Summer 6-1953

Stratigraphy of Kootenai in Montana

B. B. Jarrett

GEOLOGY 72
Second Semester
Senior Year

GEOLOGY THESIS

STRATIGRAPHY OF KOOTENAI IN MONTANA

By

B. B. Jarrett

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geologic Engineering

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ACKNOWLEDGEMENT

The author does here wish to thank Dr. O. D. Blake for his valuable assistance in aiding him to obtain the information necessary for the report. The knowledge gained from the study of the subject and advice recieved being invaluable in future studies of this nature.

ABSTRACT

The Kootenai of Montana is a variable formation as far as composition is concerned. The formation consisting largely of a series of sandstones, shales, and shaly sandstones. The presence of the limestone and carbonaceous members being irregular indicating variable climatic conditions throughout the deposition of the sediments. The fresh water environment being confined to the western slope, while the central and the eastern portions had more swampy conditions with local fresh water deposition.

The formations persistence being local rather than over large areas. The sandstones form prominent ridges with the vegetation growing along these ridges. The sand and shale members varying in thickness as we move across the state, showing how conditions changed throughout the period.

The economic aspects of the Kootenai are very good. The Kootenai formation being the main producer of oil and gas in the state, besides producing commercial quantities of coal, building stone, and refractory material. The formation is the best water carrier in the state, due to the porous sands of coarse to medium grained texture.

CONTENTS

STRATIGRAPHY OF KOOTENIA IN MONTANA

BY

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INTRODUCTION

The following investigation was taken primarily as a problem in the stratigraphy of the Kootenai in the state of Montana, with reference to the Cloverly in the northern part of Wyoming and the type section in southern Alberta. The report is being presented as part of the requirement for the Degree of Bachelor of Science in Geological Engineering at the Montana School of Mines

The information for this report being gathered from library research. The report will try to determine the economic value and the correlation of the Kootenai as it moves across the state. Under the correlation I will try to explain the reasons for certain members being absent by means of stratigraphic sections and an exclamation of each section. The report will also cover the description of the type section of southern Alberta, with a description of various areas throughout the state indicating any differences from the type section.

The final part of the report will be devoted to the commercial products of the Kootenai with a brief discussion on the clays and the water accumulation in the formation.

HISTORY

The Kootenai formation derived its name from a Indian tribe that hunted in the southern Canadian Rockies nearby the area which was orginally described by Dr. G. Dawson[1] in 1855. It is described as being a series of beds consisting of shales, sandstones, and shaly sandstones with occassional layers of conglomerate and a zone of workable coal beds. The area described lying between the 49th parallel and the Medicine Bow river, an area 140 miles long and 40 miles wide.

J. S. Newberry in 1889 found fossil plant remains in the coal bearing rocks of the Great Falls region which correlated with the Kootenai described by Dawson, north of the international boundary. According to the W. H. Weed's report,[2] the 300 feet of the bed near the Great Falls area known as the Cascade formation were regarded as Kootenai, and lower Cretaceous in age.

OCCURENCE AND DISTRIBUTION

The Kootenai formation has bright maroon shales and brown, pink, gray, or black-and-white sandstone as distinguishing features, with prominent cross-bedding. The sand members stand out as bold ridges being timbered with pine usually.

In the Crow Nest Pass of southern Alberta The maximum thickness of the Kootenai is 9,750 feet.[3] South of this area the formation

1.) Fisher, C. A. Southern Extension of The Kootenai and Montana Coal Bearing Formations in Northern Mont. Econ Geology, Vol 3.
2.) Pirsson, L. V. U. S. G. S., Atlas, Fort Benton Folio, No. 55, 7pp
3.) Wills, B. U. S. G. S., Professional Paper 71, p. 625, 1912.

becomes buried by sediments of later ages before reaching the International boundary, and outcrops in a belt adjacent to the Rocky mountains. Measures of exposed areas in Montana are as follows:

Blackfoot Indian Reservation[4]	1200 feet
Near Cinnabar Mountain[5]	577 feet
Lewiston[6]	512 feet
Near Crazy Mountains[7]	235 feet
Belt[8]	450 feet

STRATIGRAPHIC DESCRIPTIONS

The type section in southern Alberta is composed of sandstone interbedded with shale and shaly sandstone of variegated colors, the prediomant color being red. The zone has a few conglomerate beds, with a bed 2800 feet thick of organic material that contains coal. The thickness of the beds being approximately 9,750 feet.

The Blackfoot Indian section is 1200 feet thick being exposed along the Rocky mountains, the exposures being highly deformed by folding and faulting. The section is composed of alternating beds of dark green shale and sandstone of variegated colors. Several zones of gritty and conglomerate material within the sandstone indicate possible reservoirs

4.) Stebinger, E. U.S.G.S., Bull 641-J,pp 281-305
5.) Calvert, W. R. U.S.G.S., Bull 641-G,pp 199-214
6.) Calvert, W. R. U.S.G.S., Bull 341,pp 108-22
7.) Stone, R. W. U.S.G.S., Bull 341,p 80, 1907
8.) Fisher, C. A. U.S.G.S., Bull 356, 85 pp

for oil, these zones of sandstone, conglomerate and grit varying from 20 to 70 feet in thickness. Thin streaks of black carbonaceous shale and coal appear, the coal having small commercial value. The appearance of limestone within the formation occurs, being present in sparing amounts as concretions and thin lenticular beds in the shale members.

The Great Falls section has a massive sandstone at the base, with the sandstone beds in the upper portion decreasing and being largely replaced by red shales and clays. The coal beds occur 60 feet above the base with a concretionary limestone member 220 feet from the top of the formation. The section is between 450 and 500 feet thick.

The Lewistown section is an argillaceous shale with interbedded coarse grained sandstone. The sandstone has a cross bedded structure present. This is followed by massive conglomeratic sandstone, weathered gray carbonaceous shale, and alternating sandy shale and sandstone in thin beds. The sandstone being exposed as bold ridges with pines and other vegetation growing upon them. The section is 512 feet thick.

The Musselshell valley area Kootenai formation is alternating beds of maroon sandy shale with thin sandstone beds and massive conglomerate sandstones. At the top of the formation is 50 feet of thin bedded platy sandstone having worm trails,[9] the base being a coarse gray sandstone. Coal beds are absent, the exposures occuring in the Shawmut anticline and Little Elk dome. The formation is 250 feet thick.

9.) Bowen, C. F. U. S. G. S., Bull 691, pp 185-209

The south central area of Montana thickness varies from 160 to 235 feet. The lower half of the formation being a red and green shale and the upper half a sandstone of variegated colors. The central portion just beneath the massive sandstone is a coarse grained formation containing thin layers of quartz and chert pebbles, followed by a black shale about a foot or more in thickness having a slightly bituminous appearance. Coal producing zones in the Great Falls and Lewistown area occur at this horizon.

The Livingston and Trail creek Coal fields area have distinct members, three in number. The top member is a massive quartzite, followed by beds of reddish clay, and this in turn underlain by a conglomerate sandstone. The total thickness is 500 feet without any sign of carboneous material in the area.

The Philipsburg section is a thick formation measuring 1,500 feet. The formation being composed of " Salt and Pepper " sandstone at the base and shale, with two beds of limestone and dark calcareous shale. The first limestone member appears near the top being known as the Gastropod limestone from the oyster fossils found there. This member being separated from the lower limestone by a mottled green and red sandstone and shale. The lower limestone member is a fine grained texture limestone containing twigs like bodies of calcite.

GEOLOGIC HISTORY

The period from the Jurassic to the lower Cretaceous in Wyoming and the southern part of Montana is questionable, as a

terrestial deposit (Morrison), is considered by some geologists to be Jurassic in age while others consider it a transition period between the two sediments. The deposition of the lower Cretaceous in the rest of Montana continuing with the land conditions of later Jurassic time still persisting. The deposits range from 200 to 1500 feet thick in central and northern Montana and are known as the Kootenai formation. The formation consisting of coarse sediments that where spread by strong currents onto a piedmont plain. The clastic being considered as deposited by rivers flowing east over a flood plain that lies east of the highland masses in British Columbia, Oregon, and Washington. Since coal and evidence of cross bedding in the sandstone members of the Lewistown area, as stated by Calvert,[10] are found in the formation, the land must have had some swampy areas. Fresh water Gastropods are found in the limestones, in western part of state , of the formation indicating that the limestone member is of fresh water origin. Up till today not any marine fossils have been found in the formation. Furthermore, Perry concludes that the sediments are of the above mentioned origin. He basis his evidence on the fact that the sediments are partly conglomeratic and more than a 1000 feet thick in British Columbia. The conglomeratic beds being found in western Montana but absent in the eastern part of the state.

10.) Calvert, W. R. U. S. G. S., Bull 341, pp 108-22

SECTIONS OF THE STATE STUDIED

The stratigraphy of the Kootenai will be studied under several sections in the state. The plates will try to give an over all picture of the formation in the state, with a brief explanation to follow on each plate. The explanation will also include some reference to the absence of members with an attempt to explain why the members are absent.

Plate 1.

This plate shows the changes in the Kootenai of central Montana. Logs being taken from the Crazy mountains, east of the Big Snowy mountains, the Little Rocky mountain, and the Sweetgrass Arch.

The Little Rocky mountain exposures are much thicker than those in the Snowy mountains and contains less red shales. The Kootenai of the Sweetgrass Arch is thicker as the north boundary is approached, the formation resembling the Little Rocky mountain area, having a much darker appearance than the Great Falls area. The rest of the sections are fairly constant thickness of about 500 feet.

The Kootenai in the Sweetgrass Arch is a series of shales, sandstones, and shaly sandstone members, which as we move toward the Little Rocky mountain area become thinner probably due to erosion. The appearance of more sandy zones and shale are prevalent in this area, the shaly sandstones being absent. The waters in

this area being less turbulent probably, resulting in the deposition of the finer particles. The Big Snowy area south of this section has more shaly sandstones with aseries of shales and sandstones further south. The sandy zones now being located at the top of the formation whereas previously had a central location. The Kootenai is also divided, the last 200 feet being known as the Morrison. Some paleontologist claim this should be lower Cretaceous, as contains dinosaur and plant fossils of this age, though some paleontologist still place the Morrison as late Jurassic.[11] The presence of the Morrison farther north, as the term is used today, have not been recognized and it is still a problem to know exactly whether these members are pinched out or what? The Crazy mountain area has shale with some conglomerate and limestone indicating fresh water deposition with fairly strong currents. The shale being replaced by sandy shale further south in the area with some carboneous material occuring, probably as a result of swampy conditions. The streams being more quiescent than further north in the area, resulting in more sandy conditions with the shale deposition.

Plate 11.

The plate shows the Kootenai in the northern most cross section of the state discussed in this report. The sections logged being taken from Cut Bank, Kevin-Sunburst, Bowes structure near Havre, and Bowdoin dome near Saco.

11.) Bassler, R. S. A. A. P. G. Bull., Vol 7, 1923.

The Kootenai lies unconformably on the Ellis throughout the section with the contact between the Colorado shale and the top of the Kootenai being difficult to determine. For instance, in the Kevin Sunburst area, according to Mr. F. Clark,[12] some logs indicated red beds lying below the gas sands, which is considered the base of the Colorado. The red beds being generally accepted as the top of the Kootenai, however in some logs these beds were absent so the base of the gas sand would be taken as the contact.

The sections taken show the Kootenai as a series of alternating shale and sandstone zones with a small amount of limestone being deposited in the Kevin - Sunburst area, showing about the limit of fresh water deposition in the formation. The sand zones varying in thickness because of the sands lack of persistence causing it to be pinched out or form thinner stringers. The shales being more resistant with most of their changes in thickness probably due to erosion. The shales occuring at the top of the formation, with the thicker sand zones appearing near the base.

Plate III.

This plate is a cross section of the Kootenai from the Idaho - Montana line near Yellowstone National park to the vicinity of Helena, Montana. The formation being known as the Cloverly and may or maynot include the Morrison at the line and the Kootenai further north. The formation ranges in thickness from 1000 to 1500

12.) Clark, F. R. A.A.P.G.Bull., Vol 7, pp 263-76.

feet. The Kootenai lying unconformably on the Ellis with the top of the formation being uncertain.

The Kootenai formation is composed of shales, red shales , shaly sandstones, and sandstones with a thin member of conglomeratic sandstone in the central portion. The top of the formation is a gray gastropod limestone with the sandstone member, that is generally present above the limestone, being absent.

The limestone indicates fresh water deposition, the sands and shales being possibly shallow water deposition with strong currents. The conglomerate sandstone member is much thinner as we move south in the section, indicating probably that we are further away from the source of the material or the water currents where much weaker. The sandstones are persistent in the north, as they form hogbacks, while the shale members are being pinched out by the sandstone or becoming sandy in texture, as shown near the top of the formation by Helena. The sandstones near the state line though seems to be less prominent with the shale members becoming thicker, in fact the basal sandstone is absent, the only sand member being present near the central portion of the section.

FENCE DIAGRAM

The Kootenai is concentrated in the central and western portion of the state,.The greatest thickness of your formation lying along the mountain range in the western part of the state with a gradually thinning of the formation as we move to the eastern part of the state.

The formation is mainly a series of shales, sandstones, and sandy shales. The presence of limestones in the western part are quite prominent. The limestones being of fresh water, however this limestone member is pinched out as we move into the central portion of the state, indicating most of the fresh water must have been near the highland areas where a fairly good runoff so the water was not allowed to accumulate. The coal zones, of the formation, that are found in the central part of the area indicate a large valley or low lying area must of run in a north south direction. The area being highly saturated with water creating a swampy conditions resulting in the plant growth being abundant, and under varying temperature changes and pressures carbonized to form coal. The clay material present in the Great Falls area is also further indications of swampy conditions. The conglomerate sandstones are fairly thick in the western portion, probably caused by streams having a greater rapidy due to the highlands west of the area. The water carrying the finer sands out onto the flood plains. The evidence of the finer sands on the flood plains is brought out by the fact that the conglomerates are

lacking in the eastern portion.

The sands in the northern and eastern part of the formation are less persistent with three members of sand being present. These sands were also pinched out in many spots and in other areas eroded off. The sands to the west are more persistent and usually stand out as ridges with timber growing along them. These sands range from five to eight members, being of a much coarser variety due to the presence of conglomeratic material. The sands of this area have the appearance of Salt and Pepper at the base, due to the presence of small pieces of black chert cemented with the sandstone. The member aids in the correlation of the base of the Kootenai with the Morrison.

The shales occur at the top of these formations in the northern portion, with the sandstones being prominently at the top in the southern portion. The shales are of greater thickness on the flood plain area indicating that there was less erosional action on the flat lying area then near the highlands. The waters being less turbulent by the presence of finer sands in the central and eastern part of the formation.

The correlation of the formation with top formations was a difficult job, in fact most of the beds at the top are not definitely correlated today as the variations are so variable. Reference lines are generally used to indicate the top beds.

For instance, in logging of the Kevin - Sunburst field the geologist where using the red beds below the gas sand as there contact point between the Colorado and Kootenai. The correlation method however proved highly unsuccessful, as these red beds would appear at different horizons or be absent, so the only way they could correlate the area was by taking the base of the gas sand. The correlation of the base of the Kootenai has fairly well being established as lying unconformably on the Ellis. The only difficult occuring with the Morrison in the south western portion of the state, where the geollogists opinions differ somewhat. The point being discussed earlier in the report.

The correlation with other states varies little, the only difference being in the names used. The Cloverly for the Wyoming area, with the Dakota - Lakota and the Morrison being the principle constituents toward the Dakotas area. The Cloverly are merely sandstone and shale members with a conglomerate occuring at the base near the Elk Basin area. The section toward the Black Hills area of the Dakotas is a series of sandstones, and shales, the conglomerate member not being present. The north east section has little information published as yet, but should be more extensive in the next few years with all the work being carried out in the Williston basin. The Billings Geology Report

Number 2 of 1951 gives some information as to relative thickness but very little as to the description of the area. They did disclose that it was a series of sandstones and shales. The Lakota sandstone having some fresh water Ostracods present. The presence of plant fossils in the shales was also stated. The correlation of the Kootenai towards British Columbia and Alberta, The type section area, is a series of shales, sandstones and shaly sandstones having increased thickness. The coal beds of Alberta being much thicker than the Montana section, while the conglomerates increase in thickness towards British Columbia. In fact, this is considered the source direction of the sediments for the Kootenai formation.

Conclusion

The Kootenai as established to day seems to have the possibility of being expanded to include the Lakota - Dakota formations towards the east and the Cloverly of the Wyoming section. The Cloverly appears to have all the characteristic of this formation. The conglomeratic sandstone material occuring at the base of the Elk Basin area being further evidence. Further we may be able to draw a conclusion through a study of the origin to see how it compares with that of the Kootenai in Montana. The area east also has possibilities of being correlated as it appears to be a series of sandstones and shales. The

presence of plant fossils in the shale members and Ostracods in the sandstone members, as stated in the Billings Geology Field Report Number 2 may provide further evidence. The correlation of these plant fossils in the area with those in the Great Falls and Alberta sections to see how they compare. The correlation by means of plant fossils is not too good for large areas but for local correlation is fairly successful. Therefore emphasis for correlation by this means are not to substantial.

Further study of the economic aspects of the sands of the area may help some. The formations appear in a rich Oil and Gas producing zone of Montana, and surrounding states and since the Kootenai is considered the best producer of these products in the state, the possibilities are good. The sands may be good water bearers, as some more proof for calling them the Kootenai formation. The correlation of this area surrounding the Kootenai would simplify the geology.

Mr. Perry stated that some day the whole area will be known as the Kootenai.[13] Fisher also stated in his article on the Great Falls Coal Fields, that the Kootenai formation is much thicker than we suppose. The proof of his statement is doubtful though, as our evidence up till today does not seem to verify his statement and has shown little indications of doing so in the future.

13.) Chamberlain, V. R. Thesis (B. S.), M. S. M., 1938

ECONOMICS

Clays in Kootenai

The clays present in the formation are found in the eastern part of the Cascade county, in the Belt and Highwood range of mountains. The Kootenai occupying the greater part of the surface in this area, with clay and shale deposits being exposed.

The clay beds are four feet six inches thick and lie about 26 feet above the coal beds. The clay being of fine texture, having a sub conchoidal fracture with indistinct laminations in places. The beds are of uniform thickness, with a few small sand lenses and pyrite being the only impurities. Above this there is a yellowish sandy clay, being very hard material and breaking with irregular fractures. The yellowish color caused by the association of limonite. This clay occurs as bands or in joint planes and is used primarily for the manufacture of bricks. There is another bed of clay 30 feet thick, but has little value commercially.

The clay deposits of the Kootenai have a small commercial value as far as world market is concerned. However the Anaconda Copper Mining Co. uses the locally known flint and plastic clays as refractories intheir various smelters

throughout the state. The refractory clays in the Lewistown area are used in Ceramic industry.

Coal

The coal beds of commercial value occur in the Great Falls field, with traces of coal in the Lewistown area and the Crazy mountains area being unworkable as far as commercial value is concerned. The thickness of the commercial zone in southern Alberta is 2800 feet, there being 14 workable beds of coal. The Great Falls area has only one workable horizon, which is not a continuous seam but becomes thinner in the Judith range where the coal is of a poorer quality.

The coal in the Great Falls area is of a low Bituminous rank, being 6 feet to 14 feet thick and located 60 feet to 90 feet above the base of the Kootenai. The coal occurs in three benches, the lower and upper benches being 3 feet thick and the middle bench 1 foot thick.

Oil and Gas

The Kootenai is the main producer of Oil and Gas in the state. The production coming mainly from the lower sands.

The Kevin - Sunburst Field, in Toole county, has its main production from the Sunburst sand of the Kootenai. The sand being lenticular in nature and not to persistent as pinch

outs of the sands occur quite frequently. The sands occurs near the base.

The Cat Creek Field has production in three sands, the main production coming from the lower or Lupton sand. This sand is 30 to 40 feet thick, producing a high grade paraffin base oil. The upper sand of the Cat Creek Field is water soaked and produces no gas or oil.

Miscellaneous

The Kootenai basal sandstones in the Great Falls and Bozeman area are used for building stone. [14]

Ground Water

The Kootenai is an excellent water carrier except where oil and gas are not found. The basal sandstones providing the greatest water supply of the formation.

The reason these sands are good water bearers is because of medium to coarse grained textured sand grains that are very porous, so when structural conditions are favorable the sands readily absorb the water. Artesian wells result in the Kootenai from the impervious Colorado shale overlying the sandstones, while springs form in other areas. The springs being free flowing in some cases.

14.) Fisher, C. A. U. S. G. S., Bull 356, 85 pp.

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STRATIGRAPHY IN MONTANA

BY C.M. BAUER AND E.G. ROBINSON.

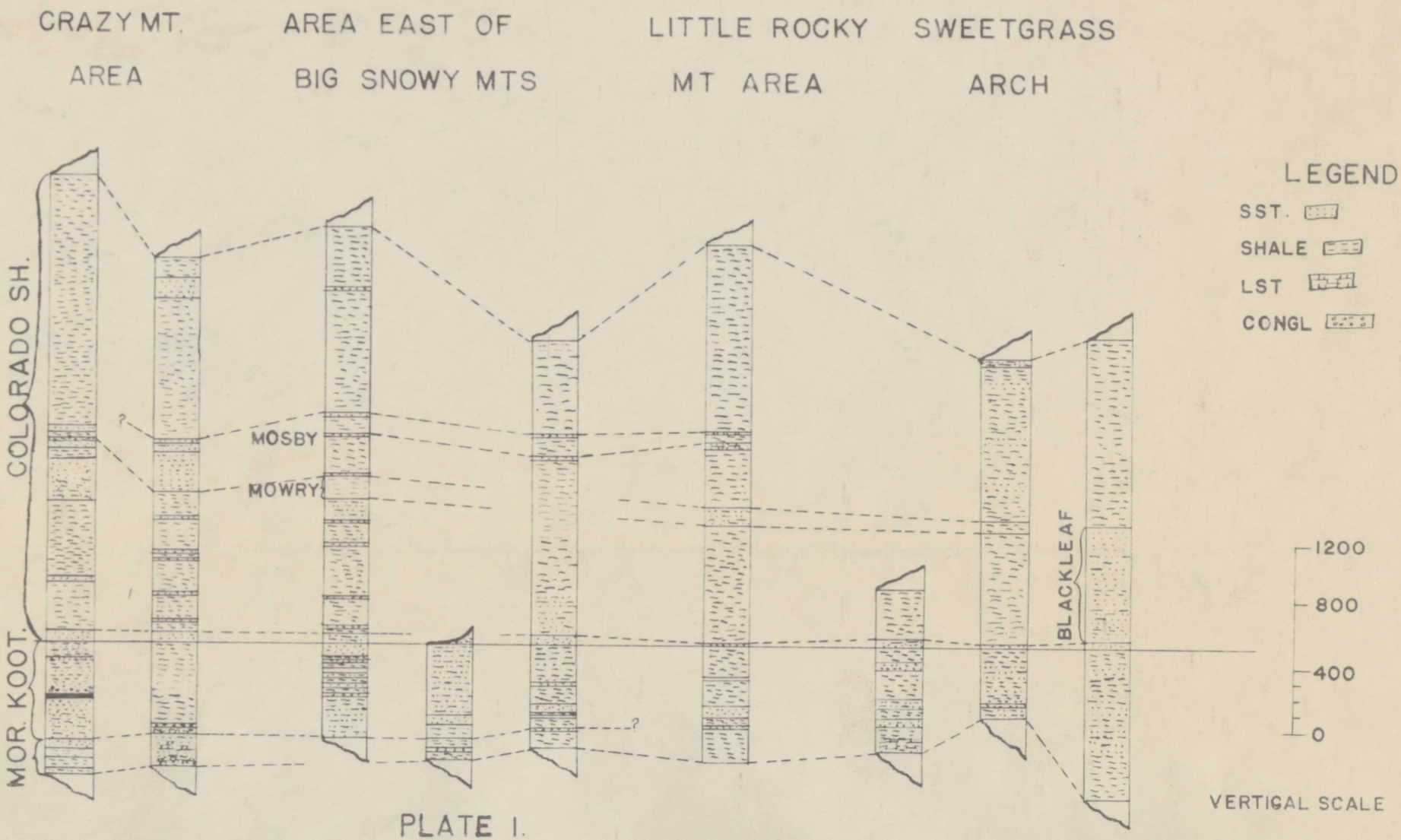


PLATE I.

WEST - EAST SECTION

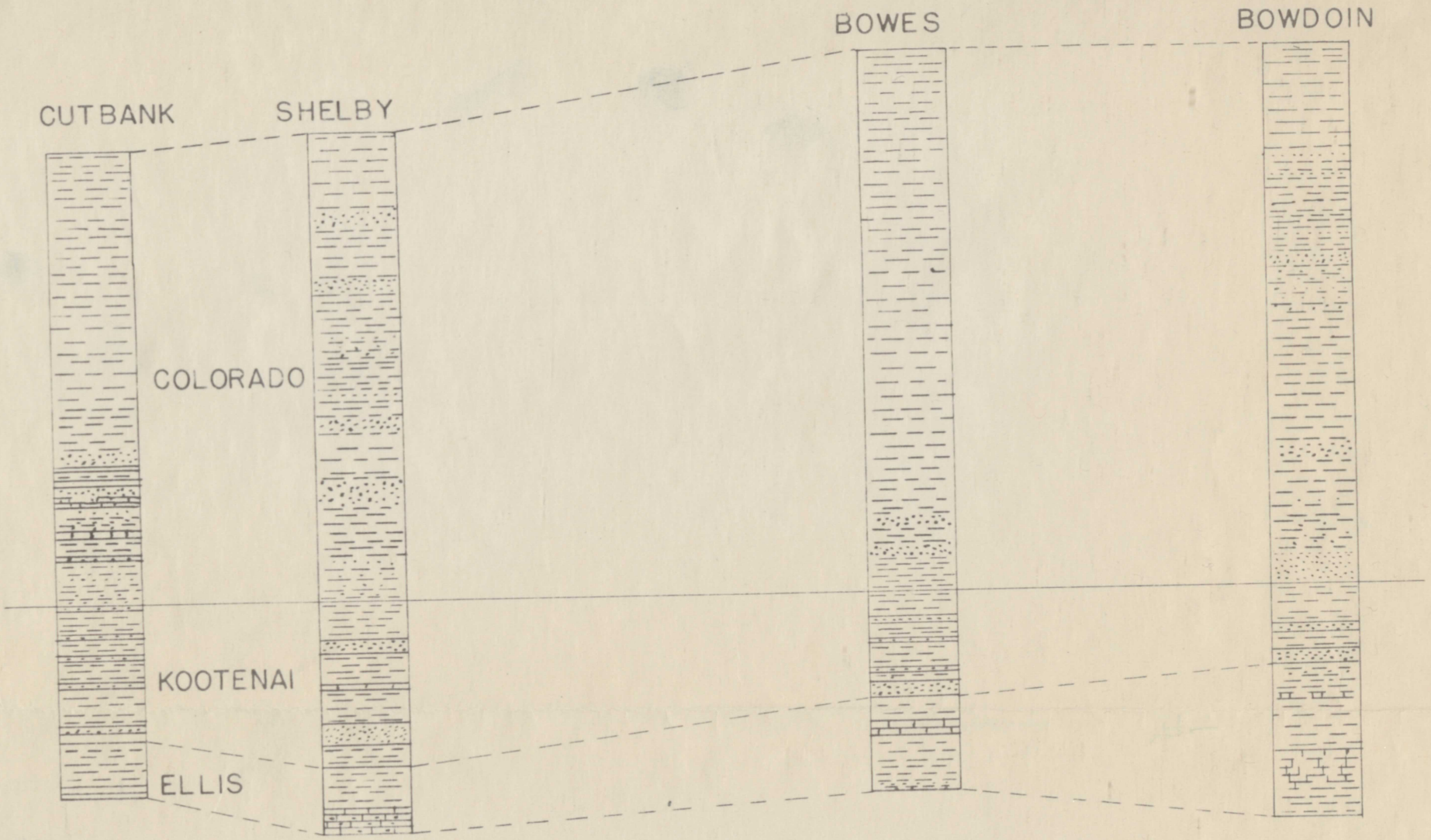


PLATE 2.

VERTSCALE 1"=500'

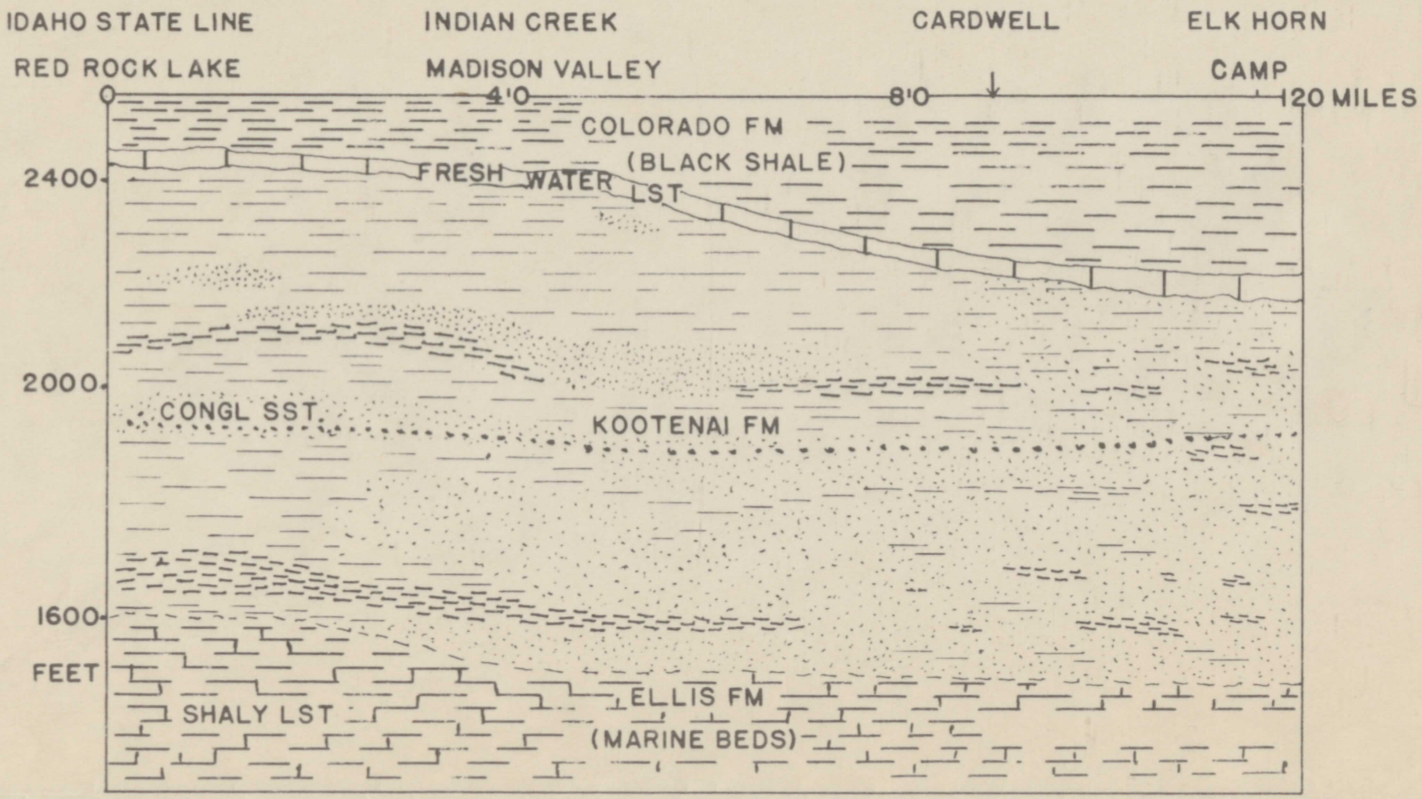


PLATE 3.

CROSS SECTION FROM IDAHO-MONTANA STATE LINE NEAR YELLOWSTONE NAT'L PK TO VICINITY OF HELENA, MONT.

BY CONDIT, D.D.

U.S.G.S., PROF. PAPER 120, 1918.

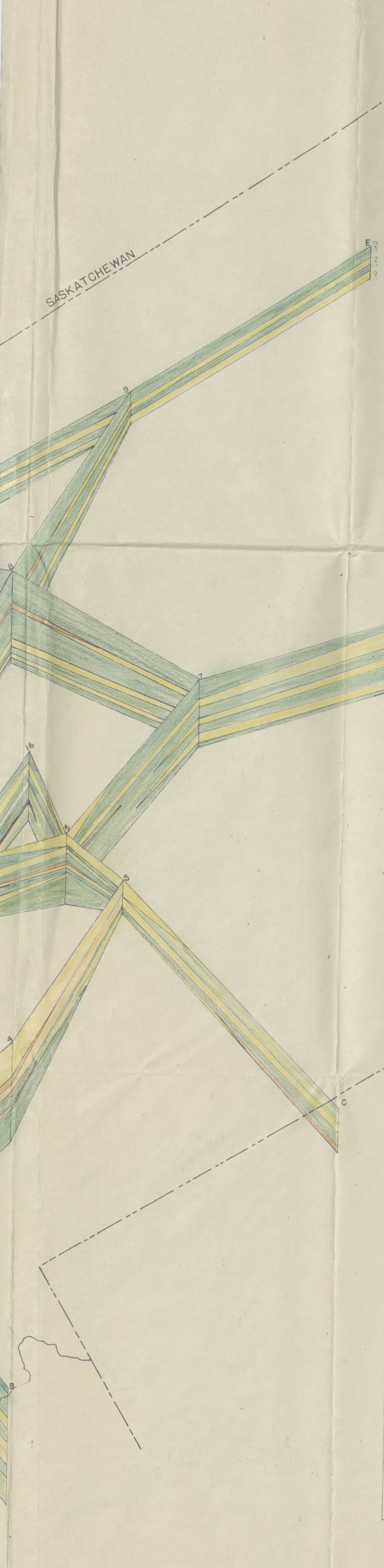
A) ALBERTA COAL FIELDS - 1100', 1400'
BASSLER, R.S. A.A.P.G. BULL., VOL 7, 1923.

B) RED ROCK LAKE - 900'
CONDIT, D.D. U.S.G.S., PROF. PAPER 120, 1918.

C) ELK BASIN - 350'
HANCOCK, E.T. U.S.G.S., BULL. 711-G, PP 105-48.

D) BAKER GLENDIVE FIELD - 550'
CHAMBERLAIN, V.R. THESIS (B.S.), M.S.M., 1938.

E) INFORMATION NOT AVIALABLE



1) BLACKFOOT RESERVATION - 1200'
STEBINGER, E. U.S.G.S., BULL. 641-J, PP 281-305
2) PHILISBURG QUADRANGLE - 1500'
CALKINS, F.C. GEOL. ATLAS, PHILIPSBURG FOLIO, NO 196
3) SOUTH BOULDER AREA - 900'
DOUGHERTY, E.T. GEOL FIELD TRIP, 1940.
4) CRAZY MTS. - 585'
BASSLER, R.S. A.A.P.G. BULL., VOL 7, 1923.
5) SHAWMUT ANTICLINE - 250'
BOWEN, C.F. U.S.G.S., BULL 691, PP 185-209.
6) BIG SNOWY MTS - 535'
BASSLER, R.S. A.A.P.G. BULL., VOL 7, 1923.
7) CAT CREEK FIELD - 500'
CHAMBERLAIN, V.R. THESIS (B.S.), M.S.M., 1938.
8) LITTLE ROCKY MTS - 700'
BASSLER, R.S. A.A.P.G. BULL., VOL 7, 1923.
9) BOWDOIN DOME - 250'
CHAMBERLAIN, V.R. THESIS (B.S.), M.S.M., 1938.
10) BOWES DOME - 350'
IBID
11) SWEETGRASS ARCH - 500'
BASSLER, R.S. A.A.P.G. BULL., VOL 7, 1923.
12) SHELBY - 550'
CHAMBERLAIN, V.R. THESIS (B.S.), M.S.M., 1938.
13) GREAT FALLS FIELD - 475'
FISHER, C.A. U.S.G.S. BULL. 316, PP 161-73.
14) BELT MTS - 450'
FISHER, C.A. U.S.G.S. BULL. 356, 85 PP
15) BELT MTS - 450'
IBID.
16) LEWISTOWN COAL FIELD - 512'
CALVERT, W.R. U.S.G.S., BULL. 341, PP 108-22.

VERTICAL SCALE = 1" = 500'

FENCE DIAGRAM OF THE KOOTENAI OF MONT

BY B.B. JARRETT.

LEGEND:

SHALE -------
SANDSTONE ---
SHALY SST ----
CONGLOMERATE
LIMESTONE -----
COAL ---------
CLAY ----------