPER	BOWES		625 (190)	Limestone, white to buff, brown, or gray, dense, finely crystalline, dolomitic, oolitic, fossiliferous; shale, red, gray-green, and purple, silty; gypsum and anhydrite. Recognized members include the Bowes Member (shale) at the top; the Firemoon Limestone (known also as "Piper Limestone"); the Tampico Shale; the Kline Member (limestone); the Picard Member (shale); the Poe Member (mainly shale and anhydrite); and the Dunham Salt at or near the base.
						FIREMOON			
						TAMPICO			
						KLINE			
						PICARD			
						POE			
						DUNHAM SALT	Salt		
190		TRIASSIC			SPEARFISH	SAUDE		750 (225)	Siltstone, moderate- to light-brown and reddish-brown; sandstone, fine-grained, frosted, rounded grains, slightly calcareous; halite, massive, clear, large crystals with anhydrite, white, silty; interbeds of shale, gray, fissile, and mudstone, reddish-orange; traces of pyrite and dolomite. Recognized members include the Saude Member, Pine Salt, and Belfield Member.
225						PINE SALT	Salt		
						BELFIELD	Oil		
		PERMIAN			MINNEKAHTA			40 (12)	Limestone, creamy, pink, and purple mottled, chalky to sublithographic, clayey, anhydritic locally.
					OPECHE		Salt	400 (120)	Shale, orange-red, slightly dolomitic, locally silty, streaks of anhydrite and gypsum; halite in central basin area.
				MINNELUSA	BROOM CREEK		Nitrogen	335 (100)	Sandstone, pinkish-gray to pale-reddish-brown, fine- to medium-grained, subangular to well-rounded, shaly, locally dolomitic; interbedded with pinkish-gray to grayish-red, microcrystalline dolomite; local interbeds of grayish-red shale; cherty at unconformity top.
280		PENNSYLVANIAN			AMSDEN			450 (135)	Dolomite, pinkish-gray to pale-yellowish-brown, microcrystalline to coarse-crystalline, dense, sandy; interbedded shale, dark-reddish-brown, silty, blocky fissility; and anhydrite, white to grayish-brown, fine crystalline, dolomitic; sandstone near top, gray to pale-red, fine-grained, calcareous. Alaska Bench Member at base is limestone, pinkish-gray to pale-yellowish-brown, micritic, shaly.
						ALASKA BENCH			
					TYLER		Nitrogen Oil	270 (80)	Shale and limestone, medium- to dark-gray to red and varicolored, carbonaceous near base; sandstone, fine- to medium-grained; channels, barrier islands, and shoreline deposits.
320					OTTER			200 (60)	Shale, greenish- and reddish-gray, variegated near basin edge, carbonaceous; minor limestone, gray to green, marly, fossiliferous, oolitic, thin-bedded.
				BIG SNOWY	KIBBEY		Oil	250 (75)	Sandstone, reddish- to light-gray, fine- to medium-grained, rounded; limestone, white to brown, dense, dolomitic; shale, reddish to variegated, silty, interbedded gypsum. Limestone ("Kibbey lime") is excellent log marker.
					CHARLES		Salt Oil	2 000 (600)	The Charles, Mission Canyon, and Lodgepole Formations are facies that cut across log markers. Several marker-defined stratigraphic intervals, recognized on geophysical logs, are commonly informally used to define Madison Group stratigraphy. The term "Madison Undifferentiated" is used in the central Williston Basin where geophysical log markers, used for correlation purposes elsewhere, are absent. Poplar interval: evaporites; interbedded anhydrite, halite, dolomite, mudstone, and shale; iron staining common; the Poplar interval contains most of the halite of the Madison Group; maximum thickness: 600 ft (185 m). Ratcliffe interval: limestone, pale-yellow-brown, dolomitic, oolitic; alternating with dolomitic limestone, anhydritic, and shale beds; Midale marker at the base is dolomitic limestone; Ratcliffe interval includes the deepest Madison salt on the Nesson Anticline ("last salt"); maximum thickness: 250 ft (75 m). Frobisher-Alida interval: limestone, yellow-brown to pink, fine, fragmental, oolitic, and pseudo-oolitic; intertonguing lenses of anhydrite and shaly dolomitic limestone; increasingly evaporitic eastward; Rival marker at the top of the interval is anhydrite and dolomitic limestone; includes the "X salt," the lowermost Mississippian salt; maximum thickness: 585 ft (180 m). Tilston interval: limestone, pale-yellowish-brown to pink, dolomitic, fine-grained to coarsely crystalline, oolitic and crinoidal, cherty; anhydrite; minor gray shale; maximum thickness: 230 ft (70 m). Flossie Lake, Whitewater Lake, Virden, and Scallion intervals (collectively approximately equivalent to the Bottineau interval): limestone, dark-gray to brown to pale-orange or pinkish, argillaceous to cherty to dolomitic, fragmental, finely crystalline to granular, oolitic, dense, vuggy to fine intergranular; maximum thickness: 630 ft (190 m). Carrington shale facies: shale, dark-gray to red with green mottling, noncalcareous, clayey. Present on the eastern flank of the basin only; maximum thickness: 90 ft (30 m).
					MADISON	MISSION CANYON	Oil		
						LODGEPOLE	Oil		
345	PALEOZOIC				BAKKEN		Oil	110 (35)	Shale, black, noncalcareous, carbonaceous, fissile, pyritic; gray, argillaceous dolomite in middle part; pebble conglomerate at base near basin margin.
		DEVONIAN	KASKASKIA		THREE FORKS		Oil	240 (75)	Siltstone and shale, grayish shades of red, green, and orange, interbedded and interlaminated, dolomitic, anhydritic; sandstone ("Sanish sand") locally at top, silty to fine-grained.
				JEFFERSON	BIRDBEAR		Oil	125 (40)	Limestone and some dolomite, light-gray to medium-brownish-gray, thick-bedded, finely crystalline, porous, fossiliferous; anhydrite, brownish- to medium-gray. Called Nisku Formation by some.
					DUPEROW		Oil	460 (140)	Limestone, light-brownish-gray, crystalline to granular, dense; dolomite, grayish-brown, microcrystalline to sucrosic, anhydritic, porous, and permeable; interbedded shale, siltstone, sand, and cyclical evaporites.
				MANITOBA	SOURIS RIVER		Oil	350 (105)	Dolomite and limestone, light- to dark-gray and brownish-gray, crystalline to dense, anhydritic, clayey or silty in part, interbeds of silt, shale, and evaporites. "First Red" at base.
					DAWSON BAY		Oil	185 (55)	Limestone, gray to brown, dense, fossiliferous, clayey, silty, and sandy near the eastern limit; dolomite, brown, microcrystalline to microgranular, anhydritic, porous. "Second Red" at base.
				ELK POINT	PRAIRIE	MOUNTRAIL	Potash	650 (200)	Evaporites: potassium and sodium salts interbedded with thin anhydrite beds; locally absent due to salt solution; multiple sequence salt solution has resulted in development of complex structural features over stratigraphically limited intervals. Three potash beds recognized are the Mountrail Member, Belle Plaine Member, and Esterhazy Member.
						BELLE PLAINE	Salt		
						ESTERHAZY			
					WINNIPEGOSIS		Oil	400 (120)	Upper part: dolomite, reddish-brown, shaly, anhydritic, crystalline, dense; has marked thickness variations due to the development of reef and inter-reef facies. Lower part: limestone, dolomite, dark-gray to -brown, dense, clayey to shaly and dolomitic shale, shades of red, white, and green; locally brecciated; locally anhydritic; in part equivalent to beds that have been called Ashern Formation ("Third Red").
395		SILURIAN	TIPPECANOE		INTERLAKE		Oil Gas	1 100 (335)	Upper part: dolomite and limestone, light-brownish-gray to light-gray, finely crystalline, fragmental and microgranular, vuggy porosity; silty and sandy near the base. Middle part: dolomite, light-yellowish-gray to pale-orange, microgranular and lithographic, fine- to medium-crystalline, cherty. Lower part: dolomite, light-brownish-gray to brownish-gray, finely crystalline; thin anhydrite interbedding in central basin area.
				BIG HORN	STONEWALL		Oil	120 (35)	Dolomite and limestone, light-brownish-gray, finely crystalline; thin anhydrite interbedding in central basin area.
440					STONY MOUNTAIN	GUNTON		200 (60)	Gunton Member: dolomite, brownish-gray to yellowish-brown, finely crystalline, limy; limestone, dolomitic, and fossiliferous; thin anhydrite in central basin area; sandy zones near the top. Stoughton Member: limestone and shale, dark-gray, interbedded, fossiliferous, pyritic.
						STOUGHTON			
		ORDOVICIAN			RED RIVER		Oil Gas	700 (215)	Upper part: limestone and dolomite, mottled yellowish- to brownish-gray, fragmental, argillaceous; thin beds of anhydrite. Lower part: limestone, mottled gray to pale-brown, dolomitic, finely fossiliferous and fragmental, finely crystalline. The porosity zones indicated on the electric logs (on right) range from less than 10 feet thick ("A") to as much as 70 feet thick ("D").
					ROUGHLOCK			90 (30)	Siltstone and sandstone, light-gray, fine-grained, calcareous; gradational into shale, greenish-gray, silty, calcareous.
				WINNIPEG	ICEBOX			145 (45)	Shale, greenish-gray, splintery to fissile, waxy, noncalcareous; black phosphate nodules; some sand lenses.
					BLACK ISLAND		Oil Gas	170 (50)	Sandstone, mottled light-gray with clay, fine- to medium-grained; poorly sorted in central basin; well-sorted on eastern shelf; well-rounded, frosted, friable, quartzose; some pyrite.
500		CAMBRIAN	SAUK		DEADWOOD		Oil Gas	1 000 (300)	Limestone, sandstone, and shale. Limestone, light-gray, fine- to medium-crystalline, dolomitic, sandy, glauconitic; sandstone, slightly calcareous, quartzose, medium to coarse, well-rounded, poorly cemented, frosted, glauconitic and dolomitic in east; shale, grayish-red to greenish- and medium-gray, calcareous.
570		PRECAMBRIAN		STRUCTURAL PROVINCES: CHURCHILL PROVINCE — SUPERIOR PROVINCE			Oil Gas	Unknown	Eastern North Dakota (Superior Province): greenschist and amphibolite facies, intermediate-mafic schists; banded iron formation; stretched pebble conglomerate; metabasalt; serpentinite; felsic tuff; mylonite; intermediate-felsic plutonic rocks; migmatite; layered gneiss. Western North Dakota (Churchill Province): greenschist and amphibolite facies schists; intermediate-felsic plutonic rocks; diabase; amphibolite-granulite facies gneiss.
4 700									

EXPLANATION

The three left-hand columns (age, era, period) on this Stratigraphic Column represent continuous geologic time. The age column lists, in millions of years before the present generally accepted ages of time unit boundaries. The age approximations do not necessarily refer to the ages of the oldest materials lying on materials of the next older period in North Dakota, but rather, to generally cited world-wide ages of the time-unit boundaries. Colors in the period column are those commonly used to characterize each geologic period.

The sequence, rock unit (group-formation-member), and pictorial rock columns represent the discontinuous geologic record, the preserved sedimentary section from which we can interpret the geologic history of North Dakota.

Unconformities are shown on the rock column by wavy, horizontal lines; major unconformities are marked by heavier lines than the less significant ones. Major unconformities subdivide the Stratigraphic Column into six units (sequences) that can be identified, where they are preserved, in cratonic interior areas of North America.

The arched right-hand side on the rock column represents relative resistance to weathering of the rocks exposed in North Dakota. Colors on the rock column are used in conjunction with lithologic symbols to help in distinguishing lithology (see Rock Column Legend, below). Generally, conventional lithologic colors are used for materials that are known only from drill-hole data. Carbonates are shown as shades of blue, sands or sandstones as yellow, and shales as colors approximating the actual rock color.

The mineral resources column emphasizes the economic importance of certain rock units. Mineral resources presently or previously produced in North Dakota are noted in black. Known resources not yet utilized are noted in blue.

The geophysical logs reproduced below illustrate log characteristics of the rock units included on this Stratigraphic Column. Logs from wells near the center of the Williston Basin (Gulf Oil's Zabolotny No. 1-3-4-A in Billings County--the deepest well yet drilled in the basin at the time the Stratigraphic Column was compiled); from north-central North Dakota (Union Oil's Steen No. 1 in Bottineau County); and from the southeastern part of the basin (Hunt Oil's Emma Kleven No. 1 in Burleigh County) were chosen to illustrate differing situations. A geophysical log from southwestern North Dakota (North Dakota State Water Commission test hole 4811) is included to illustrate log characteristics of a part of the Tertiary and upper Cretaceous section. Tops for formations and members are indicated and certain other log markers are designated on these geophysical logs where they could be recognized. The omission of formation or member tops on the geophysical logs does not necessarily mean the units are absent; they could not be readily recognized on that log.

ROCK COLUMN LEGEND

Siltstone, silt and soil · Pebbly, sandy, silty clay (glacial till) · Unbedded sand · Bedded sand · Cross-bedded sand · Firmly cemented sandstone · Silty sand · Sand and silt with interbedded lignite and natural brick ("scoria") · Thick- or thin-bedded shale · Calcareous or dolomitic shale · Siliceous shale

Carbonaceous shale · Coarse- or fine-bedded limestone · Dolomitic limestone or calcareous dolomite · Coarse- or fine-bedded dolomite · Clayey limestone or dolomite · Cherty limestone or dolomite · Crystalline limestone or dolomite · Halite · Potash · Anhydrite · Igneous and metamorphic rocks

Fossiliferous sediment · Silcrete zone · Unconformity

NDGS–151
Hunt Oil Co.
Emma Kleven No. 1
SW¼SW¼ sec 18, T140N, R80W
Burleigh County

NDGS–4790
Union Oil
Steen No. 1
SE¼SE¼ sec 20, T159N, R81W
Bottineau County

NDGS–6228
Gulf Oil
Zabolotny No. 1-3-4A
NW¼SE¼ sec 3, T144N, R98W
Dunn County

Log 6228 (Continued)

NDSWC–4811
SE¼SE¼ sec 31, T136N, R100W
Slope County