from the tables. At the Wano mill in 1942 and 1943, a sulfide concentrate containing about 30 percent of lead, 3 percent of copper, and 20 to 30 ounces of silver to the ton was recovered.

## Persistence with Depth

The fluorspar deposits so far exposed by mining range in altitude from 6,870 to 7,600 feet. Most of the workings are moderately shallow, ranging from 50 to 300 feet below the surface. Few mines have been worked below tunnel level. In January 1944, however, the Emmett shaft reached a depth of 480 feet and was still in good fluorspar ore. The Alice workings attain a depth of 440 feet, but they were opened chiefly for lead-silver ore. In nearly all the deposits that have been explored in depth, the fluorspar bodies in the bottom levels are as large and of as good grade as they are at the surface. In the Emmett vein the ore body in the 480-foot level is as large as at the surface and of slightly better grade. In the Chancellor vein the ore body is of about the same size and grade at a depth of 150 feet as it is at the surface. In each of these mines the productive part of the vein is only about 120 feet long on the surface and thus the vertical extent is greater than the horizontal. This fact and the lenticular character of the breccia zones suggest that many of the ore bodies may be pipelike in shape, and, in spite of their short horizontal dimensions, may persist to a considerable depth beneath the present workings. In the Alice mine, the irregular fluorspar vein, which is only about 120 feet long and has a width near the surface of 3 to 8 feet, persists to a depth of 440 feet where it is reported to be 3 to 11 feet wide and of good grade. It therefore seems reasonable to expect that most of the larger fluorspar bodies will persist to a depth of at least 300 feet and many may persist to more than 500 feet.

## Origin

The fluorspar deposits are rather closely grouped on the south and west sides of the Porphyry Mountain stock; available evidence seems to indicate that these deposits bear a close genetic relationship to the stock, and that the fissures and breccia zones occupied by the fluorspar were produced by forces resulting from the intrusion of the stock. The latter problem is discussed in detail in an earlier paper.[7]

The genetic relationship between the stock and the fluorspar deposits is indicated by a number of features observed in the field. Parts of the stock have been brecciated and recemented by more porphyry, and in the breccia miarolitic cavities contain crystals of both green and violet fluorite associated with quartz and adularia. There are also small pegmatite dikes, both in the sodic granite-quartz monzonite stock and in the granodiorite, that contain violet fluorite intergrown with quartz and feldspar. In one place, a short distance south of the stock, a sodic quartz monzonite porphyry dike tails out into a narrow fluorspar vein bordered by coarse biotite, and in another small deposit, breccia fragments of granite are coated with biotite and cemented with fluorite. Another group of small sodic granite porphyry dikes closely resembles the porphyry of Porphyry Mountain but was intruded after the deposition of the fluorite and its subsequent brecciation. One of these cuts the Emmett vein and includes a large fragment of brecciated fluorite. (See pl. 10.) From the above evidence, it is concluded that the fluorine-bearing solutions were differentiation products of the same magma that gave rise to the Porphyry Mountain stock.

Large fragments of pure fluorite in a few of the veins suggest that the original fluorspar veins were high-grade and contained relatively small amounts of quartz and sulfide minerals. Nearly all these veins as well as the breccia zones, however, have been so thoroughly broken up that the fluorite is now well mixed with altered granitic material, quartz fragments, and sulfide minerals. This strong brecciation and thorough mixing even in narrow veins is suggestive of explosive action, and the pipelike shape of some of the deposits also hints at an explosive origin. Diligent search by the writer and his assistant, however, failed to uncover any evidence that would support such a theory. On the contrary, considerable evidence points to a gradual collapse of the vein material, and it seems likely that much of the brecciation and mixing are the result of this process. In several of the mines, notably the Emmett, Burlington, and Argo, occasional lenticular bodies of mixed fluorspar and gran-

[7]Goddard, E. N., op. cit., pp. 370-386.

ite fragmental material show a rough sorting and stratification. The fragments in the layers range in size from gravel through sand to silt particles. The layers range from a fraction of an inch to a few feet in thickness, the smaller ones being composed chiefly of the silty material. All lie at rather low angles to the horizontal. The largest stratified lens exposed is on the 280-foot level of the Emmett mine. (See fig. 2.) This gently inclined layer is about 22 inches

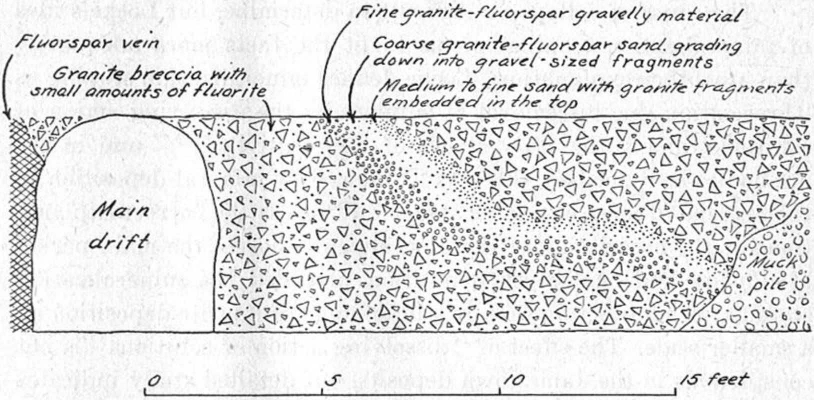


Fig. 2. Sketch showing lenticular body of stratified fragmental fluorspar material in granite breccia; east wall of crosscut 125 feet northwest of shaft, 280-foot level of the Emmett mine.

thick and is composed of gravelly material grading upward into fine sandy material. Granite breccia fragments are embedded in the upper part of the sandy layer and coarse granite breccia lies both above and below the lens. Near this point the Emmett vein terminates abruptly against granite breccia (see pl. 10), and it seems likely that a segment of the vein has slumped out of place. Nearby, isolated fragments of granite porphyry are completely enclosed in the granite breccia. In the Burlington tunnel, at the northeast end of the fluorspar breccia zone, a few widely scattered, slightly rounded fragments of fluorite are entirely enclosed in granite breccia, and the widely-scattered fragments of galena and pyrite in both the Burlington and Argo breccia zones have already been mentioned. This wide scattering and mixing of different mineral and rock fragments might be attributed to explosion, but other features, some of which have been previously mentioned, are hardly compatible with an explosion theory. In many places, fragments of fluorspar are grouped closely together in approximately their original position with respect to each other (see pl. 5), and the same grouping is shown by granite and pyrite fragments. Such slight brecciation and fracturing locally would be difficult to explain as a result of explosive action but would be compatible with a theory of collapse and gradual settling and breaking up.

The cause of collapse is difficult to determine, but Locke's idea of mineralization stoping[8] seems to fit the facts more adequately than any other explanation. Locke defines mineralization stoping as "brecciation due to removal of support by the dissolving action of solutions during the early stages of their activity***" and in the ore bodies he described, this was "followed by mineral deposition in the brecciated mass at a later stage." If this is the correct explanation for the brecciation of the Jamestown deposits, the main period of fluorite and lead-silver deposition preceded the mineralization stoping, which was followed by a later stage of fluorite deposition on a smaller scale. The effect of "dissolving action of solutions" is not conspicuous in the Jamestown deposits, but detailed study indicates that it was widespread. In the Emmett vein the borders of many of the coarsely crystalline fluorite fragments are corroded, the corners are rounded, and the fragments are indented along fractures. A thin rim of late purple fluorite commonly coats these corroded fragments. The Emmett vein is the only vein in which the corrosion is readily apparent, but a study of many thin sections shows that corrosion was effective in nearly all the deposits. Many fluorite grains are rounded and indented, and many of the quartz fragments are corroded. In several thin sections, prism and pyramidal faces of quartz crystal fragments are deeply embayed. In a thin section of ore from the Brown Spar 300-foot level, the incipient stages of this corrosion and breaking down process are observable. Bodies of early fine-grained fluorite (grain size about 0.4 millimeters) are penetrated along grain boundaries by irregular narrow fractures, now filled with clay minerals and carbonate, and the bordering grains are somewhat corroded. Other fractures are wider and more ir-

[8]Locke, Augustus, The formation of certain ore bodies by mineralization stoping: Econ. Geology, vol. 21, no. 5, pp. 431-453, 1926.

regular, and in still other parts of the thin section the fluorite has broken down into a fine breccia of rounded grains having an average size of 0.25 millimeter.

From the above observations it is inferred that the major period of fluorite deposition was followed by a change in the character of the solutions, possibly from alkaline to acid, and a certain amount of the fluorite already deposited was dissolved. Solution progressed chiefly along fractures and grain boundaries and produced a porous mass, which gradually collapsed of its own weight. It is even possible that fairly large cavities were developed in the lower parts of these veins. As collapse and settling gradually proceeded upward, blocks and fragments of the granite or granodiorite wall rock caved and were mixed with the brecciated fluorite. Fine-grained fluorite apparently crumbled into a fine sand that readily flowed into the interstices between breccia fragments and was mixed with granite dust that sifted down from above and was later altered to clay minerals. Veins of galena, pyrite, and other sulfides and of quartz, would be broken up by the collapse and as the fragments gradually worked down they would tend to spread as mine timbers do in a caved stope when the filling settles or is drawn off. The final result would be isolated granite, galena, and pyrite fragments in fluorspar breccia and isolated fluorite fragments in granite breccia, such as has already been described. As caving approached the top of the vein, more and more granite would be mixed with the fluorite, and at the top large amounts of granite breccia would contain only scattered small amounts of fluorite. This condition is to be observed at the surface in several of the nearly barren breccia zones, notably the Emmett breccia zone northwest of the Emmett vein, the breccia zone east of the Argo shaft, the Nations Treasure breccia zone, and the zone northeast of the Brown Spar mine. (See pl. 2.) If the above speculation is correct, parts of these breccia zones may be underlain by fluorspar deposits comparable to some of those now being exploited.

It seems unlikely that the mineralization stoping ever reached the surface. The Flattop peneplain exposed near the crest of the range, 10 to 12 miles west of Jamestown, is referred to the Eocene by Van Tuyl and Lovering,[9] and if projected it would pass over the Jamestown district at an altitude of between 10,300 and 10,500 feet. In the Jamestown area, at the time of deposition of the fluorspar deposits this surface was thus about 3,000 feet above the present surface. The veins are very narrow compared to this height. Rice, in discussing caving in mine workings, states that "a flat dome is formed which, with successive falls, becomes higher." However, "the dome of breaking will not reach the surface unless the deposit is very thick, in comparison to its depth below the surface, as the broken rock will wedge, and their increase of volume by breaking will fill the dome."[10]

Though the evidence discussed above seems to indicate that the brecciation of the fluorspar ore bodies was due to collapse, it is unlikely that the large nearly barren breccia zones resulted from this process alone. It is believed that these large zones were first brecciated by the intrusion of the Porphyry Mountain stock and only parts of them were rebrecciated by mineralization stoping. In fact it is quite possible that later brecciation was augmented by gradual settling of large blocks of ground due to contraction of the Porphyry Mountain stock during cooling. That the later brecciation took place over a considerable period of time is indicated by the fact that a late granite porphyry dike, which cuts the Emmett vein and includes a fragment of brecciated fluorspar, is in turn locally brecciated and mixed with broken granite and fluorspar. This stage of collapse may have been due to withdrawal of magmatic material from below when the dikes were intruded.

The brecciation process, therefore, is very complex and took place over a considerable space of time and at several different periods. The history of the fluorspar deposits as interpreted by the writer is summarized as follows:

1. Intrusion of the Porphyry Mountain stock accompanied by brecciation and fracturing of the rocks on its west and south sides.

2. Deposition of small amounts of fluorite associated with quartz, feldspar, arfvedsonite, and biotite, in the pegmatite phase of the Porphyry Mountain stock.

[9]Van Tuyl, F. M., and Lovering, T. S., Physiographic development of the Front Range: Geol. Soc. Am. Bull., vol. 46, p. 1332, 1935.

[10]Rice, George S., Some problems in ground movement and subsidence: Am. Inst. Min. Met. Eng. Trans., vol. 69, pp. 389, 393, 1923.

3. Deposition of most of the fluorite, both coarsely crystalline and fine-grained, together with quartz, pyrite, galena, and other sulfides.

4. Solution of a part of the fluorite due to a change in composition of the mineralizing liquids, and gradual collapse and brecciation of the fluorspar bodies and adjacent wall rock.

5. Deposition of fine-grained fluorite in parts of the earlier deposits.

6. Intrusion of late granite porphyry dikes.

7. Local brecciation due to further collapse, as at the Emmett mine.

## Resources

The fluorspar deposits range in grade from 5 to 85 percent of $CaF_2$; however, ore containing more than about 75 percent of $CaF_2$ occurs only in small pockets and no large bodies of such high-grade ore have been mined in recent years. In 1943, ore containing as little as 45 percent of $CaF_2$ was mined, and it seems probable that with improved milling procedure or increased price, material of lower grade may be profitably mined in the future; however, material containing less than 20 percent of $CaF_2$ is not likely to be commercial for many years to come. It therefore seems suitable to divide the resources into two classes on the basis of grade; one of medium to relatively high grade, containing from 45 to 75 percent of $CaF_2$ and averaging 60 percent, which includes fluorspar that can be mined under present conditions; the other of low grade, containing from 20 to 45 percent of $CaF_2$ and averaging 30 percent, which includes material that could be mined under improved price and milling conditions.

In only a few of the mines has the ore been developed and sampled sufficiently well to class it as measured, and some of this ore has been mined since the writer's field work in July, 1943. It therefore seems best for the purposes of this report to group measured and indicated ore together as indicated or probable reserves.

In 1935, the writer estimated the reserves of the district assuming a lower limit of 200 feet below the surface for indicated (probable) ore and 400 feet for inferred (possible) ore. Since then new development has shown that the Emmett ore body persists to a depth of at least 480 feet, the Brown Spar to more than 300 feet and several others to depths of from 120 to 150 feet. From these new data, it seems reasonable to extend the general lower limit of both classes of ore another 100 feet, and for the Emmett and Brown Spar mines another 200 feet. The indicated and inferred ore, therefore have each been computed (with the two above mentioned exceptions) on the assumption that the deposits continue in approximately the same size and grade to depths of 300 and 500 feet below the surface, respectively. It is assumed that possible new discoveries along the strike of known deposits will compensate for unpredictable lean portions in the known ore bodies. Allowance for possible discoveries of new ore shoots, as in some of the large nearly barren breccia zones, is included in the inferred ore. In computing the reserves, a conversion factor of 11 cubic feet to the ton was used for the better grade of ore and, owing to its slightly greater porosity, a factor of 12 for the lower-grade ore.

The estimated fluorspar resources of the Jamestown district, as computed on the above assumptions, are given in the following table:

ESTIMATED RESOURCES OF CRUDE FLUORSPAR ORE IN THE JAMESTOWN DISTRICT, BOULDER COUNTY, COLO., AS OF JANUARY 1, 1944.

| $CaF_2$ content | Indicated ore within 300 feet of surface (with a few exceptions) (short tons) | Inferred ore between 300 and 500 feet beneath the surface (short tons) | Totals (short tons) |
|---|---|---|---|
| 45 to 75 percent (average 60 percent) | 305,000 | 340,000 | 645,000 |
| 20 to 45 percent (average 30 percent) | 170,000 | 160,000 | 330,000 |

## Future Possibilities

Most of the fluorspar deposits give promise of extending to considerable depth below the present workings; in fact, some that appear to be pipelike have already been developed to depths greater than their lengths. The productive deposits have been developed to depths ranging from 50 to 480 feet below the surface, and in none of these, with the possible exception of the Upper Alice, where the workings are shallow, is there any indication that the ore is giving out with depth. In the Argo and Burlington mines, the breccia zones appear to be consolidating downward into veins of higher grade. It therefore seems likely that nearly all the larger deposits are worthy of exploration at greater depth. These include the Argo, Blue Jay, Burlington, Chancellor, Emmett, and Yellow Girl deposits. In addition, several large nearly barren breccia zones that show small amounts of fluorspar at the surface are considered to be worthy of exploration at depths ranging from 100 to 200 feet. These include the Nations Treasure breccia zone, the Emmett breccia zone northwest of the Emmett mine, the breccia zone 200 to 800 feet east of the Argo shaft, and the breccia zone 200 to 600 feet northeast of the Brown Spar shaft.

Diamond drilling would probably be the most suitable method of initially exploring these breccia zones, but some difficulties would undoubtedly be encountered. The wall rocks throughout the area are rather soft altered granite and granodiorite. Although the granite is sericitized, it holds fairly good walls, but it is much fractured and in some places brecciated. The granodiorite is altered to clay minerals and chlorite and tends to cave readily. Parts of the fluorspar veins and breccia zones are soft and friable, but other parts are fairly hard. For these reasons, it seems unlikely that a large percentage of whole cores could be recovered in the drilling of these deposits. However, the violet color of most of the fluorspar can be readily detected in drill cuttings and sludge, and if care is taken in recovering them, it is believed that the width and grade of fluorspar bodies penetrated by a drill could be determined with a fair degree of accuracy. If results of the first drilling show very low recoveries and give little reliable information, then diamond drilling should be abandoned and other forms of exploration considered.

## Mines

The principal fluorspar mines in the district are briefly discussed in the following pages. Production figures for most of the mines are incomplete, but data for 1942 and 1943 were kindly furnished by the General Chemical Co. and Harry M. Williamson and Son, the chief operators in the district.

### Alice Mine

The Alice mine is on the west side of Porphyry Mountain, about 1 mile N. 26° W. of Jamestown, at an altitude of 7,450 feet. (See pls. 1 and 2.) The mine was idle in 1943, but the General Chemical Co. expected to open it in the near future. It is chiefly a lead-silver mine, but some fluorspar has been produced, though the exact amount is not known.

The property comprises a group of 7 claims and is 1,500 feet long and 1,050 feet wide. The workings consist of a vertical shaft 400 feet deep with four levels and a crosscut tunnel 150 feet long. A winze connects with a short level 40 feet below the bottom of the shaft. The shaft was inaccessible for many years but was reconditioned in 1936.

An irregular vein of fine-grained fluorspar is exposed in the workings; in the upper levels it is about 120 feet long and from 1 to 8 feet wide, averaging about 3 feet. The vein strikes about N. 15° W. and dips 70°-80°SW., but steepens to become nearly vertical in the lower levels. The wall rock is sericitized granite. The fluorspar contains scattered fragments of granite, quartz, and pyrite. On the footwall side of the vein, there was a pipelike body of lead-silver ore 8 to 20 feet long and 3 to 8 feet wide that was apparently continuous nearly to the bottom level. The lower levels were always inaccessible at the time of the writer's visits, but according to R. H. Dickson, mining engineer of the General Chemcal Co., the fluorspar vein is from 2 to 11 feet wide in the lower levels. Local mining men report that lead-silver ore gave place to a mixture of pyrite and chalcopyrite containing a little gold near the bottom of the shaft. Nearly all the lead-silver as well as some of the fluorspar ore has been mined out, but some fluorspar of good grade remains. Samples taken by Mr. Dickson contained from 40.7 to 82.1 percent of $CaF_2$ and from 11.65 to 42.26 percent of silica.

## Upper Alice Mine

About 380 feet southeast of the Alice shaft is a group of workings known as the Upper Alice from which some fluorspar has been mined. (See pls. 1 and 2.) These workings are on the Alice property and consist of a crosscut tunnel 155 feet long which intersects a body of fluorspar ore about 50 feet below the outcrop and connects with a glory hole. The deposit was last worked in June, 1943.

The deposit is a fluorspar breccia zone about 80 feet long and 45 feet wide that contains irregular veins of good grade fluorspar. The deposit has a general westward trend and a steep dip, and lies in a narrow westward-trending barren breccia zone near its junction with a zone that trends northeastward. The wall rock is chiefly sericitized Silver Plume granite, but two small altered post-ore dikes of granite porphyry are exposed in the workings.

The ore is fine-grained fluorite mixed with clay minerals, quartz, and some pyrite and contains granite fragments in some places. The exact grade of the ore is not known, but it is estimated to contain from 50 to 75 percent of $CaF_2$. It is reported that the ore body terminated a short distance below the tunnel level, but the underhand stopes are now so thoroughly filled that this could not be verified. Judging from the depths to which other deposits of the same type are known to extend, it seems unlikely that this ore body has entirely given out so near the surface. Exploration at greater depth seems justified to determine whether or not this is merely a lean spot in the breccia zone.

## Argo Mine

The Argo mine is on the north side of Little James Creek, about 6,000 feet N. 35° W. of Jamestown, at an altitude of 7,328 feet. (See pls. 1 and 2.) It has been one of the most productive fluorspar and lead-silver mines in the district, but it was largely idle during the period 1931-1942. In 1943, Harry M. Williamson and Son, operating under lease from the Boulder Fluorspar and Radium Co., reopened the winze and began mining fluorspar from the bottom level. The former output is not known but it has probably amounted to more than 10,000 tons of crude ore. Mr. Williamson reported that

2,356 tons of crude ore averaging 57 percent of $CaF_2$ were mined in 1943.

The workings consist of a shaft more than 100 feet deep (caved below the tunnel level) and a crosscut tunnel 600 feet long that connects with the shaft about 90 feet below the collar. (See pl. 6.) A lower level connects with the tunnel through a 66-foot winze.

The Argo mine is on a fluorspar breccia zone more than 250 feet long and 60 feet wide that trends about N. 80° E. and dips about 85° S. (See pls. 2 and 6.) The wall rock is sericitized granite. Barren granite breccia borders the fluorspar zone on the south and apparently extends east of it. The fluorspar breccia zone is made up of altered granite fragments in a matrix of fine-grained sugary fluorite (see pl. 4), which is mixed with clay minerals.

Small fragments of fine-grained fluorite are locally abundant, and small quartz fragments, many of microscopic size, are common throughout. A microscopic study of low- and medium-grade ores shows the matrix to be made up of two generations of fluorite, early fragmental material and later finely granular fluorite deposited after brecciation. The grade seems to depend largely on the amount of later fluorite deposited. The size of the fluorite grain in the matrix ranges from 0.016 to 2.0 millimeters and averages about 0.4 millimeter. Fragments of lead-silver ore, chiefly galena, as much as 18 inches in diameter are locally present in the fluorspar breccia, and pyrite is disseminated throughout. In a few places, notably 40 feet northeast of the shaft, there are small pockets of pyrite, tennantite, and chalcopyrite that carry some silver.

On the tunnel level, small irregular veins of relatively high grade fluorspar from 1 to 10 feet wide and 25 to 50 feet long are scattered through the breccia zone. Some of these trend roughly north and others east. (See pl. 6.) However, in the lower level the better-grade fluorspar is chiefly concentrated in a nearly continuous vein that strikes about N. 80° E. and dips 69°-80° SE. On the south side, south of the winze, is an irregular eastward-trending branch. This vein ranges from 5 to 8 feet in width throughout most of its extent and is bordered by narrow zones of medium- to low-grade breccia. The veins are composed mainly of fine-grained deep-violet fluorite, much of which appears to be of the second generation.

Ore mined from the lower level in the Argo mine during the summer of 1943, contained from 52.4 to 69.2 percent of $CaF_2$ and from 21.53 to 32.06 percent of silica.[11] No data are available as to grade of ore mined from the upper level, but it probably averaged 60 percent or more of $CaF_2$. Shipments of lead-silver ore sorted from the fluorspar breccia from time to time during the period 1900-1933 contained 0.06 to 0.3 ounces of gold and 7 to 26 ounces of silver to the ton, 22 to 40 percent of lead, and as much as 5 percent of copper.

As shown in section *A-A′* of plate 6, about half of the breccia zone above the bottom level still remains unmined. Most of this is of a grade too low to mine at the present time, but some good ore remains. In addition, the deposit, which is one of the largest in the district, gives promise of extending to a depth of at least a few and possibly several hundred feet below the present workings.

### Blue Jay Mine

The Blue Jay mine is in McCorkle Gulch about 3,000 feet S. 20° E. of Jamestown, at an altitude of about 7,100 feet. (See pl. 1.) It is developed on one of the most extensive fluorspar veins in the district, and one of the first to be mined. It is owned by the Boulder Fluorspar and Radium Co., but is under lease to Harry M. Williamson and Son. The mine was idle in 1943 and most of the workings were caved. The past output has probably amounted to at least a few thousand tons, but accurate figures are not available.

The mine workings consist of several short tunnels, drifts, shallow shafts, and open cuts and probably do not extend to a depth of more than 50 feet beneath the surface. (See pl. 3.)

The Blue Jay vein strikes about N. 70° W., dips steeply north in places and south in others, and can be traced on the surface for about 1,000 feet. (See pl. 3.) For most of its extent it ranges in width from 6 inches to 7 feet, but at one place where two branches come together it is 16 feet wide. Most of the vein cuts granodiorite but the eastern part extends into granite and pegmatite. The granodiorite is largely altered to clay minerals and chlorite and forms very loose ground. The vein is filled with strongly-brecciated deep-violet

[11] Data furnished by H. B. Williamson.

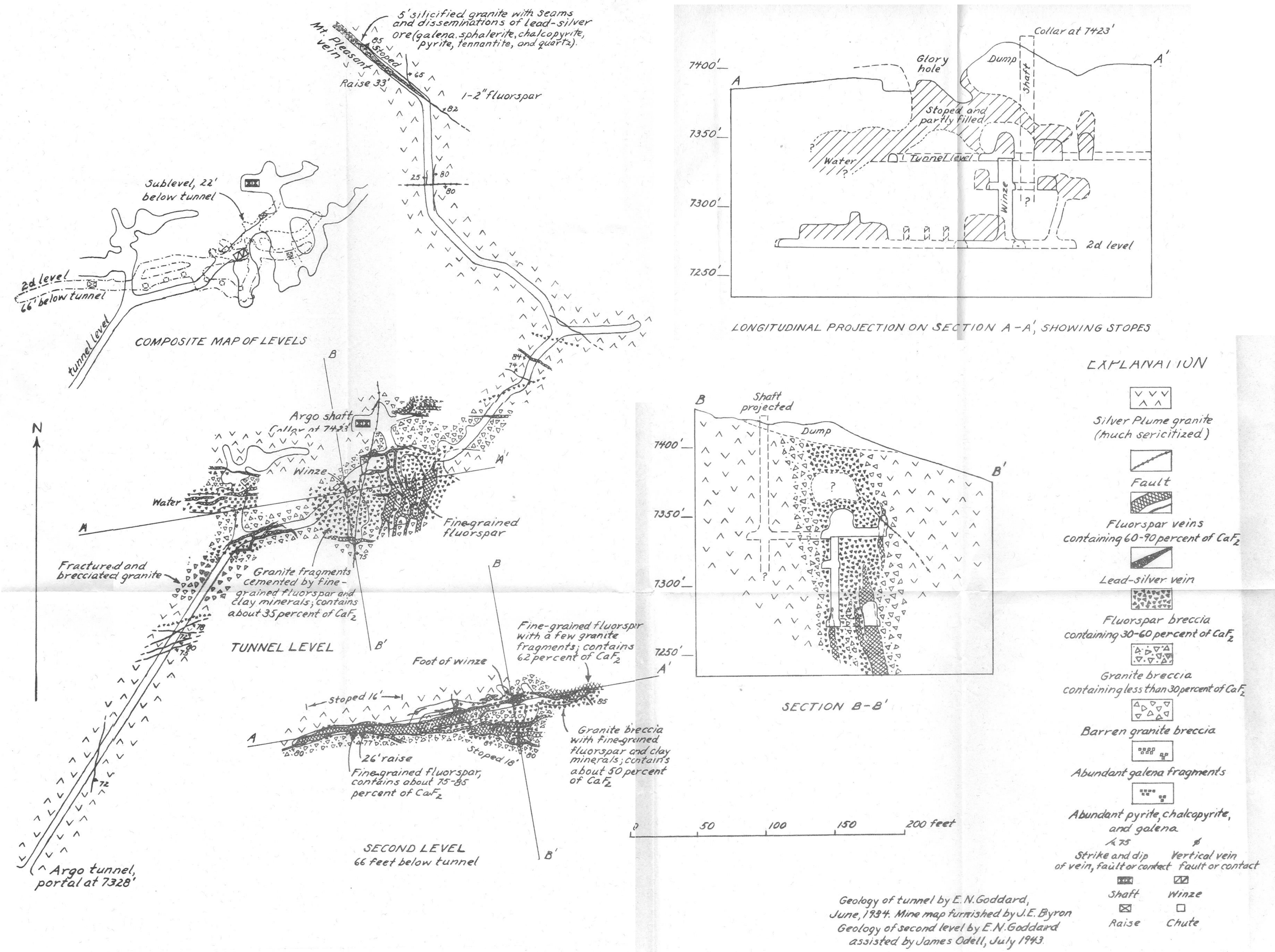


PLATE 6. GEOLOGIC MAPS AND SECTIONS OF THE ARGO MINE

coarsely crystalline fluorite, cemented by a fine-grained mixture of fluorite, quartz, ankerite, and clay minerals. (See pl. 5, A.) Fine-grained pyrite, small amounts of galena, and rare minute grains of pitchblende are disseminated in the matrix.

The grade of fluorspar shipped from the Blue Jay mine prior to 1941 is not known, but is thought to have averaged as high as that shipped or sampled subsequently. Twenty-five tons shipped in 1941 contained 67 percent of $CaF_2$. A number of samples taken by H. B. Williamson ranged from 70 to 90.75 percent of $CaF_2$ and from 7.70 to 24 percent of silica; one sample contained 57 percent of $CaF_2$ and 36 percent of silica. Other impurities are clay minerals, carbonate, and small amounts of pyrite and other sulfides. Some of this ore can probably be concentrated mechanically and shipped as metallurgical-grade fluorspar, but most of it will probably have to be finely ground and milled by flotation because of the high silica content. It could then be marketed as acid- or ceramic-grade fluorspar.

This vein, because of its width, continuity, and extent is believed to contain fairly large reserves and to merit exploration at greater depth. The most favorable part of the vein is the segment extending northwestward from the Blue Jay shaft to the sharp bend on the road. (See pl. 3.) Exploration could be carried on either by clearing out the Blue Jay shaft, sinking, and drifting or by diamond drilling.

## Veins on Blue Jay Hill

On Blue Jay Hill, just east of the Blue Jay mine (see pl. 3) several veins that trend east and northeast seem to be related to the Blue Jay vein, but do not appear to connect with it. They have been intersected by a number of short crosscut tunnels, the lowest of which is about 65 feet below the vein outcrops, but these workings are mostly caved, and the veins are very poorly exposed. The veins cut schist, granite, and granodiorite and contain the same kind of brecciated deep-violet fluorite that is characteristic of the Blue Jay vein. From a few meager exposures, it appears that the veins are narrow and the ore is pockety. Some production has come from these veins, but the grade and tonnage are not known.

## Brown Spar Mine

The Brown Spar mine, operated by Harry M. Williamson and Son under lease from the Boulder Fluorspar and Radium Co., is on the north side of Little James Creek 3,600 feet N. 36° W. of Jamestown, at an altitude of 7,310 feet. (See pls. 1 and 2.) The workings consist of a shaft 300 feet deep, and 3 levels aggregating about 500 feet. A "glory hole" formed by near surface caving has been largely filled with dump material.

The Brown Spar property covers a network of irregular intersecting veins in granodiorite. (See pl. 2.) The main vein strikes N. 70°-80° E. in the main workings, and is intersected by short irregular veins that trend northwest, northeast, north, and east; all dip steeply. Northeast of the mine workings the trend of the main vein swings to N. 50° E.; still farther northeast, a breccia zone of the same trend extends across the granodiorite border into Silver Plume granite. This zone is 15 to 40 feet wide in the granodiorite but widens to as much as 90 feet in the granite. It contains several small discontinuous fluorspar breccia zones and veins, but none are exploitable.

The chief ore body in the Brown Spar mine, at the intersection of the main vein with other irregular veins, is from 60 to 100 feet long and 7 to 25 feet wide or possibly more; it has been followed from the surface to a depth of 300 feet. (See pl. 7.) Near the surface this body contained rather large pockets of coarsely crystalline fluorite, but in the three lower levels it is made up of fine-grained fluorite mixed with clay minerals and ankerite. In this material are fragments of fine-grained fluorite, quartz, intergrown fluorite and chalcedony, and locally, pyrite and galena. Pyrite is finely disseminated throughout and granodiorite fragments are locally abundant. Most of the fine-grained fluorite is fragmental material derived from the granulation of finely crystalline fluorite, but some of the fine-grained material was introduced after the brecciation. The size of the fluorite grains is about 0.2 to 0.5 millimeters, (50 to 125 mesh.) From accessible exposures in the mine workings, it appears that the proportion of fine-grained matrix to fragments is increasing with depth and consequently the grade is decreasing.