AMERADA BAKKEN

WANETE-LEE

HUNT-WALD

HUNT-SHOEMAKER

AJAX-BELL

AMSDEN

HEATH

&

OTTER

KIBBY

CHARLES

MISSION CANYON

LODGEPOLE

ENGLEWOOD

7000

7500

8000

8500

9000

9500

5500

6000

6500

4500

5000

5500

3500

4000

Shift

3000

3400

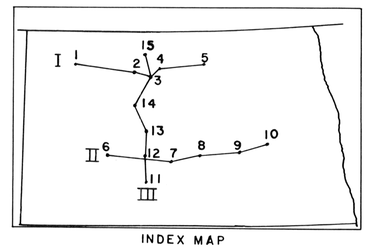
157-95-12

156-85-2

155-81-23

157-78-28

158-72-28



INDEX MAP

1. Bakken
2. Lee
3. Wald
4. Shoemaker
5. Bell
6. Leutz
7. Davidson
8. State A.
9. Gaier
10. Peplinski
11. Dakota-1
12. Semling
13. Samedan
14. McLean Co.
15. Thompson

COLOR

Porous
Oil show
Oil production
Fossiliferous
Vugular
Radioactivity log

Variegated Shale
Dark gray, black
Gray, olive gray
Light gray, yellow gray, pink gray
Brown, brown gray, lt brown gray
White, tan, lt olive gray
Orange, pale orange
Red, reddish brown
Gray and red mixed
Yellow brown and pale brown

TEXTURE

Fine to medium
Coarse
Dense crystalline
Fragmental
Oolitic
Fragmental and Oolitic

LITHOLOGY

Limestone
dolomitic
shaly
sandy
anhydritic
Shale
calcareous
Salt
Anhydrite
Dolomite
calcitic
shaly
sandy
anhydritic
Sandstone
shaly
calcareous

SCALE—1 INCH = 5 MILES

STRATIGRAPHIC SECTIONS OF THE MISSISSIPPIAN SYSTEM IN NORTH DAKOTA

By Sidney B. Anderson

CROSS SECTION I – EAST-WEST

KELLY-PLYMOUTH
LEUTZ
142-89-28

CONTINENTAL-PURE
DAVIDSON
140-71-6

MAGNOLIA
STATE-A
141-73-36

BARNETT
GAIER
141-67-11

GENERAL-ATLAS
PEPLINSKI
142-63-21

6500
7000
7500
8000
8500
9000
4000
4500
5000
3500
4000
2500
1900

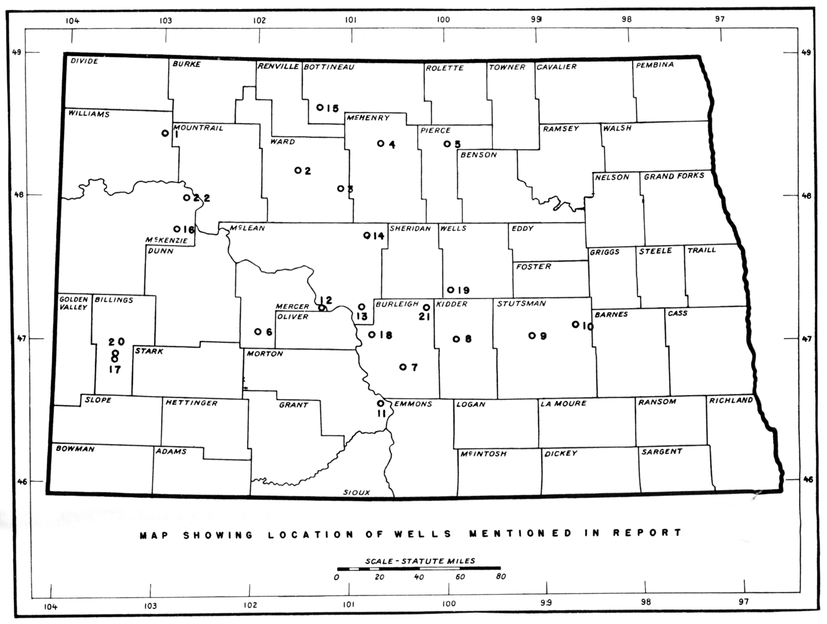
AMSDEN
HEATH
&
OTTER
KIBBY
CHARLES
MISSION
CANYON
LODGEPOLE
ENGLEWOOD

79 MILES
27 MILES
36 MILES
21 MILES

STRATIGRAPHIC SECTIONS OF THE MISSISSIPPIAN SYSTEM IN NORTH DAKOTA

By Sidney B. Anderson

CROSS SECTION II – EAST-WEST



MAP SHOWING LOCATION OF WELLS MENTIONED IN REPORT

KEY TO WELLS USED ON LOCATION MAP

1. Amerada Henry O. Bakken No. 1
2. Wanete Lee No. 1
3. Hunt Joe Wald No. 1
4. Hunt Shoemaker No. 1
5. Ajax Bell No. 1
6. Kelly-Plymouth Fritz Leutz No. 1
7. Continental-Pure Davidson No. 1
8. Magnolia Dakota A No. 1
9. Barnett Drilling Gaier No. 1
10. General Atlas Carbon Co. Alvin Peplinski No. 1
11. Phillips-Carter Dakota A No. 1
12. Carter Semling No. 1
13. Samedan Vaughn Hanson No. 1
14. Stanolind McLean Co. No. 1
15. California Co. Blanche Thompson No. 1
16. Amerada Benhomer Risser No. 1
17. Amerada Herman May No. 1
18. Hunt Kleven No. 1
19. Continental Leuth No. 1
20. Amerada W. E. Logan No. 1
21. Continental Dronen No. 1
22. Stanolind W. Starr No. 1

PHILLIPS–CARTER–DAKOTA–1
136–81–29

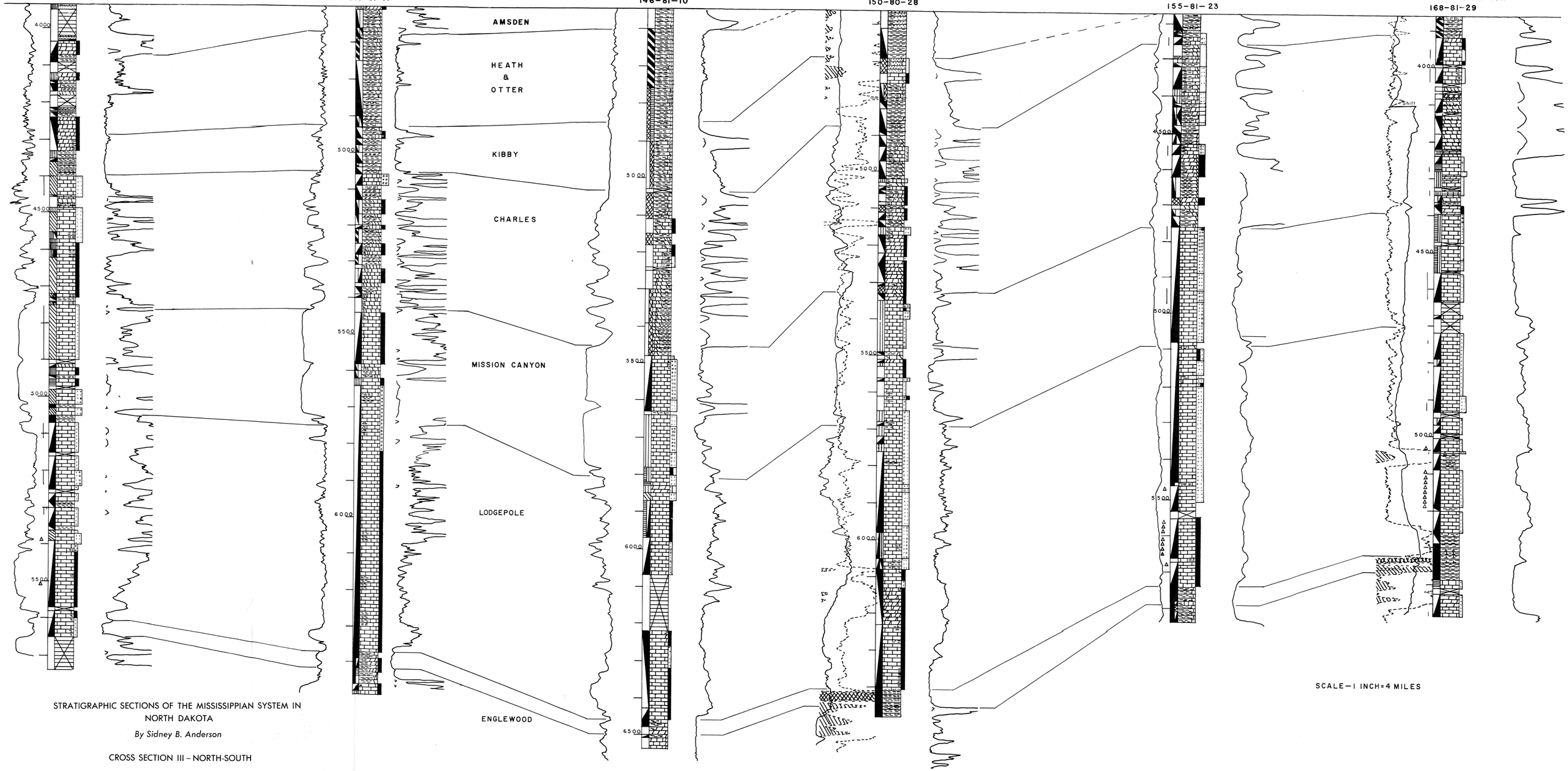
CARTER–SEMLING
141–81–18

SAMEDAN–HANSON
146–81–10

STANOLIND–McLEAN CO.
150–80–28

HUNT–WALD
155–81–23

CALIF.CO.–THOMPSON
168–81–29



STRATIGRAPHIC SECTIONS OF THE MISSISSIPPIAN SYSTEM IN NORTH DAKOTA

By Sidney B. Anderson

CROSS SECTION III – NORTH-SOUTH

SCALE–1 INCH=4 MILES

NORTH DAKOTA GEOLOGICAL SURVEY
WILSON M. LAIRD, State Geologist

Stratigraphic Sections of the Mississippian System in North Dakota

by
SIDNEY B. ANDERSON

Report of Investigations No. 16

Grand Forks, North Dakota. 1954

ABSTRACT

This report provides a comprehensive study of certain stratigraphic sections in the Mississippian system of North Dakota as shown by wells drilled for oil and gas. The names and definitions of formations, occurrence, lithology, thickness, and correlations are given. Three electric and lithologic log cross sections are included.

ACKNOWLEDGEMENTS

The writer wishes to thank Dr. Stanley P. Fisher for the gathering of much of the reference material used in this report, and Miller Hansen, Assistant State Geologist for his assistance in its preparation.

INTRODUCTION

Practically all the oil that is now being produced in North Dakota is from rocks of Mississippian age. It is hoped that this report will provide data that will be helpful in further investigations into the possibility of producing more oil from the Mississippian.

Mississippian oil was discovered in the upper part of the Mission Canyon in the Amerada—Henry O. Bakken No. 1 Well (Well No. 1 on cross section No. 1) and is now being produced in Beaver Lodge, Tioga, Charlson, Hoffland, Keene, Croff and Fryburg pools. Even more recently oil was discovered in the Heath sands in Amerada's—W. E. Logan No. 1 Well (Well No. 20 on index map) which is an offset to the Herman May well (Well No. 17 on index map) in the Fryburg area.

All of the oil being produced from the Mission Canyon is of high gravity averaging about 42° A.P.I. and the recent Heath discovery also shows high gravity oil. In Bottineau County, oil is being produced in small amounts from the Mississippian Charles formation.

The logs in the cross-sections show the general lithology in the central strip, the color in the left hand strip and the texture on the right hand strip. Color was determined by use of the Rock Color Chart of the National Research Council.

Fabric terms used are crystalline, fragmental, sugary and oolitic. Non-interlocking aggregates of crystals or angular crystal fragments are described as sugary if no rounded grains or obvious rock or fossil fragments are found. Aggregates of rock or fossil fragments are fragmental. Crystalline rocks are those with interlocked crystals and usually have little intergranular porosity. Spherical to sub-spherical grains are called oolites without regard to internal structure. Many mixtures of fabric are possible and these are indicated in the column on the log by appropriate combinations of symbols. Texture is shown by the strip on the right side of the log. The pattern shows the type of fabric and the width of the strip indicates grain size.

Limestone, dolomite, and combinations of the two were identified by using 7:1 dilute hydrochloric acid. Fossils are noted when present. However, more fossils are found in cores than in cuttings, so recognizable fossil content is dependent on cores and the quality of the cuttings.

Porosity is shown by a line and oil shows and oil production are shown by appropriate symbols to the left of the color column.

The purpose of this report is to identify and to show the extent and thickness of the formations within the Mississippian system in the North Dakota portion of the Williston Basin.

Porous zones, oil shows, oil production and varying lithologies of the formations are illustrated and described. In order to facilitate the study two east-west cross-sections and one north-south cross section were prepared by the use of sample, electric and radioactivity logs.

Each formation is studied separately, and lateral changes in formations from well to well are discussed.

ENGLEWOOD

The Englewood limestone was described by N. H. Darton[1] in 1901. The name was suggested by T. A. Jagger, from the town of Englewood, in the Northern Black Hills, where it is well exposed.

The Englewood in the Black Hills is a pink slabby limestone underlying the Pahasapa limestone, but in North Dakota it is generally a dark gray to black shale, grading to reddish on the east side of the basin. In the deeper part of the basin there is some sandstone which is overlain and underlain by the dark shales, this sand may be equivalent to the Banff sands of Canada. A carbon tetrachloride oil cut was obtained from this sand in the H. O. Bakken No. 1 Well. Recently Stanolind Oil and Gas Company completed their Woodrow Starr No. 1 Well (Well no. 22 on index map) as an oil well in the Englewood sand. In the south-central part of the state there is a considerable amount of limestone or shaly limestone in the Englewood.

The Englewood is overlain by the Mississippian Lodgepole formation and is underlain by the Devonian Lyleton formation, which is a reddish or pinkish dolomite, shaly dolomite or shale. Upper and lower boundaries of the Englewood are conformable with adjacent formations.

Recently, the approximate equivalent of the Englewood in the Williston Basin[2] has been informally termed the Bakken formation from the H. O. Bakken No. 1 Well in the Tioga pool.

Occurrence and Lithologic Character

The Englewood is well exposed in the Northern Black Hills, but in North Dakota and Eastern Montana the Englewood is confined to the subsurface. Extending over the greater part of North Dakota, it is absent only in the extreme eastern part of the basin where there are no rocks of Mississippian age. In outcrop the Englewood limestone is described by Darton[3] as being 25 to 60 feet thick. The Englewood in North Dakota varies from approximately 100 feet in thickness in the H. O. Bakken No. 1 Well (Well No. 1 on cross section No. 1) to 30 or 40 feet in the wells on the eastern side of the Williston Basin.

According to Nordquist[4] there is some doubt as to whether the Englewood or "Bakken" of North Dakota and Montana is correlative with the Englewood of the Black Hills, and he states that it is probably correlative to the lower beds of the Lodgepole.

MADISON GROUP

The Madison Group is divided into three units consisting of the basal Lodgepole, the Mission Canyon, and the Charles formations, which form a section of over 2,000 feet in thickness in the western part of North Dakota. Here the Madison consists primarily of limestones, dolomites and evaporites. The Lodgepole is made up principally of limestones, with a cherty limestone at the base. The Mission Canyon is also chiefly limestone, with some dolomites, containing highly fossilferous oolitic intervals. The Charles is primarily an evaporitic section consisting of salt, anhydrites, shales, dolomite, and limestone.

LODGEPOLE

Name and Definition

The Lodgepole limestone is the lower unit of the Madison limestone which was first described by A. C. Peale[5] in 1893. The Lodgepole was first named by A. J. Collier and S. H. Cathcart[6] for exposures in Lodgepole Canyon in the Little Rocky Mountains, where it is described as consisting of thin-bedded limestones and shales containing many fossils. In North Dakota the Lodgepole is generally light to medium gray to brownish in color, with the texture ranging from fine and medium crystalline to oolitic and fragmental limestone. The Lodgepole in general in North Dakota is quite dense.

Occurrence and Lithologic Character

The Lodgepole is exposed in the Little Rocky Mountains in eastern Montana. The Madison group of which the Lodgepole is the basal member extends over most of Wyoming, Montana, eastern Colorado and South Dakota. In North Dakota the Lodgepole and the entire Madison group is confined to the subsurface, where it conformably overlies the Englewood formation and is conformably overlain by the Mission Canyon formation.

In North Dakota along the western part of the southern E-W cross-section from the Kelly-Plymouth, Fritz Leutz No. 1 Well (Well No. 6 on cross section No. 2) to the General Atlas Carbon Company's Alvin Peplinski No. 1 Well (Well No. 10 on cross section No. 2) the Lodgepole is generally light-gray and locally medium-gray with the texture ranging from fine- or medium-crystalline to oolitic and fragmental limestone.

The lower part of the Lodgepole ranges from gray to brownish limestone in this area, and the texture varies from dense and fine crystalline to medium fragmental or locally coarse fragmental. This unit also contains considerable chert, shaly limestones and dark shales in most wells. In the eastern part of the area covered by the southern E-W cross-section, the Lodgepole is white to pale orange or pink in color, and the texture ranges from fragmental to oolitic with some medium to dark gray shale throughout.

The northern E-W cross-section shows the Lodgepole to be light gray in the Amerada H. O. Bakken No. 1 Well in Williams County, light gray or light brown mottled in Ward, McHenry, and Bottineau County wells, while in the Ajax Bell No. 1 Well (Well No. 5 on cross-section No. 1) in Pierce County it is yellow gray dolomite. In texture the Lodgepole ranges from fine grained and dense to sugary in the upper part of the Amerada H. O. Bakken well with some good porosity in the upper 150 feet. In Ward, Bottineau and McHenry Counties the Lodgepole is mainly fragmental and in the Stanolind-McLean County No. 1 Well (Well No. 14 on cross-section No. 3) it is oolitic to coarse fragmental. In the Ajax Bell No. 1 Well it is mainly crystalline with oolitic limestone zones, and in general the lower part contains chert and gray shales. The Wanete Lee No. 1 Well (Well No. 2 on cross-section No. 1) shows some "floating" sand grains in this zone.

MISSION CANYON

Name and Definition

The Mission Canyon limestone is the upper unit of the Madison limestone which was first described by A. C. Peale[7] in 1893. The Mission Canyon was first described as such by A. J. Collier and S. H. Cathcart[8] for exposures in Mission Canyon in the Little Rocky Mountains.

In the Little Rocky Mountains, the Mission Canyon is a massive white marine limestone 500 feet thick, and less fossilferous that the Lodgepole limestone. In North Dakota the Mission Canyon may be described in general as being a thick marine limestone ranging in color from yellowish-brown to brownish gray, and in texture from oolitic and fragmental to fine crystalline.

Occurrence and Lithologic Character

The Mission Canyon formation crops out widely in Montana and Wyoming, and in the Black Hills where it is known as the Pahasapa formation. It is widespread in the subsurface of the northern and central Rocky Mountains the Northern Great Plains and in North Dakota. In North Dakota it is present over approximately the western two-thirds of the state, and is underlain conformably by the Lodgepole formation, and conformably overlain by the Charles formation.

In North Dakota along the southern E-W cross-section, the Mission Canyon is pale or yellow-brown to pale orange in the western part, and from Burleigh County eastward the limestone becomes brown to brown-gray. The texture is generally oolitic to fragmental in the west, from Burleigh County eastward it is often earthy to fine crystalline, although oolitic textures are still important. Porosity is most notable in the upper part.

Along the northern E-W cross-section the Mission Canyon is in general light gray to brown-gray limestone with some brown dolomite and pink-gray limestone to the eastward. The texture ranges from oolitic and fragmental to fine-grained dense. As along the southern E-W cross-section porosity is most notable in the upper part, in some of the wells there is much pin-point to vugular porosity in this zone. All of the oil being produced from the Mission Canyon comes from this zone.

The Mission Canyon shows up quite distinctively on electric and radioactivity logs. The S. P. curve shows a high even negative reading broken in the center by a sharp low negative S. P. value and a high resistivity value. The gamma ray log shows low, even radioactivity broken in the center by a sharp high radioactivity value.

The zone of the "S. P. and gamma ray break" near the middle of the Mission Canyon has the following lithologic character based on sample examination.

Kelly-Plymouth Fritz Leutz No. 1 Well-porous zone
Carter Emma Semling No. 1 Well—28′ Anhydrite
Hunt Kleven No. 1 Well—about 20′ Anhydrite
Continental-Pure Davidson No. 1 Well—more than 30′ light yellow brown, coarse grained dolomite with minor anhydrite seams; good flourescence at base.
Continental-Duemeland Well—Anhydrite in approximate middle of the formation
Magnolia Dakota A No. 1 Well—pale gray calcareous fine to medium grained sandstone in approximate middle of the formation.
Carter State No. 1 Well—limy sandstone in middle
Samedan Vaughn Hanson No. 1 Well—10′ anhydrite with limestone above and below
Stanolind McLean Co. No. 1 Well—anhydrite just below middle of section
Continental Leuth No. 1 Well—core of pink to tan dolomite with some limestone and anhydrite in the middle of the formation

The Mission Canyon thins eastward; the thinning of the upper part in the eastermost part of the basin is due to post Mission Canyon erosion. In the Barnett Drilling Company's Gaier No. 1 Well (Well No. 9 on cross-section No. 2) only the lower unit persists. The Mission Canyon in the above mentioned Gaier No. 1 Well is directly overlain by the Jurassic Piper formation.

CHARLES

Name and Definition

The Charles formation was first named by O. A. Seager[9] from the Arro Oil and California Company's Charles No. 4 Well Secton 21, T. 15N., R. 30E., Garfield County, Montana. Seager placed the Charles in the Big Snowy group, but more recent work[10] indicates that the Charles deposition is genetically related to that of the underlying Mission Canyon.

The Charles formation is a sequence of limestone, anhydrite, brown to red shales and siltstones, and dolomite lying between the Kibbey and the Mission Canyon limestone.

Occurrence and Lithologic Character

The Charles is present in the subsurface of North Dakota and eastern and central Montana. Rocks similar to the subsurface Charles are not definitely known in the Mississippian outcrops in the Black Hills and the Big Snowy Mountains, but some geologists consider certain limestone rubble zones above the Mission Canyon formation in those places equivalent to the Charles.

In southern North Dakota the Charles consists of pale-brown to light-gray, shaly, fine fragmental limestone and some brown shale. The middle and lower parts contain white to gray, granular to dense limestone and thick anhydrite beds. East of the Missouri River the upper part becomes yellowish-gray, and there are more thick anhydrites in the basal part. There is a bed of anhydrite 18 feet thick at the base of the Charles in the Hunt Kleven No. 1 Well (Well No. 13 on index map) and a 21 foot section of anhydrite is found at the base in the Continental Dronen No. 1 Well (Well No. 21 on index map).

In northwestern North Dakota, the Charles is similar to that in the southwestern part of the state. The Amerada H. O. Bakken No. 1 well has a thick salt bed at the top of the Charles, 40 feet of salt in the lower part, and dolomite and anhydrite at the base. The salt disappears to the east; there is only a small salt section in the California Thompson Well (Well No. 15 on cross section No. 3). The basal part of the Charles is dolomitic brown siltstone and silty dolomite in the Thompson well. The dolomites and anhydrite of the basal unit extend into the Hunt Shoemaker No. 1 Well (Well No. 4 on cross section No. 1); at the Ajax Bell No. 1 Well (Well No. 5 on cross section No. 1) in the east the Charles is largely shale with some anhydrite and dolomite.

The base of the Charles grades into the Mission Canyon below, and there is some evidence of regional interfingering of the two formations, on the eastern flank of the basin.

Oil is produced from the upper part of the Charles formation in northern Bottineau County.

KIBBEY

The Kibbey sandstone was named by W. H. Weed[11] in 1899, he placed the Kibbey in the Quadrant formation as the basal member. The Kibbey was named for outcrops near Kibbey, Montana, on Little Otter Creek in Cascade County. H. W. Scott[12] in 1935, placed the Kibbey as the lowest formation of the Big Snowy Group.

The name Big Snowy group is assigned to the lower beds of the former Quadrant formation to which they had been previously assigned in central Montana. The Big Snowy group was named for its excellent exposures in the Big Snowy Mountains; it is also exposed in the Little Belt Mountains.

The Kibbey formation is a sequence of shales, sandstone and limestone lying between the Otter and Charles formations.

Occurrence and Lithologic Character

The Kibbey formation is present in the subsurface of North Dakota and eastern Montana, where it immediately overlies the limestone and anhydrite of the Charles in the deeper parts of the Williston Basin, and underlies the Otter and Heath shales where they are not eroded. In North Dakota the Kibbey formation is present over approximately the western half of the state.

The Kibbey is described by Weed[13] as being reddish and yellow clayey sandstones often with interbedded layers of gypsum. Near Riceville, Montana, it attains a thickness of 153 feet.

In North Dakota the Kibbey is usually a reddish and occasionally light gray, medium to fine-grained rounded sandstone with a limestone or occasionally dolomite section below the sand with variegated shale at the base.

The Kibbey attains a thickness of approximately 225′ in the Kelley Plymouth Leutz No. 1 Well (Well No. 6 on cross section No. 2) where it is represented by about 75′ of sandstone with some intercalated shale at the top, a middle zone 70 feet thick of limestone with some shale and 80 feet of variegated shale at the base.

There is a very distinctive "kick" on the resistivity curve selected as the top of the Kibbey. This is a rather controversial pick as a number of geologists place the top of the Charles on this "kick". It is felt by the author, however, that this belongs in the Kibbey and it is treated as such in this report.

OTTER

The Otter shale member was named by W. H. Weed[14] in 1899 for outcrops along the Little Otter Creek in Cascade County, Montana, and was described as the upper member of the Quadrant formation.

H. W. Scott[15] in 1935 included the Otter in his Big Snowy group as the middle member.

The Otter formation may described generally as a sequence of variegated shales interbedded with thin limestone.

Occurrence and Lithologic Character

The Otter is exposed along Little Otter Creek in Cascade County, Montana, the Big Snowy Mountains, and Little Belt Mountains; however, in North Dakota and eastern Montana the Otter is confined to the subsurface. It is present over approximately the western half of North Dakota.

The Otter formation is described by Weed[16] as consisting of dark gray or purplish shale near the base becoming a bright coppery green color higher up, interbedded with thin limestones which are frequently oolitic, carrying Lower Carboniferous fossils. The green shales are replaced by red and veriegated shales east of the Big Snowy Mountains, presumably as a result of more complete oxidation. The light colored oolitic and ostracodal limestone content increases to the east, with a few anhydrites usually present.

The Otter in North Dakota consists mainly of variegated shale and small amounts of limestone. It is difficult to pick in samples and also difficult to recognize on electric logs, however, it may be more easily recognized on radioactivity logs as the unit lying between the Heath and Kibbey. Weed[17] described the Otter as having a thickness of 303 feet, where it crops out along Little Otter Creek. In North Dakota the Otter is approximately 330 feet thick in the Amerada H. O. Bakken No. 1 Well (Well No. 1 on cross section No. 1) in Williams County. In Ward County in the Wanete M. O. Lee No. 1 Well (Well No. 2 on cross section No. 1) the combined thickness of the Heath and Otter is about 100′ and the Otter is not present in the Hunt Wald No. 1 (Well No. 3 on cross section No. 1) in eastern Ward County.

HEATH

Name and Definition

The Heath formation was named by H. W. Scott[18] in 1935. The Heath may be described as a sequence of sandstones and black shales, lying between the Otter and Amsden formations.

Occurrence and Lithologic Character

The Heath is well exposed in the Big Snowy Mountains, and is also exposed in the Little Belt Mountains. In North Dakota and eastern Montana, however, the Heath is confined to the subsurface, and is present over approximately the western half of North Dakota.

Scott[19] describes the Heath as consisting of black petroliferous shales and sandstone, but consisting primarily of black shales. Three sandstone beds which occur in the upper part in most areas, have been grouped under the name "Van Dusen Sand" in central Montana, where oil is produced from this member. The Heath also contains some minor cross bedded gray limestone.

The Heath excited considerable interest in western North Dakota since Amerada Petroleum Corporation discovered 49° gravity oil in the Heath in its No. 1 Logan Well (Well No. 20 on index map) in Billings County.

According to Scott the thickness of the Heath may reach 500 feet, and the sands may reach 20 feet in thickness. In North Dakota the maximum thickness of the Heath yet penetrated is approximately 130 feet.

The Heath makes an excellent marker on radioactivity logs, the gamma ray curve showing a very high radioactivity reading.

AMSDEN

Name and Definition

The Amsden was named by N. H. Darton[20] for exposures on the Amsden Branch of the Tongue River, west of Dayton, Wyoming.

The Amsden is generally placed in the Pennsylvanian, but is locally placed in the Mississippian, as fossils of Mississippian age have been described from the Amsden by Sloss[21].

The Amsden has been tentatively placed in the Pennsylvanian in a recent paper by Harris[22] because of a possible direct correlation with the Pennsylvanian Minnelusa in the Black Hills, and also because the Amsden aquires Pennsylvanian faunal types eastward from the type section in Montana. Harris states " . . . the Minnelusa and Amsden formations, as now interpreted in the North Dakota subsurface, ocupy the same stratigraphic position and should probably be considered equivalent." This, however, is not the opinion of the author of this paper wherein the Amsedn is regarded as being Mississippian in age.

The Amsden may be described as being a sequence of limestone and dolomite, dark or colored shales and a few anhydrites, with some local sands at or near the top.

Occurrence and Lithologic Character

The Amsden in North Dakota and eastern Montana is confined to the subsurface, and is present over approximately the western half of North Dakota, where it rests with angular unconformity on the Big Snowy group. The Spearfish rests unconformably on the Amsden; except in the extreme southwestern part of the state where the Amsden is overlain by the Pennsylvanian Minnelusa.

The Amsden is described by Darton[23] as consisting of red shales, white limestone and cherty and sandy limestone. In North Dakota the Amsden ranges from pale orange to pink-gray dense dolomite with local sands at or near the top, and it usually contains some dark or colored shales, with a few anhydrites.

Darton[24] describes the Amsden as being 150 to 350 feet in thickness. In North Dakota the Amsden is 160 feet thick in the Amerada Bakken No. 1 well. It thins rapidly eastward, where it pinches out between the Amerada Bakken and the Wanete Lee No. 1 Well. The Amsden is 140 feet thick in the Kelly-Plymouth Fritz Leutz No. 1 Well and pinches out between the Magnolia State A No. 1 Well (Well No. 8 on cross section No. 2) and the Barnett Gaier No. 1 Well. (Well No. 9 on cross section No. 2)

CONCLUSION

The Mississippian system is distinguished by its position below the Pennsylvanian Minnelusa formation; where the Minnelusa is absent it more easily disinguished by its position below the Triassic Spearfish formation. To the eastward where the Spearfish is absent the Mississippian lies below the Jurassic Piper formation, and above the Devonian Lyleton formation.

The Amsden, Charles, Mission Canyon, Lodgepole and the Englewood formations are quite easily distinguished on good quality electric and radioactivity logs. The individual formations of the Big Snowy group are difficult to distinguish on electric logs, but the Big Snowy group as a whole can be distinguished quite readily on electric and radioactivity logs. The Heath formation is quite easily distinguished on radioactivity logs.

The Mission Canyon has more porosity than the Lodgepole and Charles and appears to be, at present, the most favorable formation of the Madison group for the production of oil.

The Heath also is proven favorable for oil production by Amerada's recent discovery in the Heath, in its No. 1 Logan well, which is the first well in North Dakota indicated to be commercially productive from a sand. Recently Stanolind Oil and Gas Company's Woodrow Starr No. 1 Well, located in Sec. 21, T. 152N., R. 94W., in McKenzie County was completed as a producing well in the Englewood or "Bakken" sands, for an initial production of about 1420 barrels of 44° gravity oil, with one million cubic feet of gas per day.

The Kibbey sand should also provide a fair reservoir under proper structural and stratigraphic conditions. The unconformity at the top of the Mississippian system over a large part of the state also presents some interesting stratigraphic possibilities for the production of oil. Much more stratigraphic information and study is needed before the possibilities of oil production from the Mississippian can be fully known.

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[1] Darton, N. H., Geology and Water Resources of the Southern Half of the Black Hills and Adjoining Regions in South Dakota and Wyoming: U. S. Geol. Survey, 21st Ann. Rpt., pt. 4, p. 509. 1901.
[2] American Association of Petroleum Geologists, Williston Basin Committee on Nomenclature & Correlation, Preliminary Williston Basin Correlation Chart. 1953.
[3] *op cit;* Darton, p. 509.
[4] Nordquist, Jack W., Mississippian Stratigraphy of Northern Montana: Billings Geological Society; Guidebook, 4th Ann. Field Conference, pp. 72-74. 1953.
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[6] Collier, A. J. and Cathcart, S. H., Possibility of finding oil in laccolithic domes south of the Little Rocky Mountains, Montana. U. S. Geol. Survey Bull. 736 F, p. 173. 1922.
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