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THE SACAJAWEA FORMATION AND THE DARWIN SANDSTONE IN THE SOUTHEAST WIND RIVER MOUNTAINS, WYOMING

BY

DENNY N. BEARCE

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE, GEOLOGY MAJOR

Rolla, Missouri

1963

Approved by

Richard H. Kennedy (advisor) ______

______ E. D. Fisher

ABSTRACT

The area under study is located along the southeast flank of the Wind River Range in Fremont County, Wyoming. Beds overlying the Madison Group are measured and described in six locations within this area. These locations are: North Fork Popo Agie River, Sink's Canyon, Crooked Creek, Canyon Creek, Little Popo Agie River, and Cherry Creek.

Laboratory studies are used as an aid in correlating the sandstone and dolomite sequences described in the six sections. These studies include sieve and heavy mineral analyses and thin section examination.

Sorting factors, obtained from the sieve analyses, and heavy mineral suites indicate that the Darwin Sandstone which occurs at North Fork Popo Agie River also is present to the southeast at Crooked Creek and Canyon Creek. The heavy mineral suite of a sandstone in Sink's Canyon differs markedly from those from sands in the other locations. A younger age is postulated for the Sink's Canyon sandstone.

Thin-bedded dolomites overlying the Madison Group in Sink's Canyon, Little Popo Agie River, and Cherry Creek are correlated with the upper thin-bedded limestones included in the Sacajawea Formation at its type area, Bull Lake Creek. Fossils from Sink's Canyon and Cherry Creek aid in this correlation.

It is postulated that during late Chesterian time a shallow sea existed in western Wyoming. Beds of the Sacajawea Formation were laid down in this body of water. With retreat of the sea northward at the end of the Mississippian Period red beds from a southern source began to accumulate over the beds of the Sacajawea Formation. Erosion of local highs re-exposed the Madison Limestone in certain areas. With the start of the Pennsylvanian Period the Darwin Sandstone began to accumulate from the northeast on an erosion surface of either the Madison Limestone or the Sacajawea Formation, depending on the extent of prior erosion. The Darwin Sandstone lenses out in the southeast portion of the Wind River Range. Isolated lenses of Darwin Sandstone occur south of North Fork Popo Agie River where it rests on an eroded Madison surface. Elsewhere in this area the sand was probably mixed with red shale from the south. Thus, the Darwin Sandstone is generally equivalent in age to the sandy red shale found along the southeast flank of the Wind River Range.

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I. INTRODUCTION

A. Purpose and Scope

This thesis is the result of a study of the sedimentary beds that disconformably overlie the Madison Group along the southeast slope of the Wind River Range in Fremont County, Wyoming. It is primarily concerned with a lithologic description and a determination of the depositional environment of these beds, their age and correlation with beds to the northwest of this area in the Wind River Range.

B. Location and Accessibility

The area lies in Fremont Country in western Wyoming between 42° 38' and 42° 52' north latitude and between 108° 42' and 108° 53' west longitude. Fossil Hill, Wolf Point, Mt. Arter and Mt. Arter SE 7½' quadrangles are included in the area (Figure 1). Measured sections extend over a distance of approximately 18 miles along the mountain front.

The two northwesternmost locations at North Fork, Popo Agie River, and Sink's Canyon are accessible by automobile. The four southeasternmost measured sections are several miles from all roads, save cattle trails. Here it was most feasible to travel by horse to the areas and camp as near as possible to the outcrops. This avoided loss of time in crossing the often extremely rugged terrain.

C. Physical Features

The Wind River Mountains form the southwest side of the Wind River Basin in western Wyoming. They consist of a central Precambrian igneous core with associated Precambrian metamorphics. Sediments of Paleozoic through Tertiary age overlie this core except where it has been exposed by erosion. These sediments form dip slopes along the southeast side of the range. They show little deformation other than local faults and folds. The beds dip gently northeastward, leveling gradually and ending rather abruptly in a tightly folded northwest trending anticlinal zone. The latter is the site for many oil producing domes along the western flank of the Wind River Basin.

The various stratigraphic sections lie within the southeasternmost portion of the above mentioned sedimentary beds, and to the west of the tightly folded anticlinal zone.

The massive bedded Madison Limestone forms conspicuous outcrops of steep cliffs. The red shale of the Amsden Formation forms a fairly steep slope above the Madison Limestone up to the massive light tan bluffs and cliffs of the Tensleep Sandstone. If the Madison Limestone is followed up dip it soon rises in broad, easily recognized, light to medium grey, dip slopes beyond the cover of red soil derived from Amsden Shale.

Outcrops of the Sacajawea Formation and the Darwin Sandstone Member of the Amsden Formation are scarce, and

and where present, are poorly and discontinuously exposed. Only rarely are these beds not completely covered with soil and rock debris from the overlying Phosphoria, Tensleep, and Amsden Formations.

D. Previous Work

E. B. Branson (1918) collected fossils of Ste. Genevieve age from a series of beds which he called the Amsden Formation at Bull Lake Creek and Cherry Creek in the southeastern Wind River Mountains. Prior to Branson's work (1918) the Amsden Formation was held to be entirely Pennsylvanian in age. Since his work considerable disagreement has evolved regarding the correct location of the top of the Madison Group and the base of the Amsden Formation. At Bull Lake Creek Branson measured 76 feet 8 inches of sandy, granular to coarsely crystalline limestone in his Amsden section. Branson described a heterogeneous mixture of limestone, sandstone, shale and conglomerate occurring at the base in peculiarly arched structures containing caves. Contact with the Madison Group below is sharp and disconformable with a conglomeratic breccia zone. Contact between these beds and an overlying sandstone which Branson called the Tensleep is also disconformable. At Cherry Creek Branson described Amsden outcrops as poor, consisting of only a few feet of rock in place. Here he found over three feet of sandy, highly ferruginous shales about 60 feet above the base of the formation. The shales grade upward into a concretionary iron oxide zone. Fossils occur above in yellow, red, and purple, impure limestone. These fossils weather out on the slopes up to 20 feet above the shale.

Branson's son, C. C. Branson, proposed (1937) the name "Sacajawea Formation" for about two feet to 11 feet of sandstone, shale, and breccia overlain by 43 feet of limestone, bearing in its lower part a Ste. Genevieve fauna. This assemblage lies disconformably on the Madison Limestone in the Bull Lake region where E. B. Branson had examined these beds. Above the Sacajawea Formation C. C. Branson noted 21 feet of non-fossiliferous, laminated limestone in irregular contact with the beds below. A buff to reddish sandstone unconformably overlies the laminated limestones. C. C. Branson based the naming of the Sacajawea Formation on a faunal assemblage typified by _Spirifer welleri_, a small brachiopod not found in Madison beds or in higher Amsden beds. He did not include the laminated limestones in the Sacajawea Formation, due to the apparent lack of fossils. However, he also gave these beds a possible Chesterian age. He located the base of the Amsden Formation at the unconformity between the laminated limestones and the overlying sandstone.

E. B. Branson and C. C. Branson (1941) re-examined the Madison-Amsden section at Bull Lake Creek. Elsewhere in the Wind River Mountains they described the Sacajawea Formation as red shale overlain by cherty limestone. At Bull Lake Creek they observed that the red shale was replaced by a red and yellow-brown sandstone breccia. They mention abundant fauna in the limonitic and hematitic upper part of the red shale. They also state that the only significant fauna of these beds occurs in the Wind River Mountains. They again note that 60 feet of laminated limestone without fossils lies in irregular contact on the Sacajawea Formation, and that these beds are overlain disconformably by sandstone above. E. B. Branson concurred with his son that these laminated limestones might constitute still another formation, possibly of Chesterian age.

C. I. Biggs (1951), after visiting the Bull Lake and Cherry Creek areas, concludes that E. B. Branson in 1918 mistakenly collected fossils from the Madison Limestone at Bull Lake Creek instead of from the Amsden Formation. He also notes that Branson's Cherry Creek fossils must have come from slope wash since the Amsden Formation is poorly exposed. He grants the possibility that the fossils are of lower Amsden age. Biggs concludes that Branson's Bull Lake fossils can not be used to date the Amsden Formation and, in particular, give to its lower part a Mississippian age. Biggs also concludes that there are not beds that justly warrant the name Sacajawea Formation. He appears to include everything in the Madison Group from the solution breccia-cave-like zone at the base of C. C. Branson's Sacajawea Formation, up through the laminated limestones to the disconformable contact with the overlying sandstone. The latter he correlates with the basal Darwin Sandstone of the Amsden Formation further north. Biggs states that the Darwin Sandstone thins southeastward to a thickness of about 15 feet near Lander.

D. J. Love (1954), after examination of the Amsden Formation in the Wind River Mountains, concludes that all beds below the Amsden and above the Madison warrant the name Sacajawea. He extends the Sacajawea Formation upward to include the laminated limestones. Correspondence between Love (1962) and the author indicates that Love favors the possibility of interpreting the shaly facies as the Darwin Sandstone at Cherry Creek.

A. B. Shaw (1955) describes the Amsden Formation at Cherry Creek as about 20 feet of soft, white and pink, fine-grained, slope forming sandstone topped by 60 feet of sandy siltstone, a few thick limestone beds, and red, conglomeratic claystone. This sequence is underlain by about 20 feet of hard, thin-bedded limestone, covered at the base, and overlying the massive bedded, cliff forming, typical Madison Limestone. Shaw notes a disconformity between the sandstone and the thin bedded limestone below. He places all beds below the sandstone in the Madison Group. In his summary of problems of the Amsden Formation he points out that C. A. Burke (1954) found a fauna at South Pass near the southern end of the range similar to Branson's Cherry Creek fauna. Shaw states that extension of this faunal zone from Cherry Creek to South Pass shows that the Cherry Creek situation is not unique.

It was earlier noted that the lowest faunal zone of the Amsden, the Spirifer welleri zone and the middle faunal zone of the Amsden, the Spirifer opimus zone, are much closer together at Cherry Creek than at Bull Lake and other areas farther north in the Wind River Mountains. The thinner stratigraphic interval between these two zones at South Pass also, suggested to Shaw that the Darwin Sandstone, which occurs between the two, is generally lacking in the southern end of the Wind River Mountains. He believes that correlation of any sandy Amsden units in this area with the Darwin Sandstone is incorrect. He suggests an offlap of Chesterian seas to the north, accompanied by erosion, as a cause of Darwin Sandstone absence. As evidence he notes the general absence of Chesterian strata in this area. If this is the case, according to Shaw the Darwin Sandstone would be Mississippian, and the base of the Amsden would thus not be the base of Pennsylvanian strata.

The Wyoming Geological Association, (1956), mentions the strata at the base of the Amsden Formation.

> " The erosional edge of the thick Brazer Limestone of Meramecian and Chesterian age in western Wyoming has been recognized by paleontological evidence in the Wind River Mountains."

These sediments were named Sacajawea by Branson, but the Association includes them in the Madison Group, since they, thus far, have not been found to be distinct from the Madison Limestone and do not form a mappable unit in the Wind River Range. The Association further states that if these sediments should eventually be found to be lithologically distinct from the Madison Limestone and easily recognized, the term Brazer would apply , having precedence over Sacajawea.

J. W. Strickland (1956) feels that the term Brazer should be restricted to strata of Meramecian age in western Wyoming, Utah, and Idaho. Rocks of Chesterian age in these areas should be separated from the Brazer Formation. According to Strickland (1956), in western Wyoming, the name Sacajawea should apply to all strata below the Darwin Sandstone and above the top of the Madison Group. Strickland (1956) further states that the Sacajawea Formation is present only in western Wyoming where it generally consists of an upper sequence of thin-bedded, generally unfossiliferous limestone and dolomite and a lower unit of red shale and siltstone. He notes that the formation varies in thickness from a few inches to 90 feet. It is highly variable in lithology and often contains thin streaks of red and grey-green platy mudstones, or, it may consist of only red shale and siltstone. The formation rests unconformably on the Madison Group and is unconformably overlain by the Darwin Sandstone. Strickland correlates the Sacajawea Formation with the Big Snowy Group of Montana. Strickland agrees with Shaw that the Darwin Sandstone is absent at Cherry Creek, and he notes that a Darwin zone, depicted by conglomerate 68 feet to 73 feet above the top of the Madison, at Cherry Creek, marks the base of the Amsden Formation. Strickland believes the Chesterian fauna at Cherry Creek is from an isolated remnant of the Sacajawea Formation.

In summary, the Amsden-Madison problem is one of deciding where the boundaries between these two formations lie. If the Amsden Formation is to contain no beds older than Morrowan, then beds with Chesterian fauna must be placed elsewhere. If the Madison Group contains fauna no younger than Osagean in western Wyoming, as is held by the Wyoming Geological Association, then it cannot contain Chesterian beds. If the Darwin Sandstone is Mississippian then Chesterian strata may be included in the Amsden Formation. It is still an assumption that the Amsden Formation contains beds no older than Morrowan, since this is based on an unconformity existing between the Amsden Formation and the Madison Group and the lack of evidence to the contrary. Thus one must choose, apparently, between the terms Brazer and Sacajawea for these controversial sediments.

Shaw (1955) believes that the ultimate solution to the problem is at the type section for the Amsden Formation (Darton, 1904) at Amsden Creek in the Bighorn Mountains of northwest Wyoming. However, the present investigator believed, after a review of the problem, that the answer is to be found in a more comprehensive study of the controversial areas along the southeast flank of the Wind River Range.

E. Field Work and Laboratory Procedures

By artificially exposing the beds immediately overlying the Madison Group in the controversial areas mentioned above, so that their lithologies and contacts with underlying and overlying units could be studied in detail, the author would be able to compile a series of more accurately described sections than were previously known from the interval.

The author realized when he undertook this study that his field work would present two major problems, both stemming from the fact that the Amsden Formation is so poorly exposed in the southern portion of the Wind River Range. The first of these problems is locating oneself in the stratigraphic section in order to pick the proper outcrop. The second problem was to obtain good exposures of the beds in question.

There are no cliffs in the interval between the top of the Madison Limestone cliff and the base of the sandstone-dolomite sequence which marks the transition zone from upper Amsden to Tensleep. This interval is mainly a shale slope and is easily located. It contains occasional limestone and sandstone beds which protrude as small outcrops, and care must be taken in determining the correct top of the Madison Limestone.

Weathered shale and debris from the Tensleep almost completely obscure the beds above the Madison Group. These beds were excavated by means of pick and shovel from lower to upper contact. Bedding strike was obtained by means of the Brunton compass. The beds were excavated along strike so that thickness might be measured directly. Samples were obtained from each lithology and at two foot intervals over each section. All features were noted as carefully as possible, considering the limited exposures. Photographs of each section and of the terrain surrounding the sections were taken to complete the record.

Laboratory analyses, which would aid in correlation of the sections described with those of other workers, include grain size analysis, heavy mineral separation, and thin section study.

Sandstones from the North Fork, Sink's Canyon, Crooked Creek, and Canyon Creek sections were analyzed for grain size frequency, heavy mineral content, and individual grain characteristics. Samples from the top, middle and bottom of each section were disaggregated by bucking. Each sample was then sieved for a period of 16 minutes by means of a Ro-Tap machine. The following Wentworth sieve sizes were used; 0.495 mm., 0.246 mm., 0.124 mm., and 0.061 mm..

In graphing the results of the sieve analysis and in calculating the modal distribution of the sand grain sizes phi values of the sand grain sizes were used rather than the sizes themselves. Phi values are the negative logarithms to the base 2 of Wentworth grade scales. These values have equal intervals: log Φ 0.5 equals 1Φ, log Φ 0.25 equals 2Φ, etc. These values permit the use of ordinary arithmetic graph paper in plotting weight versus grain size phi values without distorting the true grain size frequency picture. On such graph paper a well-sorted sand would be indicated by a smooth s-shaped cumulative curve. The first and third quartiles, median, skewness and kurtosis phi values were calculated from the cumulative curves, the relative, rather than the absolute, values being of use for section comparison.

The following equations give the phi values for skewness and kurtosis.

$$Sk = \frac{Q_1 + Q_3}{2} - Md; \qquad K = \frac{Q_3 - Q_1}{2(P_{90} - P_{10})}$$

where Sk is the skewness, Q_1 and Q_3 the first and third quartiles, Md the median, K the kurtosis, and P_{10} and P_{90} the 90 and 10 percentiles. For further information on these values the reader is referred to Krumbein and Pettijohn (1938, p. 232-239).

The cumulative curves were plotted on a single sheet of arithmetic graph paper for shape comparison.

All sizes from each sample were later examined with a binocular microscope to determine individual grain shapes and surface characteristics.

Heavy mineral separations were made with the heavy liquid bromoform. The heavy liquid was poured into a funnel with a clamped rubber tube at its lower end leading to another funnel containing a filter paper with a beaker beneath for collecting the heavy liquid. Twelve such setups were assembled to permit all sizes from each sample from one section to be treated simultaneously. The individual size fractions were then poured into their respective funnels of heavy liquid and stirred about 10 times over a period of about 18 hours. The heavy liquid and heavy minerals were then drawn off. The less dense sand on top was discarded. The heavy minerals were washed clean with benzene and examined and identified by means of the petrographic microscope.

In addition to the heavy mineral study of the sandstones, several thin sections were made of samples taken from different stratigraphic positions in the sections at Crooked Creek and Canyon Creek. Carbonates from Sink's Canyon, Little Popo Agie River, and Cherry Creek were also studied by means of selected thin sections. A total of 34 thin sections were prepared.

F. Acknowledgements

The author expresses thanks to Professor R. R. Kennedy, Dr. A. C. Spreng, and Dr. P. D. Proctor of the Geology Department, Missouri School of Mines and Metallurgy, for suggestions and helpful criticisms concerning the thesis. Acknowledgement is also given for use of facilities of the Geology Department. Appreciation is expressed for the encouragement and suggestions by Dr. D. J. Love of the United States Geological Survey, Laramie, Wyoming, concerning field work. The author is grateful to Mr. Thomas Wakefield of Lander, Wyoming, who supplied a horse for the author's transportation. Appreciation is given to my wife, Judith Lee, for her able assistance and encouragement.

II. STRATIGRAPHY, SEDIMENTARY PETROLOGY AND PETROGRAPHY, AGE, AND CORRELATION OF MEASURED SECTIONS

A. North Fork, Popo Agie River

The North Fork measured section is located on the north side of North Fork Creek (Fig. 1). Outcrops of massive weathering, cross-bedded, pink to light brown sandstone stretch for several hundred yards up the dip slope along the north bank of the creek from the point where the massive-bedded, cherty,medium grey Madison Limestone dips beneath the surface.

The sandstone rests disconformably on an eroded Madison surface. Lowermost sandstone beds appear quite limey and contain granules of Madison Limestone. Many small caves up to six feet high, 15 feet deep, and 20 feet wide are weathered into the lowest sandstone bed, the floor of the caves being the Madison Limestone. A red shale conformably overlies the sandstone.

Thickness of the sandstone unit varies from 60 feet to 70 feet. The lower 30 feet contain strong deltaic cross-beds in sets up to four feet thick. The beds thin upward, and cross-bedding also disappears upward.

Laboratory examination of samples from the sandstone indicates a gradation from fine-grained to very fine-grained from the base upward to the top of the measured section. Roundness is most pronounced in the largest (greater than 0.246 mm.) size. Generally the sands are sub-angular to sub-rounded. Overgrowths are abundant throughout. Frosting is light, many grains being clear and colorless or having a light-yellow limonitic stain. White powdery calcite serves as cement throughout the section. The sands are generally quite friable, and are well-sorted (Table 1).

Heavy minerals in order of abundance are tourmaline, leucoxene (?), and zircon. These are concentrated mainly in the 0.061 mm. to 0.246 mm. sizes.

C. I. Biggs (1951) and others correlate this sandstone with the Darwin Sandstone Member of the Amsden Formation. The author concurs with this correlation (Fig. 2).

B. Sink's Canyon, Middle Popo Agie River

The Sink's Canyon measured section is located on the northwest wall of Sink's Canyon about one-half mile northeast (down canyon) from the Shoshone National Forest boundary fence (Fig. 1). In this area the red shale slope of the Amsden Formation commences, rising above the Madison cliff (Plate 2). Some limited exposures of beds immediately overlying the Madison cliff are found here.

Thin-bedded, slabby, laminated, grey-tan, cherty, slope forming dolomite lies disconformably on a slightly channeled Madison surface (Plate 5). The dolomite appears to grade upward to a tan, calcareous, thin-to lamellar-bedded, fissile shale. This shale was exposed in a four foot deep trench (Plate 6) dug into the slope above the dolomite.

About 30 feet above the top of the dolomite a limestone outcrop, approximately 40 feet in lateral extent and about 20 feet in thickness (Plate 2), protrudes from the shale slope. Overlying it, paraconformably, is a 48 foot thick sequence of red, cross-bedded, massive weathering sandstone (Plate 4) of the same outcrop width. Red shale overlies this sandstone.

The true thickness of the shale overlying the dolomite is not known. The massive-bedded, grey limestone outcrop grades downward into thinner-bedded light-grey carbonates which resemble the dolomite beds overlying the Madison Limestone. Shale debris from above covers the base of these thinner beds.

Thin section study of the beds immediately overlying the Madison reveals a porous, fine-grained dolomite. About 95% of the material is tiny dolomite rhombs, and 5% is organic matter and limonite. Possible brachiopod shell cross-sections are present as randomly oriented, arc-shaped areas filled with platy dolomite or calcite.

Numerous microscopic structures of almost perfect circular cross-section occur in the lower three feet of the beds (Plate 30). These spirules average about 90 microns in diameter. Many of them have a circular central area surrounded by a concentric outer ring. Both center and outer ring may be filled with dolomite crystal fragments, or one or the other or both may be partially or wholly unfilled with only a thin ring of fine dolomite crystals separating inner from outer component.

Occasionally the central area is displaced toward one side of the outer ring. Under crossed nicols the filled centers show varied extinction while in most cases a dark cross, parallel to the upper and lower nicol vibration directions, forms in the outer ring, its center at the center of the spirule. The cross indicates a unit crystal of dolomite in the outer ring which has been broken. Spirule distribution in the thin section is random. No bedding planes appear in the thin section. Above the three foot level in the measured section spirules and other structures of possible fossil origin disappear, leaving only a porous, fine-grained dolomite. These spirules may possibly be fossil plant spores. They may be inorganic oolitic structures, however. The latter possibility is favored by J. W. Koenig (1962) Personal Communication), Missouri Geological Survey.

A thin fossiliferous zone at about the three foot level in the section was discovered by the author. Molds and casts of a single small brachiopod species and a single small pelecypod species were numerous. No internal features were preserved. By external shape the pelecypod was tentatively identified by the author as Gramatodon politus Girty (H. Chronic, 1952). Dr. A. C. Spreng, Missouri School of Mines and Metallurgy, and G. Fraunfelter, University of Missouri, tentatively identified the brachiopod as Spiriferina browni Branson on basis of external shape, number of costae, cardinal area characteristics, and possible puncta. E. B. Branson (1918) describes this brachiopod from the Sacajawea Formation at Bull Lake Creek. A. B. Shaw (1955) describes the same species from the Amsden Formation at Cherry Creek. It is not listed under Madison Group fauna, in so far as the author can determine.

The author correlates the thin-bedded dolomite overlying the Madison Group in Sink's Canyon with the thin-bedded, laminated carbonates overlying C. C. Branson's faunally defined Sacajawea Formation at Bull Lake Creek (Fig. 2).

Laboratory analysis of the upper red sandstone in Sink's Canyon indicates a well-sorted sand, cemented by hematite and calcite (Table 41).

Heavy minerals in order of abundance are tourmaline, topaz, detrital calcite, and muscovite. They are concentrated mainly in the 0.061 mm. to 0.246 mm. grain sizes.

The author would locate this sand stratigraphically in the upper portion of the Amsden Formation.

C. Crooked Creek

The Crooked Creek measured section is located on the northwest bank of Crooked Creek, 100 yards west of the corner of the Shoshone National Forest boundary fence (Fig. 1).

A broad dip slope is formed by the Madison Limestone in this area. For a distance of 100 yards east and west of the fence are found scattered outcrops of brown,

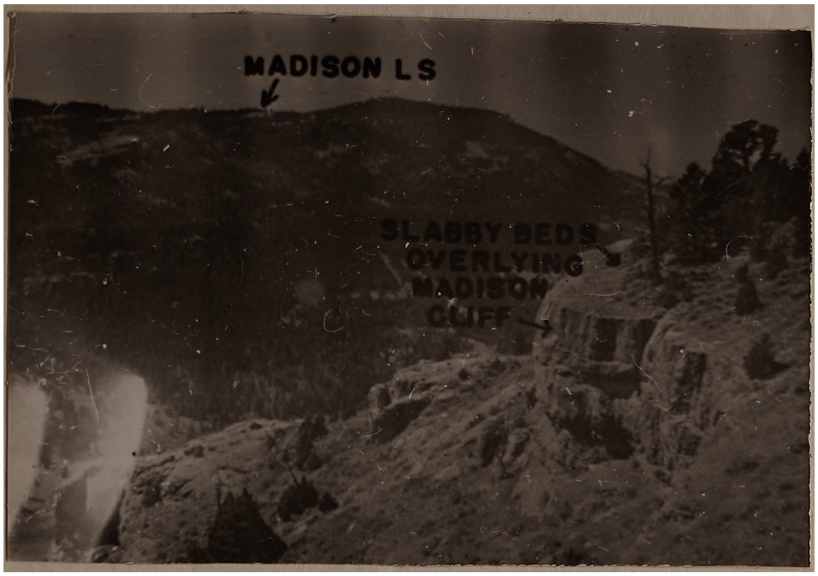


Plate 1
Facing Southwest.
Madison Limestone Cliff at Sink's Canyon.
SE ¼ Sec. 18, T32N, R 100 W.

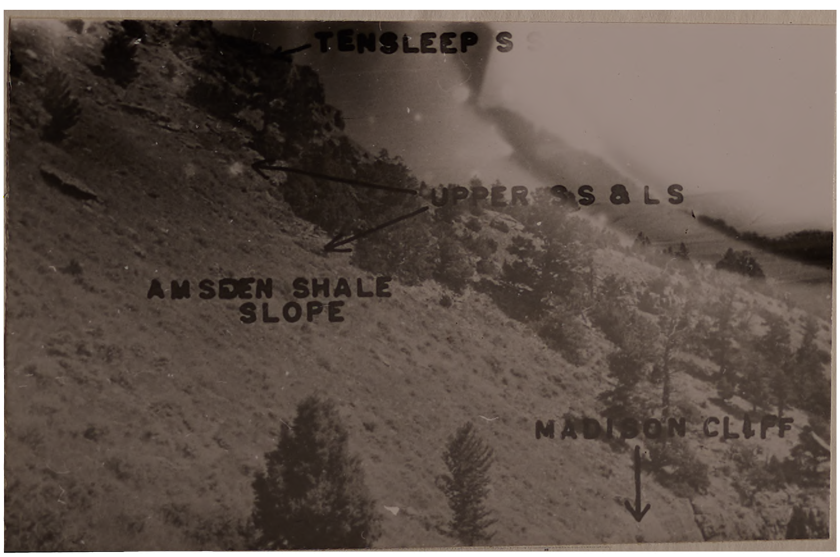


Plate 2
Facing Northeast.
Shale Slope of the Amsden Formation at Sink's Canyon.
SE ¼ Sec. 18, T32N, R. 100 W.

Plate 3
Facing Northwest.
Trench exposing dolomite beds overlying Madison Limestone Cliff at Sink's Canyon.
SE $\frac{1}{4}$ Sec. 18, T32N, R 100 W.

Plate 4
Facing Northwest.
Upper red sandstone of the Amsden Formation at Sink's Canyon.
SE $\frac{1}{4}$ Sec. 18, T32N, R 100 W.

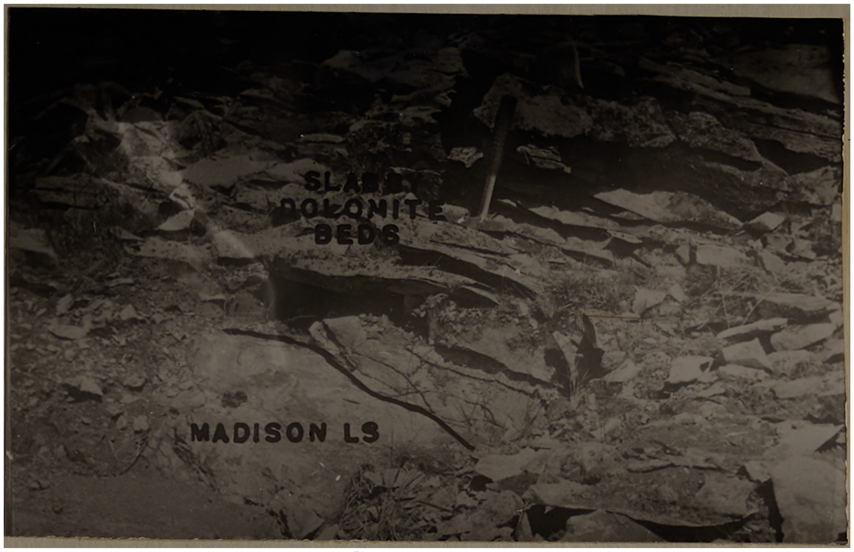


Plate 5
Facing West.
Contact between slabby dolomite beds and Madison Limestone below at Sink's Canyon.
SE ¼ Sec. 18, T32N, R 100 W.

Plate 6 Facing Northwest.
Excavation at top of dolomite section at Sink's Canyon.

Plate 7
Close up of shale exposed in excavation at Sink's Canyon.

SE ¼ Sec. 18, T32N, R 100 W.

thin-to-medium-bedded sandstone (Plate 9). The top of the Madison Limestone dips below the surface in this area. The sandstone outcrops lie very near the highest elevation on the dip slope close to the fence. A veneer of soil and red shale from two feet to ten feet in thickness overlies the sandstone.

A disconformity between the Madison Limestone and the sandstone is indicated by a sandy conglomerate containing granules of Madison Limestone and varying in thickness from two inches to six inches. In addition, there appears to be a solution-breccia zone from two feet to four feet in thickness below the conglomerate. This zone contains two inch to six inch angular blocks of Madison Limestone cemented by brown sandstone, white, powdery limestone, and chert. Contact between the sandstone and the overlying shale is conformable with gradation from brown sandstone through yellow-brown, shaly, platy sandstone, and red, clayey shale.

Laboratory examination of the sandstone shows that it is generally fine-grained throughout. Grain shape varies from sub-angular to sub-rounded, the smaller grains being the more angular. Light frosting occurs on most grains, and overgrowths are abundant. Grain color varies from colorless to light-yellow, due to limonitic staining. Sands from the Crooked Creek section are well sorted (Table 1).

Plate 8
Facing Southwest.
Brown sandstone overlying Madison Limestone at Crooked Creek. Dip slope of Madison Limestone in background.
NE¼ Sec. 32, T32N, R 100 W.

Plate 9
Facing Northeast.
Lowermost laminated sandstone beds overlying conglomerate and breccia zone at Crooked Creek.
NE¼ Sec. 32, T32N, R 100 W.

Plate 10
Facing Northwest.
Upper half of measured section of sandstone at Crooked Creek.
NE$\frac{1}{4}$ Sec. 32, T32N, R 100 W.

Plate 11
Facing North.
Lenticular-bedded sandstone near base of section at Crooked Creek.
NE$\frac{1}{4}$ Sec. 32, T32N, R 100 W.

Heavy minerals in order of abundance are tourmaline, leucoxene (?), and zircon. They are concentrated mainly in the 0.061 mm. to 0.246 mm. sizes. Thin sections show approximately the following constituents for these sands; quartz grains 80%, fibrous calcite cement 10%, limonite and heavy minerals 10%.

The author correlates the sandstone at Crooked Creek with the Darwin Sandstone.

D. Canyon Creek

The Canyon Creek measured section is located several hundred yards west of Tige Alder Draw, a tributary flowing south into Canyon Creek (Fig. 1).

In the general area of the section the Madison Limestone rises in steep cliffs above Canyon Creek. The red shale slope of the Amsden Formation stretches from the top of the Madison cliff up to the white bluffs of Tensleep Sandstone.

Disconformably overlying the Madison Limestone is a sandstone unit which crops out for 200 yards to either side of the measured section. There are three outcropping ledges in this sandstone, located at the base, midway up the section, and at the top (Plate 12).

Shale conformably overlies the sandstone. One mile up the canyon from the measured section about 100 feet above the top of the Madison Limestone cliff there is an outcrop of massive-bedded, medium-grey limestone overlain by pink to red sandstone. The outcrop width is about 40 feet. Three feet of the limestone and five feet of the sandstone are exposed. Except for thickness this outcrop is similar both in lithology and stratigraphic position to the upper limestone and sandstone outcrop mentioned in Sink's Canyon.

Laboratory examination of the Canyon Creek sandstone shows a gradation from medium-to fine-grained at the base to fine-to very fine-grained in the middle and upward to the top of the measured section.

The majority of grains are sub-angular to sub-rounded, angularity increasing with decreasing size. Grains are colorless to light-yellow, due to limonitic staining, and are generally lightly frosted. Overgrowth are abundant throughout. These sands are well-sorted throughout (Table 1). Heavy minerals in order of abundance are tourmaline, leucoxene (?), and zircon. They are concentrated in the 0.061 mm. to 0.246 mm. sizes.

Thin sections indicate a calcite cement decreasing in quantity from the base upward. The more shaly beds have a matrix of very minute quartz particles and limonite cementing larger quartz grains. Laminations are indicated by layers of large quartz grains alternating with layers of smaller grains. There is no rhythmic pattern to the width or contents of these layers.

The author correlates the Canyon creek sandstone overlying the Madison Limestone with the Darwin Sand-

Plate 12
Facing Northwest.
Tan sandstone overlying Madison Limestone at Canyon Creek. One half-mile west of Sec. 13, T31N, R 100 W.

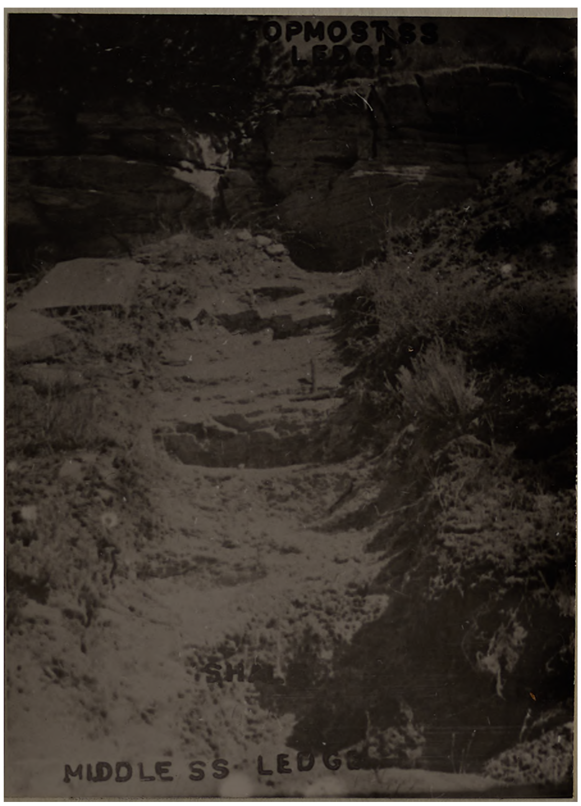


Plate 13 Facing N 25 E Plate 14
Excavated portions of sandstone section at Canyon Creek. One half-mile west of Sec. 13, T 31 N, R 100 W.

Plate 15
Facing Northeast.
Layer of coarse sand overlying basal conglomerate at Canyon Creek.
One half-mile west of Sec.13, T31N, R100W.

Plate 16
Facing Northeast.
Contact between sandstone and underlying Madison Limestone at Canyon Creek.
One half-mile west of Sec.13, T31N, R100W.

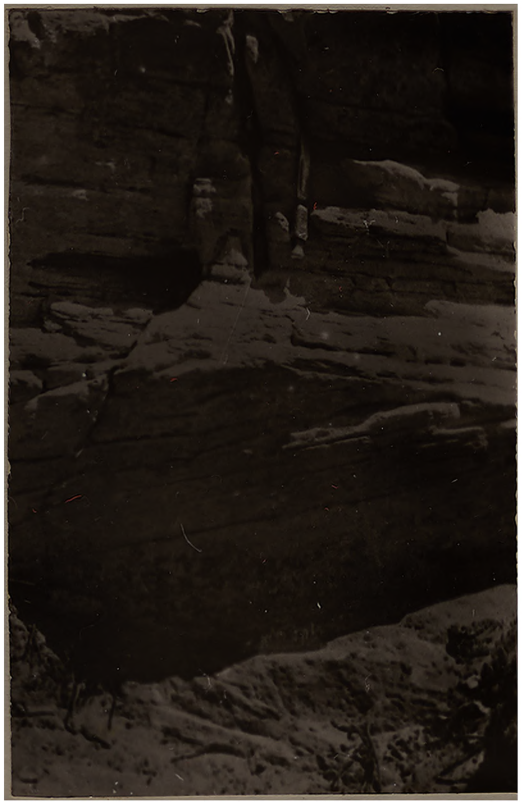


Plate 17
Facing N 25 E.
Cross-bedding in uppermost sandstone ledge of measured section at Canyon Creek.

Plate 18
Facing N 25 E.
Thin-bedded sandstone beneath top ledge of measured section at Canyon Creek.

One half-mile west of Sec.13, T31N, R100W.

stone Member of the Amsden Formation.

E. Little Popo Agie River

The Little Popo Agie River measured section lies on the south side of the canyon through which the Little Popo Agie River flows, about one-half mile east of the Shoshone National Forest boundary fence (Fig. 1).

The Madison Limestone forms vertical cliffs along this canyon (Plate 19) which are topped by a steep slope ending at the Tensleep Sandstone cliffs. This slope is thickly vegetated with pines and brush. Much debris from formations above, in addition to the vegetation, completely obscures the geology from a few feet above the Madison Limestone to the Tensleep cliffs.

Occasionally along the top of the Madison Limestone cliff outcrops of slabby, thin-bedded, laminated dolomite, varying in color from light-yellow to reddish-tan, rest disconformably on an eroded Madison surface (Plate 20). In some localities on this surface deep holes occur in the Madison Limestone. These are filled with a breccia of Madison Limestone cobbles, chert, and material similar to the thin, slabby beds above. The overlying beds sag slightly into these holes (Plate 23).

A trench dug at the top of the thin slabby beds showed that they are overlain by red shale. A gradational zone exists, but the topmost beds are distorted and broken up by roots, and as a result the gradational relationship is indistinct (Plates 21 and 22).

Many scattered, banded chert lenses up to six inches in thickness and three feet in length occur in the dolomite beds. They have planar structures parallel to the bedding planes of the dolomite.

Thin sections of the beds of the measured section at the Little Popo Agie River reveal a fine-grained, porous dolomite with wavy bedding traces. Long needle-like fractures filled with clear platy calcite extend up from the bottom of the lowermost bed. These may be a form of stylolite resulting from compaction and solution.

About two feet above the Madison contact spirules occur similar to those in Sink's Canyon. At this level quartz grains suddenly become abundant, filling pore spaces and spirules. This quartz often contains inclusions of tiny, well formed dolomite rhombs. The spirule centers may be dolomite surrounded by a quartz filled ring or vice-versa. Occasionally both ring and center are quartz filled, or one or the other may not have been filled with any material. Size of these spirules are concentrated along the bedding planes.

A few are-like shapes resembling brachiopod shells are present. Quartz rather than clear platy dolomite or calcite fills these shapes. Rarely, some relict bryozoan structures occur.

Plate 19
Facing Northeast.
Madison Limestone cliff forming canyon wall at Little Popo Agie River.
SW ¼ Sec. 14, T31N, R 99 W.

Plate 20
Facing North.
Slabby dolomite beds overlying Madison Limestone at Little Popo Agie River measured section location.
SW ¼ Sec. 14, T31N, R 99 W.

Plate 21
Facing North 80° East.
Trench at top of measured section of dolomite at Little Popo Agie River.
SW $\frac{1}{4}$ Sec.14, T31N, R 99 W.

Plate 22
Facing North 80° East.
Closeup of transition zone between dolomite and red shale exposed in trench at top of Little Popo Agie River section. SW $\frac{1}{4}$ Sec. 14, T31N, R 99 W.

Plate 23

Facing Southeast   Facing Southwest

Channels filled with breccia at top of Madison Limestone cliff near measured section at Little Popo Agie River.

SW $\frac{1}{4}$ Sec. 14, T31N, R 99 W.

Beds containing abundant spirules consist of about 80% dolomite and 20% quartz. The quartz disappears a few feet below the top of the section and above this point there are very few spirules.

The author correlates these dolomite beds with the dolomite beds in Sink's Canyon.

F. Cherry Creek

The measured section at Cherry Creek lies on the north side of the creek about one mile from the Shoshone National Forest boundary fence (Fig. 1). In this area the top of the Madison Limestone is well exposed. Cherry Creek, flowing down the regional dip, has cut through the Madison Limestone, leaving a V-shaped outcrop pattern, the apex of which is only a few hundred yards from the location of the Measured section (Plate 24).

Slabby, light-tan dolomite beds disconformably overlie the Madison Limestone in poorly exposed outcrops that extend only about 150 yards west of the measured section (Plate 26). The top of these slope forming beds lies at the highest point on the low hill where the outcrops occur. This top bed can be traced eastward across a draw where it dips beneath a slope of red, sandy, hematitic shale (Plate 27). The contact between shale and dolomite may or may not be conformable. A trench was dug into this shale slope above the top dolomite bed to determine the nature of the overlying material, however, too little of the contact was exposed to draw any conclusion. The shale appears to extend up to cherty, massive limestone beds overlain by massive weathering, cross-bedded, tan sandstone (Plate 25). Above this outcrop, 20-foot boulders of Tensleep Sandstone dot the slope, and bluffs of the Tensleep form the hill crest. The above sandstone outcrop appears to be the base of the Tensleep Sandstone in this area.

The dolomite beds are uniform in appearance throughout the section. They contain occasional chert lenses similar to, but less numerous than those in the Little Popo Agie River section.

A thin fossiliferous zone occurs five feet below the top of the section. Casts and molds of fossils similar to those found in Sink's Canyon are present. The single brachiopod species was identified as Spiriferina browni Branson, and the single pelecypod species as Gramatodon politus Girty.

Thin sections from these beds reveal a granular, porous dolomite consisting of small dolomite rhombs and much smaller fragments. The lowest beds are 100% dolomite. They contain numerous circular to oval spirules (Plate 30). These consist of a ring of very fine dolomite granules, the interior of which is filled with much larger, well-formed dolomite rhombs. Occasionally a small amount of reddish-brown material occurs amidst these larger rhombs. This may possibly be spore material.

Two feet above the base of the Cherry Creek Section quartz appears within pore spaces and spirules of the dolomite beds as in the Little Popo Agie River section. These spirules are concentrated along bedding planes. Organic streaks denoting bedding planes are displaced around the spirules. Shapes of the spirules vary from circular to oval to irregular and in size they vary from 90 microns to 250 microns (Plate 30).

Many randomly oriented, arc-shaped structures are present in the thin sections. In one case two such forms fit together, concave sides facing each other. These forms are probably brachiopod shell cross-sections.

Above six feet in the section quartz grains disappear. Above 17 feet the spirules are also absent and above this point thin sections show only a porous, fine-grained dolomite.

The author correlates these dolomite beds with those at Sink's Canyon and Little Popo Agie River.

G. Summary and Conclusions

The dolomite beds overlying the top massive beds of Madison Limestone at Sink's Canyon, Little Popo Agie River, and Cherry Creek, are similar in many respects. In each of these areas the stratigraphic position of these beds is the same. Each dolomite section disconformably overlies the Madison Limestone and, in turn, is overlain by red shale. The micro-spirules found in

Plate 24
Facing Southwest.
Madison Limestone dip slope in vicinity of Cherry Creek measured section location.
SW ¼ Sec. 19, T31N, R 99 W.

Plate 25
Facing Northeast.
Red shale slope of Amsden Formation topped by Tensleep Sandstone across gully northeast of Cherry Creek measured section.
SW ¼ Sec. 19, T31N, R 99 W.

Plate 26
Facing Northeast.
Basal slabby dolomite beds overlying Madison Limestone at Cherry Creek measured section location.
SW ¼ Sec. 19, T31N, R 99 W.

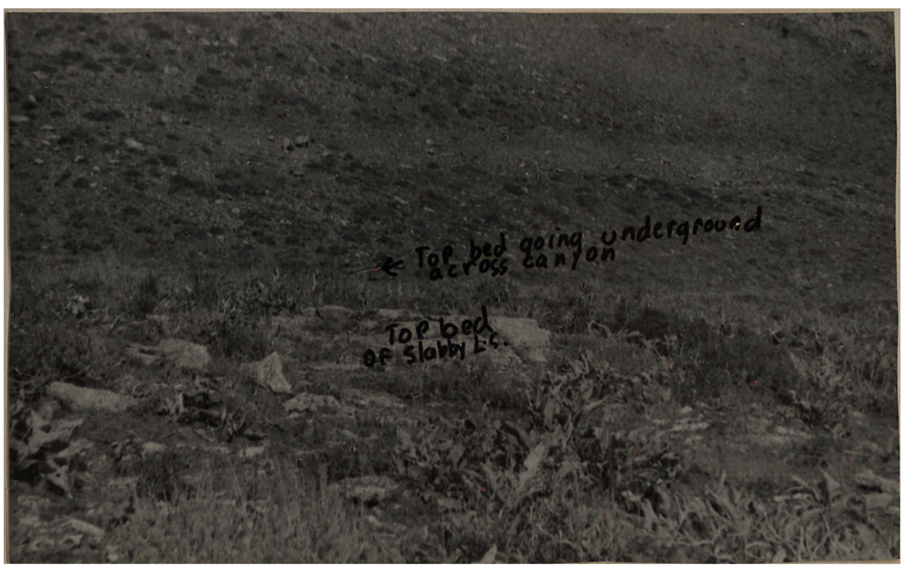


Plate 27
Facing Northeast.
Topmost dolomite bed of Cherry Creek measured section dipping under shale slope of Amsden Formation across gully to northeast of measured section.
SW ¼ Sec. 19, T31N, R 99 W.

Plate 28
Laminations in dolomite beds of Cherry Creek measured section.
SW ¼ Sec. 19, T31N, R 99 W.

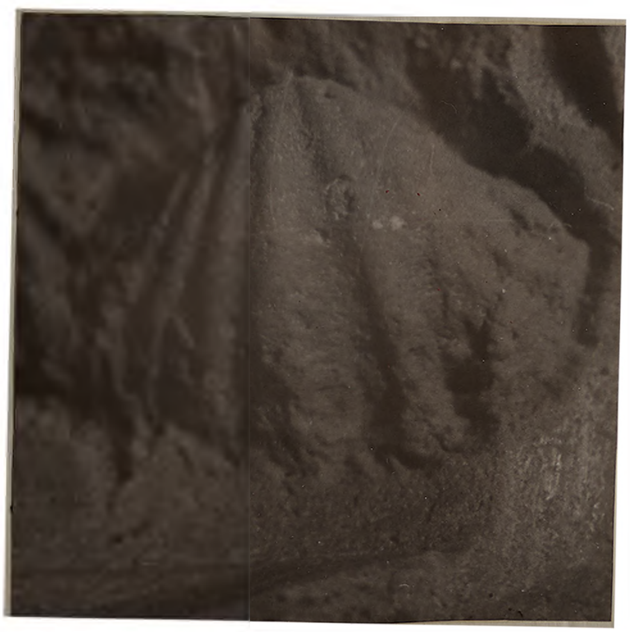


Plate 29
Fossil from Cherry Creek measured section identified as Spiriferina browni Branson.
6x

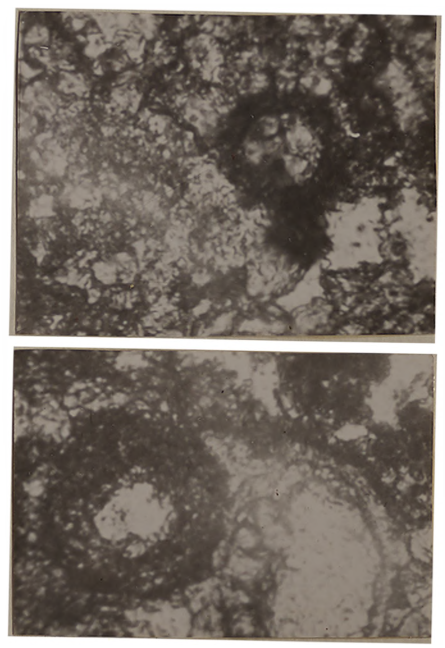


Plate 30
Micro-spirules characteristic of lower beds in Sink's Canyon, Little Popo Agie River, and Cherry Creek measured sections.
173x

all three sections indicate equivalence in age and a similar depositional environment. The lithology of each section is the same; a porous, crystalline dolomite in thin, laminated beds forming a slope above the Madison cliff. The presence of quartz in the dolomite sections at Cherry Creek and Little Popo Agie River and its absence in the Sink's Canyon section may indicate that the Sink's Canyon section was deposited further from shore than the other two sections. Fossils from the Sink's Canyon section are identical to those from the Cherry Creek section.

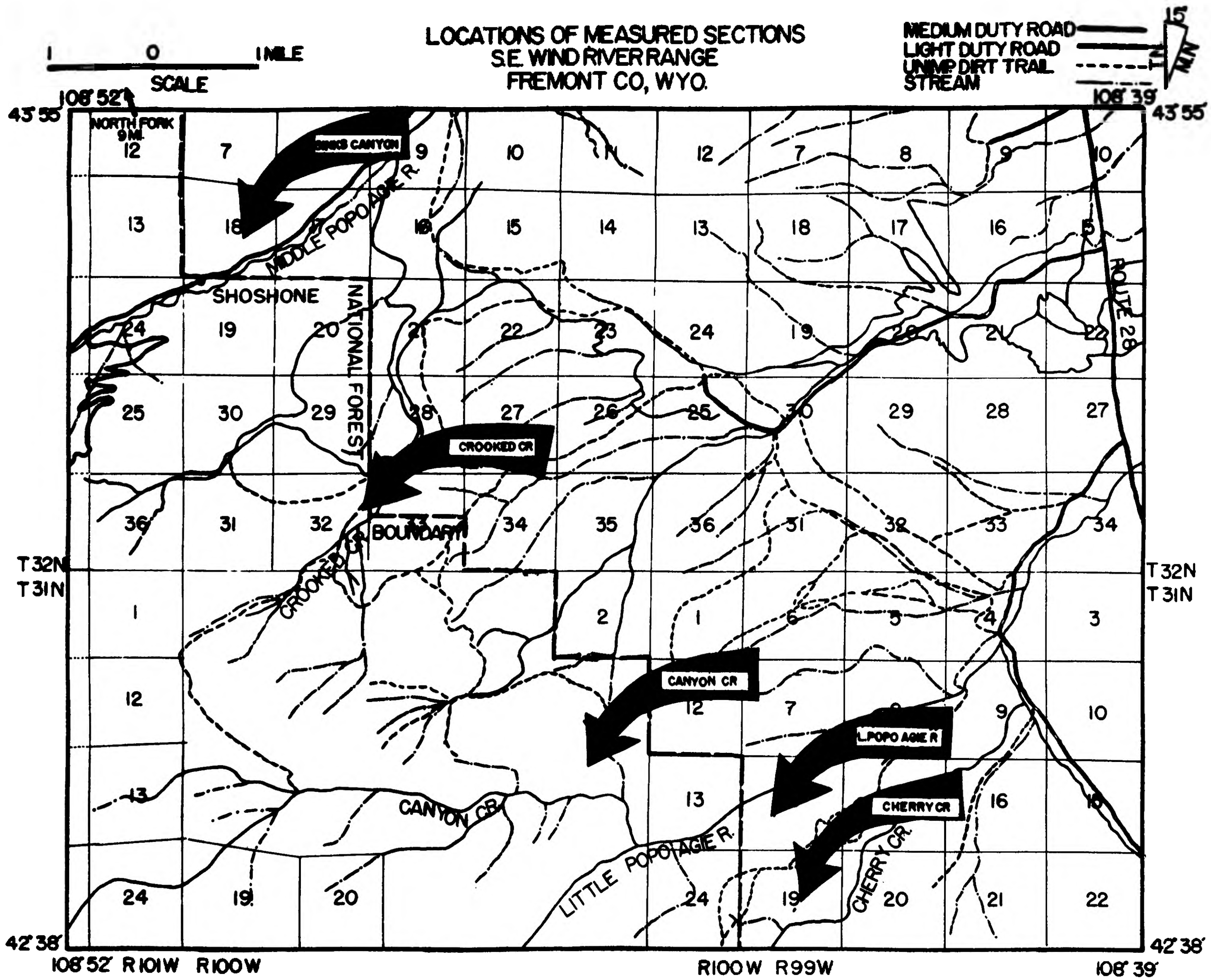
The above similarities show that the dolomite sections at Sink's Canyon, Little Popo Agie River and Cherry Creek should be correlated with each other.

The author correlates the dolomite sections at Sink's Canyon, Little Popo Agie River, and Cherry Creek with the laminated, thin-bedded limestones included in the Sacajawea Formation (D. J. Love, 1954) at Bull Lake Creek, the type area for the Sacajawea Formation (Fig. 2). The occurence of Spiriferina browni Branson both in the dolomite beds at Sink's Canyon and Cherry Creek and in the lower massive limestone beds of the Sacajawea Formation at Bull Lake Creek point to the above correlation. To the author's knowledge no fossils have been collected as yet from the upper thin laminated limestones of the Sacajawea Formation at Bull Lake Creek. This apparent lack of fossils was C. C. Branson's (1937) reason for excluding these beds from his faunally defined Sacajawea Formation. Discovery of Spiriferina browni Branson in equivalent beds by the author at Cherry Creek and Sink's Canyon lead him to conclude that these thin-bedded, laminated dolomites are of Chesterian age, as is the lower portion of the Sacajawea Formation at Bull Lake Creek.

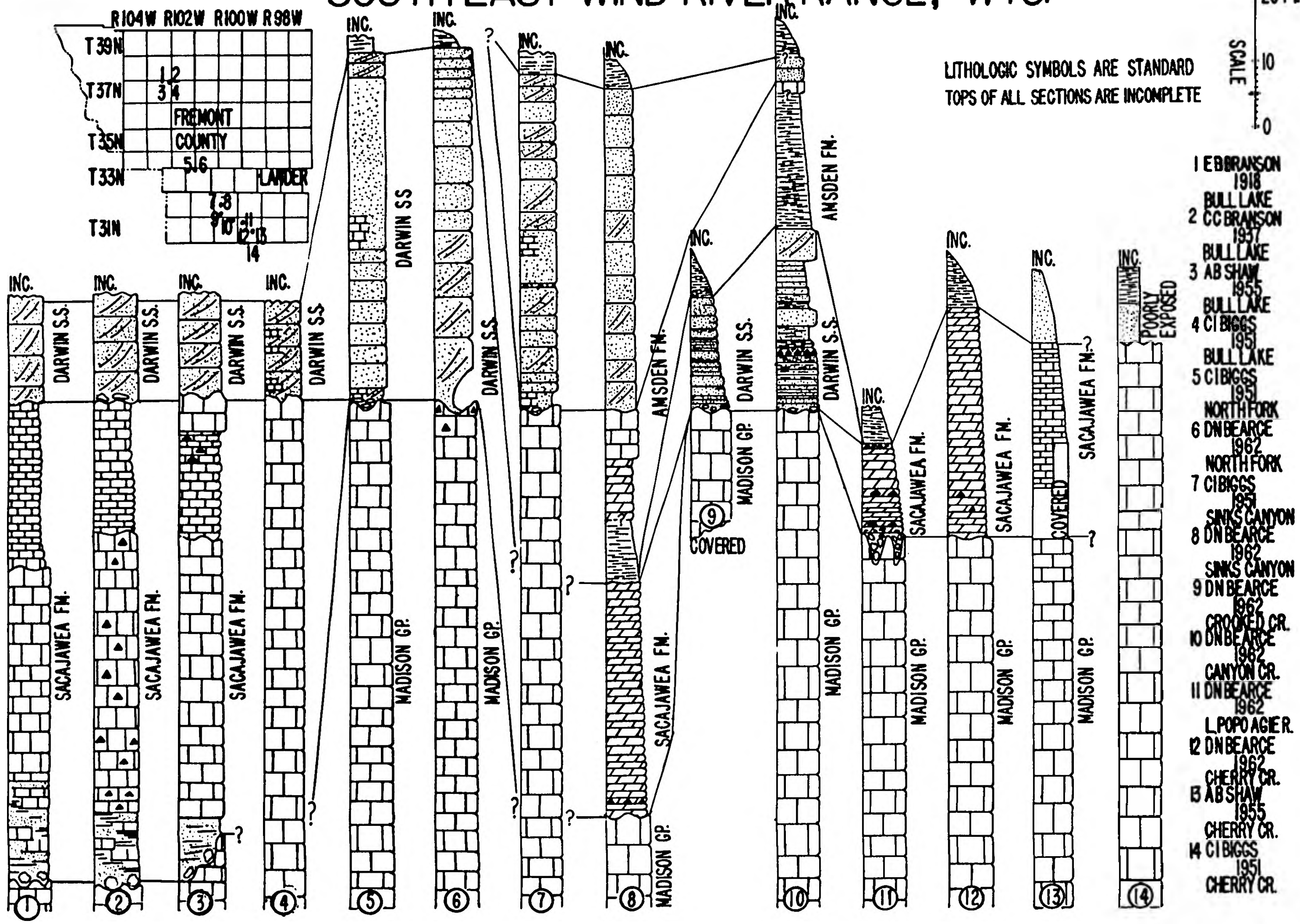
The Darwin Sandstone at North Fork, Popo Agie River is similar to the sandstones at Crooked Creek and Cherry Creek in the following respects. All three sandstones disconformably overlie the top of the Madison Limestone cliff, and are, in turn, overlain by red shale. All three have similar sorting and grain size characteristics and possess identical heavy mineral suites. The above similarities lead the author to correlate the sandstones at Canyon Creek and Crooked Creek with the Darwin Sandstone at North Fork.

The red sandstone occurring above the measured section of dolomite in Sink's Canyon possesses sorting and grain size characteristics similar to those of the sands at North Fork, Crooked Creek and Cherry Creek. The heavy mineral suite of the Sink's Canyon sand differs from the suites of the other three sands. Since the Sink's Canyon section lies between the North Fork and Crooked Creek sections, the difference in heavy mineral suites cannot be due to a variance in distance from a common source. While the Sink's Canyon sand overlies a massive-bedded limestone, this limestone is set well back from and well above the top of the Madison Limestone cliff. This, together with the fact that a shale zone lies between this sandstone and the Madison cliff top, and with the observation that a similar sandstone occurs above the Darwin Sandstone at Canyon Creek, leads the author to conclude that the Sink's Canyon sandstone is younger than the Darwin Sandstone. A. B. Shaw (1955) states that there are two sandstones in the Amsden Formation in the Wind River Range. The author contends that the Sink's Canyon sandstone is the upper of these two sandstones. These relationships are shown in Figure 2.

Field evidence indicates to the author that the Darwin Sandstone is missing at Sink's Canyon, Little Popo Agie River, and Cherry Creek. In these areas a red shale occurs in the interval occupied by the Darwin Sandstone at North Fork, Crooked Creek, and Canyon Creek. At Canyon Creek the Darwin Sandstone contains interbeds of shale. These observations lead the author to conclude that the Darwin Sandstone lenses out southeast of North Fork and intertongues with a red shale in the region from Sink's Canyon southeast to Cherry Creek.


LOCATIONS OF MEASURED SECTIONS
S.E. WIND RIVER RANGE
FREMONT CO, WYO.
1 0 1 MILE
SCALE
MEDIUM DUTY ROAD
LIGHT DUTY ROAD
UNIMP DIRT TRAIL
STREAM
15°
M.N.
108°52'
108°39'
43°55'
42°38'
NORTH FORK 9 MI.
SINKS CANYON
MIDDLE POPO AGIE R.
SHOSHONE
NATIONAL FOREST
BOUNDARY
CROOKED CR
CANYON CR
L.POPO AGIE R
CHERRY CR
CANYON CR.
LITTLE POPO AGIE R.
CHERRY CR.
ROUTE 28
T32N
T31N
R101W
R100W
R99W

CORRELATION OF MEASURED SECTIONS WITH OTHERS PREVIOUSLY DESCRIBED SOUTH EAST WIND RIVER RANGE, WYO.



PHI VALUE CUMULATIVE CURVES OF SANDSTONES
FROM FOUR AMSDEN FORMATION LOCALITIES
GRAIN SIZE VERSUS WEIGHT
SOUTHEAST WIND RIVER RANGE, FREMONT COUNTY, WYO.

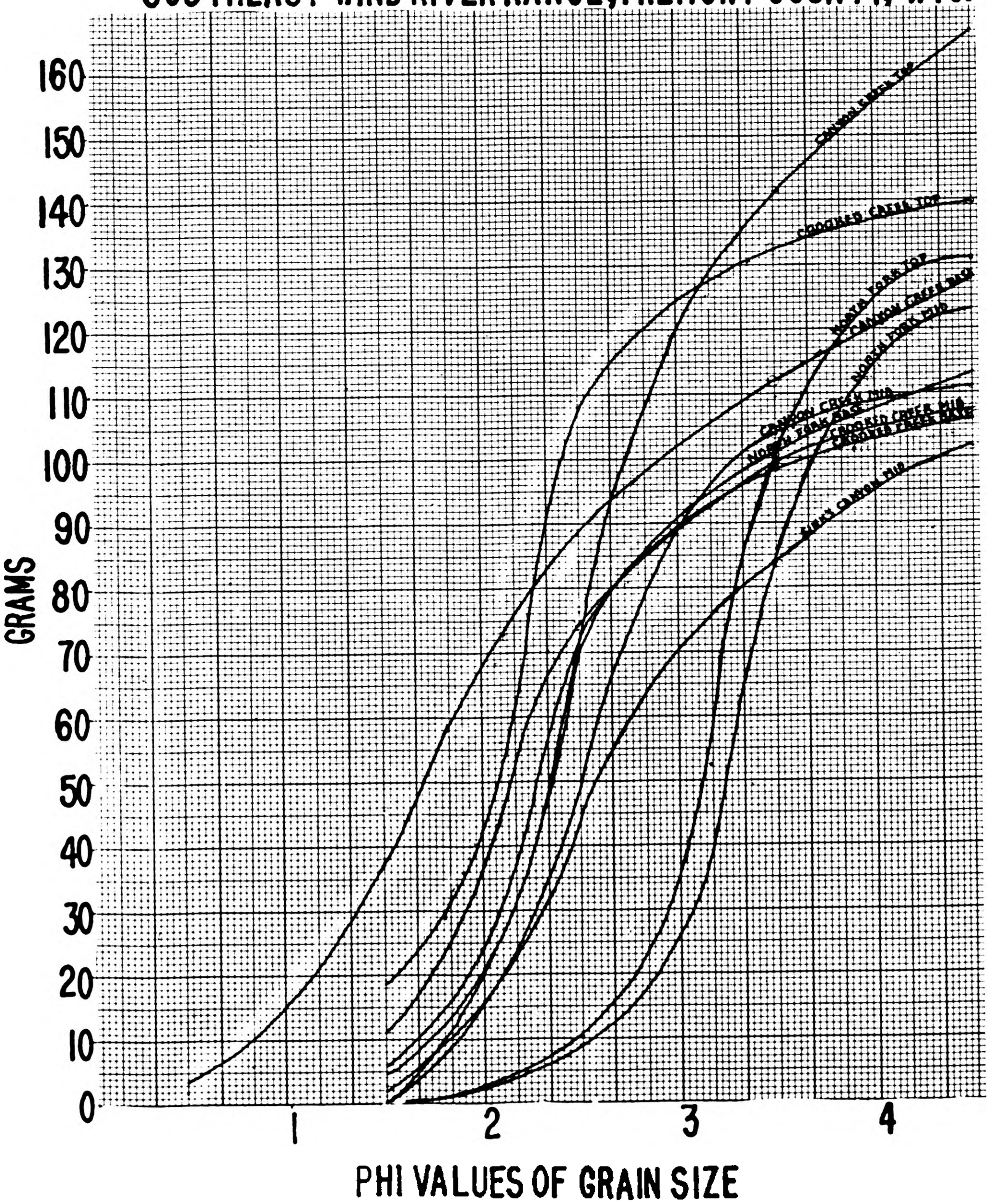


FIG. 3

SIEVE ANALYSIS RESULTS OF SANDSTONES FROM FOUR AMSDEN FORMATION LOCALITIES, SOUTHEAST WIND RIVER MOUNTAINS, WYOMING

Section Location	1st Quartile Φ value	3rd Quartile Φ value	Median Φ value	Skewness Φ value	Kurtosis Φ value
North Fork					
Top	3.03	3.50	3.34	.08	.20
Mid	3.00	3.45	3.33	- .11	.20
Base	2.04	2.79	2.38	.03	.29
Sink's Canyon					
Mid	2.20	3.13	2.62	.03	.23
Crooked Creek					
Top	1.88	2.48	2.19	-.01	.20
Mid	1.90	2.69	2.27	.02	.23
Base	1.73	2.60	2.20	-.04	.22
Canyon Creek					
Top	2.24	2.91	2.53	-.04	.20
Mid	2.24	2.99	2.50	.12	.29
Base	2.36	3.67	3.03	-.02	.30

TABLE I

III. A SUMMARY OF GEOLOGIC HISTORY

During Mississippian time Wyoming was a fairly stable shelf area, bordering the north-south trending Cordilleran Geosyncline to the west. Generally shallow seas covered the state through Meramecian time. The Madison Limestone was deposited in these seas from Kinderhookian through Meramecian time.

In post-Meramecian time a mild uplift commenced in Wyoming, causing the seas to retreat westward toward the miogeosyncline. The present Wind River Basin region was exposed to erosion. In certain localities deep channels were eroded in the Madison Limestone by torrential streams. These channels became filled with sand and shale mixed with blocks of Madison Limestone.

The sea advanced over the Wind River Basin region once again during Chesterian time. A series of massive limestone beds was deposited on an eroded Madison Limestone surface. As this sea advanced southeastward past the Bull Lake region deposition of thin-bedded, laminated dolomite commenced. As far northwest as Sink's Canyon these dolomite beds were laid down directly on the eroded Madison Limestone surface.

The sea reached as far south as South Pass in the present Wind River Range when uplift of the shelf commenced again. Non-marine sediments, carried from the south by streams, were deposited over the dolomite beds. As the sea retreated to the northwest local highs developed in the Wind River Mountains region. Erosion of these highs re-exposed the Madison Limestone in certain areas, such as the Crooked Creek-Canyon Creek region. To the northwest, beyond the reach of the streams depositing the non-marine red sediments an erosion surface was developed on the Chesterian carbonate beds. By early Pennsylvanian time erosion had breached Maramecian carbonate beds over most of Wyoming. Chesterian carbonate beds remained in the northwest corner of the Wind River Basin, the northern half of the Wind River Mountains and in certain localities in the southern portion of the Wind River Mountains, such as Sink's Canyon, Little Popo Agie River, and Cherry Creek. A karst topography was developed in the Madison Limestone over most of the rest of the state.

Deposition of Darwin Sandstone in Morrowan time was started by streams which at times were torrential. In channels cut by these streams, sometimes below the surface, blocks of Madison Limestone became cemented with red sandstone. The sands were supplied by either of two sources. To the west was a long, narrow, positive area with a Precambrian core, parallel to the Cordilleran Geosyncline. East of Wyoming lay a broad, northeast trending land mass crossing North and South Dakota and Nebraska (R. Agatston, 1957).

As Darwin time progressed a shallow sea engulfed Wyoming, which once again assumed the characteristics of a stable platform.

Non-marine sediments, still being supplied from the south, started to accumulate northward over the Darwin Sandstone. In the pinch-out region of the Darwin Sandstone in the southern portion of the Wind River Range, these red shales often mingled with the Darwin Sand, forming sequences of shale and sand beds, as at Canyon Creek.

By mid-Pennsylvanian time the sea had receded east from the Wind River Basin region. An uplift west of Wyoming started to supply sands for the Tensleep Formation. The sea withdrew progressively eastward, and by late Pennsylvanian time the Wind River Basin was a positive region.

From Permian to Jurassic time Wyoming remained a shelf area, repeatedly exposed and covered by shallow seas. At times these seas became restricted by barriers such as the Belt Island Uplift of west central Montana in mid-Jurassic time. Thus, beds deposited during this time interval vary from limestones of a normal marine environment to evaporites to non-marine red beds and sandstones.

During Jurassic time the Wind River Basin began to form, along with other basins and mountain ranges in western Wyoming.

In Cretaceous time the alternating marine and non-marine conditions came to a close in Wyoming. Late Cretaceous seas withdrew eastward from the Wind River Basin. Local arching announced the advent of the Laramide orogeny in the basin.

A prolonged period of tectonic activity and erosion occurred in Wyoming after deposition of Paleocene sediments. Tertiary sediments in the Wind River Basin are intermontane basin deposits with much volcanic debris from the Yellowstone, Absaroka, and Rattlesnake volcanic centers. The most intense Laramide deformation in the Wind River Basin occurred in late Paleocene and earliest Eocene time. During this interval the Wind River uplift was raised and thrust southwestward while the Wind River Basin was differentially downwarped. After Eocene time a gradual regional uplift commenced in the basin, culminating in Quaternary times.

During Oligocene time deposition of the White River Formation commenced. A basal volcanic-rich arcose was laid down in valleys and on flood plains, followed by tuffaceous and bentonitic mudstones and fine-grained sandstones. Miocene and Pliocene(?) beds were deposited either conformably or with minor unconformity over the White River Formation.

Pleistocene glaciation has left moraines, huge erratic igneous boulders, and bevelled slopes in the Wind River Mountains.

APPENDIX

SECTION OF DARWIN SANDSTONE
MEASURED AT NORTH FORK, POP AGIE RIVER
(SW¼, SW¼ Sec. 36, T. 34N., R. 101 W)

Fremont County, Wyoming

Overlying Unit: Red shale of Amsden Formation

1. Sandstone: Strong deltaic crossbeds occur in the lower half of the section. Crossbeds die out upward. Beds grade from massive weathering with caves at the base to thin-(½")bedded with parallel bedding planes at the top. The sand is yellow to brown, and is cemented with calcite. It appears unfossiliferous . . . . 63'

Total thickness . . . . 63'

Disconformity

SECTION OF SACAJAWEA FORMATION

MEASURED AT SINK'S CANYON

(NE¼, SW¼ Sec. 18, T. 32N., R. 100 W)

Fremont County, Wyoming

Overlying Unit: Red shale of Amsden Formation.

3. Dolomite: Bedding planes are sharp by partings, and are mainly parallel with slight undulations. Individual beds are thin, varying from one inch to 18 inches and averaging four inches. Beds contain thin laminae along which partings occur. Fossil molds and casts of a small brachiopod and a small pelecypod occur on bedding planes near the base. Banded chert lenses are saattered throughout this unit. Color is light grey-tan . . . . 33'

2. Chert: Single chart bed, dark grey and six inches thick appears to be a continuous unit in the section. It has parallel partings, and its upper and lower surfaces are planar and parallel. Thickness is uniform . . . . .0.5'

1. Dolomite: This unit is similar to unit three. Its lowest bed contains granules of Madison Limestone . . . . .2.5'

Total thickness . . . . .36'

Disconformity

SECTION OF DARWIN SANDSTONE

MEASURED AT CROOKED CREEK

(SW¼. NE¼ Sec. 32, T. 32N., R. 100 W)

Fremont County, Wyo.

Overlying Unit: Red shale of Amsden Formation

2. Sandstone: Lenticular bedded, brown, limonitic sandstone contains beds from one-fourth inch to nine inches thick. Beds usually are not uniform in thickness but lense out within two feet of their centers. Cusp type ripple marks are found on some surfaces. Limonite veins are abundant, often crossing bedding traces. Lowermost beds and lenses slump into hollows in underlying unit. Calcite is the cementing agent. No fossils are evident. . . . . .16.5'

1. Conglomerate: Pebbles and granules of Madison Limestone are cemented by a mixture of yellow sand and powdery white limestone. Unit varies in thickness from two inches to eight inches. No fossils are evident . . . . 0.5'

Total thickness . . . . 17'

Disconformity

SECTION OF DARWIN SANDSTONE

MEASURED AT CANYON CREEK

(One-half mile west of Sec. 13, T. 31N., R. 100 W)

Fremont County, Wyoming

Overlying Unit: Red shale of Amsden Formation

7. Sandstone: The topmost ledge is a massive weathering, yellow-tan calcite cemented sand with strong deltaic cross-bedding. A few sand dikes one-half inch wide and ten inches long occur, cross-cutting laminae. No fossils are present . . . . .4.8'

6. Sandstone: Color grades upward from yellow-tan to pink-tan. Bedding is parallel with planar surfaces. Beds vary from one-quarter inch to one-half inch in thickness. The calcite cement is weak and leached. No fossils are present . . . . 6.8'

5. Shale: Red, chunky, fissile, sandy shale at base grades upward to light brown-red to yellow shaly sand and sandstone in beds one-half inch thick. Bedding planes are parallel. Calcite forms the cement. No fossils are present . . . . 2'

4. Sandstone: A massive weathering, parallel-bedded, yellow, calcite-cemented sandstone crops out mid-section. No fossils are present . . . . .2'

3. Shale: A red, fissile, thin-bedded, sandy shale grades upward to pink, parallel-bedded shaly sandstone in beds two inches thick. The unit appears unfossiliferous . . . . 2.7'

2. Siltstone: A hard, dark red siltstone with parallel two inch thick beds containing cusp type ripple marks on surfaces, grades upward from sandstone unit below. Unit is calcite-cemented. A chert nodule zone occurs three inches below the top. Chert is in irregular porous masses up to one-half foot in diameter. Beds are broken up around chert masses. The unit appears unfossiliferous . . . . .3.5'

1. Sandstone: Lowermost outcrop is a massive-to thin-bedded weathering, tan to red-brown sandstone, coarse-grained and conglomeratic at the base. It becomes fine-grained upward and grades into red siltstone, Small crossbeds and cross-laminations occur in beds which generally undulate toward the base and become planar upward. Cusp type ripple marks occur on some surfaces. The unit appears unfossiliferous . . . . .5.2'

Total thickness . . . . .27'

Disconformity

SECTION OF THE SACAJAWEA FORMATION
MEASURED AT LITTLE POPO AGIE RIVER
(SW$\frac{1}{4}$, NW$\frac{1}{4}$ Sec. 18, T. 31N., R. 99 W)

Fremont County, Wyoming

Overlying Unit: Red shale of Amsden Formation.

1. Dolomite: Unit is a slabby, laminated, hard, brittle, rock. Beds vary from one-half inch to two inches thick and vary in color from yellow-tan to muddy brown. Bedding surfaces are generally parallel and either planar or rippled to varying degrees. Some lower beds ring like glass when struck. Chert concretions and lenses are abundant. Concretions are up to ten inches in diameter and are usually oblate spheroids, completely solid. Lenses are up to 10 inches thick and three or four feet long. They are banded, and adjacent beds are deflected above and below. Some concretions and lenses are limonite coated. No fossils are evident . . . . 14'

Total thickness . . . . 14'

Disconformity

SECTION OF THE SACAJAWEA FORMATION

MEASURED AT CHERRY CREEK

(NW$\frac{1}{4}$, SE$\frac{1}{4}$ Sec. 19, T. 31N., R. 99 W)

Fremont County, Wyoming

Overlying Unit: Red shale of Amsden Formation

1. Dolomite: The unit is a slabby thin-bedded to medium-bedded (one-and-one-half feet) medium brown to yellow-tan rock. Thicker beds show laminations from one-eighth to one half-inch in width. Bedding traces are parallel, planar, and sharp by partings. A few banded chert lenses up to 10 inches thick and four feet long occur. Adjacent beds are deflected above and below lenses. Near the top of the unit fossil casts and molds of a small brachiopod and a small pelecypod lie on bedding planes. . . . . 35'

Total thickness . . . . 35'

Disconformity

BIBLIOGRAPHY

Agatston, R. S., (1954), Pennsylvanian and Lower Permian of Northern and Eastern Wyoming: Bull. A.A.P.G., Vol. 38, No. 4 (April), pp. 508-583.

_______________, (1957), Pennsylvanian of the Wind River Basin, Wyoming Geological Association Guide Book, Southwest Wind River Basin, pp. 29-34.

Barnes, T. R., (1953), Williston Basin-New Province for Exploration: Bull. A.A.P.G. Vol. 37, No. 2 (February), pp. 340-354.

Biggs, C. I., (1951), Stratigraphy of the Amsden Formation of the Wind River Range and adjacent areas in Northwestern Wyoming: Unpublished Master's Thesis, University of Wyoming.

Branson, C. C., (1937), Stratigraphy and Fauna of the Sacajawea Formation, Mississippian, of Wyoming: Jour. Paleo, Vol. 11, No. 8 (December), pp. 650-660.

_______, E. B., and Branson, C. C., (1941), Geology of the Wind River Mountains, Wyoming: Bull. A.A.P.G. Vol. 25, pp. 120-151.

_______________, and Gregor, D. K., (1918), Amsden Formation of the East Slope of the Wind River Mountains and Its Fauna: Bull. G.S.A., Vol. 29, pp. 309-326.

Burke, C. A., (1954), Faunas and Age of the Amsden Formation in Wyoming: Jour. Paleo., Vol. 28, No. 1 (January) pp. 1-16.

Chronic, H., (1952), Molluscan Fauna from the Permian Kaibab Formation, Walnut Canyon, Arizona: Bull. G.S.A., Vol. 63, pp. 95-166.

Dapples, E. C., (1959), The Behavior of Silica in Diagenesis; Silica in Sediments. Society of Economic Paleontologists and Mineralogists, Sp. Pub. No. 7, March, 1959.

Darton, N. H., (1904), Comparison of the Stratigraphy of the Black Hills, Bighorn Mountains, and Rocky Mountain Front Range: Bull. G.S.A., Vol. 15, pp. 379-448.

Heaton, R. L., (1950), Late Paleozoic and Mesozoic History of Colorado and Adjacent Areas: Bull. A.A.P.G., Vol. 34, No. 8 (August), pp. 1659-1698.

Koenig, J. W., (1962), Personal Communication.

Krumbein, W. C., and Pettijohn, F. J., (1938), Manual of Sedimentary Petrography: Appelton-Century Earth Science Series.

Love, D. J., (1954), A Tentative Diagrammatic Correlation of the Tensleep, Amsden, Casper, and Hartville Formations in Wyoming: Wyoming Geological Association Guidebook, Casper Area, Ninth Annual Field Conference, Encl.

__________, (1962), Personal communication.

Shaw, A. B., (1955), Correlation of the Paleozoic Formations of Wyoming: Wyoming Geological Association Guidebook, Casper Area, Ninth Annual Field Conference, Encl.

__________, The Amsden Formation in Southwest and Southcentral Wyoming: Wyoming Geological Association Guidebook, Wind River Area, Tenth Annual Field Conference, pp. 60-63.

__________, and Bell, W. G., (1955), Age of the Amsden Formation at Cherry Creek, Wind River Mountains, Wyoming: Bull. A.A.P.G., Vol. 39, pp. 333-337.

Sloss, L. Z., and Moritz, C. A., (1951), Paleozoic Stratigraphy of Southwestern Montana: Bull. A.A.P.G., Vol. 35, No. 10 (October), pp. 2135-2168.

Strickland, J. W., (1956), Mississippian Stratigraphy, Western Wyoming; Wyoming Geological Association Guidebook, Jackson Hole, Eleventh Annual Field Conference, pp. 51-57.

_______________, (1957), Summary of Mississippian and Devonian Stratigraphy Wind River Basin, Wyoming, Wyoming Geological Association Guidebook, Twelfth Annual Field Conference, pp. 20-28.

Wyoming Geological Association, (1956), Wyoming Stratigraphy: Wyoming Geological Association Guidebook, Jackson Hole, Eleventh Annual Field Conference, p. 24.

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