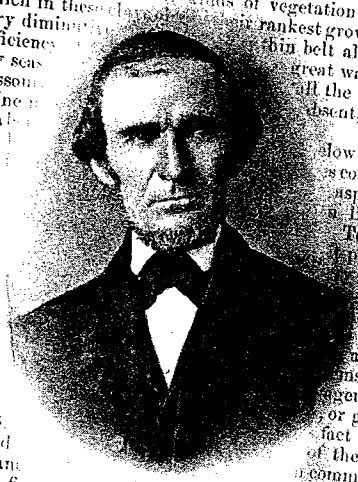
A GUIDE TO THE STRATIGRAPHY OF SOUTH DAKOTA

post at that place, are a beautiful series of bluffs approaching the river, and filled with finely wooded ravines and springs of water. From this point the soil of the country begins to look less favorable for agricultural purposes, composed mostly of clays of the Cretaceous system, and highly impregnated with saline substances, which seem to be prejudicial to all kinds of vegetation except chenopodiaceous, which in these [illegible] rankest growth. The timber becomes very dimin[illegible] thin belt along the river. Besides a deficienc[illegible] great want of water, and in the dry sea[illegible] all the small tributaries of the Misso[illegible] descent, or so impregnated with saline [illegible]



FIELDING BRADFORD MEEK

A[illegible] low Fort Pierre, the black clay [illegible] s covering the whole country as w[illegible] aspect. This bed extends al[illegible] Ball river, and over the re[illegible] Teton, Shyenne, Morean, a[illegible] prevails, the soil, if there h[illegible] scanty vegetation, and so[illegible] blackened appearance, w[illegible] y of the Great Bend la[illegible] hills" are extremely st[illegible] a burnt and blackened ap[illegible] mselves the appellation of [illegible] geurs. These hills are cover[illegible] or gypsum, which glisten in the [illegible] fact are sometimes called the sand[illegible] of the Cannon Ball river, appearan[illegible] commence, and the general with a fin[illegible] ved; the upland is covered strea[illegible] ber is seen along the

About fifty miles [illegible] er, is the first cedar island, a favorite wooding place for steamboats in their ascent of the river. This island is one of three which are destined to be of much interest to the settlers along the Missouri. They have an area of several hundred acres, and are covered with a dense growth, so crowded that the largest trees are not more than two feet in diameter. A large quantity of fine timber might be selected from these islands with advantage to the remainder. They are also the resort of myriads of birds and larger animals, which gather to these places to rear their young undisturbed.

The country in the vicinity of Fort Pierre, and north towards the Black Hills, though mostly sterile or entirely barren, contains some plateaus that are covered with a fine growth of grass. The region through which the main body of the Shyenne passes is sterile in the extreme. It is cut up by temporary streams into ravines and gullies to a frightful extent, and barren black hills, sometimes producing a few stunted cedars, meet the eye on every side. Between the two forks of the Shyenne, and in the vicinity of Bear Butte, a portion of the Black Hills is quite a large area, which seems to have been levelled by de-

nudation, and greets the eye of the traveller with joy, who has for some time previously seen nothing but the sterile country before mentioned. The streams which flow into the Shyenne at this point have their origin in perpetual springs in the Black Hills, and contain an abundance of fish, and swarms of beaver live along their banks. They are skirted with excellent timber of ash, oak, elm, and box-elder, and the level plains are covered with a fine carpet of grass which, in spring and early summer, is enamelled with myriads of flowers of the richest hues. On the 9th of March, 1855, I ascended Bear Butte, and on the south side, six hundred feet above the level prairie, I found a beautiful plant, *Glycimone Pulsus*, just putting forth its blossoms. The Indians call it the navel flower, for they say that when it blooms the young spring is born. At that time the grass was springing up quite green, and herds of antelopes were quietly reposing upon the sunny sides of streams, like flocks of sheep. This is a portion of the country similar to White river valley, well adapted for grazing purposes, and capable of sustaining a tolerably dense population. The Black Hills which appear in the distance, and derive their name from their dark and gloomy appearance, contain an inexhaustible quantity of the finest timber, mostly pine, which will doubtless remain undisturbed for many years to come. I will, however, [illegible] plan for obtaining this timber, and render it useful to [illegible] some hesitation, lest it may seem [illegible] ough I do it with Shyenne passes through the nort[illegible] ft fork of the even there is a considerable [illegible] lack Hills, and In the spring the river is [illegible] fifty yards wide. rapid, and the timber, if [illegible] ent exceedingly be floated down into the [illegible] the river, might [illegible] y and ease.

FERDINAND VANDEVEER HAYDEN

The character of the [illegible] Fort Union to the mountains, and [illegible] lowstone is similar to that in the [illegible] gricultural resources are concentra[illegible] lers and Indians raise very good [illegible] have met with very good success, [illegible] early frosts destroy their [illegible] souri are somewhat of an [illegible] Fort Berthold raised, in 185[illegible] eans, pumpkins in proportion[illegible] thou- sand five hundred bush[illegible] thou- sand bushels. The [illegible] oyed their crops, which, in [illegible] sing. At Fort Pierre, also, th[illegible] with some success, perhaps [illegible]

To present an idea of [illegible] of travelling on the pr[illegible] tarted made on a tour to the Ba[illegible] ar and from Fort Pierre May 7, w[illegible] making a a boy, with several horses and [illegible] collection of mammalian and [illegible] and remarkable cemetery. The weather was warm, and sun shining brightly. Most of the usual spring birds had come, and the ravines and water courses

Allen F. Agnew
Paul C. Tychsen

SOUTH DAKOTA
STATE GEOLOGICAL SURVEY
BULLETIN 14

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Bulletin 14

A GUIDE TO THE STRATIGRAPHY OF SOUTH DAKOTA

by
Allen F. Agnew and Paul C. Tychsen

Science Center
University of South Dakota
Vermillion, South Dakota
1965

CONTENTS

ILLUSTRATIONS

A GUIDE TO THE STRATIGRAPHY OF SOUTH DAKOTA

by
Allen F. Agnew[1] and Paul C. Tychsen[2]

ABSTRACT

The history of the nomenclature, and the changes in lithologic description are given for 283 stratigraphic terms in South Dakota, excluding the Precambrian and Tertiary igneous and metamorphic rocks, and the Pleistocene and Recent sediments. Of these terms, 111 are accepted by the South Dakota Geological Survey as of good standing. Many that are in the category of being "not accepted yet for South Dakota" will likely be acceptable after further stratigraphic study and as more information becomes available. The "Code of Stratigraphic Nomenclature" of the American Commission on Stratigraphic Nomenclature (1961, Am. Assoc. Petroleum Geologists Bull., v. 45, p. 645-665) serves as the basis for this stratigraphic classification and terminology in South Dakota.

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INTRODUCTION

General Discussion

A guide to the stratigraphic units and their names is fundamental to most geologic endeavors that involve sedimentary rocks. Guide means to direct in a way, to conduct; it "implies intimate knowledge of the course or way and of all its difficulties," according to Webster's New Collegiate Dictionary.

Thus a guide is more than an index, which is a table or list, usually alphabetical, for reference to topics, names, or objects. A guide is more than a dictionary or lexicon, which is an alphabetical arrangement of the words in a language. A guide is also more than a glossary, which is a partial dictionary of a special area of knowledge explaining terms or words. And finally, a guide is more than a catalogue, which is a list of items arranged methodically, often in alphabetical order, and usually with descriptive details for each item.

In this "Guide to the Stratigraphy of South Dakota" we have attempted to apply our small fund of knowledge as stratigraphers to the multitudinous facets of the complex field of geology that is stratigraphy. We may possess "intimate knowledge of the course or way and of all its difficulties," but we hasten to add that it does not follow that we possess the solutions to all of these difficulties.

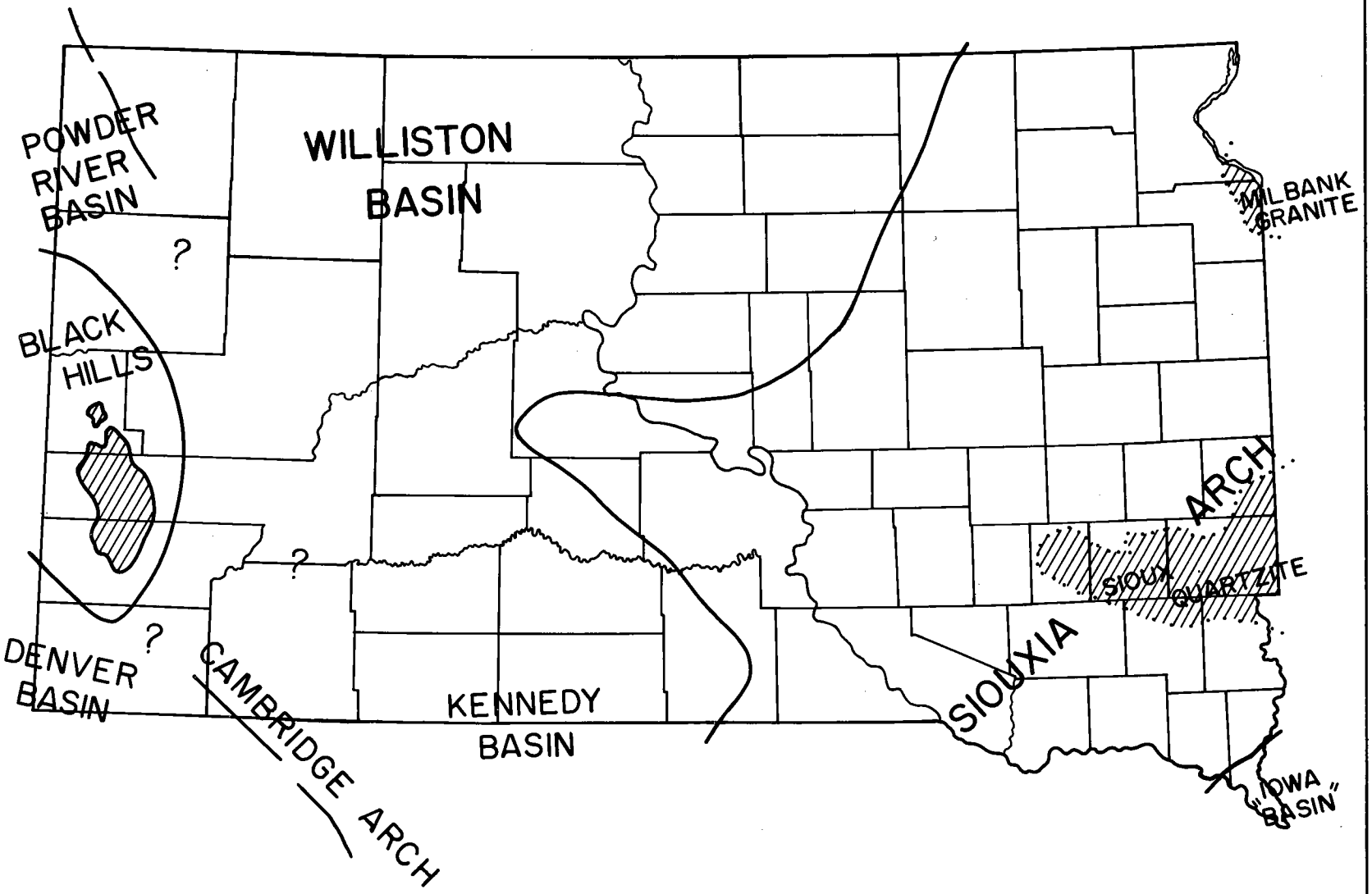
Our decisions, understandably, were based on all the available published material, coupled with our own diverse experience in the field. Just as understandably, many of our decisions may well appear arbitrary to those who may possess different interpretations of the data. Nevertheless, decisions had to be made, and we hope that the purpose of this Guide has been served thereby.

South Dakota is in the enviable position of being astride many tectonic subdivisions (fig. 1) of the North American Craton. The Black Hills uplift, which began in Late Cretaceous time, separates the Paleozoic Williston Basin on the northeast from the post-Cretaceous Powder River Basin on the southwest.

The northern tip of the Cambridge (Chadron) Arch of Nebraska separates the post-Cretaceous Denver Basin on the southwest from the depressed area to the northeast, which plunges northward into the Williston Basin and southward into the Kennedy Basin of north-central Nebraska.

The ridge of Precambrian Sioux Quartzite extends in an easterly fashion across much of southeastern South Dakota (Steece, 1961, 1962). This ridge lies athwart the southwesterly-trending Siouxia Arch (Levorsen, 1960, Paleogeologic Maps: W.H. Freeman and Co., p. 120-122, figs. 6-5 and 6-6), which appears to have been active during post-Jurassic, pre-Cretaceous time just as the Cambridge (Chadron) Arch was. The northwest-trending Cambridge Arch, however, was apparently superimposed on the northeast-trending ancestral Rockies, which extended into part of southwestern and south-central South Dakota during post-Mississippian, pre-Pennsylvanian time (Levorsen, 1960, figs. 6-3 and 6-4). In the extreme southeastern

Fig. I. Map of South Dakota, showing structural provinces and exposures of Precambrian rocks.



corner of the State the early Paleozoic sediments appear to be correlative with those in central Iowa.

And in northeastern South Dakota the Cretaceous sediments rise beneath the glacial drift to the surface as they lap onto the Precambrian granite of the Milbank area.

Thus we eventually might have the following four sets of stratigraphic nomenclature in South Dakota--for the Williston Basin, the Powder River-Denver Basin, the Black Hills, and the Kennedy Basin-Iowa "Basin." However, our knowledge in these areas is not equal. Thus we are forced to temporize and to generalize--we have therefore extended names and correlations from better-known areas such as the first two, into lesser-known ones such as the last two.

We have limited this Guide to the part of the stratigraphic column that includes the Cambrian rocks at the base and the Pliocene sediments at the top. We have omitted the Precambrian, and the Pleistocene and Recent because the stratigraphy and nomenclature for their rocks and unconsolidated materials have not yet been thoroughly worked out, although progress is being made in both of these parts of the geologic column. A brief statement discusses the Precambrian situation, and others do the same for the glacial and nonglacial Pleistocene and Recent; we hope that these statements will open the door to the challenges and opportunities of stratigraphic work in these difficult parts of the stratigraphic column of South Dakota.

We used as our basic source the excellent lexicon of Geologic Names of the United States, by M. Grace Wilmarth (1938), and the two lists of geologic names in North America during the period 1936-1955, assembled by Druid Wilson and others (1957, 1959), were very helpful in providing a check against the material that we had been compiling.

References are as cited in the U. S. Geological Survey Bibliography of North American Geology.

Procedure and Acknowledgments

The senior author began work on this guide in the summer of 1959 with the assistance of John M. Keach, who worked as a research participation graduate student in the Department of Geology at the University of South Dakota under the sponsorship of the National Science Foundation. This work was resumed under the same auspices during the summer of 1960 by the junior author. He transferred the material from index cards to typescript during the school year 1960-1961 at Wisconsin State College. The project was recessed until the summer of 1963 when the senior author brought the entries up to date since the compilation's original terminal date of 1955. The descriptions of individual units were revised, Precambrian and Pleistocene and Recent names were deleted, and the text was written. References are believed to be complete through 1962, and a few 1963 references have been cited.

We wish to thank George V. Cohee and the Geologic Names Committee of the U. S. Geological Survey for checking the entries against their records, and for reviewing the manuscript. We likewise wish to express our appreciation to J.P. Gries of the Department of Geology and Geological Engineering at the South Dakota School of Mines and Technology for similar help and

also for numerous conferences during which he supplied much useful information. We are pleased to acknowledge the interest and suggestions of R.E. Stevenson of the Department of Geology at the University of South Dakota. We are also grateful for the many helpful suggestions made by members of the staffs of the South Dakota Geological Survey and the U. S. Geological Survey. We would be remiss if we did not recognize the magnificent assistance given by the junior author's wife, Amy Tychsen, during the preparation of the first draft of the manuscript.

The inspiration behind this volume on the stratigraphy of South Dakota goes to E.P. Rothrock, former State Geologist, who conceived a three-part series entitled "Geology of South Dakota." He was able to publish Part I, dealing with "The Surface" as South Dakota Geological Survey Bulletin 13 in 1943, and Part III, dealing with "Mineral Resources" as Bulletin 15 in 1944, but the writing of Bulletin 14, on the stratigraphy of the State, eluded him. This Guide is published as Bulletin 14 of the South Dakota Geological Survey with the hope that it will partly fill this gap. Certainly, an interpretation of the stratigraphic relations of the complete sedimentary section of South Dakota has long been needed, and this publication should prove invaluable to the petroleum industry, especially, and to others as well.

PRINCIPLES OF STRATIGRAPHIC NOMENCLATURE

As a result of the senior author's attendance at the deliberations of the American Commission on Stratigraphic Nomenclature during the years of formulating the Code, after the Code of Stratigraphic Nomenclature was published in May 1961, it was adopted by the South Dakota Geological Survey in July 1961.

The Code establishes (Art. 2) four categories of stratigraphic units: rock-stratigraphic, soil-stratigraphic, biostratigraphic, and time-stratigraphic. The Guide to the Stratigraphy of South Dakota presents units of the rock-stratigraphic category, with reference in many individual descriptions to biostratigraphic units. Where the information is available, rock-stratigraphic units are assigned to time-stratigraphic units. Soil-stratigraphic units are not referred to in this Guide.

The Code also recognized (Art. 2) geologic-time units and geologic-climate units. These are not discussed or otherwise referred to in this Guide.

Following the Code (Arts. 4-17) this Guide recognizes a formal rock-stratigraphic unit as a rock subdivision that is distinguished and delimited on the basis of lithologic characteristics. Boundaries of rock-stratigraphic units are placed at positions of lithologic change, which may be sharp contacts or may be arbitrarily fixed within zones of gradation such as characterize facies. Mechanical logs have been used to aid in this distinction, but such "kicks" bound units that are informal.

A formation is the fundamental unit in rock-stratigraphic classification. It is characterized by lithologic homogeneity and is mappable at the earth's surface or is traceable in the subsurface. A member is a part

of a formation, and it may contain recognizable "beds." Beds may be distinctive economically--e.g., a coal seam or an oil sand, or they may be key beds for mapping or tracing--e.g., a bentonite bed or limestone bed. A group consists of two or more associated formations. A group may be divisible into formations in one area, and may be undifferentiated in other areas. The same is true of a formation. A formation may be divisible into members in one area, and may be undifferentiated in other areas. Facies are two or more lateral differences in lithology of rocks or sediments, included within the bounds of one formation or member.

Groups, formations, members, and facies are treated as formal units. The names of formations and members consist of geographic names followed by the characteristic lithology--e.g., Pahasapa Limestone, Pool Creek Shale Member, Giannonatti Lignite Facies, and the geographic names of groups are coupled with that term--e.g., Inyan Kara Group. Some formations that are uniform in their heterogeneity are not assigned a lithologic surname--e.g., Lakota Formation.

Most beds or sands are treated as informal units--e.g., Leo sand, Bison coal, Big bentonite bed, because of their limited geographic extent. A few widespread and distinctive beds, however, are treated as formal units--e.g., Mowry Bentonite Bed. Other terms, including zone, are recognized as informal units not only because of their limited geographic extent but also because no formal description has been applied to them--e.g., Basal coal zone, Basal laterite, Dakota silt, Lower micaceous bentonite, Red Marker shale. Two units that should have formation rank but have not been adequately described in print are recognized only as informal units--e.g., Pine salt and Saude formation.

The rule of priority has been applied in deciding what constitutes a valid name for a rock-stratigraphic unit.

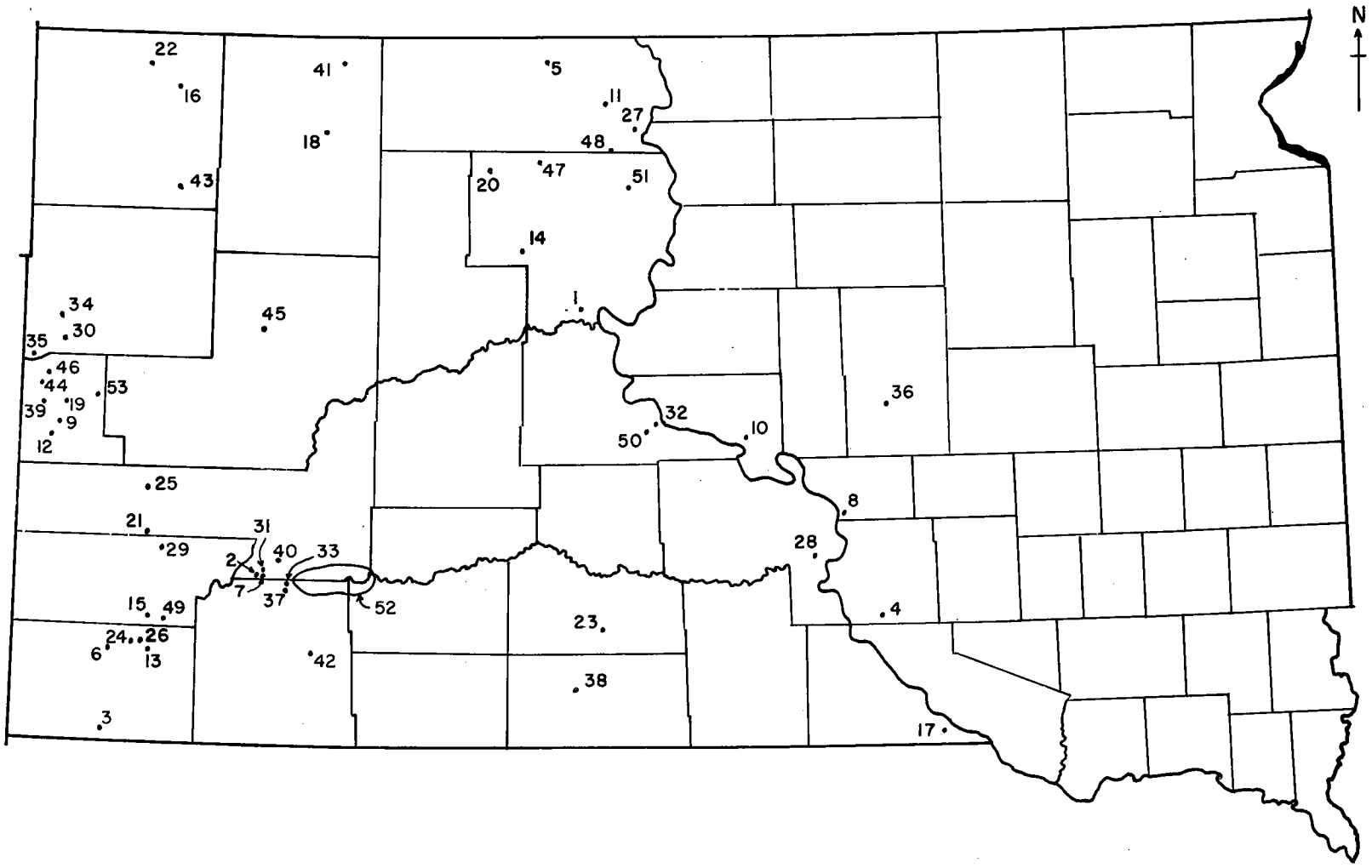
The South Dakota Geological Survey began capitalizing the surname of stratigraphic terms (Group, Formation, etc.) in 1958, as is seen in the specific entries. Because the Code was published in 1961, stratigraphic terms cited in references published by other organizations in 1962 and later, have been capitalized in the present Guide.

Locations of type sections in South Dakota are shown in figure 2.

STRATIGRAPHIC COLUMNS FOR SOUTH DAKOTA

The names of stratigraphic units accepted by the South Dakota Geological Survey, which are useful in the four general areas of the State--(1) Western basins (Williston Basin-Denver Basin-Kennedy Basin-Powder River Basin), (2) Black Hills, (3) Siouxia Arch, and (4) Iowa "Basin"--are listed beginning on page 9.

Figure 2. Map showing type localities or areas of accepted, or possibly acceptable names of stratigraphic units in South Dakota. (see page 8 for unit names)



1. Agency
2. Ahearn
3. Ardmore
4. Bijou
5. Bullhead
6. Chilson
7. Crazy Johnson
8. Crow Creek
9. Deadwood
10. DeGrey
11. Elk Butte
12. Englewood
13. Fall River
14. Fox Hills
15. Fuson
16. Giannonatti
17. Gregory
18. Hillen
19. Ice Box
20. Isabel-Firesteel
21. Lakota
22. Ludlow
23. Mellette
24. Minnekahta
25. Minnelusa
26. Minnewaste
27. Mobridge
28. Oacoma
29. Opeche
30. Orman Lake
31. Peanut Peak
32. Pierre
33. Poleslide
34. Pool Creek
35. Redwater
36. Ree
37. Rockyford
38. Rosebud
39. Roughlock
40. Scenic
41. Shadehill
42. Sharps
43. Slim Buttes
44. Spearfish
45. Stoneville
46. Sundance
47. Timber Lake
48. Trail City
49. Unkpapa
50. Verendrye
51. Virgin Creek
52. White River
53. Whitewood

1. Western South Dakota Basins

Accepted Names	Not Yet Accepted
Tertiary	
Pliocene	
Ogallala Group (including Bijou Quartzite Facies)	(Kimball Formation, Snake Creek beds)
Ash Hollow Formation	
Valentine Formation	
Miocene	
Arikaree Group (including Rosebud Facies, Mellette Facies)	(Sheep Creek beds, Marsland Formation, Hemingford Group, Gering Facies)
Harrison Formation	
Monroe Creek Formation	
Sharps Formation (including Rockyford Ash Bed)	
Oligocene	
White River Group	(Ree beds)
Brule Formation	
Scenic Member	
Poleslide Member	
Chadron Formation	(Ahearn Member, Crazy Johnson Member, Peanut Peak Member)
Eocene	(Slim Buttes Formation, Golden Valley Formation)
Paleocene	
Fort Union Group	
Tongue River Formation (including Lodgepole Lignite Facies)	
Cannonball Formation	
Ludlow Formation (including Giannonatti Lignite Facies, Harmon Lignite Bed, Hillen Lignite Facies, Scotch Cap Sandstone, Shadehill Lignite Facies)	

Cretaceous

Hell Creek Formation (including Isabel-Firesteel Lignite Facies) (Breien Member)

Montana Group

Fox Hills Formation

(Central and Northwest marine) (West-Central continental)

Colgate Sandstone Member — White Owl Creek Member

Bullhead Member — (including Enning Facies)

Timber Lake Member — Fairpoint Member (including

Trail City Member — Stoneville Lignite Facies)

Pierre Shale

(Central)

Elk Butte Member

Mobridge Member

Virgin Creek Member

Verendrye Member

DeGrey Member (including Oacoma Manganiferous Shale Facies, Agency Siliceous Shale Facies) — Monument Hill Bentonite Bed

Crow Creek Member

Gregory Member — Red Bird Silty Member

Sharon Springs Member (including Ardmore Bentonite Bed) — Mitten Black Shale Member

Gammon Ferruginous Member (including Groat Sandstone Bed) (Eagle Sandstone)

Colorado Group

Niobrara Marl

Carlile Shale

(Central) (Western)

Unnamed shale — Sage Breaks Shale Member

Codell Sandstone Member — Turner Sandy Member (including Wall Creek sands)

Unnamed shale
Greenhorn Limestone (including Orman Lake Limestone Member)
Graneros Shale
Belle Fourche Shale Member
Mowry Siliceous Shale Member (including Clay Spur Bentonite Bed, D sand, G sand, Dynneson Sandstone Member)
Newcastle Sandstone Member (including J sand)
Skull Creek Shale Member

Dakota Group, undifferentiated (including Dakota silt)

Jurassic

Morrison Formation
Sundance Formation
Swift Member
Rierdon Member
Piper Formation

Triassic

Spearfish Formation (including Pine salt, Saude formation)

Permian

Minnekahta Limestone
Opeche Shale

Pool Creek Shale Member

Permo-Pennsylvanian

Minnelusa Formation (including Bell sand, Tyler sand, Converse sand, Leo sand, Red Marker shale) (Cassa, Broom Creek, Wendover-Meek, Hayden, Roundtop, Reclamation, and Fairbank Formations; Owl Canyon Member)

Pennsylvanian

Amsden Formation

Mississippian

Big Snowy Group (Heath Formation)
- Otter Shale
- Kibbey Sandstone

Madison Group
- Charles Formation
- Mission Canyon Limestone
- Lodgepole Limestone (including Englewood Limestone Facies)

Devonian

Three Forks Shale

Jefferson Group
- Birdbear Formation
- Duperow Formation

Souris River Formation (Manitoba Group)

Silurian

Ashern Formation

Interlake Group (Stonewall Limestone)

Ordovician

Bighorn Group
Stony Mountain Formation
Gunton Member
Stoughton Member
Red River Limestone (including Hecla Facies)
Winnipeg Formation (Black Island Member)
Roughlock Siltstone Member
Ice Box Shale Member

Cambro-Ordovician

Deadwood Formation

2. Black Hills

Cretaceous (lower)

Inyan Kara Group
Fall River Formation (including Keyhole Sandstone Member)
Lakota Formation (including Minnewaste Limestone Member, Fuson Shale Facies, Chilson Member)

Jurassic

Morrison Formation (including Unkpapa Sandstone Facies)
Sundance Formation
Redwater Shale Member
Lak Shale Member
Hulett Sandstone Member
Stockade Beaver Shale Member
Canyon Springs Sandstone Member
Gypsum Spring Formation

Triassic

Spearfish Formation

Permian

Minnekahta Limestone
Opeche Shale

Permo-Pennsylvanian

Minnelusa Formation (including Bell sand, Leo sand, Converse sand, Red Marker shale)

Mississippian

Madison Group
Pahasapa Limestone
Englewood Limestone

Ordovician

Bighorn Group
Whitewood Limestone
Winnipeg Formation
Roughlock Siltstone Member
Ice Box Shale Member

Cambro-Ordovician

Deadwood Formation (including Scolithus sandstone)

3. Siouxia Arch

Cretaceous

Pierre Shale
- Elk Butte Member
- Mobridge Member
- Virgin Creek Member
- Verendrye Member
- DeGrey Member
- Crow Creek Member
- Gregory Member
- Sharon Springs Member

Niobrara Marl (Fort Hays Limestone Member, Smoky Hill Chalky Member)

Carlile Shale
- (Unnamed shale)
- Codell Sandstone Member
- (Unnamed shale)

Greenhorn Limestone
Graneros Shale
Dakota Group

4. Iowa "Basin"

Cretaceous

Carlile Shale
Greenhorn Limestone
Graneros Shale (Ponca Sandstone, Sergeant Shale, Nishnabotna Sandstone)

Ordovician ?

Unnamed limestone, shale, sandstone (Galena (Trenton) Limestone, Decorah Shale, Platteville Limestone, Saint Peter Sandstone, Shakopee Dolomite, New Richmond Sandstone, Oneota Dolomite)

Cambrian ?

Unnamed limestone, shale, sandstone

PLEISTOCENE AND RECENT SEDIMENTS

Glacial Deposits

The glacial and nonglacial sediments of South Dakota have not been studied in sufficient detail to enable us to present an adequate system of named units within the framework of the Code of Stratigraphic Nomenclature at this time. Geologic-climate units are provided for in the Code (Art. 39); they are bodies of rock, soil and organic material, with boundaries that are defined by some kind of stratigraphic unit. Although locally these stratigraphic boundaries are isochronous, at different latitudes they are probably not isochronous; thus geologic-climate units differ from geologic-time units. The fundamental units of geologic-climate classification are glaciation and interglaciation--e.g., Wisconsin Glaciation, Aftonian Interglaciation. Stade and interstade are subdivisions of a glaciation--e.g., Tazewell Stade, Two Creeks Interstade.

J.C. Frye and H.B. Willman, 1960 (Ill. Geol. Survey Circ. 285, p. 1-16) have proposed the morphostratigraphic unit, a body of rock that is identified primarily from the surface form it displays; it may or may not be distinctive lithologically from contiguous units; it may or may not transgress time throughout its extent. They suggest as the basic unit the moraine, and the deposits they assigned to this morphostratigraphic unit include the drift of the end moraine that identifies it, the associated outwash apron (if present), and the drift continuing into the associated ground moraine. This type of unit obviously is most useful in a limited geographic area, but just as obviously that is where the basic stratigraphic work with glacial deposits must be carried out.

The most recent comprehensive publication on the Pleistocene glacial deposits of South Dakota is by R.F. Flint, 1955 (U. S. Geol. Survey Prof. Paper 262, 173 p.). His classification was followed by the reports of two of his students, D.R. Crandell, 1958 (U. S. Geol. Survey Prof. Paper 307, 83 p.) in the Pierre area of central South Dakota, and H.E. Simpson, 1960 (U. S. Geol. Survey Prof. Paper 328, 124 p.) in the Yankton area of southeastern South Dakota and northeastern Nebraska.

The surface drift in South Dakota has been dated (U. S. Geological Survey and Yale University Laboratories) by wood from six localities as 12,050 to 12,760 years B.P. (F.V. Steece, personal communication, July 1963).

F.V. Steece has described (1960, S. Dak. Acad. Science Proc., v. 38, 1959, p. 41-44) occurrences of Pearlette ash of Late Kansan age in eastern South Dakota. Steece (1959, [Abs.] S. Dak. Acad. Science Proc., 1958, v. 37, p. 148) has also described mollusks from the Yarmouth Interglaciation of northwestern Iowa.

M.J. Tipton and F.V. Steece of the South Dakota Geological Survey have been studying the glacial deposits of the State in considerable detail since 1957, and a revised classification of the glacial Pleistocene is currently in preparation. Preliminary information on this re-classification is presented in F.V. Steece and others, 1960 (Guidebook, Midwest Friends of the Pleistocene, 11th Annual Field Conference, eastern South Dakota, S. Dak. Geol. Survey, 21 p.).

Nonglacial Deposits, Southern South Dakota

In the western half of South Dakota, that part west of the Missouri River in general, the time since the Ogallala sediments were laid down (Mid-Pliocene) is represented by gravel and sand deposits at several altitudes above present stream bottoms. The South Dakota Geological Survey has concluded that some of these high-level gravel remnants of former streams in the west-central part of the State are as old as questionable Pliocene in age (A.F. Agnew, 1957, S. Dak. Geol. Survey, Geol. Quad., White River). At lower altitudes, terraces at several levels are capped with sands or gravels, but these, too, have not been accurately dated. Flint (1955), Crandell (1958), and Simpson (1960) described briefly patches of western-derived deposits in eastern South Dakota.

The Pleistocene Sand Hills Formation of Nebraska, whose surface is marked by densely grassed large dunes, has been mapped by the South Dakota Geological Survey in the High Plains physiographic division of the State athwart the Nebraska border in Bennett and Todd Counties (S.G. Collins, 1959, S. Dak. Geol. Survey, Geol. Quad., Martin; W.D. Sevon, 1960 and 1961, S. Dak. Geol. Survey, Geol. Quads., Spring Creek and Vetal). This formation was described by A.L. Lugn in 1935 (Nebr. Geol. Survey Bull. 10, p. 158-168), in his report on the Pleistocene of Nebraska.

Also in southern South Dakota, but farther east near the valley of the Missouri River, is the Pleistocene deposit known as the Herrick sand. This deposit has been mapped and described by R.E. Stevenson, 1958 and 1959 (S. Dak. Geol. Survey, Geol. Quads., Gregory and Dallas). Similar sands have been described in Nebraska by G.E. Condra and E.C. Reed, 1950 (Nebr. Geol. Survey Bull. 15A, 52 p.).

The Pleistocene of the Central Great Plains has been correlated with the glacial Pleistocene of western Iowa and the Upper Mississippi Valley by J.C. Frye and others, 1948 (Jour. Geology, v. 56, p. 501-525), and A.B. Leonard and J.C. Frye, 1956 (Internat. Quaternary Cong., 4th, Rome-Pisa, 1953, Actes, v. 2, p. 877-884) have discussed the relation of fossil mollusks to Quaternary stratigraphy in the central United States.

Nonglacial Deposits, Black Hills and Northwestern South Dakota

The geomorphic effects of the rise of the Black Hills throughout the late Tertiary and into the Pleistocene were described in two reports, 17 and 36 years ago. Louise Fillman described the Cenozoic history of the Black Hills in 1929 (Univ. Iowa Studies in Nat. History, v. 13, no. 1, 50 p.) and concluded from terrace remnants in the northern Black Hills that there was a "Mountain Meadow Surface" developed in early Tertiary time, which was terminated by a mid-Oligocene uplift. She described a later high terrace, the "Rapid Surface," and its gravel as the Rapid Formation; she also described a low terrace, the "Sturgis Surface," and its gravel as the Sturgis Formation. She placed the time of development of both the latter surfaces in the Pleistocene.

In 1948 W.J. Plumley (Jour. Geology, v. 56, p. 526-577) studied the gravels along three streams on the eastern side of the Black Hills. Along Rapid Creek he found Miss Fillman's Mountain Meadow surface; he also mapped her Rapid terrace about 180 feet above the present stream valley, and the Sturgis terrace about 60 feet above the present valley; in addition, he named the Farmingdale Terrace, which begins 18 miles southeast of Rapid City and merges upstream with the present-day flood plain of Rapid Creek. He also detected a fourth terrace about 2 miles east of Rapid City and 80 feet above the present valley, but he was unable to correlate it with either the Rapid or the Sturgis terraces.

To the north, along Bear Creek he mapped the Rapid and Sturgis terraces about 170 feet and 70 feet, respectively, above the present valley. He named the Bear Butte Terrace as the main one downstream along the Belle Fourche River; a fourth terrace extends from the juncture of Bear Butte Creek and the Belle Fourche River, upstream along the river for 3 miles where it merges with the present-day flood plain.

To the south of Rapid Creek, he mapped several terraces along Battle Creek near Hermosa. The Rapid terrace is 230 feet above the present valley floor. The Sturgis terrace is also present, 90 feet below. Remnants of the Bear Butte terrace are present 30 feet lower. The Farmingdale terrace is not present along Battle Creek, but was noted along the Cheyenne River into which the latter flows.

Plumley listed anomalous terraces along each of the three streams. He dated the major terraces as follows: Mountain Meadow, Mio-Pliocene, questionably equivalent to the Flaxville of eastern Montana-western North Dakota (A.D. Howard, 1960, U. S. Geol. Survey Prof. Paper 326, 107 p.); Rapid Gravel, Aftonian Interglacial (possibly equivalent to the Cartwright of Montana-North Dakota); Sturgis gravel, Yarmouth Interglacial (possibly the Crane Creek of Montana-North Dakota); Bear Butte gravel, Sangamon Interglacial; and Farmingdale gravel, one of the Wisconsin Interstadials.

M.M. Knechtel and S.H. Patterson, 1962 (U. S. Geol. Survey Bull. 1082-M, p. 932-933) described the "Stoneville surface" in the Wyoming part of the northern Black Hills, and also discussed three pre-Stoneville terraces and two post-Stoneville ones. They assigned them to Tertiary (?) and Quaternary ages, but did not relate them to Plumley's terraces.

Obviously, there is much work to be done in the nonglacial Pleistocene of South Dakota.

IGNEOUS AND METAMORPHIC ROCKS

The Code provides that volcanic rocks which are mappable "should be treated as formations like any stratified sequence of sedimentary rocks;" that "units composed of intrusive igneous rock which are discriminated by mineralogic or textural characteristics, or chemical composition, may be classed as formations;" and that "formations composed of metamorphic rock are, like other formations, distinguished primarily by lithologic composition," and that different mineral facies "do not necessarily require definition of a new formation."

The Code provides (Art. 10i) for the naming of igneous rocks by combining "a geographic term and the petrographic name of the dominant rock type"--e.g., Harney Peak Granite. "Metamorphic rock recognized as a normal stratified sequence should be classified [like sedimentary rocks] as named groups, formations, and members"--e.g., Ellison Formation of the Lead Group; in addition, "metamorphic or metasomatic rocks, not classifiable by normal stratigraphic methods, should be given a... geographic name [and] the petrographic term for the dominant rock of the unit"--e.g., Veblen Schist.

The Code thus provides for the classification of igneous and metamorphic rock-stratigraphic units. It also mentions the difficulty of classifying on the basis of time-stratigraphic units (Art. 28f), and suggests that, until such time as the interregional correlations are worked out, Precambrian time-stratigraphic terms should be limited to the local area, and should be only relative--e.g., Lower Precambrian, Upper Precambrian.

Precambrian

In South Dakota the Precambrian is well known in the Black Hills, and less known elsewhere. F.V. Steece, 1961 (S. Dak. Geol. Survey Min. Res. Inv. Map 2) and 1962 (S. Dak. Acad. Science Proc., v. 41, p. 51-56) has noted briefly the rock types of the Precambrian in deep wells in South Dakota, and also in the well-known outcrop areas of the Black Hills, and near Milbank, and Sioux Falls. K.Y. Lee, 1958 (S. Dak. Acad. Science Proc., v. 36, p. 117-122) described hydrothermal effects in a volcanic rock from a well in Sanborn County, eastern South Dakota.

Names used for Precambrian rocks in southeastern South Dakota include Sioux Quartzite (C.A. White, 1870, Iowa Geol. Survey, v. 1, p. 167-171) and Corson Diabase (C.R. Keyes, 1914, Iowa Acad. Science Proc., v. 21, p. 187). Pipestone interbedded with the quartzite of the Sioux has been dated as 1.2 billion years old (S.S. Goldich, et al, 1959, Am. Assoc. Petroleum Geologists Bull., v. 43, p. 660).

The granite in the northeastern part of the State has been called Milbank granite, and S.S. Goldich, et al, 1961 (Minn. Geol. Survey Bull. 41, p. 146) have shown that this granite is similar to the Ortonville (Odessa) Granite of adjoining parts of Minnesota; furthermore, the Milbank granite has an average date of 2.0 billion years, which corresponds generally to the age of the Odessa-Ortonville granite.

In the Black Hills the Precambrian stratigraphic units were first discriminated during the work of Sidney Paige in 1900-1915 (published as N.H. Darton and Sidney Paige, 1925, U. S. Geol. Survey Geol. Atlas, Folio No. 219), but the units were not named. The naming was accomplished by J.O. Hosted and L.B. Wright, 1923 (Eng. and Min. Jour. Press, v. 115, p. 793-799, 836-843), as follows:

Pluma formation (youngest)--alternating garnet schist and carbonaceous slates, some pyritiferous; 4,000 feet.

Garfield formation--black and red, banded fine-grained cherty ferruginous quartzite, pyritiferous, locally called Iron Dike; some carbonate; 60 feet.

Northwestern formation--green finely foliated garnet-mica-schist and quartzite; 2,200 feet.
West Ledge formation--siliceous dolomitic limestone, chloritic; grades to impure calcareous phyllite; 100 feet.
Ellison formation--massive hard medium-grained quartzite interbedded with quartz-mica schist; 300 feet.
Homestake formation--cummingtonite and chlorite beds with contorted quartz stringers; in places dolomitic; constitutes the main ledge series; 70 feet.
DeSmet formation--garnet schist in alternating light and dark bands, micaceous, fibrous, thinly foliated; 300 feet.
Poorman formation--slates and phyllites, calcareous, graphitic, pyritiferous; 2,500 feet.

J.J. Runner, 1934 (Am. Jour. Science, ser. 5, v. 28, p. 353-372) was the first to name the rocks in the Nemo area of the northern Black Hills, as follows (descending):

Lead* system	Garfield fm.--pyrite-quartzite layers (not a sedimentary rock?).	
	Northwestern fm.--garnetiferous mica schist; several thousand feet.	
	Ellison fm. (in part)--slate, quartzite; 400-600 ft.	
	Homestake fm. (in part)--siliceous and iron-carbonate beds.	
	Poorman fm.--limestone and calcareous slate; 400-1,000 ft.	
Estes** system	conglomerate, quartzite, quartz schist, iron formation, limestone, slate; total 15,000 ft. (about 5,000 ft. conglomerate; remainder mostly quartzite and quartz schist).	
Nemo*** system	banded iron formation) arenaceous beds)	5,000-12,000 feet thick.

* Named for Lead mining district, T. 4-5 N., R. 3 E., Lawrence County, South Dakota (p. 365).

** Named for Estes Creek, T. 2 N., R. 5 E., Lawrence County, South Dakota (p. 359).

*** Apparently named for Nemo District, T. 2-3 N., R. 5 E., Lawrence County, South Dakota (p. 355).

Gneissoid granite and amphibolite intrude the Nemo system, and are not named.

J.K. Gustafson, 1933 (Econ. Geology, v. 28, p. 123-163) noted that, of Hosted and Wright's (1923) formations: the Pluma (upper) and Garfield do not crop out, the Northwestern was satisfactory, and West Ledge formation was renamed Upper Ledge to avoid conflict with other local usage of the term West Ledge, the Ellison and Homestake were satisfactory, and the Poorman and DeSmet were combined because they are gradational and form a single convenient mapping unit. Similar formations recur as far south as Rochford and the Golden West Mine on Castle Creek. The Homestake and Upper Ledge formations are practically identical lithologically. The upper contact of the Homestake is sharp, but the lower contact with the Poorman-DeSmet formation is less definite.

J.R. Berg, 1946 (S. Dak. Geol. Survey Rept. Inv. 52, p. 9-14) recognized in the Rochford District of the northern Black Hills the following six stratigraphic units, named in the Lead District 20 miles to the north (descending):

Roubaix Group
- Black quartz schist or biotite schist
- Blue-gray quartzite or gray-brown quartz schist

Lead Group
- Pluma formation
- Garfield formation
- Northwestern formation
- Ellison formation
- Homestake formation
- Poorman formation

Thus he used the nomenclature of Runner (1934) from the Nemo District. Berg noted that the Pluma formation is not present in the Lead District, suggesting that the rocks at Galena-Roubaix District might actually not be the same as the rocks in the Lead District. In addition, he described the Roubaix group, a series of unnamed arkoses, quartzites, and coarse gritstones.

J.A. Noble and J.O. Harder, 1948 (Geol. Soc. America Bull., v. 59, p. 941-976) described the stratigraphy of the rocks in the Lead District as (descending):

Grizzly formation	fine-grained dark-gray sericitic phyllite; 3,000+ ft.
Flag Rock formation	light-gray sericitic phyllite or schist; sooty-black schist or phyllite with abundant pyrite, quartzite; thin beds of brown sideroplesite schist, some beds of yellow sandy schist or micaceous sandstone; jasper; 4,000-5,000 ft.
Unconformity	
Northwestern formation	phyllite, schist, some slate; 0-4,000 ft.

Ellison formation	phyllite, schist, dark quartzite; 3,000-5,000 ft.
Homestake formation	sideroplesite-quartz schist; 200-300 ft.
Poorman formation	gray phyllite; banded in part (formerly called DeSmet Formation but now recognized as only a facies); some ankerite; 2,000± ft.

The Northwestern formation is missing northwest of the Lead District, and is likewise absent 20 miles south at Rochford. Noble and Harder noted that two groups of igneous and metamorphic rocks occur in the Lead District: the Precambrian amphibolites (Dodge, 1942) and the Tertiary porphyries (Noble, et al, 1949). The same sequence of Precambrian metasediments is present in the Rochford District, 20 miles to the south. They do not feel that the rocks can be recognized at Nemo, 15 miles southeast of Lead, despite Runner's (1934) statement that the Poorman, Homestake, and Ellison were recognizable there as parts of his Lead system.

G.L. Taylor, 1935 (Am. Jour. Science, ser. 5, v. 29, p. 278-291) described the granites of the Black Hills and applied names to them. The Game Lodge granite occurs in the southern Hills east of Custer, and intrudes Precambrian sediments that J.J. Runner thinks are the Estes system. The Game Lodge granite is cut by veins of the Harney Peak "fine grained" granite and pegmatite, which Taylor says occurs in the southern third of the Hills (south of Hill City). The Little Elk gneissoid granite occurs in the northern Hills, 10 miles southeast of the Lead District. Lead-uranium ratios indicate that the Little Elk may be younger than the Harney Peak or the Game Lodge (Taylor, 1935).

L.R. Page, et al, 1953 (U. S. Geol. Survey Prof. Paper 247, p. 6) described the pegmatites of the southern half of the Black Hills (south of Hill City), and at Tinton 40 miles to the northwest (15 miles west of the Lead District). They applied no names, but noted that the pegmatites intruded various folded, dark-gray fine- to coarse-grained quartz-mica schists and quartzites in the Custer and Hill City Districts. They described south and east of Custer schists containing sillimanite and garnet, and southwest of Custer mica schist with some areas of sillimanite schist. Quartzite is abundant southeast of Custer and northeast of Hill City.

In the Keystone District (10 miles east of Hill City) hornblende schists and gneisses are interbedded with quartz-mica schists, quartzites, and graphitic schists. The metamorphic rocks of the Tinton District are similar to those in the Keystone District.

The Harney Peak granite intrudes the metamorphic rocks, with many granite sills and dikes especially south of the main body. The pegmatites are believed to be closely related to the granite in age and origin.

P.M. Orville, 1960 (Geol. Soc. America Bull., v. 71, p. 1467-1490) described three pegmatites in the southern Black Hills near Keystone. They were given the geographic names Camp Judson, Burnt Area, and Buell Ranch. These pegmatites are all just outside the northeast border of the Harney Peak granite. Rubidium-strontium age determinations on muscovite give

ages of 1.7 billion years for the Bob Ingersoll zones pegmatite (not described herein), and 1.76 billion years for the Buell Ranch. They are closely related to the Harney Peak granite in composition and physical relations.

S.S. Goldich, et al, 1961 (Minn. Geol. Survey Bull. 41, p. 157) stated that the pegmatites in the southern Black Hills were intruded 1.62 billion years ago on the basis of an analysis of a uraninite from the Bob Ingersoll Mine (W.R. Eckelmann and J.L. Kulp, 1957, Geol. Soc. America Bull., v. 68, p. 1130). Goldich concluded that the pegmatites may be a late kinematic phase of the orogenic cycle following the deposition of a thick sequence of sediments that is well exposed in the northern part of the Black Hills.

D.H. Kupfer, 1963 (U. S. Geol. Survey Bull. 1142-E, p. 4) stated that two rocks of granitic composition have been mapped in the Calamity Peak area (5 miles east of Custer): (1) pegmatite, and (2) granite-pegmatite complex (layered granite or pegmatite). The so-called granite batholith of Harney Peak is actually a group of separate or interconnected masses of granite-pegmatite complex.

The South Dakota Geological Survey has not yet established an accepted terminology for the State's Precambrian igneous and metamorphic rocks; this should await a thorough study that involves the Precambrian throughout the State.

Tertiary Igneous Rocks

Sidney Paige, 1925 (U. S. Geol. Survey Geol. Atlas, Folio No. 219) mapped six igneous rock units of Tertiary age, which intruded 11 metamorphic and two igneous rock units of Precambrian age in the Black Hills. He applied no formation names to these rock units, which include rhyolite, quartz-monzonite, monzonite, quartz-tinguaite porphyries, grorudite, aegirite phonolite, and rhyolite (intrusive and extrusive).

W.C. Smith and L.R. Page, 1941 (U. S. Geol. Survey Bull. 922-T, p. 595-630) described the pegmatites of the Tinton District (15 miles west of the Lead District), using the rock units of N.H. Darton and W.S.T. Smith, 1905 (U. S. Geol. Survey Geol. Atlas, Folio No. 127), but with no names. The Tertiary intrusives in the Precambrian quartz-mica, graphite, and hornblende schist, and in the pegmatite dikes, are of three age groups (descending):

Lamprophyre dikes.
Pseudoleucite- and nepheline-bearing dikes.
Monzonite and syenite porphyries as dikes in the Precambrian and as sills and laccoliths in the Cambrian Deadwood Formation.

The tin ore occurs in certain of the pegmatite dikes.

J.A. Noble, 1948 (Geol. Soc. America Bull., v. 59, p. 927-940) discussed the Tertiary igneous rocks of the northern Black Hills with especial reference to the Homestake Mines. He recognized five rock types but applied no names. He noted that a swarm of rhyolite dikes in the Homestake

Mine comprises rocks of two different types: (1) low-potash rocks, and (2) high-potash rocks.

J.A. Noble, et al, 1949 (Geol. Soc. America Bull., v. 60, p. 321-352) discussed the Tertiary rocks and their effect on the deformation of the Precambrian rocks of the Lead District. They gave geographic names to two stocks--the Cutting Stock, and the Sheep Mountain Stock. Deformation of the Black Hills began in Eocene time (p. 348) and there has been little or no movement of the Black Hills since Oligocene time (p. 349).

No stratigraphic terminology has been published for the Tertiary igneous rocks of the Black Hills region.

SYMBOLS

The names used herein are classified by the South Dakota Geological Survey according to four categories:

All capitals--accepted.
Capitals and lower case, underlined--not accepted yet; further work may enable it to qualify for boldface type.
Capitals and lower case--rejected or abandoned; because of priority, insufficient or incorrect description, or practice.
Capitals and lower case, in quotes--informal term; useful in local areas or for limited purposes.

It is significant that of the 283 names included in this guide, 40 percent are accepted, 28 percent are rejected or abandoned, 17 percent may yet qualify for use in South Dakota, and 15 percent are used informally.

References to published articles are according to date as listed in the editions through 1959 of the "Bibliography of North American Geology," published by the U. S. Geological Survey; the same form of citation is used also for references omitted therefrom, and for post-1959 references. Only those references which contributed to increased or revised knowledge of a term are cited. Finally, a statement regarding the acceptance or rejection by the South Dakota Geological Survey is included where necessary.

AGENCY SILICEOUS SHALE FACIES (of DeGrey Member)

Upper Cretaceous: Central S. Dak.

Russell, W.L., 1930 (S. Dak. Geol. and Nat. Hist. Survey Rept. Inv. 7, p. 5). Agency shale member of Pierre shale--shale, hard, fissile, very light-gray, weathers to loose plates and chips. Zone of large grayish-white limestone concretions (fossiliferous) at top. Member extends up the Missouri River to within a few miles of the mouth of the Moreau River, down the Missouri below the mouth of the Cheyenne River, and some distance up the Cheyenne River. Exposed thickness is about 120 feet.

Gries, J.P., 1942 (S. Dak. Geol. Survey Rept. Inv. 43, p. 17). Noted that a distinctive bentonite bed at the base of the overlying Oacoma unit at Fort Pierre (halfway between the type area of the Oacoma and that of the Agency) is recognized 72 feet below the top of the Agency unit at Cheyenne Agency, and concluded that "the Oacoma zone as defined by Searight [1937], included not only the light and dark banded beds of Russell [Russell, W.L., 1930, S. Dak. Geol. and Nat. Hist. Survey Rept. Inv. 7, p. 5] but also part, if not all, of the Agency zone [of the Oacoma type area].... Inasmuch as it is not possible to draw the line between the true [type] Agency and the banded beds in the type locality of Searight's Oacoma zone, it is here suggested that both terms be retained, and that all beds lying between Crow Creek chalk [below] and the base of the Verendrye zone [above] be hereafter referred to as the Agency-Oacoma zone."

Crandell, D.R., 1950 (Amer. Assoc. Petroleum Geologists Bull., v. 34, p. 2339-2346). Considered the retention of Gries' term "Agency-Oacoma" inadvisable. Type sections are 100 miles apart and incomplete. Neither at Cheyenne Agency nor at Oacoma is there a representative section of the complete Agency-Oacoma zone of Gries. A new name, the DeGrey member of the Pierre shale is proposed for this unit. To preserve the identity of the subdivisions of the Sully member, Crandell proposed raising the Verendrye unit, the Agency-Oacoma unit (DeGrey Member of Crandell) and the Crow Creek unit to the rank of members. (Sully is therefore dropped from use.)

Type locality: Not designated

Name: From Cheyenne River Indian Agency, Dewey County, South Dakota

Agency-Oacoma zone (of DeGrey Member)

See Agency Siliceous Shale Facies.

Ahearn Member (of Chadron Formation)

Oligocene: Southwestern S. Dak.

Clark, John, 1954 (Carnegie Museum Annals, v. 33, art. 11, p. 197-198). The Ahearn member [lower Chadron] is characterized by: red sediments, basal conglomerate and other conglomerate low in feldspars; general gradation from coarse sediment at the base to fine at the top, and restricted white channel-fills with basal conglomerate but lacking red sediment. Only 30 miles in extent (Clark, John, 1937, Carnegie Museum Annals, v. 25, p. 287).
Type locality: South Fork, Indian Creek, Sec. 34, T. 3 S., R. 12 E., to Sec. 10, T. 4 S., R. 12 E., Pennington County, South Dakota
Name: From ranch at mouth of South Fork of Indian Creek

Ainsworth Formation

Upper Cretaceous: Southwestern S. Dak., northwestern Nebr.

Cook, H.J., 1922 (Pan-Am. Geologist, v. 37, p. 421-424). The "Rusty" member of Pierre shale or Ainsworth formation, as it is sometimes called, unconformably underlies Chadron formation to south and east of Black Hills uplift in South Dakota and Nebraska.
Type locality: Not designated
Name: Probably from Ainsworth, Nebraska

Apparently same as "Interior phase" of Ward (1922, S. Dak. Geol. and Nat. Hist. Survey Bull. 11, p. 18-20) - A.F.A.

Aladdin Sandstone

Ordovician (Middle?): S. Dak. (Black Hills), Wyo.

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 46-47). Aladdin sandstone--quartzose, locally calcareous, commonly 12-25 feet thick. Hard, fine- to medium-grained, moderately well-sorted, moderately porous sandstone, well-cemented and commonly characterized by "worm-eaten" appearance due to borings of marine worm Skolithos. In the vicinity of Nemo, South Dakota, the Aladdin changes from a thin marine sandstone to a thick (50-60 feet) red, deltaic deposit indicating wedge-edge deposition. The Aladdin has often been referred to as the "Scolithus" sandstone and lies above the Deadwood sandstone and beneath the Ice Box shale. A hiatus is believed to exist between the Aladdin sandstone and the Ice Box shale. East of the Black Hills the Aladdin disappears, probably by non-deposition, in the region of Pierre. The sandstone has not yielded fossils other than Skolithos, and exact age assignment cannot be made on a paleontologic basis.

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35, p. 49-51, figs. 10-11). Stated that the Skolithos-bearing sandstone is physically a part of the Deadwood, and recommended that the term Aladdin be rejected, as it is only "a relatively insignificant part of the Deadwood formation." Carlson also disagreed (p. 49) with McCoy's correlation of the Aladdin with the lower sand member of the Winnipeg formation.

Type locality: Bear Lodge Mountains, Crook County, Wyoming, Sec. 14, T. 52 N., R. 63 W.

Name: From Aladdin, Wyoming

AMSDEN FORMATION

Lower Pennsylvanian: Wyo., Mont., western S. Dak., western N. Dak.

Darton, N.H., 1904 (Geol. Soc. America Bull., v. 15, p. 394-401). Amsden formation--red shales, white limestones and cherty and sandy limestones. Thickness 150-350 feet. Underlies Tensleep sandstone and overlies (without apparent unconformity) the Little Horn limestone (now replaced by Madison limestone). In some areas, fossils of Mississippian age have been found in the basal part of what is considered to be Amsden formation.

Baker, C.L., 1951 (S. Dak. Geol. Survey Rept. Inv. 67, p. 29). Reported 172 feet of Amsden formation in the Christiana No. 1 Government oil test, Sec. 10, T. 11 S., R. 1 E., Fall River County, South Dakota.

Sloss, L.L., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 69). The "Amsden" of the Williston Basin is probably represented in the Black Hills section by the lower part of the Minnelusa formation, as suggested on the cross section.

Agatston, R.S., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 515). Said that Amsden equivalents are "absent throughout most of the Black Hills." The age, based on fusulinids, is Early Pennsylvanian Atokan (above) and Morrowan (below), in the upper half of the unit (p. 520). The lower half has not been correlated as yet, and may possibly be Late Mississippian (Chesterian). The Darwin sandstone at the base of the Amsden is the equivalent of the Fairbank formation, or Bell sand (p. 515) in the Hartville, Wyoming, area [and adjacent part of the southern Black Hills - A.F.A.]. The rest of the Amsden is the equivalent of the Reclamation group of the Hartville (Table 5, on p. 549).

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that Amsden equivalents--questionable Fairbank below, Reclamation and Roundtop groups above--are present in west-central South Dakota.

Willis, R.P., 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1940-1966). Extended the names Tyler-Heath (below) and Amsden (restricted) eastward from central Montana into the Williston Basin of North Dakota. [The Tyler-Heath apparently includes the Fairbank sand of the Hartville area, and the lower part of the Reclamation-Roundtop--thus, the lower part of Agatston's Amsden - A.F.A.]

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 68). Recognized the term Amsden in North Dakota, but not in South Dakota, where it is apparently included in the lower part of the Minnelusa.
Type locality: Not designated
Name: From Amsden Branch of Tongue River, west of Dayton, Wyoming

The Amsden is accepted in South Dakota according to Agatston's usage - A.F.A.

ARDMORE BENTONITE BED (of Sharon Springs Member)

Upper Cretaceous: Southwestern S. Dak.

Spivey, R.C., 1940 (S. Dak. Geol. Survey Rept. Inv. 36, p. 23-34). In the southwest part of South Dakota, the bentonite beds are confined mostly to a 15- to 20-foot zone, beginning some 60 or 70 feet above the bottom of the Pierre shale. The lowest bed of the zone is about 8 inches thick and is almost invariably brown in color. The next overlying bentonite bed averages a little more than 3 feet thick. Overlying the Ardmore bed are alternating layers of bentonite and shale, the bentonites ranging from 1 inch to 20 inches thick.
Rothrock, E.P., 1944 (S. Dak. Geol. Survey Bull. 15, p. 187, 189). The Ardmore bed is as much as 38 inches thick near Ardmore, South Dakota, in Fall River County. The bentonite lies approximately in the middle of the Sharon Springs member of the Pierre shale.
Kepferle, R.C., 1959 (U. S. Geol. Survey Bull. 1046-R, p. 584). Said that it is the basal bentonite bed of the middle, bentonitic unit of the three-unit Sharon Springs shale along the southern and eastern flanks of the Black Hills, from Rapid City southward and westward to the Wyoming line.
Tourtelot, H.A., 1962 (U. S. Geol. Survey Prof. Paper 390, p. 8). Noted that J.R. Gill correlates the Ardmore Bentonite Bed with the Pedro Bentonite Bed farther north, along the west side of the Black Hills.
Type locality: Not designated
Name: From Ardmore, Fall River County, South Dakota

ARIKAREE GROUP

Miocene: Western Nebr., southeastern Wyo., western S. Dak., northeastern Colo.

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 732, 735, 742, 743-748, pl. 82, 83, 84, 85, 88). Arikaree formation--series of gray sands everywhere characterized by layers of dark-gray concretions which often have a tubular form; underlies Ogallala formation in western Nebraska with distinct erosional unconformity and overlap. Rests (usually conformably) on Gering formation, where latter is present; where Gering is absent, rests on Brule clay. Upper member of Gering formation may be basal part of Arikaree formation. The Arikaree enters Nebraska from Wyoming, and thins out beneath Ogallala formation in eastern part of Banner County, Nebraska. Thickness 400 feet in

Scotts Bluff County, and 500 feet in Sioux and Dawes Counties; thickness increases as the Arikaree displaces the Ogallala formation northward. Extensively exposed along Niobrara River, apparently to the east of Valentine, and locally along western edge of sand-hill district, but not yet distinctly recognized in region drained by Loup Fork or along Platte River east of Cheyenne County, Nebraska. In upper part [Harrison - A.F.A.] are beds containing the large Daemonelix. Formation includes large amount of volcanic ash as general admixture, as well as beds of considerable extent and thickness. Contains a number of channels filled with conglomerates.

Darton, N.H., 1903 (U. S. Geol. Survey Prof. Paper 17). Mapped Arikaree formation across western northern Nebraska up to South Dakota line, but did not show any Ogallala above it in that area. In 1909 (U. S. Geol. Survey Water-Supply Paper 227) Darton mapped Arikaree formation across southern South Dakota from near Fall River County on the west to beyond Missouri River on east, but did not show any younger formation, and did not mention presence of Ogallala formation in South Dakota.

Osborn, H.F., 1909 (U. S. Geol. Survey Bull. 361, p. 65). The Arikaree of northwestern Nebraska and southeastern Wyoming is all of early Miocene age, while the Arikaree of northern Nebraska and adjacent Little White River region, South Dakota, includes upper Miocene and upper middle Miocene deposits equivalent to lower part of Ogallala formation of southwest Nebraska, and these late middle Miocene deposits are separated from beds equivalent to lower Miocene Arikaree of northwestern Nebraska and southeastern Wyoming by a large hiatus.

Osborn, H.F., 1912 (Geol. Soc. America Bull., v. 23, p. 247, 249). Assigned Arikaree formation of South Dakota to Miocene and Oligocene. In 1918 (Am. Mus. Nat. History Mem., n.s., vol. 2, pt. 1, p. 9, 12) he stated that Arikaree formation includes some Pliocene, lower Miocene, and possibly some upper Oligocene.

Troxell, E.L., 1922 (Geol. Soc. America Bull., v. 33, p. 210). Stated that his study of vertebrate fossils in the Marsh collection leads to the conclusion that the Arikaree formation is upper Oligocene.

Cook, H.J. and Cook, M.C., 1933 (Nebr. Geol. Survey Paper No. 5). Stated that vertebrates of "Arikaree" formation are Miocene and upper Oligocene. G.E. Condra in a preface to same reference stated that he believes that the Gering (the equivalent of lower part of Arikaree) is Miocene and not Oligocene as classified by H.J. and M.C. Cook. [This would assign all of Arikaree to Miocene, which is present age designation of U. S. Geological Survey--Wilmarth, 1938.]

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1251-1253, 1264, 1266-1269, 1270-1271). Raised the Arikaree to a group, containing at the base the valley-filling Gering formation, followed by the Monroe Creek and Harrison formations. Considered the term "Rosebud" the eastern equivalent of the Arikaree group and the lower part of the overlying Marsland formation, but did not recommend discarding "Rosebud."

Agnew, A.F., 1957 (S. Dak. Geol. Survey, Geol. Quad., White River). Mapping in south-central South Dakota, northeast of Sheridan County, Nebraska,

restricted the Arikaree formation there to reddish-brown cross-bedded quartzose channel sand and overlying gray to pink unconsolidated tuffaceous quartzose sands, which are overlain by the Mellette formation--a series of pink fine-grained limestones that are accompanied by thick red and grayish-pink tuffaceous sands.

Sevon, W.D., 1959 (S. Dak. Geol. Survey, Geol. Quad., Okreek). Mapping a quadrangle adjacent to the White River quadrangle, reduced the Mellette to a facies of the Arikaree Formation.

Collins, S.G., 1959 (S. Dak. Geol. Survey, Geol. Quad., Martin). Mapping in the area 70 miles west of Okreek and directly north of Sheridan County, Nebraska, recognized two (Monroe Creek, Harrison) of the three members of the Arikaree of Lugn (1939).

Harksen, J.C., 1960 (S. Dak. Geol. Survey, Geol. Quad., Sharps Corner). Described a new flood-plain silt formation with nodules and named it the Sharps, in Shannon County 50 miles west of the Martin quadrangle. Although he did not include it in the Arikaree Group at this time, the paper describing the new Sharps Formation by Harksen and others, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 674-678) included it as the basal formation in southwestern South Dakota, below the Monroe Creek Formation and resting on the White River Group, as did S.G. Collins, 1960 (S. Dak. Geol. Survey, Geol. Quad., Patricia). [The Gering channel sands have not been recognized in South Dakota - A.F.A.] Harksen also described the Rosebud Facies at the top of the Arikaree Group, above the Harrison Formation.

Sevon, W.D., 1961 (S. Dak. Geol. Survey, Geol. Quad., Vetal). Mapped the area of transition between the recognizable threefold subdivisions of the Arikaree Group--Sharps, Monroe Creek, Harrison--to the undifferentiated Arikaree Group, 15 miles east of Collins' Martin-Patricia mapping.

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that in the type area of the Rosebud Formation (Todd County, South Dakota) the Rosebud is exposed above the Brule and below the Valentine Formation. These beds are traced westward through scattered outcrops along most of the southern border of South Dakota. In the Porcupine Creek and Wounded Knee Creek area (Shannon County, South Dakota), the Rosebud Formation overlies the Harrison Formation and is the most widely exposed lithic unit in the southern part of the area. The Rosebud at its type locality appears to be the age equivalent of the Arikaree and overlying Rosebud in the Shannon County exposures, 100 miles to the west.

In northwestern South Dakota, N.M. Denson, G.O. Bachman, and H.D. Zeller, 1959 (U. S. Geol. Survey Bull. 1055, p. 23-27) described rocks which they referred to the Arikaree, because of their stratigraphic position and lithologic similarity to the middle Miocene Arikaree of the Big Badlands of southern South Dakota.

Type locality: Not designated

Name: From Arikaree Indians--at one time identified with the area in which the formation is most largely developed, western Nebraska and South Dakota.

ASHERN FORMATION

Devonian: Man., N. Dak., S. Dak., Sask., Mont.

Baillie, A.D., 1950 (Man. Dept. Mines and Nat. Resources, Mines Br. Pub. 49-2, p. 9-12). Thickness 5-125 feet. Red to pink to orange dolomite, and dolomitic red to green shales, often silty to sandy. May be brecciated at base and appears to fill holes in "karst-like" topography of underlying Silurian. Difficult at times to determine from sample cuttings. Possibly represents a "fossil laterite" or soil profile developed on Silurian rock surface in the interval between Silurian and Devonian deposition. Equivalent to "3rd red" of Saskatchewan.

Harris, S.H. and Mallin, J.W., 1957 (Williston Basin Oil Review, July, p. 15-16). Stated that in the Williston Basin the Ashern, the lowest Devonian unit, is as much as 50 feet of fine clastics and carbonates, usually red to pink. Fossils north of Winnipeg show Middle Devonian age. Represents the initial stage of deposition on a pre-Devonian karst topography of low relief; transgresses time boundaries.

North Dakota Geological Society, 1961 (Stratigraphy of the Williston Basin: Devonian System: N. Dak. Geol. Society, p. 809). Stated that the Ashern is overlain by the Winnipegosis formation throughout much of the Williston Basin [but not in South Dakota - A.F.A.]. On the other hand, similar basal red shales were deposited by the Dawson Bay, Souris River, and Duperow seas of later Devonian time, and locally rest unconformably on the "true" Ashern but are impossible to differentiate from it. Thus the Society recommended that the "Ashern" be mapped "together with the basal red shales of... whatever the identifiable Devonian formation onlapping the truncated Silurian of older beds may be" (p. 9).

Type locality: Not designated

Name: From village of Ashern, Manitoba

In South Dakota, the Ashern is treated as a basal Devonian red shale, deposited on and residual from the eroded underlying Silurian limestone - A.F.A.

ASH HOLLOW FORMATION (of Ogallala Group)

Pliocene: Nebr., S. Dak., Wyo. (?), Kans. (?), Okla. (?), Tex. (?), N. Mex. (?), Colo. (?)

Engelmann, Henry, 1859 (Rept. of Explorations Across Great Basin of Utah, p. 260-262; Capt. J.H. Simpson). Near the junction of north and south forks of Platte River lies a series of well exposed sediments in Ash Hollow, about 250 feet thick and consisting of an alternation of loose, finely sandy, calcareous sandstone and gritty impure limestone. Locally the sand is coarse. Age is probably Pliocene.

Lugn, A.L., 1938 (Am. Jour. Science, 5th ser., v. 36, p. 223-224, 227). The mortar beds division of the Ogallala group, which in the main is

the only part exposed in the type locality (?) near Ogallala, Nebraska, as defined by Elias, is now to be known as the Ash Hollow formation, 100 to 250 feet thick. It contains the "cap rock bed" of the Krynitzkia coroniformis fossil seed zone, the "fragmental vertebrate" fossil zone (the third and highest faunal zone of Stirton and McGrew, 1935, mistakenly called "Valentine" by them) in the lower part of the formation. The remainder of the Ash Hollow formation includes most of the Biorbia fossilia seed zone of Elias (1932, 1935; Chaney and Elias, 1936).

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1261). Ash Hollow formation--redefinition of Ogallala puts the Ash Hollow formation as second from the base, overlying Valentine formation and underlying Sidney gravel, all of the Ogallala. Lithology, thickness, location, and type section remain the same as in H. Engelmann's report (1859). Referred to as "mortar beds" by M.K. Elias.

Elias, M.K., 1942 (Geol. Soc. America Spec. Paper 41, p. 139-145). Stated that the Ash Hollow is differentiated from the underlying Valentine by the introduction of the herb Krynitzkia coroniformis, and locally by the change from the unconsolidated sands of the Valentine to the mortar beds of the Ash Hollow. As much as 350 feet thick at the type locality.

Agnew, A.F., 1958 (Geol. Soc. America Bull., v. 69, p. 1721). Stated that the Ash Hollow is the upper formation of the Ogallala Group in south-central South Dakota, where it is generally well cemented (in contrast to the underlying Valentine) and possesses a network of calcareous plant rootlets and clumps of Celtis seeds.

Type locality: Ash Hollow Canyon, southeast of Lewellen, Nebraska
Name: From Ash Hollow Canyon

Assiniboian Series

Upper Cretaceous (Western United States)

Keyes, C.R., 1923 (Pan-Am. Geologist, v. 43, p. 287-302). Applied the name Assiniboian series to the strata between his Dakota series, below, and his Foxian series above (pl. xvii and p. 300). It thus included the Benton shales, the Niobrara chalk, and the Pierre shale. However, he included his Foxian series in the Assiniboian on two other figures (pl. xvi and xviii).

In 1935 (Pan-Am. Geologist, v. 63, p. 41-72) he rehashed this, and also called it the Assiniboian centrum (pl. iv and p. 51).

Type locality: Not designated
Name: "from the Canadian province of Assiniboia" (p. 299)

Atlantosaurus beds

Upper Jurassic

A paleontologic term applied in early reports to the Morrison Formation and also to lower part only of the Morrison.

"B lignite bed" (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the "B" lignite bed as being 90 feet below the top of the Ludlow formation, 250 feet thick.

This lignite bed marks the base of the Giannonatti Lignite Facies, mapped by the South Dakota Geological Survey in six quadrangles in Harding County (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

Bakken Formation

Mississippian-Devonian: Sask., Man., N. Dak., S. Dak. (?), Mont.

Nordquist, J.W., 1953 (Billings Geol. Society Gdbk., 4th Ann. Field Conf., p. 72-74, figs. 4, 5). A thin clastic zone between the Madison group and the Upper Devonian throughout an extensive area of the Williston Basin. It represents an excellent cartographic unit easily recognized by its lithology and also by its electrical and radioactive characteristics. Essentially the unit consists of two thin highly radioactive black shales separated by gray calcareous sandstone, siltstone, or dolomite. The unit is most commonly called Kinderhook or Englewood by workers south of the international boundary. Nordquist believed that the Englewood of the Black Hills is correlative with beds in the lower part of the Lodgepole rather than with this unit.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2328). Stated that the Bakken is present in the central part of the Williston Basin and in northeastern and north-central Montana. "Where the Bakken was not deposited on the southern and eastern margins of the... basin, the lowermost Mississippian beds are correlated with the Englewood limestone of the Black Hills." These relations were described in more detail by Sandberg in 1962 (U. S. Geol. Survey Rept. TEI-809, p. 55 and fig. 13).

Kume, Jack, 1963 (N. Dak. Geol. Survey Bull. 39, p. 38). Stated that in northwestern South Dakota the Bakken Formation ranges in thickness from a maximum of 42 feet in Perkins County (fig. 14 on p. 36 shows a maximum of 30 feet), to a knife edge in northern Butte and Meade Counties.

He believed that the Bakken is overlain by the Englewood in Butte County (p. 38 and fig. 12 on p. 27).
Type locality: (Subsurface) Between depths of 9,615 and 9,720 feet, oil test in SW¼ NW¼ sec. 12, T. 157 N., R. 95 W., Williams County, North Dakota
Name: From Amerada #1 Bakken oil test

The South Dakota Geological Survey, pending completion of a current study of this part of the section of all the wells in the northwestern part of the State, does not yet accept the term Bakken in South Dakota - A.F.A.

"Banded beds" (of Fox Hills Formation)

Upper Cretaceous: S. Dak.

Morgan, R.E. and Petsch, B.C., 1945 (S. Dak. Geol. Survey Rept. Inv. 49, p. 17). A series of very thin-bedded, olive-drab shales intercalated with equally thin sands. The exposure is in the center of the south line of Sec. 18, T. 17 N., R. 24 E. The banded beds may be equivalent to a "banded member" described by W.V. Searight in the SE¼ sec. 21, and the SW¼ sec. 22, T. 16 N., R. 22 E. (1932, S. Dak. Geol. Survey Rept. Inv. 10). Thickness varies between 75 and 110 feet (?).
Baldwin, Brewster, 1951 (S. Dak. Geol. Survey, Geol. Quad., Mahto). Referred to "Banded Silts" member of the Fox Hills formation, overlying the Timber Lake and Trail City members of the Fox Hills. Lithology, thin-bedded gray silt and silty clay; hard white siltstone near base.
Stevenson, R.E., 1956 (S. Dak. Geol. Survey, Geol. Quad., Bullhead). Named the "Banded beds" the Bullhead member for the good exposures near the Indian village of that name. (See Bullhead Member.)
Type locality: Not designated
Name: From lithology

"Bar-H lignite" (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the Bar-H lignite as being 135 feet below the top of the Ludlow formation, 250 feet thick, and 15 feet below the Mendenhall lignite.
Type locality: Not designated
Name: From Bar-H Ranch, Harding County, South Dakota

The Bar-H lignite apparently marks the base of the Hillen Lignite Facies, mapped by the South Dakota Geological Survey in 11 quadrangles of

northwestern South Dakota (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

Barrett Shale

Lower Cretaceous: Northeastern Wyo., western S. Dak. (Black Hills)

Jenney, W.P., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 2, p. 593, fig. 122, map). Barrett shales (Lower Cret.)--shales and massive sandstones, unconformably underlying Oak Creek beds and overlying (without positive evidence of unconformability) the Hay Creek coal formation in the Black Hills. Formerly included in Dakota sandstone (Upper Cret.). Thickness 45 to 75 feet. [Appears to be same as middle part of Lakota formation--Wilmarth, 1938.]
Type locality: At Barrett, Crook County, Wyoming
Name: From Barrett

"Basal coal zone" (of Ludlow Formation)

Paleocene: Northwestern S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 17). Basal Coal Zone--this zone of the Ludlow-Cannonball is a succession of beds of clay, coal, and shale which lies at the base of the Ludlow-Cannonball everywhere in central Perkins County. It has been identified in the mapped area wherever exposures are good, and it appears to be continuous outside the area eastward to the vicinity of Coal Springs and westward to the locality south of Strool. Where best exposed, the "basal coal zone" consists of four coal beds separated by clay, clay-shale and shale, rarely sand. The coal beds are black, and vary in thickness from a few inches up to 5 feet. The entire "basal coal zone" varies from approximately 15 to 60 feet in thickness.
Type locality: Not designated
Name: From position in stratigraphic section

The Shadehill Facies, mapped in 24 quadrangles of northwestern South Dakota, may be correlative or partly correlative with the "basal coal zone" of Searight - A.F.A.

"Basal laterite" (of Minnelusa Formation)

Pennsylvanian: S. Dak.

Rothrock, E.P., 1949 (S. Dak. Geol. Survey Rept. Inv. 62, p. 30). A driller's term. The basal red shale zone is a good marker for the

base of the formation. It is some 25 feet in thickness. Where not present, it is sometimes difficult to determine the lower contact of the formation because of the numerous lime beds in the base of the Minnelusa, which are like the Pahasapa below. The shale beds become rather thin in the lower part, and the Minnelusa appears to grade into the underlying Pahasapa limestone. The thickest section of these lateritic beds in Fall River County was recorded in the Osage #1 Moody oil test where 100 feet was assigned to this zone. It is described as red clay, cream- and red-colored sandstone, and some chert. The thinnest section is recorded from the Black Hills Ordnance Depot #1 water well where 30 feet of pink limestone and pink and red shales and mudstone are assigned to it. On the outcrop it is usually a smooth red shale which is supposed to have been deeply weathered and leached, producing lateritic clay high in iron.

Type locality: Not designated

Name: From lithology

Beaver Creek Chalky Member (of Niobrara Marl)

Upper Cretaceous: Northeastern Wyo., southeastern Mont.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). Beaver Creek chalky member--chalk, marl and calcareous siltstone, gray where fresh; weathers to light yellow. Marine fossils. Thickness 125 to 200 feet. Upper member of Niobrara formation. Overlies Sage Breaks shale member of Niobrara.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 77). It is likely that most or nearly all of the Niobrara as recognized in South Dakota is included in the Beaver Creek member.

Type locality: Along Beaver Creek in T. 46 N., R. 64 W., Weston County, Wyoming

Name: From Beaver Creek

Since W.A. Cobban, 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2187-2190) placed the lower, or Sage Breaks member of Rubey's Niobrara in the underlying Carlile, there is apparently no need for the term Beaver Creek, and it has not been adopted for South Dakota - A.F.A.

Beaverhill Lake Group

Upper and Middle Devonian: Sask., Man., N. Dak., S. Dak., Mont.

Stanton, M.S., 1953 (Billings Geol. Society Gdbk., 4th Ann. Field Conf., p. 61). The Beaverhill Lake group includes the series of dominantly normal marine carbonates with intermittent evaporites overlying the

Elk Point group and extending upward to a prominent gamma-ray kick marking the top of a widespread argillaceous carbonate zone. The Beaverhill Lake group has a thickness ranging from slightly less than 300 feet in the extreme southwest of Saskatchewan to a known thickness of 750 feet in the area immediately south of Saskatoon. The Beaverhill Lake group has been divided into two formations, in ascending order, the Dawson Bay and Souris River. The Dawson Bay formation consists of limestone and dolomite and the Souris River formation of variable limestone, dolomite, anhydrite and salt. "The term 'Beaverhill Lake' is here used in quotation marks since this gamma ray marker... occurs some 70 to 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."

Type locality: Not designated

Name: From Beaverhill Lake, Saskatchewan

The Beaverhill Lake formation, named by Layer, et al, 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 1823-1825, from the Anglo-Canada #2 Beaverhill Lake oil well in southeastern Alberta), is apparently the equivalent of the upper part of the Souris River (C.T. Walker, 1956, 1st Internat. Williston Basin Symposium, p. 131), or the equivalent of nearly all of the Manitoba Group (Andrew Baillie, 1955, Am. Assoc. Petroleum Geologists Bull., v. 39, p. 579), which see - A.F.A.

"Bell sand" (of Minnelusa Formation)

Pennsylvanian: S. Dak. (Black Hills), Wyo.

A driller's term used to designate the basal sand or sands of the Minnelusa in eastern Wyoming and the western side of the Black Hills in South Dakota.

Agatston, R.S., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 515). Stated that the Bell is the same as the Fairbank formation, and R.L. Bates (1955, Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1991) agreed.

Type locality: Not designated

Name: Apparently first used in print by E.W. Krampert (1940, Kansas Geol. Society Gdbk., 14th Ann. Field Conf., p. 152), in the Lance Creek oil field, Wyoming

BELLE FOURCHE SHALE MEMBER (of Graneros Shale)

Upper Cretaceous: Northwestern Wyo., western S. Dak.

Collier, A.J., 1920 (U. S. Geol. Survey Press Bull. 9065). Belle Fourche shale, Upper Cretaceous, underlies Greenhorn limestone and overlies Mowry shale.

Collier, A.J., 1922 (U. S. Geol. Survey Bull. 736, table opp. p. 76, p. 83, etc.). Belle Fourche shale member--top member of Graneros shale. Consists of dark-gray shale which varies in hardness but is all softer than underlying Mowry shale. Thickness 560± feet. Contains calcareous concretions near top and zone of Mowry-like shale 100± feet below top. Many ironstone concretions in lower part, and a thick bed of bentonite near base. Few fossils.

Moore, R.C., 1949 (Geol. Soc. America Mem. 39, fig. 18). Portrayed the facies relationships of the Belle Fourche and the underlying Greenhorn limestone along the Wyoming-Montana border north of the Black Hills from unpublished studies of M.N. Bramlette and W.W. Rubey. They showed that the calcareous shale and thin limestones of the Greenhorn facies occur lower in the stratigraphic column, at the expense of the dark noncalcareous shale of the Belle Fourche facies, southeasterly toward the Black Hills. They drew the contact between the two at the base of the lowest limestone, which they called the Bull Creek sandy limestone. Cobban and Reeside, 1952 (p. 1031) stated that the Bull Creek is the same as the Orman Lake, and used the latter term.

Cobban, W.A., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2181-2182). Described the Belle Fourche in the northern Black Hills as black-gray to dark bluish-gray fossil shale that contains ferruginous concretions and numerous thin layers of bentonite. Near the Belle Fourche River in Sec. 22, T. 57 N., R. 62 W., Crook County, Wyoming, the formation is 565 feet thick and consists of the following three members, in descending order:

> Dark bluish-gray shale, with lenticular brown-weathering ferruginous concretions and numerous creamy-white bentonite layers; 285 feet thick.
>
> More or less sandy shale, with several thin layers of bentonite and sporadic brown-weathering concretions; 233 feet.
>
> Shale with abundant hard clay-ironstone concretions that weather dark purplish-brown, and two bentonite beds each a foot or more thick; 47 feet.

The Belle Fourche shale is Cenomanian in age (p. 2197).

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 76). This formation consists in South Dakota of about 350 feet of soft, dark-gray marine shale with minor ledges of black iron-manganese carbonate concretions. North of the Black Hills it contains a single thin bed of limestone [Orman Lake, which see - A.F.A.] containing sharks' teeth, and east of the Hills, at about the same horizon, a thin bed of impure limestone carrying imprints of a clam indistinguishable from Inoceramus labiatus. The Belle Fourche shale thickens to 700 feet or more west of the Black Hills.

Knechtel, M.M. and Patterson, S.H., 1962 (U. S. Geol. Survey Bull. 1082-M, p. 914-919). Divided the Belle Fourche in the northern part of the Black Hills into:

> Upper member--soft dark-gray shale with a few strata containing calcareous concretions and some bentonite beds including

bentonite bed G of the west side of the district. The member rests on bentonite bed F. Lateral facies changes cause the Belle Fourche-Greenhorn contact to drop lower in the section from the western side of the Black Hills to the northeastern side, so that east of Alzada, Montana, the base of the Greenhorn is 45-60 feet below bed G, and the upper member of the Belle Fourche is only 32 feet thick; it is only 6 feet thick 4 miles northwest of Belle Fourche, where bed F thins out.

Lower member--(three units) Upper unit, soft dark-gray shale with many bentonite beds and calcareous concretions and cone-in-cone near the top; 200 feet thick near Belle Fourche, but thickens to west as the Greenhorn contact rises in the section. Middle unit, sandy shale with thin lenses of soft gray sandstone and thick layers of dark-gray, soft fissile shale; bentonite beds common; 215 feet thick. Probably equals the Frontier sands farther west. Lower unit, dark shale that is harder and less fissile than the overlying units; abundant oblate spheroidal corrugated or pitted concretions of siderite; 30-45 feet thick. Includes bentonite beds D and E, and rests on Clay Spur Bentonite Bed of Mowry. Resembles "oligonite zone" of R.C. Spivey, 1940 (S. Dak. Geol. Survey Rept. Inv. 36), which comprises 60-80 feet of strata above the Mowry Shale.

Cobban, W.A. and Reeside, J.B., Jr., 1952 (Geol. Soc. America Bull., v. 63, pl. 1). Placed the boundary between the Lower Cretaceous and Upper Cretaceous at the base of the Belle Fourche shale.

Type locality: Exposure along Belle Fourche River in neighborhood of Wind Creek, Crook County, Wyoming

Name: From Belle Fourche River

In eastern South Dakota, the Clay Spur Bentonite Bed is missing, and the Belle Fourche and Mowry shales lose their distinctive character, and have been termed Graneros - A.F.A.

Benton Shale

Upper Cretaceous: Southeastern Mont., S. Dak., eastern Wyo., Nebr.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 419, 421). Fort Benton group (Formation No. 2 of Cretaceous). Dark-gray laminated clays, sometimes alternating near upper part with seams and layers of gray and light-colored limestone. Fossiliferous. Thickness 800 feet in vicinity of Fort Benton, on upper Missouri River. Also occurs along Missouri River in Nebraska from 10 miles

above James River to Big Sioux River, along eastern slope of Rocky Mountains, and in Black Hills. Overlies Dakota group and underlies Niobrara division. [This paper by Meek and Hayden describes rocks of Nebraska Territory which at that time included Wyoming, Montana, and Dakota - A.F.A.] Is lower formation of Colorado group. For many years the "Fort" has been dropped from the name and Benton shale has been used. Named for Fort Benton, on Missouri River, about 40 miles below Great Falls, Montana, but the stratigraphic limits of the formation are based largely on sections along Missouri River in northern Nebraska where the Benton rests on Dakota sandstone and is overlain by Niobrara limestone.

Keyes, C.F., 1925 (Pan-Am. Geologist, v. 43, pl. 17 on p. 293). Showed the Benton shales to be composed of (descending): Hawarden shales, Crill chalk, and Woodbury shales.

[The early Cretaceous rocks of central Montana region including Fort Benton are now classified as lower Cretaceous Colorado shale (Niobrara, above, and Benton) and Kootenai formation. In parts of Wyoming and eastern Colorado the rocks formerly called Benton are now divided into (descending) Carlile shale, Frontier formation, Mowry shale, and Thermopolis shale - Wilmarth, 1938.]

Type locality: Not designated

Name: From Fort Benton, Montana

The individual formation names--Carlile (above), Greenhorn, and Graneros--are used in South Dakota - A.F.A.

Beulah clays

Upper Jurassic: Northeastern Wyo., western S. Dak. (Black Hills)

Jenney, W.P., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 2, p. 593, fig. 122, map). Beulah clays--Upper Jurassic fresh- or brackish-water deposits. In Hay Creek coal field, Crook County, Wyoming, consists of: (1) Atlantosaurus beds, 25 to 35 feet of whitish and light-gray clays with some sandy shales and concretions of white calcareous clay, the upper layers in many localities carrying fossil wood and saurians' bones; (2) light-gray thin-bedded sandstone 5 to 10 feet. Underlies Hay Creek coal formation with great unconformability and unconformably overlies lower Jurassic marine beds. Long outcrops of these clays occur 3 or 4 miles north of Beulah, in Red Water Valley (Crook County, Wyoming). [Same as Morrison formation which has priority - Wilmarth, 1938.]

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 50-52). Discussed the Morrison-Lakota contact in the Black Hills, noting that it may be gradational or it may suggest angular discordance. The Unkpapa and similar sands in the Morrison are distinct from the overlying Lakota sands, but the mudstones and claystones of the Morrison and Lakota are the difficult ones. Actually, the beds called Morrison in the Black

Hills may be equivalent to only part of the type Morrison in Colorado, so that Darton's term Beulah in the Black Hills, which has been suppressed in favor of Morrison, may still have some validity.
Type locality: Not designated
Name: From Beulah, Crook County, Wyoming

"Big bentonite bed" (of Pierre Shale)

Upper Cretaceous: S. Dak.

Petsch, B.C., 1946 (S. Dak. Geol. Survey Rept. Inv. 53, p. 35, fig. 5, 10). About 5 to 10 feet below the "Upper micaceous bentonite" at the top of the Oacoma is a thick layer of bentonite varying from 4 to 10 inches in thickness. Beneath it is a $\frac{1}{2}$- to $1\frac{1}{2}$-inch shale, then another layer of bentonite, usually 1 inch thick. This last sequence of bentonite-shale-bentonite constitutes the "Big bentonite bed." The Big bentonite is a key bed of the Oacoma and can be traced many miles in outcrops.
Type locality: Not designated
Name: From lithology

BIGHORN GROUP

Middle and Upper Ordovician: Wyo., Mont., N. Dak., S. Dak.

Darton, N.H., 1904 (Geol. Soc. America Bull., v. 15, p. 394-401). Bighorn limestone--on east side of Bighorn Mountains. Consists of 250-300 feet of limestone, mostly hard and massive. Top member is thin-bedded impure limestone, with Late Ordovician Richmond fauna. Middle member is somewhat massive and in places is fine-grained light-colored limestone containing corals. Lower member is hard massive impure light-gray or faint-buff limestone, with a network of silica veinlets that weathers to a honeycomb appearance. Fossils in the lower member are Middle Ordovician Trenton in age. Underlies Madison limestone, and overlies Deadwood formation.
Ross, R.J., 1957 (U. S. Geol. Survey Bull. 1021-M, p. 444-445). Raised the Bighorn to group for the Williston Basin area, including the Red River, below, and Stony Mountain formations. This usage was followed by J.G.C.M. Fuller, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1343 and figs. 4-6).
Type locality: Not designated
Name: Bighorn Mountains, Wyoming

Big Snowy Group

Mississippian: Central Mont., northwestern S. Dak. (?)

Scott, H.W., 1935 (Geol. Soc. America Proc., 1934, p. 367). Big Snowy group is made up of Kibbey, Otter, and Heath formations. Is mainly variegated shale with intercalated limestones and sandstones. Overlies Madison limestone.

Scott, H.W., 1935 (Jour. Geology, v. 43, p. 1011-1032). Big Snowy group--new name for lower part of beds heretofore assigned to Quadrant formation in central Montana. True Quadrant formation is absent in central Montana where the rocks heretofore assigned to it are all of Mississippian age, are all older than typical Quadrant formation of Quadrant Mountain, Yellowstone National Park (which is of basal Pennsylvanian age, and unquestionably a westward extension of Tensleep sandstone, into which it grades), and are also older than Amsden formation, which is Mississippian; underlies the Quadrant of Quadrant Mountain as well as the Quadrant of southern Montana, and overlies Big Snowy group in central Montana. This group has maximum thickness of 1,200 feet and rests on the Madison limestone. Divided into three conformable formations in descending order: Heath formation (new name), Otter formation, and Kibbey formation.

Perry, E.S. and Sloss, L.L., 1943 (Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1287-1304). Described the Big Snowy group of the northern Great Plains, and showed (figs. 4, 5, 7) that only the lower formation, or Charles [which they included in the Big Snowy - A.F.A.], is present to any extent in South Dakota, as the overlying Kibbey and Otter pinch out just within the State (fig. 7). (The Heath at the top is present farther north, in Montana and North Dakota.) The Charles is 600 feet thick in State Royalty #1 State oil test in northwestern South Dakota, but is absent in the Black Hills.

Bolin, E.J. and Petsch, B.C., 1954 (S. Dak. Geol. Survey Rept. Inv. 75, p. 1). Big Snowy and Devonian strata are present east of the Missouri River in northern South Dakota.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 64-65). Reported that the Big Snowy Group is represented in northwestern South Dakota by the Kibbey Sandstone. It rests on the Charles Limestone of the Mississippian Madison Group, and is overlain by the Tyler-Heath interval at the base of the Minnelusa, according to R.P. Willis, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1940-1966), who reported (p. 1943) that although no identifiable fossils had been found in the Kibbey, it was probably Chester in age.

Type locality: Not designated

Name: From Big Snowy Mountains, Montana

The name Big Snowy is not accepted yet by the South Dakota Geological Survey, as the Kibbey is its only recognized representative. If Heath

should be recognized in South Dakota, then the term Big Snowy would be more useful - A.F.A.

BIJOU QUARTZITE FACIES (of Ogallala Group)

Pliocene: S. Dak.

Stevenson, R.E. and Carlson, L.A., 1950 (S. Dak. Geol. Survey, Geol. Quad., Bonesteel). The strata, though named here, were not described until 1953.

Stevenson, R.E., 1953 (S. Dak. Acad. Science Proc., v. 32, p. 86-89). Characterized by a green siliceous coarse quartzose sandstone (orthoquartzite) which makes up about 21 percent of the formation. Associated with it is a greenish slightly lutaceous fine-grained quartzose sand. The bulk of the formation consists of greenish to gray bentonitic clay and the above sand. Scattered throughout are beds of greenish to pink sandy siltstone, and gray coarse-, medium- and fine-grained lutaceous sand as well as lenses and nodules of caliche. The base, where it rests on the eroded surface of the Pierre shale, is slightly conglomeratic, with clay pebbles. The thickness of the formation varies from 38 to 54 feet. The formation is well exposed on the divide between Ponca Creek and the Missouri River and also on the east side of the Missouri River in the vicinity of Lake Andes and Pickstown.

Stevenson, R.E., 1958 (S. Dak. Acad. Science Proc., v. 36, p. 134-138). The formation is herein redefined as a lithofacies within the Miocene and Pliocene rocks of south-central South Dakota.

Agnew, A.F., 1958 (S. Dak. Acad. Science Proc., v. 36, p. 129-133). Was more specific when he stated that "the Bijou quartzite is a widespread silica-cemented facies of lower Ogallala sediments." [Subsequently, geologic quadrangle maps in south-central South Dakota have shown it in this way - A.F.A.]

Type locality: None chosen "because of the changing lithologic character of this formation."

Name: From the Bijou Hills, Brule County, South Dakota

BIRDBEAR FORMATION

Upper Devonian: N. Dak., Mont., S. Dak., Sask., Man.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2318-2322). The Birdbear is a light-gray to medium brownish-gray, finely crystalline porous fossiliferous dolomite and limestone that overlies the Duperow and underlies the Three Forks in the Williston Basin. The upper third of the Birdbear is locally anhydrite. The Birdbear is 75-115 feet thick. It is bounded below by

the shale which marks the top of the Duperow, and above by the Three Forks shale; thus it is easily recognized on mechanical well logs. The age is Late Devonian, based on fossils in the overlying and underlying rocks. The Birdbear and the underlying Duperow constitute the Jefferson group.

The Birdbear is the unit that had been called the "Nisku" in the Williston Basin by the North Dakota Geological Society, 1954. However, because the Nisku of its type area in Alberta is restricted to the Alberta Basin and is separated by anhydritic and redbed facies, the name Nisku should not be used in the Williston Basin. (N. Dak. Geol. Society, 1961, p. 27-28.)

Type locality: (Subsurface) Between depths of 10,310 and 10,400 in the Mobil #1 Birdbear oil test in Sec. 22, T. 149 N., R. 91 W., Dunn County, North Dakota

Name: From Birdbear lease

"Bison coal" (of Ludlow Formation)

Paleocene: S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 31). A thin succession of sandstone, shale and a thin coal lies between the Scotch Cap sandstone, and the Bison silt and sandstone zone. This group of beds is rarely well exposed, but has been identified in the vicinity of Bison and as far northwest as the prominent butte in Sec. 31, T. 19 N., R. 13 E. A coal bed penetrated in numerous wells in the town of Bison lies apparently at this horizon.

Bolin, E.J., 1955 (S. Dak. Geol. Survey, Geol. Quad., Bison). The top coal horizon, the Bison facies, is thin and poorly developed in this area. It was exposed only along the road north of Bison, where it is less than 3 feet thick and includes a single, thin coal. This facies may be of very local extent.

Type locality: Not designated

Name: From Bison, Perkins County, South Dakota

This facies occurs about 200 feet above the base of the Ludlow, and about 125 feet below its top in the Bison quadrangle, Perkins County, South Dakota. It is probably the equivalent of part of the Giannonatti Lignite Facies, 50 miles to the west - A.F.A.

"Bison silt and sandstone" (of Ludlow Formation)

Paleocene: S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 33). The Bison silt and sandstone zone is a conspicuous and readily identifiable succession of silty and sandy calcareous beds which are the

uppermost beds of the Ludlow-Cannonball member of the Lance in central Perkins County, South Dakota. In the weathered outcrop these beds are yellowish-buff and buff. They are the bedrock of the divide between South Fork of Grand River and Thunder Butte Creek, and thus underlie the town of Bison. The greater part of the succession is composed of alternating beds of buff and gray shale, silt, and fine sandstone. Gray clay and buff silt predominate in the lower part, whereas thin, cross-bedded sandy strata become increasingly important in the upper part. The Bison beds are probably 100 feet or more thick.

Bolin, E.J., 1955 (S. Dak. Geol. Survey, Geol. Quad., Bison). The Bison silt and sandstone may be represented on the generalized columnar section above the Bison "facies."

Type locality: Not designated

Name: From Bison, Perkins County, South Dakota

The Bison silt and sandstone is not used by the South Dakota Geological Survey - A.F.A.

Blackhorse Shale

Upper Cretaceous: Central-northern S. Dak., southwestern N. Dak.

Keyes, C.R., 1922 (Pan-Am. Geologist, v. 37, p. 63-64). Blackhorse shales--500 feet thick, underlie Ludlow lignites and overlie Fox [Fox Hills - A.F.A.] sandstones. Basal shale of Lance formation in South Dakota and North Dakota. Blackhorse Butte is conspicuous landmark in Schanasse (?) County [Corson County - A.F.A.], South Dakota, and overlooks Grand River Valley and the basal shale of the Lance.

Type locality: Not designated

Name: From Blackhorse Butte, Corson County, South Dakota

This formation is apparently the same as the Hell Creek - A.F.A.

Black Island Member (of Winnipeg Formation)

Ordovician: Man. (?), Sask., N. Dak., north-central S. Dak.

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35, p. 49-51, 55-58). Applied the name Black Island to the lower sandstone of the Winnipeg formation in the Williston Basin, and pointed out its presence in the north-central part of South Dakota (p. 49 and fig. 14). In the deeper part of the Williston Basin (northwestern North Dakota), the Black Island is 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. Petroleum Geologists Bull., v. 45, p. 1341). Believed that the Black Island of Carlson in North Dakota is not the same as that named Black Island in Manitoba by G.J. Genik (1954, Alta. Soc. Petroleum Geologists News Bull., v. 2, no. 5, p. 2-5), and he replaced this name with Burgen, from the Mid-Continent area. [This extension of the name Burgen into northern South Dakota is unacceptable to the South Dakota Geological Survey at this time - A.F.A.]

Type locality: Not designated

Name: From Black Island, Lake Winnipeg, Manitoba

Black River Group

Middle Ordovician: N.Y. and Pa.

Vanuxem, L., 1842 (Geol. of New York, pt. 3, p. 38-45). Black River limestone--underlies Trenton limestone and overlies Calciferous group.

Baker, C.L., 1952 (S. Dak. Geol. Survey Rept. Inv. 68, p. 21). Referred to the Black River formation which is actually a group. Baker mentioned that the Black River is equivalent to the Glenwood of northeastern Iowa and southeastern Minnesota and to the upper part of the Winnipeg formation of Manitoba. Fossils in exposures in eastern part of town of Deadwood are of Black River age. It is mostly dull-green very flaky, fissile and splintery shale, caving badly where water-soaked, and composed largely of bentonite.

Type locality: Not designated

Name: Derivation not indicated

The term Black River is not accepted by the South Dakota Geological Survey; these rocks are called the Winnipeg Formation except in the extreme southeastern part of the State where the terms Decorah and Platteville may be applicable - A.F.A.

Breien Member (of Hell Creek Formation)

Upper Cretaceous: N. Dak., S. Dak. (?)

Laird, W.M. and Mitchell, R.H., 1942 (N. Dak. Geol. Survey Bull. 14, p. 14-15). Described a thin fossiliferous marine member interfingering in the basal part of the nonmarine Hell Creek, and gave it the name Breien. The Breien occurs about 20 feet above the base of the Hell Creek, and consists of two beds of gray sand separated by gray bentonite. The upper sand is greenish, suggesting a marine color; W.A. Cobban, who discovered the unit, then found marine fossils. It is 31 feet thick in Morton County, North Dakota, and has been reported farther south, west of Fort Yates, North Dakota.

Type locality: Near the village of Breien, T. 134 N., R. 82 W., Morton County, North Dakota
Name: From Breien

Fort Yates is only 15 miles north of the South Dakota border, but the South Dakota Geological Survey has not recognized this unit in the Hell Creek. Laird and Mitchell suggested that the Breien might be present in South Dakota, as they say a seaway from the south or east apparently invaded this territory for a short distance, depositing the sands and bentonite of the Breien. They declared the Breien to be of unusual interest because it represents a temporary return of the sea into an area of predominantly continental deposits.

It appears that the Breien might have been what was mapped just south of the border by Brewster Baldwin, 1951 (S. Dak. Geol. Survey, Geol. Quad., Mahto) as the sandstone caprock in the lower part of the Hell Creek, except that it was called Bijou? of Mio-Pliocene? age by him. The Breien may also be correlative with the oyster-bearing sandstone mapped as Colgate by R.E. Stevenson, 1957 (S. Dak. Geol. Survey, Geol. Quad., McLaughlin) about 15 miles west of the Mahto occurrence - A.F.A.

Broom Creek Formation

Permian: Wyo., Colo., western S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 4, 19, 45). Comprises interval from base of Cassa group to top of Wendover group--thickness 14 to 75 feet. Well shown in the Hartville and Black Hills areas, and probably extends under western Nebraska. Consists of siltstone, limestone, sandy shale, and sandstone.

Reed, E.C., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 46). The lower 110 feet of the Cassa group of Condra, Reed, and Scherer should be included with the underlying Broom Creek group, thus expanding the thickness of the Broom Creek group in the Hartville area from about 70 feet to about 180 feet. Thus the more indurated beds formerly placed in the lower Cassa are included with very similar lithologies in the Broom Creek group. It is further concluded that this group is Permian and not Pennsylvanian in age.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said the Broom Creek group of dolomite, anhydrite and shale is present in western South Dakota. Rests on "Red Marker shale" at top of Wendover group, and is overlain by Cassa group.

Type locality: Broom Creek Valley, Sec. 10, T. 28 N., R. 66 W., Platte County, Wyoming
Name: From Broom Creek Valley

BRULE FORMATION (of White River Group)

Upper and Middle Oligocene: Western Nebr., S. Dak., northeastern Colo., eastern Wyo.

Hayden, F.V., 1857 (Notes on the Geology of the Mauvaises Terres of White River, Nebr.: Phila. Acad. Nat. Sci. Proc., v. 9, p. 151-158). The Brule formation had originally been termed Turtle and Oreodon beds by Hayden, and Oreodon beds by Hayden, 1867 (Rept. of F.V. Hayden: U. S. Geol. Survey Terr. 1st Ann. Rept.).

Wortman, J.L., 1893 (On the Divisions of the White River of Lower Miocene of Dakota: Am. Mus. Nat. History Bull., v. 5, p. 95-105). Subdivided the unit into the Oreodon beds (lower unit) and Protoceras beds (upper unit). The Protoceras beds have also been called the Leptauchenia beds and the Protoceras-Leptauchenia beds. All these terms are deeply rooted in the Oligocene literature.

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 736, 755-759). The White River beds in their extension from South Dakota into Nebraska present some differences in stratigraphic range and relations. They expand considerably and include, at top, beds which appear not to be represented in the typical regions. Accordingly, to afford distinct definitions for the members in Nebraska, Darton introduced the designation Brule clay and separated the underlying Titanotherium beds as Chadron formation. The Brule consists mainly of a hard sandy pink clay. Thickness about 600 feet in vicinity of Wyoming line, but diminishes greatly eastward; in vicinity of 103 meridian in northwest part of Nebraska it is 320 feet thick. It has not been recognized east of longitude 101° 30', where it appears to sink beneath the surface in Platte Valley. Extends far to northeast in South Dakota. [Is upper formation of White River group - Wilmarth, 1938.]

Bump, J.D., 1956 (Am. Jour. Science, v. 254, p. 429-432). The Brule formation as it is exposed in the Big Badlands of South Dakota is divided into two members. The lower member, which includes a major part of the classic Oreodon beds, is designated the Scenic member and subdivided into two units, an Upper Nodular zone and a Lower Nodular zone. The upper portion, which includes the Protoceras-Leptauchenia beds, is designated the Poleslide member and subdivided into three units, the Upper zone, Middle zone, and Lower zone.

[While accepting the names Scenic and Poleslide for the Big Badlands, the South Dakota Geological Survey has not used these names in mapping the Brule in approximately 15 geologic quadrangles 100 miles farther east in south-central South Dakota. The Brule is divided there (A.F. Agnew, 1957, S. Dak. Geol. Survey, Geol. Quad., White River) into two units: (1) a lower banded pinkish and grayish clayey tuffaceous laminated siltstone and fine sandstone interbedded with silty bentonite claystone, which weathers to a stair-step profile and is about 110 feet thick; and (2) an upper pink and greenish tuffaceous siltstone overlain by pinkish to brownish highly bentonitic clay including pink waxy clay and brown and pink nodular fine sand, which weathers to rounded humps and totals 77 feet in thickness - A.F.A.]

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that the Miocene Rosebud in its type area of Todd County, South Dakota, overlies the Brule [with apparent conformity - A.F.A.]. Farther west, the essentially equivalent Arikaree Group rests on the Brule.
Type locality: Not designated
Name: From Brule Indians, who formerly roamed the southern part of South Dakota and western Nebraska

Bull Creek sand (of Hell Creek Formation)

Upper Cretaceous: S. Dak.

Rothrock, E.P., 1937 (S. Dak. Geol. Survey Rept. Inv. 28, p. 10). Bull Creek sand--uniform medium-grained golden-yellow sand "designated as the Bull Creek sand in mapping." Thickness of approximately 12 feet.
Type locality: Not designated
Name: Probably from Bull Creek, Harding County, South Dakota

This name was not used subsequently in Harding County by Rothrock (1952, S. Dak. Geol. Survey Rept. Inv. 68), and has not been used in later publications of the Survey - A.F.A.

Bull Creek Sandy Limestone (of Greenhorn Limestone)

See Orman Lake.

BULLHEAD MEMBER (of Fox Hills Formation)

Upper Cretaceous: S. Dak.

Stevenson, R.E., 1956 (S. Dak. Geol. Survey, Geol. Quad., Bullhead). This member has been considered a separate stratigraphic unit since 1931 when Searight referred to these strata as the "Banded Beds," and this informal terminology was followed by R.E. Morgan and B.C. Petsch (1945, S. Dak. Geol. Survey Rept. Inv. 49) and State Geological Survey quadrangle maps in 1953 and 1954. Scattered outcrops occur on the uplands and high valley-sides in the southern half of the quadrangle. Consists of alternating thin (1 inch to 14 inches) beds of light-gray medium- to fine-grained locally cross-laminated subgraywacke sand, and thin (1 inch to 9 inches) beds of dark-gray fissile clay. Scattered throughout the member and along some bedding planes are orange-brown limonitic concretions. The Bullhead member has a variable slightly gradational contact with the underlying and overlying members, from which it is distinguished by its clay strata. The lower 25 feet of the 135-foot thick member is characterized by the fauna of the Timber Lake member. In the upper part of the member there are a few scattered layers of Ostrea glabra.

Waage, Karl, 1961 (Wyoming Geol. Association, 16th Ann. Field Conf., p. 237). Stated that the facies relationships between the Bullhead and the Colgate are a source of confusion in mapping, as lenses of Colgate-like sand occur in the lower part of the Bullhead as well as at the top, in north-central South Dakota. Thus the Colgate and the upper part of the banded beds are lateral facies.
Type locality: Syntype section in Secs. 11, 12, and 23, T. 21 N., R. 24 E., Corson County, South Dakota.
Name: From Bullhead

The Bullhead has been mapped in 11 quadrangles of northwestern South Dakota, 1954-1961 - A.F.A.

"C lignite bed" (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated "C lignite bed" as being 50 feet below the top of the Ludlow formation, 250 feet thick.

This lignite bed occurs near the middle of the Giannonatti Lignite Facies, mapped by the South Dakota Geological Survey in six quadrangles in Harding County (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

CANNONBALL FORMATION (of Fort Union Group)

Upper Cretaceous: Southwestern N. Dak., northwestern S. Dak.

Lloyd, E.R., 1914 (U. S. Geol. Survey Bull. 541, p. 248-249). The Cannonball marine member comprises the upper 250 to 300 feet of the Lance formation. It consists of 144½ feet of (descending): (1) calcareous sandstone, 6 inches; (2) gray, partly consolidated sandstone containing numerous layers cemented with iron, 10½ 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 a layer of marine shells 20 feet from base and with "cannonball" concretions, 103 feet; base concealed. Several collections of marine invertebrates have been identified by T.W. Stanton as belonging to a modified Fox Hills fauna. [Underlies Fort Union formation, and rests on 400 to 450 feet of somber-colored shale, yellow sandstone, and thin lignite beds composing lower part of Lance formation - Wilmarth, 1938.]
Lloyd, E.R. and Hares, C.J., 1915 (Jour. Geology, v. 23, p. 523-547). In a large region west of Missouri River in North Dakota and South Dakota,

the Lance formation consists of two distinct parts, a lower nonmarine part containing a flora very similar to, if not identical with, that of Fort Union, and an upper marine member containing a fauna closely resembling, but not identical with, that of Fox Hills sandstone. This upper part, on account of its peculiar fauna, has been mapped separately and named Cannonball marine member of Lance formation. Farther west, nonmarine beds bearing lignite and occupying a similar stratigraphic position have been named Ludlow lignitic member of the Lance. The Cannonball marine member has been mapped from Mandan, North Dakota, to a point 4 miles west of Haley, North Dakota, a total distance of about 130 miles. The presence of brackish-water fossils, Ostrea glabra, near Yale on the Little Missouri River in Billings County, North Dakota, shows that the sea probably extended some distance farther west than its sediments have been mapped. The extent of this member east of the Missouri River is unknown. Cannonball member becomes gradually thinner to the west, and the sea in which it was deposited perhaps did not extend as far west as Montana line; the oyster beds near Yale, Billings County, may represent western limit of Cannonball sea. This sea presumably advanced into western North Dakota and South Dakota from east or northeast, and by inference the Cannonball member continued with undiminished or with increased thickness to the north and northeast, but the region is too deeply drift-covered to prove this. The Cannonball is contemporaneous with the Ludlow lignitic member and overlies 400 to 525 feet of somber-colored shale, yellow sandstone, and thin lignite beds composing the lower (nonmarine) member of the Lance. It consists chiefly of dark, sandy shale or shaly sandstone with a subordinate amount of dark-yellow and gray sandstone and some thin limestones. All the strata are lenticular and individual beds can be followed for only a short distance. (Gives detailed sections, in some of which beds belonging to Cannonball marine member are shown as overlying Ludlow lignitic member, and in others as grading laterally into the Ludlow.) A peculiar feature of both the Fox Hills sandstone and Cannonball member of Lance is the abundance of round concretions commonly known as "cannonballs," formed by cementation of the sandy shale by calcium carbonate. No definite line could be drawn between Cannonball marine member and lower part of Lance, it being impossible to tell where nonmarine beds stop and marine beds begin. [Lower part of Lance was later named Hell Creek member - Wilmarth, 1938.]

Dorf, E., 1940 (Geol. Soc. America Bull., v. 51, p. 213-236). The paleobotanical evidence supports the known vertebrate evidence in placing the boundary between the true Lance and the Fort Union at the base of the nondinosaur-bearing Tullock, Ludlow, or Bear formations or their equivalents--in other words, at the top of the Triceratops-bearing Hell Creek or Lance formations as originally defined. Such a view is not contradicted by the marine invertebrates of the Cannonball bed--which interfingers with the Ludlow.

Type locality: Along Cannonball River in Twps. 132 and 133 N., R. 8 W., Morton County, North Dakota
Name: From Cannonball River

The U. S. Geological Survey considered the Ludlow as Upper Cretaceous (Wilmarth, 1938) until N.M. Denson, et al, 1955 (U. S. Geol. Survey Map C-33) classified it, the Cannonball, and the Tongue River, all members of the Fort Union formation, as Paleocene in age - A.F.A.

To the east in South Dakota the Cannonball marine facies replaces the upper and middle parts of the Ludlow continental facies, as is shown by 10 geologic quadrangle maps of the South Dakota Geological Survey, 1954-1957 - A.F.A.

CANYON SPRINGS SANDSTONE MEMBER (of Sundance Formation)

Upper Jurassic: Wyo., S. Dak.

Imlay, R.M., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 247-251). The Canyon Springs sandstone member of the Sundance formation comprises a basal marine sandstone locally including some red to gray shale, and attaining 30 to 45 feet in thickness. The type section consists of about 26 feet of soft fine-grained calcareous fossiliferous white sandstone that is well exposed on the south slope of the butte. It is recognizable as a member only along the south and west margins of the Black Hills. The age is earliest Late Jurassic.

Young, R.C. and Waterman, J.L., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 60). Stated that the Canyon Springs is absent north of the Black Hills, but is present in the southern Black Hills (fig. 1). To the north, its place is taken by the overlying Stockade Beaver shale. Thus it is correlative with the base of the Rierdon of North Dakota and eastern Montana.

Type locality: A conical butte about 4 miles west of Horton, Wyoming, a quarter of a mile north of the road from Horton to Upton, near the center of Sec. 23, T. 48 N., R. 62 W., Wyoming
Name: From Canyon Springs Prairie immediately east of the type locality

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic formations (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Springs), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

CARLILE SHALE (of Colorado Group)

Upper Cretaceous: Eastern Colo. and Wyo., northeastern N. Mex., Nebr., S. Dak., Kans., southeastern Mont., N. Dak.

Gilbert, G.K., 1896 (U. S. Geol. Survey 17th Ann. Rept., pt. 2, p. 565). Chiefly medium-gray shale; at top a thin purplish limestone or a thicker yellow sandstone. Thickness in Arkansas Valley region, eastern Colorado, 175-200 feet. Top formation of Benton group. Underlies Timpas limestone [in South Dakota, the Niobrara - A.F.A.] and overlies Greenhorn limestone.

[The Niobrara and Benton are not now treated as groups, the broader term Colorado group, which includes them both, being considered the more useful name. Where the Niobrara and Benton deposits are not subdivided they are called Niobrara limestone and Benton shale, respectively - Wilmarth, 1938.]

Cobban, W.A., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2187-2190). Described the Carlile in the northern Black Hills as consisting of a basal unnamed dark-gray shale, 75-155 feet thick, a medial gray sandy member (Turner), 185-260 feet thick, and an upper dark-gray shale (Sage Breaks), 195-305 feet thick.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 77). The formation varies in thickness from 370 to 440 feet in western South Dakota, which is somewhat thicker than it appears in Wyoming, Colorado, or Kansas. The formation underlies almost the entire States of North and South Dakota, but is apparently much thinner on the eastern side of the Dakota Basin. The lower half of the formation consists of dark-gray fissile shale and very finely interbedded shale and glauconitic siltstone, with some thin sandstone streaks and large limestone concretions. In the upper half as many as three definite but thin sandstones are present. On the Wyoming side of the Black Hills these have been loosely called the Frontier or Wall Creek sands, or more recently, the Turner sandstone zone. A sandstone near the top of the formation in south-central South Dakota, at the site of the Fort Randall dam, has been correlated with the Codell sandstone of Kansas.

Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87-88). Described the three members of the Carlile shale in the Powder River Basin of Wyoming as: lower shale, 60-125 feet thick, light- to dark-gray, partly silty or sandy and partly calcareous, with a bentonite and a zone of dark-gray fossiliferous limestone concretions in the middle; Turner, 150-170 feet thick, fine- to medium-grained sandstone, gray shale, and many yellow sandy calcareous concretions (eastern extension of the Wall Creek sandstone); Sage Breaks, 200-300 feet thick, dark-gray fissile shale with several zones of yellow calcareous concretions. Fossils are Turonian in age.

Knechtel, M.M. and Patterson, S.H., 1962 (U. S. Geol. Survey Bull. 1082-M, p. 920-925). Described the Carlile in the northern Black Hills as

consisting of three members, in descending order:

Sage Breaks Shale Member--dark-gray noncalcareous shale with many limestone concretions. Six miles north of Belle Fourche it is 195 feet thick, whereas 20 miles farther west it is 300.

Turner Sandy Member--dark shale with many limestone concretions and lenses of light-gray sandstone and sandy shale. Six miles north of Belle Fourche it is 260 feet thick, whereas 20 miles farther west it is only 210, caused by pinching out of some of the lower beds.

Pool Creek Shale Member--made up of (1) an upper unit of 81 feet of black-gray shale that contains in the lower part two bentonite layers, and in the upper 37 feet numerous clay-ironstone concretions; and (2) a lower unit of 13 feet of dark-gray soft papery shale, with a layer of large limestone concretions at its top.

Hattin, D.E., 1962 (Kans. Geol. Survey Bull. 156, p. 18-23). Discussed the Carlile Shale classification in Kansas, and its distribution in South Dakota. He proposed that the Kansas nomenclature be:

Carlile Subgroup
- Blue Hill Shale Formation (above)
  - Unnamed shale member
  - Codell Sandstone member
  - Saline Valley Shale member
- Fairport Chalk Formation

but the Kansas Geological Survey has not accepted that classification. Rather, it refers to the rocks as:

Carlile Shale Formation
- Codell Sandstone Member
- Blue Hill Shale Member
- Fairport Chalk Member

The Nebraska Geological Survey uses the latter nomenclature, finding the thicknesses to be 5-10 feet for the Codell, 80 (east) to 500 (northwest) for the Blue Hill, and 60-80 for the Fairport.

Type locality: Not designated

Name: From Carlile Spring and Carlile Station, 21 miles west of Pueblo, Colorado

In southern and eastern South Dakota the Codell Sandstone Member of the Carlile Shale has been recognized since 1952 (R.C. Barkley, S. Dak. Geol. Survey Rept. Inv. 71, p. 8), but the name Blue Hill has not been applied. One reason is that the calcareous Fairport Chalk Facies at the base of the Carlile has not been recognized in South Dakota. Also, the fact that 15-20 feet of Carlile Shale overlies the Codell in much of eastern South Dakota has caused the South Dakota Geological Survey to refrain from using the name Blue Hill for the shale below the Codell; rather, both lower and upper shales have been referred to as Carlile. This corroborates Hattin's observation (p. 20) in Kansas, where dark-gray noncalcareous clayey shale a few feet thick lies between the Codell Sandstone Member and the Niobrara Chalk - A.F.A.

Cassa Formation

Permian: Wyo., Colo., western S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 4, 19, 45). Comprises upper 180 feet of Division 1. (See Condra and Reed, 1935, Nebr. Geol. Survey Paper 9.) Hartville "formation" is overlain by Broom Creek group; thickness 175 to 328 feet. The Cassa group is very persistent but marked by facies changes. Its basal sand and the thin limestone next above extend from the Owl Canyon section of Colorado to the Hot Springs section of South Dakota. The Cassa group grades northward and northwestward into a sandstone facies, i.e., into the Tensleep sandstone which is of Permian age.

Reed, E.C., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 46). It is believed that the Cassa group should be restricted to the upper 70 feet of the unit originally classified as Cassa. This upper part consists of dominantly sandstone with some interbedded red shale. The lower 110 feet of the Cassa group of Condra, Reed, and Scherer should be included with the underlying Broom Creek group, thus expanding the thickness of the Broom Creek group in the Hartville area from about 70 to about 180 feet. Thus the more indurated beds formerly placed in the lower Cassa are included with very similar lithologies in the Broom Creek group. It is further concluded that this group is Permian and not Pennsylvanian in age.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that the Cassa Group of sandstone and shale is present in western South Dakota. Rests on Broom Creek group, and is overlain by Opeche shale. Includes "Converse sands."

Type locality: Buckshot Canyon (also called Ragan Canyon), T. 29 N., R. 67 W., 3 miles northeast of Cassa, Platte County, Wyoming

Name: From Cassa

Ceratops beds

Upper Cretaceous

A paleontologic term applied in early reports to the Lance Formation.

CHADRON FORMATION (of White River Group)

Lower Oligocene: Western Nebr. and S. Dak., eastern Wyo., northeastern Colo.

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 736, 759, pl. 82). A thin sheet of light-greenish sandy clay, underlying Brule clay and forming basal member of White River group. Formerly

called "Titanotherium beds." Rests unconformably on Pierre shale. Thickness 30-60 feet in outcrops along foot of Pine Ridge, but thickens considerably in vicinity of Adelia [Nebraska - A.F.A.], where some masses of dark-gray and buff sandstone of coarse texture are included. Appears not to extend far east in southern Nebraska, and is absent along Republican River. Underlies part of Colorado and South Dakota. Is lower formation of White River group.

Clark, John, 1937 (Carnegie Museum Annals, v. 25, p. 261-350). Divided the Chadron into three unnamed members based on local lithology.

Clark, John, 1954 (Carnegie Museum Annals, v. 33, p. 179-198). Proposed formal geographic names for these subdivisions, namely Peanut Peak (upper) member, Crazy Johnson member, and Ahearn member.

Type locality: Type section of Titanotherium beds is Bear Creek, Sec. 34, T. 2 S., R. 13 E., Pennington County, South Dakota

Name: From Chadron, Nebraska

The South Dakota Geological Survey has not used these names in mapping the Chadron in approximately 15 geologic quadrangles, 100 miles farther east, in south-central South Dakota. There the Chadron is mainly light-greenish and olive-gray silty, very bentonitic clay that contains near the base a poorly cemented white quartz conglomerate and sand. The Chadron weathers into rounded humps, and is 20-40 feet thick. (A.F. Agnew, 1957, S. Dak. Geol. Survey, Geol. Quad., White River.) - A.F.A.

CHARLES FORMATION (of Madison Group)

Mississippian: Mont., N. Dak., S. Dak.

Seager, O.A., et al, 1942 (Am. Assoc. Petroleum Geologists Bull., v. 26, p. 1420). Thickness 810 feet. Brown shale, salt, anhydrite, and earthy limestone. Represents post-Madison, pre-Kibbey sedimentation. Placed in Big Snowy group. Now believed to be an upper formation in the Madison group and not a part of the Big Snowy group as originally proposed.

Perry, E.S. and Sloss, L.L., 1943 (Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1287-1304). Described the Big Snowy group of the northern Great Plains, and showed (figs. 4, 5, 7) that only the lower formation, or Charles, is present to any extent in South Dakota, as the overlying Kibbey and Otter pinch out just within the State (fig. 7). (The Heath at the top is present farther north, in Montana and North Dakota.) The Charles is 600 feet thick in State Royalty #1 State oil test in northwestern South Dakota, but is absent in the Black Hills.

Sloss, L.L., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 67). Dolomitic and brecciated zones high in the Pahasapa section of the Black Hills are probably Charles equivalents. Thickness 50-600 feet.

Andrichuk, J.M., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2170-2210). Meramec in age. Andrichuk mapped the Charles equivalent as his upper unit of the Madison, plus the upper (second) evaporite zone of his middle unit. In South Dakota he recognized it as being present north of the middle Black Hills, reaching a thickness greater than 300 feet at the North Dakota border.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 61). Characterized the Charles as consisting of cyclically interbedded limestone, dolomite, anhydrite or salt, and shale; the carbonate rocks are less fragmental than those in the Mission Canyon below.

Type locality: (Subsurface) Between depths of 3,200 and 3,800 feet in Argo-California #4 Charles oil test in Sec. 12, T. 15 N., R. 30 E., Garfield County, Montana (Andrichuk, 1955)

Name: From Charles lease

CHILSON MEMBER (of Lakota Formation)

Lower Cretaceous: Southern Black Hills, S. Dak.

Post, E.V. and Bell, Henry, 1961 (U. S. Geol. Survey Prof. Paper 424-D, p. 173-178). Recognized that the overlying Fuson Shale could be distinguished from the lower (mainly sandstone) part of Karl Waage's (1959, U. S. Geol. Survey Bull. 1081-B, p. 26-33) Lakota Formation, whether the intervening Minnewaste Limestone was present or not. To the lower unit of the Lakota Formation they gave the name Chilson. The Chilson is composed of two conspicuous fluvial sandstone bodies, each of which fingers laterally into flood-plain, lacustrine, or paludal facies. The lower body ranges from 0 to 400 feet thick; the upper body ranges from 0 to 437 feet. The Chilson rests on either the Morrison Shale or the Unkpapa Sandstone.

Type locality: Three localities: Sec. 32, T. 8 S., R. 4 E.; Sec. 33, T. 8 S., R. 5 E.; Sec. 29, T. 7 S., R. 3 E., Fall River County, South Dakota.

Name: From Chilson Canyon

Cimarronian series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Spearfish in South Dakota.

CLAY SPUR BENTONITE BED (of Mowry Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., western S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165, p. 4). Clay spur bentonite bed, 1 to 4 feet thick, lies at top of Mowry siliceous shale member of Graneros shale, over entire area discussed.

Wing, M.E., 1940 (S. Dak. Geol. Survey Rept. Inv. 35, p. 4). The principal bed of bentonite northwest of Belle Fourche is reported by some as occurring just above, and by others as 8 feet above the Mowry. In much of the district near Belle Fourche, gray-white siliceous shale containing fish scales extends to 2 or 3 feet above the thick bed of bentonite. The lowermost oligonite concretions occur at least 3 feet above the thick bed of bentonite. Consequently it is believed that this bed of bentonite, from which production in the Belle Fourche region comes, lies in the top of the Mowry.

Cobban, W.A., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2179). Described the Mowry of the northern Black Hills, and noted that the Clay Spur bentonite bed occurs at its top.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 76). Thin bentonites characterize the Mowry formation. One, known as the Clay Spur bed, lies at the top of the Mowry and reaches a thickness of 3 to 4 feet over wide areas in South Dakota and Montana and Wyoming.

Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 86). Stated, however, that along the western side of the Black Hills the top of the Mowry occurs 20-30 feet below the base of the Clay Spur bentonite, which is underlain as well as overlain by Belle Fourche-type shale.

In contrast, M.M. Knechtel and S.H. Patterson, 1962 (U. S. Geol. Survey Bull. 1082-M, p. 911) stated that the Clay Spur Bentonite Bed marking the top of the Mowry Shale is overlain by a few feet of typical Mowry siliceous shale.

Type locality: Sec. 30, T. 47 N., R. 63 W., Weston County, Wyoming

Name: From exposure near Clay Spur, Wyoming

CODELL SANDSTONE MEMBER (of Carlile Shale)

Upper Cretaceous: Western Kans., eastern Colo., S. Dak., Nebr., northeastern N. Mex.

Bass, N.W., 1926 (Kans. Geol. Survey Bull. 11, p. 28, 64). Codell sandstone bed--sandy zone forming topmost 20 to 25 feet of Blue Hill shale member of Carlile shale in western Kansas.

Mather, K.F., Gilluly, James, and Lusk, R.G., 1928 (U. S. Geol. Survey Bull. 796-B, p. 81). Applied Codell sandstone member to topmost 3 to 20 feet of Benton shale in eastern Larimer County, Colorado, or to sandstone called "Niobenton sand" by drillers.

Dane, C.H. and Pierce, W.G., 1933 (U. S. Geol. Survey Press Notice, June 8). Elevated Codell sandstone to rank of a member at top of Carlile shale and restricted Blue Hill shale member to underlying part of the Blue Hill shale of previous reports.

Hattin, D.E., 1962 (Kans. Geol. Survey Bull. 156, p. 18-23). Wanted to place the Codell as a member of the Blue Hill Shale Formation; previously both, together with the underlying Fairport Chalk, had been classed as the three members of the Carlile Shale in Kansas. His reasons included the fact that the Blue Hill Shale and Codell Sandstone were transitional, and also because a thin shale overlies the Codell in places. [This is similar to the situation in southern and eastern South Dakota, where the South Dakota Geological Survey has recognized the Codell Sandstone Member of the Carlile Shale (R.C. Barkley, 1952, S. Dak. Geol. Survey Rept. Inv. 71, p. 8). Because the Blue Hill and Fairport lithologies have not been distinguished in South Dakota, those names have not been used. The Codell is probably the equivalent of the Turner Sandy Member in the Black Hills area - A.F.A.]

Type locality: 5 miles south and a little west of Codell, Ellis County, Kansas

Name: From Codell

COLGATE SANDSTONE MEMBER (of Fox Hills Formation)

Upper Cretaceous: Eastern Mont., southwestern N. Dak., northern S. Dak.

Calvert, W.R., 1912 (U. S. Geol. Survey Bull. 471, p. 189-198). Colgate sandstone member of Lance formation--white and yellowish sandstone, 185 feet thick, forming basal member of Lance formation as here interpreted. Exposed on both sides of Cedar Creek anticline, Dawson County, Montana. In vicinity of Iron Bluff, in northeast part of T. 14 N., R. 55 E., it consists of following beds (descending): (1) massive white sandstone, most prominent stratum in region, 35 feet; (2) brown sandstone, 75 feet; fossil leaves in bottom part; forms summit of Iron Bluff, Montana; (3) shale and sandstone, 75 feet, fossil leaves in upper 20 feet. Overlies Pierre shale and underlies, with only local unconformity, 500± feet of somber-colored clay and lenticular sandstones containing a few lignite beds which compose upper part of Lance. Although in Iron Bluff section there is an appearance of transition between Colgate sandstone and Pierre shale, which suggests the sandstone occupies the stratigraphic position of the Fox Hills, the evidence of fossil leaves indicates that much if not all of it is of later age. Lower part may be Fox Hills, but if flora collected 70 feet above base is found to continue to base of Colgate, then it should be considered merely as a member of the Lance formation.

Thom, W.T., Jr. and Dobbin, C.E., 1924 (Geol. Soc. America Bull., v. 35, p. 484-497). Colgate sandstone member is here redefined and name is applied to the conspicuous white upper sandstone of the Fox Hills, typically developed between Colgate Station and Glendive, Montana, and extensively exposed along Cedar Creek anticline and elsewhere in

eastern Montana. The 35-foot white sandstone is the upper (Colgate) member of the Fox Hills and forms top part of the lower 75-foot sandstone of Iron Bluff, its white color being masked in the Iron Bluff exposure by ferruginous matter leached from the overlying brown sandstone of the Lance. In addition to fossil leaves the Colgate sandstone as here defined contains abundant casts of Halymenites major in exposure along Cedar Creek anticline and is gradational into underlying marine strata on Little Beaver Creek, south of Baker. The Colgate is strikingly developed along the Missouri between Hell Creek and Musselshell River, consisting of 15 to 50 feet of white sandstone resembling its type development. That the fluviatile basal sandstone of Lance in central Montana is the equivalent of the Colgate sandstone and upper white sandstone of type Fox Hills the writers feel confident, although this has not been conclusively demonstrated by continuous tracing.

Hares, C.J., 1928 (U. S. Geol. Survey Bull. 775). Identified 17 to 40 feet of Colgate sandstone member in top of Fox Hills sandstone of Marmarth lignite field, North Dakota.

Waage, Karl, 1961 (Wyo. Geol. Association, 16th Ann. Field Conf., p. 237). Stated that the facies relationships between the Bullhead and the Colgate are a source of confusion in mapping, as lenses of Colgate-like sand occur in the lower part of the Bullhead, as well as at the top, in north-central South Dakota. Thus the Colgate and the upper part of the banded beds are lateral facies.

Type locality: Between Colgate Station and Glendive, Montana

Name: From Colgate Station

The Colgate Member has been mapped in 12 quadrangles of northwestern South Dakota, 1954-1961 - A.F.A.

Coloradan series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include his Woodbury (below), Crill, Hawarden, and Niobrara [equal to Graneros, Greenhorn, Carlile, and Niobrara - A.F.A.] in South Dakota; thus used in the same sense as Colorado Group, which see.

Colorado Group

Upper Cretaceous: Colo., Wyo., Mont., Idaho, N. Dak., S. Dak., northeastern N. Mex., Nebr., Iowa

Hayden, F.V., 1876 (U. S. Geol. and Geog. Survey Terr. 8th Ann. Rept., p. 45). Numbers 2, 3 and 4 of the Cretaceous (the Fort Benton, Niobrara, and Fort Pierre divisions) may be regarded as one group, under the name of Colorado group as adopted by Clarence King, 1876

(U. S. Geol. Expl. 40th Par., 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. Survey Terr. 10th Ann. Rept., p. 21, 22, 30). While adopting the name Colorado group, White, for paleontological reasons chiefly, so restricted its application as to include only what he understood to be equivalent with numbers 2 (Fort Benton) and 3 (Niobrara) of Meek and Hayden's original section, leaving the equivalent of number 4 (or Fort Pierre group) to be included with the strata of Fox Hills group, instead of with Colorado Group, as King had done. [Meek, who studied the paleontology of these groups so carefully, has shown in his works that while the paleontological affinities between the Fort Benton the Niobrara groups, and the Fort Pierre and Fox Hills groups, respectively, are very close, they are comparatively very slight between the two former and the two latter groups, respectively. The generally accepted definition of Colorado group includes only Benton and Niobrara and their equivalents - Wilmarth, 1938.]

Cobban, W.A. and Reeside, J.B., Jr., 1952 (Geol. Soc. America Bull., v. 63, pl. 1). Redefined the base of the Colorado group as the contact between the Mowry and the Belle Fourche shales.

Rothrock, E.P., 1934 (S. Dak. Geol. Survey Rept. Inv. 20, fig. opp. p. 18). Used the terms Colorado group and Montana group for bedrock penetrated below the glacial drift and above the Precambrian granite in Grant County of northeastern South Dakota.

Type locality: Not designated

Name: For exposures at eastern base of Colorado Range or Front Range, Colorado

The South Dakota Geological Survey does not use the name Colorado Group, but rather uses the names of the individual formations and members - A.F.A.

Comanchan series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Lakota, Minnewaste, and Fuson in South Dakota.

"Converse sand" (of Minnelusa Formation)

Pennsylvanian: S. Dak. (Black Hills), Wyo.

A driller's term used to designate as many as three sands near the top of the Minnelusa Formation, in eastern Wyoming and near the Black Hills in South Dakota.

Rothrock, E.P., 1949 (S. Dak. Geol. Survey Rept. Inv. 62, p. 30). The thickest section of the Converse sand [in the southern Black Hills] appeared in the Hollingworth #1 Childers oil test where about 18 feet was measured. In the Black Hills Ordnance #3 water well, only about half that amount was encountered.

Bates, R.L., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1995). Stated that the Converse sands are at the top of the Minnelusa formation in the Lance Creek oil field of eastern Wyoming, and R.A. Agatston (1954, Am. Assoc. Petroleum Geologists Bull., v. 38, p. 534) placed them in the Cassa group.

Type locality: Not designated

Name: Apparently first used in print by G.W. Krampert (1940, Kans. Geol. Society Gdbk., 14th Ann. Field Conf., p. 152), in the Lance Creek oil field, Wyoming

Crazy Johnson Member (of Chadron Formation)

Oligocene: S. Dak.

Clark, John, 1954 (Carnegie Museum Annals, v. 33, art. 11, p. 197-198). A name proposed by Clark for the Middle Chadron. There are no inherited red sediments in the middle member, as the occasional red beds, unlike those below, are diagenetic. In general, the beds are gray-green silts, clays and channel sandstones. Only 20 miles in extent (John Clark, 1937, Carnegie Museum Annals, v. 25, p. 287).

Type locality: Butte in southern part of Sec. 10, T. 4 S., R. 12 E., Pennington County, South Dakota

Name: From Crazy Johnson Butte (also called Peanut Peak)

Crill Limestone

Upper Cretaceous: Northwestern Iowa, southeastern S. Dak.

Keyes, C.R., 1912 (Iowa Acad. Science Proc., v. 19, p. 148, 150). Crill chalks and limestones, 100 feet thick, underlie Hawarden shale and overlie Woodbury shale.

Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Crill terrane in South Dakota, 50 feet of limestones, resting on Woodbury terrane, and underlying Hawarden terrane.

Type locality: Not designated

Name: From Crill mill, on Sioux River, above Sioux City, Iowa

This is the Greenhorn Limestone of the South Dakota Geological Survey's classification. It probably is the equivalent of divisions "A" and "B" of Nicollet's Dixon's Group in Nebraska, 12 miles above Sioux City - A.F.A.

CROW CREEK MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 5, 14-17). The basal sand and associated chalky beds of the Sully member have previously been correlated with the Gregory chalk of the Rosebud Bridge section. There are actually two calcareous zones in this Gregory County section, and the Sully marl is correlated with the upper one rather than with the lower, or Gregory chalk. Since the name Gregory does not apply, the sand and marl at the base of the Sully member is here called the Crow Creek zone.

Crandell, D.R., 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 2345). The Crow Creek is raised from zone to member of the Pierre shale, along with the overlying DeGrey member and the Verendrye member, thus abandoning the term Sully member.

Stevenson, R.E., 1951 (Geol. Soc. America Bull., v. 62, p. 1542). Noted that the Crow Creek marl facies of the Sully member shows its greatest stratigraphic variation in Charles Mix and Gregory Counties, South Dakota, where it is thicker and is separated locally by the Gregory clay into two marls. It is a marl and chalky marl with scattered quartz grains; locally the base is a sandy marl. The Crow Creek contains a Gumbelina-Globigerina microfauna.

Crandell, D.R., 1952 (Am. Assoc. Petroleum Geologists Bull., v. 36, p. 1754-1765). The Crow Creek member of the Pierre shale consists of a basal siltstone 10-15 inches thick, and an overlying marl 7-10 feet thick. Because of the presence of Foraminifera, it seems certain the Crow Creek member is wholly of marine origin.

Type locality: At and south of the mouth of Crow Creek, southwestern Buffalo County, South Dakota

Name: From Crow Creek

Recent unpublished stratigraphic work by L.G. Schultz of the U. S. Geological Survey (summer, 1963) indicates that there is an upper marl zone (in the Oacoma Facies of the DeGrey) in Gregory County and to the east, which has been erroneously called Crow Creek in the past. The true Crow Creek, he finds, is the lower marl in these areas, and lies below the Oacoma Facies and rests on a very thin Gregory Member which in turn rests on the Sharon Springs. The true Crow Creek is recognized by, among other factors, the presence of a quartz sand zone at its base; the upper marl zone does not possess this sand - A.F.A.

"D lignite bed" (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated "D lignite bed" as being 10 feet below the top of the Ludlow formation, 250 feet thick.

This lignite bed occurs at the top of the Giannonatti Lignite Facies, mapped by the South Dakota Geological Survey in six quadrangles in Harding County (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

"D" sand (of Mowry Shale)

Lower Cretaceous: Southeastern Wyo., western Nebr., northeastern Colo., southwestern S. Dak.

An informal term for the highest of a series of oil sands that are productive in the Denver Basin. Equivalent to part of the Mowry, which see.

DAKOTA GROUP

Upper Cretaceous: N. Dak., S. Dak., southeastern Mont. (?), eastern Wyo. (?), eastern Colo., Nebr., Kans., northeastern N. Mex., northwestern Okla.

Meek, F.B. and Hayden, F.V., 1861 (Phila. Acad. Nat. Science Proc., v. 13, p. 419, 420). Dakota group (Formation No. 1 of Cretaceous)--Yellowish, reddish and occasionally white sandstone, locally with alternations of varicolored clays and lignite beds. Thickness 400 feet. Occurs in hills back of town of Dakota, and extensively developed in Dakota County (Nebr.) below mouth of Big Sioux River, thence south into northeastern Kansas and beyond. Underlies Fort Benton group, of which it may probably be only a member. In the Black Hills the Dakota group of Meek and Hayden included the "beds of transition, or passage" [Morrison shale - A.F.A.] at the base, according to Karl Waage (1959, U. S. Geol. Survey Bull. 1081-B, p. 19).

Newton, Henry and Jenney, W.P., 1880 (U. S. Geog. and Geol. Survey Rocky Mt. Region, p. 151-180). Included in their Dakota group only the equivalents of the Lakota, Fuson, and Fall River.

Jenney, W.P., 1899, 1901 (U. S. Geol. Survey 19th Ann. Rept., pt. 2-3, p. 568-593). Restricted the term Dakota to the upper sandstone of the former Dakota group, in the northern Black Hills, and N.H. Darton, 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 489-599) used the term similarly in the southern Black Hills, for the unit which Russell (1927) renamed Fall River. This unit contains Late Cretaceous fossils, whereas the underlying rocks contain Early Cretaceous fossils.

Russell, W.L., 1927 (Am. Jour. Science, 5th ser., v. 14, p. 402). Has shown elsewhere (S. Dak. Geol. and Nat. Hist. Survey Bull. 14*, 1927, in press) that so-called Dakota sandstone of Black Hills region is in reality older than true Dakota, and it will be called Fall River formation in this paper. Overlies Fuson formation and underlies Graneros shale.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 5). Fall River sandstone is so-called Dakota sandstone of previous reports on Black

* never published

Hills region. It is top formation of Inyan Kara group, of Early Cretaceous age. Conformably underlies Graneros shale and overlies Fuson formation. Continental except upper 20 feet, which contains marine fossils.

[For many years the Dakota had been considered as an Upper Cretaceous unit; in fact, the reason that Russell (1927, 1928) applied the name Fall River in the Black Hills to what had been formerly called Dakota there, was the finding of Early Cretaceous fossils in it. However, A.C. Tester (1931, Iowa Geol. Survey, v. 35, p. 200-332) assigned the Dakota of the type area to the Early Cretaceous on the basis of both megafossils and microfossils - A.F.A.]

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 446-449). Did not use the term Dakota in the Black Hills, but applied the term Dakota group to the thick sandstone sequence in central South Dakota, where he called it the "true Dakota," and where it overlies the Skull Creek shale. He pointed out that the "true Dakota" is the age equivalent of the Newcastle-Mowry interval, and that what is called Dakota in the Williston Basin to the north is actually the Fall River sandstone (fig. 6). Gries further supported this view in 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., fig. 5 on p. 169), but he reduced the Dakota to formation and showed that it is traceable into the Newcastle of the Black Hills.

In 1955 Karl Waage (U. S. Geol. Survey Prof. Paper 274-B, p. 19) applied the term Dakota group to the sandstone and shale sequence in the northern Front Range of Colorado, which correlated with strata including the Lakota (below) and Newcastle (above).

In 1955 Waage (U. S. Geol. Survey Bull. 1081-B, p. 24) pointed out that the Lakota, Fuson, and Fall River of the Inyan Kara group of the southern Black Hills were unmappable separately in the northwestern Black Hills. Further, he noted that geologists had distinguished the Skull Creek shale (A.J. Collier, 1922, U. S. Geol. Survey Bull. 736-D, p. 71-110) and Newcastle sandstone (E.T. Hancock, 1920, U. S. Geol. Survey Bull. 716-C, p. 35-53) as members of the overlying Graneros formation. Both the Skull Creek and the Newcastle were raised to formation rank by J.B. Reeside in 1944 (U. S. Geol. Survey Oil and Gas Invest. Prelim. Map 10).

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 94-95). Used the term Dakota Group in the Williston Basin to include only what the Inyan Kara Group comprises in the Black Hills--that is, Lakota and Fall River.

Type locality: Not designated

Name: From Dakota County, Nebraska

The South Dakota Geological Survey uses a dual nomenclature for the State, as follows:

Black Hills

Inyan Kara Group < "Newcastle" Sandstone
Skull Creek Shale
Fall River Formation
Lakota Formation

Central South Dakota

Dakota Group, undifferentiated < "Newcastle" sand, Skull Creek Shale > where recognizable
"Dakota sands and shales"

The Central South Dakota nomenclature is more applicable to the Williston Basin, as the Fall River-Lakota relationships are not clear cut. Preliminary correlations from samples and electric logs in two holes drilled recently by the South Dakota Geological Survey in southeastern South Dakota, 40 to 60 miles northwest of the type area of the Dakota, show a threefold subdivision of the Dakota which is very similar to that recognized by C.R. Keyes (1912, Iowa Acad. Science Proc., v. 19, p. 148, 150), as follows:

Dakotan series	Ponca	sandstones	75 feet
	Sergeant	shales	60 feet
	Nishnabotna	sandstones	300 feet

These units seem to differ in thickness from those of G.E. Condra and E.C. Reed, 1959 (Neb. Geol. Survey Bull. 14A, p. 18-19), described in Dakota County, Nebraska, only 7 miles south of the type area:

Dakota group	Omadi sandstone formation	147 feet
	Fuson shale (subsurface)	75 feet
	Lakota sandstone (subsurface)	170 feet

The stratigraphic relations of the type area of the Dakota, as well as the tracing of the Dakota to central South Dakota need to be studied further - A.F.A.

"Dakota silt"

Lower Cretaceous: Williston Basin, Powder River Basin

Informal term applied in the subsurface to the uppermost, silty part of the Fall River Formation. G.R. Wulf, 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1379) noted that "Dakota silt" should be

abandoned because the term Dakota had been used in a different sense previously.

Dakotan series or sandstone

A term introduced by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include his Nishnabotna, Sergeant, and Ponca in South Dakota.

DEADWOOD FORMATION

Upper Cambrian: S. Dak. (Black Hills), eastern Wyo., southeastern Mont.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 505). Deadwood formation--red-brown quartzite and sandstone, locally conglomeratic and partly massive. Thickness 4 to 150 feet in Black Hills. Upper part is thinner-bedded softer sandstone, in some cases interbedded with more or less shale. Basal member is usually hard massive reddish-brown quartzite; portions of basal beds are conglomeratic, ranging from a sprinkling of quartz pebbles in the sandstone, to a very coarse heavy conglomerate of large rounded masses of crystalline rocks and vein quartz in a red-brown matrix. Rests unconformably on PreCambrian granites and schists and underlies Englewood limestone (Mississippian). In northern Black Hills separated from the Englewood limestone by a mass of buff limestone of Silurian age [actually, the Whitewood limestone of pre-Richmond Late Ordovician age - A.F.A.].

Furnish, W.M., Barragy, E.J., and Miller, A.K., 1936 (Am. Assoc. Petroleum Geologists Bull., v. 20, p. 1329-1341). Reported poorly preserved Middle (?) Ordovician fossils in upper 70 feet of Deadwood formation at type section, and recommended transfer of these beds from Deadwood formation to overlying Whitewood limestone (which is classified by U. S. Geological Survey as upper Ordovician). These 70 feet consist of (descending): (1) transition, 10 feet; (2) siltstone member, 20 feet, numerous fossils; (3) shale member, 40 feet, few fossils. They rest on a sandstone, called "Scolithus sandstone," 15 feet thick, which has not yielded fossils. Concluded that it seems advisable for the present at least to include all Ordovician beds above Scolithus sandstone in Whitewood formation.

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 45-47). Changed Scolithus sandstone to Aladdin sandstone and took it out of the Deadwood formation. (See Aladdin sandstone.) Thickness of revised Deadwood, 350± feet.

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35, p. 49). Disagreed with McCoy's correlation of the Aladdin with the lower sand member of the Winnipeg formation. He also pointed out that the Deadwood, which ranges up to 650 feet thick in South Dakota, can be divided into several lithologic units (figs. 9, 10).

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 23-27). Discussed the Deadwood and showed (fig. 7) that in South Dakota it increases northwestward to about 700 feet thick. The Deadwood has basal grayish-red conglomeratic quartzitic sandstone. The 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. The Deadwood is Late Cambrian in age.

Type locality: Along Whitewood Creek, Deadwood, Lawrence County, South Dakota

Name: From Deadwood

Decorah Shale

Middle Ordovician (Trenton and late Black River): Southeastern Wis., southern Minn., Iowa, western Ill., Mo., southeastern S. Dak. (?)

Calvin, S., 1906 (Iowa Geol. Survey, v. 16, p. 60, 84). Very calcareous green shale with numerous bands and nodules of limestone, 25 to 30 feet thick, forming top shaly member of Platteville stage. Overlies Platteville limestone (lower formation of Platteville stage) and underlies Galena limestone. Within city of Decorah (Winneshiek County, northeastern Iowa) and vicinity is very calcareous.

[Adopted by U. S. Geological Survey in 1910 as a distinct formation overlying Platteville limestone restricted, and underlying Galena dolomite. It was understood to have been included in Platteville limestone as originally defined, and that it was the "green shales" of early Minnesota reports. Fauna considered by E.O. Ulrich (1923) to be of late Black River age - Wilmarth, 1938.]

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2, p. 21, 26, 30, 46). Borings reported to have encountered Black River (Decorah-Platteville) varying in thickness from 50 to 90 feet.

Type locality: Not designated

Name: From city of Decorah, Winneshiek County, Iowa

Name may be applicable in the southeastern corner of the State; elsewhere in South Dakota the rock should be called Winnipeg - A.F.A.

DEGREY MEMBER (of Pierre Shale)

Upper Cretaceous: Central S. Dak.

Crandell, D.R., 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 2341-2346). Considered retention of Gries' (1942, S. Dak. Geol. Survey Rept. Inv. 43, p. 17) term "Agency-Oacoma" inadvisable. Type sections are 100 miles apart and incomplete. Neither at Cheyenne Agency nor at Oacoma is there a representative section of the complete Agency-Oacoma zone of Gries. A new name, the DeGrey member of Pierre shale,

is proposed for this unit, which consists of shale, clay, and bentonite beds. Top is placed between the "gumbo-forming" shale and clay of overlying Verendrye member and the "step-forming" shale of DeGrey member. Base of member is contact between noncalcareous shale of DeGrey member and calcareous beds of the underlying Crow Creek member. At type locality, 82 feet thick.

Type locality: 2 miles southeast of DeGrey in cutbank of Missouri River, in western edge of the NW$\frac{1}{4}$ sec. 8, T. 109 N., R. 75 W., Hughes County, South Dakota

Name: From DeGrey Post Office

Devil's Gulch beds

See Valentine Formation.

Dixon's Group

Upper Cretaceous: Eastern Nebr., western Iowa, southeastern S. Dak.

Nicollet, I.N., 1843 (Rept. intended to illust. map of hydrographical basin of Upper Miss. River: 26th Cong., 2nd Sess., S. Ex. Doc. 237, p. 35, 37). Dixon's Group or Dixon's Bluff--(in descending order):

D--vast deposit of plastic clay with loose pieces of limestone, 200 feet.

C--slightly ferruginous clay bank of yellowish color with selenite seams, and occasionally rounded masses of septaria. Rests on Carboniferous or mountain limestone.

B--gray, bluish-gray, and sometimes yellow calcareous marl, generally 30-40 feet thick (but at Dixon's bluff reduced by a slide to 15-20 feet); few fossils (Orbicula, fish scales).

A--argillaceous limestone containing many compressed Inoceramus barabini [labiatus], giving the rock a slaty structure; up to 20 feet.

Keyes, C.R., 1925 (Pan-Am. Geologist, v. 44, p. 147-149). Dixon chalk or Dixon limestone has priority and should be used. If Gilbert's Greenhorn limestone of Colorado is the same formation (as Todd believes), then it, too, is in synonymy. However, Keyes did not think it the same as the Greenhorn. Not knowing of Nicollet's designation, Keyes gave it the name Crill limestone in Iowa.

Type locality: Not designated

Name: From Dixon's bluff, Dixon County, Nebraska, about 12 miles above Sioux City, Iowa

DUPEROW FORMATION

Upper Devonian: Sask., Man., N. Dak., Mont., northern S. Dak.

Owen, J.R., 1952 (Oil in Canada, v. 5, no. 1, p. 54). Williston Basin Correlation Committee, February 18, 1953.

Stanton, M.S., 1953 (Billings Geol. Society Gdbk., 4th Ann. Field Conf., p. 62). 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 are present. Characteristically, the limestone is light-gray to gray-brown, microcrystalline to fine crystalline, and dense.

Includes the strata lying above the well defined gamma-ray "kick" marking the upper limit of the Souris River formation, upwards to the top of the equally well defined and persistent gamma-ray marker at the base of the "Nesker" (Nisku) formation. Thickness varies between 50 and 500 feet.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2315-2318). Designated the type section, and mapped its extent in South Dakota (fig. 3). Contains Late Devonian fossils. The Duperow and the overlying Birdbear constitute the Jefferson group.

Type locality: (Subsurface) Between depths of 10,400 and 10,743 in Mobil #1 Birdbear oil test in Sec. 22, T. 149 N., R. 91 W., Dunn County, North Dakota

Name: Tidewater Duperow-Crown lease, southwestern Saskatchewan

Dynneson Sandstone Member (of Mowry Shale)

Lower Cretaceous: Williston Basin, northwestern S. Dak. (?)

Wulf, G.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1396-1402). Subdivided the Mowry Shale in the Williston Basin into two units, separated by a marker bentonite bed. The lower, or Dynneson unit, is essentially a shale with two prominent sandstone lithofacies, the Dynneson (Williston Basin) and the Bow Island (northwest Montana). The Dynneson unit is as much as 75 feet thick in northwestern South Dakota, and most of this thickness is sand. The Dynneson unit is marked by a disconformity at the top of the Skull Creek. Where the Dynneson sand is absent, the unit is called the "Lower Mowry" Unit. [It would conform to the principles of stratigraphic classification if Wulf had applied the name Dynneson to only the sand zone, and to have continued to use the name Lower Mowry unit - A.F.A.] The Dynneson Sandstone Member is a blanket-type sandstone, with shoestring sandstone bodies at the top. The grains are light gray and fine in size.

Type locality: (Subsurface) Between depths of 5,310-5,450 feet in Sun #1 Dynneson, Sec. 30, T. 24 N., R. 58 E., Richland County, Montana

Name: From Dynneson lease

"E lignite bed" (of Tongue River Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the "E lignite bed" as being 60 feet above the base of the Tongue River formation, 600 feet thick, atop a 60-foot quartzite marker bed.

The position of this lignite bed apparently is 100-125 feet below the Lodgepole Lignite Facies; however, it was not mapped by the South Dakota Geological Survey in the Lodgepole area (R.E. Stevenson, 1954, S. Dak. Geol. Survey, Geol. Quad., Lemmon) - A.F.A.

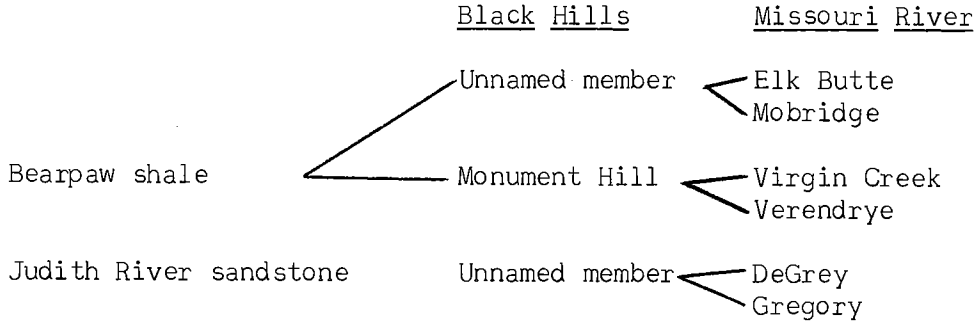
Eagle Sandstone (of Montana Group)

Upper Cretaceous: Mont., central-northern Wyo., northwestern S. Dak. (?)

Weed, W.H., 1899 (U. S. Geol. Survey Geol. Atlas, Folio No. 55, Fort Benton). Basal part consists of thinly laminated sandstone stained light brown by lignitic material, and containing concretions and nodular masses of iron ore. Grades up into very pure white sandstone, which forms bluffs 75 to 100 feet high along Missouri River. Upper part of formation consists of less shaly sandstone with interbedded lignite seams. Total thickness 200 to 235 feet. Overlain by 2,000 feet of marine beds, designated as Montana formation. Underlain by Colorado formation, 1,850 feet thick.

Hatcher, J.B. and Stanton, T.W., 1903 (Science, n.s., v. 18, p. 211-212). Divided the beds of Montana age overlying the Eagle sandstone into (ascending): Claggett formation, 400 feet; Judith River beds, 500-600 feet; Bearpaw shale, 600 feet. The Eagle sandstone, as now defined, underlies Claggett formation and in most areas overlies Colorado shale, and is brown lignitic nodular, to white and friable sandstone; massive, cliff-forming units.

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 451). Correlated Rubey's (1930) units of the Black Hills with the Missouri River section and with north-central Montana as follows (descending):



(continued)

	Black Hills	Missouri River
Claggett shale	Mitten shale	Sharon Springs
Eagle sandstone	Gammon-Groat	---
Telegraph Creek	---	---

Type locality: Exposures along Missouri River about mouth of Eagle Creek, Montana (40 miles below Fort Benton)
Name: From Eagle Creek

ELK BUTTE MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 50-55, pl. 3). Very fine-textured medium-gray shale; breaks down into fine, thin, flat polygonal chips with submetallic luster. Includes as its basal beds the noncalcareous shale which immediately overlies the calcareous, buff-weathering shale of Mobridge member. Overlain by Fox Hills sandstone; the contact is gradational. Thickness varies from 60 to 310 feet.
Type locality: Type section designated by Crandell (1950, Am. Assoc. Petroleum Geologists Bull., v. 34, p. 2338) along U. S. Highway 12, between 1½ and 5 miles west of Wakpala, Corson County, South Dakota.
Name: From Elk Butte, South Dakota (actually, type location is on Rattlesnake Butte)

The unit is recognizable in central South Dakota - A.F.A.

Elk Point Group

Devonian: Alta., Sask., Man., Mont., N. Dak., northwestern S. Dak. (?)

McGehee, J.R., 1949 (Am. Assoc. Petroleum Geologists Bull., v. 33, p. 603, 606-611). The formation underlies a thick section of Upper Devonian strata and in turn lies on Ordovician, Cambrian, or Precambrian rocks. It generally consists of two conspicuous red shales, anhydritic dolomites, and thin slightly fossiliferous argillaceous silty limestones, in addition to one to three shale members. Maximum thickness of entire formation is 1,550 feet. The age is probably Silurian, but recent evidence suggests that at least the upper part of the formation is Middle Devonian.
McGehee, J.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 64). Recent wells in southern Saskatchewan, southwestern Manitoba, eastern Montana and North Dakota have encountered a sequence of strata believed to be equivalent to the Elk Point formation of the Alberta Plains. The beds so far studied consist mainly of evaporites, and usually underlie a thick section of Upper Devonian and Upper Middle Devonian carbonate rocks. The similarity in lithology and in position

underlying readily correlated Devonian sediments, points to Elk Point age for the evaporite portion of these deposits. The tentative "Silurian" correlation advanced by the present writer in his original definition of the Elk Point formation is abandoned by the author in favor of a Middle Devonian age designation.

Williston Basin Correlation Committee, February 18, 1953. The Elk Point group comprises a series of strata consisting dominantly of marine carbonates and evaporite beds. Of the four groups of the Devonian, it is the one exhibiting the greatest degree of shelf and basin differentiation. The Elk Point group has been subdivided into three formations, which are in ascending order: Ashern, Winnipegosis, and Prairie. A maximum thickness of 800 feet is reported in the vicinity of Saskatoon.

Baillie, A.D., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 590). Since the Middle Devonian evaporitic section of the Williston Basin is part of a sequence that is divided into several lithologic units of formation rank, it is proposed to designate the strata that include these formations as the Elk Point group. The formations that are included in the group are, in ascending order, the Ashern formation, Elk Point limestone, Winnipegosis formation, and Prairie evaporite.

Type locality: The Elk Point area, near the North Saskatchewan River, Saskatchewan

Name: From Elk Point

In South Dakota the Ashern is the only representative of the Elk Point group that is present. Thus the South Dakota Geological Survey has not adopted the name Elk Point - A.F.A.

Ellis Group

Upper Jurassic: Mont., N. Dak., Wyo.

Peale, A.C., 1893 (U. S. Geol. Survey Bull. 110, map). This map of vicinity of Three Forks, Montana, shows Ellis formation as overlying Quadrant formation and underlying Cretaceous (the basal formation of which is designated Dakota formation), but does not describe the deposits.

Iddings, J.P. and Weed, W.H., 1894 (U. S. Geol. Survey Geol. Atlas, Folio no. 1, Livingston). Ellis limestone underlain by Myacites beds, the latter consisting of impure fossiliferous limestones of soft earthy calcareous rocks of dark-gray color, with sandstones at base. Thickness 400 feet. At Cinnabar Mountain the Myacites beds rest upon a massive cross-bedded, ripple-marked sandstone, underlain by a bright red sandstone which may be the equivalent of the Red-bed sandstones of more southern localities. Underlies Dakota formation and overlies Quadrant quartzite.

Peale, A.C., 1896 (U. S. Geol. Survey Geol. Atlas, Folio No. 24, Three Forks). Ellis formation (Jurassic) basal part consists of 40-60 feet

of nonfossiliferous quartzitic sandstone, which probably belongs to the Jurassic but which may possibly be Carboniferous. Above this basal quartzite the formation consists largely of argillaceous limestone, many of the beds crowded with Jurassic fossils. The middle and upper parts of formation are more arenaceous and devoid of fossils. Total thickness 300 to 500 feet. Overlies Quadrant formation and underlies Dakota formation.

[The commonly accepted definition of Ellis formation applies to Upper Jurassic marine strata and excludes any older beds that may inadvertently have been included in the earlier mapping. It has been raised to group status with following formation subdivisions (descending): Swift, Rierdon, and Piper or Sawtooth. Equivalent to Sundance of Wyoming and South Dakota, and Fernie of Alberta. Thickness 100-400 feet - Wilmarth, 1938.]

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 469). Proposed that the Sundance formation in eastern Wyoming and western South Dakota be raised to the rank of a group comprising two formations, which are correlated with the Swift and Rierdon formations of the Ellis group of Montana. Because of historical significance, however, the term "Sundance" should be retained, and therefore, despite its correlation with the upper units of the Ellis group, the term "Sundance group" is here applied to the marine Upper Jurassic rocks of the Black Hills and vicinity, the northernmost part of Colorado, the subsurface of western Nebraska, and all but westernmost Wyoming. Subsequent work may indicate that it is desirable to expand the "Sundance group" to include the Gypsum Spring formation. Peterson stated (p. 464) that the Sundance ranges in age from Callovian to Oxfordian (Late Jurassic), and if the Gypsum Spring is included, it includes the Middle Jurassic Bajocian.

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation, and retained the Lakota, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained the Sundance name as including the Rierdon and Swift.

Type locality: Near Fort Ellis, southeast of Bozeman, Montana
Name: From Fort Ellis

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic formations (except the Gypsum Spring at the base), including the Canyon Springs, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

ENGLEWOOD LIMESTONE (of Madison Group)

Mississippian (Kinderhook): Western S. Dak. (Black Hills), northern Wyo.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 509). Pink slabby limestone, 20-30 (or 25 to 60) feet thick, underlying Pahasapa limestone and overlying Deadwood formation (Cambrian). Merges rapidly into Pahasapa limestone, with occasionally a few feet of impure buff limestone intervening. In northern Black Hills a mass of buff limestone of Silurian age [Upper Ordovician Whitewood Limestone - A.F.A.] intervenes between Englewood limestone and Deadwood formation.

Andrichuk, J.M., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2176). Near the town of Deadwood in the Black Hills, South Dakota, the Englewood is dark-gray to dark purple-gray shale containing Mississippian graptolites. The Englewood can be recognized as a reddish-colored zone in the basal Mississippian in the subsurface to the west and north. On page 2188 he stated that the Englewood is dolomitic and silty shales, and minor shaly dolomites.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2328). Stated that the Englewood along the southern and eastern margins of the Williston Basin is correlative with beds just above the Bakken formation of the central part of that basin.

Klapper, Gilbert, and Furnish, W.M., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 2071-2078). Examined the conodonts of the Englewood Formation in the Black Hills, and found an Upper Devonian fauna in the middle part of the formation, and a Lower Mississippian fauna.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 59). Reduced the Englewood in the Williston Basin to an argillaceous facies of the Lodgepole Limestone, sporadically present at or near the base of the formation in north-central South Dakota and south-central and eastern North Dakota.

Kume, Jack, 1963 (N. Dak. Geol. Survey Bull. 39, p. 23-25). Recognized three subdivisions of the Englewood Formation in the Deadwood junkyard reference section: gray silty shale, 28 feet (below); grayish-red, purple, argillaceous and partly shaly limestone, 24 feet thick; and yellowish-gray dolomitic limestone, 5 feet thick (above). Ten miles to the north, in the Weller-Bush #1 Weisman oil test, the lithology of the three subdivisions has changed to: medium-gray calcareous siltstone, 10 feet (above); grayish-red, purple silty limestone, 25 feet; and grayish-red, purple calcareous argillaceous siltstone (below). Sixty miles to the north, in northern Butte County, the Englewood is very dark-red to pinkish-gray argillaceous limestone, 15 feet thick. Kume showed (1963, fig. 12 on p. 27) that the Englewood is a facies of the lower part of the Lodgepole in northwestern South Dakota, and is overlain by Lodgepole in northern Butte County.

Type locality: C.B.& Q. R.R. cut; 2 miles south of Englewood, Lawrence County, South Dakota

Name: From Englewood Station

Fairbank Formation

Pennsylvanian: Wyo., west-central S. Dak. (?)

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 32). Comprises Division 6 (Condra and Reed, 1935) of Hartville formation, thickness 30 to 100 feet. Predominantly sandstone. The Fairbank formation encircles the Black Hills region without much facies change. In general, however, the rest of the Pennsylvanian becomes more sandy and not very fossiliferous northward in this region. Correlates with lowest part of the Minnelusa of the Black Hills.

Agatston, R.S., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 508-583). Fairbank is absent in wells on the north side of the Black Hills, and he considers the Fairbank to be equivalent to the Darwin sandstone at the base of the Amsden formation of central Wyoming. The Fairbank formation constitutes the "Bell sand" of the Lance Creek oil field.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that as much as 100 feet of questionable Fairbank is present in west-central South Dakota. Overlain by the Reclamation group, underlain unconformably by Mississippian.

Type locality: North Platte River bluffs immediately north and northwest of the site of an abandoned village known as Fairbank, in Sec. 27, T. 27 N., R. 66 W., Platte County, Wyoming

Name: From village of Fairbank

FALL RIVER SANDSTONE (Inyan Kara Group)

Lower Cretaceous: Western S. Dak. (Black Hills), northeastern Wyo., southeastern Mont. (in wells)

Russell, W.L., 1927 (Am. Jour. Science, 5th ser., v. 14, p. 402). It has been shown by writer elsewhere (S. Dak. Geol. and Nat. Hist. Survey Bull. 14*, 1927, in press) that so-called Dakota sandstone of Black Hills region is in reality older than true Dakota, and it will be called Fall River formation in this paper. Overlies Fuson formation and underlies Graneros shale.

Russell, W.L., 1928 (Econ. Geology, v. 23, p. 136-137). The so-called Dakota sandstone of Black Hills region is here renamed Fall River formation. According to fossil plants identified by E. W. Berry, it is much older than typical Dakota sandstone of eastern Nebraska. It consists of 75 feet of sandstones and interbedded shales underlying Graneros shale and overlying Fuson shale.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 5). Fall River sandstone is so-called Dakota sandstone of previous reports on Black Hills region. It is top formation of Inyan Kara group of Early Cretaceous age. Conformably underlies Graneros shale and overlies Fuson

* never published

formation. Continental except upper 20 feet, which contains marine fossils.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 75). The Fall River and the Dakota (?) are unquestionably a continuous blanket of sand, but lack of good subsurface data kept the Dakota-Fall River relationship uncertain in the Dakota Basin. A recent well at Kadoka, South Dakota, suggests, according to one interpretation, that the artesian sand encountered there and to the east is part of a sand wedge coming in from the east, of about the same age as the siliceous Mowry shale farther west. Beneath this sand, the Newcastle sandstone and a shale interval of 180 feet are penetrated before the top of the Fall River-Fuson-Lakota series is encountered. On this slim evidence it might be postulated that the true Dakota of the Missouri River area is Mowry in age, and that the black shale and perhaps the Fall River-Fuson-Lakota series have wedged out within the next 100 miles to the east [of Kadoka - A.F.A.]. The Fall River appears to range from a minimum of 54 feet to a maximum of 196 feet in the outcrop area around the Black Hills.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 26-33). Redefined the Inyan Kara group to show the change in environment of deposition from continental (Lakota) to marginal marine (Fall River). The upper one-third of the Inyan Kara is thus well-bedded fine-grained brown-weathering sandstone with intercalated gray to black shale and siltstone; the lower two-thirds is much more variable, containing varicolored and variegated claystone and siltstone, and massive, locally poorly sorted sandstone, carbonaceous shale and coal, and lacustrine shale and limestone. These two units are separated by a transgressive disconformity. The upper unit (Fall River) is 120-150 feet thick, and the lower is highly variable in both thickness and lithology, ranging from 60 to 200 feet in the northern Black Hills to more than 200 in the southern Hills. The contact with the underlying Morrison is locally difficult to define because of the lack of a persistent lithologic change (p. 50).

Gries, J.P., 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., p. 167). Disagreed with Waage on the limited geographic usefulness of the Lakota, and stated that it should be recognized eastward from the Black Hills as far as the overlying marine Skull Creek Shale can be identified.

Type locality: Evans Quarry on Fall River, below Hot Springs, Fall River County, South Dakota

Name: From Fall River

Fort Hays Limestone Member (of Niobrara Marl)

Upper Cretaceous: Western Kans., eastern Colo., S. Dak., Nebr., Wyo.

Williston, S.W., 1893 (Kans. Acad. Science Trans., v. 13, p. 108-109). Very characteristic heavy stratified chalk or soft white limestone at

base of [Niobrara] formation, about 80 feet thick; extends across Kansas from near Mankato, Jewell County, on north to north of Coolidge, in Hamilton or Greeley County, Colorado, on west. Its character and thickness are unmistakable. Further he spoke of "the stratified, or Fort Hays beds, as I will call them in Ness and Trego Counties," and stated: "The divisional line between Benton and Niobrara I take at top of the stratified beds already mentioned, following Mudge, but I am not at all certain that it should not be placed below this, or even below the subjacent dark-blue shale."

As above defined, Fort Hays limestone was tentatively included in the Benton. In 1896, however, Cragin (1896) and Williston (1893) included it in the Niobrara as the basal member, underlying Smoky Hill chalk member. [This is commonly accepted definition. The limestone is top member of Fort Hays division or group of Mudge (1876). In 1933 the U. S. Geological Survey and Kansas Geological Survey agreed to change the name of Hays limestone, "the name of the town having been changed from Fort Hays to Hays, and geologists working in Kansas having become accustomed to calling the limestone Hays limestone." (Am. Assoc. Petroleum Geologists Bull., v. 18, p. 1494, 1934). Later the Kansas Geological Society reported that the beds were named for old Fort Hays, a well-known landmark in western Kansas, and the name Fort Hays limestone member was therefore restored - Wilmarth, 1938.]

Bolin, E.J., 1952 (S. Dak. Geol. Survey Rept. Inv. 70, p. 4-5). Stated that in South Dakota, although there is a faunal break in the Niobrara which he has designated as the contact between the Fort Hays and the Smoky Hill, it is "extremely difficult to recognize a lithologic subdivision of the Niobrara formation in this area.... Since the main basis for subdivision is micropaleontologic rather than lithologic, it remains very difficult if not impossible to distinguish between the two members in the field...." Thus he took exception with G.J. Loetterle, 1937 (Nebr. Geol. Survey Bull. 12, p. 14).

Type locality: Not designated

Name: From Fort Hays, Kansas

Fort Niobrara beds

See Valentine Formation.

Fort Pierre Group

Upper Cretaceous

A term applied in early reports on Rocky Mountain region to Upper Cretaceous deposits now known as Pierre Shale.

FORT UNION GROUP

Eocene (early): N. Dak., northwestern S. Dak., Wyo., Mont., and northwestern Colo.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 433). Fort Union or Great Lignite group--clay and sand, with round ferruginous concretions, numerous beds, seams, and local deposits of lignite, and great numbers of dicotyledonous leaves, stems, etc., of many genera. Thickness 2,000 plus feet [not in South Dakota - A.F.A.]. Overlies Fox Hills beds (Cretaceous) and underlies Wind River deposits. Occupies whole country around Fort Union and extends north into British possessions unknown distances and southward to Fort Clark. Seen under White River group on North Platte River above Fort Laramie, and on west side of Wind River Mountains. Probably Eocene.

Meek, F.B., 1876 (U. S. Geol. and Geog. Survey Terr., Mon. 9, p. lix). The section of Fort Union group at Fort Union is as follows (descending):

(1) Ferruginous marl, with arenaceous concretions, upper part sometimes concretionary sandstone ledges several feet thick; 20-30 feet.
(2) Drab indurated arenaceous clay, 20 feet.
(3) Impure lignite, with numerous crystals of selenite, 1 foot.
(4) Gray and drab indurated clay, with locally numerous leaf impressions of dicot and fern, 50-70 feet.
(5) Impure lignite, with much silicified wood, $1\frac{1}{2}$ feet.
(6) Gray indurated sand, with a slight mixture of clay. Contains numerous intervening beds (fossils) and also many fragments and entire stumps of trees (silicified), 30 feet.
(7) Impure lignite, 1/3 foot.
(8) Yellowish-gray indurated clay, 2 feet.

Hayden, F.V., 1878 (U. S. Geol. Survey Terr., Mon. 7, pt. 2, p. iv). Stated that his "Lignitic group" included Laramie and Fort Union, and that latter was probably identical with whole, or at least a part of Wasatch group.

King, Clarence, 1878 (U. S. Geol. Exploration 40th Par., v. 1, p. 351-354). Stated that he had never visited Fort Union locality, but that "the correlation of the upper plant beds of Fort Union with the Wasatch (by Vermillion Creek) seems the most prodigious strain."

In 1893 (U. S. Geol. Survey Bull. 105) and 1896 (Am. Geologist, v. 18, p. 201 plus), W.H. Weed divided Fort Union or Lignitic group of Hayden ("also called Laramie group by Hayden") near Livingston, Montana, into (descending): (1) Fort Union formation (Eocene), 4,000 to 8,000 feet of rather massive cross-bedded sandstone with gray silty shales and local lenses of impure limestone, "believed to be a distinct formation, corresponding in lithology, stratigraphic position, and fossil contents to beds exposed along Missouri River at mouth of Yellowstone, so long known in geological literature as Fort

Union beds," resting unconformably on (2) Livingston beds, 7000 plus or minus feet of chiefly assorted and water-worn volcanic material, somber-colored sandstone, shales, and grits, which rest unconformably on (3) 1,000 feet of massive, light-colored coal-bearing sandstone and intercalated shales containing leaf remains and invertebrates and corresponding to Cretaceous Laramie formation of King, Newberry, Emmons, and Cross. [The Livingston formation was not assigned to either Eocene or Cretaceous by Weed - Wilmarth, 1938.]

Later and more detailed work in Crazy Mountain region, Montana, by R.W. Stone and W.R. Calvert resulted in differentiating in that region (Econ. Geology, v. 5, p. 551-557, 652-669, 741-764, 1910) the following formations (descending): (1) Fort Union formation, 4,000 plus feet thick, consisting of massive sandstone and shales, with Lebo andesitic member at base, the latter 450 to 2,200 feet thick and containing Fort Union (Eocene) fossils; (2) Lance formation ("Ceratops beds"), 1,000 to 2,400 feet of light-gray sandstone and variegated shale; (3) Lennep sandstone, 250 to 400 feet of sandstone with intercalated shales which 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 (Lower Cretaceous). They also ascertained that the andesitic Livingston formation of Weed included equivalents of Lebo andesitic member of Fort Union formation and all other formations mentioned above down to top of Eagle sandstone which was called Laramie by Weed.

[Reports of different geologists published since 1910 have described and mapped the Fort Union formation (Eocene) over large areas in Montana, North Dakota, South Dakota, and down into central Wyoming. More recent work by J.B. Reeside, Jr., resulted in discovery that Wasatch formation of 1924 Wyoming geological map as mapped in southern Wyoming (where it was shown resting on Lance formation) included a representative of Fort Union formation. That the Fort Union formation is of Eocene age, and that it underlies Wasatch formation and overlies Lance formation is definitely now accepted by most if not all geologists - Wilmarth, 1938.]

Stevenson, R.E., 1957 (S. Dak. Geol. Survey, Geol. Quad., Ralph). Fort Union in South Dakota is represented by the Tongue River formation which lies unconformably on the Lance formation. The Fort Union is now divided into upper member, called Tongue River, and lower member, called Lebo shale.

Denson, N.M., et al, 1959 (U. S. Geol. Survey Bull. 1055-B, p. 21). Included the Sentinel Butte shale at the top of the Fort Union in southwestern North Dakota, but noted that the shale had been removed by erosion from all parts of northwestern South Dakota.

Type locality: Not designated

Name: From exposures at Old Fort Union, near mouth of Yellowstone River, later called Fort Buford, and now town of Buford, North Dakota

The South Dakota Geological Survey accepts the Ludlow (not Lebo), below, Cannonball, and Tongue River as formations of the Fort Union Group, Paleocene in age - A.F.A.

FOX HILLS FORMATION

Upper Cretaceous: S. Dak., N. Dak., eastern Mont., eastern Colo., Wyo.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 419-427). Fox Hills beds (Formation No. 5 of Cretaceous)--gray, ferruginous and yellowish sandstone and arenaceous clays. Occurs at Fox Hills, near Moreau River, along base of Bighorn Mountains, and on North and South Platte Rivers. Thickness 500 feet. Top formation of upper Cretaceous in Nebraska [which at that time included Wyoming, Montana, and Dakota - Wilmarth, 1938]. Underlies the Tertiary Fort Union or Great Lignite group and overlies Fort Pierre group.

White, C.A., 1878 (U. S. Geol. and Geog. Survey Terr., 10th Ann. Rept., p. 21, 22, 30). Transferred "Fort Pierre group" [Pierre Shale - A.F.A.] from Colorado group, in which it had for many years been included, to overlying Fox Hills group.

White, C.A., 1879 (U. S. Geol. and Geog. Survey Terr., 10th Ann. Rept., p. 186-187). Fox Hills group, a consolidation of Fort Pierre group (Cretaceous No. 4) and Fox Hills group (Cretaceous No. 5) for Colorado and adjacent territories, but not for Upper Missouri River region, where it will continue to be used in restricted sense of Meek and Hayden.

Eldridge, G.H., 1888 (Colo. Sci. Society Proc., v. 3, pt. 1, p. 93, footnote). With the approval of C.A. White, introduced Montana group to replace Fox Hills in broad sense of White [i.e., to include Fox Hills sandstone and Pierre shale of present nomenclature - Wilmarth, 1938].

Rocky Mountain Association of Petroleum Geologists Committee, 1932 (Am. Assoc. Petroleum Geologists Bull., v. 16, p. 702-703). After field conference (in eastern Colorado) agreed to restrict term Fox Hills in that area (see Waage, 1961, p. 229) as follows: the base of Fox Hills formation shall be considered as horizon below which the section is predominantly gray marine clay shales and sandy shales of Pierre age, and above which the section changes rapidly to a buff to brown sandstone containing numerous large gray to brown hard sandy concretions. This lower concretionary member is commonly overlain by a series of light-gray to brown sandstone and sandy shale. The top of the Fox Hills formation shall be considered as horizon above which the section is composed predominantly of fresh- and brackish-water deposits accompanied by coals and lignitic shales, and below which it is dominantly marine.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 78). The formation is the deposit of a retreating Cretaceous sea,

and is not all of the same age. The thickness of the Fox Hills is roughly 100 feet, though it ranges from as little as 25 feet to nearly 400 feet in the type area.

Robinson, C.S., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Noted that along the west and north flanks of the Black Hills, the Fox Hills lithology is present at lower stratigraphic positions so that the upper four baculite zones of the Pierre in central South Dakota are in the Fox Hills in the Black Hills.

In a definitive paper on the Fox Hills, K.M. Waage, 1961 (Wyo. Geol. Association, 16th Ann. Field Conf., p. 229-240) has redescribed the Fox Hills in its type area, and correlated it to the west and south. He pointed out that although gross uniformity characterizes the Fox Hills in Corson, Dewey, and Ziebach Counties, South Dakota, each of its four members (Colgate, Bullhead, Timber Lake, and Trail City, in descending order) varies considerably in stratigraphic detail and in part each is a lateral facies of the members above and below it. The lower two members are rich in marine fossils. Except for the Colgate (which term is applied rather loosely in eastern Montana and Wyoming and the Dakotas to any gray-white sandstone at or near the Fox Hills-Hell Creek contact), the members are local subdivisions of the type area and "closely adjacent parts" of the Fox Hills outcrop.

Fifty miles west of the type area, the Bullhead lithology is recognizable below the Hell Creek (A.U. Lange, 1962, S. Dak. Geol. Survey, Geol. Quads., Signal Butte and Cedar Canyon).

Fifty to 75 miles south of the area mapped by Lange, Karl Waage (1961, p. 238 and fig. 5) described in Meade County, South Dakota, a continental facies of the Fox Hills that is totally unlike the marine sediments of the type area. This fresh-water and brackish-water sequence is dominantly sand and silt, and contains zones of thin coals.

The Fox Hills is Maestrichtian in age (Cobban and Reeside, 1952).

Type locality: Apparently at the east end of Fox Ridge, in northwestern Armstrong and southwestern Dewey Counties, South Dakota

Name: From Fox Ridge

Foxian series

A term applied by C.R. Keyes, 1925 (Pan-Am. Geologist, v. 43, p. 132) to Fox Hills Formation and its supposed equivalents.

FUSON SHALE FACIES (of Lakota Formation)

Lower Cretaceous: Western S. Dak., southeastern Mont., eastern Wyo., northwestern Nebr.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 530). Fuson formation--very fine-grained sandstone and massive shale and

clay; white, gray, buff, purple, and maroon. Thickness 30-100 feet. Underlies Dakota sandstone [Fall River sandstone - Wilmarth, 1938], and overlies Minnewaste limestone. Included in Dakota sandstone of previous reports.

Rubey, W.W. (1930) made this the middle formation of Inyan Kara group.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 75). The interval which may reasonably be assigned to the Fuson varies from 35 to 188 feet thick in the outcrop area around the Black Hills. It is 88 feet thick at the type section. The Fuson should not be considered a separate formation, but merely a shaly closing phase of Lakota deposition. Similar pink, gray, and buff clays may be traced in subsurface east of the Missouri River. They occur to the west also, and while some geologists try to carry the three-fold Lakota-Fuson-Fall River of Dakota (?) divisions westward, there is a growing tendency to lump the three as Dakota or Cloverly group. Fossil plants are abundant in the formation and are classified as lower Cretaceous.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 33). Suggested that the term Fuson be dropped because of its close facies relationship with the Lakota formation and its miscorrelations elsewhere. He pointed out that where the local Minnewaste limestone is present, the use of the term Fuson locally might be helpful, but that a new type section should be given because the base of the Fuson is not present at Darton's type section.

Post, E.V. and Bell, Henry, 1961 (U. S. Geol. Survey Prof. Paper 424-D, p. 173-178). Reported that in detailed mapping in the southern Black Hills they were able to trace the boundary between the lower part of the Lakota Formation and the overlying Fuson even where the Minnewaste Limestone was absent. They named this lower member of the Lakota the Chilson Member.

Type locality: Fuson Canyon, northwest of Buffalo Gap, Custer County, South Dakota

Name: Fuson Canyon

"G" sand (of Mowry Shale)

Lower Cretaceous: Southeastern Wyo., western Nebr., northeastern Colo., southwestern S. Dak.

An informal term for the middle of a series of Cretaceous oil sands that are productive in the Denver Basin. Equivalent to part of the Mowry.

Galena Limestone

Middle Ordovician: Ill., Iowa, Wis., Minn., southeastern S. Dak. (?)

Hall, James, 1851 (Rept. of geol. of Lake Superior land dist., pt. 2, p. 146-148). Name Galena limestone in Wisconsin, Illinois and Iowa

applied to cliff-forming gray or drab limestone, which contains the lead sulfide, galena. It is fossiliferous and rests on the Trenton.

Winchell, N.H. and Ulrich, E.O., 1879 (Minn. Geol. and Nat. Hist. Survey, v. 3, pt. 2, Final Rept., p. lxxxix). Assigned the Galena to the Trenton and the underlying so-called Trenton shale and limestone [Decorah and Platteville - Wilmarth, 1938] to the Black River.

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, p. 26). Applied the name to a well in Stanley County, for Ordovician dolomite below the Mississippian and above the Platteville.

Type locality: Exposures in bluffs of Mississippi River near Galena, Jo Daviess County, Illinois

Name: From Galena

This name should not be used in South Dakota except possibly in the extreme southeastern part of the State; elsewhere the rocks should be termed Red River - A.F.A.

GAMMON FERRUGINOUS MEMBER (of Pierre Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., Black Hills of S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). Gammon ferruginous member--basal member of Pierre shale in northeastern Wyoming and southeastern Montana. Consists of 800 to 1,000 feet of light-gray mudstone and shale with abundant concretions and thin beds of siderite. Fossils scarce, but marine. Commonly forms bare buttes. Includes Groat sandstone, 150 feet thick, near top, and Pedro bentonite bed at base. Rests on Beaver Creek chalky member of Niobrara formation. Possible unconformity at or near base of Gammon member.

Cobban, W.A., 1952 (Billings Geol. Society, 3rd Ann. Field Conf., p. 87). The Gammon member, which makes up the lower half of the formation, thins rapidly eastward across the north flank of the Black Hills uplift. Is well exposed in vicinity of common corner of Montana, Wyoming, and South Dakota, where it is about 800 feet thick and divisible into three units. The lower unit consists of 600 feet of gray mudstone that is slightly calcareous in the basal 150 feet. Numerous rusty-weathering ferruginous concretions and thin shaly ferruginous layers are present throughout the unit. In addition, the upper part contains gray calcareous concretions. The middle unit is the Groat sandstone, about 50 feet thick. It is buff to green, fine-grained, and glauconitic. The upper unit of the Gammon is 150 feet of gray mudstone with numerous ferruginous and calcareous concretions.

Robinson, C.W., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Described the Gammon ferruginous member along the west and north flanks of the Black Hills as being 800 feet thick and consisting of the following units, in descending order:

Upper unit--dark-gray mudstone and shale, with dark-gray iron-cemented septarian concretions; "H" bentonite is 75 feet below top.

Groat sandstone bed--light gray glauconitic iron-stained sandstone above, becoming silty and shaly below; 75-125 feet thick.

Lower unit--same as upper, but concretions are not septarian.

The Groat rests on the Niobrara calcareous shale, and underlies the Mitten black-shale member of the Pierre. Groat fossils are the same as those in the Telegraph Creek shale (below) and Eagle sandstone, of Montana, and the same as those in the Shannon sandstone of the Powder River Basin in Wyoming.

Tourtelot, H.A., 1962 (U. S. Geol. Survey Prof. Paper 390, p. 8). Points out that the Gammon is not present south of Newcastle, Wyoming, on the western side of the Black Hills, and that from there southward the overlying Mitten organic-rich shale becomes the Sharon Springs Shale of the southern part of the Black Hills.

Type locality: Along Gammon Creek, T. 57 N., R. 67 and 68 W., Crook County, Wyoming

Name: From Gammon Creek

Gering Facies (of Arikaree Group)

Miocene: Western Nebr., southern S. Dak. (?)

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 735, 747-755). Coarse sand, soft sandstone, and conglomerate; sand is laminated, massive, cross bedded, and light gray. Often comprises two or more members, more or less distinctly separated by unconformities. Greatest development southwest of Gering, Nebraska, where it is 200 feet thick. It is possible that upper member of Gering formation is basal portion of overlying Arikaree formation. Rests unconformably on White River group.

[These deposits are now considered to be local sediments in stream channels, and are covered by the broader term Arikaree formation, of which they form basal part - Wilmarth, 1938.]

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1251-1252, 1264, 1266-1269, 1270-1271). Lists the Gering formation in Nebraska as the basal unit of the Arikaree group. "The deeper pre-Arikaree valleys contain the Gering formation of bedded and cross-bedded fine to coarse channel sands and gravels. The maximum thickness of the Gering formation is approximately 230 feet." It nearly fills the valleys of the "pronounced erosional unconformity on the Brule clay [White River group, and] the higher levels of the old Brule surface are overlapped generally by some part of the Monroe Creek formation.... The Gering horizon [not the Gering formation - A.F.A.] seems to change to a flood-plain facies closely resembling the Monroe Creek formation from Chadron eastward across northern Sheridan County [Nebraska]."

Collins, S.G., 1960 (S. Dak. Geol. Survey, Geol. Quad., Patricia). Mapped as Gering (?) Facies, coarse clastic sediments that filled channels cut

into Sharps Formation in a small area of Washabaugh County, 20 miles northeast of Martin. He stated, however, that "the upper contact of the unit is by no means clearly displayed," and thus did not rule out the possibility that this Gering (?) material might actually be later than Miocene in age [thus, the Gering of Schultz and Stout, 1961, is not yet recognized in South Dakota - A.F.A.].

Harksen, J.C., and others, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 674-678, May). Described a new flood-plain silt formation with nodules, the Sharps, in southwestern South Dakota. Its position, below the Monroe Creek Formation and above the White River Group, represents the same position as the Gering channel sands of western Nebraska, but with different lithology and depositional environment.

Schultz, C.B. and Stout, T.M., 1961 (Univ. Nebr. State Museum, Spec. Pub. No. 2, p. 7, 47, fig. 15, July). On the other hand, they felt that the name Sharps is a synonym of Gering because it "occupies the position of the Gering" (p. 7). They did not describe the flood-plain facies of this expanded Gering (although it is shown in Figure 15); in fact, the descriptive notes for the Gering seen on the field trip record that it has "a fine channel development" (p. 47).

Type locality: Apparently southwest of Gering; Osborn, 1909 (p. 71), stated that the type locality was at "Scotts Bluff."

Name: From Gering, Scotts Bluff County, Nebraska

GIANNONATTI LIGNITE FACIES (of Ludlow Formation)

Paleocene: S. Dak.

Lloyd, E.R. and Hares, C.J., 1915 (Jour. Geology, v. 23, p. 520). The Giannonatti lignite bed was mapped in T. 21 N., R. 7 E., Harding County, South Dakota, as being 11 feet, 8 inches thick.

Winchester, D.F., Hares, C.J., Lloyd, E.R., and Parks, E.M., 1916 (U. S. Geol. Survey Bull. 627, p. 22, 94). There is an abundance of lignite in this township (T. 21 N., R. 7 E.). Two important beds and several unimportant ones were mapped. The thinner beds are the lowest. The Giannonatti bed is the highest and thickest, having a maximum thickness of 13 feet, 6 inches in the northeast corner of Sec. 29, T. 21 N., R. 7 E., and an average thickness in this township of more than 8 feet.

Stevenson, R.E., 1956 (S. Dak. Geol. Survey, Geol. Quad., Ludlow). Referred to the Giannonatti as a facies of the Ludlow formation. A series of interbedded buff to gray sandy clay and clay, brown to tan fissile silty clay with plant fragments, buff fine-grained subgraywacke, brown peat-clay, and one to five seams (1 inch to 174 inches thick) of black, blocky, and fissile lignite. The facies, which is about 60 feet thick, may be the correlative of the Bison facies farther east. The U. S. Geological Survey's "B", "C", and "D" seams (King, 1955, N. Dak. Geol. Society Gdbk., Black Hills Field Conf.) are equivalent to this facies.

Type locality: Presumably Secs. 20 and 29, T. 21 N., R. 7 E., Harding County, South Dakota

Name: From Giannonatti Mines

The Giannonatti Facies marks the top of the Ludlow throughout six quadrangles of Harding County - A.F.A.

Golden Valley Formation

Eocene: Southwestern N. Dak., northwestern S. Dak. (?)

Benson, W.E. and Laird, W.M., 1947 (Geol. Soc. America Bull., v. 58, p. 1166-1167). Applied the name Golden Valley formation to a series of fine-grained micaceous sands with minor amounts of light-colored clays and shales (upper unit), which rest on (lower unit) hard, white to dark-gray clay and locally lignite. Near the middle of the lower unit is a reddish-yellow mottled "marker bed." These beds were formerly known as the "unnamed formation" of the Wasatch group. The Golden Valley overlies the Paleocene Sentinel Butte shale member of the Fort Union formation, and is unconformably overlain by the Oligocene White River group. The fossil fern Salvinia preauriculata marks the Golden Valley formation.

Benson, W.E., 1949 (Geol. Soc. America Bull., v. 60, p. 1873-1874). Elaborated on this somewhat when he distinguished two members of the Golden Valley formation (descending):

Upper member--fine- to coarse-grained micaceous sands and silts with small clay lenses;

Lower member--purplish-gray carbonaceous shales interbedded with white sandy bentonitic clays commonly stained bright yellow-orange.

The Golden Valley formation is conformable with the underlying Tongue River formation and unconformable with the overlying White River group. In places, pre-Oligocene erosion removed the entire Golden Valley formation before the White River sediments were deposited. Agreed with R.W. Brown that the Sentinel Butte is only a facies of the Tongue River member of the Fort Union formation.

Type locality: "Near town of Golden Valley," North Dakota

Name: From town of Golden Valley

May possibly be present in the Slim Buttes of northwestern South Dakota, where similar sediments have been called Slim Buttes Formation of earliest Oligocene age. May also be present in east Short Pine Hills (M.J. Tipton and J.C. Harksen, personal communication, August 1964) - A.F.A.

Goose Egg Formation

Permian: Wyo.

Burk, C.A. and Thomas, H.D., 1956 (Wyo. Geol. Survey Rept. Inv. 6, 11 p.). Described the Goose Egg formation of eastern Wyoming as a sequence of interbedded red to ocher shales and siltstone, thin limestone, gypsum, and limestone breccia. It rests on the Minnelusa and equivalents (Tensleep, Casper, and Hartville), and underlies the Spearfish and equivalent (Chugwater). The Minnekahta is the limestone with farthest east extent, and is underlain by the Opeche shale; less extensive are the overlying Forelle and Ervay limestones, all of the Phosphoria.

Type locality: NW¼ Sec. 12, T. 32 N., R. 81 W., Natrona County, Wyoming
Name: From Goose Egg Post Office

Apparently a significant part of what is considered Spearfish by the South Dakota Geological Survey is included in the upper part of the Goose Egg, but its relations are not adequately described - A.F.A.

GRANEROS SHALE

Upper Cretaceous: Eastern Colo., Wyo., southeastern Mont., S. Dak., Nebr., Kans., northeastern N. Mex.

Gilbert, G.K., 1896 (U. S. Geol. Survey 17th Ann. Rept., pt. 2, p. 564). Graneros shale--name suggested by R.C. Hills. Laminated argillaceous or clayey gray shale with very little limy or sandy material. Thickness 200 to 210 feet. Bottom formation of Benton group in Arkansas Valley region, Colorado. Underlies Greenhorn limestone and overlies Dakota sandstone.

Graneros shale is divided into four members (descending): (1) Belle Fourche shale; (2) Mowry shale; (3) Newcastle sandstone; (4) Skull Creek shale. [The Niobrara and Benton are not now treated as groups, the broader term Colorado group, which includes them both, being considered the more useful name. Where the Niobrara and Benton are not subdivided, they are called Niobrara limestone and Benton shale, respectively - Wilmarth, 1938.]

Wing, M.E., 1940 (S. Dak. Geol. Survey Rept. Inv. 35, p. 6, chart facing p. 10). Graneros formation divided into three groups: upper--equivalent of Belle Fourche shale; middle--equivalent of Mowry shale; lower--equivalent of Newcastle sandstone and Skull Creek shale. Also noted 600 feet (approx.) of Belle Fourche shale or Upper Graneros observed in the Belle Fourche district.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 75). The Skull Creek shale and the Newcastle sandstone are known to carry a lower Cretaceous microfauna whereas the Mowry shale and the Belle Fourche shale are considered to be upper Cretaceous. The simplest solution would be to discard the term Graneros and raise the above-listed units to formation rank.

Type locality: Not designated
Name: From Graneros Creek, Pueblo County, Colorado

The fact that the formation contains the boundary between two different time units is no reason to discard it. As the individual units Belle Fourche, Mowry, Newcastle and Skull Creek are of member rank, the term Graneros Formation is acceptable in western South Dakota where these members are recognizable, as well as in eastern South Dakota where they are not - A.F.A.

"Gray limestone"

Mississippian (Lower)

Refers to Pahasapa Limestone prior to 1901 when renamed by N.H. Darton.

GREENHORN LIMESTONE

Upper Cretaceous: Eastern Colo., Wyo., southeastern Mont., Nebr., S. Dak., Kans., northeastern N. Mex.

Gilbert, G.K., 1896 (U. S. Geol. Survey 17th Ann. Rept., pt. 2, p. 564). Greenhorn limestone--limestone beds, 3 to 12 inches thick, separated by somewhat thicker shale beds. Thickness of formation 25 to 40 feet. Middle formation of Benton group in Arkansas Valley region, Colorado. Underlies Carlile shale and overlies Graneros shale.

[The Niobrara and Benton are not now treated as groups, the broader term Colorado group, which includes them both, being considered the more useful name. Where Niobrara and Benton deposits are not subdivided they are called Niobrara limestone and Benton shale, respectively - Wilmarth, 1938.]

Moore, R.C., 1949 (Geol. Soc. America Mem. 39, fig. 18). Portrayed the facies relationships of the Greenhorn limestone and the underlying Belle Fourche shale along the Wyoming-Montana border north of the Black Hills, from unpublished studies of M.N. Bramlette and W.W. Rubey. They showed that the calcareous shale and thin limestones of the Greenhorn facies occur lower in the stratigraphic column, at the expense of the dark noncalcareous shale of the Belle Fourche facies, southeasterly toward the Black Hills. They drew the contact between the two at the base of the lowest limestone, which they called the Bull Creek sandy limestone. Cobban and Reeside (1952, p. 1931) stated that the Bull Creek is the same as the Orman Lake, and used the latter term.

Cobban, W.A., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2183). Described the Greenhorn around the north flank of the Black Hills as being divisible into four lithologic units, in descending order:

Bluish- to whitish-weathering marl with limestone lenses and concretions, 60 feet thick.

Dark bluish-gray noncalcareous very fissile shale with numerous soft yellow limonitic nodules, 22 feet.

Calcareous shale and impure calcareous marl, containing calcareous ferruginous concretions and buff-weathering thin shaly limestone beds, 33-80 feet.

Light-gray calcareous mudstone with interbedded marl, shaly limestone, and black-gray noncalcareous shale, 125-250 feet.

At some localities the base is marked by a buff shaly limestone about 1 foot thick, which is called the Orman Lake limestone (formerly this limestone was named the Middle Creek limestone). The age of the Greenhorn is Cenomanian and Turonian (p. 2197).

Gries, J.P., 1952 (Billings Geol. Society, 3rd Ann. Field Conf., p. 76). The Greenhorn consists of 35 to 65 feet of thin limestones, with thick partings of calcareous shale. The most conspicuous fossil is Inoceramus labiatus. Often referred to in the subsurface of the Williston Basin as "Second white specks zone."

Knechtel, M.M. and Patterson, S.H., 1962 (U. S. Geol. Survey Bull. 1082-M, p. 918-920). Described the facies relationship of the Greenhorn and the underlying Belle Fourche, which causes the contact to migrate downward 45-60 feet from a position above bentonite bed "G", from west to east across the northern Black Hills to the Belle Fourche area. Thus the thinned upper member of the Belle Fourche is replaced by the thickened lower part of the Greenhorn.

Type locality: Greenhorn Station, 14 miles south of Pueblo, Colorado
Name: From Greenhorn Station and Greenhorn Creek

Gregory Marl (of Pierre Shale)

Upper Cretaceous: S. Dak.

Moxon, A.L., Olson, O.E., Searight, W.V., and Sandals, K.M., 1938 (Am. Jour. Botany, v. 25, p. 795, 796). See Gregory Member and Crow Creek Member of Pierre Shale.

GREGORY MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 10-20, pl. 3). Gregory member of Pierre shale--two lithologically and faunally distinct subdivisions. Lower Gregory consists of dark, bentonitic, bituminous shale which contains numerous fish scales. Upper Gregory is thin chalk, chalky argillaceous chalk, or marl. Basal member of Pierre formation includes all beds from the top of the Niobrara up to the manganiferous (Oacoma) beds south of the Great Bend; and northward from this locality, all beds lying below the Agency shale zone, which intervenes between the uppermost bed of the Gregory member and the manganese-bearing zone of the overlying Sully member.

Moxon, A.L., Olson, O.E., Searight, W.V., and Sandals, K.M., 1938 (Am. Jour. Botany, v. 25, p. 795, 796). Referred to Upper Gregory of the 1937 report as the Gregory marl [now called Crow Creek member - A.F.A.] and no longer used the name Gregory as a member of the Pierre formation, but as a subdivision of the Sully member. The Lower Gregory of the 1937 report was changed to Sharon Springs member of Pierre formation.

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 5, 11-17). The beds comprising the "upper" unit of Searight's

Sharon Springs member lie above a marl; thus the original Gregory member of Searight contained two marls. In an attempt to clarify the situation, Gries and Rothrock changed the name of the upper part of the Sharon Springs to Gregory member, and introduced the name Crow Creek marl and sand for Searight's upper Gregory marl and the thin sandstone directly beneath it.

Type locality: Exposure in Gregory County, South Dakota, at the south end of Rosebud bridge, south of Wheeler

Name: From Gregory County

Recent stratigraphic work by L.G. Schultz of the U. S. Geological Survey, as yet unpublished, has clarified some of the relationships of the Gregory and overlying Crow Creek (see Crow Creek Member) - A.F.A.

GROAT SANDSTONE (of Gammon Member)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., northwestern S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). Groat sandstone bed--ferruginous and glauconitic sandstone and siltstone, 150 feet thick in northern part of the area. Lies near top of Gammon ferruginous member of Pierre shale.

Robinson, C.W., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Described the Gammon ferruginous member along the west and north flanks of the Black Hills as being 800 feet thick and consisting of the following units, in descending order:

Upper unit--dark-gray mudstone and shale, with dark-gray iron-cemented septarian concretions; "H" bentonite is 75 feet below top.

Groat sandstone bed--light-gray glauconitic iron-stained sandstone above, becoming silty and shaly below, 75-125 feet thick.

Lower unit--same as upper, but concretions are not septarian.

The Groat rests on the Niobrara calcareous shale, and underlies the Mitten black shale member of the Pierre. Groat fossils are the same as those in the Telegraph Creek shale (below) and Eagle sandstone of Montana, and the same as those in the Shannon sandstone of the Powder River Basin in Wyoming.

Type locality: From exposures along Groat Creek in T. 7 S., R. 56 E., Carter County, Montana

Name: From Groat Creek

Gunn Member (of Stony Mountain Formation)

Upper Ordovician: Man., N. Dak., S. Dak., Sask.

Sinclair, G.W. and Leith, E.I., 1958 (Jour. Paleontology, v. 32, p. 243-244). Applied the name Gunn to the lower, or shale member of the

Stony Mountain, because of the confusion resulting from having the Stony Mountain shale member of the Stony Mountain formation, and the incorrectness of it. It is about 75 feet thick, but only the upper 15 feet are exposed.

Carlson, C.G. and Eastwood, W.P., 1962 (N. Dak. Geol. Survey Bull. 38, p. 6). Accepted the Saskatchewan name, Stoughton, for the unit (Sask. Geol. Society, 1958).

Type locality: Quarry on the ground of the Stony Mountain penitentiary, Saskatchewan

Name: From Gunn quarry

GUNTON MEMBER (of Stony Mountain Formation)

Upper Ordovician: Man., N. Dak., eastern Mont., northern S. Dak.

Okulitch, V.J., 1943 (Royal Soc. Canada Trans., ser. 4, v. 37, p. 60, 62-63). Upper member of the Stony Mountain formation. The exact age of the Gunton member is not established; it probably represents the transition from Ordovician to Silurian. The Gunton member is sometimes called Birse. Consists of dolomite, shale, and sandstone. Approximately 100 (?) feet thick in northwest South Dakota.

Baillie, A.D., 1952 (Man. Dept. Mines and Nat. Resources, Mines Br., Pub. 51-2, p. 34-35). Combined the Gunton and Birse as the upper member of the Stony Mountain in Manitoba.

Stearn, C.W., 1956 (Can. Geol. Survey Mem. 281, 162 p.). Indicated an Ordovician age for the Gunton, based on Ordovician fossils in the overlying Stonewall.

Carlson, C.G. and Eastwood, W.P., 1962 (N. Dak. Geol. Survey Bull. 38, p. 6). Described the Upper Ordovician and Silurian rocks of North Dakota, and recognized the Gunton as the upper member of the Stony Mountain, overlying the Stoughton Member of that formation, and underlying the Stonewall Formation. The Gunton interval appears to be as much as 60 feet thick in South Dakota.

Type locality: Not designated

Name: Apparently from the town of Gunton, Manitoba

GYPSUM SPRING FORMATION

Middle Jurassic: Wyo., S. Dak., Mont.

Love, J.D., 1939 (Geol. Soc. America Spec. Paper 20, p. 45-46). Gypsum Spring member (Chugwater formation)--lower half nearly pure-white cliff-forming gypsum, and upper half variegated shale, sandstone and limestone. About 250 feet thick in Maverick Springs oil field. Age Triassic (?). Overlain by Sundance formation and underlain by Popo Agie member of Chugwater. Sharp unconformity between Chugwater formation and Sundance formation.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 227-273). Recognized that a sequence of gypsiferous beds that underlies the Sundance formation in some parts of the Black Hills region, and which previously had been considered part of the Spearfish formation of Triassic age was probably correlative with the Gypsum Spring formation of central Wyoming. The lowest marine Jurassic beds (p. 237), herein included in the Gypsum Spring formation, comprise two laterally intergrading facies. One facies consists of gypsum, generally interbedded with soft maroon siltstone and shale, and attains locally 45 feet in thickness. It extends roughly on the western side of the Black Hills from Elk Mountain to Sundance and on the northeastern side from about 10 miles south of Sturgis to the vicinity of Spearfish. A second facies consists of interbedded gray shale, limestone, and dolomite, occurs in the northwestern end of the Black Hills, attains at least 21 feet in thickness, and is particularly well exposed on the road from Hulett to Alva.

Mapel, W.J. and Bergendahl, M.H., 1956 (Am. Assoc. Petroleum Geologists Bull., v. 40, p. 84-93). The gypsum and red-bed sequence which Imlay had placed in the Gypsum Spring formation in the Elk Mountain-Sundance region and in the Sturgis-Spearfish region is present also in the vicinity of Hulett, Wyoming, where it ranges in thickness from a feather edge to 125 feet. At Spearfish, South Dakota, it is 40 feet thick. It is absent along the southern and eastern sides of the Black Hills.

Although no diagnostic fossils have been reported from the Gypsum Spring formation in the Black Hills, the lithologic character and stratigraphic position of the formation suggest that it represents an eastward extension of the Gypsum Spring formation of central and northern Wyoming, and of the lower and middle parts of the Piper formation of Middle Jurassic age of south-central Montana. The Piper is Bajocian in age (J.A. Peterson, 1954, Am. Assoc. Petroleum Geologists Bull., v. 38, p. 464).

Type locality: Not designated

Name: From Gypsum Spring in Red Creek, Wyoming

HARMON LIGNITE BED (of Fort Union Formation)

Paleocene: N. Dak., S. Dak., Mont.

Leonard, A.G., 1908 (N. Dak. Geol. Survey 5th Bienn. Rept., p. 80-90). Near the base of the Fort Union formation is a group of thick lignite beds called by Leonard the Great Bend group. The Harmon bed is the upper one of three beds in the Great Bend lignite group, or bed I of the Great Bend group. About three-quarters of a mile above the Harmon Ranch, the thickest coal seam in Sec. 5, T. 138 N., R. 102 W., is approximately 11 feet, 8 inches.

Hares, C.J., 1928 (U. S. Geol. Survey Bull. 775, p. 49). An estimate based on the mapped outcrop of the Harmon bed or zone indicates that it

underlies at least 5,500 square miles, and it may be workable over a much greater area in adjacent fields. This compares with the areal distribution of the great Pittsburgh bed of Pennsylvania, Ohio, and West Virginia, which underlies somewhat less than 6,000 square miles.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the Harmon Lignite as being 420 feet below the top of the Tongue River, which is 600 feet thick, and resting on a 5-foot quartzite marker bed.

Type locality: Not designated

Name: From Harmon Ranch, North Dakota

Lodgepole Lignite Facies appears to be the equivalent of the Harmon coal of R.C. Kepferle and W.C. Culbertson, 1955 (U. S. Geol. Survey Bull. 1015-B), South Dakota, and is called Harmon in South Dakota by the U. S. Geological Survey (N.M. Denson, et al, 1959), and is so accepted by the South Dakota Geological Survey - A.F.A.

HARRISON FORMATION (of Arikaree Group)

Lower Miocene: Western Nebr., eastern Wyo., southern S. Dak.

Hatcher, J.B., 1902 (Am. Philos. Society Proc., v. 41, p. 117). Fine-grained rather incoherent sandstone permeated by great numbers of vertical siliceous tubes. Characterized by Daemonelix and other Miocene mammals. Well shown in bluffs of all small streams that head near summit of Pine Ridge in vicinity of Harrison, Nebraska. Covers considerable area, extending well into Wyoming. Part of Arikaree formation, of lower Miocene age, according to H.F. Osborn, 1909 (U. S. Geol. Survey Bull. 361, p. 65-75), and H.J. and M.C. Cook, 1933 (Nebr. Geol. Survey Paper No. 5, p. 44). Characterized by "pipy" concretions in lower 100 feet. Total thickness about 200 feet. The formation has thick channel fills.

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1251-1253, 1264, 1266-1269). Raised the Harrison to a formation, the upper one of the Arikaree group. Noted that the Harrison does not include the "so-called Upper Harrison (now Marsland formation), which came into use a little later (Peterson, 1906; Cook, 1915; Schultz, 1938)."

Collins, S.G., 1959 (S. Dak. Geol. Survey, Geol. Quad., Martin). Mapping in an area 125 miles northeast of the type locality, first recognized the Harrison Formation in South Dakota. It is similar to the Monroe Creek, but contains zones of concretions. It is approximately 150 feet thick.

Harksen, J.C., 1960 (S. Dak. Geol. Survey, Geol. Quad., Sharps Corner). Recognized in an area 75 miles northeast of the type locality that the Harrison is overlain by Rosebud Facies. Elsewhere, it is overlain by Ogallala Group. The Harrison is as much as 125 feet thick, and consists mainly of massive gray partly cross-bedded poorly consolidated fine sand, with thin layers of wormy grayish-white sandy marl. Large pipy concretions and small spherical concretions are abundant.

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that in the Porcupine Creek and Wounded Knee Creek area (Shannon County, South Dakota), the Rosebud Formation overlies the Harrison

Formation and is the most widely exposed lithic unit in the southern part of the area. In recent years, these beds have been referred to the Marsland Formation on the basis of the fossil fauna. Although partially equivalent in age, these beds are quite distinct lithologically from the Marsland or "Upper Harrison" of western Nebraska.
Type locality: Not designated
Name: From Harrison, Nebraska

Hartville Formation

Pennsylvanian and Mississippian: Southeastern Wyo. (Hartville uplift)

Smith, W.S.T. and Darton, N.H., 1903 (U. S. Geol. Survey Geol. Atlas, Folio No. 91, Hartville). Hartville formation--massive gray limestone, some beds containing chert nodules; occasional beds of white, gray, buff, and red sandstone. In lower part red shale and gray limestone; at base 50 feet of red quartzite streaked with white. Total thickness 650 feet. Conformably underlies Opeche formation and unconformably overlies Guernsey formation. Contains Pennsylvanian fossils in upper part and Mississippian fossils in lower part.

Condra, G.E. and Reed, E.C., 1935 (Nebr. Geol. Survey Paper No. 9). Reported results of a detailed lithologic, faunal, and correlation study of Hartville formation which they divided into six unnamed units, the upper one of which they concluded is probably Permian; the next underlying four fossiliferous units are certainly Pennsylvanian, while the stratigraphic relations of basal unit suggest it is lower Pennsylvanian.

Condra, G.E., Reed, E.C., and Scherer, L.J., 1940 (Nebr. Geol. Survey Bull. 13). Published a more detailed classification in which the rocks were subdivided into seven named groups and one formation. The term Hartville formation was not used, and the above units were subdivisions of the Pennsylvanian "subsystem" and the Permian system. The Cassa and Broom Creek are Permian Wolfcampian in age; and the Hayden-Roundtop-Reclamation-Fairbank are Des Moines.

Denson, N.M. and Botinelly, T., 1949 (U. S. Geol. Survey Oil and Gas Inv. Prelim. Map OM-102). A modified version of the earlier six-fold classification, in which Divisions 4 and 5 were mapped and discussed as a unit--has been used by the U. S. Geological Survey in surface mapping in the Hartville uplift area. Additional references:

Love, J.D., Denson, N.M., and Botinelly, T., 1949 (U. S. Geol. Survey Oil and Gas Inv. Series Prelim. Map OM-92). Faunal Atokan fusulinids near the contact of the Roundtop and Reclamation.

Love, J.D., Henbest, L.G., and Denson, N.M., 1953 (U. S. Geol. Survey Oil and Gas Inv. Chart OC-44). Faunal studies show that the upper sandstone-breccia part of the Hartville is probably Early Permian (Wolfcamp) in age; the middle dolomite-limestone part is of Virgil, Missouri, and Des Moines ages, and the lower limestone-shale part is of Atoka age. The fauna from the lowest few feet is not diagnostic and there is a possibility that these beds may be Late Mississippian.

Agatston, R.S., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 508-583). Used a modified version of Condra, et al (1940) in which the

Roundtop and Reclamation groups are combined as well as the Wendover, Meek, and Hayden groups. The term Hartville formation is preserved. The Cassa is Wolfcampian in age.

Bates, R.L., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1989-1990). Toward the north and east, between the Hartville uplift and the Black Hills, the Hartville formation merges with the Minnelusa. In the subsurface the two are indistinguishable in all respects except for anhydrite content. If the anhydrite in the upper part of the section has been leached, the term Hartville is applied; if the anhydrite is still present, the term Minnelusa should be used. [See Minnelusa - A.F.A.]

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that the Hartville and Minnelusa are equivalent.

Type locality: Not designated

Name: From Hartville, Wyoming

Hawarden Shale

Upper Cretaceous: Northwestern Iowa, southeastern S. Dak.

Keyes, C.R., 1912 (Iowa Acad. Science Proc., v. 19, p. 148). Hawarden terrane. Shale, 125 feet thick, underlying Niobrara terrane and overlying Crill terrane. All included in Coloradan series.

Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Hawarden terrane in South Dakota, 600 feet of shale, resting on Crill terrane and underlying Niobrara terrane.

Type locality: Not designated

Name: Probably from Hawarden, Sioux County, Iowa

This is the Carlile Shale of the South Dakota Geological Survey's classification. It may be the equivalent of division "C" of Nicollet's Dixon's Group in Nebraska, 12 miles above Sioux City - A.F.A.

Hay Creek Formation

Lower Cretaceous: Northeastern Wyo., western S. Dak. (Black Hills)

Jenney, W.P., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 2, p. 593, fig. 122, map). Hay Creek coal formation--in Hay Creek coal field, Crook County, Wyoming, consists of (descending): (1) massive sandstone, ocher-yellow weathering yellow-brown, underlain by gray and drab clay shales with local thin coals and plant remains, 10 to 20 feet; (2) coal, mined at Larrabee, Young, and Barrett, 2 to 6 feet; (3) gray clay-shale and sandy shale with plant remains, 20 to 35 feet; (4) soft gray or yellow sandstones with carbonized plant remains, 5 to 20 feet. Underlies Barrett shales, without positive evidence of

unconformity, and unconformably overlies Upper Jurassic Beulah clays (Morrison formation) in Black Hills. (In Wyoming these beds are mapped along South Fork of Hay Creek.)
Type locality: Not designated
Name: Presumably from Hay Creek, Crook County, Wyoming, and Butte County, South Dakota

Appears to be same as Lakota Formation, a better established name - A.F.A.

Hayden Formation

Pennsylvanian: Wyo., Colo., western S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 22, 45). Comprises Division 3 (Condra and Reed, 1935) of Hartville "formation"; thickness 120 feet. Varied lithology, mostly limestone.
McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that Hayden group is present in western South Dakota. At base is 20-50 feet of sand ("third Leo sand") and dolomite; upper part is 100 feet of sandy argillaceous dolomite, sand, shale, anhydrite. Rests on Roundtop, overlain by Meek.
Type locality: Hayden Cliff, Sec. 22, T. 27 N., R. 66 W., Platte County, Wyoming
Name: From Hayden Cliff

Hays Limestone Member (of Niobrara Marl)

Refers to Fort Hays Limestone Member, lower member of Niobrara Marl.

Heath Formation (of Big Snowy Group)

Mississippian: Mont., N. Dak., northwestern S. Dak. (?)

Scott, H.W., 1935 (Geol. Soc. America Proc., 1934, p. 367). Big Snowy group is made up of Kibbey, Otter, and Heath formations. Is mainly variegated shale with intercalated limestones and sandstones. Overlies Madison limestone.
Scott, H.W., 1935 (Jour. Geology, v. 43, p. 1016-1032). Heath formation--black petroliferous shales and sandstone, primarily black shales, forming upper formation of Big Snowy group. Thickness may reach 500 feet. In most sections three sandstone beds occur in upper half. On southeast flank of Big Snowy Mountains these sandstone beds have been grouped under name Van Dusen sand, which should be considered as a member at top of Heath formation. On northeastern flank of Big Snowy

Mountains, sandstone beds occupying same stratigraphic zone at top of Heath formation have been named by O.W. Freeman (1922) the Tyler sand, which should be treated as a member of Heath formation. The formation conformably underlies Amsden formation and conformably overlies Otter formation. Fossils closely related to fauna of Brazer limestone of Idaho and Moorefield formation of Arkansas are not older than Warsaw nor younger than Upper Chester.

Perry, E.S. and Sloss, L.L., 1943 (Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1287-1304). Described the Big Snowy group of the northern Great Plains, and showed (figs. 4, 5, 7) that only the lower formation, or Charles, is present to any extent in South Dakota, as the overlying Kibbey and Otter pinch out just within the State (fig. 7). The Heath at the top is present farther north, in Montana and North Dakota. The Charles is 600 feet thick in State Royalty #1 State oil test in northwestern South Dakota, but is absent in the Black Hills.

Willis, R.P., 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1940-1966). Extended the names Tyler-Heath eastward from central Montana into the Williston Basin of North Dakota. [This interval apparently includes the Fairbank sand of the Powder River Basin, and the lower part of the Reclamation-Roundtop - A.F.A.] The Tyler-Heath is overlain by the restricted Amsden, and is early Pennsylvanian in age (Morrowan-Atokan).

Type locality: North flank of Big Snowy Mountains in Sec. 6, T. 12 N., R. 20 E., Montana

Name: Derivation not indicated

The Heath may be present in South Dakota, although it has not yet been identified - A.F.A.

Hecla Facies (of Red River Limestone)

Middle Ordovician: Man., N. Dak., S. Dak.

Fuller, J.G.C.M., 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1345-1348). Stated that the Hecla beds of Baillie (1952, Man. Mines Branch Pub. 51-6, p. 15, 43 ff.; Baillie did not use the name Hecla, but had continued Foerste's, 1929, Dog Head) at the base of the Red River in the Williston Basin interior, are typically calcareous, variably sandy and argillaceous, sporadically glauconitic, and range between 10 and 40 feet in thickness. These beds yielded Middle Ordovician graptolites from State Royalty #1 State oil test in SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 35, T. 18 N., R. 1 E., in Harding County, South Dakota, according to C.E. Decker (1942, Am. Assoc. Petroleum Geologists Bull., v. 26, p. 123-125). The Hecla beds are the "transitional" beds of Furnish, et al (1936, Am. Assoc. Petroleum Geologists Bull., v. 20, p. 1329-1341) in the Black Hills. Fuller placed the Hecla beds in the Red River (p. 1341 and fig. 6), although C.A. Sandberg later said that

they are part of the underlying Winnipeg (1962, U. S. Geol. Survey TEI-809, p. 28), as did C.G. Carlson (1960, N. Dak. Geol. Survey, Bull. 35, p. 61) who stated that they are the upper part of the Roughlock.

Type locality: Hecla Island near Grindstone Point on the west shore of Lake Winnipeg, Manitoba

Name: From Hecla Island

HELL CREEK FORMATION

Upper Cretaceous: Mont., N. Dak., S. Dak.

Brown, Barnum, 1907 (Am. Mus. Nat. History Bull., v. 23, art. 33, p. 829-835). Hell Creek beds--fossil-bearing, fresh-water deposits of alternating sandstone and clay 560 feet thick in western half of Dawson County, Montana. Most constant member of series is massive sandstone at base, 0-160 feet thick. Probably continuous with the dinosaur-bearing beds of Little Missouri, Grand and Moreau Rivers, judging from fauna. Assigned to Upper Cretaceous: Separated from overlying Fort Union formation by 100 feet of lignite beds, here called Fort Union (?). Rests unconformably on Fox Hills formation. Lithologically similar in almost every respect to Ceratops beds of Converse County, Wyoming.

Thom, W.T., Jr. and Dobbin, C.E., 1924 (Geol. Soc. America Bull., v. 35, p. 484-499). Hell Creek member of Lance formation as here defined is "Hell Creek beds" plus "lignite beds" of Brown (1907) occupying the interval between Fox Hills sandstone below and the yellow Tullock member of the Lance above. In southwest North Dakota overlain by either Ludlow lignitic member of the Lance or the contemporaneous Cannonball marine member of the Lance, and it rests on Fox Hills sandstone. Consists of somber badlands clays, probably accumulated in topset swamps of a great delta, and fluviatile sandstones, the latter being more numerous and conspicuous toward southwest. Remains of a few small mammals have been found in the sandstone. Dinosaurs (including Triceratops) are numerous below the "A" lignite, which marks base of Brown's "lignite beds," but probably have not been found above that horizon. The Hell Creek and overlying strata are markedly calcareous in contrast with the brown member of the Fox Hills and older rocks, which are relatively free from lime. In Cedar Creek anticline, Montana, the Hell Creek member overlies the Colgate sandstone member of Fox Hills sandstone (diagram on p. 484 shows no unconformity above or below Hell Creek member).

Type locality: Hell Creek, Garfield County, Montana

Name: From Hell Creek

The Hell Creek has been recognized by the South Dakota Geological Survey since 1930 (W.V. Searight, S. Dak. Geol. Survey Rept. Inv. 3), and has

been mapped in 34 quadrangles in the northwestern part of the State, 1954-1962. In the eastern part of that area it has been divided into upper and lower units, separated by the Isabel-Firesteel Lignite Facies (which see) - A.F.A.

"Hell Creek lignite" (of Hell Creek Formation)

Upper Cretaceous: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the Hell Creek lignite as being 10 feet below the top of the Hell Creek formation.

The Hell Creek lignite apparently is the same as the lower coal of the Shadehill Lignite Facies of the South Dakota Geological Survey, mapped in 24 quadrangles of northwestern South Dakota. (See R.E. Stevenson, 1954, S. Dak. Geol. Survey, Geol. Quad., Lemmon) - A.F.A.

Hemingford Group

Miocene: Nebr., Wyo., southwestern S. Dak. (?)

Lugn, A.L., 1938 (Am. Jour. Science, 5th ser., v. 36, no. 213, p. 226, 227). The Hemingford group is a new division suggested by C.B. Schultz, although Lugn's is the first publication of the new term. The Hemingford group includes the Marsland and Sheep Creek formations (which see).

Elias, M.K., 1942 (Geol. Soc. America Spec. Paper 41, p. 124-125). Stated that the Hemingford group includes all rocks between the Harrison formation below and the Valentine formation above. It includes the Lower and Upper Sheep Creek faunas of Matthew and Cook, and at least part of their "Lower Snake Creek" fauna. It is a useful stratigraphic unit, of late Miocene age, and represents a complete climatic cycle according to the changes in the prairie vegetation.

Type locality: Not designated

Name: From Hemingford, Box Butte County, Nebraska

Apparently the name Hemingford Group has no application in South Dakota, as its two formations are not yet fully recognized there because of their nondistinctive lithologies. (See S.G. Collins, 1959 and 1960; S. Dak. Geol. Survey, Geol. Quads., Martin and Patricia.) - A.F.A.

Hermosa lens (of Newcastle Sandstone Member)

Upper Cretaceous: S. Dak.

Grace, R.M., 1952 (Wyo. Geol. Survey Bull. 44, p. 14, 17). An exposure of the Newcastle formation begins 16 miles south of Rapid City and extends for 3 miles, forming a dumbbell-shaped lens 16 feet thick on the south end. This lens is composed predominantly of sandstone and is located in T. 2 S., R. 8 E., near the town of Hermosa, South Dakota. For 20 miles south of Hermosa, the outcrop belt of the Newcastle formation is covered by a blanket of Tertiary rocks.
Type locality: T. 2 S., R. 8 E., near the town of Hermosa, South Dakota
Name: From Hermosa

HILLEN LIGNITE FACIES (of Ludlow Formation)

Paleocene: Northwestern S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 16, 23, 24, 25). In central Perkins County the Hillen coal zone is a zone of clay, shale, sandstone, and coal lying above the lower sandstone and below the Scotch Cap sandstone. The Hillen zone is especially well developed in the southern tier of sections across T. 19 N., R. 14 E., and crops out also in the southern part of T. 19 N., R. 13 E. Where best exposed, as in the mine in the NE$\frac{1}{4}$ sec. 31, T. 19 N., R. 14 E., the lower part of the zone consists of four coal beds. The lower three beds are separated by thin beds of clay. The third coal in the succession is underlain by sandstone in typical exposures, and is in turn overlain by sandstone. Underclays separate the lower coals of the Hillen zone. The total thickness of the Hillen coal zone is probably approximately 90 feet.
Stevenson, R.E., 1956 (S. Dak. Geol. Survey, Geol. Quad., Ludlow). About 140 feet above the Shadehill is another lignite facies, the Hillen. It is approximately 35 feet of interbedded gray, slightly bentonitic clay and sandy clay, brown peat-clay, black lignitic peat-clay, and three to five seams (6 inches to 123 inches thick) of black blocky to fissile lignite. The facies includes the Widow Clark seam of Winchester (1916) and Searight (1930).
Type locality: Not designated
Name: From Hillen coal mine, Perkins County, South Dakota

This facies is present about 100-150 feet above the base of the Ludlow, and about 200-250 feet below the top of the Ludlow throughout 11 quadrangles of northwestern South Dakota, and appears to include the coals called the Bar-H and Mendenhall lignites of N.M. Denson, G.O. Bachman, and H.D. Zeller, 1959 (U. S. Geol. Survey Bull. 1055) - A.F.A.

HULETT SANDSTONE MEMBER (of Sundance Formation)

Upper Jurassic: Wyo., S. Dak.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 255-257). The Hulett sandstone member of the Sundance formation includes 25-120 feet of marine sandy beds consisting mainly of grayish moderately hard thin to thick-bedded, fine-grained calcareous glauconitic ripple-marked sandstone. It grades into the underlying gray Stockade Beaver shale member and into the overlying maroon sandstone and siltstone of the Lak member of the Sundance, but the contacts can be selected within a few feet.

The Hulett sandstone member is generally well exposed along the southeastern and southern margins of the Black Hills where it ranges in thickness from about 25 to 55 feet, and is characterized by hard microglauconitic, yellowish to greenish-gray thin-bedded slabby sandstone, interbedded with considerable gray to greenish-gray sandy shale. Sandstone predominates in the lower part of the member, and locally forms low cliffs. Northward the Hulett sandstone member thickens in an irregular manner to about 120 feet along Redwater Creek at the north end of the Black Hills.

Type locality: North side of Bush Canyon, about $2\frac{1}{2}$ miles north of Hulett, Wyoming, in Secs. 25 and 36, T. 55 N., R. 65 W.

Name: From Hulett

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic members (except the Gypsum Spring) including the Canyon Springs at the base and the Redwater at the top. In the Williston Basin, the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota, the Survey uses the term Sundance Formation - A.F.A.

ICE BOX SHALE MEMBER (of Winnipeg Formation)

Middle Ordovician: S. Dak.

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 44-46). A silty, fissile, greenish-gray to olive-colored shale; soft, noncalcareous, occasionally platy to splintery, with black phosphate nodules several millimeters in diameter in upper part; thickness 30-35 feet; overlies the Aladdin sandstone and underlies Roughlock siltstone. (This bed was the bottom of the redefined Whitewood of Furnish, Barragy, and Miller, 1936. See Whitewood limestone.)

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35, p. 58-59). Accepted Ice Box as the lower member of the Winnipeg in South Dakota (middle member in the deeper part of the Williston Basin in North Dakota).
Fuller, J.G.C.M., 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1341). Agreed with Carlson.
Type locality: Secs. 14 and 23, T. 5 N., R. 3 E., about half a mile west of the junction of U. S. Highways 14 and 85, Lawrence County, South Dakota
Name: From Ice Box Gulch

Inoceramus beds

Upper Cretaceous: Northwestern Iowa, southeastern S. Dak.

White, C.A., 1870 (Geol. of Iowa, v. 1, p. 26, 239, 293-294, chart opp. p. 168). Described the Inoceramus beds as 50 feet of calcareous material, in three units (descending):
Shale and chalky limestone;
Thin and regularly bedded chalk with much iron oxide;
Fine-grained, soft, poorly stratified calcareous silt.
White noted (1870, v. 2, p. 199) that these rocks are present in [South] Dakota, 30 miles above Sioux City, just above the level of the Sioux River, opposite Indian Creek.
Type locality: Not designated
Name: Paleontological

These strata are called Greenhorn Limestone by the South Dakota Geological Survey - A.F.A.

Interior weathered zone

Upper Cretaceous: Southwestern S. Dak., northwestern Nebr.

Ward, Freeman, 1922 (S. Dak. Geol. and Nat. Hist. Survey Bull. 11, p. 18-20, and map). Interior phase of the Pierre--thin-bedded sandy shale, predominantly yellow-brown, but variegated with browner and purpler colors in upper portions, forming top 35 feet of Pierre in southeastern part of Pennington County, and southwestern part of Jackson County, South Dakota. Fossils warrant placing the beds in the Pierre, although in field they were called Fox Hills. If accepted as Pierre, the strong color contrast and sandier texture require explanation. Grades into underlying typical Pierre, which consists of dark gray-blue shale containing occasional thin calcareous concretionary lenses. Unconformably underlies Chadron formation (Oligocene). The Nebraska Geological Survey has called these beds "Rusty member" of the Pierre (E.F. Schram - personal communication).

Wanless, H.R., 1923 (Am. Philos. Society Proc., v. 62, p. 194). Interior formation of Ward consists of 0-45 feet of lavender and blue clays weathering to rusty-brown color, diversified by calcareous nodules with cone-in-cone structure and concentrically banded nodules of pink or red color strongly impregnated with oxides of iron. Ward believed that these clays represent Fox Hills. W.C. Toepelman (1922, S. Dak. Geol. and Nat. Hist. Survey Bull. 11, p. 64) suggested that they may be a slightly sandy phase of Pierre, formed by weathering and leaching, rather than that their characteristics are primary, and Wanless agreed. Rests on Pierre shale with very irregular surface.

Ward, Freeman, 1926 (Am. Jour. Science, 5th ser., v. 11, p. 350-352). Type locality of Interior formation is a few miles west of Interior, Jackson County, South Dakota, where thickness is almost 30 feet. It is 45 feet thick 21 miles north of type locality. In Ward's 1922 report there was some disagreement as to whether the beds were basal Fox Hills or upper Pierre, the latter position finally being agreed upon. Since then, Ward has seen additional exposures, and concluded that Interior formation is really Fox Hills.

Type locality: A few miles west of Interior, Jackson County, South Dakota
Name: From Interior

Dunham, R.J., 1961 (Geology of Uranium in Chadron area, Nebr.-S. Dak.: U. S. Geol. Survey Open File Report, p. 55-98). Discussed the weathered zone formed on rocks ranging from the Pierre Shale downward to the Niobrara Marl, and Carlile Shale, and concluded that it is Eocene in age. This is the same weathered zone that has been called Interior Formation - A.F.A.

INTERLAKE GROUP

Silurian: Man., Sask., N. Dak., northwestern S. Dak., eastern Mont.

Baillie, A.D., 1951 (Man. Dept. Mines and Nat. Resources, Div. Mines Pub. 50-1, p. 6). Light-colored 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. The Interlake group is divided into five formations, but at present only the basal formation (Stonewall) has been named. Upper formation of Interlake shows good porosity. Great difference of opinion exists as to both top and bottom of this unit as found in the subsurface of the Williston Basin. Thickness 200-800 feet.

Stearn, C.W., 1953 (Geol. Soc. America Bull., v. 64, p. 1477-1478). Noted that the Stonewall fauna is late Ordovician in age, and recommended its removal from the Interlake for that reason, because the rest of the Interlake is Middle Silurian in age. For lithologic reasons, however, J.M. Andrichuk, 1959 (Am. Assoc. Petroleum Geologists Bull.,

v. 43, p. 2381) retained the Stonewall in the Interlake, as the most recognizable unconformity occurs at its base.

More recently, J.G.C.M. Fuller, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1350-1351) and C.G. Carlson and W.P. Eastwood, 1962 (N. Dak. Geol. Survey Bull. 38, p. 8-9) in the Williston Basin and North Dakota, respectively, sided with Stearn.

Fuller described the Interlake as a succession of pale-colored dolomite, anhydrite, and calcareous sandstone. He mapped the Interlake as three unnamed units, two of which are present in the northwestern part of South Dakota (figs. 17, 19). The thickness of the Interlake in South Dakota reaches 300 feet. The Interlake rests conformably on the underlying Stony Mountain (Carlson and Eastwood, 1962, p. 10), and is unconformably overlain by the Souris River Formation of Devonian age.

Type locality: Quarries at Stonewall, Manitoba

Name: From exposures in Interlake area, Manitoba

The South Dakota Geological Survey agrees with Andrichuk, and does not consider the Stonewall separately, but includes it in the Interlake - A.F.A.

INYAN KARA GROUP

Lower Cretaceous: Western S. Dak., northeastern Wyo., southeastern Mont.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). An extremely variable group, consisting of discontinuous beds of sandstone, sandy shale, conglomerate, lignite and variegated siltstone. In general, the higher sandstones are more heavily iron-stained and slabby, and the lower ones lighter gray and massive. Continental fossils occur throughout greater part but marine fossils in upper 20 feet. Thickness 150-350 feet. Includes (descending) Fall River sandstone (so-called Dakota sandstone of previous reports on northeast Wyoming and southeast Montana), Fuson formation, and Lakota sandstone.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 26-33). Redefined the Inyan Kara group to show the change in environment of deposition from continental (Lakota) to marginal marine (Fall River). The upper one-third of the Inyan Kara is thus well-bedded fine-grained brown-weathering sandstone with intercalated gray to black shale and siltstone; the lower two-thirds is much more variable, containing varicolored and variegated claystone and siltstone, and massive locally poorly sorted sandstone, carbonaceous shale and coal, and lacustrine shale and limestone. These two units are separated by a transgressive disconformity. The upper unit (Fall River) is 120-150 feet thick, and the lower is highly variable in both thickness and lithology, ranging from 60 to 200 feet in the northern Black Hills, to more than 200 in

the southern. The contact with the underlying Morrison is locally difficult to define because of the lack of a persistent lithologic change (Waage, 1959, p. 50).
Type locality: Not designated
Name: From Inyan Kara Creek, northeastern part of Moorcroft Quadrangle, Wyoming

ISABEL-FIRESTEEL LIGNITE FACIES (of Hell Creek Formation)

Upper Cretaceous: S. Dak.

Curtiss, R.E., 1952 (S. Dak. Geol. Survey, Geol. Quad., Isabel). The coal bed varies from 0-6 feet in thickness. The coal often contains "blackjack," a tough carbonaceous clay. "Pseudoscoria," a buff to red clinkered claystone, indicates the former presence of the coal. Ashes are frequently encountered directly beneath the "pseudoscoria." Fossil resin, pyrite, marcasite, and limonite occur spasmodically in the coal.
Type locality: Not designated
Name: From towns of Isabel and Firesteel, Dewey County, South Dakota, and the Firesteel Coal Company

"J" sand

Lower Cretaceous: Southeastern Wyo., western Nebr., northeastern Colo., southwestern S. Dak.

An informal term for the lowest of a series of oil sands that are productive in the Denver-Julesberg Basin. Equivalent to part of the Mowry or Newcastle.
Wulf, G.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1384). Stated that the exact relations of the Muddy and the "J" sands with the Newcastle Sandstone are unclear.

JEFFERSON GROUP

Middle Devonian: Mont., western Wyo., Idaho, Utah, N. Dak., S. Dak.

Peale, A.C., 1893 (U. S. Geol. Survey Bull. 110, p. 27-28). Brown and black crystalline limestones, 640 feet thick; underlies Three Forks shale and conformably overlies Gallatin formation. Well exposed in hills on both sides of Missouri River just below junction of the Three Forks of the Missouri, and on both sides of the Jefferson a few miles above its mouth, in Three Forks quadrangle, southwestern Montana.
Probably correlated with part of Beaverhill Lake formation of Saskatchewan, and Manitoba formation of North Dakota and Manitoba.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2315). Divided the Jefferson group into the Duperow, below, and the Birdbear formation, and showed their distribution in South Dakota (fig. 3). The Jefferson group is the equivalent of the Saskatchewan group of the Alberta Basin (N. Dak. Geol. Society, 1961, p. 24), and reaches a thickness in South Dakota of 300 feet (pl. 4).
Type locality: Not designated
Name: From Jefferson River, Montana

KEYHOLE SANDSTONE MEMBER (of Fall River Formation)

Lower Cretaceous: Northern Black Hills, S. Dak. and Wyo.

Davis, R.E. and Izett, G.A., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2745-2750). Applied the name Keyhole to a prominent sandstone in the Fall River of the northern Black Hills. In this area the Fall River may be divided into (descending):

Nonresistant dark-gray fissile siltstone and silty shale interbedded with light-gray thin-bedded siltstone and silty to very fine-grained sandstone; as much as 60 feet thick.

Keyhole sandstone--light- to medium-brown very fine-grained massive cross-stratified sandstone, with iron-cemented concretions; bottom contact gradational; 10-60 feet thick.

Nonresistant unit like the upper one; 50-75 feet thick.

Type locality: NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 21, T. 51 N., R. 66 W., Crook County, Wyoming
Name: From Keyhole Dam, one-quarter of a mile south of type locality

KIBBEY SANDSTONE (of Big Snowy Group)

Mississippian: Central and eastern Mont., western N. Dak., northwestern S. Dak.

Weed, W.H., 1899 (U. S. Geol. Survey Geol. Atlas, Folio No. 55). Constituted the lowest beds of the Quadrant formation. [The U. S. Geological Survey adopted Kibbey sandstone member of Quadrant formation in 1907 - Wilmarth, 1938.]

Scott, H.W., 1935 (Jour. Geology, v. 43, p. 1011-1032). Big Snowy group--new name for lower part of beds heretofore assigned to Quadrant formation in central Montana. Divided into three conformable formations in descending order, Heath formation (new name), Weed's Otter formation, and Weed's Kibbey formation. Red to yellow dirty sand and red shale, with occasional gypsum or anhydrite. Few limestones. Thickness 50-300 feet.

Perry, E.S. and Sloss, L.L., 1943 (Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1287-1304). Described the Big Snowy group of the northern Great Plains, and showed (figs. 4, 5, 7) that only the lower formation,

or Charles, is present to any extent in South Dakota, as the overlying Kibbey and Otter pinch out just within the State (fig. 7). (The Heath at the top is present farther north, in Montana and North Dakota.) The Charles is 600 feet thick in State Royalty #1 State oil test in northwestern South Dakota, but is absent in the Black Hills.

The Kibbey Sandstone, according to C.A. Sandberg, 1962 (U. S. Geol. Survey TEI-809, p. 65-66) is present in northwestern South Dakota as the only representative of the Big Snowy group. It is grayish-red siltstone, sandstone, and shale interbedded with limestone, dolomite, and anhydrite. It is usually divided into three units on the basis of a middle limestone, which is a good marker bed on mechanical well logs. The Kibbey is late Mississippian in age.

Type locality: Not designated

Name: From Kibbey Post Office, central Montana

Kimball Formation (of Ogallala Group)

Pliocene: Nebr., southwestern S. Dak. (?)

Lugn, A.L., 1938 (Am. Jour. Science, 5th ser., v. 36, no. 213, p. 224, 227). A fourth and uppermost formation in the Ogallala group is the Kimball formation from its typical occurrence at the highest remnant levels of the High Plains in Kimball County, Nebraska. The thickness of the Kimball formation ranges up to 30 or 40 feet, and it consists of silt, clay, and fine sand more or less cemented with caliche, with one or two algal limestone beds at the very top. It is pinkish to reddish, contains the fossil seeds Echinochloa, Panicum, and Biorbia.

Type locality: Not designated

Name: From Kimball County, Nebraska

The Kimball has not yet been mapped in South Dakota, although some geologists think that it may be present along the Nebraska border - A.F.A.

LAK SHALE MEMBER (of Sundance Formation)

Upper Jurassic: Wyo., S. Dak.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 257-259). The Lak member of the Sundance formation is herein defined as 25-100 feet or more of dominantly red fine-grained sandstone and siltstone overlying gradationally the cliff-forming Hulett sandstone member and underlying sharply the glauconitic Redwater shale member. At type section, the Lak member consists of at least 80 feet of soft maroon sandstone and siltstone, including a 2-foot bed of greenish-gray siltstone 15 feet below the top. The thickness of the Lak member changes considerably within short distances. Coarser grained sandstone is most common in the southern and southeastern parts of the

Black Hills, particularly east of Hot Springs. The member is softest, least sandy, and least conspicuous in the northwestern part of the Black Hills. It is differentiated from the red Spearfish formation by being a somewhat lighter red, by lacking gypsum in some areas, and by being more poorly-bedded.

Type locality: West side of Stockade Beaver Creek, in Sec. 18, T. 45 N., R. 60 W., about 5 miles northeast of Newcastle, Wyoming

Name: From Lak reservoir on the L.A.K. ranch, Wyoming

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic members (except the Gypsum Spring) including the Canyon Springs at the base and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

LAKOTA FORMATION (of Inyan Kara Group)

Lower Cretaceous: Western S. Dak., eastern Wyo., southeastern Mont., northwestern Nebr.

Darton, N.H., 1899 (Geol. Soc. America Bull., v. 10, p. 387). Coarse buff sandstone with fine clays and local coal beds; overlies Beulah shale (= Morrison formation) in Black Hills, South Dakota. Early Cretaceous or Jurassic in age.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 526). Massive buff coarse cross-bedded sandstone with some intercalated shale and locally coal beds. Top member is dull-yellow sandstone. Thickness 200-300 feet. If not Jurassic it represents earliest deposit of Lower Cretaceous. Contains local unconformities. Underlies Minnewaste limestone and unconformably overlies Jurassic Beulah shale (= Morrison formation). Included in Dakota sandstone of early reports.

Darton, N.H. and O'Harra, C.C., 1909 (U. S. Geol. Survey Geol. Atlas, Folio No. 164, p. 4). Type locality of Lakota sandstone is Lakota Peak, a summit on hogback range 4 miles northwest of Hermosa, South Dakota.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 74). In outcrops around the Black Hills, 75-485 feet of Lakota have been measured. It can be traced eastward in subsurface to the town of Kadoka, Jackson County; east of that point the correlation of various Cretaceous sands is not satisfactory.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 26-33). Redefined the Inyan Kara group to show the change in environment of deposition from continental (Lakota) to marginal marine (Fall River). The upper one-third of the Inyan Kara is thus well bedded fine-grained

brown-weathering sandstone with intercalated gray to black shale and siltstone; the lower two-thirds is much more variable, containing varicolored and variegated claystone and siltstone, and massive locally poorly sorted sandstone, carbonaceous shale and coal, and lacustrine shale and limestone. These two units are separated by a transgressive disconformity. The upper unit (Fall River) is 120-150 feet thick, and the lower is highly variable in both thickness and lithology, ranging from 60-200 feet in the northern Black Hills, to more than 200 in the southern. The contact with the underlying Morrison is locally difficult to define because of the lack of a persistent lithologic change (p. 50).

Post, E.V. and Bell, Henry, 1961 (U. S. Geol. Survey Prof. Paper 424-D, p. 173-178). Recognized that the overlying Fuson Shale could be distinguished from the lower (mainly sandstone) part of Waage's Lakota Formation, whether the intervening Minnewaste Limestone was present or not. To the lower unit of the Lakota Formation they gave the name Chilson. The Chilson is composed of two conspicuous fluvial sandstone bodies, each of which fingers laterally into flood-plain, lacustrine, or paludal facies. The lower body ranges from 0 to 400 feet thick; the upper body ranges from 0 to 437 feet. The Chilson rests on either the Morrison Shale or the Unkpapa Sandstone.

Gries, J.P., 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., p. 163, fig. 3). Disagreed with Waage on the limited geographic usefulness of the Lakota, and stated that it should be recognized eastward from the Black Hills as far as the overlying marine Fall River and Skull Creek Formations can be identified.

Type locality: Lakota Peak, a summit on hogback range 4 miles northwest of Hermosa, South Dakota

Name: Derived from one of tribal divisions of Sioux Indians

Lance Formation

Upper Cretaceous: Wyo., Mont., western N. Dak., southwestern S. Dak., northwestern Colo.

Hatcher, J.B., 1903 (Am. Geologist, v. 31, p. 369-375). Lance Creek (Ceratops) beds--the name Ceratops beds cannot be used for these Wyoming deposits. Conformably overlie the Fox Hills in this region, corroborated by investigations of T.W. Stanton and F.H. Knowlton. (On p. 374, Hatcher called these beds the Laramie (Lance Creek) beds of Converse County, Wyoming.) The beds are overlain by Fort Union.

Stanton, T.W., 1910 (Am. Jour. Science, 4th ser., v. 30, p. 172-188). Lance formation (Ceratops beds)--the name Lance formation has recently been adopted by the U. S. Geological Survey for the "Ceratops beds" of eastern Wyoming and adjacent areas. It is an abbreviated form of "Lance Creek beds." A real transition from the marine Cretaceous Fox Hills sandstone into Lance formation, and sedimentation was practically

continuous from the one into the other and probably on through the (overlying) Fort Union. If true, then the Lance formation includes or forms part of the Laramie.

Lloyd, E.R. and Hares, C.J., 1915 (Jour. Geology, v. 23, p. 523-547). In a large region west of Missouri River in North Dakota and South Dakota, the Lance formation consists of two distinct parts. A lower nonmarine part contains a fauna closely resembling, but not identical with, that of Fox Hills sandstone. The upper part, on account of its peculiar fauna, has been mapped separately and named Cannonball marine member of Lance formation. Farther west, nonmarine beds bearing lignite and occupying a similar stratigraphic position have been named Ludlow lignitic member of the Lance. [See Cannonball Marine Member of Lance Formation - A.F.A.]

Type locality: Exposures on Lance Creek, Niobrara County, Wyoming

Name: From Lance Creek

The name Lance is not used by the South Dakota Geological Survey, which instead uses Hell Creek (below), and Ludlow and Cannonball (above) - A.F.A.

Lance Creek beds

See Lance Formation.

"Leo sand" (of Minnelusa Formation)

Pennsylvanian: S. Dak. (Black Hills), Wyo.

A driller's term used to designate a series of thin sandstones, three or four of which are prominent enough to be noted and given numbers by drillers. In most well logs these have been separated by anhydrite beds. The name Joss has been applied to a lower sand of the Leo sands in the southern Black Hills.

Rothrock, E.P., 1949 (S. Dak. Geol. Survey Rept. Inv. 62, p. 30). To date, the Leo sands are the most promising oil horizons in the formation. The thickness of the Leo sand zone is not well defined. In the Black Hills Ordnance Depot #1 water well, a thickness of 170 feet was found.

Bates, R.L., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1995). Stated that the Leo sand and sands are present in the Minnelusa below the "Red Marker" shale in the Lance Creek oil field of eastern Wyoming. R.S. Agatston (1954, Am. Assoc. Petroleum Geologists Bull., v. 38, p. 533) had earlier noted these sands in nearby oil fields, in the Hartville formation (equivalent to the Minnelusa).

Type locality: Not designated

Name: Apparently first used in print by E.W. Krampert, 1940 (Kans. Geol. Survey Gdbk., 14th Ann. Field Conf., p. 152), in the Lance Creek oil field, Wyoming

Leptauchenia beds

A paleontological name applied to upper part of Brule clay (Oligocene) of western Nebraska and South Dakota. Also called Protoceras beds. (See Brule Formation.)

Little White River beds

Pliocene: South-central S. Dak.

O'Harra, C.C., 1920 (S. Dak. Sch. Mines Bull. 13, p. 36, 47-48). Little White River beds, the lower Pliocene. Hipparion zone of White River Badlands. Unconformably overlies upper Miocene Procamelus zone of Nebraska beds in Little White River valley (S. Dak.) and the valley of the Niobrara (Nebr.). Fossiliferous. Local names have been used to designate the beds in the localities where fossil hunting has been carried on. Among these names are Snake Creek, Oak Creek, Little White River, Niobrara River, and Spoon Butte.

Type locality: Along Little White River, South Dakota

Name: From valley of Little White River

Mapped as Ogallala by South Dakota Geological Survey - A.F.A.

Lodgepole Lignite Facies (of Tongue River Formation)

Paleocene: S. Dak.

Winchester, D.E., Hares, C.J., Lloyd, E.R., and Parks, E.M., 1916 (U. S. Geol. Survey Bull. 627, p. 78). Description of portion of Fort Union formation, bearing lignite beds near Lodgepole Buttes, South Dakota.

Searight, W.V., 1930 (S. Dak. Geol. Survey Rept. Inv. 3, p. 45, 46). Description of portion of Fort Union formation near Lodgepole. The region around Lodgepole comprises the greater portion of the Fort Union coal of the State. The coal underlies two important areas, one south and one north of Lodgepole. The section south of Lodgepole totals 69 feet in thickness with thickest coal bed being 8 feet. The section north of Lodgepole totals 33 feet, the thickest coal seam here being 8 feet.

Stevenson, R.E., 1954 (S. Dak. Geol. Survey, Geol. Quad., Lemmon). About 90 feet above the base of the Tongue River formation is the Lodgepole lignite facies, a discontinuous seam 9-23 inches thick. Consists of black, fissile clayey lignite with associated clays and peat clays. About 3 feet thick. In the next quadrangle west (Haynes) it reaches a thickness of 26 feet.

This coal facies appears to be the equivalent of the Harmon lignite of R.C. Kepferle and W.C. Culbertson, 1955 (U. S. Geol. Survey

Bull. 1015-E), in the Scranton, North Dakota area, 15 miles northwest of Lodgepole, South Dakota, and is called Harmon in South Dakota by the U. S. Geological Survey (Denson, N.M., et al, 1959). Also, the name Lodgepole is preoccupied. (See Harmon Lignite Bed.) - A.F.A.
Type locality: Not designated
Name: From Lodgepole, South Dakota

LODGEPOLE LIMESTONE (of Madison Group)

Lower Mississippian: Mont., N. Dak., S. Dak.

Collier, A.J. and Cathcart, S.H., 1922 (U. S. Geol. Survey Bull. 736F, p. 173). In this part of Montana (Little Rocky Mountain region) the Madison limestone becomes a group, divisible into two distinct formations, here named Lodgepole limestone (lower) and Mission Canyon limestone (upper). The Lodgepole consists of 800 feet of thin-bedded limestone and shale containing many fossils. Overlies Jefferson limestone.

Andrichuk, J.M., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2170-2210). Stated that the lower unit of his Madison in Wyoming and Montana (Lodgepole and lower part of the Mission Canyon) is porous crystalline dolomite in the Black Hills area and thins from 500 feet at the North Dakota border to 200 feet at the Nebraska-South Dakota border with Wyoming; he separated the lower 50 feet as the Englewood formation, consisting of purplish-gray dolomitic and silty shales and minor shaly dolomites.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 59). Stated that the Lodgepole basin facies is dark-colored organic limestone and shale, whereas the shelf facies is light-colored fragmental limestone.
Type locality: Exposures in Lodgepole Canyon, Montana
Name: From Lodgepole Canyon

Loup Fork Group

Miocene, Pliocene, Pleistocene (?): Nebr., S. Dak., eastern Colo.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 415-435). Loup River beds--fine loose sand with some layers of limestone, thickness 300-400 feet. All fresh water fossils. Assigned to Pliocene. Extends from Loup Fork of Platte River north to Niobrara River and south to unknown distance beyond the Platte. Overlies the White River group (Miocene). [No later formation than Loup Fork mentioned. Apparently included Ogallala and Arikaree Groups, which overlie White River Group (Oligocene) - A.F.A.]

Cope, E.D., 1880 (U. S. Geol. and Geog. Survey Terr. Bull. 5, p. 50-51). Loup Fork divided into Procamelus beds above and Ticholeptus beds below. Underlies Pliocene and overlies White River.

Cope, E.D., 1888 (Am. Geologist, v. 2, p. 290-292). Loup Fork formation (upper Miocene) has wide extent. Overlies White River beds in Nebraska, Wyoming, and Colorado, and extends into Kansas, where it rests on Cretaceous. There is a second area in northern central New Mexico. According to King is 2,000 feet thick in Wyoming, but thins gradually to east and is only 250 feet thick on White River, according to Hayden. Is same as Niobrara of Marsh.

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 732, 734, 735). Divided typical Loup Fork beds of Nebraska into Ogallala (above) and Arikaree formation (below).

Type locality: Not designated

Name: From Loup Fork of Platte River, Nebraska

Loupian Series

A name introduced by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Arikaree deposits of South Dakota.

Loup River beds

A name applied by some geologists (F.B. Meek and F.V. Hayden, 1862) to deposits called "Loup Fork beds" by later geologists; since known as Ogallala and Arikaree Groups. (See Loup Fork Group.)

"Lower micaceous bentonite" (of Pierre Shale)

Upper Cretaceous: S. Dak.

Petsch, B.C., 1946 (S. Dak. Geol. Survey Rept. Inv. 53, p. 35, fig. 5, 10, 24). A layer of bentonite about 4 inches thick, which has many biotite mica flakes in it, marks the base of the Oacoma zone. The "Lower micaceous bentonite" is a key bed of the Oacoma [Manganiferous Shale Facies - A.F.A.] and can be traced for many miles. It is 32-38 feet below the "Upper micaceous bentonite."

Type locality: Not designated

Name: From lithology

"Lower nodular zone"

See Scenic Member.

LUDLOW FORMATION (of Fort Union Group)

Upper Cretaceous: Southwestern N. Dak., northwestern S. Dak., northeastern Mont.

Lloyd, E.R. and Hares, C.J., 1915 (Jour. Geology, 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 in Perkins County, South Dakota, where it merges with Cannonball marine member. In vicinity of Ludlow, South Dakota, it consists of 350 feet of loosely consolidated buff and cream-colored calcareous sandstone and shale with interbedded lignite. It contains most of lignite of South Dakota, and the presence of this lignite is one of the chief criteria for considering it a distinct member of Lance formation. In South Dakota its lithologic character is very like the Fort Union group, and its fossil flora so far as determined is identical with that of Fort Union; its flora is unlike that of lower part of Lance, but its lithology resembles lower part of Lance except for numerous lignite beds. It is this variation in color and lithology that renders its separation from overlying Fort Union so difficult. All of the Triceratops collected in Little Missouri country came from below the T-Cross lignite bed (in lower part of Ludlow), and the oysters from above it. Calvert, 1912 (U. S. Geol. Survey Bull. 471, p. 197), however, stated that ceratopsian bones of Montana age were found just above the lowest persistent lignite bed, but there is certainly nothing in character of overlying strata to suggest that similar bones do not occur therein up through a stratigraphic distance of perhaps 500 feet. The T-Cross lignite bed was mapped westward to Montana state line, and it is undoubtedly the same lignite as the "persistent lignite" referred to above.

Dorf, E., 1940 (Geol. Soc. America Bull., v. 51, p. 213-236). The paleobotanical evidence supports the known vertebrate evidence in placing the boundary between the true Lance and the Fort Union at the base of the nondinosaur-bearing Tullock, Ludlow, or Bear formations or their equivalents--in other words, at the top of the Triceratops-bearing Hell Creek or Lance formations as originally defined. Such a view is not contradicted by the marine invertebrates of the Cannonball formation--which interfingers with the Ludlow.

The U. S. Geological Survey considered the Ludlow as Upper Cretaceous (Wilmarth, 1938) until N.M. Denson, et al, 1955 (U. S. Geol. Survey, Map C-33) classified it and the Cannonball and the Tongue River, all members of the Fort Union formation, as Paleocene in age.

Brown, R.W., 1952 (Billings Geol. Survey, 3rd Ann. Field Conf., p. 91). Pointed out that the Fort Union in eastern Montana is divided into Tullock sandstone (below), Lebo shale, Tongue River sandstone, and Sentinel Butte shale. However, east of Miles City, Montana, the two

lower members merge in facies so that they are lumped as Ludlow in North Dakota and South Dakota. [Similarly, farther east the Cannonball marine facies replaces the upper part of the Ludlow Formation, as is shown by 10 geologic quadrangle maps of the South Dakota Geological Survey, 1954-1957 - A.F.A.]

Type locality: Vicinity of Ludlow, Harding County, South Dakota

Name: From Ludlow

MADISON GROUP

Lower Mississippian: Wyo., Mont., N. Dak., S. Dak., Sask., Man.

Peale, A.C., 1893 (U. S. Geol. Survey Bull. 110, p. 33-39). Madison limestone--consists of (descending): massive jaspery limestone, 575 feet; light bluish-gray massive limestone, 350 feet; dark-colored compact laminated limestone, 325 feet. Listed fossils. Rests on Devonian Threeforks shale and is overlain by Quadrant formation.

Collier, A.J. and Cathcart, S.H., 1922 (U. S. Geol. Survey Bull. 736F, p. 173). In this part of Montana (Little Rocky Mountain region) the Madison limestone becomes a group divisible into two distinct formations, here mapped and named Lodgepole limestone (lower), and Mission Canyon limestone (upper).

Sloss, L.L., 1952 (Billings Geol. Society, 3rd Ann. Field Conf., p. 66-67). Described the Madison rocks of the Williston Basin as consisting of three formations, from top to bottom the:

- Charles formation--thick succession of limestone, dolomite, evaporite, originally placed in the Big Snowy group.
- Mission Canyon limestone--massive fine granular limestone with significant units of dolomite, especially toward the top.
- Lodgepole limestone--black shale at base, passing upward through dark shaly limestone into thin cherty limestone with thin limey shale interbeds, and upward into crinoid-fragmental fairly massive beds.

Noted that the lithologies between the formations are transitional, so that the contact was picked higher in some places than in others. Also noted that in the Black Hills the Pahasapa contains both of the lower two units.

Andrichuk, J.M., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2170-2210). Stated that the Madison was divided into three cyclic units, which did not correspond exactly to Lodgepole, Mission Canyon, and Charles, but rather had boundaries about 30-40 feet above the base of their contacts, in southeastern Montana. These units are:

- Upper--upper marine zone, First evaporite zone, lower marine zone.
- Middle--Second evaporite zone, marine zone, thin Third evaporite zone, marine zone.
- Lower--marine limestone and chert, argillaceous.

Lower unit includes the Lodgepole and lower part of the overlying Mission Canyon; middle unit includes basal Charles anhydrite as the base of Second evaporite zone. Upper unit is most variable laterally. In southern Black Hills only the lower unit is represented in the Pahasapa and underlying Englewood (fig. 3). In northern Black Hills, both the lower unit (fig. 7) and middle unit (fig. 10) are recognized, and a very thin upper unit (fig. 12). Thicknesses for lower unit range from 200 feet at southwest corner of South Dakota to 500 feet at North Dakota border; middle unit is likewise 500 feet thick at North Dakota border, and upper unit is more than 300 feet thick there.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 56-64). Noted that the Mission Canyon is a facies of the Lodgepole, below, or of the Charles, above.

Type locality: Possibly north bank of Gallatin River, at Logan, Gallatin County, Montana

Name: From Madison Range, Montana

Mancos Shale

Keyes, C.R., 1925 (Pan-Am. Geologist, v. 43, p. 132). Said that the Pierre and Colorado shales, lumped together, should not be called Mancos shale, as it serves no useful purpose. On the other hand, if such a lumping is needed, Powell's term Sulphur Creek has priority.

Mandanan Series

Tertiary (?): Western N. Dak. and S. Dak.

Keyes, C.R., 1925 (Pan-Am. Geologist, v. 43, p. 135). The Cannonball shale is evidently not the sole member of the sedimental province in which it is found. So, while retaining the title for the member best known at present, the provincial unit may well be designated the Mandanan series. Of Tertic age.

[Probably named for development of Cannonball marine member of Lance formation at and around village of Mandan, Morton County, North Dakota - Wilmarth, 1938.]

Type locality: Not designated

Name: Probably from Mandan, North Dakota

Manitoba Group

Devonian: N. Dak., Mont., Man., Sask., S. Dak.

Baillie, A.D., 1953 (Man. Dept. Mines Pub. 52-5, p. 25-26). The term Manitoba group is proposed for the sequence of carbonate and argillaceous strata overlying the Elk Point group in the Williston Basin

area. The name Manitoban was originally used for all the Devonian strata overlying the Winnipegosis formation and disconformably underlying the Mesozoic in the Manitoba outcrop area. The Manitoba group has the same areal extent as the Elk Point group. Over much of the area, the group is less than 300 feet thick. The lithology is characterized by repetitive sequences of carbonate strata, punctuated by thin persistent shaly beds. A complete sequence consists of shale and argillaceous limestone that grades upward to light-colored bedded limestone overlain by a fragmental and reefoid zone. Evaporites commonly mark the upper member of a sequence. The basal sequence of the group exposed in the outcrop area is named the Dawson Bay formation.

Type locality: Not designated

Name: Presumably from province of Manitoba

The North Dakota Geological Society, 1961 (Stratigraphy of the Williston Basin: Devonian System, pl. 1) listed the Dawson Bay and overlying Souris River as the formations that make up the Manitoba Group. Only the Souris River Formation is present in South Dakota, according to C.A. Sandberg, 1958 (fig. 3), and the South Dakota Geological Survey has not adopted the term Manitoba Group - A.F.A.

Marsland Formation

Miocene: Nebr., Wyo., S. Dak. (?)

Schultz, C.B., 1938 (Am. Jour. Science, 5th ser., v. 35, no. 210, p. 443-444). To the deposits ("upper Harrison beds") which immediately overlie the Arikaree group and which are faunally and lithologically distinct from the typical Arikaree, suggested the name Marsland formation. Includes some 150 feet of buff and gray soft sandstones. Consists in part of valley fills, and in places seems to mantle the slopes of certain large valleys. Upper part of the Marsland formation in this region is more gritty and mostly buff colored. Fauna seems to be intermediate between that of Harrison formation and overlying Sheep Creek formation and perhaps should provisionally be considered as lower part of the upper Miocene.

Lugn, A.L., 1959 (Geol. Soc. America Bull., v. 50, p. 1253-1254). Stated that the application of the term "upper Harrison" by Peterson (1906, Carnegie Museum Annals, v. 4, p. 21-72) and Cook (1915, Nebr. Geol. Survey, v. 7, pt. 11, p. 59-75) to these beds was unfortunate because they have "no very close stratigraphic or faunal relation to the true Harrison," and are separated from the true Harrison by an important unconformity. Thus a more appropriate name was needed, and Marsland is accepted.

Lugn stated (p. 1258) that where the basal channels of the overlying Sheep Creek formation are absent, the upper or flood-plain phase

of the Sheep Creek formation has been included in the Marsland, as their distribution is similar and no recognizable stratigraphic break is present between them. (See also R.C. Cady, 1946, U. S. Geol. Survey Water-Supply Paper 969, p. 32-35.)

Type locality: Schultz and Stout, 1961 (p. 49), stated that type locality is in quarry 6 miles south of town of Marsland, Sec. 25, T. 28 N., R. 52 W., Box Butte County, Nebraska

Name: From Marsland

The Marsland has not been mapped in South Dakota, although its sediments may have been included in the upper part of the Harrison in the Martin and Patricia Quadrangles of Bennett County by S.G. Collins, 1959 and 1960 (S. Dak. Geol. Survey, Geol. Quads.) - A.F.A.

Meek Formation

Pennsylvanian: Wyo., Colo., western S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 22, 44). Comprises lower 130 feet of Division 2 (Condra and Reed, 1935) of Hartville formation; thickness 119-130 feet. Varied lithology, predominantly limestone, sandstone.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that the Meek group of dolomite, sandstone, and shale is present in western South Dakota. Rests on Hayden group. Together with overlying Wendover, includes "second Leo sand" (near base) and "first Leo sand" (near top).

Type locality: Presumably Meek Cliff, Sec. 22, T. 27 N., R. 66 W., Platte County, Wyoming

Name: From Meek Cliff

MELLETTE LIMESTONE FACIES (of Arikaree Group)

Miocene: South-central S. Dak.

Agnew, A.F., 1957 (S. Dak. Geol. Survey, Geol. Quad., White River). Restricted Arikaree formation in south-central South Dakota to reddish-brown cross-bedded quartzose channel sand and overlying gray to pink unconsolidated tuffaceous quartzose sands, which are overlain by the Mellette formation--a series of pink fine-grained limestones that are accompanied by thick red and grayish-pink tuffaceous sands.

Sevon, W.D., 1959 (S. Dak. Geol. Survey, Geol. Quad., Okreek). Mapping a quadrangle adjacent to the White River Quadrangle, reduced the Mellette to a facies of the Arikaree. This usage has been followed subsequently (Sevon, 1960, S. Dak. Geol. Survey, Geol. Quad., Ring Thunder).

Type locality: Along line between Secs. 14 and 23, T. 41 N., R. 28 W., Mellette County, South Dakota
Name: From Mellette triangulation station

Mendenhall lignite (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the Mendenhall lignite as being 120 feet below the top of the Ludlow formation, 250 feet thick, and 15 feet above the Bar-H lignite.

The Mendenhall lignite, together with the overlying Mendenhall rider and underlying Olesrud, "Y" and "Z" beds (Denson, et al, 1959, p. 104-105), is equivalent to the Hillen Lignite Facies, mapped by the South Dakota Geological Survey in 11 quadrangles of northwestern South Dakota (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

Metamynodon sandstone

A paleontologic name applied to the basal sandstone of Brule clay (Oligocene) in South Dakota.

Middle Creek Limestone (of Greenhorn Limestone)

Upper Cretaceous: S. Dak.

Wing, M.E., 1940 (S. Dak. Geol. Survey Rept. Inv. 35, p. 6, chart facing p. 10). Approximately 200 feet below Greenhorn limestone and near middle of Belle Fourche shale member of Graneros is a thin but persistent limestone ledge. This limestone ledge, herein called the Middle Creek, caps and causes the escarpment trending northwest from Belle Fourche along the northeast side of Middle Creek Valley. It is a semi-crystalline limestone and weathers somewhat sandy, contains many black grains and flakes of organic material, and emits a strong petroleum odor when broken. It contains many shark teeth, fossil Inoceramus, and a large ribbed ammonite, probably Prionocyclus.

Petsch, B.C., 1949 (S. Dak. Geol. Survey Rept. Inv. 65, p. 9). Abandoned the name Middle Creek for this limestone because the name has prior usage elsewhere. Renamed it the Orman Lake limestone (which see).

Type locality: Not designated
Name: From Middle Creek, T. 9 N., R. 1 E., Butte County, South Dakota

"Millstone grit"

Bolin, E.J. and Petsch, B.C., 1954 (S. Dak. Geol. Survey Rept. Inv. 75, p. 77). Informal name applied by C.L. Baker to detrital zone at base of Cretaceous rocks in subsurface of northeastern South Dakota; probably of Pennsylvanian or Permian age. Rests on Precambrian rocks or locally on the "Minnelusa" sandstone.

Minnechaduza beds (in Ash Hollow Formation)

Pliocene (Ogallala): Nebr., southern S. Dak.

Stirton, R.A., 1939 (Am. Jour. Science, v. 237, no. 6, p. 433). U. S. Geological Survey adopted the name Valentine for a limestone member in a Devonian formation in southeast Nebraska. The term "Valentine" as used by Stirton and McGrew in 1935 must then be replaced. In following the suggestion of M.K. Elias (written communication), proposed the name "Minnechaduza" taken from Minnechaduza Creek in Cherry County, Nebraska.

[Lithologically, this formation is not unlike the Ogallala farther south, and although it may be the same formation, no one has definitely traced it through the sand hills of middle Nebraska. In South Dakota it is comparable to the exposures along the Little White River which were mentioned and briefly discussed by Matthew and Gidley (1904). Near Valentine this formation rests unconformably on a reddish, slightly banded, loessic formation which Matthew considered lower Miocene - Wilmarth, 1938.]

Type locality: Divide between Little Beaver and Crooked Creeks, $SW\frac{1}{4}SW\frac{1}{4}$ sec. 8, T. 34 N., R. 26 W., north pasture Niobrara Game Refuge, Univ. Calif. Loc. V3326, Nebraska

Name: From Minnechaduza Creek, Cherry County, Nebraska

See Valentine Formation.

MINNEKAHTA LIMESTONE

Permian (?) (Triassic): Western S. Dak., eastern Wyo., northwestern Nebr.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 514). Thin-bedded gray limestone, 30-50 feet thick, underlying Spearfish formation and overlying Opeche formation in Black Hills. In previous reports called "Purple limestone."

Burk, C.A. and Thomas, H.D., 1956 (Wyo. Geol. Survey Rept. Inv. 6, 11 p.). Described the Goose Egg formation of eastern Wyoming as a sequence of interbedded red to ocher shales and siltstones, thin limestones, gypsums and limestone breccias. It rests on the Minnelusa and its

equivalents (Tensleep, Casper, and Hartville), and underlies the Spearfish and its equivalents (Chugwater). The Minnekahta is the limestone with farthest easterly extent, and is underlain by Opeche shale; less extensive are overlying Forelle and Ervay limestones, all of the Phosphoria.

Goldsmith, J.W., 1959 (U. S. Geol. Survey Misc. Geol. Inv. Map I-300, p. 4). Stated that the Minnekahta is Permian (possibly Leonard) in age.

Type locality: "Region near the Hot Springs" at Hot Springs, South Dakota

Name: From Indian term "Minnekahta" (hot springs)

Apparently a significant part of what is considered Spearfish by the South Dakota Geological Survey is included in the upper part of the Goose Egg, but its relations are not adequately described - A.F.A.

MINNELUSA FORMATION

Pennsylvanian: Western S. Dak., northeastern Wyo.

Winchell, H.N., 1875 (Black Hills of Dakota, by William Ludlow, U. S. Eng. Dept. U. S. Army, p. 38, 65, map). Minnelusa sandstone or Upper sandstone--nearly white, crystalline, subsaccharoidal sandstone, coarsely granular when weathered and hard; has somewhat the aspect of crinoidal limestone but without crinoid stems. [In another place he described it as a white sandstone, locally stained with iron to a brick-red color - Wilmarth, 1938.] Thickness 75 feet in Black Hills, South Dakota. Underlies Upper limestone and overlies Lower limestone.

Jagger, T.A., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 3, p. 178-181, map). Minnelusa sandstone and limestone--in northern Black Hills consists of (descending): (1) Minnelusa saccharoidal sandstone, 200 feet; (2) Minnelusa "alternate" series, 300 feet; (3) Minnelusa white sandstone, 100 feet. Separated from overlying Minnekahta limestone by 90 feet of red sandstone and shale. Rests on 200-700 feet of gray limestone equivalent to Madison limestone.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 510). Minnelusa formation--sandstones, mainly buff and red, in greater part calcareous; some thin limestone. Thickness 400-450 feet. Minnelusa was applied by N.H. Winchell in 1875 to a portion of the bright-colored members of the Carboniferous lying above the gray Pahasapa limestone. In this report the name was used to designate all sandstone and limestone in Black Hills region lying between well-defined limits of Pahasapa limestone below and deep-red sandstone and shales of Opeche formation above.

[The formation possibly includes some Permian at top and some Mississippian at base. Thickest section in northern Black Hills, 1,310 feet. Equivalent to Tensleep sandstone and Amsden formation of central Wyoming and southern Montana - Wilmarth, 1938.]

Gries, J.P. and Tullis, E.L., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 34). Although there is as yet no fossil evidence

in the Black Hills, lithologic correlation of upper Minnelusa beds with those in western Nebraska-Hartville, Wyoming, area suggests that uppermost Minnelusa in the Black Hills may be of early Permian age.

Reed, E.C., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 46). Placed the Pennsylvanian-Permian boundary in eastern Wyoming and southwestern South Dakota in the Hartville and Minnelusa formations at the top of the Wendover group, and about 150 feet below the top of the "Minnelusa formation" in the Black Hills.

Bates, R.L., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1991-1995). Term "Minnelusa sandstone" is a misnomer; the formation in type area, Rapid Creek Canyon, contains only about 58 percent sandstone, and subsurface sections contain a lower proportion. On purely lithologic grounds it is here suggested that the brecciated upper Minnelusa in the southern Black Hills outcrop is correlative with the upper evaporite zone of the subsurface Minnelusa. The Black Hills Minnelusa formation thus represents a leached, thinner counterpart of the more completely developed formation toward the southwest (Hartville). The upper evaporite zone of the subsurface Minnelusa appears contemporaneous with the upper Hartville ("Divisional") which Love, Henbest, and Denson, 1953 (U. S. Geol. Survey Oil and Gas Inv. Chart OC-44) consider to be Wolfcampian (?) in age. Gries (personal communication) states that there is as yet no paleontologic evidence from the Black Hills either to refute or to support this correlation.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that the Minnelusa and Hartville are equivalent.

Jennings, T.V., 1959 (Jour. Paleontology, v. 33, p. 994). Said that the "Red Marker" separated the Pennsylvanian from the Permian part of the Minnelusa and correlated the Pennsylvanian part with the Missourian-Virgilian, the Desmoinesian, and the Atokan stages (fig. 2 on p. 992).

Type locality: Not designated

Name: From Indian name for Rapid Creek (Minnelusa), Pennington County, South Dakota

The South Dakota Geological Survey accepts the Amsden as equivalent to the basal, or Fairbank-Reclamation part (Agatston, 1954, table 5) of the Minnelusa Formation, and applied the term Minnelusa to the remaining rocks below the Opeche Shale - A.F.A.

MINNEWASTE LIMESTONE MEMBER (of Lakota Formation)

Lower Cretaceous: Western S. Dak. (southeastern part of Black Hills)

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 529). Nearly pure light-gray limestone, 0-30 feet thick, underlying Fuson formation and overlying Lakota formation. Contains no fossils. Formerly included in Dakota sandstone. Extensively exposed in anticline 2 miles east of Hot Springs, South Dakota.

Darton, N.H. and Paige, Sidney, 1925 (U. S. Geol. Survey Geol. Atlas, Folio No. 219, p. 12). In southeastern part of Black Hills uplift the Lakota sandstone is overlain by Minnewaste limestone, a thin sheet which terminates between Buffalo Gap and Fuson Canyon. This limestone is about 12 feet thick in Buffalo Gap and 18 feet thick on plateau south of Calico Canyon.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 75). A maximum thickness of 33 feet is known. The Minnewaste grades westward into a calcareous sandstone in the vicinity of Edgemont, and northeastward into a calcareous shale near Fairburn. The Minnewaste should not be considered a formation, but merely a local calcareous phase in a period of continuous Lakota-Fuson deposition.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 33). Suggested that the Minnewaste be considered a local member of the Lakota formation and that the term Fuson for the overlying shale be dropped because of its close facies relationship with the Lakota formation.

Type locality: Presumably an area 2 miles east of Hot Springs, South Dakota

Name: Minnewaste is Indian name for Cheyenne River

MISSION CANYON LIMESTONE (of Madison Group)

Lower Mississippian: Eastern Mont., N. Dak., S. Dak., Alta., Sask., Man.

Collier, A.J. and Cathcart, S.H., 1922 (U. S. Geol. Survey Bull. 736F, p. 173). In this part of Montana (Little Rocky Mountain region) the Madison limestone becomes a group divisible into two distinct formations here named Mission Canyon limestone (upper) and Lodgepole limestone (lower). The Mission Canyon limestone is a massive white clastic marine limestone not so fossiliferous as the underlying Lodgepole. Thickness varies from 300-500 feet. Equivalent to part of Rundle and the Banff limestone of Alberta.

Andrichuk, J.M., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2170-2210). Mapped the Mission Canyon equivalent as the lower part of his middle unit, and the upper part of his lower unit of the Madison. In South Dakota he recognized it as being present (like the overlying unit) north of the middle Black Hills, attaining a thickness of 500 feet at the North Dakota border.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 60). Pointed out that the shelf facies of the Mission Canyon is coarser, and more fragmental and more massively bedded than that of the Lodgepole, which is argillaceous organic limestone. The upper half of the Mission Canyon is a facies of the Charles, however, if the base of the lowest thick bed of salt or anhydrite is taken as the contact.

Type locality: Not designated

Name: From Mission Canyon, Little Rocky Mountains, Montana

Missourian Series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Minnelusa in South Dakota.

MITTEN BLACK SHALE MEMBER (of Pierre Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 3). Mitten black shale member of Pierre shale--blue-black fissile shale with few iron-stained calcareous concretions. Marine fossils. Forms prominent scarp. Thickness 150-200 feet. Overlies Gammon ferruginous member of Pierre shale and top lies 500-800 feet below Monument Hill bentonitic member of Pierre.

Robinson, C.S., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Mapped the Mitten black shale member of Pierre in north and west parts of Black Hills as 150 feet of soft fissile noncalcareous grayish-black shale with dark-gray septarian concretions that weather orange. Bentonite bed "I", 2-12 feet thick, occurs at the base. The Mitten rests on the Gammon, and underlies an unnamed brownish-gray silty and sandy shale that is 200 feet thick.

Tourtelot, H.A., 1962 (U. S. Geol. Survey Prof. Paper 390, p. 8). Stated that the name Mitten is not applied south of Newcastle, where the underlying Gammon wedges out, as the dark basal shale of the Pierre is there called the Sharon Springs Member.

The Mitten is the equivalent of the Claggett shale of Montana.

Type locality: Not designated

Name: From exposures along Mitten Prong in T. 56 N., R. 68 W., Crook County, Wyoming

MOBRIDGE MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 44-49, pl. 3). Medium-gray and medium bluish-gray to dark-gray shale and chalk. Everywhere beds are calcareous and more or less chalky. Appears massive but actually thin laminated beds only a fraction of an inch thick. Weathers to a light buff, to brownish buff. The lighter shades of buff generally predominate in the upper and lower parts. Beds are more uniform than other members of Pierre. Thickness 90-230 feet. The Mobridge member is a succession of highly calcareous shale, marl, and chalk beds above the gumbo-forming shale of the Virgin Creek member and below the noncalcareous shale of Elk Butte member (forms a distinctive buff band between other two members).

Type locality: Typical exposure above the west end of old highway bridge across Missouri River at Mobridge, Walworth County, South Dakota.
Name: From Mobridge

MONROE CREEK FORMATION

Miocene (lower): Western Nebr., eastern Wyo., southern S. Dak.

Hatcher, J.B., 1902 (Am. Philos. Society Proc., v. 41, p. 116). Monroe Creek beds--very light-colored fine-grained, not very hard but firm and massive sandstone, 300 feet thick. Grades into overlying Harrison beds and overlies Gering sandstones. Scant fauna. Assigned to Miocene.
[Is a part of Arikaree formation. Assigned to Miocene by most geologists, but H.J. and M.C. Cook, 1933 (Nebr. Geol. Survey Paper No. 5, p. 44) assigned it upper Oligocene - Wilmarth, 1938.]
Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1251-1253, 1264, 1266-1269). Raised the Monroe Creek to a formation, the middle one of the Arikaree group.
Sevon, W.D., 1961 (S. Dak. Geol. Survey, Geol. Quad., Vetal). Traced the Monroe Creek Formation in southern South Dakota eastward to a point about 125 miles northeast of the type locality; east of there, he included it with the Arikaree Group, undifferentiated.
Type locality: Northern face of Pine Ridge, at mouth of Monroe Creek Canyon, 5 miles north of Harrison, Nebraska
Name: From Monroe Creek Canyon

MONTANA GROUP

Upper Cretaceous: Mont., Wyo., N. Dak., S. Dak., Colo., Utah

Eldridge, G.H., 1888 (Colo. Sci. Society Proc., v. 3, pt. 1, p. 93, footnote). With the approval of C.A. White introduced Montana group to replace Fox Hills in broad sense of White [to include Fox Hills Sandstone and Pierre Shale of present nomenclature - A.F.A.].
Rothrock, E.P., 1934 (S. Dak. Geol. Survey Rept. Inv. 20, fig. opp. p. 18). Used the terms Colorado group and Montana group for bedrock penetrated below glacial drift and above Precambrian granite in Grant County of northeastern South Dakota.
Type locality: Not designated
Name: From State of Montana, where extensively exposed

The South Dakota Geological Survey does not use the term Montana Group, except in the extreme northeastern part of the State, but rather uses the individual formation and member names - A.F.A.

Montana Series

Name proposed by G.H. Ashley, 1923 (Eng. and Min. Journal-Press, v. 115, no. 25, p. 1106-1108) to include Montana Group and overlying Laramie Formation.

Montanan Series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Pierre and Fox Hills; thus the same as Montana Group of Rothrock, 1934, in South Dakota.

MONUMENT HILL BENTONITIC MEMBER (of Pierre Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., Black Hills of S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 3). Monument Hill bentonitic member of Pierre shale--impure bentonite and siltstone; some calcareous concretions and barite concretions. Marine fossils. Commonly forms a scarp. Thickness 150 feet. Top lies 150-250 feet below Fox Hills sandstone. Separated from underlying Mitten black shale member of Pierre shale by 500-800 feet of dark mudstone and shale.

Robinson, C.S., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Described the Monument Hill bentonitic member of the Pierre shale along the north and west flanks of the Black Hills as light-gray weathered bentonite and silty shale, 150-220 feet thick. Overlain by 200 feet of unnamed member of Pierre, which is dark gray-black shale with gray and brown-weathering limestone concretions, and rests on similarly unnamed member that is 250 feet of dark gray-black shale with gray-weathering septarian concretions and red-weathering concretions. Monument Hill fossils are present in the DeGrey member of the Pierre in central South Dakota.

Type locality: Sec. 32, T. 56 N., R. 68 W., Crook County, Wyoming

Name: From exposures at Monument Hill, Crook County, Wyoming

MORRISON FORMATION

Upper Jurassic: Colo., northern N. Mex., northeastern Ariz., eastern Utah, Wyo., western S. Dak., central and southern Mont., western Okla., western Kans. (?)

Eldridge, G.H., 1896 (U. S. Geol. Survey Mon. 27). The formation was named by Eldridge who described its type locality, but was preceded

by Whitman Cross, by whom the formation was also described, in 1894 (U. S. Geol. Atlas, Folio No. 7).

Morrison Formation--throughout Denver region and for much of distance along eastern base of Rocky Mountains in Colorado, the Jurassic is essentially fresh-water marls, averaging 200 feet. Its upper limit is sharply defined by Dakota sandstone, while the brown and pink sandstone closing the Triassic marks its lower limit as clearly. The marls are green, drab, or gray, and carry in lower two-thirds numerous lenticular bodies of limestones of characteristic drab color, and a persistent band of alternating limestone and sandstone, or all sandstone, 10-15 feet thick. At Morrison, the top member of underlying Wyoming formation consists of 15-25 feet of persistent sandstone, fine-grained, often massive, pink and brown. The clays of lower two-thirds are remarkable for their reptilian remains and have been designated "Atlantosaurus clays." The upper third is generally a succession of sandstone and marls, of which the sandstone predominates. The most important sandstone occurs just above the Atlantosaurus clays, is very persistent, and has been called Saurian sandstone. It varies in thickness between 5 and 35 feet, and in its distance below the Dakota from 10 to 125 feet, although usually from 50 to 80 feet. The Morrison appears to be unconformable with underlying Wyoming formation [now divided into--descending--Lykins formation, Lyons sandstone, Ingleside formation and Fountain formation--all Wyoming - Wilmarth, 1938].

[In western South Dakota, Wyoming, and as far south in eastern Colorado as Loveland, the Morrison formation is underlain by marine Sundance formation, of Late Jurassic age. The age of the Morrison was long questioned, some geologists considering it Late Jurassic, others considering it Early Cretaceous. The U. S. Geological Survey now classifies it as Late Jurassic - Wilmarth, 1938.]

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 464). Stated that the Morrison is Kimmeridgian (Late Jurassic) in age.

Francis, D.R., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 393). Described the Morrison of the Williston Basin as a complex series of shales and sandstones in which facies changes are abrupt. He noted that in North Dakota the Morrison is light- and dark-gray shale interbedded with light-gray fine-grained sandstone. The Morrison reaches 125 feet in thickness in South Dakota (fig. 13), and its age is Late Jurassic.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 50-52). Discussed the Morrison-Lakota contact in the Black Hills, noting that it may be gradational or it may suggest angular discordance. The Unkpapa and similar sands in the Morrison are distinct from the overlying Lakota sands, but the mudstones and claystones of the Morrison and Lakota are the difficult ones. Actually, the beds called Morrison in the Black Hills may be equivalent to only part of the type Morrison in Colorado, so that Darton's term Beulah in the Black Hills, which has been suppressed in favor of Morrison, may still have some validity.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 90-91). Pointed out that in some areas of the Williston Basin, sandstone in the upper part of the Morrison is indistinguishable from sandstone at the base of the overlying Dakota Group of Early Cretaceous age.
Type locality: Not designated
Name: From Morrison, Colorado

Morrisonian Series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Morrison in South Dakota.

"Mortar beds"

Descriptive term applied to Ogallala Group.

MOWRY SILICEOUS SHALE MEMBER (of Graneros Shale)

Upper Cretaceous: Wyo., Mont., western S. Dak.

Darton, N.H., 1904 (Geol. Soc. America Bull., v. 15, p. 394-401). Mowrie beds--hard lighter-gray shale and thin-bedded sandstone that weather light-gray and form ridges. Contains large numbers of fish scales and occasional fish teeth and bones. Thickness 150 feet on east side of Bighorn Mountains. Distinctive Benton fossils occur above it, and in other parts of eastern Wyoming. Its relations indicate that it occurs below middle of Graneros. Is included in Benton formation of this area [east side of Bighorn Mountains - Wilmarth, 1938]. Separated from older Cloverly formation by several hundred feet of dark shale underlain by dark-gray shale in part sandy and rusty-brown. with occasional thin beds of brown sandstone, all of which are here included in Benton formation, although it is possible part of the dark-gray beds may represent Dakota sandstone.

[Mowry has been approved spelling of this name since 1906 - Wilmarth, 1938.]

In 1916 (U. S. Geol. Survey Bull. 621, p. 168), C.T. Lupton applied name Thermopolis shale to the 700 feet of beds conformably underlying Mowry shale and conformably overlying Greybull sand of drillers (top member of Cloverly formation). [This is the present (1936) approved definition of U. S. Geological Survey, except that in the Black Hills region the 10-50 feet of dark-gray shale and sandy shale to which Collier applied name Nefsy shale member of Graneros shale, and which represents upper part of Thermopolis shale, is now included in Mowry shale, and Nefsy has been abandoned. In the latter region, the Mowry as thus redefined rests on Newcastle sandstone member

of Graneros, and the beds overlying the Mowry and underlying the Greenhorn are the Belle Fourche member of Graneros shale - Wilmarth, 1938.]

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 76). The Mowry consists of 200-250 feet of light-gray siliceous shale. It becomes less siliceous to the southeast and is difficult to recognize in outcrops southeast of the Hills. Thin bentonites characterize the formation; one, known as the Clayspur bed, lies at the top of the Mowry, and reaches a thickness of 3-4 feet over wide areas in South Dakota, Montana, and Wyoming.

Hadley, H.D., Lewis, P.J., and Larsen, R.B., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 138). Its relations indicate that the Mowry occurs below the middle of the Graneros.

Cobban, W.A. and Reeside, J.B., Jr., 1952 (Geol. Soc. America Bull., v. 63, pl. 1). Placed the boundary between the Lower and Upper Cretaceous at the top of the Mowry shale. Thus the Mowry is Aptian.

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 446-449). Did not use the term Dakota in the Black Hills, but applied the term Dakota group to the thick sandstone sequence in central South Dakota where he called it the "true Dakota," and where it overlies the Skull Creek shale. He pointed out that the "true Dakota" is the age equivalent of the Newcastle-Mowry interval, and that what is called Dakota in the Williston Basin to the north is actually the Fall River sandstone (fig. 6). Gries further supported this view in 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., fig. 5 on p. 169), but he reduced the term Dakota to formation and showed that it is traceable into the Newcastle of the Black Hills.

Gries, J.P., 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., p. 170). Pointed out that east of the Black Hills, the Mowry Shale interval is only irregularly silicified, and that much of it resembles the underlying Skull Creek Shale in lithology. Also, where the Clay Spur Bentonite at the top of the Mowry in the Black Hills is missing to the east and the Mowry begins to sand up, it merges with the Dakota of central South Dakota (fig. 2). South and southeast of the Black Hills, major sandstone tongues in the Mowry may be correlated with the "D", "G", and "J" sands of Nebraska.

Wulf, G.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1396-1402). Subdivided the Mowry Shale in the Williston Basin into two units, separated by a marker bentonite bed. The lower, or Dynneson unit, is essentially a shale with two prominent sandstone lithofacies; the Dynneson (Williston Basin) and the Bow Island (northwest Montana). The Dynneson unit is as much as 75 feet thick in northwestern South Dakota, and most of this thickness is sand. The Dynneson unit is marked by a disconformity at the top of the Skull Creek. Where the Dynneson sand is absent, the unit is called the "Lower Mowry" unit. [It would conform to the principles of stratigraphic classification if Wulf had applied the name Dynneson to only the sand zone, and to have continued to use the name Lower Mowry unit for the more inclusive sequence - A.F.A.] The Dynneson Sandstone Member is a blanket-type sandstone, with shoestring sandstone bodies on top. The grains are light gray and fine in size.

Wulf continued that the Upper Mowry unit contains lenses of sandstone in central South Dakota (p. 1403), which are similar in all respects to the Dynneson. The Upper Mowry unit is as much as 150 feet thick in South Dakota.
Type locality: Not designated
Name: From Mowrie Creek, Johnson County, Wyoming

In eastern South Dakota, the Clay Spur Bentonite Bed is missing, and the Belle Fourche and Mowry shales lose their distinctive character, and have been termed Graneros - A.F.A.

"Muddy sand"

Upper Cretaceous: Eastern Wyo., eastern Mont., western N. Dak. and S. Dak.

Driller's name for a sand (or sands) in Thermopolis Shale (Upper Cretaceous) of Bighorn Basin and other areas in Wyoming. F.F. Hintze, Jr., 1915 (Wyo. Geol. Survey Bull. 10, p. 20-21), who described the sand as occurring in lower part of Benton shale, stated that it is almost pure white on outcrop, but that probably in drilling, the soft shales above and below it are so mixed with the white sand grains that the mixture has a muddy appearance--hence the name. The name has also been applied by drillers to sands in strata that have been identified by geologists as lying in the Cloverly Formation, which underlies Thermopolis Shale. In Rock Creek oil field, south-central Wyoming, the name First Muddy sand has been applied by drillers to a sand in the Thermopolis Shale; Second Muddy sand to a sand in what is said to be top of Cloverly Formation; and Third Muddy sand to a sand in the lower part of the Cloverly. There are at least eight Muddy Creeks in Wyoming, but although the sand crops out, it is not known to be exposed on any Muddy Creek. Equivalent to Newcastle Sand of southwest Black Hills area. Thickness 2-40 feet.
Wulf, G.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1384). Stated that the exact relations of the Muddy and the "J" sandstones with the Newcastle Sandstone are unclear.
Type locality: Not designated
Name: Probably descriptive, a driller's term

Nebraska beds

Upper Miocene: South-central S. Dak., north-central Nebr.

O'Harra, C.C., 1920 (S. Dak. Sch. Mines Bull. 13, p. 36, 47). The Nebraska beds are present as widely scattered river channel and flood-plain deposits immediately above the Harrison beds in various areas "not yet carefully mapped along the Niobrara River." Farther south they

pass below, or blend into the Ogallala formation. The Procamelus zone.

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1271). Quoting Simpson (1933) showed that the Nebraska beds of Scott (1893) are equivalent to the Valentine. However, Hatcher (1902) and Peterson (1906) applied the name to much older beds now included in the Harrison.

Type locality: Not designated

Name: Derivation not given

Nefsy Shale Member (of Graneros Shale)

Upper Cretaceous: Northeastern Wyo., western S. Dak.

Collier, A.J., 1922 (U. S. Geol. Survey Bull. 736, table opp. p. 76, p. 82, etc.). Soft dark shale interbedded with lenses of sandy shale. Thickness 25-50 feet. Overlies Newcastle sandstone member of Graneros and underlies Mowry shale member of Graneros.

[This soft shale is now included in base of Mowry shale member into which it grades, and Nefsy has been abandoned (see W.W. Rubey, 1930, U. S. Geol. Survey Prof. Paper 165, p. 4) - Wilmarth, 1938.]

Type locality: Not designated

Name: From Nefsy town site at Osage, Wyoming

NEWCASTLE SANDSTONE MEMBER (of Graneros Shale)

Upper Cretaceous: Northeastern Wyo., western S. Dak.

Hancock, E.T., 1920 (U. S. Geol. Survey Bull. 716, p. 39, 42, 96). Reddish to light-yellow sandstone associated with black carbonaceous shale. In Lance Creek field, Wyoming, it is divisible into upper sandstone, 20 feet; middle shale, 15 feet; and lower sandstone, 15± feet. In Mule Creek field, Wyoming, the Newcastle member is 3-15 feet thick. In both fields it is separated from overlying Mowry shale member of Graneros by 25 feet of dark sandy shale (Nefsy shale member of Collier's 1922 report, but now included in Mowry shale and Nefsy discarded).

Schramm, E.F. and Cook, H.J., 1921 (Kanoka Petroleum Company, Geol. Dept. Bull. A, p. 12, 14). In Agate, Nebraska, Anticline (Sioux County, northwestern Nebraska) Newcastle sandstone member of Graneros shale is 3-50 feet thick.

Reeside, J.B., Jr., 1944 (U. S. Geol. Survey Oil and Gas Invest., Prelim. Map No. 10). Suggested that the Newcastle is the basal upper Cretaceous sand of the Black Hills area.

Crowley, A.J., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 83-107). Suggested that the Black Hills were uplifted during the closing stage of Early Cretaceous time, and that the Precambrian core of the

Black Hills itself supplied the sand for the Newcastle. The Newcastle is thus interpreted as a closing phase of lower Cretaceous deposition, and the overlying Mowry as the introductory phase of the upper Cretaceous.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 76). Did not consider Crowley's hypothesis tenable. Collections near Rapid City have been variously reported to contain lower and upper Cretaceous species.

Grace, R.M., 1952 (Wyo. Geol. Survey Bull. 44, p. 5). The Newcastle formation has a shale and siltstone facies with a distribution of equal magnitude to that of the sandstone facies. In order to avoid any misconceptions the term Newcastle sandstone of previous workers is here replaced by the more inclusive term, Newcastle formation. Two phases of the formation are discriminated--a carbonaceous one on the west and northwest flanks of the Black Hills, and a noncarbonaceous one on the east flank.

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 446-449). Did not use the term Dakota in the Black Hills, but applied the term Dakota group to the thick sequence in central South Dakota where he called it the "true Dakota," and where it overlies the Skull Creek shale. He pointed out that the "true Dakota" is the age equivalent of the Newcastle-Mowry interval, and that what is called Dakota in the Williston Basin to the north is actually the Fall River sandstone (fig. 6). Gries further supported this view in 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., fig. 5 on p. 169), but he reduced the term Dakota to formation and showed that it is traceable into the Newcastle of the Black Hills.

Gries, J.P., 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., p. 170). Described the Newcastle as a series of bars along a constantly changing shoreline, rather than due to uplift of the Black Hills postulated by Crowley (p. 89), Grace (p. 20-22), or Skolnick, 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 799).

Wulf, G.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 1378). Described a new unit, the Dynneson sand in northwestern South Dakota and the adjoining parts of Wyoming, Montana, and North Dakota which has been called Newcastle in the past in the Williston Basin (p. 1384 and fig. 3). He stated (p. 1384, 1390-1394) that the Newcastle is a lenticular sand member of the top of the Skull Creek Shale. He concluded that the Newcastle is a channel sandstone (p. 1392).

Wulf showed the Newcastle delta extending westward from western South Dakota into northeastern Wyoming and southeastern Montana (fig. 16 and p. 1408, 1412).

Type locality: Not designated

Name: From Newcastle, Wyoming

New Richmond Sandstone

Lower Ordovician: Central and western Wis., southeastern Minn., Iowa, southeastern S. Dak. (?)

Wooster, L.C., 1878 (Wis. Geol. Survey Ann. Rept. 1877, p. 36-41). In vicinity of New Richmond (St. Croix County, Wisconsin) there appear to be bodies of sandstone in upper part of Lower Magnesian which may possibly represent horizon of Jordan sandstone of Minnesota.

Wooster, L.C., 1882 (Geol. of Wisconsin, v. 4, p. 106, 123-129). The sandstone beds between the Willow River beds and the Lower Magnesian proper [Oneota dolomite - Wilmarth, 1938] will be called the New Richmond beds. About 100 feet from the base and about 80 feet from the top of the Lower Magnesian limestone in several localities, is a varying amount of white quartzose sand that probably represents the horizon of Jordan sandstone of Minnesota.

[Wooster's name New Richmond sandstone was introduced into Minnesota reports as early as 1886, into Iowa reports by 1895, and Illinois reports by 1910, for a sandy unit in the middle of Prairie du Chien group. U. S. Geological Survey treats New Richmond sandstone as middle formation of Prairie du Chien group and assigned it to Lower Ordovician - Wilmarth, 1938.]

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2). Reported that three borings in South Dakota intersected New Richmond with thickness of 20, 30, and 75 feet.

Type locality: Not designated

Name: From New Richmond, Wisconsin

Name should not be used in South Dakota except possibly in extreme southeast corner of State; elsewhere should be called Deadwood - A.F.A.

NIOBRARA MARL (NIOBRARA CHALK)

Upper Cretaceous: Nebr., S. Dak., N. Dak., central, southern, and southeastern Mont., eastern Wyo., eastern Colo., northeastern N. Mex., Kans., southern Minn.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 419, 422). Niobrara division (Formation No. 3 of Cretaceous)--upper part is lead-gray calcareous marl weathering to yellowish or whitish chalky appearance; lower part is light-yellowish and whitish limestone. Total thickness 200 feet. Fossils listed. Occurs in bluffs along the Missouri below Great Bend to vicinity of Big Sioux River, also below there on hilltops [loess? - A.F.A.]. Overlies Fort Benton group (Benton shale) and underlies Fort Pierre group (Pierre shale).

[Is upper formation of Colorado group. In some reports on eastern Colorado, the Niobrara deposits have been treated as a group, divided

into Apishapa shale above and Timpas limestone below. In some regions the deposits are chiefly or wholly shale and are called Niobrara shale. Niobrara in South Dakota is generally divided into two members (descending): Smoky Hill and the Fort Hays. Named for exposures along Missouri River near mouth of Niobrara River, Knox County, Nebraska - Wilmarth, 1938.]

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 77). The formation is about 160 feet thick in eastern South Dakota, and thickens gradually to 200-225 feet of chalky shale around the Black Hills. In the Powder River Basin, west of the Hills, where the formation may reach as much as 850 feet in thickness, it is divisible into a lower or Sage Breaks member, and an upper, Beaver Creek chalky member which is about 200 feet thick. It is likely that most or nearly all of the Niobrara as recognized in South Dakota is included in the Beaver Creek member.

Bolin, E.J., 1952 (S. Dak. Geol. Survey Rept. Inv. 70, p. 4-5). Stated that in South Dakota, although there is a faunal break in the Niobrara, which he has designated as the contact between the Fort Hays and the Smoky Hill, it is "extremely difficult to recognize a lithologic subdivision of the Niobrara formation in this area.... Since the main basis for subdivision is micropaleontologic rather than lithologic, it remains very difficult if not impossible to distinguish between the two members in the field...." Thus he took exception with G.J. Loetterle, 1937 (Nebr. Geol. Survey Bull. 12, p. 14).

Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87-88). Removed the Sage Breaks member from the Niobrara and placed it in the Carlile, following W.A. Cobban, 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2187).

Type locality: Not designated

Name: From exposures along the Missouri River near mouth of Niobrara River, Knox County, Nebraska

Niobrara River channel sands (in Valentine Formation)

Miocene to Pliocene: Nebr.

Elias, M.K., 1942 (Geol. Soc. America Spec. Paper 41, p. 137). The lowermost described occurrence of the well preserved and rich mammalian fauna is at the so-called Railroad quarries on the south side of Niobrara River fauna of Stirton and McGrew, and Elias designated the channel sands from which this fauna has been collected--the Niobrara River channel. The channel sands, in which the Niobrara River fauna occurs, are about 70-100 feet above the "lower Miocene formation." The age of the fauna is regarded as transitional from Miocene to Pliocene, with some emphasis on Miocene relations (Stirton and McGrew, 1935; McGrew and Meade, 1938), but the geologists and paleontologists of Nebraska prefer to place the Miocene-Pliocene boundary at the base

of the Valentine, which makes the Ogallala group, in its present understanding, correspond exactly to the Pliocene (Lugn, 1938, 1939).
Type locality: South side of Niobrara River, south of Valentine, Cherry County, Nebraska
Name: From Niobrara River

Nishnabotna Sandstone

Lower Cretaceous: Western Iowa, southeastern S. Dak.

White, C.A., 1867 (Am. Jour. Science, 2nd ser., v. 44, p. 27, 31). Nishnabotany [sic] sandstone. Coarse-grained friable ferruginous sandstone, sometimes more than 30 feet thick, lying unconformably on Coal Measures in Mills, Montgomery, Cass, and Pottawotamie Counties, Iowa. Supposedly Cretaceous in age and suspected to be part of the Dakota group.
White, C.A., 1870 (Iowa Geol. Survey, v. 1, p. 26, opp. p. 168, 289). Divided Cretaceous of Iowa into (descending): Inoceramus beds, 50 feet; Woodbury sandstones and shales, 150 feet; and Nishnabotany [sic] sandstone, 100 feet.
Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Nishnabotna sandstones in South Dakota, 300 feet thick, resting unconformably on the Fuson terrane, and overlain by the Sergeant terrane. Basal part of Dakota series.
Type locality: Not designated
Name: From Nishnabotna River, Iowa

The Nishnabotna is equivalent to the lower part of the threefold Dakota sequence in the type area near Sioux City, Iowa - A.F.A.

Nisku Formation

Devonian: Alta., Mont., northwestern S. Dak.

Layer, D.B., 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 1815-1816). This member is a widely recognized unit; it remains remarkably uniform in character, the main variation being the sporadic presence of anhydrite. Dolomite is the typical rock of the Nisku member throughout its areal extent; it is biostromal in character because the dolomite fingers out into anhydrite southward and siltstones northward. The variation in thickness of the member is slight within the area of the dolomite facies.
Baillie, A.D., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 607). The name Nisku was introduced by Layer to define closely equivalent strata in central Alberta, and, as the lithologic character of these strata in the Williston Basin area is similar to that of the type area, the name was retained, although it was raised from member to formation

rank. The upper limit of the formation coincides with the upper limit of the Saskatchewan group. The formation is rarely greater than 150 feet thick.

Type locality: British American #1 PYRCZ, LSD. 12, Sec. 25, T. 50, R. 26 W. 4M, Alberta

Name: After railway siding of Nisku, 7 miles east of well

This unit is called Birdbear in South Dakota, Montana, and North Dakota - A.F.A.

OACOMA MANGANIFEROUS SHALE FACIES (of DeGrey Member)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 23-25, pl. 3). Barren rounded clay knobs draped with dark purplish-black manganiferous concretions, comprising a dark zone between lighter-colored gray shale zones; traced from Charles Mix County northward to Great Bend of the Missouri River. Alternating with the beds of gray shale are thin beds of bentonite and bentonitic clay. Thickness about 30-45 feet. (Oacoma zone is medial subdivision of Sully member of Pierre shale; overlain by Verendrye member and underlain by Agency siliceous shale facies.)

Gries, J.P., 1942 (S. Dak. Geol. Survey Rept. Inv. 43, p. 17). Noted that a distinctive bentonite bed at the base of the Oacoma zone at Fort Pierre (halfway between the type area of the Oacoma and that of the Agency) is recognized 72 feet below the top of the Agency unit at Cheyenne Agency, and concluded that "the Oacoma zone as defined by Searight included not only the light-and dark-banded beds of Russell [W.L. Russell, 1930, S. Dak. Geol. and Nat. Hist. Survey Rept. Inv. 7, p. 5] but also part, if not all of the Agency zone [of the Oacoma type area].... Inasmuch as it is not possible to draw the line between the true [type] Agency and the banded beds in the type locality of Searight's Oacoma zone, it is here suggested that both terms be retained, and that all beds lying between Crow Creek chalk [below] and the base of the Verendrye zone [above] be hereafter referred to as Agency-Oacoma zone."

Petsch, B.C., 1946 (S. Dak. Geol. Survey Rept. Inv. 53, p. 30, fig. 5, 10). Recognized in the Oacoma zone three beds (descending): Upper micaceous bentonite, Big bentonite bed, Lower micaceous bentonite (Missouri Valley).

Crandell, D.R., 1950 (Amer. Assoc. Petroleum Geologists Bull., v. 34, p. 2337-2346). Considered the retention of Gries' term "Agency-Oacoma" inadvisable. Type sections are 100 miles apart and incomplete. Neither at Cheyenne Agency nor at Oacoma is there a representative section of the complete Agency-Oacoma zone of Gries. A new name, the DeGrey member of Pierre shale, was proposed for this unit.

To preserve the identify of the subdivisions of the Sully member, Crandell proposed raising the Verendrye unit, the Agency-Oacoma unit

(the DeGrey member), and the Crow Creek unit to rank of members. (Sully was therefore dropped from use.)
Type locality: Not designated
Name: From Oacoma, Lyman County, South Dakota

Oak Creek beds

Lower Cretaceous: Northeastern Wyo., western S. Dak. (Black Hills)

Jenney, W.P., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 2, p. 593, fig. 122, map). Lower Cretaceous clays and sandstone; upper beds mostly soft clays, clay shales, sandy shales, and soft sandstones, 60-120 feet thick; basal 35-40 feet consists of massive yellow sandstone often cross-bedded. Unconformably underlie Dakota sandstone and unconformably overlie Barrett shales in Black Hills. Formerly included in Dakota sandstone (Upper Cretaceous). Map shows these beds along Oak Creek, Crook County, Wyoming.

[According to W.W. Rubey (personal communication, January 1937) the rocks described are Fuson formation and upper part of Lakota sandstone as mapped in U. S. Geological Survey Aladdin Folio (Geol. Atlas No. 128, 1905) - Wilmarth, 1938.]

Type locality: Not designated
Name: From Oak Creek, Crook County, Wyoming

Oak Creek Formation

Pliocene (early) or upper Miocene: Central and southern S. Dak. (Mellette Co.)

Troxell, E.L., 1916 (Am. Jour. Science, 4th ser., v. 42, p. 345-348). Very fine-grained sandstone, probably a stream-channel deposit resting upon and within the upper Miocene or earliest Pliocene. Fauna (including a new species of horse) indicates early Pliocene. Occurs in eastern part of Rosebud Indian Reservation, near town of Mission, South Dakota.

Osborn, H.F., 1918 (Am. Mus. Nat. History Mem., n.s., v. 2, pt. 1, p. 23). Oak Creek formation, near Mission, South Dakota, is upper Miocene or lower Pliocene.

Gregory, J.T., 1942 (Univ. Calif. Pub., Dept. Geol. Science Bull., v. 26, no. 4, p. 315). Stated that the name Oak Creek is preoccupied. He thus referred the beds to the Ogallala group "without formal formational designation."

Type locality: Not designated
Name: From Oak Creek, Mellette County, South Dakota

OGALLALA GROUP

Miocene (upper) and Pliocene: Western Nebr., northeastern Colo., southeastern Wyo., southern and northwestern S. Dak., western and central Kans., western Okla., northwestern Tex., eastern N. Mex.

Darton, N.H., 1899 (U. S. Geol. Survey 19th Ann. Rept., pt. 4, p. 732-742). Calcareous grit or soft limestone, sandy clay, and sand, with basal conglomerate at many places. Of late Tertiary (Pliocene?) age. Thickness 150-300 feet. Unconformably underlies Equus beds and unconformably overlies Arikaree formation. Extends from Kansas and Colorado far into Nebraska. Is part, if not all, of the deposit which in Kansas and southward has been called "Mortar beds," "Tertiary grit," and other names. Is upper part of Loup Fork beds, the lower part of Loup Fork being Arikaree formation.

Darton, N.H., 1920 (U. S. Geol. Survey Geol. Atlas, Folio No. 212). Thick sheet of sand and gravel (chiefly sand) of late Tertiary age, which constitutes surface of Great Plains in western Kansas region and occupies most of highlands of Syracuse and Lakin Quadrangles. Thickness 180-300 or more feet. Believed to be a stratigraphic unit and to be continuous from type locality near Ogallala Station in western Nebraska. Hay supposed the deposits comprised two formations, "Plains marl" at top and "Mortar bed" below, but later studies by Haworth, Adams, and others have shown that these apparent divisions are local features and that generally fine-grained sediments alternate with the coarser "mortar beds" at different horizons. It is possible the 300 feet or more of beds that constitute Ogallala formation comprise deposits elsewhere separable. Originally the entire formation was known as "Loup Fork beds" but this term also included Arikaree formation, which is older than the Ogallala. Fossils in the Ogallala of Nebraska and Kansas range in age from very late Miocene to early Pleistocene, indicating a longer range in time than would appear to have been required for the continuous deposition of the Ogallala. Most of material appears to have been laid down rapidly by streams, although the fine-grained strata required considerable time.

Elias, M.K., 1931 (Univ. Kans. Bull., v. 32, no. 7; Kans. Geol. Survey Bull. 18, p. 131-180). Ogallala formation is here restricted to beds beneath "Plains marl." In Wallace County, Kansas, the Ogallala rests unconformably on Pierre shale, and is unconformably overlain by Pleistocene loess. Present experience indicated Biorbia rugosa fruits as most valuable index fossil of the Ogallala. Fossils in middle part of typical "mortar beds" of Wallace County are Lower Pliocene.

Cook, H.J. and Cook, M.C., 1933 (Nebr. Geol. Survey Paper No. 5, p. 43, footnote, 44). Assigned Ogallala formation to Pliocene and upper Miocene.

Hesse, C.J., 1935 (Univ. Kans. Science Bull., v. 22, no. 5, p. 79-117). Described vertebrate fauna from Feldt ranch, Nebraska, which he

stated is type location of Ogallala formation. Assigned fossils to Miocene, Pliocene, and Pleistocene, but stated the latter are not regarded as belonging to Ogallala.

Lugn, A.L., 1938 (Am. Jour. Science, 5th ser., v. 36, p. 225). Stated the position of the Nebraska Geological Survey when he redefined the Ogallala as a group consisting of four definite and mappable formations, in ascending order the Valentine, Ash Hollow, Sidney, and Kimball. This was amplified in Lugn's 1939 discussion (Geol. Soc. America Bull., v. 50, p. 1258-1259).

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 46). The Ogallala group, consisting of the Valentine, Ash Hollow, Sidney, and Kimball formations, occupies much of the surface in an area lying southeast of a line between Hay Spring, Alliance, and Broadwater in Nebraska, and Pine Bluff in Wyoming.

Brown, R.W., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 89). Overlying the Oligocene White River beds exposed in the pine-clad hills southeast of Ekalaka, Montana, and in some of the higher hills of western South Dakota, are hard strata that make protective mesa caps. These generally unfossiliferous rocks, because of their lithologic features and stratigraphic position, have been referred to by some as early Miocene Arikaree formation, but the finding in them of a late Miocene rodent (Wood, H.E., 1945, Am. Mus. Novitates, No. 1299) suggested that they may represent the Ogallala formation instead.

Agnew, A.F., 1958 (Geol. Soc. America Bull., v. 69, p. 1721). Stated that the Ash Hollow is the upper formation of the Ogallala Group in south-central South Dakota, where it is generally well cemented (in contrast to the underlying Valentine) and possesses a network of calcareous plant rootlets and clumps of Celtis seeds.

Denson, N.M., Bachman, G.O., and Zeller, H.D., 1959 (U. S. Geol. Survey Bull. 1055, p. 23-27). Refuted Brown's statement on the possibility of Ogallala in northwestern South Dakota in these words. "The rocks referred to the Arikaree formation in northwestern South Dakota... are so assigned because of their stratigraphic position and lithologic similarity to the middle Miocene Arikaree formation in the Big Badlands of southern South Dakota. On the basis of age determination of a beaver fossil collected... Wood (1945, p. 15) interpreted [these rocks] to be of upper rather than of middle Miocene age. The rocks, however, are lithologically more closely related to the Arikaree formation than to the Ogallala formation of the Great Plains."

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that the Miocene Rosebud underlies the Valentine [with erosional unconformity - A.F.A.].

Type locality: Area "near Ogallala Station," western Nebraska

Name: From Ogallala Station

Oklahoman Series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Opeche and Minnekahta in South Dakota.

"Olesrud lignite bed"

Paleocene: Northwestern S. Dak.

Denson, N.M., et al, 1959 (U. S. Geol. Survey Bull. 1055-C, p. 104-105). Stated that the Olesrud lignite bed, consisting of two benches, occurs below the Mendenhall lignite bed in the Slim Buttes of southeastern Harding County.

This lignite bed, together with the overlying Mendenhall rider and Mendenhall beds, and the underlying "Y" and "Z" lignite beds, is equivalent to the Hillen Lignite Facies mapped by the South Dakota Geological Survey in 11 quadrangles of northwestern South Dakota (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.

Oneota Dolomite

Lower Ordovician: Iowa, southern Minn., Wis., northwestern Ill., southeastern S. Dak.

McGee, W.J., 1891 (U. S. Geol. Survey 11th Ann. Rept., pt. 1, p. 331, 332). Oneota limestone--arenaceous dolomite, with intercalations of sandstone in upper part; dolomite usually coarsely saccharoidal, frequently vesicular and cavernous and generally buff-yellow or light-brown. Thickness 200-300 feet. Corresponds to "Main body" of Lower Magnesian limestone of Minnesota and Wisconsin which underlies New Richmond sandstone and overlies Jordan sandstone.

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2). Table indicated that three borings encountered the Oneota with thicknesses of 230, 340, and 350 feet.

Type locality: Not designated

Name: From exposures along Oneota River, Allamakee County, Iowa

Name should not be applied in South Dakota except possibly in extreme southeastern part of State; elsewhere is part of Deadwood - A.F.A.

OPECHE SHALE

Permian: Western S. Dak., Wyo., northwestern Nebr.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 513). Red soft slabby sandstone and sandy shale; deep-purple shale at top, for first few feet below Minnekahta limestone; basal beds are usually red sandstones, varying in thickness from 4 to 15 inches; a few local gypsum beds. Thickness 90 to 130 feet in Black Hills. Underlies Minnekahta limestone and overlies Minnelusa formation. Typically developed on Battle Creek, the Indian name for which is Opeche.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 72). In the southern Black Hills, between typical Minnelusa and typical Opeche beds, up to 120 feet of "transition beds," consisting of fine sandstone which is brick-red on the outcrop, but orange or mottled red and orange in subsurface. Condra and Reed, 1940 (Geol. Society, 14th Ann. Field Conf. Gdbk., p. 127-128) included these beds with their Cassa group of the Minnelusa. Other workers have placed the entire section in the Opeche. There are no fossils in the Opeche--it is usually considered to be Permian.

Burk, C.A. and Thomas, H.D., 1956 (Wyo. Geol. Survey Rept. Inv. 6, 11 p.). Described the Goose Egg formation of eastern Wyoming as a sequence of interbedded red to ocher shale and siltstone, thin limestone, gypsum, and limestone breccia. Rests on the Minnelusa and its equivalents (Tensleep, Casper, and Hartville), and underlies the Spearfish and its equivalent (Chugwater). The Minnekahta is the limestone with farthest east extent, and is underlain by the Opeche shale; less extensive are the overlying Forelle and Ervay limestones, all in the Phosphoria.

Type locality: Presumably on Battle Creek, South Dakota

Name: From Indian term "Opeche" (Battle Creek)

Apparently a significant part of what is considered Spearfish by the South Dakota Geological Survey is included in the upper part of the Goose Egg, but its relations are not adequately described - A.F.A.

Orella Member (of Brule Formation)

Oligocene: Nebr.

Schultz, C.B. and Stout, T.M., 1938 ([Abs.] Geol. Soc. America Bull., v.49, no. 12, pt. 2, p. 1921). In northwestern Nebraska the Oligocene deposits consist of the Chadron and Brule formations of Darton. The contact here between these two formations is provisionally drawn at the base of a continuous purple-tinted white, sometimes silicified, limestone layer, which is the upper of several such limestone beds in the lower part of the local section. A lithologic break and in places a significant and pronounced disconformity divides the Brule formation into two widespread lithologic units which should now be considered as stratigraphic members. For the lower or Oreodon zone portion of the Brule formation as it occurs in northwestern Nebraska, the name Orella member is proposed. At the typical exposure of this member it attains a thickness of about 150 feet, and is disconformably overlain by the Whitney member.

Schultz, C.B. and Stout, T.M., 1955 (Nebr. Univ. State Museum Bull., v. 4, no. 2, p. 39). Considerable progress has been made in late years toward achieving better correlations between the Nebraska and South Dakota outcrops for the Brule and younger sediments. At least the Upper purplish white layer, the Orella "A" unit, and the Orella "B"

unit, can be recognized in many parts of the Big Badlands of South Dakota as a result of the writers' efforts to match lithologies, and of studies by Stout relating the fossil rodent successions between the two states.

Type locality: 2½ miles southwest of Orella Station, in vicinity of Toadstool Park, Sec. 8, T. 33 N., R. 53 W., Sioux County, Nebraska

Name: From Orella

See Scenic Member.

Oreodon beds

Wortman, J.L., 1893 (Am. Mus. Nat. History Bull. 5, p. 95-105). Applied this term to the lower part of what was later (1899) termed the Brule Formation by Darton.

See Scenic Member.

ORMAN LAKE LIMESTONE MEMBER (of Greenhorn Limestone)

Upper Cretaceous: S. Dak., Wyo.

Petsch, B.C., 1949 (S. Dak. Geol. Survey Rept. Inv. 65, p. 9-10). Near the middle of the Belle Fourche shale member of the Graneros is a horizon of flaggy limestone, which forms an escarpment trending northwest from Belle Fourche along the northeast side of Middle Creek valley, and is prominent on both sides of the anticline. It was called the Middle Creek limestone by M.E. Wing (1940). It is here proposed to abandon the name Middle Creek because the name was preoccupied. The bed, therefore, will be called the Orman Lake limestone in this report. Orman Lake section contains about 35± feet, interbedded limestone, shale, and bentonite. The Orman Lake limestone is a beach coquina. The material is composed entirely of broken shells reduced to all sizes. It contains black grains and flakes of organic material and emits a strong petroleum odor when struck with hammer. Contains abundant shark teeth.

Cobban, W.A., 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2183). Described the Belle Fourche shale and Greenhorn limestone in the northern Black Hills. Noted that at some localities the Orman Lake limestone bed is present, and placed it at the base of the Greenhorn calcareous shale and limestone unit, which is contacted with the underlying Belle Fourche dark noncalcareous shale. He noted further that in 1949 the Orman Lake limestone was called the Bull Creek sandy limestone by Bramlette and Rubey (in R.C. Moore, 1949, fig. 18).

Type locality: On the west and south sides of Orman Lake, T. 9 N., R. 3 E., Butte County, South Dakota

Name: From Orman Lake

Otter Shale Member (of Big Snowy Group)

Mississippian (upper): Central and northern Mont., northwestern S. Dak.

Weed, W.H., 1892 (Geol. Soc. America Bull., v. 3, p. 307). Published a detailed section on Belt Creek, Montana, in which he gave following succession in lower part: (1) conglomerate and sandstone containing Jurassic fossils, 215 feet; (2) white limestone, red earthy patches, Paleozoic facies, 90 feet; (3) Otter Creek shale--alternating gray, purple, green, and black shale and earthy limestones yielding Carboniferous fossils, 212 feet; (4) black chert belt, 8 feet; (5) limestone and shale, 80 feet; (6) gypsum, 3 feet.

Weed, W.H., 1899 (U. S. Geol. Survey Geol. Atlas, Folio No. 55). In this quadrangle (Fort Benton) lowest beds of Quadrant formation are the gypsiferous Kibbey sandstone, which is overlain by Otter shale, the upper member of the Quadrant, consisting of 303 feet of dark-gray or purplish shales near the base, becoming a bright coppery-green color higher up, and interbedded with limestone, the latter seldom more than 1 or 2 feet thick, frequently oolitic, and carrying lower Carboniferous fossils. Assigned to Carboniferous. The Otter shale is overlain by Ellis formation.

[The U. S. Geological Survey adopted Otter shale member of Quadrant formation in 1907. See under Big Snowy group, of which H.W. Scott (1935) treats this as middle formation. Thickness varies from 100-500 feet - Wilmarth, 1938.]

Scott, H.W., 1935 (Geol. Soc. America Proc., 1934, p. 367). Big Snowy group is made up of Kibbey, Otter, and Heath formations. Is mainly varietaged shale with intercalated limestones and sandstones. Overlies Madison limestone.

Perry, E.S. and Sloss, L.L., 1943 (Am. Assoc. Petroelum Geologists Bull., v. 27, p. 1287-1304). Described the Big Snowy group of the Northern Great Plains, and showed (figs. 4, 5, 7) that only the lower formation, or Charles, is present to any extent in South Dakota, as the overlying Kibbey and Otter pinch out just within the State (fig. 7). (The Heath at the top is present farther north, in Montana and North Dakota.) The Charles is 600 feet thick in State Royalty #1 State oil test in northwestern South Dakota, but is absent in the Black Hills.

Sandberg, C.A., 1962 (U. S. Geol. Survey TEI-809, p. 64-65). Reported that the Big Snowy Group is represented in northwestern South Dakota by the Kibbey Sandstone. It rests on the Charles Limestone of the Mississippian Madison Group, and is overlain by the Tyler-Heath interval at the base of the Minnelusa, according to R.P. Willis, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1956), who reported (p. 1943) that although no identifiable fossils had been found in the Kibbey, it was probably Chester in age.

Type locality: Not designated

Name: From Otter Creek, Fort Benton Quadrangle, Montana

Owl Canyon Member (of Cassa Formation)

Permian: Colo., S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 4, 19, 45). Comprises that part of the Cassa group below the Lyons sandstone; thickness, 90-275 feet. The Cassa group is very persistent but marked by facies changes. Its basal sand and the thin limestone next above extend from the Owl Canyon section of Colorado to the Hot Springs section of South Dakota. To the south, the Owl Canyon formation consists of red shale and sands, which grade northward into red sands and some shale. The lower part of this formation becomes sand, mudstone, and thin dolomitic limestone in the Broom Creek section and changes back to less limestone in the southern Black Hills.
Type locality: Lower part of Owl Canyon, NW¼ sec. 6, T. 9 N., R. 59 W., and NE¼ sec. 1, T. 9 N., R. 70 W., [sic] Larimer County, Colorado.
Name: From Owl Canyon

PAHASAPA LIMESTONE (of Madison Group)

Mississippian (lower): Western S. Dak., northeastern Wyo. (Black Hills)

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 509). Massive gray limestone, 250-500 feet thick, heretofore called Gray limestone. Underlies Minnelusa formation and overlies Englewood limestone. [Referred to in Wyoming as the Madison limestone - Wilmarth, 1938.]
Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 71). On the outcrop it consists of 300-630 feet of medium-crystalline, light-gray to buff limestone or dolomitic limestone. In general it thickens to 700 feet in the northwestern corner of the state, but feathers out against Precambrian highs southeast of the Black Hills and in the central part of the state. Fossils indicate a Kinderhook-Osage age.
Type locality: Not designated
Name: From Sioux Indian name for Black Hills (Pahasapa)

Away from the Black Hills outcrop, these beds are termed Madison Group - A.F.A.

Peanut Peak Member (of Chadron Formation)

Oligocene (lower): S. Dak.

Clark, John, 1954 (Carnegie Museum Annals, v. 33, art. 11, p. 197,198). Name proposed for Upper Chadron. The Peanut Peak member level is marked by

a decrease in the sandstone channels. Near the top there is often a concentration of the thin limestone lenses that are scattered through both the middle and upper members. Only 20 miles in extent (John Clark, 1937, Carnegie Museum Annals, v. 25, p. 287.).

Type locality: Butte in southern part of Sec. 10, T. 4 S., R. 12 E., Pennington County, South Dakota

Name: From Peanut Peak (also called Crazy Johnson Butte)

Pierran Series

A term applied by C.R. Keyes, 1925 (Pan-Am. Geologist, v. 43, pl. viii) to Pierre Shale and its supposed equivalents.

PIERRE SHALE

Upper Cretaceous: S. Dak., N. Dak., eastern Wyo., eastern Mont., eastern Colo., Nebr., western Minn.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., v. 13, p. 419, 424). Named Fort Pierre group (Formation No. 4 of Cretaceous). Thickness 700 feet in Nebraska (which then included Wyoming, Montana, and the Dakotas). Underlies Fox Hills beds and overlies Niobrara division. Consists of (descending): (1) dark-gray and bluish fossiliferous plastic clays exposed on Sage Creek, on Cheyenne River, and on White River above Badlands; (2) middle zone, nearly barren of fossils, which occurs at Fort Pierre and out onto Badlands, down the Missouri on high country to Great Bend; (3) lower fossiliferous zone, which occurs at Great Bend of the Missouri below Fort Pierre; and (4) dark bed of very fine unctuous clay containing much carbonaceous matter with veins and seams of gypsum, masses of sulphuret of iron, and numerous small scales of fish, and occurring near Bijou Hills on the Missouri. The formation was named the Fort Pierre by Meek and Hayden in 1861 and the name was shortened to Pierre as early as 1896 (Darton, 1896, U. S. Geol. Survey Ann. Rept., pt. 2, p. 8).

Darton, N.H., 1905 (U. S. Geol. Survey House Doc. 780). Previous descriptions are repeated and amplified and the distribution nearly to Yankton and under Turkey Ridge is noted. At this time the occurrence of "some local chalky deposits to the south" (Crow Creek member of Searight, 1937) are noted in South Dakota, and Darton observed also in northern Nebraska, along Missouri and Niobrara valleys, the occurrence of "very dark clays varying in thickness from 10-30 feet or more. This is overlain by lighter-colored clays with thin seams of iron-oxide averaging 100 feet thick. Next above is a series of light-colored clays containing impure chalky beds weathering to buff and reddish tints, about 100 feet thick."

Russell, W.L., 1930 (S. Dak. Geol. and Nat. Hist. Survey Rept. Inv. 7, p. 3-5). A succession of 475-500 feet of beds is described.

Elias, M.K., 1931 (Univ. Kansas Bull., v. 32, no. 7). Sharon Springs shale member--basal member of Pierre shale in Wallace County, Kansas; its lithology differs widely from that of rest of formation. Believed to extend into Nebraska and South Dakota.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27). Subdivisions of the Pierre shale in central South Dakota include in descending order: Elk Butte member, Mobridge member, Virgin Creek member, Sully member (which includes the Verendrye beds, Oacoma zone, Agency shale), and the Gregory member.

Moxon, A.L., Olson, O.E., Searight, W.V., and Sandals, K.M., 1938 (Am. Jour. Botany, v. 25, p. 795, 796). In this report the Lower Gregory of the 1937 report was changed to Sharon Springs member of the Pierre formation.

Moxon, A.L., Olson, O.E., and Searight, W.V., 1939 (S. Dak. Agr. Exp. Station Tech. Bull. 2, p. 20). Subdivided the Sharon Springs on the basis of lithology into a lower unit and an upper unit and stated, "In South Dakota, all beds above the Niobrara formation and below Gregory marl (Crow Creek member) are included in the Sharon Springs member."

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 9). Detailed work has shown that the beds comprising "the upper" member (Searight's Sharon Springs, 1939) actually lie above the Gregory marl, and are characterized by a general absence of fish remains. Thus the lower part of Searight's Gregory becomes the Sharon Springs and the upper part joins the Gregory member.

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 5, 14-17). The basal sand and associated chalky beds of the Sully member have previously been correlated with the Gregory chalk of the Rosebud Bridge section. There are actually two calcareous zones in the Gregory County section, and the Sully marl is correlated with the upper one rather than with the lower or Gregory chalk. As the name Gregory does not apply, the sand and marl at the base of the Sully member is here called the Crow Creek zone, from exposures at and south of the mouth of Crow Creek, southwestern Buffalo County.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 77). Northwest of the Black Hills the units of Searight cannot be recognized, but Rubey, 1930 (U. S. Geol. Survey Prof. Paper 165A) had previously suggested a sevenfold subdivision of the Pierre formation in that area.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 3-4). Subdivided the Pierre in the Black Hills as follows (descending):

Unnamed shale--dark-gray fissile shale and mudstone with calcareous concretions; locally light-buff sandy shale; marine fossils; 150-250 feet thick.

Monument Hill bentonite member--impure bentonite and siltstone with some calcareous and barite concretions; marine fossils; about 150 feet thick.

Unnamed shale--dark mudstone and shale with abundant calcareous concretions; light-gray in upper part, iron-stained below; marine fossils; 500-800 feet thick.

Mitten black shale member--blue-black fissile shale with few iron-stained calcareous concretions; marine fossils; 150-200 feet thick.

Gammon ferruginous member--800-1,000 feet thick; abundant iron-stained concretions and thin beds of siderite in light-gray mudstone and shale. Groat sandstone bed--ferruginous and glauconitic sandstone and siltstone, near top of member; 150 feet thick in northern part. Pedro bentonite bed at base of member--hard white massive clay and tuff, locally 20 feet thick but not widespread.

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 451). Correlated Rubey's (1930) units of the Black Hills with the Missouri River section and with north-central Montana as follows (descending):

North-Central Montana	Black Hills	Missouri River
Bearpaw shale	Unnamed member	Elk Butte
		Mobridge
	Monument Hill	Virgin Creek
		Verendrye
Judith River sandstone	Unnamed member	DeGrey
		Gregory
Claggett shale	Mitten shale	Sharon Springs
Eagle sandstone	Gammon-Groat	---
Telegraph Creek	---	---

Robinson, C.S., et al, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 101-123). Used Rubey's units in describing the Pierre shale along the north and west flanks of the Black Hills as follows:

Unnamed shale--dark gray-black shale with gray- and brown-weathering limestone concretions; 200 feet thick.

Monument Hill bentonitic member--light-gray weathered bentonitic and silty shale; 150-220 feet thick.

Unnamed shale--dark gray-black shale with gray-weathering septarian concretions and red weathering concretions; 250 feet thick.

Unnamed shale--gray to brownish-gray silty and sandy shale with septarian concretions that weather gray and brown; 200 feet thick.

Mitten black shale member--soft fissile noncalcareous grayish-black shale, with dark-gray septarian concretions that weather orange; at base is 2-12 feet of brittle dark-gray fissile shale and Bentonite bed "I"; 150 feet thick.

Gammon ferruginous member--(upper unit): dark-gray mudstone and shale, weathering light gray; dark-gray iron-bearing septarian concretions; Bentonite bed "H", 1-2 feet thick, is 75 feet below top; (Groat sandstone bed): light-gray glauconitic iron-bearing sandstone, becoming silty and shaly below, 75-125 feet thick; (lower unit): same as upper unit but without septarian; total Gammon thickness 800 feet.

Correlated the Groat with the Telegraph Creek shale and Eagle sandstone of Montana, and the Shannon sandstone in the Powder River Basin. Correlated the unnamed shale immediately above the Mitten with the Gregory shale of central South Dakota, the Parkman sandstone of the Powder River Basin, and the Hygiene sandstone of north-central Colorado. They correlated the Monument Hill and the unnamed shale just below with the DeGrey of central South Dakota. The highest baculite zone of Cobban is B. reesidei, whereas in the central South Dakota section, four higher zones are found. This is caused by Fox Hills lithology occupying a lower position in the stratigraphic section of the northern Black Hills than in central South Dakota.

Gill, J.R. and Cobban, W.A., 1962 (U. S. Geol. Survey Prof. Paper 450-B, p. 21-24). Applied the name Red Bird Silty Member to the lowest of the two unnamed shales above the Mitten Member and below the Monument Hill. The Red Bird is 200-725 feet of gray marine silty shale in eastern Montana and Wyoming, and western South Dakota.

Type locality: Not designated

Name: From Fort Pierre, South Dakota

"Pine salt"

Jurassic: N. Dak., S. Dak., Mont.

Zieglar, D.L., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 49-51). Widespread drilling activity in the Williston Basin and adjoining areas in recent years has furnished much information concerning the "red beds" underlying marine strata of middle Jurassic age and overlying either the Minnekahta limestone of Permian age, or the post-Paleozoic unconformity in areas where the Minnekahta has been removed by erosion. Showed the distribution and correlation of four mappable units within this "red-bed" sequence and restricted the name Spearfish to the lower unit. The upper three units were tentatively named, in ascending order: Pine salt, Saude formation, and Dunham salt.

Pine salt is essentially an evaporitic deposit with salt predominant. Anhydrite and reddish-brown mudstone is also apparent. Thickness varies from 0 to 300 feet.

Type locality: Not designated
Name: Not given

PIPER FORMATION (of Sundance Group)

Middle Jurassic: Mont., western N. Dak., S. Dak.

Imlay, R.W., and others, 1948 (U. S. Geol. Survey Oil and Gas Inv., Prelim. Chart 32). Red to varicolored shale and silty thin limestone, and some gypsum. Correlates with the Gypsum Spring of Wyoming and intertongues with the Sawtooth of northern Montana and southern Saskatchewan. Has persistent limestone unit (Piper limestone) which makes excellent sample and E-log marker. Thickness 0-190 feet.

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 469). Proposed that the Sundance formation in eastern Wyoming and western South Dakota be raised to the rank of a group comprising two formations, which are correlated with the Swift and Rierdon formations of the Ellis group of Montana. Because of historical significance, however, the term "Sundance" should be retained, and therefore, despite its correlation with the upper units of the Ellis group, the term "Sundance group" is here applied to the marine Upper Jurassic rocks of the Black Hills and vicinity, the northernmost part of Colorado, the subsurface of western Nebraska, and all but westernmost Wyoming. Subsequent work may indicate that it is desirable to expand the "Sundance group" to include the Gypsum Spring formation. Peterson stated (p. 464) that the Sundance ranges in age from Callovian to Oxfordian (Late Jurassic), and if the Gypsum Spring is included, it includes the Middle Jurassic Bajocian. Peterson said that the Piper is Bajocian (Middle Jurassic) in age.

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that, although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation and retained the Lak, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained the Sundance name as including the Rierdon and Swift.

Peterson described (1957, p. 404, 406) the Piper as being more than 400 feet thick in the Williston Basin, where it is divisible into the three units, "A" (lower), "B", and "C" (upper) of R.W. Imlay, et al, 1948 (U. S. Geol. Survey Prelim. Oil and Gas Chart OC-32). Piper "A" is red bed and gypsum, Piper "B" is carbonate and green or gray shale, and Piper "C" is red bed with some gypsum locally. In the Williston Basin, Piper "B" tends to separate into two prominent limestone and interbedded shale units, one of which is an excellent electric log and seismic datum referred to as the "Piper lime."

Type locality: Near town of Piper, Fergus County, Montana
Name: From Piper

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic members (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

Platteville Limestone

Middle Ordovician (Black River): Southwestern Wis., southern Minn., Iowa, northwestern Ill., southeastern S. Dak. (?)

Bain, H.F., 1905 (U. S. Geol. Survey Bull. 246, p. 18, 19). Platteville limestone--the beds heretofore called "Trenton limestone" in Mississippi valley region, but older than Trenton. Consists of (descending): (1) 10-20 feet of thin beds of limestone and shale; (2) 25-30 feet of thin-bedded brittle limestone breaking with conchoidal fracture and at times called "glass-rock"; (3) 20-25 feet of buff to blue magnesium heavy-bedded limestone, frequently a dolomite; and (4) 1-5 feet of blue shale and sandy shale. Overlies St. Peter sandstone and underlies the massive Galena limestone.

[As above defined, included at top the beds later (1906) named Decorah shale and now treated as a distinct formation. Some writers now exclude from base of Platteville the shale which has been named Glenwood shale. The U. S. Geological Survey and the 1935 Conference Report of the Kansas Geological Society include this shale in Platteville limestone. The U. S. Geological Survey has for many years excluded the "glass rock" from Platteville limestone and included it in overlying Decorah shale, but Decorah shale as recently defined by Kay, et al (1935), is applied to beds stated to have heretofore been included in Galena dolomite - Wilmarth, 1938.]

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2, p. 26, 46, 63). Borings reported to have intersected the Black River (Decorah-Platteville) ranging in thickness from 50-90 feet.

Type locality: Vicinity of Platteville, Grant County, Wisconsin

Name: From Platteville

Name may be applicable in southeastern corner of State; elsewhere the rocks should be called Winnipeg - A.F.A.

POLESLIDE MEMBER (of Brule Formation)

Oligocene: S. Dak.

Bump, J.D., 1956 (Am. Jour. Science, v. 254, p. 429-432). Recognizing that the Brule formation could be divided into two stratigraphic units,

and that the terms Orella (lower) and Whitney (upper) had been proposed in Nebraska for the two faunal zones (Oreodon and Protoceras, respectively) of the Brule, established the names Scenic and Poleslide for the lower and upper members of the Brule formation in the Big Badlands of South Dakota. Stated that the Scenic and Poleslide are remarkably uniform in an east-west direction, but change greatly in a north-south direction. Thus the lithologic boundaries of the Nebraska Oligocene do not appear to correspond closely to those in South Dakota. Conformably underlies the basal Arikaree white ash (Rockyford Ash), and rests conformably on Scenic member of the Brule formation.

Bump described three units of the Poleslide, as follows:

Upper zone--gray silty ash; 85 feet.

Middle zone--buff and gray-colored clays. Protoceras-bearing channel sandstones at several levels in upper third. Sandstones highly fossiliferous, clays less so; 111 feet.

Lower zone--light-gray color with brown band above and below (light-weathering band of Wanless, 1923 (Am. Philos. Soc. Proc., v. 62, p. 160-269), 13 feet, overlying brownish-gray clays, 90 feet.

Type locality: NW¼ sec. 23 (33?), T. 43 N., R. 44 W., 8½ miles south of Scenic, on southern rim of Sheep Mountain Table, Shannon County, South Dakota.

Name: Derived from wooden chutes used to slide cedar posts down to a point where they could be reached with a team and wagon (J.C. Harksen, personal communication, January 1965).

Ponca Sandstone

Lower Cretaceous: Northwestern Iowa, northeastern Nebr., southeastern S. Dak.

Keyes, C.R., 1912 (Iowa Acad. Science Proc., v. 19, p. 148, 150). Ponca sandstone, 25 feet thick, underlying Woodbury shale and overlying Sergeant shale. Composed top formation of Dakotan series.

Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Ponca sandstone, 75 feet thick, above Sargeant [sic] terrane, and below Woodbury terrane. Top formation of Dakotan series.

Type locality: Not designated

Name: From Ponca, Dixon County, Nebraska

The Ponca is equivalent to the upper part of the threefold Dakota sequence in the type area near Sioux City, Iowa - A.F.A.

POOL CREEK SHALE MEMBER (of Carlile Shale)

Upper Cretaceous: Eastern Wyo., S. Dak.

Knechtel, M.M. and Patterson, S.H., 1962 (U. S. Geol. Survey Bull. 1082-M, p. 921-922). Named the lower shale member of the Carlile, the Pool

Creek, and described it as consisting of a lower unit of 13 feet of dark-gray soft papery shale with a few layers of limestone concretions at its top, and an upper unit of 81 feet of black-gray shale that contains in the lower part two bentonite layers, and in the upper 37 feet, numerous clay-ironstone concretions. Its fossils are middle Turonian in age, according to J.D. Haun, 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87).

Type locality: Near the place where Highway 85 crosses the head of Pool Creek, 5 miles north of Belle Fourche, Butte County, South Dakota

Name: From Pool Creek

Potsdam Sandstone

Name applied in early reports (pre 1901) to Deadwood sandstone.

Protoceras beds

Wortman, J.L., 1893 (Am. Mus. Nat. History Bull. 5, p. 95-105). Named the upper part of what was later (1899) called the Brule formation by Darton, the Protoceras beds. See Poleslide Member.

Also called Leptauchenia beds.

"Purple limestone"

Refers to Minnekahta Limestone in reports prior to 1901. See Minnekahta Limestone.

Rapid City lens (of Newcastle Sandstone Member)

Upper Cretaceous: S. Dak.

Grace, R.M., 1952 (Wyo. Geol. Survey Bull. 44, p. 14, 17). The Newcastle formation thickens into lenses in seven of the areas studied. The Rapid City lens--the first outcrop found southeast from Tilford--is at a point 3 miles north of Rapid City. Here the formation is 27 feet thick, consisting primarily of shale, but containing 3 feet of sandstone. The Newcastle formation is not exposed between this point and Rapid City. Within the city limits of Rapid City the Newcastle formation is 25 feet thick, consisting almost entirely of sandstone and forming a ridge 1 mile long.

Type locality: Not designated

Name: From Rapid City, South Dakota

Reclamation Formation

Pennsylvanian: Wyo., west-central S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 32). Comprises Division 5 (Condra and Reed, 1935) of Hartville "formation"; thickness 72-87 feet. Varied lithology, consisting mostly of limestone and shale. The group encircles the Black Hills region without much facies change. Correlates with lower part of Minnelusa in the Black Hills.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Says that Reclamation group of limestone and dolomite is present in west-central South Dakota, as much as 150 feet thick. Rests on the Fairbank, below the Roundtop.

Type locality: Reclamation Hills, Sec. 27, T. 27 N., R. 66 W., Platte County, Wyoming

Name: From Reclamation Hills

"Red beds"

Descriptive term applied to Opeche Shale and Spearfish Formation, sometimes including Minnekahta Limestone.

RED BIRD SILTY MEMBER (of Pierre Shale)

Upper Cretaceous: Eastern Wyo., eastern Mont., western S. Dak.

Gill, J.R. and Cobban, W.A., 1962 (U. S. Geol. Survey Prof. Paper 450-B, p. 21-24). Named the Red Bird for the silty shale unit that rests on the Mitten Black Shale Member and underlies the unnamed upper shale of the Pierre. It can be traced eastward into the Gregory (below) and Crow Creek Members of the Pierre in central South Dakota, westward into the Parkman Sandstone of the Mesaverde in the Powder River Basin, and northwestward into the Judith River Formation of eastern Montana. The Red Bird is soft silty shale that weathers light to medium gray and contains numerous concretions that weather light gray to yellowish orange. The member is 690-745 feet thick in the type area, and includes three of Cobban's baculite zones.

Type locality: $NW\frac{1}{4}SW\frac{1}{4}$ sec. 13, and $NE\frac{1}{4}NE\frac{1}{4}$ sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming, about 2 miles northeast of Red Bird store.

Name: From Bed Bird store.

"Red Marker shale" (of Minnelusa Formation)

Pennsylvanian: S. Dak., Wyo.

A driller's term used to designate a zone of red shales lying about 500 feet below the top of the Minnelusa Formation. It is usually not very thick, but serves to indicate that Leo sands are being approached. Good gamma ray kick.

Bates, R.L., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 1995). Stated that the "Red Marker" can be used in subsurface correlation of the Minnelusa for many miles away from the Lance Creek oil field of the eastern Powder River Basin in Wyoming, echoing the work of R.S. Agatston, 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 533-534), who described it as part of the Hartville formation (equivalent to Minnelusa).

Agatston stated that the Red Marker separates the Pennsylvanian from the Permian part of the section, and T.V. Jennings (1959, Jour. Paleontology, v. 33, p. 994) agreed.

Type locality: Not designated

Name: From lithology. Apparently first used in print by E.Q. Krampert, 1940, Kans. Geol. Survey Gdbk., 14th Ann. Field Conf., p. 160, in the Dewey Dome and Dewey Terrace fields, Wyoming.

RED RIVER DOLOMITE (of Bighorn Group)

Ordovician: Man., Sask., N. Dak., northern S. Dak., eastern Mont.

Foerste, A.F., 1929 (Denison University Bull., Jour. Sci. Lab., v. 29, no. 2, p. 35, 37). From quarries along shores of Lake Winnipeg, Manitoba. Thick-bedded crystalline to fragmental limestones and dolomites. Sometimes shaly in basal unit and often sandy to cherty in medial unit. Very uniform and widespread and one of the most consistent formations in the Williston Basin. In outcrop has been divided into three units as follows, descending: Selkirk--limestone; Cat Head--dolomite and chert; Dog Head--dolomitic limestone.

In the subsurface, this formation also has a distinctive threefold aspect which for want of correct terminology has been called Units A, B, and C. The Red River is the equivalent of the Whitewood of the Black Hills, and the Bighorn dolomite of Montana. Thickness 250-1,100 feet.

Erickson, H.D., 1954 (S. Dak. Geol. Survey Rept. Inv. 74, p. 43). Introduced the term Red River for rocks that the Survey had previously called Trenton, Decorah, and Platteville. In the Hunt #2 School Land oil test in Hyde County, the Red River consists of pink to buff, hard fossiliferous dolomite, 100 feet thick, underlain by 70 feet of fine light-gray to pinkish, hard dolomitic limestone with clay streaks.

Ross, R.J., 1957 (U. S. Geol. Survey Bull. 1021-M, p. 444-445). Included the Red River and overlying Stony Mountain limestones of the Williston

Basin in the Bighorn group. J.G.C.M. Fuller, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1343 and figs. 4-6) agreed and divided the Red River into two general lithologic units; a lower marine fossiliferous limestone that is variably dolomitized, which in South Dakota ranges up to 525 feet thick (fig. 9); and an upper evaporitic, thin-bedded carbonate sequence, 65-140 feet thick. The "transition" beds at the base (called Hecla), are part of the Red River, although C.A. Sandberg, 1961 (U. S. Geol. Survey TEI-809, p. 28) and C.G. Carlson, 1960 (N. Dak. Geol. Survey Bull. 35, p. 61) placed them in the underlying Winnipeg. The top of the Red River marks the end of the Middle Ordovician, according to Fuller (p. 1349).

Type locality: Not designated

Name: Probably from Red River, Manitoba

REDWATER SHALE MEMBER (of Sundance Formation)

Upper Jurassic: S. Dak., Wyo.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 259-264). The Redwater shale member of Sundance formation consists of 80-190 feet or more of greenish-gray to gray, soft fissile shale that includes some soft glauconitic sandstone in the lower 20-30 feet, and some thin beds of coquinoid or oolitic limestone in the upper half. The contact with the overlying Morrison formation is gradational within an interval of 10-15 feet and must generally be chosen arbitrarily. At type locality the lower 18 feet of the member consists of alternating beds of gray shale and soft yellow sandstone. The upper 118 feet consists mainly of soft dark-gray shale, but contains lenses of sandy limestone at several levels and many limestone concretions in the upper half. Overlain by 5-10 feet of soft yellow sandstone, and that by gray shale containing small calcareous pellets typical of the Morrison formation.

The Redwater shale member averages 100-150 feet in thickness, and appears to be a little thicker along the western than the eastern side of the Black Hills. The Redwater shale member of the Sundance formation correlates faunally with the Curtis formation of Utah, the Stump sandstone of eastern Idaho and western Wyoming, the Swift formation of Montana, and the "Upper Sundance" formation in central Wyoming.

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that, although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation and retained the Lak, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained the Sundance name including the Rierdon and Swift.

Type locality: One-half mile north of Redwater Creek, 9 miles northwest of Spearfish, in the southern half Sec. 2, T. 7 N., R. 1 E., Butte County, South Dakota

Name: From Redwater Creek

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic formations (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance - A.F.A.

Ree beds

Oligocene?: S. Dak.

Cope, E.D., 1892 (Am. Assoc. Adv. Science Proc., v. 40, p. 285). In a description of the Ree Hills, South Dakota, described a chalky matrix, of Oligocene or Eocene age, underlying the glacial drift and containing many fossil fishes, "probably fresh water," but not enough fossils to determine age. "Should the calcareous stratum in which these fossils are found not turn out to be an outlier of the White River beds, I propose that they be called the Ree beds."

Type locality: Ree Hills, just south of Ree Heights, Hand County, South Dakota

Name: From Ree Hills

The exact stratigraphic position of the Ree beds has not yet been established, but regional geology suggests that they may be late Tertiary in age - A.F.A.

RIERDON FORMATION (of Sundance Group)

Upper Jurassic: Mont., S. Dak., N. Dak., Wyo.

Cobban, W.A., 1945 (Am. Assoc. Petroleum Geologists Bull., v. 29, p. 1277-1281). The name Rierdon is herein applied to the group of alternating gray limy shales and limestones overlying the upper sandy beds of the Sawtooth and disconformably underlying the dark-gray micaceous shale and sandstone of the Swift formation. The Rierdon is defined solely on the basis of its lithologic character. At the type locality the lower part of the formation is of upper Bathonian age and the remainder lower Callovian. The age range of the formation varies. Its basal beds are younger on the flanks of the south arch than along the Rocky Mountain front. The Rierdon is 137 feet thick at the type locality.

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 475). The term Rierdon is here applied to the lower unit of the Sundance group in eastern Wyoming ("lower Sundance" of some authors) and western South Dakota, which includes the sequence of nonglauconitic silty shale, sandstone, limestone, and red beds that underlie the Swift

formation ("upper Sundance"). The information used in compiling this report provides convincing evidence for lithologic correlation of the "lower Sundance" in eastern Wyoming, the Canyon Springs, Stockade Beaver, Hulett, and Lak members in the Black Hills, and the Rierdon formation in Montana. Peterson said (p. 464) that the Rierdon is Callovian (Upper Jurassic) in age.

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation and retained the Lak, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained the Sundance name as including the Rierdon and Swift.

The Rierdon seas deposited three main lithologic units in the Williston Basin, called "A" (below), "B", and "C". Rierdon "A" is calcareous and gives a good electric log shoulder; Rierdon "B" is shale; and Rierdon "C" is sandy. The Rierdon is as much as 350 feet thick in the central part of the Williston Basin.

Type locality: Sec. 23, T. 24 N., R. 9 W., in Rierdon Gulch, Montana
Name: From Rierdon Gulch

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic members (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

ROCKYFORD ASH MEMBER (of Sharps Formation)

Miocene (lower): Southwestern S. Dak.

Nicknish, J.M. and Macdonald, J.R., 1962 (Am. Assoc. Petroleum Geologists Bull., v. 46, p. 685-690). Named the Rockyford Ash as the basal member of the Sharps Formation of southwestern South Dakota. It is "possibly correlative" with an ash in the Gering Formation of Nebraska.

Harksen, J.C., 1960 (S. Dak. Geol. Survey, Geol. Quad., Sharps Corner), and Harksen and others, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 674). Had earlier used the Rockyford Ash as the basal unit of the Sharps Formation, giving credit to Nicknish for his unpublished thesis (1957, S. Dak. Sch. Mines and Technology, Rapid City).

Type locality: SE$\frac{1}{4}$NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 32, T. 43 N., R. 44 W., Shannon County, South Dakota
Name: From town of Rockyford, 10 miles to south

ROSEBUD FORMATION (of Arikaree Group)

Miocene (lower and early middle): Central and southern S. Dak., north-central Nebr.

Gidley, J.W., 1904 (Am. Mus. Nat. History Bull., v. 20, p. 241-246). The lower Miocene formation (probably the lowest stage of the lower Miocene) of southern South Dakota. Best exposed along Little White River and in vicinity of Rosebud Agency (Todd County). Closely resembles portions of upper Oligocene beds, both in character and general appearance, except that they contain a little more sand. Lithology of these river and plains deposits is so unreliable that paleontological evidence is necessary to determine horizon. Overlain unconformably by Loup Fork beds (uppermost Miocene). No traces of middle Miocene in region. Is possibly equivalent of Gering beds of Darton in northwest corner of Nebraska.

Osborn, H.F., 1909 (U. S. Geol. Survey Bull. 361, p. 65). Showed these beds as lower and early middle Miocene, and as the equivalent of Arikaree formation of northwest Nebraska and southeastern Wyoming. Arikaree has priority.

Johnson, F.W., 1938 (Am. Jour. Science, 5th ser., v. 36, p. 215-219). Included these beds in his generalized section of the Valentine area in Cherry County, Nebraska. Indicated an Oligocene age and assigned them to the Brule (?). [Recent work by the South Dakota Geological Survey in that area indicates that the Rosebud Formation overlies the Brule there - A.F.A.]

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1270-1271). Considered the term "Rosebud" the eastern equivalent of the Arikaree group and the lower part of the overlying Marsland formation; however, he did not recommend discarding the term Rosebud in South Dakota and northern Nebraska "as an inclusive term for the correlative formations where they are too indistinct for differentiation." [Thus it seems to be the same usage as the Arikaree Group of the South Dakota Geological Survey, according to W.D. Sevon, 1960 (S. Dak. Geol. Survey, Geol. Quad., Spring Creek) - A.F.A.]

Macdonald, J.R., 1958 (S. Dak. Acad. Science Proc., v. 36, p. 113-114). Had earlier noted some similarities and some differences between the Rosebud on the one hand, and between the Arikaree and its subdivisions Gering, Monroe Creek, and Harrison together with the overlying Marsland, on the other.

Harksen, J.C., 1960 (S. Dak. Geol. Survey, Geol. Quad., Sharps Corner). Described the "Rosebud Facies" of the Arikaree Group as resting on the Harrison Formation in Shannon County. This "Rosebud Facies" is unlike the typical Marsland of Nebraska (which rests on the Harrison), although it may be of the same age.

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that in the type area of the Rosebud Formation (Todd County, South Dakota) the Rosebud is exposed above the Brule and below the Valentine Formation. These beds are traced westward through scattered outcrops along most of the southern border of South Dakota. In the Porcupine Creek and Wounded Knee Creek area (Shannon County, South Dakota), the Rosebud Formation overlies the Harrison Formation and

is the most widely exposed lithic unit in the southern part of the area. In recent years, these beds have been referred to the Marsland Formation on the basis of the fossil fauna. Although partially equivalent in age, these beds are quite distinct lithologically from the Marsland or "Upper Harrison" of western Nebraska. The Rosebud at its type locality appears to be the age equivalent of the Arikaree and the overlying Rosebud in the Shannon County exposures, 100 miles to the west. [This, together with its mappability, has caused its designation by the South Dakota Geological Survey to be changed from a facies to a formation - A.F.A.]

Type locality: Not designated

Name: From Rosebud Agency, Todd County, South Dakota

ROUGHLOCK SILTSTONE MEMBER (of Winnipeg Formation)

Ordovician (middle): S. Dak. (Black Hills)

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 44-46). Lower part moderately argillaceous, quartzose siltstone; middle part pure quartzose siltstone, occasionally limonite stained; upper part varies from siltstone to fine-grained sandstone. Contact with overlying Whitewood limestone conformable; underlain by Ice Box shale. Thickness 25-30 feet. Conodonts well preserved. Unit disappears by nondeposition 10 miles south of Deadwood, South Dakota.

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35, p. 59-61). Accepted Roughlock as the upper member of the Winnipeg in the Williston Basin, and J.G.C.M. Fuller agreed (1961, Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1341). However, Fuller pointed out that this applied only to the lower, or siltstone part of McCoy's Roughlock. The upper part ("transitional beds" of Furnish, et al, 1936, Am. Assoc. Petroleum Geologists Bull., v. 20, p. 1320-1341), is traceable into the Hecla beds at the base of the Red River, says Fuller.

Type locality: 2.4 (6.5?) miles above (southwest?) Maurice, in Spearfish Canyon, Lawrence County, South Dakota

Name: From Roughlock Falls, South Dakota

Roundtop Formation

Pennsylvanian: Wyo., western and southwestern S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 32, 44). Comprises Division 4 (Condra and Reed, 1935) of Hartville "formation"; thickness 149 feet. Consists of interbedded shale, sandstone, and limestone. Correlates with lower part of the "Minnelusa" in the Black Hills.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that Roundtop group of shale and dolomite is present in west-central South Dakota and the southern Black Hills. Above the Reclamation, below the Hayden.

Type locality: Roundtop Mountain, Sec. 22, T. 27 N., R. 66 W., Platte County, Wyoming

Name: From Roundtop Mountain

"Rusty Member" (of Pierre Shale)
(not "Rusty beds" of Thermopolis of Wyoming)

Upper Cretaceous: Southwestern S. Dak., northwestern Nebr.

Cook, H.J., 1922 (Pan-Am. Geologist, v. 37, p. 421-424). The "Rusty" member of Pierre shale, or Ainsworth formation as it is sometimes called, unconformably underlies the Chadron south and east of Black Hills uplift in South Dakota and Nebraska.
Type locality: Not designated
Name: From color
See Interior weathered zone.

SAGE BREAKS SHALE MEMBER (of Carlile Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). Sage Breaks shale member--gray noncalcareous mudstone and shale with many large light-gray calcareous septarian concretions. Fossils scarce, marine. Commonly forms scarps and buttes. Thickness 250-325 feet. Is lower member of Niobrara formation. Underlies Beaver Creek chalky member of Niobrara and overlies Turner sandy member of Carlile shale. Included in Carlile shale in previous reports on northeastern Wyoming and southeastern Montana.
Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87-88). Placed the Sage Breaks member in the Carlile, following W.A. Cobban, 1951 (Am. Assoc. Petroleum Geologists Bull., v. 35, p. 2187), rather than in the Niobrara. Described the member at Newcastle, Wyoming, as dark-gray fissile shale with several zones of yellow concretions. It is 200-300 feet thick.
Knechtel, M.M. and Patterson, S.H., 1962 (U. S. Geol. Survey Bull. 1082-M, p. 924-925). Described the Sage Breaks in the northern Black Hills as dark-gray noncalcareous shale with many limestone concretions. Six miles north of Belle Fourche it is 195 feet thick, whereas 20 miles farther west it is 300.
Type locality: Exposure in the Sage Breaks, T. 46 N., R. 63 W., Weston County, Wyoming
Name: From Sage Breaks

St. Peter Sandstone

Lower Ordovician: Minn., Wis., Mich., Iowa, Ill., Mo., Ind., Ohio, Ky., Kans., Ark., Okla., southeastern S. Dak. (?)

Owen, D.D., 1847 (Prelim. Rept. Prog. Geol. Survey Wis. and Iowa, U. S. Gen. Land Office Rept. 1847, p. 169, 170). Soft white sandstone

(called St. Peter's soft white sandstone on p. 170) near Lake St. Croix [Minn.], capped with shell limestones such as form upper portions of hills on Wisconsin River near Prairie du Chien and constitute whole of escarpment of St. Peter's Falls, as well as bluffs on both sides of the Mississippi, from thence to Carver's Cave and St. Paul's and therefore sometimes alluded to under the local name St. Peter's formation. In the upper Mississippi valley region the St. Peter sandstone unconformably overlies Shakopee dolomite and underlies Platteville limestone.

Stauffer, C.R., 1934 (Jour. Geology, v. 42, p. 352). Minnesota River was formerly called St. Peters, and from outcrops near its mouth the St. Peter sandstone was named.

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2, p. 15, 20, 46, 53, 63). St. Peter sandstone encountered in borings. Thickness ranges from 10 to 88 feet.

Type locality: Bluff at Fort Snelling, at junction of Minnesota and Mississippi River, Minnesota

Name: From St. Peters, former name for Minnesota River

Name may be applicable in the extreme southeastern part of the State; elsewhere, it should be called Winnipeg - A.F.A.

Saskatchewan Group

Devonian: Subsurface in Sask., Man., Mont., N. Dak., S. Dak.

Baillie, A.D., 1953 (Man. Dept. Mines and Nat. Res., Mines Br. Pub. 52-5, p. 30-32) (Williston Basin Correlation Committee, Feb. 18, 1953). The Saskatchewan group consists of a thick series of strata immediately overlying the Souris River formation of the Beaverhill Lake group and underlying the carbonate-clastic-evaporite unit comprising the Qu'Appelle group. Predominant lithology consists of dolomite, anhydrite, limestone, and shale. The Saskatchewan group has been divided into two units, the Duperow and the Nisku formations, in ascending order.

Baillie, A.D., 1955 (Am. Assoc. Petroleum Geologists Bull., v. 39, p. 603). A remarkably persistent argillaceous zone occurs less than 150 feet below the top of the Saskatchewan group. The zone, easily recognized by lithologic or mechanical logs, is perhaps the most reliable marker bed in the group. The bed ranges in thickness from 10-30 feet and consists of red and green dolomitic shale, slightly silty in places, and argillaceous limestone.

Type locality: Not designated

Name: From Saskatchewan, Canada

This represents the same interval as the Jefferson Group, which term the South Dakota Geological Survey uses - A.F.A.

"Saude formation"

Jurassic: N. Dak., S. Dak., Mont., Sask., Man.

Zieglar, D.L., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 52). Widespread drilling activity in the Williston Basin and adjoining areas in recent years has furnished much information concerning the "red beds" underlying marine strata of middle Jurassic age and overlying either the Minnekahta limestone of Permian age, or the post-Paleozoic unconformity in areas where the Minnekahta has been removed by erosion. Showed the distribution and correlation of four mappable units within this "red bed" sequence and restricted the name Spearfish to the lower unit. The upper three units were tentatively named, in ascending order, Pine salt, Saude formation, and Dunham salt. The Saude formation conformably overlies the Pine salt. In areas where the Pine salt is absent, the Saude rests unconformably on rocks ranging in age from Permian (?) to Devonian and possibly older. In areas where the Dunham salt is absent, the Saude is overlain by the Piper formation with very slight evidence of erosional unconformity. The Saude is predominantly reddish-orange siltstone and very fine-grained sandstone with varying amounts of medium to coarse-grained sandstone interbeds. Reddish-brown and greenish-gray mudstone streaks also occur. Thickness 0-100 feet in South Dakota.

Type locality: Not designated

Name: Not given

SCENIC MEMBER (of Brule Formation)

Oligocene: S. Dak.

Bump, J.D., 1956 (Am. Jour. Science, v. 254, p. 429-432). Recognizing that the Brule formation could be divided into two stratigraphic units, and recognizing further that the terms Orella (lower) and Whitney (upper) had been proposed in Nebraska for the two faunal zones (Oreodon and Protoceras, respectively) of the Brule, established the names Scenic and Poleslide for the lower and upper members of the Brule formation in the Big Badlands of South Dakota. Stated that the Scenic and Poleslide are remarkably uniform in an east-west direction but change greatly in a north-south direction; thus the lithologic boundaries of the Nebraska Oligocene do not appear to correspond closely to those in South Dakota. Rests conformably on Chadron member of Brule formation. Overlain conformably by the Poleslide member.

Bump described the two units of the Scenic as follows:

"Upper nodular zone"--light cream-colored to gray clay with bedded or scattered rounded or lens-shaped silt concretions; poorly fossiliferous except for upper 12 feet; 123 feet.

"Lower nodular zone"--pink-gray clays weathering brown-gray. Numerous clay-lime concretions that weather rusty; highly fossiliferous; 36 feet.

Type locality: SE¼ sec. 23 (27?), T. 3 S., R. 13 E., 2.2 miles south of Scenic, Pennington County, South Dakota

Name: From Scenic

"Scolithus sandstone"

Upper Cambrian (?): S. Dak. (Black Hills)

Jagger, T.A., 1899 (U. S. Geol. Survey 21st Ann. Rept., pt. 3, p. 177, 178). The Cambrian section where exposed forms cliffs of red and brown color, striped parallel to stratification, one red band in upper part being conspicuous in many places (top of Deadwood formation). Immediately beneath the Silurian limestone the Cambrian usually forms a bench, occasioned by the hard and salient "worm eaten" (Scolithus) quartzite jutting out from beneath thick, soft green shale.

Furnish, W.M., Barragy, E.J., and Miller, A.K., 1936 (Am. Assoc. Petroleum Geologists Bull., v. 20, p. 1330, 1331). Scolithus sandstone lies at base of 40-foot shale unit of Whitewood and consists of 15 feet of sandstone. Remains a part of the Deadwood formation.

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 46-47). Aladdin sandstone--fine- to medium-grained quartzose sandstone 12-25 feet thick with wormy appearance due to borings of marine worm, "Skolithos." Aladdin often referred to as "Scolithus sandstone," and lies above Deadwood formation. Underlies Ice Box shale. No proof of age.

Type locality: Not designated

Name: From wormy appearance due to borings of marine worm, "Skolithos". See Aladdin Sandstone.

Scotch Cap Sandstone (of Ludlow Formation)

Paleocene: S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 28). The sandstone lying above the Hillen coal zone and below the position of the Bison coal and the Bison silt is perhaps the most conspicuous bed in the Ludlow-Cannonball succession of central Perkins County. The Scotch Cap sandstone is fairly uniform lithologically from place to place. The bed is massive and composed of fine, silty, micaceous sandstone of a light-gray or light-buff color. In many places, however, it is drab or brown. It is variable in thickness, the maximum thickness in the area being approximately 36 feet.

Type locality: Presumably NE¼NW¼ sec. 23, T. 18 N., R. 12 E., South Dakota
Name: From Scotch Cap Butte, South Dakota

Mapped in three quadrangles of central Perkins County, apparently local - A.F.A.

Sergeant Shale

Lower Cretaceous: Northwestern Iowa, southeastern S. Dak.

Keyes, C.R., 1912 (Iowa Acad. Science Proc., v. 19, p. 148, 150). Sergeant shale, 75 feet thick, underlies Ponca sandstone and overlies Nishnabotna sandstone. All included in Dakotan series.
Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Sargeant (sic) shale, 60 feet thick, below Ponca terrane and above Nishnabotna terrane, all in Dakotan series.
Type locality: Not designated
Name: From Sergeant Bluff, Woodbury County, Iowa

The Sergeant is equivalent to the middle part of the threefold Dakota sequence in the type area near Sioux City, Iowa - A.F.A.

SHADEHILL LIGNITE FACIES (of Ludlow Formation)

Paleocene: S. Dak.

Stevenson, R.E., 1954 (S. Dak. Geol. Survey, Geol. Quad., Lemmon). Locally at the base of the Ludlow formation are as many as seven coal beds with associated beds of peat-clay, clay, shale, and sand. Thickness of the facies varies greatly, and reaches maximum of 70 feet in the quadrangle.
Type locality: Not designated
Name: Apparently from Shadehill Reservoir, 15 miles south of Lemmon, Perkins County, South Dakota

This facies marks the base of the Ludlow throughout 24 quadrangles of northwestern South Dakota, and appears to be correlative with the "Basal coal zone" of Searight, 1934 (S. Dak. Geol. Survey Rept. Inv. 21, p. 17). The Shadehill Lignite Facies appears to include the coal called the "Hell Creek lignite" by N.M. Denson, G.O. Bachman, and H.D. Zeller, 1959 (U. S. Geol. Survey Bull. 1055) - A.F.A.

Shakopee Dolomite

Lower Ordovician: Southern Minn. and Wis., Iowa, northern Ill., southeastern S. Dak. (?)

Winchell, N.H., 1874 (Minn. Geol. and Nat. Hist. Survey, 2nd Ann. Rept., p. 138-147). Shakopee limestone--magnesian limestone alternating with calcareous sandstone. Thickness in Minnesota Valley, 70 feet. Is uppermost member of Lower Magnesian (later named Prairie du Chien group). Outcrops at Shakopee, Minnesota, and in general is a gray to buff, dolomitic limestone, massive to thin-bedded, often cherty and sandy, and frequently oolitic.

Baker, C.L., 1947 (S. Dak. Geol. Survey Rept. Inv. 57, pl. 2, p. 20). Indicated that four borings penetrated the Shakopee dolomite with thicknesses of 40 (?), 65, 100, and 90 feet.

Type locality: Exposures near Shakopee, Scott County, Minnesota

Name: From Shakopee

Name should not be used in South Dakota except possibly in extreme southeastern part of State; elsewhere should be called Deadwood - A.F.A.

SHARON SPRINGS MEMBER (of Pierre Shale)

Upper Cretaceous: Northwestern Kans., eastern Colo., S. Dak.

Elias, M.K., 1931 (Univ. Kansas Bull., v. 32, no. 7). Sharon Springs shale member--basal member of Pierre shale in Wallace County, Kansas; lithology differs widely from that of rest of formation. Upper 65 feet flaky, somewhat bituminous black shale and, rarely, porous light-gray shale, both with abundant fish scales, gigantic septarian and smaller tough ordinary limestone concretions; also abundant soft concentric concretions, and very few thin bentonite streaks. Lower 90 feet flaky, somewhat bituminous black shale with abundant small fish bones and scales, also somewhat rusty, gray shale; thin rusty limonite streaks rare; concretions nearly absent. Underlies Weskan shale member of Pierre and overlies Niobrara chalk. Believed to extend into Nebraska and South Dakota.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 11). Basal Pierre extends southward under Nebraska toward Kansas where possibly reappears at the surface as lithologically similar beds in Smoky Hill member of Niobrara. Presumably comes to the surface in western Kansas--as the lower part of the Sharon Springs member of Pierre.

Moxon, A.L., Olson, O.E., Searight, W.V., and Sandals, K.M., 1938 (Am. Jour. Botany, v. 25, p. 795, 796). In this report the Lower Gregory of the 1937 report was changed to Sharon Springs member of Pierre formation.

Moxon, A.L., Olson, O.E., and Searight, W.V., 1939 (S. Dak. Agr. Exper. Station Tech. Bull. 2, p. 20). Subdivided the Sharon Springs on the

basis of lithology into a lower unit and an upper unit and stated, "In South Dakota all beds above the Niobrara formation and below Gregory marl (Crow Creek member) are included in the Sharon Springs member."

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 9). Detailed work has shown that the beds comprising the "upper" member (Searight's Sharon Springs, 1939) actually lie above the Gregory marl, and are characterized by a general absence of fish remains. [Thus the lower part of the Sharon Springs of Moxon, Olson, and Searight (1939) becomes the Sharon Springs (restricted), and the upper part joins the Gregory member - A.F.A.]

Type locality: Not designated

Name: From Sharon Springs, Kansas

SHARPS FORMATION

Miocene (lower): Southwestern S. Dak.

Harksen, J.C., and others, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 674-678, May). Described a new flood-plain silt formation with nodules, the Sharps, in southwestern South Dakota. Its position as the basal formation of the Arikaree group in southwestern South Dakota, below the Monroe Creek formation and above the White River group, represents the same position as the Gering channel sands of western Nebraska, but with different lithology and depositional environment.

Schultz, C.B. and Stout, T.M., 1961 (Univ. Nebr. State Museum, Spec. Pub. No. 2, p. 7, 47, fig. 15, July). On the other hand, felt that the name Sharps is a synonym of Gering because it "occupies the position of the Gering" (p. 7). They do not describe the flood-plain facies of their expanded Gering (although it is shown in fig. 15); in fact, the descriptive notes for the Gering seen on the field trip record that it has "a fine channel development" (p. 47).

Type locality: SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 31, T. 40 N., R. 42 W., and NE$\frac{1}{4}$ sec. 20, T. 39 N., R. 43 W., Shannon County, South Dakota

Name: From Sharps Corner Store, between the two localities

The Gering of Schultz and Stout (1961) is not recognized in South Dakota - A.F.A.

Sheep Creek beds

Miocene: Western Nebr., eastern Wyo., southwestern S. Dak. (?)

Matthew, W.D. and Cook, H.J., 1909 (Am. Mus. Nat. History Bull., v. 26, art. 27, p. 362-363). Sheep Creek beds--soft, fine-grained sandy "clay," light-buff, free from pebbles and containing harder calcareous layers. Near top is 2-foot layer of dark-gray volcanic ash. Middle

Miocene fossils. Thickness 100 feet. Unconformably underlie Snake Creek beds and unconformably overlie lower Miocene beds equivalent to Daemonelix beds [Harrison] of Niobrara Valley.

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1254-1258). Stated that the Sheep Creek formation consists of channel gravels and sands, fine silty sand, silt and clay, and harder caliche beds of widely ranging textural characteristics, all of which fill narrow valleys and ravines to depths of 30-140 feet or more. These isolated deposits are widespread throughout a large area of northwestern Nebraska; in part of the southern half of Sioux County the formation extends continuously as a deposit of channel, flood-plain, and slack-water sediments. The total thickness of the Sheep Creek formation in the type locality is more than 200 feet. Mapping in southeastern Dawes County (50 miles east of the type area) shows 70 feet of beds stratigraphically higher than in the type area, and a still higher "member" (later named Box Butte by R.C. Cady, 1940, Am. Jour. Science, v. 238, p. 663-667). Late Miocene age, according to vertebrates and seeds. (These upper strata have been called Snake Creek by Matthew, 1924, Am. Mus. Nat. History Bull., v. 50, p. 59-210).

The Sheep Creek channels were cut into the Marsland or Harrison, and were filled with channel sands. Then flood-plain "marl" or eolian silt (Box Butte member) was deposited. The Box Butte has about the same distribution as the Marsland formation (p. 1258), and "generally has been included" in the Marsland. (See R.C. Cady, 1946, U. S. Geol. Survey Water-Supply Paper 969, p. 32-35.)

Elias, M.K., 1942 (Geol. Soc. America Spec. Paper 41, p. 126-132). Divided the Sheep Creek into a lower or Spotted Tail member (new); a middle or Sand Canyon member (new); and the upper, Box Butte member.

Type locality: Sheep Creek, Sioux County, Nebraska

Name: From Sheep Creek

SKULL CREEK SHALE MEMBER (of Graneros Shale)

Upper Cretaceous: Northeastern Wyo., western S. Dak.

Collier, A.J., 1922 (U. S. Geol. Survey Bull. 736, table opp. p. 76; p. 79). Basal member of Graneros shale in Osage oil field, Weston County, Wyoming. Mainly dark bluish-gray shale, about 200 feet thick. Contains a few calcareous concretions, and near the base some siliceous shale. Very few fossils. Called Thermopolis shale by drillers, but represents only basal part of true Thermopolis shale. Well exposed along Skull Creek southeast of Osage, between outcrops of Dakota sandstone below and Newcastle sandstone above.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 76). Contact with the underlying Fall River is usually sharp, but the top is hard to locate where the lower sands in the Newcastle formation are not well developed. Has an average thickness of 250 feet in subsurface around the Black Hills. Microfossils indicate an early Cretaceous age. Equivalent to the lower part of the Thermopolis shale of Wyoming.

Gries, J.P., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 446-449). Did not use the term Dakota in the Black Hills, but applied the term Dakota group to the thick sandstone sequence in central South Dakota where he called it the "true Dakota," and where it overlies the Skull Creek shale. He pointed out that the "true Dakota" is the age equivalent of the Newcastle-Mowry interval, and that what is called Dakota in the Williston Basin to the north is actually the Fall River sandstone (fig. 6). Gries further supported this view in 1962 (Wyo. Geol. Association Gdbk., 17th Ann. Field Conf., fig. 5 on p. 169), but he reduced the term Dakota to formation and showed that it is traceable into the Newcastle of the Black Hills.

Type locality: Presumably along Skull Creek, southeast of Osage, Weston County, Wyoming

Name: From Skull Creek

Slim Buttes Formation

Lower Oligocene: Northwestern S. Dak.

Skinner, M.F., 1951 (Soc. Vert. Paleontologists Gdbk., 5th Field Conf., Aug. 29-Sept. 1, 1959, p. 51-58). Described approximately 20 feet of pre-Chadron deposits at three widely spaced localities in southwestern North Dakota. These sediments rest on Fort Union formation, and are light-gray to yellowish sands or siltstones and clays, topped with an unconformity. They may represent the Golden Valley formation of Benson, 1949.

North Dakota Geological Society, 1954 (Southwestern N. Dak. Field Conf., June 25-27, p. 9-10). Described the Golden Valley formation as consisting of two members (descending):

Upper member--light-gray to yellow and brown micaceous silts and sands with few lenses of gray clay and lignite; coarser sand beds highly cross bedded.

Lower member--white to light purplish-gray kaolinitic clays mixed with silt and sand with kaolin binder; persistent white clay beds near middle stained yellow to orange by iron oxide.

Malhotra, C.L. and Tegland, E.R., 1960 (S. Dak. Acad. Science Proc., v. 38, 1959, p. 263-274). Proposed the name Slim Buttes formation for a stratigraphic unit in Harding County, South Dakota, formerly mapped as Chadron. The new name is proposed because the fauna is Duchesnean in age and because of "lithologic differences between the unit... and the

Chadron formation of South Dakota and Nebraska." The Slim Buttes formation consists of massive medium to very fine-grained sandstone that is mainly white but also light-green, red-brown, yellow, and lilac, locally bands of clay are present. The cement is largely clay with some calcareous material. The Slim Buttes formation is marked at the top by a channel-type conglomerate, underlies the Brule pink thin-bedded and massive sandy claystone and tuffaceous sandstone. The Slim Buttes overlies the Ludlow formation at a thin lignite bed or thin limonite seams. Chadron formation does not occur in the area of the Slim Buttes formation, but "it is believed to outcrop in the Northern Slim Buttes in the Reva Gap vicinity, [where it is] gray, sandy claystone which weathers into low, rounded humps" (p. 266). The formation thickens northward from 29 feet at the south face of the Slim Buttes to an unmeasured maximum along the northern face. The sediments were largely deposited in a lacustrine environment in a bowl-shaped area whose deepest part was in Sec. 32, T. 17 N., R. 8 E. The channel fill at the top indicates that, after the lake basin became filled, it was then traversed by streams. The streams probably had their source in the Bighorn Mountains.

Type locality: NW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 11, T. 16 N., R. 8 E., Harding County, South Dakota

Name: From Slim Buttes where type locality is located

Appears to be the same as the Golden Valley Formation of southwestern North Dakota, but further work is needed to substantiate it - A.F.A.

Smoky Hill Chalk Member (of Niobrara Marl)

Upper Cretaceous: Northwestern Kans., eastern Colo., S. Dak., Nebr.

Cragin, F.W., 1896 (Colo. Coll. Studies, v. 6, p. 51). Chalky and marly limestones and chalk composing upper formation of Niobrara division. Overlies Osborne [Fort Hays] limestone (lower formation of Niobrara division) and underlies Lisbon [Sharon Springs] shales of Fort Pierre division [Pierre formation].

[Top member of Niobrara formation in Kansas. In eastern Colorado it is called marl instead of chalk - Wilmarth, 1938.]

Bolin, E.J., 1952 (S. Dak. Geol. Survey Rept. Inv. 70, p. 4-5). Stated that in South Dakota, although there is a faunal break in the Niobrara which he has designated as the contact between the Fort Hays and the Smoky Hill, it is "extremely difficult to recognize a lithologic subdivision of the Niobrara formation in this area.... Since the main basis for subdivision is micropaleontologic rather than lithologic, it remains very difficult if not impossible to distinguish between the two members in the field...." Thus he took exception with G.J. Loetterle, 1937 (Nebr. Geol. Survey Bull. 12, p. 14).

Type locality: Not designated

Name: From Smoky Hill River, Kansas

Snake Creek beds

Pliocene: Western Nebr., southwestern S. Dak. (?)

Matthew, W.D. and Cook, H.J., 1909 (Am. Mus. Nat. History Bull., v. 26, art. 27, p. 362-363). Clean sand with gravel scattered through it. Lower Pliocene mammals. Regarded as an outlier of Ogallala formation. Lacks cement of the mortar beds. Overlies Sheep Creek beds unconformably. A channel fill deposit.

Lugn, A.L., 1939 (Geol. Soc. America Bull., v. 50, p. 1254-1255). Pointed out that the term Snake Creek beds unfortunately had been applied subsequently to beds, mainly channel fills, as late as Pleistocene and as early as Miocene in age. Much of the Miocene "Snake Creek" is really Sheep Creek channel beds in place. Also, some of the Miocene and "Sheep Creek" vertebrate fossils collected from "Snake Creek" channel deposits have come from very large blocks of Sheep Creek formation, which were broken away from the banks of the Snake Creek streams, but were not disintegrated and became buried in true Snake Creek sediments.

Type locality: Not designated

Name: From Snake Creek, Cherry County, Nebraska

SOURIS RIVER FORMATION

Devonian: Sask., Man., N. Dak., S. Dak., Mont.

Laird, W.M., 1953 (Interstate Oil Compact Quart. Bull., v. 12, no. 2, p. 74) (Williston Basin Correlation Committee, Feb. 18, 1953). The Beaverhill Lake group has been divided into two formations, in ascending order, the Dawson Bay and Souris River formations. The Souris River formation ranges in thickness from less than 300 feet in the southwest to nearly 600 feet in the area generally south and west of Saskatoon. Consists of variable limestone, dolomite, anhydrite, and locally salt. Argillaceous, marly, and silty phases are common in the carbonates. Colors are gray to light gray-brown for the limestones, and light brown to brown for the dolomites.

Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2310-2311). Stated that the report of the Committee was not published, and that the Souris River formation was never formally proposed nor adequately described [agreed - A.F.A.]. Proposed that the standard subsurface section for the formation be the interval 10,743 to 11,052 feet in the Mobil #1 Birdbear oil test, SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 22, T. 149 N., R. 91 W., Dunn County, North Dakota, and this was adopted by the North Dakota Geological Society, 1961 (p. 21). Sandberg and Hammond (fig. 3) mapped the Souris River in the northwestern tier of counties of South Dakota, where it attains a thickness of less than 100 feet and consists mainly of limestone with some dolomite and anhydrite.

Type locality: Interval 5,912-6,160 in California #1 Thompson, SE¼SE¼ sec. 31, T. 160 N., R. 81 W., Bottineau County, North Dakota (Williston Basin Nomenclature Committee, February, 1953)
Name: From Souris River, North Dakota

SPEARFISH FORMATION

Triassic (?) Permian (?): Western S. Dak., Wyo., and northwestern Nebr.

Darton, N.H., 1899 (Geol. Soc. America Bull., v. 10, p. 387). Spearfish formation (red beds), of Triassic age, unconformably underlies Sundance formation in Black Hills, South Dakota.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 516). Red sandy clay or shale, with gypsum beds that sometimes are 30 feet thick. Thickness of formation in Black Hills, 350-500 feet. Overlies Minnekahta limestone and unconformably underlies Sundance formation.

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 73). The Spearfish red beds extend eastward in subsurface nearly to the Missouri River, where they pinch out, due either to nondeposition or to pre-Jurassic erosion, or both. The thickness east of the Hills is about 350 feet, thickening slowly to the north and west, and reaching a thickness of nearly 1,000 feet in western North Dakota. Stratigraphic correlation with Wyoming indicates that the Spearfish is Permo-Triassic in age, but no fossils of any type have been in outcrops around the Black Hills.

Reed, E.C., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., p. 46). The age of all the Spearfish formation shown in the northwestern part of the profile section is not precisely known as it may include some Triassic as well as Permian. However there seems to be little doubt but that the lower Spearfish in the Black Hills is equivalent to middle and upper Phosphoria, and is therefore Permian and not Triassic in age. There seems to be no sound basis at the present time for subdividing the Spearfish into Triassic and Permian.

Type locality: Not designated
Name: From Spearfish, South Dakota

STOCKADE BEAVER SHALE MEMBER (of Sundance Formation)

Upper Jurassic: Wyo., S. Dak.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 251-255). The Stockade Beaver shale member of the Sundance formation includes about 50 feet of medium- to dark-gray, soft, fissile, calcareous shale lying directly below the Hulett sandstone member of the Sundance formation in the Black Hills area. Its upper contact is gradational within a few feet. Its lower contact with the Canyon

Springs sandstone member is fairly abrupt but apparently conformable. Locally it rests directly on the Gypsum Spring formation or on the Spearfish formation. At the type section the member is 63 feet thick and rests on a 12-foot ledge of white gypsum. The Stockade Beaver shale member ranges in thickness from about 5 to 85 feet and averages about 50 feet. Along the southern and central parts of the Black Hills, including the type locality, it is highly calcareous, moderately fossiliferous, and commonly contains limestone nodules in its basal part. Northward it becomes less calcareous, less fossiliferous, acquires minor amounts of soft, greenish-gray to yellowish-gray siltstone and sandstone, and becomes slightly gypsiferous. Pitted, polished, subangular pebbles of a hard dark-gray metamorphic, chert-like rock ranging from a quarter of an inch to several inches in diameter have been found at the base of the member near Minnekahta, near Pass Creek 3 miles northeast of Dewey, and near Spearfish.

Type locality: Western side of Stockade Beaver Creek, about 5 miles northeast of Newcastle, Sec. 18, T. 45 N., R. 60 W., Wyoming

Name: From Stockade Beaver Creek

The South Dakota Geological Survey continues to use the term Sundance Formation in the Black Hills area as comprising the Jurassic Members (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

STONEVILLE LIGNITE FACIES (of Fairpoint Member)

Cretaceous: S. Dak.

Searight, W.V., 1934 (S. Dak. Geol. Survey Rept. Inv. 22, p. 8-11). The Stoneville member of the Fox Hills is a thin succession of beds of clay, sandstone, and coal. It is wholly or in part of continental origin.

The Stoneville member of the Fox Hills is extremely variable in thickness. In many places, where the coals are thin, the thickness appears to be less than 10 feet. North of Stoneville, the thickness, including coal, carbonaceous shale, shale, and thin sandstones, is at least 46 feet.

Type locality: Not designated

Name: From Stoneville, Meade County, South Dakota

Stonewall Limestone

Upper Ordovician: Man., N. Dak., S. Dak., Mont.

Kindle, E.M., 1914 (Can. Geol. Survey Sum. Rept. 1912, p. 247-261). Defined the Stonewall formation to include all beds of Silurian age exposed in Manitoba.

Baillie, A.D., 1951 (Man. Dept. Mines and Nat. Resources, Pub. 50-1, p. 6). Replaced this name with the term Interlake group, and restricted Stonewall to the lowest unit of that group, as shown by exposures in the type area of the Stonewall. The Stonewall is overlain by a series of units, B, C, D, and E, in ascending order, for which naming is deferred until the units can be established in the subsurface. The Stonewall in the outcrop is arenaceous shale and dolostone above, and yellowish-gray finely crystalline dolostone with salt crystals. Thickness totals 40-50 feet. Overlies the Stony Mountains and is overlain by the Ashern red shale. The fauna is assigned to the Silurian, although several Late Ordovician types are present.

Stearn, C.W., 1953 (Geol. Soc. America Bull., v. 64, p. 1477-1478). Noted that the Stonewall fauna is late Ordovician in age, and recommended its removal from the Interlake for that reason.

For lithologic reasons, J.M. Andrichuk, 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 2381) retained it as the basal formation of the Interlake, although J.G.C.M. Fuller, 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1350-1351) sided with Stearn's classification in the Williston Basin, as did C.G. Carlson and W.P. Eastwood, 1962 (N. Dak. Geol. Survey Bull. 38, p. 8-9) in North Dakota.

Type locality: Quarries at Stonewall, Manitoba

Name: From Stonewall

The South Dakota Geological Survey does not distinguish the Stonewall Formation separately, but includes its interval in the Interlake - A.F.A.

STONY MOUNTAIN FORMATION (of Bighorn Group)

Ordovician: Man., Sask., N. Dak., northern S. Dak., eastern Mont.

Dowling, D.B., 1901 (Can. Geol. Survey Ann. Rept., n.s., v. 11, p. 46 F). The formation is divided into three members at outcrop: Upper member--Gunton dolomite and shale and sand; Medial member--Penitentiary dolomite; and Basal member--Stony Mountain shale. In subsurface is primarily a shale or shaly limestone embedded with dark-brown to black fossil fragments. Very good subsurface marker both from samples and other types of logs. The exact age of the Gunton member is not established, and it probably represents the transition from Ordovician to Silurian. Fauna from wells in eastern Montana are similar to the Maquoketa formation of Iowa. Thickness 25-200 feet.

Miller, A.K., 1930 (Am. Jour. Science, 5th ser., v. 20, p. 211). Correlated Stony Mountain formation of Manitoba with upper part of Bighorn dolomite of Richmond age.

Ross, R.J., Jr., 1957 (U. S. Geol. Survey Bull. 1021-M, p. 447). Recognized in the Williston Basin two units of the Stony Mountain formation, a lower shale and an upper dolomite. The lower is commonly called "Stony Mountain shale" by oil geologists. The upper unit includes the Penitentiary (below) and Gunton members of the Stony Mountain of A.D. Baillie, 1952 (Man. Dept. Mines and Nat. Resources, Pub. 51-6), and the restricted Stonewall formation of C.W. Stearn, 1953 (Geol. Soc. America Bull., v. 64, p. 1477-1478).

Fuller, J.G.C.M., 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1349). Described the Stony Mountain of the Williston Basin. The lower, shale member is 75 feet of very dark-gray and brown shelly argillaceous limestone with a few interbedded calcareous shale seams. In north-central South Dakota it can be divided into two units: an upper argillaceous silty dolomitic fine-grained limestone, 40 feet thick; and a lower silty and sandy dark-colored limestone and black shale, also 40 feet thick. The upper member of the Stony Mountain, called "Gunton beds," comprises 100 feet of mottled dolomitic fossiliferous fragmental limestone. This is overlain by the Stonewall limestone.

The lower, or shale member of the Stony Mountain has been called the Gunn in Manitoba by G.W. Sinclair and E.I. Leith, 1958 (Jour. Paleontology, v. 32, p. 243-244), and Stoughton in Saskatchewan by the Saskatchewan Geological Society (1958) and more recently in North Dakota by C.G. Carlson and W.P. Eastwood, 1962 (N. Dak. Geol. Survey Bull. 38, p. 6). The latter report shows the thickness in South Dakota of the lower, or shale member to reach 80 feet, thickening to the southeast; and that of the upper member to be as much as 60 feet, thickening to the northwest. Thus the total thickness of the Stony Mountain in South Dakota is greater than 140 feet.

Type locality: Not designated

Name: From Stony Mountain near Winnipeg, Manitoba

STOUGHTON MEMBER (of Stony Mountain Formation)

Upper Ordovician: Sask., N. Dak., S. Dak.

Carlson, C.G. and Eastwood, W.P., 1962 (N. Dak. Geol. Survey Bull. 38, p. 6). Accepted this name for the lower or shale member of the Stony Mountain Formation, following the Saskatchewan Geological Society (1958). J.W. Porter and J.G.C.M. Fuller, 1959 (N. Dak. Geol. Society and Sask. Geol. Society, 2nd Internat. Williston Basin Symposium, fig. 4 on p. 35) stated that the lower shale member of the Stony Mountain in the subsurface is apparently the equivalent of both the Gunn Member of G.W. Sinclair and E.I. Leith, 1958 (Jour. Paleontology, v. 32, p. 243-244) and the overlying Penitentiary Member.

Type locality: Not designated
Name: Derivation uncertain

Sully Member (of Pierre Shale)

Upper Cretaceous: S. Dak., Nebr.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 21-34, pl. 3). Shales lying between chalky beds of upper Gregory and the base of the highly bentonitic beds at the base of the Virgin Creek member. Divided into three zones--Agency shale, mostly hard light-gray siliceous shale at base; Oacoma zone, highly bentonitic shales and clays containing manganiferous iron concretions over a considerable area; and at top Verendrye shale, clay and shale containing flattish concretions of clay ironstone which contain some manganese in places.

Moxon, A.L., Olson, O.E., Searight, W.V., and Sandals, K.M., 1938 (Am. Jour. Botany, v. 25, p. 795, 796). Searight enlarged the Sully member of his 1937 report by adding the "upper" part of the Gregory member (Gregory marl) to the Sully member.

Gries, J.P. and Rothrock, E.P., 1941 (S. Dak. Geol. Survey Rept. Inv. 38, p. 15). Since the name Gregory does not apply, the sand and marl zone at the base of the Sully member is here called Crow Creek.

Crandell, D.R., 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 2345). Raised the Crow Creek to member, established DeGrey as a member incorporating the Agency and Oacoma, and elevated the Verendrye to member status. Dropped Sully as a member of the Pierre.

Type locality: At Little Bend, opposite site of old Fort Bennett, a few miles north of old Fort Sully, Sully County, South Dakota

Name: Probably from Fort Sully

SUNDANCE FORMATION, GROUP

Upper Jurassic: Southwestern S. Dak., Wyo., central Mont., northwestern Nebr., central and northern Colo.

Darton, N.H., 1899 (Geol. Soc. America Bull., v. 10, p. 387-393). Green shale and thin-bedded sandstones, 60-400 feet thick, underlying Unkpapa sandstone and unconformably overlying Spearfish formation (Red beds) in Black Hills. Marine Jurassic fossils abundant.

Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 520). Consists of dark drab or green shale and buff or reddish sandstones alternating with 25 feet of massive red sandstone at base.

Darton, N.H. and O'Harra, C.C., 1909 (U. S. Geol. Survey Geol. Atlas, Folio No. 164, p. 3). Type locality of Sundance is above Sundance, Wyoming, not far southeast [southwest? - A.F.A.] of Belle Fourche quadrangle, South Dakota.

Imlay, R.W., 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 227-273). With some modification of Darton's earlier work, the following members of the Sundance have been named, in descending order: Redwater shale member, Lak member, Hulett sandstone member, Stockade Beaver shale member, and Canyon Springs sandstone member.

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 469). Proposed that the Sundance formation in eastern Wyoming and western South Dakota be raised to the rank of a group comprising two formations, which are correlated with the Swift and Rierdon formation of the Ellis group of Montana. Because of historical significance, however, the term "Sundance" should be retained, and therefore, despite its correlation with the upper units of the Ellis group, the term "Sundance group" is here applied to the marine Upper Jurassic rocks of the Black Hills and vicinity, the northernmost part of Colorado, the subsurface of western Nebraska, and all but westernmost Wyoming. Subsequent work may indicate that it is desirable to expand the "Sundance group" to include the Gypsum Spring formation. Peterson stated (p. 464) that the Sundance ranges in age from Callovian to Oxfordian (Late Jurassic), and if the Gypsum Spring is included, it includes the Middle Jurassic Bajocian.

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that, although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation and retained the Lak, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained the Sundance name as including the Rierdon and Swift.

Type locality: Imlay (1947) examined outcrops of the Sundance Formation near Sundance, which is actually 18 miles southwest of the Belle Fourche Quadrangle, but was unable to find any outcrop adequate to serve as a type section. He deemed it advisable not to designate any section as type but instead to select one of the best exposed, most complete sections as a standard of reference. This section occurs 1 mile north-northeast of center of the city of Spearfish in Sec. 3, T. 6 N., R. 2 E., Lawrence County, South Dakota.

Name: From Sundance, Wyoming

The South Dakota Geological Survey continues to use the term Sundance in the Black Hills area as comprising the Jurassic members (except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

SWIFT FORMATION (of Sundance Group)

Upper Jurassic: Mont., Idaho, northwestern S. Dak., eastern Wyo.

Cobban, W.A., 1945 (Am. Assoc. Petroleum Geologists Bull., v. 29, p. 1281-1286). Along the Rocky Mountain front and over the Kevin-Sunburst dome, the youngest marine Jurassic rocks consist of dark-gray noncalcareous shale overlain by fine-grained glauconitic flaggy sandstone. On the south arch and along the northern flank of the Little Belt Mountains, the youngest marine Jurassic rocks consist of a massive fine-grained sandstone overlying a basal conglomerate, or consist of a massive flaggy sandstone, containing abundant dark noncalcareous shale partings. The Swift is 135 feet thick at the type locality, where it consists of two members: lower member is a dark-gray, noncalcareous shale 54½ feet thick; upper member is a flaggy ripple-marked sandstone 80 feet thick containing abundant black-gray fissile shale partings.

Peterson, J.A., 1954 (Am. Assoc. Petroleum Geologists Bull., v. 38, p. 491). The term Swift is applied here to the upper unit of the Sundance group in eastern Wyoming ("upper Sundance") and western South Dakota, and includes 100-200 feet of glauconitic, belemnite-bearing gray and green shale, sandstone, and fossiliferous limestone that constitute the upper unit of the Sundance group in that area. Lithologic and faunal studies indicate that the Swift formation or "upper Sundance" of eastern Wyoming is in its major aspects lithologically and faunally equivalent to the Swift formation of Montana, the Stump formation of southeastern Idaho and westernmost Wyoming, and the Redwater shale of the Black Hills, as defined by Imlay (1947). Peterson said that the Swift is Oxfordian (Late Jurassic) in age (p. 464).

Peterson, J.A., 1957 (Am. Assoc. Petroleum Geologists Bull., v. 41, p. 413, 417). Pointed out that, although the five Sundance subdivisions and names of the Black Hills are useful there, in the Williston and Powder River Basins the more continuous sedimentation makes the nomenclature of the Ellis group more useful. Thus he abandoned Redwater in favor of Swift formation, and retained the Lak, Hulett, Stockade Beaver, and Canyon Springs as local members of the Rierdon formation. He retained this Sundance name as including the Rierdon and Swift. At its type locality the Swift consists of two units: a lower dark-gray shale, 55 feet thick, and an upper glauconitic sandstone, 80 feet thick. In the Williston Basin these two units are present, but the lower shale is much thicker; the total thickness is 400 feet. The lower shale becomes sandier to the east of the Basin's center.

Type locality: Presumably north shore of Swift Reservoir in NE¼ sec. 27, T. 28 N., R. 10 W., Teton County, Montana

Name: From Swift Reservoir

The South Dakota Geological Survey continues to use the term Sundance Group in the Black Hills area as comprising the Jurassic formations

(except the Gypsum Spring) including the Canyon Springs at the base, and the Redwater at the top. In the Williston Basin the Survey uses the terminology Piper (= Gypsum Spring), Rierdon, and Swift (= Redwater), as formations of the Sundance Group; the term Ellis Group is not used. In central South Dakota the Survey uses the term Sundance Formation - A.F.A.

T-Cross lignite (of Ludlow Formation)

Paleocene: Northwestern S. Dak., southwestern N. Dak., Mont.

Hares, C.J., 1928 (U. S. Geol. Survey Bull. 775, p. 47). The T-Cross bed is very extensive and is the principal lignite bed in the Ludlow lignitic member of the Lance, corresponding to the Giannonatti bed of northwest South Dakota [not so; corresponds to upper Shadehill coal - A.F.A.]. It has been traced from T. 20 N., R. 8 E., South Dakota, to the vicinity of Yule and thence westward to Montana. Throughout most of this distance, the T-Cross bed is usually more than 3 feet and at many places 6 or 8 feet thick. In the vicinity of the T-Cross Ranch it is 24 feet thick. At the T-Cross Mine, Sec. 20, T. 133 N., R. 104 W., the bed is also 24 feet thick.

The T-Cross bed is undoubtedly the "lowest persistent lignite" bed mapped in eastern Montana.

King, J.W., 1955 (N. Dak. Geol. Society Gdbk., Black Hills Field Conf., columnar section on p. 85). Illustrated the T-Cross lignite as being 185 feet below the top of the Ludlow formation.

Type locality: Probably vicinity of T-Cross Ranch near Ives, North Dakota
Name: From T-Cross Ranch

The T-Cross lignite is apparently the same as the upper coal of the Shadehill Lignite Facies of the South Dakota Geological Survey, mapped in 24 quadrangles of northwestern South Dakota (R.E. Stevenson, 1954, S. Dak. Geol. Survey, Geol. Quad., Lemmon) - A.F.A.

"Tepee Buttes zone" (of Pierre Shale)

Upper Cretaceous: Colo., S. Dak., Wyo.

Gilbert, G.K. and Gulliver, F.P., 1895 (Geol. Soc. America Bull., v. 6, p. 333-342). In the Pierre shale of Colorado are limestone masses of peculiar character. Their height is greater than their width, and all dimensions are of a size to be measured by feet or yards. Resisting erosion much better than the shales, they stand above the general surface. Their fallen fragments protect sloping pedestals of shale and their positions are marked in the landscape by conical knolls or buttes.

Darton, N.H., 1909 (U. S. Geol. Survey Prof. Paper 65, p. 535). The formation (Pierre) includes at a horizon about 1,000 feet above its base, scattered lenses of limestone, usually containing numerous shells of Lucina occidentalis. The limestone lenses with Lucina vary in size from 2-3 cubic feet to masses 20 feet in diameter and 6 or 8 feet thick, usually of irregular lens shape. Owing to their hardness, these lenses, when uncovered by erosion, give rise to low conical buttes resembling in form a squat tepee. They occur in large numbers in the vicinity of Oelrichs, Fall River County, varying in height from 10 to 150 feet above the surrounding slopes.
Type locality: Not designated
Name: From resemblance to Indian tepees

"Tertiary grit"

Descriptive term applied to Ogallala Group.

THREE FORKS SHALE

Upper Devonian: Mont., western Wyo., southeastern Idaho, Utah, northwestern S. Dak.

Peale, A.C., 1893 (U. S. Geol. Survey Bull. 110, p. 29). Three Forks shales--in Three Forks region consist of, descending: (1) yellow laminated sandstone, 25 feet; (2) dark bluish-drab or black argillaceous limestone, 45 feet; (3) highly fossiliferous green, purple, and black argillaceous and calcareous shale, 70 feet; (4) grayish-brown compact, close-grained limestone, 15-20 feet; (5) reddish and brownish-yellow calcareous and argillaceous shales, 65 feet. Rests on Jefferson limestone and underlies Madison limestone. In some areas the formation becomes so calcareous that it is called Three Forks limestone.
Berry, G.W., 1943 (Geol. Soc. America Bull., v. 54, p. 14-16). Separated Peale's unit no. 1 and named it the Sappington sandstone, which is Early Mississippian in age.
Sloss, L.L. and Laird, W.M., 1946 (U. S. Geol. Survey Oil and Gas Invest., PC-25). Redefined the lower contact of Peale's Three Forks to exclude units nos. 4 and 5, which they placed in the underlying Jefferson.
Sandberg, C.A. and Hammond, C.R., 1958 (Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2323). Recommended that the lower contact of the Three Forks as originally defined by Peale be re-established. In the Williston Basin the formation is interbedded greenish-gray, grayish orange, and grayish-red dolomitic siltstone and shale.
Type locality: Not designated
Name: From Three Forks, Montana

The North Dakota Geological Society, 1961 (p. 32) stated that in South Dakota the Three Forks contains much gray, fine- to medium-grained

sandstone interbedded with red and green shale. Its distribution in South Dakota is shown by Sandberg and Hammond, 1958 (fig. 3), and it probably does not exceed 50 feet in thickness. In South Dakota they say that the Three Forks is overlain by the Mississippian Englewood limestone (p. 2326), and is Late Devonian in age - A.F.A.

"Tilford lens" (of Newcastle Formation)

Upper Cretaceous: S. Dak.

Grace, R.M., 1952 (Wyo. Geol. Survey Bull. 44, p. 14, 16). The Newcastle formation thickens into lenses in seven of the areas studied. For clarity of description, these lenses are named. Three miles northeast of Tilford, the Newcastle formation thickens to 18 feet and maintains this thickness for a distance of less than 1 mile along the outcrop. The lens is composed almost entirely of friable sandstone, yet is resistant enough to form a tree-covered hill.

Type locality: Not designated

Name: From Tilford, Meade County, South Dakota

TIMBER LAKE MEMBER (of Fox Hills Formation)

Upper Cretaceous: S. Dak.

Morgan, R.E. and Petsch, B.C., 1945 (S. Dak. Geol. Survey Rept. Inv. 49, p. 15-17, pl. 3). The Timber Lake member is the surface rock over most of the area and covers the Trail City member over much of the upland away from the larger streams.

Where the Timber Lake member is revealed in fresh exposures as in road cuts or the steep walls of valleys, the lower part is usually a greenish-yellow medium-grained soft or uncemented quartz sand. The upper part contains thin bands of fine-grained, orange to brown, well-cemented limonitic claystone, which also appears as isolated pieces or pebbles. The limonitic claystone occurs most abundantly toward the base of the series of lens-like masses formed by concretionary cementation of the otherwise soft sand.

In the Timber Lake quadrangle (R.E. Stevenson, 1960, S. Dak. Geol. Survey, Geol. Quad.) the member ranges from 110 to 230 feet in thickness.

Waage, Karl, 1961 (Wyo. Geol. Association, 16th Ann. Field Conf., p. 236). Pointed out that in north-central South Dakota the Timber Lake and the underlying Trail City are lateral facies. The Timber Lake is overlain conformably by the Bullhead.

Type locality: Not designated

Name: From the town of Timber Lake, Dewey County, South Dakota

Titanotherium beds

A paleontologic term applied in early reports to Chadron Formation. The sandstones in upper part of the Chadron have been called "Titanotherium sandstone."

See Chadron Formation.

TONGUE RIVER FORMATION (Fort Union Group)

Paleocene: Northeastern Wyo., Mont., southwestern N. Dak., northwestern S. Dak.

Taft, J.A., 1909 (U. S. Geol. Survey Bull. 341, p. 129-130). The coal-bearing rocks of Sheridan coal field, Wyoming, are divided into three coal groups, descending: Ulm coal group; intermediate coal group (equivalent, in part at least, to Sentinel Butte shale member exclusive of Roland coal); and Tongue River coal group.

Thom, W.T., Jr. and Dobbin, C.E., 1924 (Geol. Soc. America Bull., v. 35, p. 484-499). Yellow or light-colored strata containing massive sandstones and numerous thick coal beds.

Stevenson, R.E., 1956 (S. Dak. Geol. Survey, Geol. Quad., Ludlow). Formation dominantly sandy, becoming finer grained as it ascends, with subgraywacke interbedded. Thickness 285 feet with Lodgepole lignite facies about 140 feet from base. Lodgepole has black carboniferous to gray clay-shale. Appears to be upper member of Fort Union formation. Conformably overlies Ludlow formation.

Type locality: Not designated

Name: From Tongue River, Wyoming

The Tongue River Formation of the Fort Union Group was mapped by the South Dakota Geological Survey in 14 quadrangles in the northwestern part of the State (1954, 1956, 1957) - A.F.A.

TRAIL CITY MEMBER (of Fox Hills Formation)

Upper Cretaceous: S. Dak.

Morgan, R.E. and Petsch, B.C., 1945 (S. Dak. Geol. Survey Rept. Inv. 49, p. 13, 14). The Trail City is stratigraphically the lowest member of the Fox Hills. The member is usually brown or buff sandy shale, becoming more sandy toward its top. It contains 3-5 locally persistent zones of fossiliferous concretions. The concretions have cores of dense limestone, but often have sandy jackets which spall off on exposure to weathering.

Waage, Karl, 1961 (Wyo. Geol. Association, 16th Ann. Field Conf., p. 236). Pointed out that in north-central South Dakota the Trail City and the overlying Timber Lake are lateral facies.

In the Glencross Quadrangle, just west of the type locality, W.A. Pettyjohn, 1961 (S. Dak. Geol. Survey, Geol. Quad.) mapped 48-100 feet of Trail City.
Type locality: Not designated
Name: From Trail City, Corson County, South Dakota

Trenton Limestone

Another name for the Galena, which see.

Triceratops (or Ceratops) beds

Paleontologic name applied to the Lance beds of eastern Wyoming and adjacent areas (T.W. Stanton, 1910, Am. Jour. Science, 4th ser., v. 30, p. 172).

TURNER SANDY MEMBER (of Carlile Shale)

Upper Cretaceous: Northeastern Wyo., southeastern Mont., S. Dak.

Rubey, W.W., 1930 (U. S. Geol. Survey Prof. Paper 165A, p. 4). Upper and major part of Carlile shale in northeastern Wyoming and southeastern Montana. Consists of 150-200 feet of more or less sandy shale and siltstone, with iron-stained concretions, persistent thin beds of sandstones, locally conglomeratic and phosphatic and containing abundant shark teeth in lower part. Marine fossils. Forms a minor scarp. A distinct faunal break and possible unconformity at base. Overlies lower part of Carlile shale, which consists of 75 feet to 125 feet of dark-gray shale with a few calcareous concretions. Possibly correlates with the Codell.

Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87-88). Described the Turner sandy member in the Powder River basin as being 150-170 feet thick, and overlain conformably by the Sage Breaks member and underlain conformably by an unnamed shale member [Pool Creek shale - A.F.A.]. The Turner sandy member is the eastern extension of the Wall Creek sandstone of the Frontier formation. Fossils are Turonian in age.

Type locality: Presumably along Turner Creek in T. 46 and 47 N., R. 64 W., Weston County, Wyoming
Name: From Turner Creek, Wyoming

Turtle and Oreodon beds

Oligocene: S. Dak., Nebr.

Paleontologic term applied (Hayden, F.V., 1857, Phila. Acad. Nat. Science Proc., v. 9, p. 151-158) to what later was named the Brule Formation (Darton, 1899).
See Brule Formation.

"Tyler sand"

Pennsylvanian: Central Mont., Williston Basin, northwestern S. Dak.

Willis, R.P., 1959 (Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1940-1966). Extended the names Tyler-Heath (below) and Amsden (restricted) eastward from central Montana into the Williston Basin of North Dakota. The Tyler is Early Pennsylvanian (Morrowan-Atokan).
Foster, F.W., 1960 (Am. Assoc. Petroleum Geologists, Rocky Mt. Sec., Geol. Record, Feb. 1960, p. 79-84). Described the Tyler in north-central South Dakota, and correlated it with the Fairbank sand of the Hartville nomenclature.
Type locality: Not designated
Name: From Tyler Post Office, Montana

The Tyler-Heath of the Williston Basin apparently includes the Fairbank sand of the Powder River Basin, and the lower part of the Reclamation-Roundtop. Accepted informally by the South Dakota Geological Survey - A.F.A.

UNKPAPA SANDSTONE FACIES (of Morrison Formation)

Upper Jurassic: Western S. Dak. (Black Hills)

Darton, N.H., 1899 (Geol. Soc. America Bull., v. 10, p. 393). Fine-grained massive sandstone, pink, white, buff, or purple, 0-225 feet thick, overlying Sundance formation and underlying Beulah shale in the Black Hills.
Darton, N.H., 1901 (U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 524). 0-250 feet thick.
Connolly, J.P. and O'Harra, C.C., 1929 (S. Dak. School Mines Bull. 16, p. 47). Unkpapa sandstone was named for Unkpapa Peak at head of Calico Canyon, northwest of Buffalo Gap, South Dakota.
[The discrepancy of naming appears to be error on part of Connolly and O'Harra. Careful examination of maps at time of 1900's indicates that no Unkpapa Peak had been named at that time (21st Ann. Rept., pt. 4) - Wilmarth, 1938.]

Gries, J.P., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., Mesozoic Strat. of the Dakota Basin, p. 74). Except for possible remnants in the northern Black Hills, the formation is restricted to outcrops and subsurface along the eastern and southern flanks of the Black Hills. Rapid lateral variations in thickness are normal, the thickest known section totals 267 feet in Fuson Canyon, northwest of Buffalo Gap. The Unkpapa is unfossiliferous, its age is determined only by its stratigraphic position. It is thickest on the southeast side of the Black Hills, where the Morrison formation is absent. For this reason, Imlay, 1947 (Am. Assoc. Petroleum Geologists Bull., v. 31, p. 227-273) suggested that it may represent a facies of the Morrison.

Waage, Karl, 1959 (U. S. Geol. Survey Bull. 1081-B, p. 50-52). Discussed the Morrison-Lakota contact in the Black Hills, noting that it may be gradational or it may suggest angular discordance. The Unkpapa and similar sands in the Morrison are distinct from the overlying Lakota sands, but the mudstones and claystones of the Morrison and Lakota are the difficult ones. Actually, the beds called Morrison in the Black Hills may be equivalent to only part of the type Morrison in Colorado, so that Darton's term Beulah in the Black Hills, which has been suppressed in favor of Morrison, may still have some validity.

Type locality: Presumably near Unkpapa Peak, head of Calico Canyon, northwest of Buffalo Gap, Custer County, South Dakota

Name: From a tribe of Dakota Indians, at one time located about the southeast part of Black Hills, South Dakota

"Upper micaceous bentonite" (of Pierre Shale)

Upper Cretaceous: S. Dak.

Petsch, B.C., 1946 (S. Dak. Geol. Survey Rept. Inv. 53, p. 35, figs. 5, 10). At the top of the Oacoma zone of the Sully member of the Pierre formation is a micaceous bentonite, about 4 inches thick, called the Upper micaceous bentonite (UMB). It can be traced many miles in outcrop, and is 32-38 feet above the "Lower micaceous bentonite."

Type locality: Not designated

Name: From lithology

"Upper nodular zone"

See Scenic Member.

"Upper purplish white layer"

See Orella Member.

VALENTINE FORMATION (of Ogallala Group)

Pliocene: Northwestern Nebr., southwestern S. Dak.

Barbour, E.H. and Cook, H.J., 1917 (Nebr. Geol. Survey, v. 7, pt. 19, p. 173). The Valentine beds are probably a lower phase than either the Snake Creek or the Devil's Gulch.

Barbour, E.H. and Cook, H.J., 1917 (Nebr. Geol. Survey, v. 8, pt. 18, p. 170). The three phases of Pliocene in northern and northwestern Nebraska are, ascending: Valentine beds, Snake Creek beds, and Devil's Gulch beds.

Osborn, H.F., 1918 (Am. Mus. Nat. History Mem., v. 2, pt. 1, p. 23). Valentine beds of Barbour and Cook, 1917, are upper Miocene or lower Pliocene.

Cook, H.J. and Cook, M.C., 1933 (Nebr. Geol. Survey Paper No. 5, p. 42-43). Careful systematic collecting in the region about Valentine, Nebraska, by R.A. Stirton, P.O. McGrew, and others indicates that at least three faunal phases are present in that region, to only the upper one of which the term "Valentine" can properly be applied. The lower member of this section agrees closely with typical "Fort Niobrara," and there is at least one distinct stage yet to be differentiated. It will undoubtedly be shown that certain beds in the Valentine region agree closely with the phase of Snake Creek beds in which the type of Hesperopithecus was found [on Olcott Hill]. If we place beginning of Pliocene at first appearance of Hipparion, then the line between Pliocene and Miocene will occur in Valentine beds.

Johnson, F.W., 1936 (Am. Jour. Science, 5th ser., v. 31, p. 467-473). Ogallala formation of Valentine area, Cherry County, northern Nebraska, is divisible into (1) "Cap-rock bed," (2) Burge sands (name proposed for the fine- to coarse-grained sands and gravels containing the "Burge fauna," and (3) Valentine beds--consisting of 175-225 feet of chiefly fine-grained unconsolidated gray sandstones and clay beds above and below of loose channel sands containing the "Valentine fauna." Called Fort Niobrara formation by Osborn, 1918. The "cap-rock bed" and Burge sands are lower Pliocene. The Valentine beds are transitional Miocene-Pliocene and unconformably overlie Brule (?) clay of Oligocene (?)

Lugn, A.L., 1938 (Am. Jour. Science, 5th ser., v. 36, p. 223). The Valentine, as Johnson (1936) has shown, is a satisfactory stratigraphic name for all of the more or less unconsolidated fine gray sands, 175-225 feet thick, constituting the oldest and lowest formation of the Ogallala group. It occurs under the typical mortar beds or Ash Hollow formation. See also Elias, 1942 (p. 134-139).

Agnew, A.F., 1958 (Geol. Soc. America Bull., v. 69, p. 1721). Stated that the Valentine is the lower formation of the Ogallala Group in south-central South Dakota, where it is generally loose and uncemented sand and silt (in contrast to the overlying cemented Ash Hollow).

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that the Miocene Rosebud underlies the Valentine [with erosional unconformity - A.F.A.].
Type locality: South side of a drainage cut between the old and new railroad grades in NE$\frac{1}{4}$ sec. 17, T. 33 N., R. 27 W., Cherry County, Nebraska
Name: From Valentine, Nebraska

VERENDRYE MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 25, 26, 34). Verendrye zone consists of light- to medium-gray shale. Appears somewhat banded in fresh exposure; weathered appearance is banded gray and brown, 5-10 feet. Concretions light-gray to olive-green when fresh, become dark-brown on exposure. Beds of the Sully member of the Pierre lying above the manganiferous Oacoma beds and below the bentonitic basal beds of the Virgin Creek member are here called Verendrye beds. Thickness 10-200 feet.
Crandell, D.R., 1950 (Am. Assoc. Petroleum Geologists Bull., v. 34, p. 2345). To preserve the identity of the subdivisions of the Sully member, proposed raising the Verendrye unit, the Agency-Oacoma unit (DeGrey member of this paper), and the Crow Creek unit to rank of member. (Sully is therefore abandoned.)
Type locality: Presumably under Verendrye Monument at Fort Pierre, Stanley County, South Dakota
Name: From Verendrye Monument

VIRGIN CREEK MEMBER (of Pierre Shale)

Upper Cretaceous: S. Dak.

Searight, W.V., 1937 (S. Dak. Geol. Survey Rept. Inv. 27, p. 35-43, pl. 3). The Virgin Creek is divisible on the basis of lithology into two zones. The lower is relatively resistant light- to medium-gray shale which contains a number of thin but conspicuous bentonite beds. The upper part, especially at the base, breaks down to lead-gray gumbo, in many placed tinged rusty-brown. The upper Virgin Creek in many places contains characteristic small fossiliferous concretions in the lower part, and a bed containing large limestone concretions. The Virgin Creek includes all beds between the Sully member and the highly calcareous beds of the Mobridge member. It includes near the top the zone of limestone concretions which contains the Sage Creek fauna farther west.
Type locality: Presumably valley wall on Virgin Creek, about 1$\frac{1}{2}$ miles south of Promise, Dewey County, South Dakota
Name: From Virgin Creek

"Wall Creek sands" (of Carlile Shale)

Upper Cretaceous: Eastern Wyo., Black Hills of S. Dak.

Wegemann, C.H., 1911 (U. S. Geol. Survey Bull. 452, p. 43, 45). Wall Creek sandstone lentil of Benton shale--buff sandstone, ripple marked and cross bedded, firmly cemented, and of medium grain. Thickness 80-100 feet. Contains petrified wood, marine shells, and fish teeth. Is principal oil sand of Salt Creek field. Lies 220 feet below Niobrara shale and 800 feet above Mowry shale. Not exposed in Salt Creek field but reaches surface in an escarpment 12 miles west of Salt Creek, which rims Powder River dome, forming the lofty escarpment known locally as the "Wall" and is best exposed above Wall Creek, a little stream named for it. Is 80-100 feet thick along Wall Creek, but in Salt Creek thicknesses as great as 150 feet are reported in some wells.

Later work resulted in tracing this sandstone over considerable area, and the name was therefore changed to Wall Creek sandstone member. Subsequently the deposits of Benton age in this part of Wyoming were differentiated into, descending: Carlile shale, Frontier formation, Mowry shale, and Thermopolis shale, and the Wall Creek sandstone was found to form top member of Frontier formation. The drillers in this part of Wyoming began to identify sands in this part of the geologic column as, descending: "First Wall Creek sand," "Second Wall Creek sand," and "Third Wall Creek sand." Of these, the "First Wall Creek sand" is Wall Creek sandstone member as defined. The "Second Wall Creek sand" has also been called "Lower Wall Creek sand."

Rothrock, E.P., 1931 (S. Dak. Geol. Survey Rept. Inv. 8). This and later reports such as Report of Investigation No. 62, refer to the Wall Creek member of the Carlile formation. In Fall River County, South Dakota, the Wall Creek member lies about 250 feet above the base of the formation, and is characterized as a sandy zone with several very different ledgemakers. These are fairly well cemented sands and between them lie soft sands or typically alternating sand and shale. On good exposure the typical Wall Creek appears to be made of beds perhaps a quarter of an inch thick of alternating sand and black shale or carbonaceous matter.

Haun, J.D., 1958 (Wyo. Geol. Association Gdbk., 13th Ann. Field Conf., p. 87-88). Described the Turner sandy member in the Powder River basin as being 150-170 feet thick, and overlain conformably by the Sage Breaks member and underlain conformably by an unnamed shale member [Pool Creek Shale - A.F.A.]. The Turner sandy member is the eastern extension of the Wall Creek sandstone of the Frontier formation. Fossils are Turonian in age.

Type locality: Presumably in the "Wall" above Wall Creek along east side of Powder River dome, Wyoming

Name: From Wall Creek

Wendover Formation

Pennsylvanian: Wyo., Colo., western S. Dak.

Condra, G.E., Reed, E.C., and Scherer, O.J., 1940 (Nebr. Geol. Survey Bull. 13, p. 2, 3, 4, 22, 45). Comprises upper part of Division 2 (Condra and Reed, 1935) of Hartville "formation,"--thickness 104 feet. Predominant lithology is limestone.

McCauley, V.T., 1957 (Williston Basin Symposium, Oct. 9-12, 1956, p. 150-164). Said that the Wendover group of dolomite, sandstone, and shale is present in western South Dakota. Overlain by Cassa. Together with underlying Meek, includes "Second Leo Sand" (near base) and "First Leo Sand" (near top). Distinctive "Red Marker shale" at top.

Type locality: Platte River Valley in vicinity of Wendover, Platte County, Wyoming

Name: From Wendover

WHITE RIVER GROUP

Oligocene: Wyo., N. Dak., S. Dak., eastern Mont., Nebr., northeastern Colo.

Meek, F.B. and Hayden, F.V., 1858 (Phila. Acad. Nat. Science Proc., 1857, 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. [Actually, these strata are Bijou Facies of Pliocene Ogallala Group - A.F.A.] The Titanotherium bed of White River Basin is oldest member. No evidence that any Tertiary deposits known in Nebraska are older than Miocene.

Meek, F.B. and Hayden, F.V., 1862 (Phila. Acad. Nat. Science Proc., 1861, v. 13, p. 433, 434). White and light-drab clay with some sandstone beds and local layers of limestone. Thickness 1,000+ feet. Fossils contain no brackish-water or marine forms. Occurs on Bad Lands of White River, on Niobrara, and across the country to the Platte. Overlies Fort Union group on North Platte River above Fort Laramie. [No Fort Union formation is now recognized in vicinity of Fort Laramie, Goshen County, Wyoming; to east of Fort Laramie, the White River group rests on Lance formation, but to northwest, in parts of Converse and Niobrara counties, Wyoming, the Fort Union formation underlies the White River - Wilmarth, 1938.] Underlies Loup Fork beds (Pliocene).

Meek, F.B., 1876 (U. S. Geol. and Geog. Survey Terr. Mon. 9, p. lxi-lxiv). Most interesting formation because of great numbers and fine state of preservation of mammalian and chelonian remains. No marine or brackish-water remains have been found. Evidently an extensive fresh-water, lacustrine deposit. Spreads extensively south of Black Hills in Nebraska and extends into Colorado, northwest corner of Kansas, narrowing rapidly southward. Overlies Fort Union group unconformably and underlies Pliocene lake deposit on Loup River and at other places in Nebraska--the latter filling depressions in White River group.

[In many areas is treated as a group, divided into Brule clay (above) and Chadron formation (below). Where not divided, is called White River formation - Wilmarth, 1938.]

Clark, John, 1954 (Carnegie Museum Annals, v. 33, p. 179-198). So as to conform to modern usage, Clark proposed formal geographic names for the Chadron formation, namely Peanut Peak member for the Upper Chadron, Crazy Johnson member for the Middle Chadron, and Ahearn member for the Lower Chadron.

[The South Dakota Geological Survey has not used the names of Clark for the Chadron in mapping the Chadron in approximately 15 geologic quadrangles 100 miles farther east, in south-central South Dakota. There, the Chadron is mainly light greenish and olive-gray silty, very bentonitic clay that contains near the base a poorly cemented white quartz conglomerate and sand. The Chadron weathers into rounded humps, and is 20-40 feet thick there (A.F. Agnew, 1957, S. Dak. Geol. Survey, Geol. Quad., White River) - A.F.A.]

Bump, J.D., 1956 (Am. Jour. Science, v. 254, p. 429-432). The Brule formation as it is exposed in the Big Badlands of South Dakota is divided into two members. The lower member, which includes a major part of the classic Oreodon beds, is designated the Scenic member and subdivided into two units, an "Upper nodular zone" and a "Lower nodular zone." The upper portion, which includes the Protoceras-Leptauchenia beds, is designated the Poleslide member and subdivided into three units, the Upper zone, Middle zone, and Lower zone.

[While accepting the names of Bump for the Brule of the Big Badlands, the South Dakota Geological Survey has not used these names in mapping the Brule in approximately 15 geologic quadrangles 100 miles farther east in south-central South Dakota. The Brule is divided there (A.F. Agnew, 1957, S. Dak. Geol. Survey, Geol. Quad., White River) into two units: (1) a lower banded pinkish and grayish clayey tuffaceous laminated siltstone and fine sandstone interbedded with silty bentonitic claystone, which weathers to a stair-step profile, and is about 110 feet thick; and (2) an upper pink and greenish tuffaceous siltstone overlain by pinkish to brownish highly bentonitic clay including pink waxey clay and brown and pink nodular fine sand, which weathers to rounded humps and totals 77 feet in thickness - A.F.A.]

Macdonald, J.R., 1963 (Am. Mus. Nat. History Bull., v. 125, art. 3, p. 148). Stated that the Miocene Rosebud in its type area of Todd County, South Dakota, overlies the Brule [with apparent conformity - A.F.A.]. Farther west, the essentially equivalent Arikaree Group rests on the Brule.

Type locality: Not designated, but apparently along the White River Valley in the Big Badlands of South Dakota

Name: From White River

WHITEWOOD LIMESTONE (of Bighorn Group)

Upper Ordovician: S. Dak. (Black Hills)

Darton, N.H., 1904 (Geol. Soc. America Bull., v. 15, p. 385). Whitewood limestone--massive buff limestone, 0-80 feet thick, of Ordovician age and overlying Deadwood formation in Black Hills uplift.

Furnish, W.M., Barragy, E.J., and Miller, A.K., 1936 (Am. Assoc. Petroleum Geologists Bull., v. 20, p. 1329-1341). Reported finding poorly preserved Ordovician (middle?) fossils in upper 70 feet of Deadwood formation of type section, and recommended transfer of these beds from Deadwood formation to overlying Whitewood limestone [considered Upper Ordovician by U. S. Geological Survey - Wilmarth, 1938]. The 70-foot section consists of, descending: (1) transitional, 10 feet; (2) siltstone member, 20 feet, numerous fossils; (3) shale member, 40 feet, few fossils. They rest on sandstone called "Scolithus" sandstone, 15 feet thick, which has not yielded fossils.

Miller, A.K. and Furnish, W.M., 1937 (Jour. Paleontology, v. 11, p. 535-551). On the basis of the cephalopod fauna, the Whitewood limestone is believed to be slightly older than the Bighorn dolomite, and essentially the time equivalent of the Lander sandstone member of the Bighorn formation in Wyoming.

McCoy, M.R., 1952 (Billings Geol. Society Gdbk., 3rd Ann. Field Conf., p. 44-46). Transferred the lower member of the Whitewood limestone (as defined by Furnish, Barragy and Miller, 1936) out of the Whitewood and renamed it Ice Box shale. Named the siltstone member the Roughlock formation and left the transitional zone in the Whitewood limestone. Indicated that all the contacts from the Deadwood formation through the Englewood formation are conformable.

Type locality: Presumably north of Deadwood in Whitewood Canyon, Lawrence County, South Dakota

Name: From Whitewood Canyon

Away from the Black Hills outcrop area, these beds are termed Red River - A.F.A.

Whitian Series

A name introduced by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Chadron and Brule of the White River Group of South Dakota.

WHITNEY MEMBER (of Brule Formation)

Oligocene: Nebr.

Schultz, C.B. and Stout, T.M., 1938 (Geol. Soc. America Bull., v. 49, p. 1921).

Schultz, C.B. and Stout, T.M., 1955 (Nebr. Univ. State Museum Bull., v. 4, no. 2, p. 44-46). In northwestern Nebraska, the Oligocene deposits consist of the Chadron and Brule formations of Darton. The contact here between these two formations is provisionally drawn at the base of a certain continuous purple-tinted white, sometimes silicified

limestone layer which is the upper of several such limestone beds in the lower part of the local section. A lithologic break and in places a significant and pronounced disconformity divides the Brule formation into two widespread lithologic units which, it is suggested, should now be considered as stratigraphic members. For the massive clays of the upper unit of Leptauchenia zone of the Brule, the name Whitney member is proposed. This member attains the thickness of about 290 feet at the type east locality.

Type locality: East of Toadstool Park, along escarpment near Round Top in Secs. 16 and 21, T. 33 N., R. 53 W., about 16 miles west and 3 miles north of Whitney, Nebraska

Name: From Whitney

See Poleslide Member

Widow Clark coal (of Ludlow Formation)

See Hillen Lignite Facies

WINNIPEG FORMATION (of Bighorn Group)

Ordovician: Man., Sask., N. Dak., S. Dak., eastern Mont.

Dowling, D.B., 1895 (Ottawa Naturalist, v. 9, p. 65-73). Basal sandstone unit with overlying green-shale sequence. Locally some sand in upper green shale. May contain pyrite and phosphate nodules. Thin limestone beds locally. Sand quartzitic, for the most part, with some porous zones. Thickness 60-800 feet.

Erickson, H.D., 1954 (S. Dak. Geol. Survey Rept. Inv. 74, p. 43). Winnipeg formation divided into two distinct lithologic units. The upper unit, called the Winnipeg shale is present in the subsurface in northern Sully and Hyde counties. Light-gray to green, mottled bentonitic shale and siltstone with a few sandy horizons, drills with ease and is not fossiliferous. Is 120 feet thick in the Hunt-School Land oil tests (Secs. 24 and 31, T. 116 N., R. 73 W., Hyde County, South Dakota). The lower unit is known as the Winnipeg sandstone and is present in the western part of Hughes County. It is essentially a well-sorted medium-textured, clear quartz sand, with only a few fossils. It carries some water and drills easily. This unit has been called Black River and St. Peter in previous reports of the Survey.

Carlson, C.G., 1960 (N. Dak. Geol. Survey Bull. 35). Described in detail the stratigraphy of the Winnipeg in South Dakota. He noted (p. 49) that three members are present in the north-central part of the State--the Roughlock, Icebox, and Black Island Member--although only the upper two are present in the Black Hills. The Winnipeg in South Dakota is more than 160 feet thick along the northern border of the State (Carlson, 1961, fig. 12).

Fuller, J.G.C.M., 1961 (Am. Assoc. Petroleum Geologists Bull., v. 45, p. 1341). Reached the same conclusion as Carlson except that he believed the Black Island of Carlson in North Dakota is not the same as that named Black Island in Manitoba by G.J. Genik, 1954 (Alta. Soc. Petroleum Geologists News Bull., v. 2, no. 5, p. 2-5), and thus he (Fuller, 1961, p. 1339) replaced it with the name Burgen, from the Mid-Continent area. [The extension of the name Burgen into northern South Dakota is unacceptable to the South Dakota Geological Survey - A.F.A.] In addition, Fuller discussed the basal (Hecla) beds of the overlying Red River, which C.A. Sandberg (1962, U. S. Geol. Survey TEI-809, p. 28) placed in the Winnipeg.

The age of the Winnipeg is Middle Ordovician, Black Riveran and Trentonian stages, based on conodonts (Carlson, 1960, p. 73-74), despite previous generalized assignments of these rocks to the Late Ordovician Richmondian stage (George McCauley and E.I. Leith, 1951, Geol. Soc. America Bull., v. 62, p. 1461-1462). A.D. Baillie (1952, Man. Dept. Mines and Nat. Resources Pub. 51-6, p. 41) considered the Winnipeg to be "Trentonian (?)" in age, and R.J. Ross, Jr., (1957, U. S. Geol. Survey Bull. 1021-M, p. 461) noted the Middle Ordovician affinities of the Winnipeg.

Type locality: Not designated

Name: From exposures on the shores and islands of the southern part of Lake Winnipeg, Manitoba

Woodbury Shale

Upper Cretaceous: Northwestern Iowa, southeastern S. Dak.

White, C.A., 1870 (Iowa Geol. Survey, v. 1, p. 26, 291-293). Woodbury sandstone and shale. Alternating sandstone and shale, the latter sometimes sandy and sometimes clayey, with more or less calcareous material intermixed. Maximum thickness 150± feet. Overlies Nishnabotany sandstone and underlies Cretaceous Inoceramus beds. Not observed outside Woodbury County, Iowa.

Keyes, C.R., 1923 (Pan-Am. Geologist, v. 39, p. 326). Chart shows Woodbury in South Dakota, 1,000 feet of shales. Underlies Crill terrane and overlies Ponca terrane.

Type locality: Not designated

Name: From Woodbury County, Iowa

This is the Graneros sandy shale of the South Dakota Geological Survey's classification - A.F.A.

"Y" lignite (of Ludlow Formation)

Paleocene: Northwestern S. Dak.

Denson, N.M., et al, 1959 (U. S. Geol. Survey Bull. 1055-C, p. 104-105). Stated that the Olesrud lignite bed, consisting of two benches, occurs below the Mendenhall lignite bed in the Slim Buttes of southeastern Harding County.

[This lignite bed, together with the overlying Olesrud, Mendenhall and Mendenhall rider beds, and the underlying "Z" lignite bed, is equivalent to the Hillen Lignite Facies mapped by the South Dakota Geological Survey in 11 quadrangles of northwestern South Dakota (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.]

Yanktonian Series

A term applied by C.R. Keyes, 1936 (Pan-Am. Geologist, v. 66, p. 154-166) to the Benton Shale of Iowa, including the Niobrara Chalk (top), Hawarden Shale, Dixon Chalk, and Woodbury Shale (base).

"Z" lignite (of Ludlow Formation)

Paleocene: Northwestern S. Dak.

Denson, N.M., et al, 1959 (U. S. Geol. Survey Bull. 1055-C, p. 104-105). Stated that the Olesrud lignite bed, consisting of two benches, occurs below the Mendenhall lignite bed in the Slim Buttes of southeastern Harding County.

[This lignite bed, together with the overlying Olesrud, Mendenhall rider, Mendenhall and "Y" lignite beds, is equivalent to the Hillen Lignite Facies mapped by the South Dakota Geological Survey in 11 quadrangles of northwestern South Dakota (R.E. Stevenson, 1956, S. Dak. Geol. Survey, Geol. Quad., Ludlow) - A.F.A.]

Zunian (?) Series

A name proposed by C.R. Keyes, 1923 (Pan-Am. Geologist, v. 39, p. 326) to include the Sundance in South Dakota.

About the South Dakota State Geological Survey

The South Dakota Geological Survey is a research and public service agency for the State of South Dakota. Since 1893 the State Geologist has been authorized to "make an actual geological survey of the lands, the earth, and the area beneath the surface of the lands....." of the State. The purpose of the State Geological Survey is to conduct field and laboratory studies of South Dakota's geology and mineral deposits, which are the metals and non-metals, the mineral fuels including oil and gas, and ground water. The results of these studies are published in reports such as this.

The work of the State Geological Survey is continuous--its research and services are adjusted to the changing economy in order to serve South Dakota most effectively.

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