GEOLOGY OF THE MARSHALL DISTRICT,

BOULDER COUNTY, COLORADO

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INTRODUCTION

Marshall is approximately 5 miles southeast of Boulder, Colorado. The area mapped is approximately two square miles. It is in sections 16, 17, 20, and 21, township 1 south, range 70 west. The main objective in this work was the construction of a structure contour map showing the complex faulted and folded structure of the area. The mapping was done by means of closed stadia traverses. The elevation of a point on the west end of Davidson mesa was determined by triangulation to the top of the smoke stack of the University of Colorado heating plant. The elevation of the top of this stack is 5556 feet. Other elevations in the area were determined from this point.

ACKNOWLEDGMENTS

Mr. H.F. Watts assisted in all of the field work and gave information on the stratigraphy and structure that greatly expedited the work. Credit is due P.G. Worcester and Warren O. Thompson of the geology department of the University of Colorado for helpful suggestions and supervision.

PHYSICAL CONDITIONS

Relief and Elevations

The relief is about 330 feet. The elevation of the lowest point is 5509 feet, of the highest 5836 feet.

McLaughlin

Topography

There are large, flat-topped mesas north and south of Marshall. The mesa on the north is called Davidson mesa. The one on the south is Lake mesa. The tops of these mesas are about 300 feet higher than the village of Marshall.

Drainage

The area is drained by South Boulder Creek. Marshall is in a large gulch, the head of which is 1 1/2 miles east of the village. This gulch drains west into South Boulder Creek.

Outcrops

The sandstones of the Laramie formation outcrop along the tops and on the sides of the mesas. Where the strata are level the sandstones form caprocks. The most prominent outcrops are on dip slopes and on the eroded limbs of the Marshall anticline.

GEOLOGIC CONDITIONS

Stratigraphy

The Laramie formation is the only formation outcropping in the area. Four key beds designated B, M, C, and D, in ascending order, were selected for mapping the structure. Beds B and C are the same as those named by G.H. Eldridge in the Denver Basin Monograph. Eldridge evidently did not recognise the existence of a bed D above bed C in the section at Marshall. Bed M is an abbreviation of "median sandstone" which is in the middle of the coal measures. These beds are most easily identified by their position in the section. The lithologic characteristics of the Laramie beds vary too much to permit satisfactory correlations based on these features. However, a brief description of the key beds follows.

The top of bed B is approximately 100 feet above the base of the Laramie formation. Bed B is a fine-grained, massive, white sandstone composed almost entirely of quartz grains. It weathers into semi-spheroidal or pillow-shaped forms. The best exposure of sandstone B in the area is at the base of the west end of Belmont Bluff where it forms a forty foot sandstone scarp.

At Belmont Bluff there is a two foot coal bed just above the top of bed B. Between this coal and the base of bed M above are 22 feet of alternating shales and sandstones.

Bed M is a fine-grained, white sandstone about 10 feet thick. It is composed of several layers 6 to 12 inches thick. Some layers contain considerable iron oxide.

In the Marshall district the workable coal beds, two in number, are between beds M and C. The lower coal bed, two feet thick at Belmont Bluff and four feet thick at the Pinecliff mine, is two feet above the top of bed M at both places. The upper coal bed, 6 feet thick at Belmont Bluff and at the Pinecliff mine, is 15 feet above the lower coal and 15 feet below the top of sandstone C at both places. The intervening beds are alternating shales and friable sandstones. These beds are shown in detail in the columnar sections.

Bed C is a medium to coarse grained, quartzitic sandstone. It is normally white but some layers contain much iron oxide. It is approximately six feet thick. The upper surface of C is covered with large ripple marks. The distance from crest to crest of the ripples is about 4 inches. In most places this ripple marked surface is coated with a layer of iron oxide approximately 1/4 inch thick. The best exposures of bed C are in dip slopes on the southwest and southeast limbs of the Marshall anticline.

Bed D rests on top of bed C. Lithologically bed D is almost identical with bed B. Remnants of bed D cap Belmont Bluff and Davidson mesa. Bed D is complete in the section on the north side of Davidson mesa, where the vertical distance between the top of bed D and the top of bed C is 94 feet. The vertical distance from the top of bed C to the top of the upper coal bed is 30 feet.

The section near the Pinecliff mine is well exposed. From bed M to the top of bed C the section is almost identical with that of Belmont Bluff. The interval between the top of bed B and the base of bed M is 9 feet less at the Pinecliff mine than at Belmont Bluff. At Tony's mine the interval between the top of bed M and the top of bed C is 30 feet. At Belmont Bluff the same interval is 41 feet.

<u>Structure</u>

The general strike of the beds in the Marshall district is approximately N. 40° E.; the regional dip is southeasterly but is locally modified by folding and faulting. The principal structural feature of the region is a system of faults composed of three major faults and two branch faults. Minor structural features are a northwest plunging anticline, a southeast plunging syncline, and a southwest plunging anticline. The southwest plunging anticline which is called the Marshall anticline is the most prominent fold in the area.

The Faults --

The general trend of the faults is N. 40° E. The courses of the faults are independent of topography, which condition indicates that the fault planes are vertical or very steeply inclined. The faults are parallel to each other and the upthrown block is, in each place, east of the fault. The throw along the faults varies from a few feet to 280 feet.

From north to south across the district the major faults are: the Fox fault, the Belmont fault, and the Gorham fault. Two branch faults diverge from the eastern extension of the Gorham fault; the western branch is called the Ross Fault, the eastern branch is not named. The Fox fault was named by local coal miners. The other faults were named by Mr. H.F. Watts.

The Fox fault extends around the west and northwest sides of Davidson mesa. The Fox fault is manifest by the repetition of beds C and D west of the fault line. On the west, downthrown, block, bed D outcrops as a prominent 30 foot scarp of white sandstone at the foot of Davidson mesa. A remnant of bed D caps Davidson mesa east of the fault. The throw of the fault on the north side of Davidson mesa is 260 feet. Southwest of Davidson mesa, the Fox fault dies out at the base of Lake mesa where bed D extends unbroken across the fault line. Northeast of Davidson mesa, G.H. Eldridge maps the Fox fault as bending slightly westward and passing 1/2 mile west of Burnt Butte.

The Belmont fault is best disclosed at the base of Belmont Bluff where sandstone D, northwest of the fault, is faulted below bed B which forms the forty foot cliff at the west end of Belmont Bluff. The throw here is about 280 feet. To the southwest, the fault is indicated by the presence of dip slopes of sandstone C on the north side of Lake mesa and on the flat at the foot of the mesa. This fault was traced southwest to a point north of the High View mine where it disappears under stream gravels in the valley of South Boulder Creek. The throw near the High View mine is 140 feet. Northeast of Belmont Bluff, the Belmont fault is displayed as a fault line scarp of sandstone C extending along the west side of an amphitheatre eroded into the south side of Davidson mesa. The throw along this scarp is 30 to 50 feet, diminishing to the northeast. On the northern edge of the top of Davidson mesa the throw is less than ten feet.

The fault dies out here.

The Gorham fault is best revealed near the sites of the old Gorham and Crackerjack mines where it is a strike fault parallel to the north side of Lake mesa. South of the fault, bed B, outcropping on the hill side above the old Crackerjack entry, is faulted up above bed C which, north of the fault, caps Belmont Bluff. The throw is about 150 feet. Southwest of the Crackerjack entry the Gorham fault extends along a broad shelf nearly to the top of Lake mesa. It crosses a shoulder of the mesa and runs between the Premier and High View mines on the west slope of Lake mesa. The throw here is about 80 feet determined from the relative elevations of the coal bed in the Premier and High View mines. An attempt was made to trace the Gorham fault southwest of the Premier and High View mines. A compass bearing taken south along the trend of the fault intersected the mouth of Coal Creek Canon, 4 1/2 miles southwest of the Premier mine, where slickensides occur which correspond in direction with the above bearing. Furthermore, an outlier of Fountain sandstone outcrops here, east of its normal position. Although the evidence is meagre, it suggests that the Gorham fault intersects the foothills formations near the mouth of Coal Creek Canon. This may help explain the vertical sediments at the mouth of Coal Creek Canon. Northeast of the Crackerjack opening, the Gorham fault cuts through the south limb of the Marshall anticline. Here southeastward dipping beds of sandstone M are repeated south of the fault. The throw is approximately 190 feet. At first the Gorham fault was mapped as following the repeated bed of sandstone M across the road and past the New Ross mine. This interpretation had to be abandoned because several points south of the fault line had very high datum elevations compared with nearby points. For this reason, the Gorham fault is mapped as cutting through bed M south of the New Ross mine and continuing to the east. The strike of bed M is markedly different on the two sides of this fault. The extension of the Gorham fault eastward is dashed on the map because positive evidence could not be obtained. However, this interpretation is probably correct.

The Ross fault is a branch fault diverging from the Gorham fault near the site of the Crackerjack entry. This fault is indicated by the repetition of southeastward dipping C beds east of the fault line. This fault apparently dies out rapidly to the northeast because the beds on the north side of Davidson mesa are unbroken. However, at the Northern mine, on the north side of Davidson mesa, bed M is locally depressed 30 feet. This depression may be the result of the Ross fault dying out in a fold.

The eastward branch of the Gorham fault diverges from the main fault near the Gorham opening. The triangular block between the Gorham fault and this branch fault is upthrown approximately 50 feet.

Attitude of Beds in the Individual Fault Blocks --

The beds in the fault block limited on the southeast by the Fox and Belmont faults, in the northern two-thirds of the block, dip 7° S. 50° E. Southwest of the termination of the Fox fault, near the foot of Belmont Bluff, the dip of the beds gradually approaches east. On the north side of Lake mesa, 800 feet south of the Eldorado mine, the dip is 3 or 4 degrees east. This change of dip forms a shallow syncline plunging to the southeast.

The block between the Fox and Belmont faults is part of the southwest limb of the Marshall anticline. The beds dip approximately 10° S. 20° W. In the northeastern part of this block, along the top and north side of the Marshall anticline, the beds dip gently northwest.

In the fault block between the Belmont fault and the Ross and Gorham faults, the beds in the northern end of the block have the same dip as those in the block between the Fox and Belmont faults. Along the northern end of the Ross fault, the beds dip 40° S. 30° E. forming the southwest limb of the Marshall anticline. Southwest of Belmont Bluff, near the Pinecliff mine, the beds dip at a slight angle S. 60° E. Farther to the southwest, near the High View mine, the dip is practically due east. These dips indicate the presence of a southeast plunging syncline and a northwest plunging anticline in the southern two-thirds of this block (see map).

In the block between the Ross fault and the eastern branch of the Gorham fault the beds dip 41° S. 40° E. The strata are a repetition of southeastward-dipping beds of the southeast limb of the Marshall anticline.

In the triangular block between the eastern extension of the Gorham fault and the eastern branch fault, the beds dip S. 80° E. at an angle of 60 degrees or more.

Southeast of the Gorham fault, the beds near the old Gorham entry dip 39° S. 35° E. These beds are a repetition of those of the southeast limb of the Marshall anticline. Southwest of the Crackerjack mine opening, the dip of the beds gradually approaches S. 60° E. The dip angle is 38 degrees.

<u>Structural History</u>

The structures at Marshall are part of the structure of the Front Range. The following quotation by T.S. Lovering[3] outlines the major structural features of a portion of the Front Range west of Boulder, Colorado.

> "The history of faulting in the region suggests a somewhat varied response to nearly horizontal compression applied from the west-southwest. The early northwesterly faults, by virtue of their relations to the echelon folds farther north, suggest compression under sufficient loads to cause folding accompanied by faulting. The later fractures furnish evidence that compression either was focussed on the region near Boulder or lingered for a longer period of time in this locality than elsewhere. The discontinuous shear faults suggest fracturing under a lighter load than that which existed during the epoch of northwesterly faulting. The development of these two kinds of deformation and the resulting fractures can best be pictured as follows: As the persistent northwesterly faults associated with the folding are found both north and south of the mineral belt and are plainly related to the earlier stages of mountain formation, they may be considered the results of failure at the edge of the region of folding that was produced by the uplift of the Front Range during the Laramide revolution; the northeasterly shear fractures are localized in the mineral belt and are probably the result of relatively westward movement of the wedge-shaped mineralized area during long-continued compression. Failure along the

> northwest side of the wedge produced the northeasterly shear faults, and failure along the southern edge produced the late easterly fractures."

Lovering believes the two fault systems are the earliest Tertiary fractures in the region. They are clearly older than Eocene porphyry stocks which cut them.

The faults at Marshall are parallel with the northeasterly faults in the mineral belt and with the direction of schistosity in the pre-Cambrian rocks of the Ward, Gold Hill, and Jimtown districts. The Marshall faults are probably members of the northeasterly system of faults which Lovering describes.

The writer believes that the same sequence of events took place in the Marshall district as in the region which Lovering discusses. Profound modification of the southeasterly regional dip in the area between the Fox and the Gorham faults, in the writer's opinion, indicates two movements in the structural history of the Marshall district. These movements were probably, as Lovering believes, phases of one great uplift. The southeasterly regional dip and the structures with southeastward-trending axes are the results of the early movements which produced the northwestward-trending faults and echelon folds farther north along the foothills and in the mineral belt. Later movements produced the Marshall anticline and the system of northeastward-trending faults which transect the anticline.

PREVIOUS WORK DONE IN THE AREA

G.H. Eldridge[1] mapped the Fox fault correctly as the northern fracture of the Marshall subsystem of faults. He mapped the other faults as branches given off from the southeastern side of the Fox fault. The present work shows that his terminal cross fault across Davidson mesa is non-existent because unbroken beds extend across its course. He recognized the faulted origin of Belmont Bluff. However, he put his "Bluff fault" along the brow of the bluff and not south of it where the Fox fault actually occurs. His failure to trace the faults correctly was probably due to his correlation of sandstone B at the base of Belmont Bluff with the outcrops of sandstone D near the base of the bluff and on the north side of Davidson mesa.

N.M. Fenneman[2] follows Eldridge almost exactly in mapping the faults. His work was little more than replotting the lines previously traced by Eldridge.

Hugh F. Watts told the writer that he first traced the faults correctly about 1910. He plotted their courses on a large scale base map and made numerous structure profiles using a hand level.

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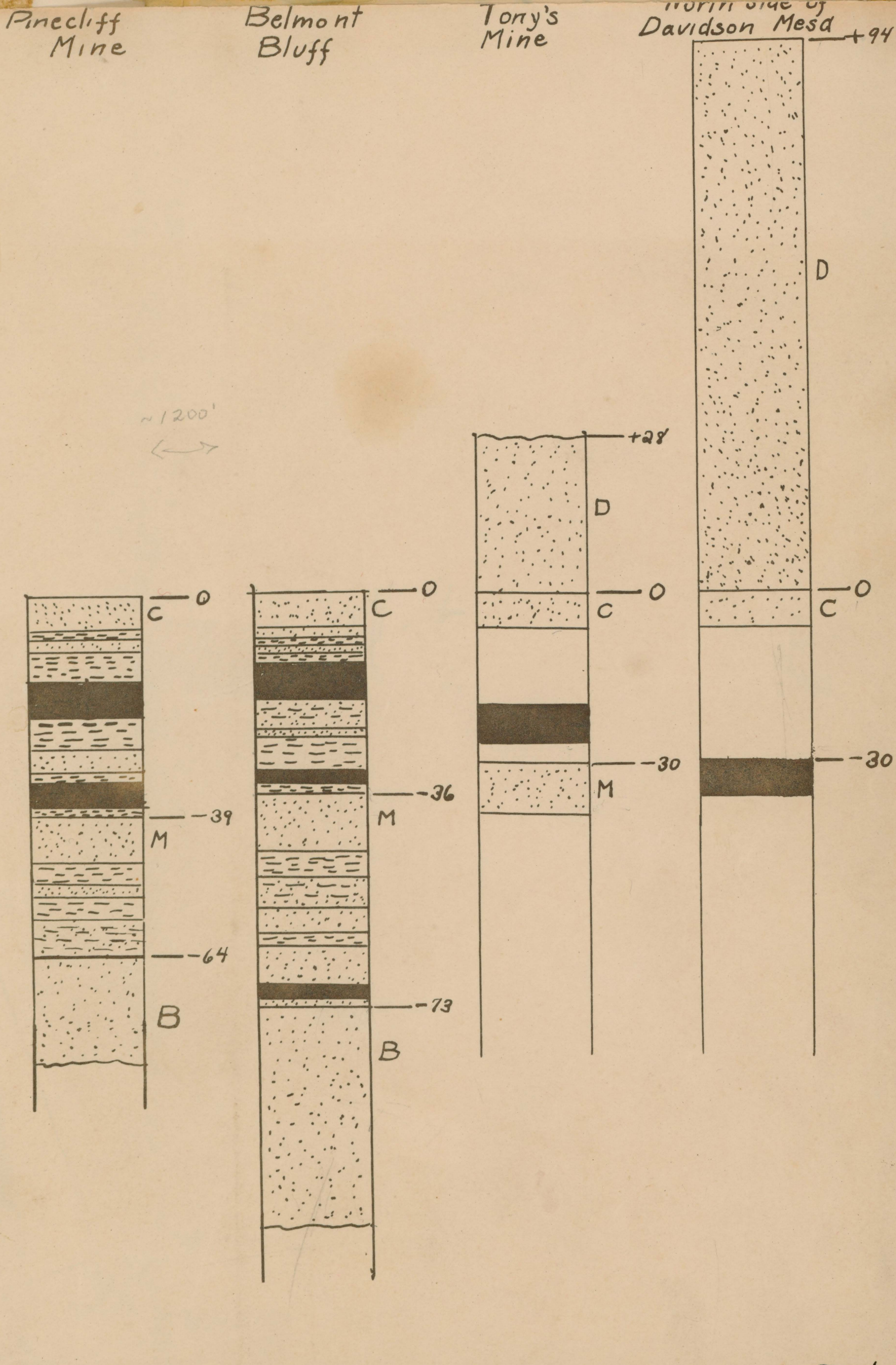


North side of Davidson Mesa
Pinecliff Mine
Belmont Bluff
Tony's Mine
~1200'
+94
D
+28
0
C
-30
M
-39
-36
-64
-73
B

Plate I.

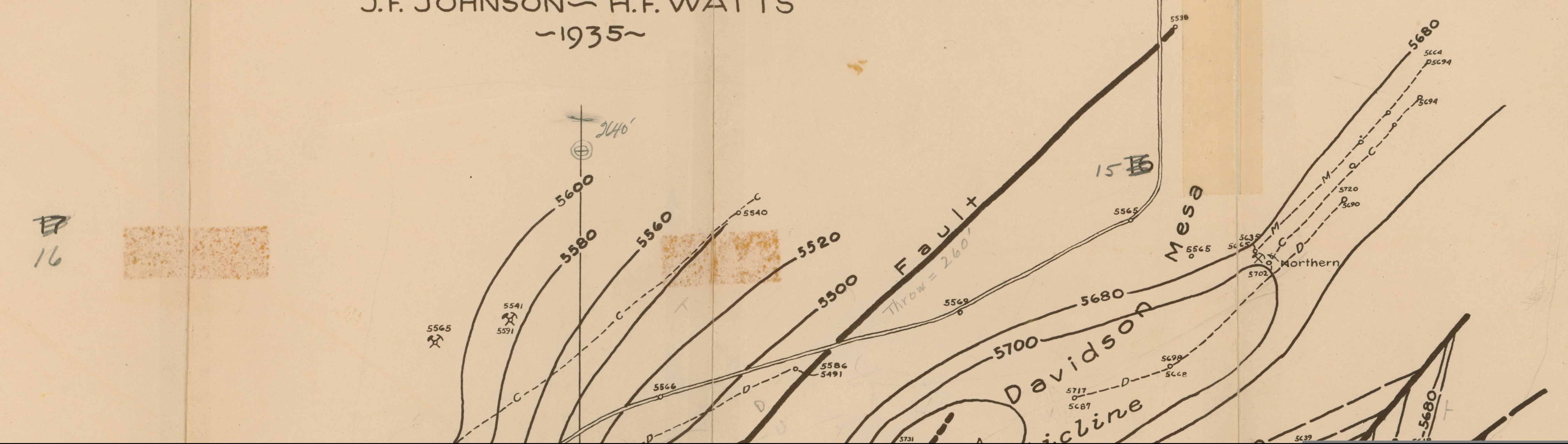
STRUCTURE CONTOUR MAP

OF THE

MARSHALL DISTRICT, COLORADO

J. F. JOHNSON — H. F. WATTS

—1935—



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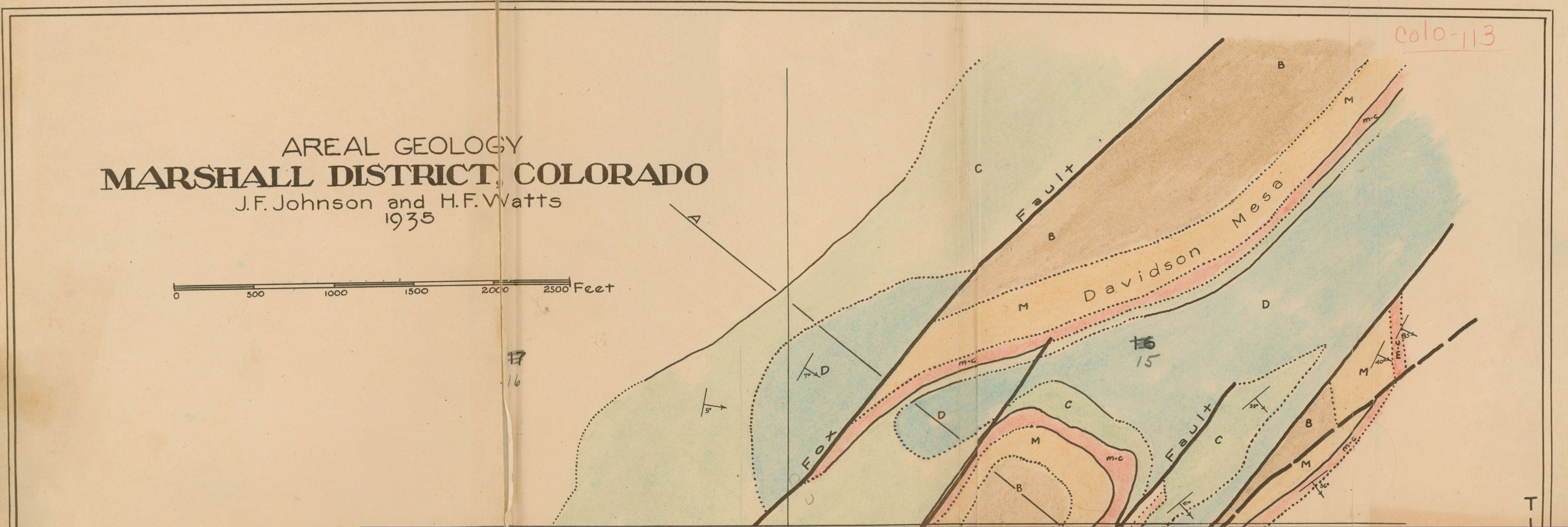

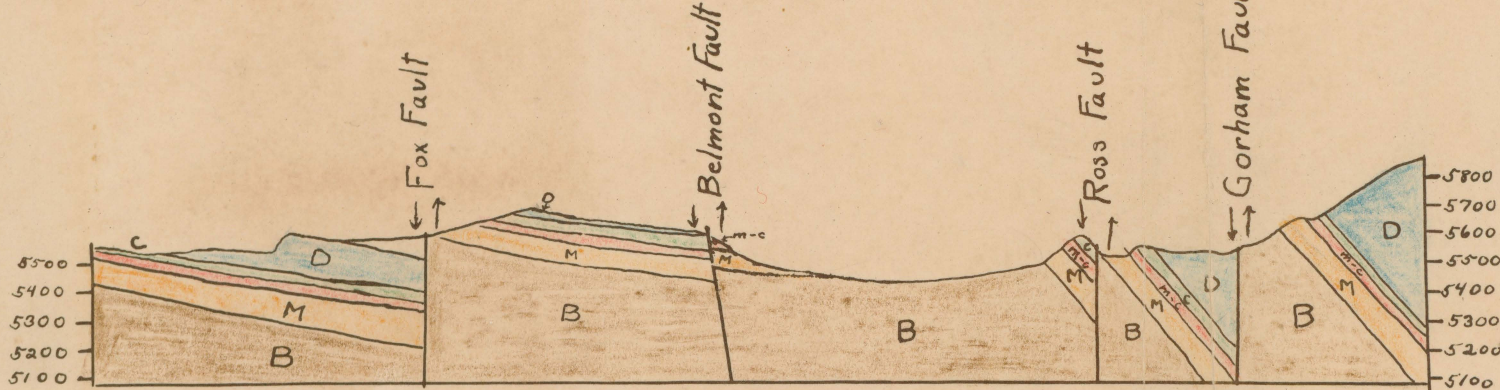

Fox Fault
Belmont Fault
Ross Fault
Gorham Fault
C
D
M
B
m-c
5500
5400
5300
5200
5100
5800
5700
5600

Panorama east from hill 1/4 mile south of Marshall.
White lines are traces of faults.

Plate V.

Panorama east from old Crackerjack mine dump.
White lines are traces of faults.

Plate VI.