Fluorspar Deposits Near Meyers Cove Lemhi County, Idaho

GEOLOGICAL SURVEY BULLETIN 1015-A

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By D. C. COX

A CONTRIBUTION TO ECONOMIC GEOLOGY

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A study of fluorspar deposits in the Gravel Range mining district of the Salmon River Mountains

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By D. C. Cox

ABSTRACT

The fluorspar deposits near Meyers Cove, Lemhi County, Idaho, are localized along three groups of shear zones: one group strikes northeast and dips steeply northwestward, another strikes northeast and dips gently northwestward, and the third strikes northwest and dips gently southwestward. The country rocks are tuffs and flows of the Casto volcanics of Permian(?) age and the Challis volcanics of late Oligocene or early Miocene age. The known deposits are in a belt about 3 miles long and 2 miles wide and crop out at altitudes between 5,100 feet and 7,200 feet above sea level.

The principal vein minerals are fluorite, chalcedony, and barite. The fluorite occurs as lodes, crusts around fragments of rock, and replacements of fine breccia. The lodes range in size from veinlets to vein zones several hundred feet long and as much as 20 feet wide and contain ore that ranges in grade from 40 percent to 85 percent CaF_2; the average grade is about 50 percent CaF_2.

INTRODUCTION

LOCATION AND GENERAL FEATURES

The fluorspar deposits near Meyers Cove are in the Salmon River Mountains in the Gravel Range mining district of western Lemhi County, Idaho. (See fig. 1.) Meyers Cove is a small settlement on the terraces of Camas Creek, a tributary to the Middle Fork of the Salmon River. Meyers Cove is in sec. 6, T. 17 N., R. 17 E., Boise meridian; the deposits are in an unsurveyed area about 2 miles north of, and downstream from, Meyers Cove. Fluorspar has been found on both sides of Camas Creek in a belt about 3 miles long and 2 miles wide. This belt (pl. 1) trends southeast from the nose of the ridge north of Duck Creek, a tributary to Camas Creek, to the ridge south of Fluorspar Gulch, a name used locally for the first gulch south of Duck Creek and first applied by A. L. Anderson (1943, p. 3). In this belt Camas Creek is a little more than 5,000 feet above sea level. The fluorspar deposits are 100 to 2,200 feet above stream level.

The area is well dissected; the mountains have steep, relatively uniform slopes and sharp ridges. The larger valleys contain a few narrow, low terraces. Spurs on both sides of Camas Creek rise to altitudes of more than 9,000 feet within 4 miles of the creek. Northward-facing slopes in the area generally are covered by thick soil that

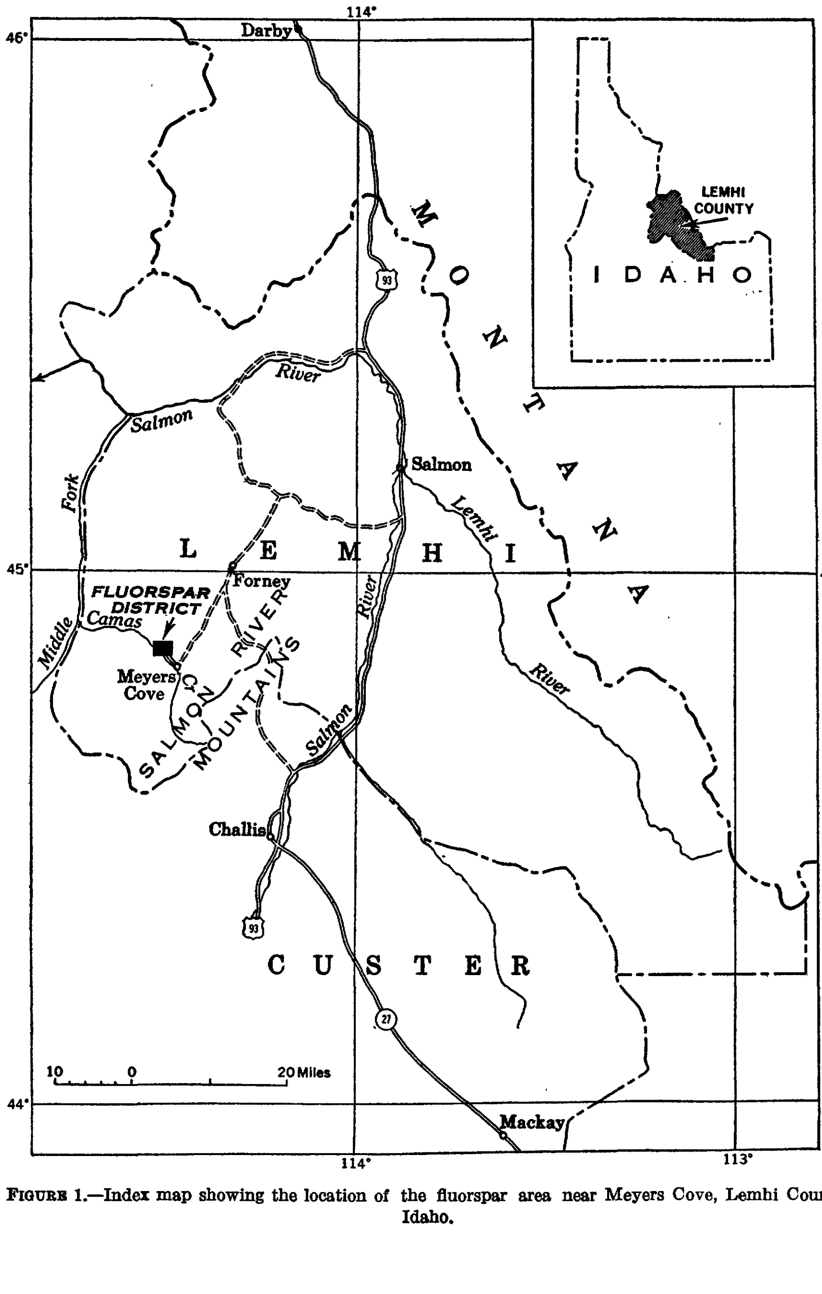

FIGURE 1.—Index map showing the location of the fluorspar area near Meyers Cove, Lemhi County, Idaho.

supports the growth of heavy evergreen forests, and the bedrock is concealed. Southward-facing slopes, however, are generally grassy, and bedrock crops out abundantly.

A graded road from Meyers Cove to some of the deposits was completed in July 1943 by the United States Forest Service. The road leads down Camas Creek about a mile, then climbs steeply up Fluorspar Gulch to the ridge between the gulch and Duck Creek. In the winter of 1943–44 Chamac Mines Co. built a road from the Forest Service road down Camas Creek for an additional 2 miles.

Meyers Cove is accessible from both Challis and Salmon by graded roads, which are graveled for most of their lengths. The road from Challis crosses a 7,500-foot divide and is about 50 miles long. Meyers Cove may be reached from Salmon by two routes: a shorter road about 65 miles long, that crosses an 8,000-foot divide and an alternate route 106 miles long that avoids this pass.

The nearest railroads are Darby, Mont., on a spur line of the Northern Pacific Railway, and Mackay, Idaho, on a spur line of the Union Pacific Railroad. Darby is 78 miles north of Salmon over graveled and paved roads, and Mackay is 54 miles southeast of Challis over paved roads.

PREVIOUS FIELD WORK

The geology of the Casto quadrangle, which contains most of the fluorspar deposits, was mapped and described by Ross (1934), who mentioned the occurrence of fluorite in some of the mineralized areas. Both Ross (1927, 1934) and Anderson (1943) described an antimony deposit near Meyers Cove that contains fluorite.

The fluorspar deposits, discovered in 1942, were first described by A. L. Anderson (1943), who made a reconnaissance study of the area in July of that year. In September 1942 J. W. Taber made a preliminary examination of the fluorspar deposits (U. S. Bur. Mines, 1943). Flotation tests on fluorspar from the district were made by the Idaho Bureau of Mines and Geology (Prater, 1943). In 1944 the U. S. Bureau of Mines trenched and sampled some of these deposits (U. S. Bur. Mines, 1945).

As part of the wartime fluorspar investigations by the U. S. Geological Survey, the author spent about a month mapping and studying the deposits near Meyers Cove during August and September 1943. During part of September J. O. Fisher assisted with this field work. The author revisited the area in June and September of 1944.

ACKNOWLEDGMENTS

Chamac Mines Co. furnished information about the deposits, for which acknowledgment is gratefully made. A. E. Chambers, owner

and manager, who was especially helpful in making accommodations available at the mining camp, deserves particular mention. Thanks are also due other individuals residing in the district and to officials of the Challis National Forest.

The base line and transit triangulations in the vicinity of the Red Spar and Purple Spar Lodes were made in cooperation with the U. S. Bureau of Mines.

GEOLOGY

LITHOLOGY

The rocks of the area are mainly tuffs and flows that range in composition from rhyolite to andesite, but a few small bodies of granophyre and lamprophyre also are present (pl. 1). The two small exposures of quartzite of pre-Cambrian age that Ross (1934, pl. 1) mapped on the east side of Duck Creek were not found because time was lacking.

The contact between the Casto (Permian?) and Challis (Tertiary) volcanics was mapped in the fluorspar area with the assistance of C. P. Ross. The distinction between these two formations is based principally on regional evidence and locally upon the degree of alteration of some of the original minerals, especially feldspars and dark minerals, in the flows and tuffs. The Challis volcanics generally are lighter colored, more finely jointed, and more conspicuously bedded than the Casto volcanics. In several places, however, the Challis is the darker, as along the contact between these two formations mapped on the ridge between Duck Creek and Fluorspar Gulch. Most of the Crystle lodes are in the Challis volcanics, but the Big Lead and the North Lead are in the Casto volcanics, as are all of the Purcell lodes that are not in intrusive masses.

The tuffs commonly are very difficult to distinguish from the flows. Some sandy rocks are almost certainly water-laid tuffs and some porphyritic rocks are definitely flows, but many of the rocks containing fine-grained rock fragments and feldspar crystals or fragments in a glassy groundmass may be either tuffs or flows. The banding, which is common in many of the unidentifiable rocks, may be either flow banding or bedding in a tuff. The glass in both tuffs and flows is generally devitrified.

Several irregular bodies of granophyre, which are a few tens to more than 1,000 feet across, have been mapped. Granophyre fragments in talus in various parts of the area indicate the presence of more granophyre bodies than have been mapped. The granophyre is pinkish brown, weathering to buff, and consists of rectangular phenocrysts of feldspar as much as one-fourth of an inch across and round phenocrysts of quartz as much as one-eighth of an inch across in a fine-grained groundmass. Some dark rocks in the area contain phenocrysts similar to those of the granophyre but have a glassy groundmass that commonly shows flow banding; these are regarded as units of the Casto volcanics. Although the granophyre is probably of Miocene age, none of these intrusive bodies were found in Challis rocks of late Oligocene or early Miocene age. The soil above granophyre bodies has a yellowish cast that is distinctive from the dark soil above Casto volcanics. Yellow soils that do not appear to have been derived from the granophyre, however, occur at some places.

The granophyre bodies apparently were favorable for the formation of fluorspar deposits. Many of the Purcell lodes are in or adjacent to granophyre bodies. The fluorspar is clearly later than the granophyre because it is found in shear zones that cut the granophyre. The localization may be structural, due to some difference in physical properties between the granophyre and the surrounding Casto volcanics.

Several bodies of lamprophyre were found in the Meyers Cove area. Most of the bodies are lenticular and range in length from a few tens of feet to several hundred feet. The lamprophyre is a black, generally very fine grained rock, although in a few places feldspar laths can be seen with the unaided eye. The lamprophyre was intruded after the granophyre was emplaced and before the fluorspar mineralization occurred. About 500 feet southwest of the Purple Spar Lode (pl. 1), lamprophyre has intruded granophyre, and south of the Big Lead fluorspar cuts a lamprophyre body (pl. 2).

STRUCTURE

According to Ross (1934, p. 77) the fluorspar area is on the southeast flank of a broad, low anticline whose axis is 6 to 8 miles to the northwest; the original average dip of the Tertiary rocks on this southeast flank was not much over 5°, but in minor flexures, as at Meyers Cove, the dip is generally 45° or more. The attitude of bedding is difficult to determine in most of the fluorspar area. On the north slope of the ridge between Duck Creek and Fluorspar Gulch the strikes range from N. 40° E. to N. 65° E. and the dips range from 40° to 80° SE. The steep dips near Fluorspar Gulch probably represent local extreme steepening of a subordinate flexure.

One group of steep normal faults in the region has an average trend of about N. 37° E., and a second group has an average trend of about N. 27° W. (Ross, 1934, p. 77–78). Several faults or shear zones of the northeast-trending group were found in the fluorspar area. Their courses commonly are marked by silicified rock and, in the northern part of the area, by fluorspar deposits. Two groups of gently dipping shear zones trending northeast and northwest also are mineralized and contain the best fluorspar deposits in the southern part of the area.

FLUORSPAR DEPOSITS

HISTORY OF DISCOVERY

Although the stibnite-barite deposit near Meyers Cove had been known for many years (Ross, 1927) and fluorite was noted in the vein material (Ross, 1934, p. 132), the fluorspar deposits in the area about a mile to the north were not discovered until the summer of 1942 (Anderson, 1943, p. 1).

Two principal groups of claims have been located on the fluorspar deposits. The southeastern, or Crystle, group was located in 1942 by Reese Miles and Roy Johnson of Salmon, Idaho. The northwestern group, known as the Purcell (also Parcell) group, was located in the summer of 1943 by H. V. St. Clair, Don Shulenberger, and Elmer Purcell, of Shoup, Idaho. Chamac Mines Co. owned the Purcell group in 1943 and had an option on the Crystle group.

LOCALIZATION

The fluorspar deposits are in northeast-striking shear zones with steep northwesterly dips, northeast-striking shear zones with gentle northwesterly dips, and northwest-striking shear zones with gentle southwesterly dips. The steep shear zones that strike northeast probably represent the regional group of steep normal faults whose strike averages about N. 37° E. Strikes in the fluorspar area range from N. 10° E. to N. 45° E., and dips range from 60° to 75° NW. In the northern part of the area these steep shear zones contain fluorspar deposits. The Purple Spar, Red Spar, and Florspar Lodes (pl. 1) have northeast strikes and steep northwest dips, and all may be in or near the same shear zone, although the fluorspar lodes are probably not continuous between any of the exposed deposits. The Morning Sun Lode and the northwesternmost heavily silicified zone shown on plate 2 also are on steep northeast-striking shear zones.

Most of the fluorspar deposits in the southern part of the area are on shear zones that strike from N. 20° E. to N. 45° E. and dip from 20° to 45° NW. Three of these zones were traced for several thousand feet, and several shorter ones are exposed on the south slope of Fluorspar Gulch. (See pl. 1.) The short mineralized shear zone (North Lead) exposed on the north side of the ridge between Duck Creek and Fluorspar Gulch at an altitude of about 6,750 feet may be a more gently dipping branch of the long mineralized shear zone (Bear Trap Lead) exposed on the south side of the ridge. The Big Lead, the most promising deposit in the southern part of the area, is on a shear zone whose strike ranges from north to N. 60° W., averaging N. 20° W., and whose dip ranges from 35° to 45° W. or SW.

In general, individual shears in several of the gently dipping zones are short, and these may differ widely in attitude from the attitude of the whole zone. An individual shear generally is steeper than the zone of which it is a part. Slickensides and striations are common. The plunge of the striations is generally about as steep as the dip of the shear surface; the direction of plunge rarely diverges from the direction of dip by more than 15°.

Most of the important fluorspar deposits are in those parts of the zones that are greatly fractured or brecciated. The fluorspar deposits are massive veins in fissures, replacements of the finer parts of breccias and even of fragments in the breccias, crusts around fragments, and fillings of openings that were formed either by late movement in the shear zones or by shrinkage due to decrease in volume resulting from replacement.

MINERALOGY

Only fluorite, chalcedony, and barite can be distinguished by eye in most of the fluorspar deposits. Calcite was not recognized in the veins, but samples contain one-half of one percent to several percent of calcite or other carbonates. (See table 1.)

The fluorite occurs chiefly in coarsely crystalline massive and fine-grained columnar forms. The earliest fluorite deposited was of two varieties: white, purplish, or greenish, coarse-grained aggregates or masses; and white, moderately fine grained aggregates. The later fluorite was also deposited in two forms: as concentric colorless, white, purple, or greenish, very fine granular coatings; and purplish or white, finely or coarsely columnar coatings. In some of the deposits, late colorless cubic crystals are a quarter to half an inch across. Purple fluorite with complexly crested edges fills a narrow vein in one deposit. In some deposits fluorite has replaced country rock for a distance of a few inches to 1½ feet beyond the walls and also has replaced wallrock fragments within the veins. The resulting material is white and resembles silicified country rock except that it is softer.

Chalcedony forms a small part of the veins, perhaps 10 percent at most where fluorite is present. Intensely silicified rock and chalcedony together commonly form from 30 to 60 percent of the veins, and silicified rock marks the extensions of veins in many places where no fluorite occurs. The wall rocks for a distance of a foot or two beyond the veins, and inclusions of country rock in the veins, generally are intensely silicified. Silicified rock is common for distances of several tens of feet from the veins. As a result of the extensive silicification, the veins and adjacent wall rocks are the best outcrops in the area and in many places form conspicuous ledges.

The chalcedony, which is generally white, was deposited early, probably contemporaneously with silicification of the country rock, and also late, as it filled voids in the last fluorite deposited. Chalcedony that was deposited at the same time as the fluorite is intermixed and banded with purplish fine-grained fluorite. The hardness of the mixtures of chalcedony and fluorite is a clue to their composition.

Barite occurs in clear or white tabular crystals, commonly a quarter of an inch to half an inch across; less commonly the crystals are an inch to several inches across. In many of the veins barite either was not seen or formed less than 10 percent, in some it constitutes from 10 to 30 percent, and in parts of a few veins it forms as much as 60 percent. Although barite was deposited later than some of the fluorite, the barite crystals commonly are covered by later fluorite.

ORIGIN

The fluorspar deposits were formed by solutions that ascended along the shear zones. The mineral composition of the deposits indicates that they were formed under epithermal conditions of low temperatures and pressures.

The fluorspar mineralization was later, at least in part, than the intrusion of the lamprophyre, as some fluorspar veinlets cut lamprophyre bodies. The mineralizing solutions and the lamprophyre intrusions may have come from the same deep-seated magmatic source, and the mineralization may have followed immediately the period of igneous activity during Miocene time.

The deposits are younger than the Challis volcanics of late Oligocene or early Miocene age and presumably older than the erosion surface of Pliocene age, the oldest such surface known in the area (Ross 1934, p. 84–86, 93). According to Ross (1934, p. 52–53), the thickness of the main mass of the Challis volcanics near Meyers Cove is at least 5,500 feet, and the original thickness of an upper rhyolite member, the youngest rock in the stratigraphic sequence, may have been 2,000 feet, making a total of 7,500 feet. The deposits in the southern part of the area, which are highest in the stratigraphic sequence, are in the lower part and probably near the base of the Challis volcanics. The deposits in the northern part of the area, which are lowest in the stratigraphic sequence, are probably 1,000 to 4,000 feet stratigraphically below the Challis volcanics.

On this basis the total vertical range through which fluorspar is exposed is about 4,000 feet, and these exposed fluorspar deposits must have formed between 7,500 and 11,500 feet stratigraphically below the top of these volcanics of late Oligocene or early Miocene age. It is not known how much of the overlying sequence had been removed by erosion before mineralization occurred, but the Pliocene erosion surface, at altitudes between 8,500 and 9,000 feet, would not have been attained at that time. The fluorspar deposits at altitudes of approximately 7,200 feet are more than 1,000 feet below this erosion surface, and those at an altitude of about 5,000 feet are approximately 3,500 feet below the surface. The depths of formation of the exposed deposits, therefore, were at least 1,000 feet and probably not more than 11,500 feet below the surface that existed at the time of the mineralization.

SIZE AND GRADE

The deposits range in size from isolated fluorspar veinlets in otherwise barren parts of shear zones to large ore bodies along shear zones. The ore bodies are as much as several hundred feet long and 20 feet wide. Those parts of shear zones that are of mineable or possibly mineable grade are known locally as lodes or leads, and these terms are so used in this report.

Table 1 gives analyses of samples taken from several deposits in the area. Additional information about some of the samples is given in the descriptions of individual lodes.

TABLE 1. *Analyses of samples from fluorspar deposits near Meyers Cove, Lemhi County, Idaho*

[Symbols: Ch, channel; G, grab; Cr, crusher; S, specimen; Cp, chip]

Sample no.	Percent					Analyzed by
	CaF_2	SiO_2	$BaSO_4$	$CaCO_3$	R_2O_3	
[1] 1	74.2	20.6	------	1.85	------	Clarence Zeuch, Idaho Bur. Mines and Geology.
[2] 2	67.37	8.93	19.64	.73	1.68	U. S. Bur. Mines.
[2] 3	61.62	12.42	16.11	.64	2.40	Do.
[2] 4	93.77	4.21	.14	.46	.64	Do.
[2] 5	92.59	1.97	2.22	.57	1.05	Do.
[3] 6	77.84	16.82	------	------	------	Booth, Garrett, & Blair, Philadelphia, Pa.
[3] 7	85.0	14.6	------	------	------	Kinetic Chemicals Inc., Wilmington, Del.
[3] 8	73.48	17.8	------	------	------	Union Assay Office, Inc., Salt Lake City, Utah.
9	53.19	------	------	------	------	Charles O. Parker & Co., Denver, Colo.
10	30.92	------	------	------	------	Do.
11	51.72	------	------	------	------	Do.
[2] 12	85.10	9.59	1.58	.50	.80	U. S. Bur. Mines.
[3] 13	97.64	1.33	------	------	------	Kinetic Chemicals Inc., Wilmington, Del.
[3] 14	95.34	3.39	------	------	------	Booth, Garrett, & Blair, Philadelphia, Pa.
[3] 15	89.30	7.29	------	------	------	Do.
[3] 16	84.5	15.4	------	------	------	Kinetic Chemicals Inc., Wilmington, Del.
17	70.57	------	------	------	------	Charles O. Parker & Co., Denver, Colo.
18	80.06	------	------	------	------	Do.
19	38.81	------	------	------	------	Do.
20	92.07	------	------	------	------	Do.
21	43.7	33.5	------	------	------	Metallurgical Laboratory, Seattle, Wash., and Union Assay Office Inc., Salt Lake City, Utah.
22	28.39	60.32	------	[4] 4.57	4.34	Norman Davidson, U. S. Geol. Survey.

See footnotes at end of table.

TABLE 1. *Analyses of samples from fluorspar deposits near Meyers Cove, Lemhi County Idaho*—Continued

[Symbols: Ch, channel; G, grab; Cr, crusher; S, specimen; Cp, chip]

Description of Samples

Sample no.	Source	Type	Width (feet)	Sampled by
[1] 1	Crystle area	? [5]	------	A. L. Anderson, Idaho Bur. Mines and Geology.
[2] 2	Bear Trap	Ch?	1.9	J. W. Taber, U. S. Bur. Mines.
[2] 3	do	Ch?	2.3	Do.
[2] 4	do	G [6]	------	Do.
[2] 5	Powder House	Ch?	0.5	Do.
[3] 6	Big Lead	Ch?	?	Chamac Mines Co.
[3] 7	do	Ch?	?	Do.
[3] 8	do	Cr [7]	------	Do.
9	do	Ch	7	D. C. Cox, U. S. Geol. Survey.
10	do	Ch	15	Do.
11	do	Ch	4	Do.
[2] 12	do	Ch?	18	J. W. Taber, U. S. Bur. Mines.
[3] 13	Red Spar	S [8]	------	Chamac Mines Co.
[3] 14	do	Ch	4	Do.
[3] 15	do	Ch?	?	Do.
[3] 16	do	Ch?	?	Do.
17	do	Ch	6	D. C. Cox, U. S. Geol. Survey.
18	do	Cp	1	Do.
19	do	Cp	2	Do.
20	do	S [8]	------	Do.
21	Florspar	Ch	14	P. J. Shenon, U. S. Geol. Survey.
22	do	S	------	Do.

[1] Prater, 1943, p. 2.
[2] U. S. Bur. Mines, 1943, p. 5; analyses published in Anderson, 1943, p. 14, 20.
[3] Oral communication, A. E. Chambers, Chamac Mines Co.
[4] Carbonates.
[5] For flotation test.
[6] Sorted ore.
[7] Mined and sorted.
[8] Best ore.

Ore that can be shipped direct to a consumer or after simple sorting, washing, or screening, occurs in very few deposits and in very small quantities. The optimum cutoff grade appears to be between 40 and 50 percent CaF_2 in the larger deposits.

Metallurgical tests made by the Idaho Bureau of Mines and Geology (Prater, 1943) on a sample of ore from the district (sample 1, table 1) indicate that this type of ore is amenable to concentration by flotation. A concentrate that contained 98 percent CaF_2 and 1 percent SiO_2 was produced with 60 to 67 percent recovery. The sample, containing about 74 percent CaF_2 and 21 percent SiO_2, represented a higher grade of ore than could be mined in large tonnages at Meyers Cove, and it contained very little barite, which is generally difficult to separate from fluorspar.

The possible production of an acid-grade product is corroborated by experiments made on ore that ranged from about 55 to 75 percent CaF_2. These tests were conducted for Chamac Mines Co. by General

Engineering Co., Inc., of Salt Lake City in February 1944. As the result of these metallurgical tests a 70-ton flotation mill was erected at the junction of Camas Creek and Duck Creek (pl. 1).

FLUORSPAR LODES

CRYSTLE AREA

The lodes near Meyers Cove are in two main areas: the Crystle area and the Purcell area. One lode, the Antimony Lode, is outside of these areas and is described separately.

The Crystle area is east of Camas Creek, between Duck Creek and Fluorspar Gulch. (See pl. 1.) The area is covered by claims known as the Crystle group; most of the Crystle area is shown on plate 2.

Chamac Camp Lode.—Two pits and a road cut expose the Chamac Camp Lode east of Camas Creek about 1,000 feet north of the camp of the Chamac Mines Co. at altitudes of 200 to 700 feet above the creek. (See pl. 1.) The road cut, at an altitude of about 5,370 feet, exposes a faulted vein segment 2 feet wide that has slid out of position from an unknown source. A vein from 1 to 1½ feet thick that strikes N. 60° E. and dips 35° NW. crops out and also is exposed in a small pit at an altitude of about 5,650 feet. The grade of ore is fairly high, ranging from 60 to 80 percent CaF_2 in this and the aforementioned lower vein. An opencut at an altitude of about 5,840 feet exposes a vein of coarse barite and coarse fluorite which strikes N. 25° E. and dips 45° NW. The ore grade is low, about 30 percent CaF_2. These veins may be parts of a single, irregular, narrow lode.

Crystle No. 1 Lode.—The Crystle No. 1 Lode (Lode No. 1 of Anderson, 1943) is on the north side of Fluorspar Gulch about 2,200 feet east of its junction with Camas Creek. (See pl. 1.) It consists of a silicified zone exposed in two pits approximately 200 feet apart. The zone in the western pit is of unknown width and contains a fluorspar vein 6 inches thick that strikes N. 10° E. and dips 45° W. The zone in the eastern pit is about 12 feet wide and contains 2 fluorspar veins, one 6 inches thick and the other 1 foot thick. One of these veins was reported to have been 4 feet thick, but the thickest part was blasted out in opening the prospect.

Anderson Lead.—The Anderson Lead (Lode No. 2 of Anderson, 1943) is located at an altitude of about 6,500 feet (pls. 1, 2) on 2 silicified shear zones that are believed to merge into a zone approximately 150 feet wide. The zones have not been prospected by workings but are well exposed in outcrops. The strike of the southern zone is N. 20° E., and that of the northern zone about N. 10° E. Both zones generally have westerly dips of from 30° to 45°, although the northern zone steepens to 60°. The best parts of the Anderson Lead are near its northern edge; one vein is 50 feet long and 2½ feet wide and ranges in grade from 35 to 65 percent CaF_2. In one place a 7-foot wide section of the zone has an average CaF_2 content of approximately 45 percent, but this width does not continue for more than 5 feet along the strike and the whole vein is only about 20 feet long. Other veins are smaller, and in other parts of the zone the fluorspar is too low grade to mine. A little chalcedony and barite are present.

South Lead.—The South Lead (Lode No. 3 of Anderson, 1943; vein no. 1 of U. S. Bur. Mines, 1943) is at an altitude of about 7,050 feet (pls. 1, 2) and is on the southernmost of two shear zones that apparently merge at the Anderson Lead. Only one cut has been made on the South Lead, but natural exposures are very good. Strikes of veins and shears range from north to N. 45° E., and dips range from 20° to 45° NW. A fluorspar vein with a maximum width of 1 foot follows the hanging wall of the shear zone, which is about 25 feet wide. A 10- to 15-foot section next to this vein is barren. A 10- to 15-foot section next to the footwall is highly silicified and contains from 10 to 40 percent barite. Within this silicified zone is an irregular mineralized zone 1 to 5 feet wide and 85 feet long; the average width is 3 feet, and the grade of ore is about 50 percent CaF_2.

Bear Trap Lead.—The Bear Trap Lead (Lode No. 4 of Anderson, 1943; vein no. 2 of U. S. Bur. Mines, 1943) is at an altitude of about 7,200 feet (pls. 1, 2, 3) and is on the northernmost of two shear zones that merge at the Anderson Lead. Only one cut has been made on the Bear Trap Lead, but natural exposures are very good. As in the South Lead, there is a hanging-wall fluorspar vein, 1 to 2 feet thick, though not continuous for the whole length of the zone. Next to this is a 6- to 10-foot wide barren or low-grade part; next to the footwall is a 10- to 15-foot wide part that is estimated to contain between 20 to 50 percent fluorite, 10 to 30 percent barite, and 30 to 80 percent chalcedony and highly silicified tuff. The best part of this zone, 5½ feet wide and 235 feet long, probably averages about 40 percent fluorite.

Powder House Lead.—The Powder House Lead (Lode No. 8 of Anderson, 1943; vein no. 4 of the U. S. Bur. Mines, 1943) is at an altitude of about 6,800 feet, about 1,200 feet northeast of the Anderson Lead. (See pls. 1, 2.) This deposit is a mineralized shear zone with a maximum width of 50 feet; it is commonly silicified throughout and locally contains small lenses of fluorspar. In a fissure a few feet from the hanging wall is a vein of purple, massive, and crested fluorite ½ to 1 foot thick and about 100 feet long. A fault near the hanging wall of the zone strikes about N. 35° E. and dips about 35° NW. Between the vein and the indefinite hanging wall is a zone 4 to 5 feet wide that contains 20 to 40 percent fluorite in veinlets.

A mineralized shear zone (Lode No. 7 of Anderson, 1943) about 500 feet east of the Powder House Lead is probably the eastward extension of this vein. (See pls. 1, 2.) The strike of a shear surface in the zone is N. 30° E., and the dip is 20° NW. Parts of the zone contain fluorspar. The best lens exposed is 40 feet long, averages about 2 feet in width, and contains about 40 percent fluorite.

Big Lead.—The Big Lead (Lode No. 9 of Anderson, 1943; vein no. 3 of U. S. Bur. Mines, 1943) appears to be the largest and highest grade lode in the Crystle area. (See pls. 1, 2, 4.) Outcrops of a part of its length are excellent; additional exposures were made in several trenches, opencuts, and a road cut. The attitude of the Big Lead, however, is difficult to determine from present exposures. Strikes of well-exposed parts of the body, of walls, and of banding within the deposit, range from N. 60° W. to north, and dips range from 25° to 60° SW. and W. The strike of the Big Lead probably changes from N. 50° to 60° W. at the north end to N. 10° W. or north in the central part and at the south end. The average dip of the deposit probably is between 35° and 45°.

The exposed length of the Big Lead is about 500 feet; maximum horizontal widths are about 25 feet. The northern end, which has horizontal widths generally between 3 and 8 feet, and the southern end, which has a maximum width of 20 feet, are of relatively uniform grade estimated to range from 50 to 75 percent CaF_2 at the north end and from 40 to 65 percent CaF_2 at the south end. Samples 6 and 7 (table 1) were taken across the vein at the opencut at the north end, and sample 8 represents material from this same opencut. The ore at the ends consists of veinlets of fluorspar and partly replaced tuff; silicified tuff is the principal impurity. Shear surfaces along the walls and in the ore are common.

The central part of the Big Lead contains lenses having the lowest and highest content of CaF_2. Samples 9 and 11 (table 1) were taken across moderately high grade parts of the Big Lead near the walls. Sample 10 was taken across a low-grade lens between the high-grade parts. Sample 12, containing 85 percent CaF_2, was taken across the high-grade part of the Big Lead. The four sample localities are shown on plate 4.

The ore consists of (1) veinlets in tuff; (2) breccia ore composed of fragments of silicified tuff, or early fluorspar surrounded by columnar or banded fluorspar locally cemented by fluorspar; and (3) massive veins with a maximum thickness of about a foot.

North Lead.—The North Lead is on the north side of the ridge between Fluorspar Gulch and Duck Creek (pls. 1, 2) at an altitude of about 6,700 feet.

The attitude of the shear zone containing the fluorspar is not definitely known because several sets of joints are present in the zone. The hanging wall of the exposed western part, however, dips about 20° NW. Although the western part of the North Lead is not well exposed, it appears to consist of fluorspar veinlets in a deposit 150 feet long and 12 feet wide; this part is estimated to average about 40 percent CaF_2. The eastern part of the North Lead is well exposed and is composed of discontinuous en echelon fluorspar veins, with maximum widths of 1 foot, cutting very highly silicified country rock.

Other lodes.—A lode that consists of several veins that strike N. 35° E. and dip 80° NW., in a zone about 100 feet wide, crops out about a mile northeast of Camas Creek near the junction of Duck Creek and its first southern tributary. (See pl. 1.) The best part of the zone, traced for about 200 feet, is a vein zone ranging from 2 to 6 feet in width and estimated to average about 30 percent CaF_2. The veins in the zone are very high grade but have maximum widths of only 1½ feet. Other parts of the zone having a comparable or higher grade do not seem large enough to mine. The whole zone appears to be cut off at its upper end by a silicified shear zone that strikes N. 30° E. and dips 20° NW.

A mineralized area (Lode No. 5 of Anderson, 1943) about 200 feet east of the southeast end of the Big Lead (pl. 2) includes several small shear zones with thin fluorspar veins. Attitudes of the mineralized shear zones differ widely; one of the zones is shown on plate 2 as striking N. 35° E. and dipping 45° NW. None of the fluorspar veins are more than 2 feet wide, and few average more than 1 foot wide. A shear zone (Lode No. 6 of Anderson, 1943) in lamprophyre, about 300 feet to the southwest (pl. 2), contains several small veins also with northeast strikes. The largest is about 1 foot thick.

Several other parts of shear zones in the Crystle area contain noteworthy quantities of fluorspar, but none approach economic value. Two of these lodes are on northeast-striking shear zones about 400 feet northwest of the Anderson Lead. (See pls. 1, 2.)

PURCELL AREA

The Purcell area is in the northwestern part of the area shown on plate 1 and contains the Morning Sun, Red Spar, Red Spar Extension, Red Spar No. 2, Purple Spar, Purple Spar Extension, Purple Spar No. 2, Purple Spar No. 4, Florspar, and East Florspar Lodes.

Morning Sun Lode.—The Morning Sun Lode, about 500 feet south of Duck Creek at an altitude of about 5,400 feet (pl. 1), is a silicified shear zone striking N. 25°–45° E. The dip is probably steep, as dips on shears and veins within the zone range from 60° NW. to 60° SE. The deposit has an exposed length of about 400 feet and an additional length of 200 feet indicated by float; it has a maximum width of about 50 feet. The fluorspar occurs as irregular veinlets in the silicified zone.

On the surface above the adit shown on plate 1 is a lens about 8 feet wide which contains approximately 60 percent CaF_2. In the adit the lens is about 5 feet wide and is of lower grade. Several lenses about 25 feet northeast are a few feet wide and contain about 40 percent CaF_2.

Red Spar Lode.—The Red Spar Lode is about 3,100 feet northwest of the junction of Duck and Camas Creeks and is southwest of Camas Creek at altitudes ranging from 30 to 250 feet above the valley floor. (See pls. 1, 5.) Bedrock crops out only as ledges projecting above the talus slope. The fluorspar occurs as veins and veinlets in a fractured zone in granophyre of Tertiary age.

Several sets of joints transect the zone; the strike of the principal set ranges from N. 10° E. to N. 45° E., and the dip ranges from 65° to 75° NW. In general, the fluorspar veins parallel this set of joints. The largest veins are at the north end, where two high-grade veins have maximum widths of 6 and 8 feet. These veins pinch abruptly in the outcrop, however, and the maximum widths probably do not extend more than a few tens of feet either along strike or vertically. A high-grade vein more than 100 feet long but only 1 or 2 feet wide branches southwest from one of these wide veins. Samples 13 to 18 (table 1), containing from 71 to 98 percent CaF_2, are from high-grade parts of the vein. Sample 19, containing 39 percent CaF_2, is from a low-grade zone next to one of the wide veins.

An adit driven from the lower end of the outcrop of the Red Spar Lode is believed to follow the principal vein for about 170 feet. The vein width averages nearly 3 feet for the first 70 feet beyond the portal but only a few inches for the next 100 feet.

At the southwestern end of the Red Spar Lode, at an altitude of 5,270 feet (pl. 5), is a fractured zone 30 feet long and 10 feet wide which contains fluorspar as veinlets and replacements of blocks of tuff. About half of the mineralized zone is fluorspar, but the quantity of fluorspar appears to decrease in depth.

The existence of a southern extension of the wide part of the Red Spar Lode does not seem probable. An area showing fluorspar float about 100 feet southwest of, and on strike with, the widest part of the Red Spar Eastern vein has been trenched deeper without disclosing bedrock since the Red Spar Lode was mapped. Trenches on the mineralized fractured zone at the southwest end of the outcrop of the Red Spar Lode have conclusively shown pinching of that lens. About 600 feet southwest of the southwesternmost deposit described above, and at an altitude of approximately 5,600 feet (pl. 1), a new vein, probably in the Casto volcanics, is exposed in one place by a bulldozer trail. The vein is about 3 feet wide, strikes N. 40° E., and dips 30° NW. No assays are available, but the grade appears low, perhaps about 30 percent CaF_2.

A vein that appears to be an extension of one of the veins in the adit was exposed northeast of the adit and on the south bank of Camas Creek during excavation for a bridge, according to A. E. Chambers of Chamac Mines Co.

Red Spar Extension Lode.—The Red Spar Extension Lode is on a spur about 4,000 feet west of the intersection of Duck Creek and Camas Creek, and about 1,200 feet above Camas Creek. (See pl. 1.) The outcrops are poor, but the fluorspar has been exposed by bulldozer cuts made by the U. S. Bureau of Mines.

The largest deposit is exposed for almost 200 feet in six bulldozer cuts across the strike. These cuts are about 40 feet apart, measured horizontally on the trace of the vein. The average strike appears to be about N. 55° E., and the dip ranges from 60° NW. to vertical. The first or northernmost cut did not reach the vein. The second cut, to the south, shows 14 feet of low-grade material containing not more than 30 percent CaF_2. The third cut, farther south, shows 22 feet of mostly high-grade material estimated to contain 80 percent or more CaF_2. The fourth cut exposes only 2 feet of high-grade material. The fifth cut did not reach bedrock, and a switchback that makes the sixth cut shows only a few stringers of fluorspar that are off the strike of the rest of the lode. Most of the country rock is granophyre, although the hanging wall at the second cut may be part of the Casto volcanics.

Another deposit is exposed in a bulldozer cut that trends east about 300 feet southwest of the largest deposit. (See pl. 1.) A lens of fluorspar is exposed for 30 feet in the direction of the cut, 10 feet normal to the cut, and 5 feet vertically. The attitude is not known. The grade is estimated to be 30 to 40 percent CaF_2. The country rock is poorly exposed but is probably granophyre.

A bulldozer trail exposes two low-grade zones about 250 feet and 500 feet, respectively, southeastward from the second deposit. These zones are a few feet wide and probably contain less than 30 percent CaF_2.

Red Spar No. 2 Lodes.—Two deposits, called the Red Spar No. 2 Lodes, are exposed in bulldozer trails about 400 and 600 feet west of the southwest end of the Red Spar Lode. (See pl. 1.) The eastern deposit is a 3-foot vein in the Casto volcanics. It strikes N. 30° E., dips 45° NW., and appears to be of good grade.

The western deposit strikes N. 30° W. and dips 40° SW. The vein is in Tertiary granophyre and is exposed for a length of about 25 feet along the side of a bulldozer trail. The vein is about 5 feet wide along most of this distance and pinches toward the northeast end. No assays are available, but the grade appears good. Some fluorspar float in a bulldozer trail 200 to 300 feet to the northwest suggests the possible continuation of the vein.

Purple Spar Lode.—The Purple Spar Lode is about 3,000 feet west of the junction of Camas Creek and Duck Creek. (See pl. 1.) It has been extensively explored on the surface. The total length is almost 300 feet; the width and grade are extremely erratic. The strike appears to average about N. 30° E. and the dip about 45° NW. Like the southwest end of the Red Spar Lode, this deposit appears to have been localized by three sets of joints in the granophyre.

The northeast end of this lode is low grade for a length of about 40 feet; the average grade apparently decreases to the north. An adjoining section to the south, about 90 feet long, shows well how fluorspar deposition was controlled by the three sets of joints; widths of this section range from 5 to 8 feet, and the ore grade may average 60 percent CaF_2. Trenches to the south expose the lode for about 80 feet; the average width appears to be about 8 feet, and the grade is estimated to be similar to that of the section to the north. A bulldozer trail about 80 feet still farther south shows fluorspar-bearing material about 10 feet wide in the lode but apparently somewhat lower in grade.

Purple Spar Extension Lode.—The Purple Spar Extension Lode is exposed in a bulldozer trail about 400 feet west of the Purple Spar Lode. It is in granophyre, strikes N. 20° E., and appears to dip steeply. The width is about 8 feet, and the ore grade is about 40 percent CaF_2.

Purple Spar No. 2 Lode.—The Purple Spar No. 2 Lode is exposed about 1,000 feet southeast of the Purple Spar Lode. (See pl. 1.) The vein strikes N. 20° E. and is about vertical. The width is about 5 feet and the average grade ranges from 40 to 50 percent CaF_2 in the 20-foot length of vein exposed.

According to Paul Raymond, who was then foreman for Chamac Mines Co., a narrow vein on strike with the Purple Spar No. 2 Lode crops out about 1,000 feet to the southwest.

Purple Spar No. 4 Lodes.—The Purple Spar No. 4 Lodes are exposed in prospect trenches about 3,000 feet southwest of the junction of Camas Creek and Duck Creek. (See pl. 1.) The western vein, in the Casto volcanics, at an altitude of about 6,300 feet, is 5 feet wide and of very low grade. The fluorspar, which follows a breccia zone, is sugary white and contains some fragments of early purple fluorite.

About 200 feet to the east and about 150 feet lower, a 2½- to 3-foot vein of white sugary fluorspar cuts a breccia zone in granophyre. The strike of the vein is N. 40° E., and the dip is vertical. The vein is of good grade for a length of about 40 feet, but to the northeast the breccia zone is barren.

Florspar Lode.—The Florspar Lode is about 2,700 feet north of the junction of Camas Creek and Duck Creek and about 1,000 feet higher than Camas Creek (pl. 1). Outcrops are very scarce, but the lode is exposed in a trench near the north end of the lode and in an opencut about 400 feet to the south. The total length of the vein is apparently almost 400 feet. The lode is in the Casto volcanics, strikes about N. 45° E., and dips 60° NW.

The trench shows 14 feet of fluorspar containing 44 percent CaF_2 (sample 21, table 1). The fluorite occurs as veinlets and botryoidal coatings on fragments of tuff. Adjoining this 14-foot section on the northwest is at least 2 feet of lower grade material containing an estimated 20 percent CaF_2. The southeast margin of the lode is a 10-foot zone containing 10 to 20 percent CaF_2; next is a heavily silicified zone as much as several hundred feet thick. The fluorspar is not exposed for more than 15 feet northeast and southwest of the trench, but the silicified zone can be traced more than 100 feet northeast and about 150 feet southwest.

The opencut exposes very poorly, and probably incompletely, a shear zone at least 8 feet wide containing a few high-grade fluorspar veins but mostly material with less than 20 percent CaF_2. Sample 22 (table 1), containing 28 percent CaF_2, represents a specimen from the cut.

East Florspar Lode.—The East Florspar Lode is about 1,500 feet northeast of the Florspar Lode, at an altitude of about 7,000 feet on the divide between Camas Creek and Duck Creek. (See pl. 1.) The lode consists of a breccia zone, cemented by fluorite and silica, which strikes N. 20°–45° E. and apparently dips about 30° NW. The highest grade section, about 50 feet long and 4 feet wide, contains about 60 percent CaF_2. The breccia zone was traced 200 feet southeast of this section, but only a few small lenses of fluorspar were observed.

ANTIMONY LODE

The Antimony Lode is about 4,000 feet south of the junction of Camas Creek and Fluorspar Gulch, at an altitude of about 5,900 feet. (See pl. 1.) The deposit has been described by Ross (1927; 1934, p. 131–132) and Anderson (1943, p. 15–16). According to Anderson the mineralized shear zone strikes N. 70° E. and dips from 40° to 45° NW.

The lode is composed of chalcedony, barite, stibnite, and a little fluorite, and cuts light-colored tuff of the Challis volcanics. It is exposed or indicated by 4 cuts for a length of about 500 feet. Fluorite was seen in one of these cuts but only in broken pieces of the lode. Some of the fluorite is in open spaces between crystals of barite. The fluorite is finely granular, pale purplish, and apparently later than the barite and stibnite; it is later than some of the chalcedony but is cut by late-stage chalcedony veinlets. Neither the fluorite nor stibnite appears to be of economic interest.

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