U.S. Geological Survey.

[Reports. Open file.]

Report on Three Dolomite Deposits near Helena, Montana. by King, Ralph H.

REPORT ON THREE DOLOMITE DEPOSITS NEAR HELENA, MONTANA

By Ralph H. King

U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Contents

Illustrations

Tables

Page

REPORT ON THREE DOLOMITE DEPOSITS NEAR HELENA, MONTANA

By Ralph H. King

- - - -

ABSTRACT

The three dolomite deposits here described near Helena, Montana, occur in the Upper Cambrian Hasmark Dolomite, which is probably equivalent to the Pilgrim Limestone. The dolomitization apparently was a result of the intrusion of the Boulder batholith.

The deposit near Colorado Gulch, about 6 miles west of Helena, consists of almost vertical beds of dolomite on the steep west limb of a large, asymmetric, plunging anticline. Much of the deposit is concealed by surface cover, and hot springs and sills have introduced some siliceous and ferruginous matter.

The deposit at Nelson Gulch, about 6 miles west of Helena and 3/4 of a mile south of the deposit near Colorado Gulch, lies on the nose of the same anticline. There is not much overburden, and hot springs and sills and dikes have introduced only a small amount of siliceous matter.

The deposit at Grizzly Gulch, about 1 mile southwest of Helena, consists of gently dipping beds in a slightly asymmetric, gently plunging syncline. There is not much overburden, but hot springs, partly associated with abundant minor faults, have introduced a large amount of siliceous and ferruginous matter.

Total reserves in the three deposits may be as large as 13,825,000 tons, of which perhaps 8,400,000 tons is recoverable. Further exploration should precede any attempt at development. The deposit at Nelson Gulch is the one most deserving of additional investigation, although the deposit near Colorado Gulch also merits some attention.

Introduction

Location of deposits

The city of Helena is situated in Lewis and Clark County, slightly south of the center of the western half of Montana (fig. 1). The valleys of Prickly Pear Creek and the Missouri River extend eastward from Helena, and the Lewis and Clark Range rises gradually to the west of the city. Railroad service is provided by the Great Northern and Northern Pacific systems.

The dolomite deposit near Colorado Gulch is about 6 miles west of Helena and about 3/4 of a mile south of U. S. Highway 10N, adjacent to the Rimini road. The deposit at Nelson Gulch is likewise about 6 miles west of Helena, and about 1 1/2 miles south of U. S. Highway 10N and about 3/4 of a mile south-southeast of the deposit near Colorado Gulch. These two deposits are separated by Nelson Gulch, from which a large amount of dolomite has been removed by erosion. The deposit at Grizzly Gulch is about 1 mile southwest of the business district and adjacent to the outskirts of Helena, just west of the junction of the Grizzly Gulch road and the Oro Fino Gulch road. It is about 5 miles east of the other two deposits.

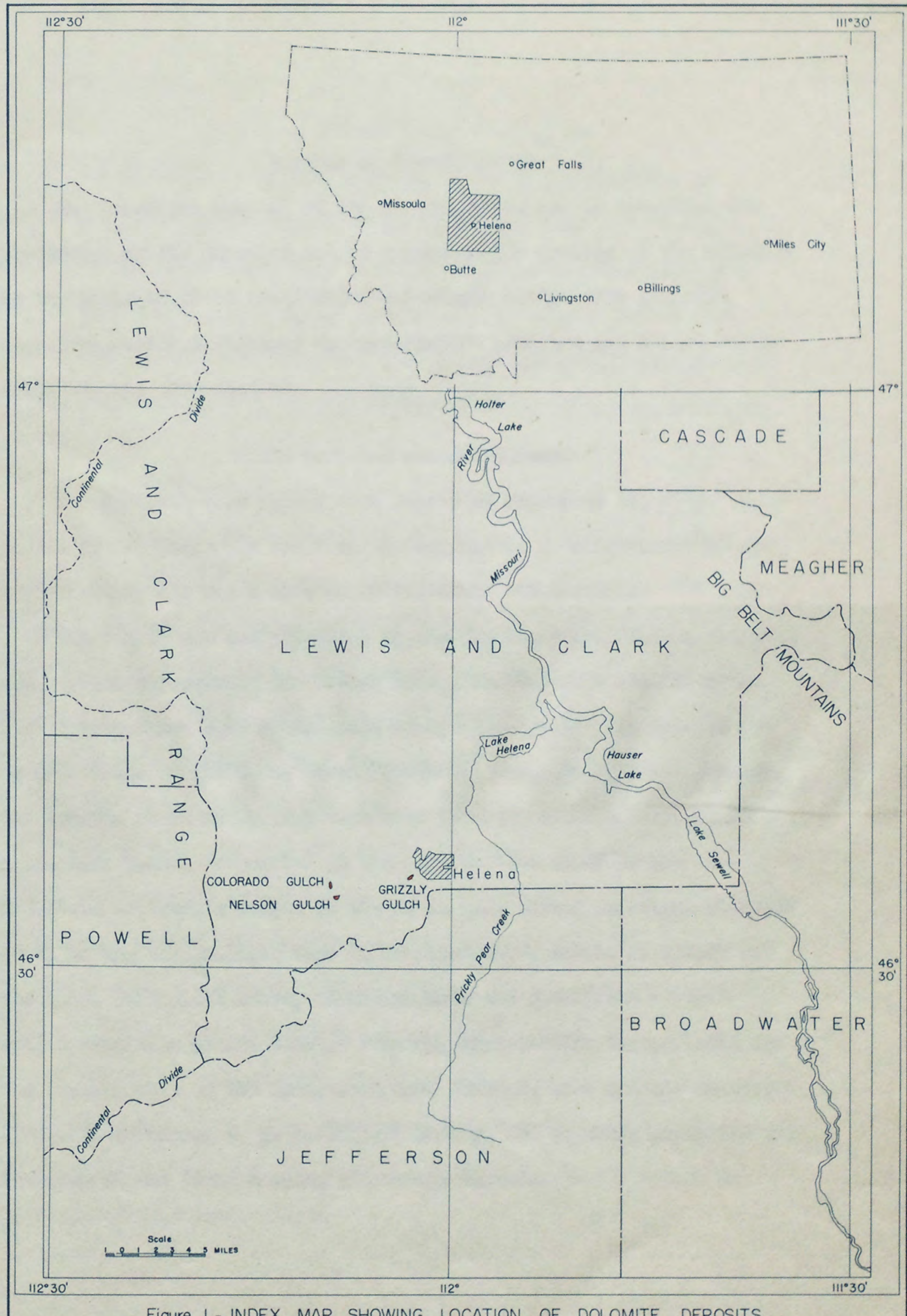


Figure I. - INDEX MAP SHOWING LOCATION OF DOLOMITE DEPOSITS

Purpose of investigation

The principal purpose of the investigation was to establish the boundaries of the deposits and to determine the quality of the dolomite on the basis of field examination and sample study. The geologic structure, which determines the underground position and extent of the dolomite, was also studied.

Field work and acknowledgments

The deposits were mapped from July 9 to September 25, 1943; a period of two weeks was spent at the deposit near Colorado Gulch, and approximately one month at each of the other two deposits.

The field work was expedited by the excellent preliminary planning and careful supervision of Charles Deiss, and the preparation of the illustrations has been facilitated by his arrangements as carried out by Ross Angle of the U. S. Forest Service. Comments by C. S. Ross on the igneous rocks of the deposits near Colorado Gulch and at Nelson Gulch have been incorporated in the report. The staff of the Cadastral Engineer's office of the U. S. Land Office in Helena assisted in adjusting the geologic maps to the land maps, and A. H. Tuttle of the U. S. Geological Survey in Helena made the facilities of that office available at all times. Finally, appreciation is expressed for the careful work of the instrument men, James W. Trow and his successor, George E. Erickson, U. S. Geological Survey, for on their precision the accuracy of the field mapping ultimately depends.

Stratigraphy

In the vicinity of Helena, Montana, rocks of the Precambrian Belt Series are overlain unconformably by Middle Cambrian strata that include the Flathead Quartzite, Wolsey Shale, Meagher Limestone, and Park Shale (Weed, 1899; Weed, in Knopf, 1913, p. 90-91; Deiss, 1936, p. 1303-1311). Of these only the last adjoins the dolomite deposits, but the Meagher Limestone is also shown on the map of the deposit near Colorado Gulch.

Conformably overlying the Middle Cambrian rocks are Upper Cambrian strata consisting of the Hasmark Dolomite (Emmons and Calkins, 1913, p. 57-61) and the Dry Creek Shale (Peale, 1893, p. 24; Weed, 1899; Weed, in Knopf, 1913, p. 91; Deiss, 1936, p. 1303-1311). As stated by Emmons and Calkins (1913, p. 63-64), the Hasmark is probably approximately equivalent to the Pilgrim Limestone (Weed, 1899), the name applied by previous writers to this unit in the vicinity of Helena (Weed, in Knopf, 1913, p. 91; Deiss, 1936, p. 1303-1311). All three dolomite deposits are in the Hasmark Dolomite. The Dry Creek Shale adjoins the deposits near Colorado Gulch and at Nelson Gulch.

Mantling parts of all three deposits are relatively thin sheets of hill slump, soil, and surface debris. Recent alluvium occupies the alluvial plain of Tenmile Creek at the north edge of the deposit near Colorado Gulch; the valley floor of Nelson Gulch and the lateral dry gully at the south edge of the deposit at Nelson Gulch; and the valley floor of Grizzly Gulch and the lateral dry gully at the southwest end of the deposit at Grizzly Gulch.

Origin of the dolomite

The Pilgrim Limestone has been described as a limestone, and its western equivalent, the Hasmark Dolomite, as predominantly a magnesian limestone containing about $6\frac{1}{2}$ percent MgO, but in the vicinity of Helena the composition approaches that of a true dolomite. It is inferred that the Hasmark has been locally dolomitized as a result of the intrusion of the Boulder batholith (which is exposed less than half a mile west of the deposit near Colorado Gulch) and by the accompanying (and later?) dikes and sills, which cut the two western deposits (Hewett, 1928, p. 860-861). Seemingly, the impervious Dry Creek and Park Shales confined the alteration to the intervening Hasmark Dolomite, for the Meagher Limestone and Jefferson Limestone are generally unaltered. South of the mapped area along Nelson Gulch, however, a green diorite dike has cut through the Dry Creek Shale into the Jefferson Limestone and has altered it to a dolomitic limestone.

To some extent the Hasmark Dolomite in all three deposits has been locally silicified by the action of hot springs, but silica was not present in appreciable amount in the original sediment. Hence, the silica and the accompanying iron oxides are relatively restricted. For want of evidence, the contacts between clean and silicified dolomite have been assumed to be vertical, although such a distribution is unlikely.

Dolomite Deposit Near Colorado Gulch

Location and ownership

The dolomite deposit near Colorado Gulch (fig. 2) is in the SW1/4 SE1/4 sec. 31, T. 10 N., R. 4 W., and the NW1/4NE1/4 sec. 6, T. 9 N., R. 4 W., about 6 miles west of Helena, on land owned by Lena B. Munding, Rimini Route, Helena, Montana.

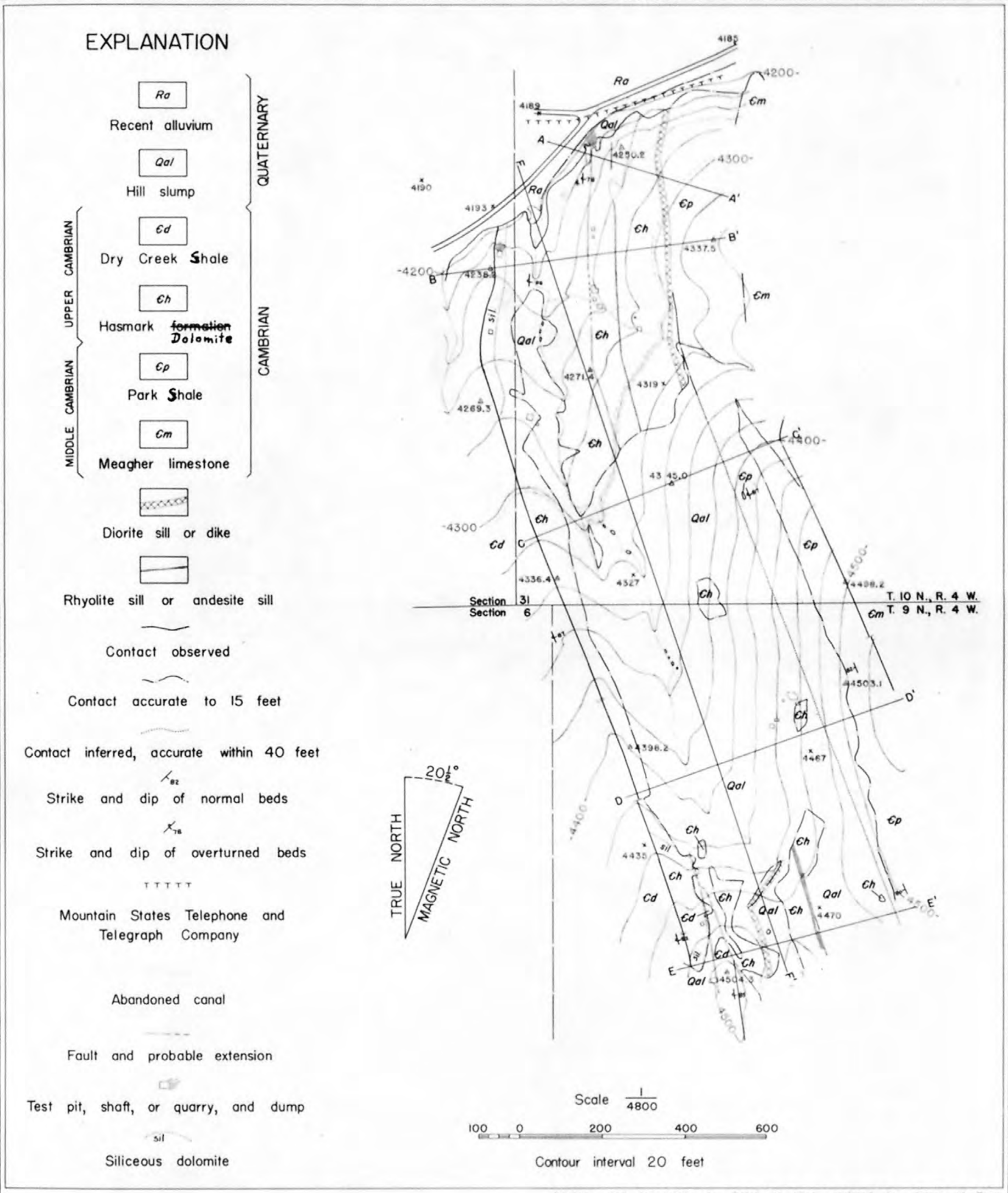
Composition of the dolomite

More than half the deposit is covered by hill slump, soil, and surface debris, possibly as much as 25 feet thick in places, and no samples of the rock thus concealed could be obtained. Five composite chip samples were collected, located as follows:

CC1 At 2-foot intervals for 128 feet across bottom part of Hasmark Dolomite from diorite sill at Park-Hasmark contact to lower fine-grained sill, along break of slope above road near northeast corner of mapped area.

CC2 At 2-foot intervals for 128 feet across bottom part of Hasmark Dolomite from diorite sill at Park-Hasmark contact to lower fine-grained sill, along swell north of forked gully and about 250 feet south of CC1.

CC3 At 3-foot intervals for 144 feet diagonally across bottom part of Hasmark Dolomite from diorite sill a few feet above Park-Hasmark contact to lower fine-grained sill, along abandoned canal on 4300-foot contour and 200 to 300 feet south of CC2.



Geology and topography by Ralph H. King assisted by James W. Trow
Surveyed in July 1943

Figure 2.- MAP OF DOLOMITE DEPOSIT NEAR COLORADO GULCH

CC4 At 3-foot intervals for 198 feet, excluding covered area, from lower fine-grained sill to siliceous ferruginous zone in upper 30 feet, west of CC3 and 350 to 500 feet south of the road.

CC5 At 3-foot intervals from Park-Hasmark contact to Hasmark-Dry Creek contact, except covered portions, in saddle at south end of mapped area.

Analyses of the samples by John E. Husted, U. S. Geological Survey, are as follows:

Table 1.--Analyses of dolomite samples from deposit near Colorado Gulch (in percent).

Sample	Insol. in HCl	R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (diff.)
CC1	2.28	0.56	30.18	53.87	43.29
CC2	3.34	0.41	29.83	53.24	43.01
CC3	3.14	2.43	29.14	52.01	42.42
CC4	0.58	0.36	20.58	54.58	44.48
CC5	1.65	0.49	30.31	54.10	43.76

The part of the Hasmark Dolomite lying above (west of) the lower fine-grained sill and extending from the road to section D-D' (fig. 2), is regarded as usable on the basis of sample CC4 and analyses of rock samples collected by C. F. Deiss and G. E. Erickson along the low bluff overlooking the road at the north end of the deposit. Of their seventeen samples, analyzed by the U. S. Bureau of Mines laboratory at Reno, Nevada, only one represented dolomite containing more than 1.5 percent insoluble material. The southern limit was approximated by interpolation between CC4 and CC5. Samples CC1, CC2, and CC3 clearly indicate that the dolomite below (east of) the lower fine-grained sill is too silicified to be usable, by present standards. The south end of the deposit, as shown by sample CC5, is somewhat siliceous, but more detailed sampling might indicate some usable rock.

Geologic structure

At the dolomite deposit near Colorado Gulch the Hasmark Dolomite dips almost vertically (fig. 2), and is on the west flank of an asymmetric, plunging anticline. At the north end of the deposit all formations are slightly overturned, and the dip is steeper on the west than on the east; hence the Hasmark seems to thicken slightly with depth. At the south end of the deposit the Park Shale and the Dry Creek Shale dip toward each other, only the Dry Creek Shale being overturned. Here the Hasmark Dolomite seems to thin slightly with depth, but a wedge of Dry Creek Shale faulted down into the Hasmark increases the apparent thinning (fig. 3, sec. E-E'). The representation of this feature on the section is diagrammatic, as lack of exposures prevented detailed study.

A green diorite sill has been intruded along the contact between the Park Shale and the Hasmark Dolomite at the north end of the deposit. About 500 feet south of the road the sill swings slightly into the Hasmark Dolomite. At the south end of the deposit similar green diorite, possibly continuous with the northern body, cuts sharply across the bedding for about 150 feet, then follows the bedding southward for about 175 feet, both ends of this exposure being covered with hill slump. In the dump material around the smallest of the group of five test pits just north of section D-D', there are bits of weathered diorite.

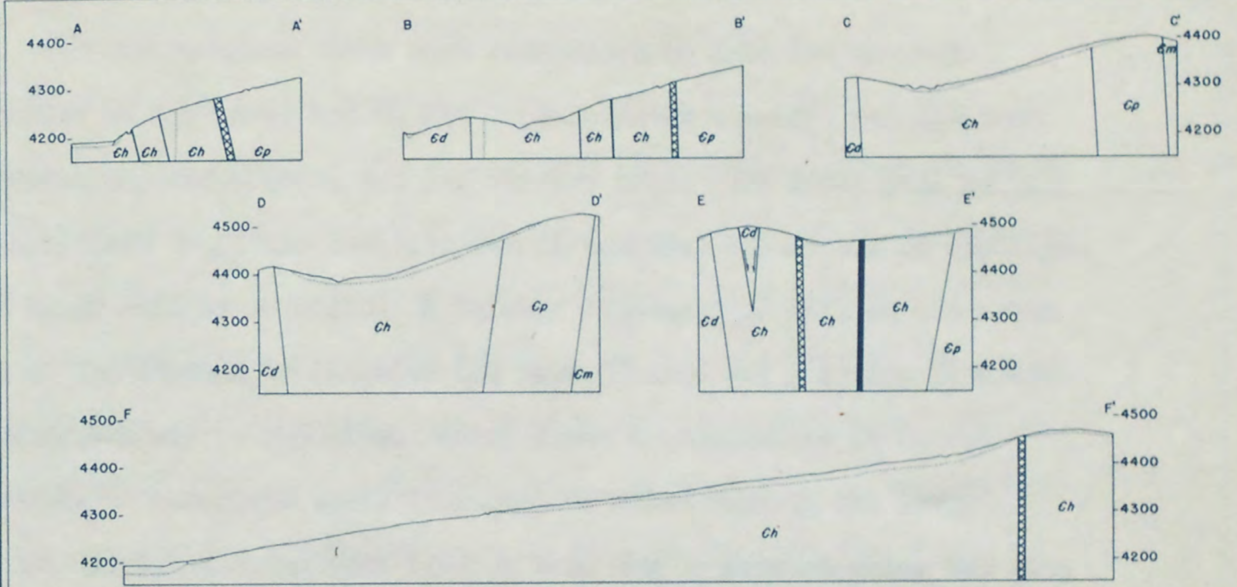


Figure 3.- STRUCTURE SECTIONS ACROSS DOLOMITE DEPOSIT NEAR COLORADO GULCH

Cm - Meagher limestone   Cp - Park shale   Ch - Hasmark formation   Cd - Dry Creek shale

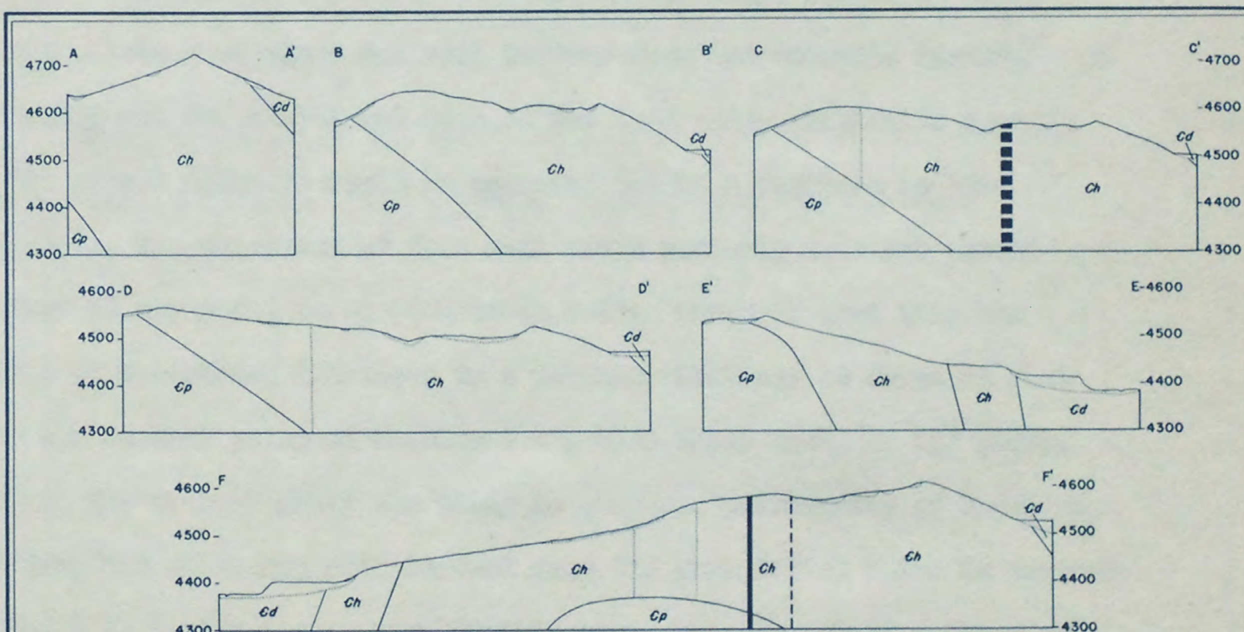


Figure 4.- STRUCTURE SECTIONS ACROSS DOLOMITE DEPOSIT AT NELSON GULCH

Cp - Park shale   Ch - Hasmark formation   Cd - Dry Creek shale

Two fine-grained sills have been intruded into the Hasmark Dolomite at the north end of the deposit about 110 feet and 170 feet respectively above (west of) the diorite sill. The lower sill is too much altered to permit positive identification, but it may be rhyolite. The upper sill is andesite. A thicker fine-grained sill at the south end of the deposit is likewise too much altered for positive identification, but may be rhyolite. Under these circumstances it is not feasible to correlate these fine-grained sills beneath the large covered area, although some igneous rock may be present along the line connecting the known bodies.

Mining conditions

Over the northern part of the deposit the small amount of overburden consists of slump and soil derived from the dolomite itself. Virtually all the silica and much of the iron oxide originally present in the eroded dolomite would be concentrated as a residuum in this material. The thickness of this soil cover probably does not exceed 10 feet at any point north of section C-C'. South of that line the amount of overburden increases to a maximum thickness of about 25 feet near the central gully at section D-D', then thins again to the south. East of the central gully the slump is composed principally of boulders, cobbles, and siliceous soil derived from the Park Shale, which is exposed on the hill to the east. Even in this area, however, small patches of dolomite crop out through the soil or slump, so the average thickness of the overburden probably is less than 15 feet.

Obviously exploitation would involve quarrying a long narrow trough following approximately the present gully. The uppermost benches on the east side would encounter siliceous dolomite and those on the west side would reach Dry Creek Shale, as limits of the workable rock. In order to extend lower benches to the same limits and still maintain safe working faces it would be necessary to extend the upper benches into waste. On the west side of the deposit the Hasmark-Dry Creek contact lies along the crest of a low ridge, but on the east side of the deposit the slope continues to rise to the east for scores of feet; within a few feet of the east edge of the deposit the amount of dolomite recovered would be exceeded by the amount of waste to be removed. Calculation of the recoverable reserves as a percentage of the total reserves involves the economic factor of dolomite-to-waste ratio.

The igneous rock of the upper sill would have to be removed from the quarried dolomite. Hand sorting would probably be the most economical method.

Production

The deposit has not been developed. The small quarries at the road fork yielded a small but unknown quantity of building stone for local use.

Deposit at Nelson Gulch

Location and ownership

The dolomite deposit at Nelson Gulch (fig. 5) is in the SE1/4 sec. 6 and the W1/2SW1/4 sec. 5, T. 9 N., R. 4 W., about 6 miles west of Helena. The E1/2 sec. 6 is owned by Lena B. Munding, Rimini Route, Helena, Montana, but a placer claim along Nelson Gulch is owned by the Broadwater Co., 2921 Chapman Street, Oakland, California. The SW1/4 sec. 5 is U. S. Government forest land.

Composition of the dolomite

Irregular areas near the center of the deposit and long shallow gullies extending north-northeast across the eastern part of the deposit are obscured by thin cover, but numerous composite chip samples across various parts of the deposit are thought to give a good idea of the quality of the dolomite at the surface. Samples collected were numbered as follows:

CN1 At 3-foot intervals from Park-Hasmark contact to alluvium of Nelson Gulch, along gully at northwest corner of mapped area.

CN2 At 2½-foot intervals near north end of section C-C' from point about 5 feet above Park-Hasmark contact to crest of ridge.

CN3 At 2½-foot (stratigraphic) intervals, from end of CN2 southward to alluvium of gully at south edge of deposit about 300 feet west of line between secs. 5 and 6, i.e., near D'.

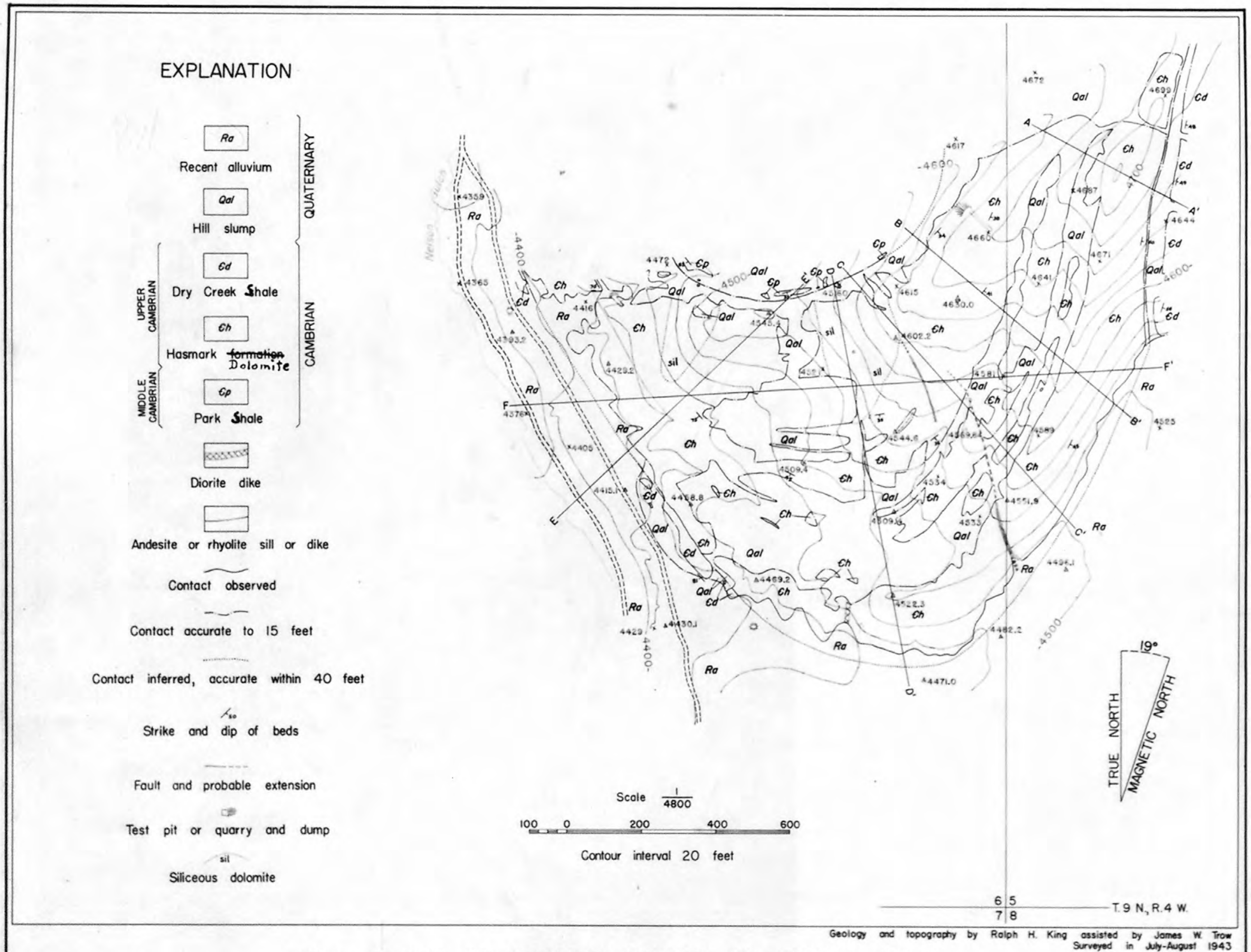


Figure 5.- MAP OF DOLOMITE DEPOSIT AT NELSON GULCH

CN4 At 5-foot intervals from test pit in faulted dike to section D-D', along edge of alluvium in gully at south edge of deposit.

CN5 Continuation of CN4 westward to test pit in alluvium 200 feet east of road, at south edge of mapped area.

CN6 Continuation on CN4 to line of section B-B'.

CN7 At 3-foot (stratigraphic) intervals from test pit east of B southeastward to Hasmark-Dry Creek contact north of F'.

CN8 At 3-foot intervals between station marked 4521 and station marked 4602.2 about 50 to 100 feet north of section F-F', across siliceous area in north-central part of ore body.

Analyses of the samples by Norman Davidson, U. S. Geological Survey, are as follows:

Table 2.--Analyses of dolomite samples from deposit at Nelson Gulch (in percent)

Sample	Insol. in 1:3 HCl	R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (diff.)
CN1	0.88	0.50	27.84	49.69	48.93
CN2	.52	.42	30.80	54.97	44.09
CN3	.46	.22	30.44	54.33	44.99
CN4	.54	.44	30.34	54.15	44.87
CN5	.74	.56	29.90	53.37	45.33
CN6	.18	.56	29.72	53.04	46.22
CN7	.12	.62	29.92	53.40	45.86
CN8	.50	.36	29.74	53.08	46.06

Note that the $MgCO_3$ content of four of the samples slightly exceeds the theoretical 45.66 percent of dolomite.

Geologic structure

The deposit is in a south-plunging asymmetric anticline (fig. 5). The west limb is appreciably steeper than the east, and the structure plunges steeply to the south. At the surface the axis occupies approximately the position of section D-D' (fig. 4), but underground it shifts progressively eastward because the axial plane is tilted.

Igneous rocks include a thin fine-grained sill 200 feet northeast of the road at the northwest corner of the deposit, an altered coarse-grained dike mapped as diorite about 120 feet west of section D-D', two fine-grained discontinuous dikes trending north-northwest near section C-C', and a probable sill of fine-grained rock, represented only by float, southeast of the intersection of sections D-D' and F-F'. All these rocks have been too extensively altered to permit positive identification except a small body of andesite adjacent to the coarse-grained dike, possibly a chilled border phase of that rock. It is possible, however, that other igneous rocks are present. The shallow elongate swales now filled with slumped material may be along altered sills that weather readily. The slump-filled groove that "pinches" the 4700-foot contour at the northeast corner of the mapped area may contain a small dike. It is noteworthy that the igneous rocks follow concentric and radial patterns with respect to the anticlinal nose.

The only fault observed is associated with the dike at the south edge of the deposit and almost on the line between secs. 5 and 6. Fine fault gouge and breccia are exposed in the test pit at the edge of the alluvium, but the extent and displacement of the fault are unknown. The dike rock is more extensively altered here than elsewhere, some large cobbles being changed almost entirely to chlorite.

Siliceous and ferruginous spring deposits occupy two relatively small areas at the north edge of the deposit where the dolomite is thinnest. The amount of impurities introduced by the springs is very small, however. (Sample CN8). The presence of small crystals and crystalline nodules of transparent to translucent bright-green tourmaline in these deposits deserves mention, although the significance, if any, is not known.

Tremolite in radiating fibrous bundles is present in the northwest corner of the mapped area, between the sill and the alluvium of Nelson Gulch, but was not observed elsewhere.

Mining conditions

The overburden on the deposit at Nelson Gulch consists mainly of thin irregular patches of dolomite slump and soil which cover much of the central part to a depth of 10 feet or less. A few long shallow swales filled with slump to a depth of 10 feet or less extend north-northeast across the eastern part of the deposit. The Dry Creek Shale dips steeply off the deposit along the east edge. Although relatively thick as overburden, the Dry Creek Shale occupies only a narrow belt, owing to its dip of 48° to 56° and its extensive removal by erosion in the gully that follows its outcrop around the structure. The slump is derived from the dolomite, and except in areas of silica and iron oxide concentration it would not need to be removed.

The deposit forms a curving ridge between two gullies that enter Nelson Gulch from the east. This ridge, which is low near Nelson Gulch, rises gradually to the middle of the deposit, then more abruptly eastward to a crest near the northeast corner of the mapped area. To mine it by surface excavation to the top of the Park Shale and to the level of the south gully would involve removal of only a small amount of overburden.

Only at the northwest corner would it be necessary to remove waste or leave dolomite in place in order to maintain a safe working face. Elsewhere the work could proceed inward from all sides or from the south, southeast, and east. Furthermore, the face northwest of section E-E' would be relatively low, and only a small amount of waste would be involved. Possibly part or all of the waste material thus removed could be milled, as it is siliceous dolomite and the overall average content of insoluble material and R_2O_3 would still be less than 2 percent. The deposit, therefore, is virtually all recoverable.

It might be feasible to quarry to the level of the valley floor of Nelson Gulch, which is about 20 feet lower than that of the south gully at its mouth. If this procedure were followed, it would probably be necessary to maintain a drainage ditch through the quarry to Nelson Gulch, or to build a levee down the south gully to prevent runoff into the quarry, or both.

The various igneous rocks would have to be removed. Hand sorting would probably be the most economical method.

Production

The deposit has not been developed. The small quarry 225 feet east of the road in the gully at the northwest corner of the mapped area yielded a small but unknown amount of building stone for local use.

Deposit at Grizzly Gulch

Location and ownership

The deposit at Grizzly Gulch (fig. 6) is in the NE1/4SW1/4 sec. 36, T. 10 N., R. 4 W., and extends a few feet into the adjoining NW1/4SW1/4 and NW1/4SE1/4 of the same section, on the southwestern outskirts of the city of Helena. Nine or ten mining claims are located partly or wholly within the mapped area, surface rights to three tracts on government land and nine on mining claims are privately owned, and the residue seems to be government land. Part of the records were not completed or have been lost.

Geology and topography by Ralph H. King assisted by James W. Trow and George E. Erickson
Surveyed in August-September 1943

Figure 6.- MAP OF DOLOMITE DEPOSIT AT GRIZZLY GULCH

Composition of the dolomite

Despite the steep slopes that characterize this deposit, two fairly extensive areas are covered with slump and soil (fig. 6). Inasmuch as the larger of these seems to be underlain almost entirely by siliceous dolomite, however, the few samples obtained should give a general idea of the character of the deposit. The samples collected were numbered as follows:

CG1 Composite chip sample from ± 30 feet above Park-Hasmark contact above old kilns east of section D-D' northward across main quarry.

CG2 Composite chip sample at 6-foot intervals along contour east of station marked 4346.7, about 90 feet east of section B-B', across the siliceous dolomite.

G1 Rock Sample 30 feet north of station marked 4313, north of old kilns east of section E-E'.

G2 Rock sample from main quarry.

G4 Rock sample 10 feet southwest of station marked 4551.0, near northwest end of section D-D'.

G7 Rock sample near west end of line of sample CG2.

Composite chip sample 43328 was collected by C. F. Deiss and G. E. Erickson from the Hasmark Dolomite between the larger patch of Park Shale at the southwest end of the deposit and a point near the northwest end of section E-E'.

Analyses of these samples by Esther Claffy, of the U. S. Geological Survey chemical laboratory, are as follows:

Table 3.--Analyses of dolomite samples from deposit at Grizzly Gulch (in percent).

Sample	Insol. in 1:3 HCl	R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (diff.)
CG1	1.69	0.34	30.41	54.28	43.69
CG2	10.22	.61	28.30	50.52	38.65
G1	23.28	.67	25.39	45.31	30.74
G2	0.67	.58	30.61	54.63	44.12
G4	2.08	.29	30.53	54.49	43.14
G7	30.65	1.05	21.23	37.88	30.42
43328	0.68	.46	30.93	55.18	43.68

Only a small part of the Hasmark Dolomite in the deposit at Grizzly Gulch contains less than 1.5 percent insoluble matter at the surface. The two principal bodies of relatively clean dolomite are a roughly semi-elliptical area on both sides of section B-B' southeast of section F-F' and an elongate area extending from the main quarry upward and westward beyond section E-E' northwest of section F-F'. A third area, along section A-A' at the northeast end of the deposit, is very small. There is also a small area of clean dolomite at the southwest end of the mapped area.

Geologic structure

The structure of the deposit is a broad, slightly asymmetric syncline plunging gently southeast (figs. 6 and 7). In general the northeast limb dips gently southwestward and the southwest limb dips eastward to northeastward somewhat more steeply. Local minor deviations are common and erratic.

Faults of small but unknown displacement are abundant, but are not easily located except where silicification of the fault breccia has produced a hard buff rock that resists weathering and stands out against the light-gray dolomite. Nearly all these small faults are strike faults, and their slip is along their strike. They are especially numerous and prominent at the southwest end of the deposit, but are scattered throughout the area.

Two shear zones of unknown displacement trend approximately at right angles to the strike of the beds, one on each limb of the syncline. The northeastern one, which trends slightly east of north, is exposed in a test pit on the ridge and in a tunnel near the base of the slope near the intersection of sections A-A' and F-F'. Its northward extension across the small gully and beyond the mapped area has resulted in the formation of a small but prominent escarpment 15 to 20 feet high crossing the next ridge. The other shear zone is exposed in the pit and tunnel south of the intersection of sections E-E' and F-F' and in the tunnels and pits 200 to 350 feet east of them. Along this shear zone small pockets of high-grade talc are developed in the

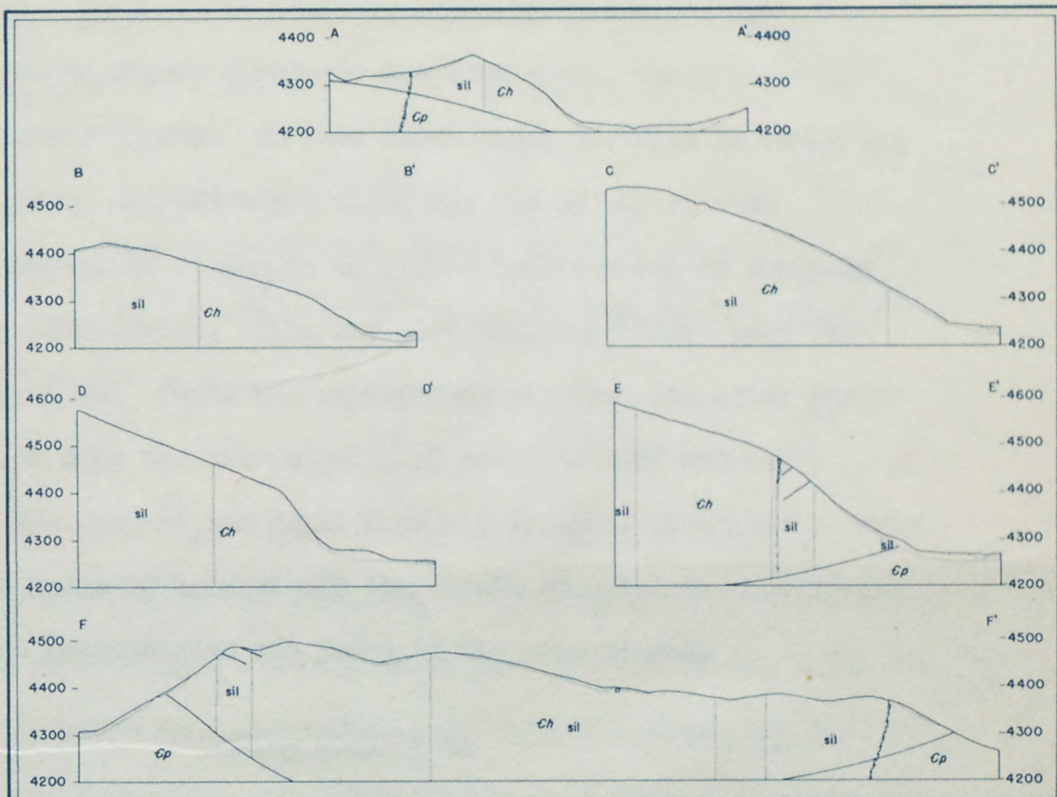


Figure 7.- STRUCTURE SECTIONS ACROSS DOLOMITE DEPOSIT AT GRIZZLY GULCH

Cp - Park shale   Ch - Hasmark formation dolomitic gouge. Coarsely crystalline dolomite is common, and there are traces of copper carbonate and iron oxide, the last being pseudomorphic after pyrite. In both shear zones the slip is along the strike of the zone, and therefore along the dip of the strata.

Spring-deposited silica is widely distributed and is commonly accompanied by iron oxides, which are especially prominent near the axis of the syncline. Small but well-formed pseudomorphs after pyrite cubes are common near the intersection of sections B-B' and F-F', especially in the dump at the small test pit north of that point. This mineralization seems to be entirely the result of extensive hot-spring activity, as no igneous rock was found in the area mapped.

Mining conditions

The only extensive area where overburden covers supposedly clean, usable dolomite is the slight gully between sections D-D' and E-E'. The maximum thickness is probably less than 10 feet.

Judging by surface evidence, the usable dolomite consists of two pockets surrounded on three sides by siliceous dolomite. The eastern pocket, that on both sides of section B-B', could be quarried by semi-circular benches down to the road level, but the other is more irregular. In both pockets the northwest face is the highest. As in the deposit near Colorado Gulch, it would be necessary to remove waste or else leave dolomite in place in order to maintain a safe working face, and the removal of waste is practicable only along the south and southwest sides of the west pocket. Estimation of recoverable reserves therefore involves a major economic factor.

Production

The quarries yielded an unknown amount of dolomite for burning in the local lime kilns many years ago. The dolomite deposit has not been developed for other uses.

Conclusions

Only in the deposit at Nelson Gulch do reserves recoverable by quarrying approach 100 percent of total reserves, although the recoverable reserves of the deposit near Colorado Gulch are probably on the order of 75 percent of the total reserves. Too little is known about the subsurface character of the deposit at Grizzly Gulch to justify any estimate of the percentage recoverable; in fact there is considerable doubt that the dolomite is actually minable to the extent indicated or inferred. On the basis of the estimates of total reserves and percentage recoverable, only the deposit at Nelson Gulch seems to merit individual consideration. Total reserves in the three deposits perhaps approaches 13,825,000 tons, of which perhaps 8,400,000 tons is recoverable. The deposits near Colorado Gulch and at Grizzly Gulch might yield supplementary amounts of dolomite for processing in a plant built to utilize dolomite from the deposit at Nelson Gulch.

Calkins, F. C., and Emmons, W. H., 1915, Description of the Philipsburg quadrangle: U.S. Geol. Survey Geol. Atlas, Philipsburg Folio 196, p. 1-25, pls. 1-12, maps, sections.

Describes the geology of a region 45-80 miles west-southwest of Helena. Same general material as Emmons and Calkins, 1913.

Deiss, C. F., 1936, Revision of type Cambrian formations and sections of Montana and Yellowstone National Park: Geol. Soc. America Bull., v. 47, p. 1257-1342, 2 pls., figs. 1-10.

Discusses Cambrian strata of the entire region, including a section at Helena. Reconciles or corrects earlier literature on these rocks.

____________ 1943, Stratigraphy and structure of southwest Saypo quadrangle, Montana: Geol. Soc. America Bull., v. 54, p. 205-262, pls. 1-5, figs. 1-3.

Describes the geology of a region 65-80 miles northwest of Helena, including an almost totally different Cambrian section.

Emmons, W. H., and Calkins, F. C., 1913, Geology and ore deposits of the Philipsburg quadrangle, Montana: U.S. Geol. Survey Prof. Paper 78, p. 1-271, pls. 1-17, figs. 1-55.

Describes the geology of a region 45-80 miles west-southwest of Helena. Herein the Hasmark Dolomite is first named and described, and it is tentatively correlated with the Pilgrim limestone.

Hewett, D. F., 1928, Dolomitization and ore deposition: Econ. Geol., v. 23, p. 821-863, figs. 1-8.

Discusses dolomitization of limestone in connection with metalliferous deposits, but data and conclusions are not restricted to such deposits.

Knopf, Ad., 1913, Ore deposits of the Helena mining region, Montana: U.S. Geol. Survey Bull. 527, p. 1-143, pls. 1-7, figs. 1-4.

Describes the rocks in the vicinity of Helena. Uses "Pilgrim Limestone" instead of "Hasmark Formation," the latter term not having been introduced until that same year. On pl. 7, p. 86, the southeast slope of Mount Helena is erroneously mapped as Devonian, for reasons not explained in the text, where these beds are classified as Pilgrim Limestone. Pl. 7 and p. 86-98 are taken from an unpublished report by W. H. Weed.

Peale, A. C., 1893, The Paleozoic section in the vicinity of Threeforks, Montana: U.S. Geol. Survey Bull. 110, p. 1-56, pls. 1-6, figs. 1-2.

Describes the geology of a region about 75 miles south-southeast of Helena. Herein are named and described the Cambrian Dry Creek Shale and the Devonian Jefferson Limestone.

__________ 1896, Description of the Threeforks sheet: U.S. Geol. Survey Geol. Atlas, Threeforks Folio 24, p. 1-5, maps, sections.

Describes the geology of a region 40-125 miles south-southeast of Helena. Same general material as Peale, 1893.

Weed, W. H., 1899, Description of the Fort Benton quadrangle: U.S. Geol. Survey Geol. Atlas, Fort Benton Folio 55, p. 1-7, maps, sections.

Describes the geology of a region 60-140 miles northeast of Helena. Herein the Park Shale and the underlying Meagher Limestone are first named and described, as is the Pilgrim Limestone, which may be equivalent to the Hasmark Dolomite.

__________ 1899a, Description of the Little Belt Mountains quadrangle: U.S. Geol. Survey Geol. Atlas, Little Belt Mountains Folio 56, p. 1-9, maps, sections.

Describes the geology of a region 50 to 100 miles east of Helena adjoining the Fort Benton quadrangle (Weed, 1899) on the south.

__________ 1900, Geology of the Little Belt Mountains, Montana: U.S. Geol. Survey 20th Ann. Rept., pt. 3, p. 257-461, pls. 36-77, figs. 36-79.

Essentially the same as Weed, 1899a, insofar as it pertains to the Cambrian and Devonian rocks that are also exposed near Helena.