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The Geology of the Limespur-Sappington Area

Frank W. Archibald
THE GEOLOGY
OF
THE LIMESPUR-SAPPINGTON AREA

Frank W. Archibald
Jan. 15, 1940
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Plate 2. North-south section of South Boulder Canyon------------------------2a

Plate 3. Geologic section of South Boulder Canyon--------------------------2b

Plate 4. Geologic map of Limespur-Sappington area--------------------------under separate cover (one map for three reports)
The Limespur-Sappington Area

In partial fulfillment of Geology 63, Geological Field Mapping, held from September 5 to September 22, 1939. The party consisted of 33 members of the Senior Class at the Montana School of Mines who had camp accommodations at LaHood Park, Montana where tents and tourist cabins were available; two meals a day were served by the U. S. C. C. C. which had a camp at this place, the third meal was carried by the party members and eaten in the field. The area surveyed is in a region unmapped except for the original U. S. G. S. in 1896 and is located in the east, central part of Jefferson County, Montana.

The area to be surveyed was divided up into sections and each crew of three or four members was assigned one of these sections.

The first two days were spent in studying and mapping the geologic section in the South Boulder Canyon where we obtained practice in alidade surveying, brunton, pacing, and auto traverse.

My crew consisting of William Brodrick, Wesley Moore, and myself were assigned an area known as the Limespur-Sappington region extending about nine miles east and west along the Jefferson River from Limespur to Sappington. This area is serviced by two main railroads, the N. P. R. R. and the C. M. St. P. & M., along with the Montana-U. S. Highway No. 10 S.
PHYSIOGRAPHY

This area is quite rugged, varying from an elevation of 5000 feet above sea level at the Jefferson River to over 7000 feet on some of the mountain tops. The resistant limestones and quartzites form the major relief with the softer shales forming the valleys. Steep bluffs are quite common and in sections travel is almost impossible.

This region is semi-arid, having only 10-15 inches of rainfall per year, but it supports a few conifers and some small bushes. Drainage is to the east by the Jefferson River.

It may be said that practically all of the erosion is mechanical due to the lack of moisture and to the extremely rigorous climate, (varying from minus $50^\circ F$ to plus $100^\circ F$.

The accompanying index map (see Plate I) gives the general location of the area.
INDEX MAP OF MONTANA SHOWING LOCATION OF AREA SURVEYED
STATIGRAPHY:

The geologic column of the South Boulder Area was studied in detail and mapped with care so that a fairly accurate section was obtained.

ARCHAEOZOIC AND PROTERZOIC

At the base, or southern end of the South Boulder Canyon are the Pony Gneisses, the oldest rocks of the section. These rocks consist of light gray feldspar gneiss with subordinate hornblende and mica, also occurring with the Pony Gneiss is a white feldspar gneiss having the appearance of metamorphosed pegmatite. These gneisses show evidence of great compressive forces in Pre-Cambrian times.

Not shown in this section, but present in many parts of the area are the Pre-Cambrian shales known as the Belt formation. These are the oldest, unaltered sedimentary rocks in the area and vary in thickness from 2300 to 6000 feet. The lower part of the formation consists of an alternation of coarse arkosic sandstone and conglomerate. The middle part consists of argillites, while in the top part siliceous limestones are found with some sandstone. Normally this formation occurs directly below the Flathead Quartzite.

CAMBRIAN:

At the base of the Cambrian formation is the Flathead Quartzite. This rock is pinkish and is probably a mosaic of quartz grains cemented with silica. Near the base are some quartz pebbles which evidently have come from the Pony Gneiss.

Above the Flathead is a soft, greenish, shale called the Wolsey Shale. The beds are thinly bedded and micaeous. It might be interesting to note that Peale, Geologist of the U. S. G. S., who surveyed the area in 1894 included the Wolshey Shale in the Flathead formation.

Immediately following the Wolsey formation and lying conformably on it is the Meagher Limestone. This limestone is characteristically fossiliferous containing trilobites especially at the base. In the upper part the distinctive "black and gold" marble is found. This
# GEOLOGIC SECTION SOUTH BOULDER CANYON

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<th>Column</th>
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<td></td>
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<td></td>
<td></td>
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<tr>
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<td>Pm</td>
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<td></td>
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<td>Ey</td>
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<td>Fw</td>
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<td></td>
<td>Flathead</td>
<td>Cf</td>
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<tr>
<td></td>
<td>Pony</td>
<td>Pr</td>
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<td>Gneiss</td>
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**Plate II**

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GEOL O C S E CT I O N O F S O U T H B OL D E R


"I" = 500
formation is about 350 feet thick.

The Park formation, a soft, sandy, green shale lies directly above the Meagher limestone and is void of fossils except for an undetermined species of Obolella. This formation is about 175 feet in thickness.

Next are the massive, mottled Pilgrim limestones which form a distinctive topographic feature wherever they occur. They derive the name mottled from the dark spots seen in the central portion of the beds. We obtained a thickness of 540 feet on this formation.

Closing the Cambrian Series with 300 feet of sediments are the Dry Creek shales, a series of brownish, red, saccharoidal shales and thinly bedded limestones. Some limestone pebbles are found in the shale and fossils are found throughout.

DEVONIAN

At the base of the Devonian are about 600 feet of black or mud colored crystalline magnesian limestone. There are a few fossils, and some of the beds have a fetid odor when freshly broken.

The Three Forks shale makes up the top of the Devonian. This formation can be divided into three parts: the lower or orange colored shales, then a band of grayish-brown argillaceous limestone and the upper a green, black argillaceous shale, crowded with Devonian fossils. In some regions a coal-black shale or slate is near the upper part and this has developed into a coal seam in the Jefferson Canyon.

MISSISSIPPIAN:

Immediately following the deposition of Devonian shales, there was a period favorable to deposition of calcareous deposits and the base of the period is marked by a tremendous thickness of Madison
limestones. Fossils of brachiopods, bryozoa, and other invertebrates are plentiful in the formation. The Madison formation can be divided into three parts. The lower part of laminated limestone with many fossils, the middle light colored, argillaceous, thinly-bedded limestone and the top of massive, white limestone referred to as the Castle member. The Madison is 2250 feet thick.

Following the deposition of the Madison limestone, there was a period of erosion and an erosional unconformity marks the base of the Amsden, a red shale member having in places conglomerates of limestone pebbles. The Amsden limestones are magnesian and it is conspicuous because of its brilliant red color. This formation is about 250 feet thick.

**PENNSYLVANIAN**

The Quadrant formation is composed of pink sandstones and quartzites with interbedded limestone members. The interbedded limestones are sugary and contain micro-fossils. This formation is the only member of the Pennsylvanian period and is about 175 feet thick.

**PERMIAN**

The Permian formation is characterized by a narrow, phosphate bearing formation which is difficult to identify unless weathered rock of this oolitic phosphate is found. Also occurring in the Phosphoria formation are some fine, paper-thin, black shales. This formation is only 70 feet wide.
MESOZOIC

JURASSIC

Just above the Phosphoria is the Ellis formation which is characterized by a quartzite ledge at the base and the top. However, the formation consists mostly of fossiliferous, calcareous beds which gradually grade into a sandstone which is devoid of fossils. The thickness of this formation is about 300 feet.

The Morrison shales which are made up of variegated green and red shales and sandstones lie directly above the Ellis formation. On a whole this formation is difficult to identify and in places has been metamorphosed to dark slates. These beds are about 200 feet thick.

CRETACEOUS

The Kootenai formation, basal Cretaceous, is one of the easiest to identify as its base is marked by a distinctive "salt and pepper" sandstone with some red cross-bedding. These basal sandstones grade into reddish and greenish shales followed by a light blue limestone composed largely of fresh-water gastropods. The thickness is 900 feet.

The Colorado formation is identified by its fine-grained, dark, marine shale. Because of the softness, the beds are usually covered and hard to find. The formation is about 200 feet thick.
The age of the Livingston volcanics has not been definitely set, but it is believed that they are upper Cretaceous but transpired after the post-Cretaceous uplifting of the region. After the Laramide Revolution there was a period of intense volcanic eruption and the base of the period is marked by large thicknesses of agglomerates made up of lava pebbles in a matrix of lava sand or mud. The andesite flows associated with the above breccias are sometimes referred to as "oatmeal" rock because of the occurrence of feldspar in a brown matrix.
HISTORICAL GEOLOGY

The oldest formation encountered in the district is the Pre-Cambrian Pony Gneiss of which the geologic history is very indefinite. Lying unconformably on this formation are the Cambrian formations which were deposited during the middle and upper part of the period. This tends to indicate a widespread land mass in Montana at the beginning of the Paleozoic era. The Cambrian seas altho of shallow mediterranean type, were widespread and deposited about 1000 feet of sediments. Near the end of the Cambrian period the seas withdrew and most of the State became a lowlying land mass.

In the middle Devonian the dark-colored magnesian limestones of the Jefferson formation were laid down. The Three Forks shales were laid down as a result of a slight elevation of the land masses.

During the Mississippian, immediately following the Devonian, the state was again submerged and about 2000 feet of crystalline limestones were laid down (Madison). Following the deposition of the Madison limestone, a land surface prevailed and the top of the limestone was eroded. Finally the land was again inundated and the Amsden formation was laid down on the Madison.

The Pennsylvanian period in Montana started with marine waters covering the southwestern part of the state.
This resulted in the deposition of the Quadrant formation.

Because the geological history of the Permian in Montana is still vague, the Phosphoria formation overlying the Quadrant in southwestern Montana is of questionable Permian age, but it seems probable that central and northern Montana were land.

At the end of the Paleozoic era and during most of the Jurassic, Montana was a land mass, but a sea spread over the state in middle Jurassic and deposited the limestones, shales, and sandstones of the Ellis formation. The Jurassic ended with Montana as a land mass and the Morisson shales were laid down during transitional time between upper Jurassic and lower Cretaceous.

Land conditions of the late Jurassic extended into the lower Cretaceous. Most of the material laid down seems to have been of the piedmont type. It is also known that a high and mountainous land extended from the Gulf of Mexico northward into Wyoming and during this time most of Montana was a low, swampy land and coal formations were formed.

During the beginning of upper Cretaceous, all of the eastern and central parts of Montana were covered by a sea which extended from the Arctic Ocean to the Gulf of Mexico and accounts for the accumulation of about 2000 feet of shaly sediments. (Colorado formation)
The Livingston formation consisting of ash, agglomerates and pyro-clastics was accumulated in a synclinal basin during upper Cretaceous.

The uplifting of the Rocky Mountains began near the close of the Cretaceous and continued into early Paleocene and Eocene. From the erosion of these mts., many feet of sediments were laid down in lake beds and as alluvium.
GEOLOGY OF THE LIMESPUR-SAPPINGTON AREA

LOCATION:

The area surveyed is located for nine miles E-W just south of Highway U.S. 10S between Limespur and Sappington Junction.

TOPOGRAPHY AND PHYSIOGRAPHY:

The western part is characterized by high uplands dipping sharply to the north into the Jefferson River Canyon. The prominent ridges of the area are formed by limestone, quartzite, and sandstone ledges while the valleys are formed by the shales.

AREAL GEOLOGY:

The control point for our survey was at the S.W. cor of Sec. 25, T.1.N., R.3.W. To the east from this point the region is covered with a thin layer of lake beds and Livingston agglomerates showing in the gulches. The rest of this region (N part of Sec. 31) is characterized by one large E-W fault with a displacement of 2500 feet to the W which greatly complicated the area and no attempt was made to correlate the beds. However, it is interesting to note that an outcropping of Colorado shale was noticed right next to a ledge of sandstone full of gastropods.

Two thousand feet N.E. of the above area, a N-S fault has thrown Kootenai against a large block of Madison limestone. The "salt and pepper" sandstone of basal Kootenai
at this point outlines a plunging anticline with the basal Kootenai on the outside and Jurassic Morrison and Ellis inside.

To the east, the next two miles were skipped in hopes that the beds could be plotted after work had been done further to the East. But this was not the case as the area left out was too great to be correlated.

Our next control point was established by running an auto traverse from the cut-off to Morrison Cave on Highway U. S. 10S to a point two miles away where the Jefferson River leaves the highway and turns south.

On following thru the canyon made by the Jefferson River cutting the beds, we encountered a normal section starting with the Livingston, Kootenai, Morrison, Ellis, Quadrant, Phosphoria, and Madison. The Amsden was missing at this point, but no evidence of faulting could be seen, so the Amsden could have been buried. At the base of the Madison is what we suppose to be an extension of the E-W fault mentioned above which throws Quadrant against the base of the Madison. This fault starts another normal section including; Quadrant, Amsden, and Madison, with the rest of the beds dipping under the alluvium.

After going thru this section, we turned east for about 1500 feet and then turned north in order to traverse
the beds once more. But we picked a poor place as we followed up the limb of a fold and the geology was very mixed up.

The final part of our survey consisted of travelling along the strike of the beds and then running a section across the beds. Here (about 3000' from the above mentioned fold) we encountered another normal section including from the gastropod limestone of the Kootenai thru the Amsden. At a point about 200' from Montana Highway No. 89 the beds dipped under and were covered by alluvium which fills the entire Jefferson Valley. Our survey was closed by tying in with the pier on the N. W. corner of the highway bridge on Montana U. S. 89 over the Jefferson River,
ECONOMIC GEOLOGY

This area we surveyed has surprisingly few economic mineral deposits of any significance. There are several small abandoned coal mines in the Kootenai, but the coal here was of a very low grade.

Near Morrison Cave is an abandoned gypsum quarry which was given up because of the intermixing of the gypsum with Jefferson and Madison limestones.

Along the Jefferson River Canyon are flumes that had evidently been used for hydraulic mining. Records show that the New London Placer Mining Co. exploited a bench on the Jefferson River about a mile east of Limespur, but whether the venture was profitable is not known. The origin of this placer gold is undoubtedly some point further up the Jefferson River or one of its tributaries and has been deposited here by the water.

The most outstanding venture was the quarrying operations of the East Butte Mining Co. which used this limestone for flux. It was first exploited in 1910 and given up in 1930 when the East Butte Co. was liquidated. The limestone here was of extreme purity, running up to as high as 99% calcium carbonate and consequently some of the limestone was used for purifying sugar in the refineries in Billings.
ACKNOWLEDGMENTS

I wish to express my gratitude to the instructors in charge of the party for their valuable aid in making the trip a great success.

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