Fluorite Deposits of the Quinn Canyon Range, Nevada

GEOLOGICAL SURVEY BULLETIN 1272-C

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By C. L. SAINSBURY *and* F. J. KLEINHAMPL

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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Description of fluorite ore bodies in limestone and altered volcanic rocks of Tertiary age

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By C. L. SAINSBURY and F. J. KLEINHAMPL

ABSTRACT

Fluorite deposits are scattered widely in an area about 15 miles square in the Quinn Canyon Range, some 90 miles south of Ely, Nev. The deposits consist of irregular replacement bodies and breccia fillings in limestone of Paleozoic age and of veins and veinlets in tabular altered zones in volcanic rocks of Tertiary age. Many of the deposits are associated with rhyolite porphyry dikes that intrude both limestone and volcanic rocks and that trend northeast and east-northeast. Some of the deposits in limestone contain ore averaging as much as 90 percent CaF_2, and are considered to be more promising than the deposits in altered volcanic rocks, which generally contain ore of lower grade.

Deposits of metallic minerals, described by previous workers and consisting of argentiferous base-metal deposits and gold-quartz veins, were examined and are located on the reconnaissance map with the fluorite deposits.

INTRODUCTION

Numerous fluorite deposits are known in the Quinn Canyon Range, which lies about 90 miles south and slightly west of Ely, Nev. (See index map on pl. 1.) The number of deposits and the size of some indicate that additional exploration might result in the discovery and production of substantial ore, although only 50 tons of CaF_2 have been mined to date (Kral, 1951).

The fieldwork upon which this report is based began in December 1956, while Sainsbury was employed by Union Carbide Ore Co., and continued from March 1 to August 7, 1957. During this time, Sainsbury, assisted at various times by geologists H. E. Abendroth, T. C. Eyde, R. J. Claus, and Victor Pelaez, prepared sketch geologic maps of the known deposits and conducted a successful program of reconnaissance geologic mapping and prospecting of most of the Quinn Canyon Range, aimed at locating new deposits.

Between 1958 and 1961, additional work was done by Sainsbury, as a geologist of the U.S. Geological Survey, during visits to the area with Richard H. Olson, of the Nevada Department of Mines, and with Kleinhampl, who had been preparing a geologic map of northern Nye County since 1960 as part of the cooperative county map program of the Nevada Bureau of Mines and the U.S. Geological Survey.

The maps and reports prepared by Sainsbury for Union Carbide Ore Co. were made available to the Nevada Bureau of Mines, and Horton (1961) utilized these to prepare a brief description of the deposits.

During the reconnaissance mapping, lode deposits of base metals and gold were examined and located on the map (pl. 1) ; they are not discussed at length in this report.

ACKNOWLEDGMENTS

The authors are indebted to the geologists of Union Carbide Ore Co., mentioned previously, for help during the early part of the work and to R. H. Olson for discussions during later work. The text is based principally upon work of Sainsbury and H. E. Abendroth, supplemented by more recent work of Kleinhampl.

Dr. O. N. Rove, chief geologist, Union Carbide Ore Co., and Mr. A. Q. Lundquist, vice president, Union Carbide Nuclear Co., have kindly given permission to publish in this report results of work done for their companies.

Many of the properties herein discussed were owned by Mr. Hubert Welch of Sparks, Nev., and his associates during the period of field studies; the time and effort he spent in showing his claims is gratefully acknowledged. Mr. and Mrs. Graecian Uhalde and Mr. and Mrs. Ollie Simpson of Adaven, Nev., generously supplied detailed knowledge of the area, and their help, as well as their hospitality, is also gratefully acknowledged.

GEOLOGIC SETTING

The Quinn Canyon Range is a typical range in the Basin and Range province. It trends about N. 20° E. and forms a topographic and geologic entity with the Grant Range, although separated from the Grant on the north by the prominent canyon of Cherry Creek. South of the mapped area, the Quinn Canyon Range passes into low rolling hills composed entirely of volcanic rocks; on the east and west it is bordered by broad alluviated intermontane basins.

Bedrock exposures in the Quinn Canyon Range are limestone, dolomite, shaly limestone, shale, and quartzite of early to middle Paleozoic age; conglomerate and fresh-water limestone of probable early to middle Tertiary age; and tuffaceous sedimentary and volcanic rocks of Tertiary age. These rocks are intruded by a small hypabyssal quartz latite porphyry pluton, by a medium- to coarse-grained granitic stock, and by numerous dikes and sills of fine- to medium-grained dacitic to rhyolitic porphyry and andesite.

SEDIMENTARY STRATA AND EXTRUSIVE VOLCANIC ROCKS

The geologic map of Kleinhampl and Ziony (1967) gives the setting of the Quinn Canyon Range in eastern Nye County and includes all the area of the range shown on the geologic map (pl. 1) of this paper. Where differences in geology are noted between the maps, the former should be accepted since it includes several revisions not found on the latter. Paleozoic carbonate rocks and the various Tertiary rocks are differentiated where sufficiently detailed mapping was done. The Paleozoic formations generally correlate with those assigned to the miogeosynclinal carbonate assemblage of the eastern Great Basin.

The oldest Tertiary unit is assigned to the Oligocene(?) and consists of conglomerate with minor interbedded fresh-water limestone. Except for locally occurring volcanic clasts and tuffaceous matrix, the unit in part resembles the prevolcanic Eocene Sheep Pass Formation of Winfrey (1960, p. 126–133). The presence of the volcanic debris, however, indicates that the two units are not correlative and that the Sheep Pass is the older. Two outcrops of conglomeratic rocks west of the Welch Ranch lack volcanic detritus and may correlate with the older Sheep Pass, but since the outcrops are small and since the absence of volcanic debris may be a local accident of deposition, the rocks are included with the Oligocene(?) conglomerate.

The extrusive volcanic rocks are chiefly rhyolite and rhyolitic to quartz latitic welded tuffs of Oligocene and Miocene age and, near the base of the section, local andesitic breccias and flows. Locally the pyroclastic and extrusive rocks are separated by, or intercalated with, tuffaceous and sedimentary strata.

PLUTONIC AND HYPABYSSAL ROCKS

The plutonic and hypabyssal rocks of the area include dikes of several distinct compositions, a small hypabyssal pluton of quartz latite porphyry (quartz porphyry), and a medium- to coarse-grained quartz monzonite or granite.

Dacitic to rhyolitic dikes ranging in thickness from a few inches to 300 feet are especially numerous in the central, east-central, and south-central parts of the area. They cut the Paleozoic formations and most of the Tertiary volcanic rocks. Most of the dikes are intruded along fractures trending northeast to east, and locally, as at the north end of the

Spar group of claims, dikes compose at least 50 percent of the bedrock. Many of the mineral deposits are localized along the contacts of light-colored rhyolitic to dacitic porphyry dikes.

A quartz porphyry, about 10 square miles in extent, in the Cottonwood Creek drainage area (south-central part of the map, pl. 1), may be genetically related to many of the porphyry dikes. Charles Sabine (oral commun., 1967) examined a thin section of rock and described it as a quartz latite porphyry, composed in part of about 10 percent quartz and 10 percent plagioclase crystals. The plagioclase is oligoclase to sodic andesine; the quartz is anhedral and embayed; and the mafics, now chlorite and magnetite, were probably augite. The groundmass is fine grained and consists of plagioclase, potash feldspar, and quartz. Zircon and apatite are present in trace amounts.

In the southwestern part of the map area, dikes and plugs and flows of similar composition are abundant; these rocks commonly cut and lap the welded tuffs.

STRUCTURE

The Quinn Canyon Range comprises several structural blocks bounded in part by alluviated intermontane basins and by Basin-and-Range type faults. In the mapped area, Paleozoic rocks are primarily restricted to several structural blocks in the north; Tertiary volcanic rocks underlie most of the remaining area and give the appearance of concealing major structural units. Those blocks in which the Paleozoic rocks crop out generally consist of gently folded or homoclinal sequences of sedimentary strata that are cut by high-angle faults. Major flat faults commonly disrupt strata within the blocks. Some of the flat faults may have formed as gravity slides, others as thrusts due to compression. In the central part of the area, west of the Mammoth property (pl. 1), older Paleozoic rocks of a thrust plate overlie younger Paleozoic rocks. The correlative segment of this plate is probably the one that is near the east front of the Grant Range (northeast edge of map, pl. 1), where older over younger and younger over older relations exist and where deformation indicates transport from the west. Locally, the low-angle faults are concealed by Tertiary volcanic rocks or pass into complexly faulted areas of Paleozoic strata.

Though the age of the thrusts is not well defined, the thrusts are most likely older than the volcanic rocks of the area because the latter have little structural similarity to the plates of Paleozoic strata. At the Spar and HiGrade groups of claims (central part of map, pl. 1, locs. 3 and 4), there is an extensive, near-horizontal, locally brecciated jasperoid mass just beneath the Tertiary section; the base of the jasperoid is mapped as a low-angle fault. Since the jasperoid commonly contains fragments of Paleozoic rocks, it may best be explained as an erosional remnant of a prevolcanic thrust breccia. Other explanations for extensive jasperoid blankets have been postulated, and detailed observation at the Spar and HiGrade groups of claims may show that the breccia is related to normal faults and the jasperoid to silica-rich solutions derived from dikes or from overlying Tertiary volcanic rocks (Lumsden, 1964, p. 118–120). Another but less likely explanation for the jasperoid is that it may be related to glide surfaces found at the base of the Tertiary, like those farther north in the Grant Range, which were described by Scott (1965, p. 51–55). There and in the White Pine Range to the north, movement along these low-angle faults and others higher in the Tertiary section was apparently initiated in the post-Oligocene as a result of uplift of the ranges and basement extension (Moores and others, 1968). Huttrer and Hyde (1964) believe that at least some thrusts postdate a granitic pluton at the Troy mine in the Grant Range. The isotope age of the pluton has been determined as 23^{-2}_{+4} m.y (million years) by the potassium-argon method (Armstrong, 1963, p. 160), but it may not represent the time of emplacement of the body.

That deformation predates in part the oldest Tertiary rocks in the area may be seen from basal Tertiary tuffaceous conglomerate and a little interbedded fresh-water limestone that lie upon upturned and eroded Paleozoic strata. Also, the lowermost volcanic rocks lie discordantly upon eroded Tertiary conglomerate and upon Paleozoic formations.

This evidence appears to conflict with that farther north in the Grant, Horse, and White Pine ranges and to the east in the Egan Range, where basal Tertiary sedimentary strata and younger rocks were deposited regionally with little discordance on a surface of low relief developed on Devonian to Permian strata (Lumsden, 1964, p. 120; Moores and others, 1968, p. 1709–1712; Winfrey, 1960, p. 126).

High-angle faults in the Paleozoic rocks appear on the map to have a greater density and complexity than those in the Tertiary rocks (pl. 1), but because the stratigraphy of the Tertiary section is not well known, it is likely that some faults in the Tertiary were not recognized. Moderate to gentle dips characterize the attitude of the Tertiary rocks, and local steep dips, some vertical, are attributed to deformation by normal faulting.

The sharp abutments of Tertiary volcanic rocks and Paleozoic strata present an enigma because along most of these abutments there is no direct physical evidence of a fault. Some, however, like the important contact trending north from the Dresser mine past the Mammoth, are believed to be fault contacts or to be controlled by faults that probably delimit major structural blocks within the range. Some of the contacts are best interpreted as depositional, like that north of Adaven, where volcanic rocks appear to lie on and smooth out irregularities of the prevolcanic surface. Mildly irregular topography existed during the Eocene in the region, for the lacustrine Sheep Pass Formation was deposited in a prevolcanic basin east of the Quinn Canyon Range. Several scattered small outcrops of conglomerate and limestone near the mouth of Cottonwood Creek (Ts, of Oligocene(?) and Oligocene age in the southern part of the area) bear a resemblance to the Sheep Pass Formation, suggesting that this area might have lain on the western periphery of the Sheep Pass basin.

The present form of the Quinn Canyon Range probably evolved from the middle through the late Tertiary, but the outline was accentuated in the Quaternary, as evidenced by dissected Pleistocene gravel terraces and the range-bounding, steeply dipping normal faults that cut both Tertiary rocks and Quaternary unconsolidated alluvial fans along the range front.

The existence of volcanic centers in the area is somewhat conjectural. The numerous volcanic plugs and flows that intrude and overlie some of the pyroclastic rocks along and just west of the southwest border of the map indicate a discrete center of volcanism, the exact shape and extent of which is not well defined. Source areas are not known for the extensive pyroclastic fields in the Quinn Canyon Range, but the source of the Needles Range Formation probably was to the east of the range, whereas great thicknesses of welded tuffs correlated with the Shingle Pass Tuff lie northwest of the range and imply a source area in that direction. Propylitic and silicic alteration, as well as broad zones of brecciation in the volcanic rocks adjacent to the Nye and Lincoln County line, indicate loci of structural weakness, but these features have not yet been related to any volcanic center.

The major dikes of the area cut northeast and nearly east across the strike of Paleozoic and Tertiary units and across the trend of major thrust faults and fold structures. The dike trend also subparallels that of the discrete mineralized alteration zones in the volcanic rocks southwest of Cottonwood Creek. Such similarities in trend and relatively late development may indicate a common origin related to a late structural and igneous event that bears on the fluorite deposits and whose major effects remain largely unknown.

MINERAL DEPOSITS

The mineral deposits of the Quinn Canyon Range include three main types: (1) fluorite (locs. 1 through 8, pl. 1), (2) base metals (east-central part of map near Adaven, pl. 1), and (3) gold-bearing quartz veins (northwestern part of map near Willow Canyon, pl. 1). Only the fluorite deposits are sufficiently well known to be described in detail; all fluorite deposits are shown on the map. Probably less than half of the known base-metal and gold deposits are shown.

FLUORITE DEPOSITS

General Description

In the Quinn Canyon Range, fluorite deposits occur both in the limestone and in the volcanic rocks. Those in limestone show more diversity, and are of higher grade; they can be classified as follows:

1. Relatively small but high-grade replacement deposits in limestone along dike walls (Spar claims, loc. 3, central part of map, pl. 1).
2. Mixed fine-grained silica (jasperoid) and fluorite that has replaced shattered limestone and dolomite, commonly forming tabular, flat lying deposits in which the bulk of the fluorite cements breccia fragments or coats vugs (Valley View and Bonanza claims, Crystal group, northeast of Adaven, loc. 1, pl. 1). Some deposits are localized in shattered jasperoid zones along thrust faults (Jumbo and Horseshoe and Spar groups, central part of pl. 1; fig. 6).
3. Veins along fractures, in which fluorite is intergrown with quartz in relatively coarse-grained intergrowths.
4. Irregular, relatively high-grade replacement deposits in limestone in which fluorite is intergrown with silica, both irregularly and rhythmically, to form banded ores ("coontail" ores), as at the HiGrade and Mammoth deposits (locs. 4 and 2, respectively, central part of map, pl. 1). Locally these replacement bodies are separated from or extend well out away from dikes and are thus distinguishable from the other class of high-grade replacement deposits described under 1, above.

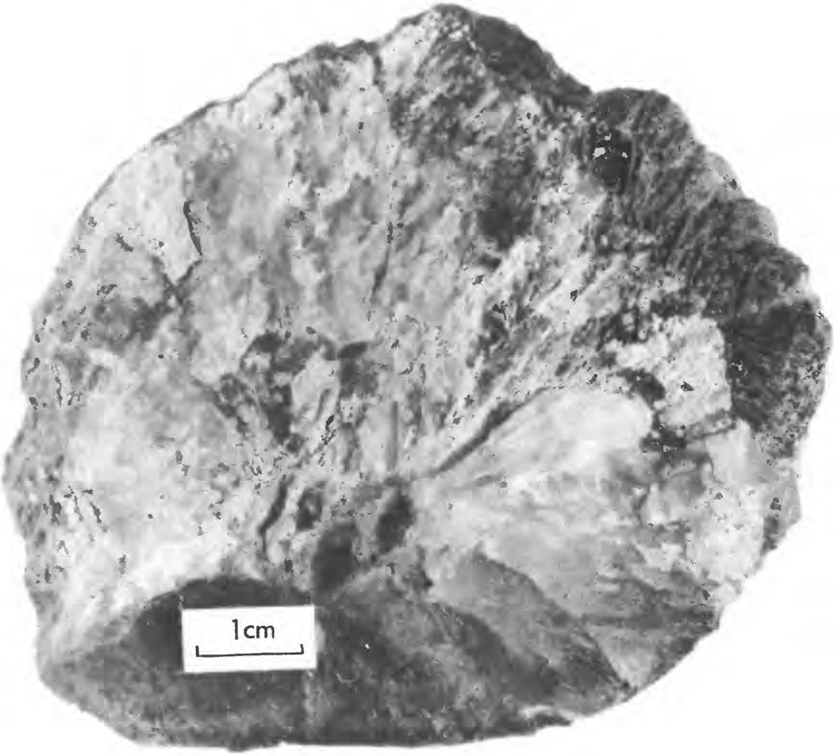
The deposits in volcanic rocks are less diverse, and only two main types are recognized:

1. Well-defined fissure veins filled with pure, coarsely crystalline fluorite. These veins are bordered by argillized wallrocks containing noticeable to abundant disseminated pyrite (Nyco mine).
2. Large tabular fluorite deposits. Fluorite occurs irregularly as discrete but discontinuous veins and veinlets, commonly intergrown with jasperoid, throughout large tabular strongly silicified zones and fractured zones in volcanic rocks. The rocks in the outer portions of the altered zones contain disseminated pyrite.

In the following discussion, the deposits are described by areas named on the map (pl. 1).

Mineralogy and Paragenesis

The mineralogy is simple: the only known ore mineral is fluorite, and the gangue minerals are quartz, jasperoid, pyrite, and hematite, which is generally pseudomorphous after pyrite. Many deposits exhibit two



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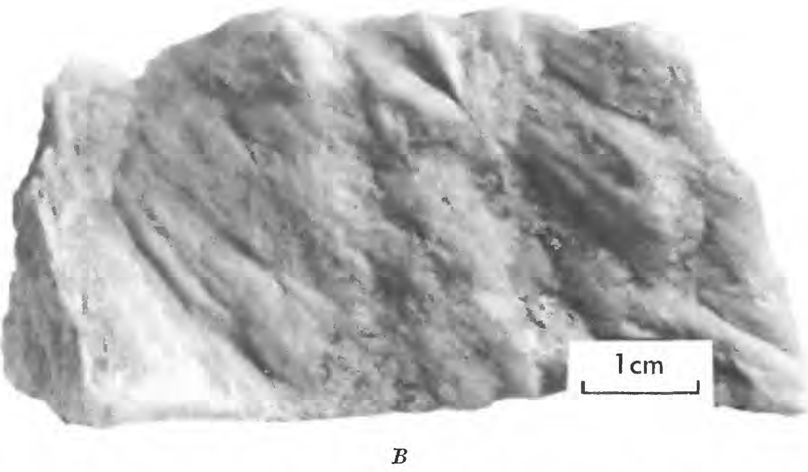
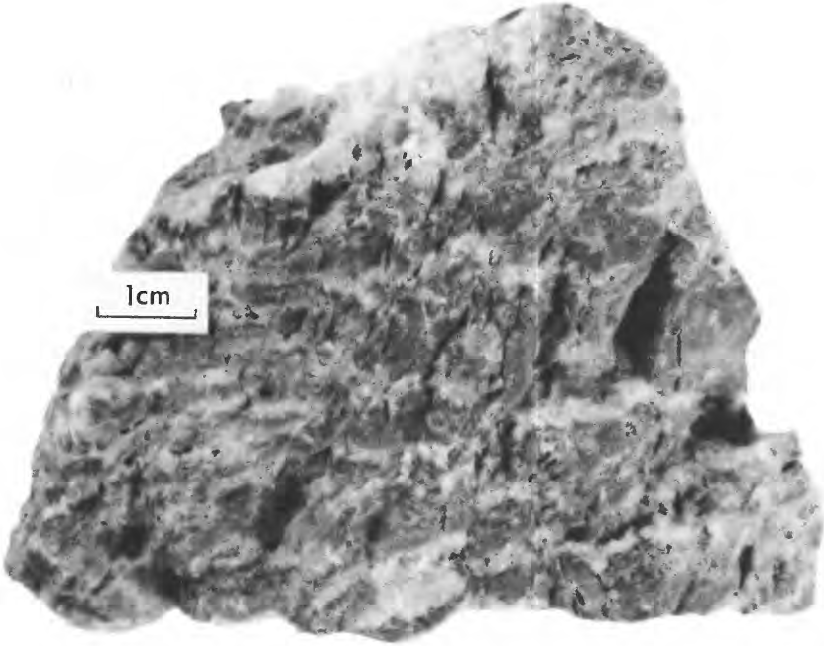


B

FIGURE 1.—Types of fluorite from deposits in the Quinn Canyon Range. *A*. Nodular fluorite from the Spar claims. *B*. Sheared pure fluorite from the Perkins claim, Spar group. *C*. Banded (''coontail'') ore from the Mammoth deposit. *D*. Porous pure fluorite from the HiGrade claims.



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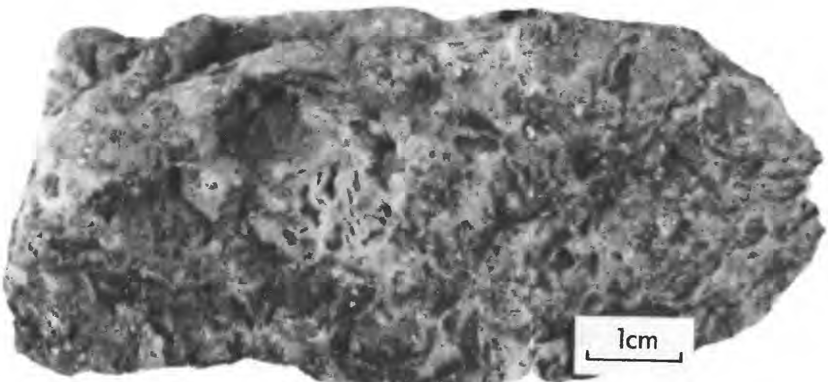


D

FIGURE 1—(For explanation see opposite page.)

generations of silica separated by a period of shattering: the earlier generation consists of tawny to reddish fluorite-free jasperoid which pervasively silicified both carbonate and volcanic rocks; the later one, cementing breccia, consists of white quartz or chalcedony accompanied by varying amounts of fluorite and by sparse pyrite converted to hematite and limonite. In places, generally single-stage replacement of limestone yielded rhythmically banded ore with ubiquitous small voids. These voids probably formed from the reduction in volume during replacement of limestone by fluorite.

Color and form of fluorite differ for different types of fluorite deposits (fig. 1). Fluorite in replacement bodies in limestone is either coarsely crystalline, nodular, and grayish white (*A* in fig. 1) or very pure, fine grained, compact, and light purple (*B* in fig. 1). The fluorite in the large, pure veins in volcanic rocks is mostly light green to colorless; the fluorite in the "coontail" ore (*C* in fig. 1) and that cementing brecciated jasperoid is colorless or white, and the fluorite which forms small cubes is very faintly green. No attempt has been made to relate the color to the content of trace elements, to crystal habit, or to internal order.

An unusual rock texture found at one deposit (fig. 2) is probably due to fluorite and quartz (not shown in fig. 2) replacing the feldspar in a feldspathic quartz vein. The general mode of occurrence of fluorite in silicified limestone is illustrated in figure 3; porous pure fluorite, common in some of the deposits in limestone, is shown in *D* in figure 1.

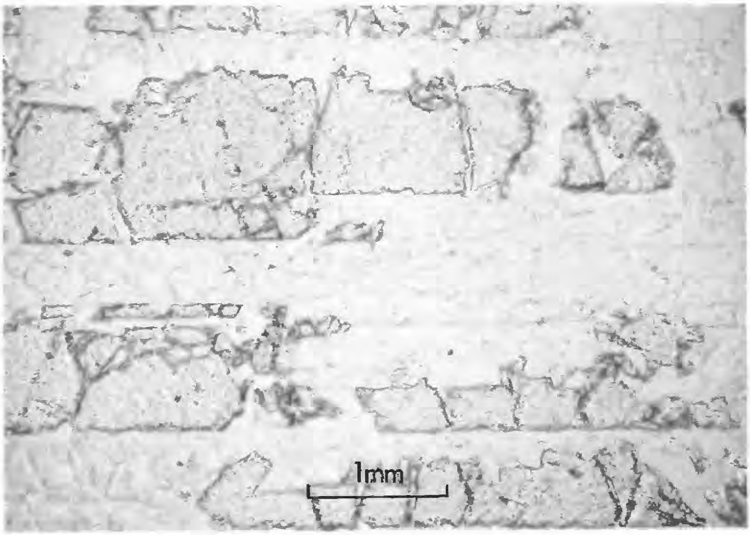


FIGURE 2.—Photomicrograph of fluorite (high relief) that replaced lamellae of albite(?), Shannon Queen fluorite deposits.

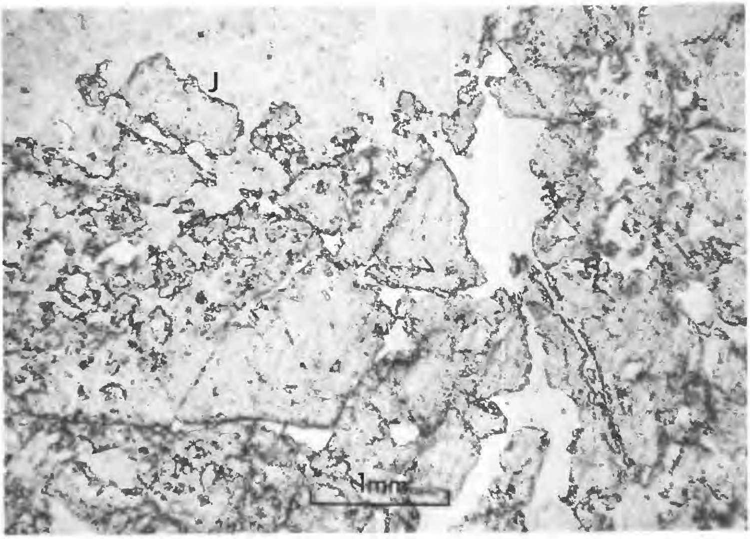


FIGURE 3.—Photomicrograph of fluorite (high relief) coating vug in porous ore from the Mammoth deposit. The fluorite is intergrown with jasperoid (j).

DESCRIPTION OF MINES AND PROSPECTS

Area 1—north of Cherry Creek

In area 1 the fluorite deposits are covered by claims known as the Crystal group (east-central part of map, pl. 1). Most are spatially associated with brecciated silicified limestone and quartzite of probable Devonian age. On the Bonanza claim, a zone of fluorite-cemented silicified breccia strikes northeast for several hundred feet. Fluorite also cements breccia zones of silicified limestone trending parallel to the bedding, which dips 25° S.

On the Valley View claim of the Crystal group, fluorite cements breccia fragments in an oval breccia pipe or diatreme that is at the contact of a rhyolite plug and shattered quartzite (figs. 4 and 5). The breccia is now mostly jasperoid, but the fragments were originally rhyolite, silicified limestone, and quartzite. The breccia pipe contains about 35 percent CaF_2, most of which cements the breccia fragments. The appearance of the ore is shown in figure 5.

On the Liberty Bell claim, fluorite occurs in and near a white quartz vein that strikes N. 70° E. and dips 25°–60° NW.; the host rock is limestone. The vein ranges from 4 inches to 4 feet in thickness and is traceable for at least 700 feet. Visible fluorite occurs only at the western end near a crosscutting zone of red jasperoid. Here the fluorite forms a significant part of the quartz vein and also forms rich banded replace-

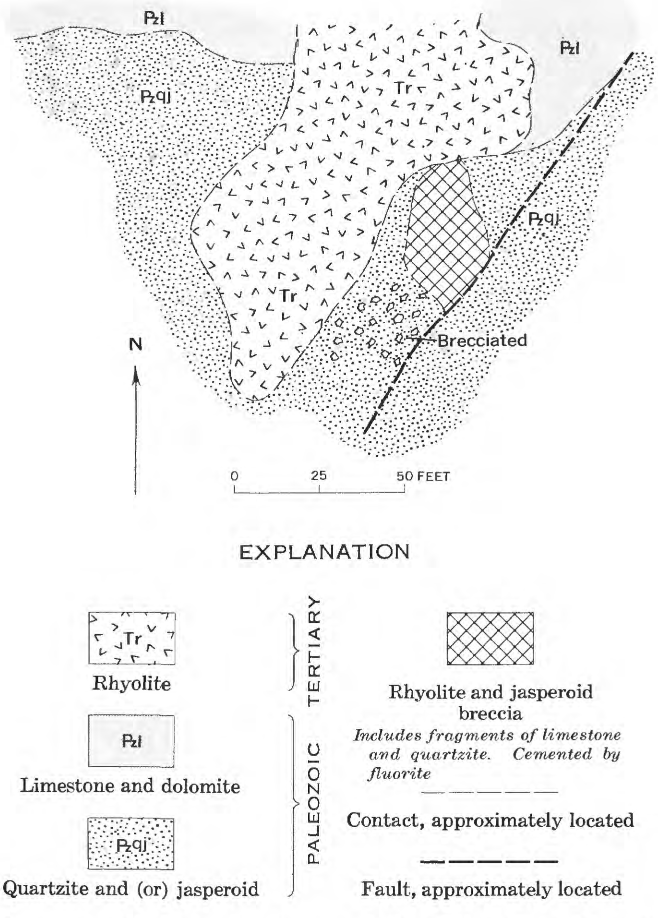


FIGURE 4.—Geologic sketch map of the Valley View (Crystal group) fluorite deposit.

ment ore in the limestone near the vein. The limestone bordering the banded ore is not silicified.

In other deposits of the Crystal group, fluorite cements silicified breccias in tabular bodies which are dip-slope erosional remnants and forms small but rich pods that replace limestone.

Area 2—on the south branch of Cherry Creek

A large, complex fluorite deposit in Sawmill Canyon off Cherry Creek, is known locally as the Mammoth (pl. 2), The deposit is associated with silicified limestone near its contact with volcanic rocks. The limestone belongs to the Antelope Valley Formation of the Pogonip Group. A cen-

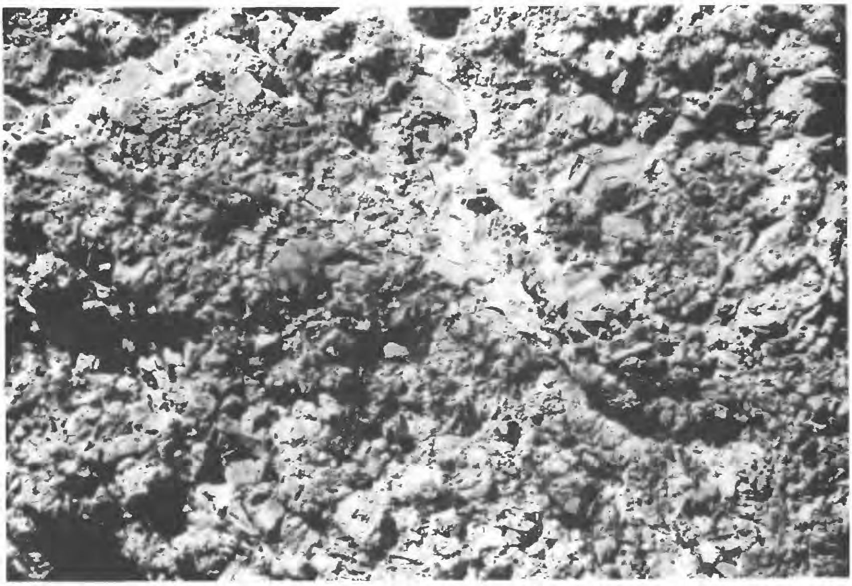
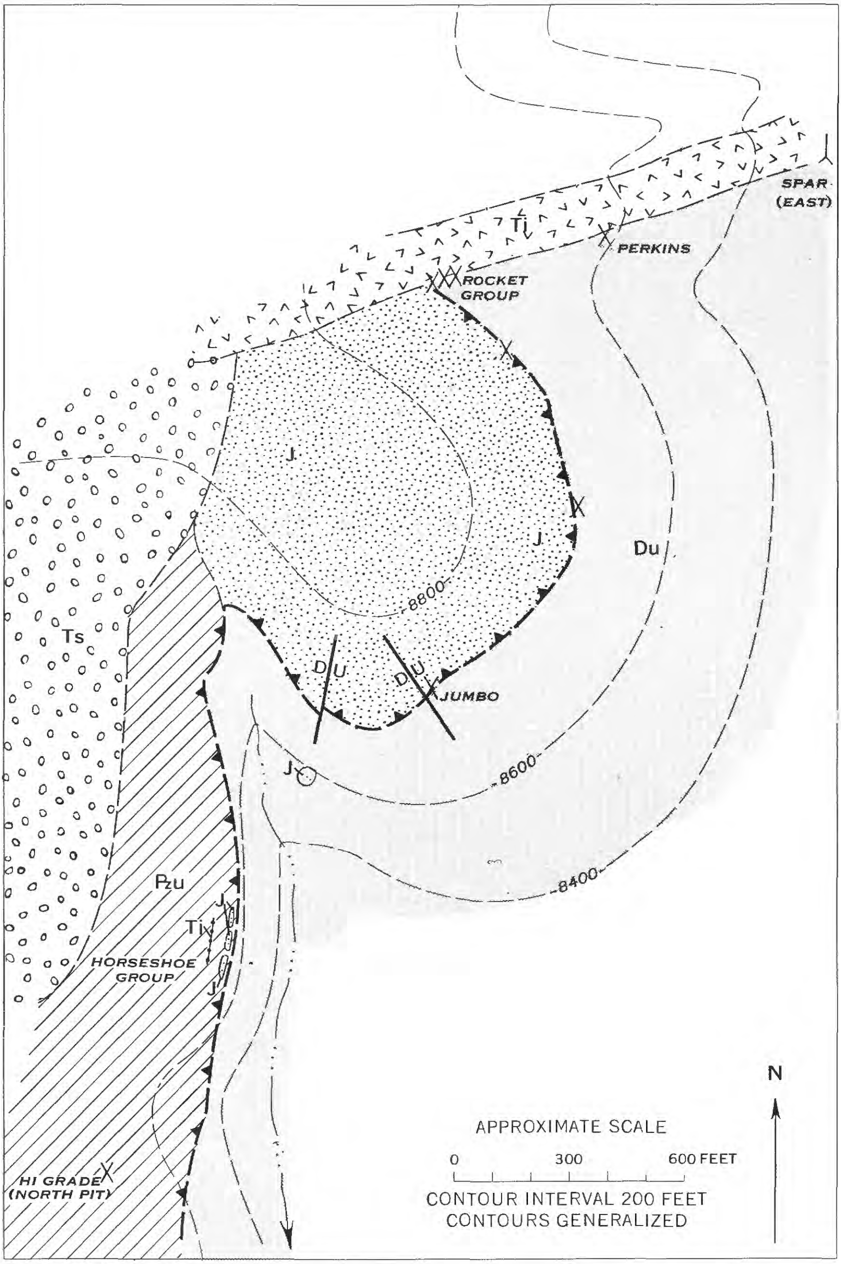


FIGURE 5.—Jasperoid breccia pipe; fragments originally rhyolite, limestone, and quartzite, now cemented by fluorite, Valley View claim of the Crystal group. Scale is about 2 feet to 1 inch.

tral core of brecciated jasperized limestone contains fluorite principally as a cement of breccia fragments. Away from the core, fluorite and fine-grained silica replace limestone along joints, crosscutting fractures, and bedding; locally the fluorite and silica form a banded "coontail" ore that is richer in fluorite than the silicified core. The amount and richness of fluorite in any particular outcrop must be interpreted with caution because the fluorite may be rindlike and surround barren limestone. (See interpretive cross sections, pl. 2.)

There are two distinct generations of fluorite: the earlier is in mammillary layers and contains myriad inclusions and the later forms clear grains as large as 0.5 mm (millimeter) in size. A few minute cubes of fluorite as much as one-eighth inch across occur in vugs in the brecciated core, but most of the fluorite is extremely fine grained. The jasperoid core contains 16–22 percent fluorite and 70–74 percent SiO_2. "Coontail," or limestone replacement, ore contains 22–35 percent fluorite and 50–65 percent SiO_2. A mill test by Gallagher Engineering Corp. of Salt Lake City has shown that an acid-grade fluorite (98 percent effective CaF_2)[1] can be prepared by flotation.

[1]The term "effective CaF_2" means the numerical value obtained by multiplying the percent of SiO_2 in the ore by 2.5 and subtracting this sum from the total CaF_2.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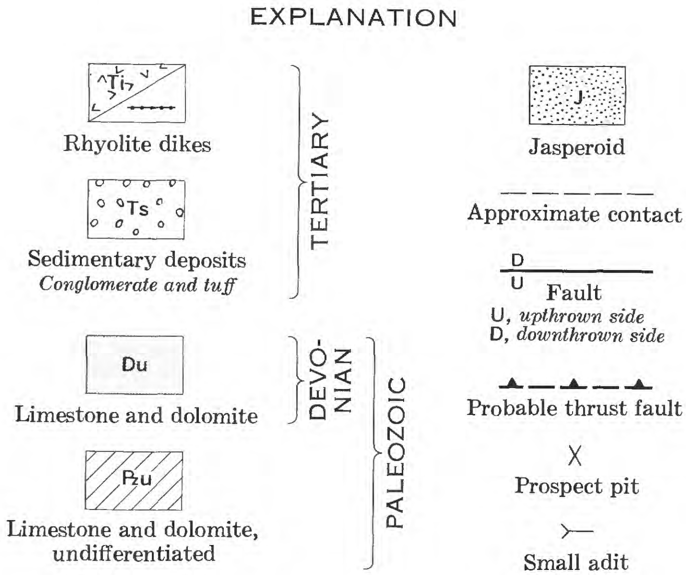

FIGURE 6.—Geologic sketch map of the fluorite deposits between the Spar and HiGrade groups of claims.

Area 3 — at the head of the north branch of Pine Creek

The several claims in this area are known locally as the Spar group (fig. 6). The Spar claim is on a thick rhyolite dike and covers several deposits of rich fluorite replacement in limestone that lie along the south contact of the dike. In these deposits, grayish nodules of pure fluorite (*A* in fig. 1) are enclosed in granular fluorite, and the grade of small bodies exceeds 90 percent CaF_2. Similar deposits of more complex outline occur westward along the dike contact and are known as the Perkins and Rocket claims.

The Perkins deposit is characterized by massive light-purple fluorite (*B* in fig. 1) that replaces limestone for as much as 30 feet outward from the dike wall. Here a shaft about 24 feet deep exposes ore in irregular bodies.

The Rocket group of deposits includes fluorspar at two places: (1) the contact of the rhyolite dike and (2) at the base of a tabular mass of jasperized limestone (jasperoid) that probably lies near or along a thrust fault. The jasperoid is brecciated and caps the hilltop, and fluorite generally coats and cements the breccia. At the Jumbo deposit, the brecciated jasperoid that is cemented by fluorite is about 40 feet long and 2–4 feet thick.

The Horseshoe group of deposits lies on the west side of a steep canyon. There three outcrops of brecciated jasperoid are 190, 200, and 250 feet in extent and are alined along a probable thrust fault (fig. 6). Fluorite cements the jasperoid breccia, replaces unsilicified limestone fragments in the breccia, and in part replaces the limestone nearby. Cliff faces about 100 feet high in the jasperoid show fluorite throughout, but the overall grade of any single body is probably less than 30 percent CaF_2. Most of the fluorspar is colorless to pale greenish white and is very fine grained.

Area 4—south fork of Pine Creek

Six claims known as the HiGrade group cover fluorite deposits in limestone. The deposits generally lie near the contact of the basal Tertiary tuffaceous conglomerate in a thrust plate of Goodwin Limestone of the Pogonip Group overlying lower plate Devonian limestone. All the deposits were found in 1957 by Sainsbury and R. J. Claus during exploration for the Union Carbide Ore Co.

The most promising deposit in the HiGrade claim contains a complex ore body in which fluorite replaces limestone and silicified limestone near a fault trending northeast along the limestone and tuffaceous conglomerate contact. The core of the deposit consists of high-grade fluorspar (75 percent CaF_2) intergrown with a small percentage of silica (fig. 7). The

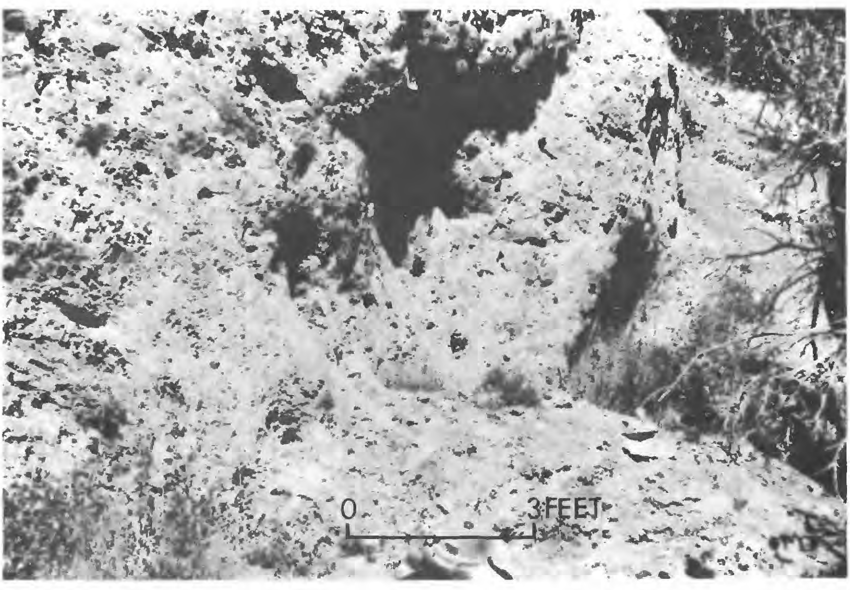

FIGURE 7.—Outcrops of the porous fluorite that forms the core of the main deposit on the HiGrade group.

core is bordered by lower grade siliceous material containing fluorite and by at least one shoot of high-grade ''coontail'' ore about 8 feet thick that can be traced northward for 120 feet from the high-grade core. On the margins of the body, coarsely crystalline calcite is intergrown with the fluorite. In the core, the color of the fluorite varies from gray white to brilliant purple. Within the outcrop area of about 28,000 square feet, where the relief is about 40 feet, the content of fluorite appears to be approximately 65 percent by weight. A bulk chip sample of the highest grade material (shown in fig. 7) contains about 75 percent CaF_2.

At the north end of the HiGrade claims (fig. 6), fluorite occurs in replaced limestone, partly silicified, in an oval area of about 6,000 square feet. The fluorite is very fine grained and almost colorless. Even when examined in detail, the ore does not seem as rich as indicated by assay, which for bulk samples show 72 percent CaF_2.

Other claims in this area are staked on fluorite deposits of unknown size, generally in areas of silicified limestone. Pits on six claims disclose fluorite, but none of the deposits has been explored sufficiently to establish the extent and grade of ore. Like the Mammoth deposit, the Hi-Grade claims are among the most promising deposits in the Quinn Canyon Range.

Area 5 — head of Water Canyon

The Nyco mine (southwestern part of map, pl. 1) may be the ''Rainbow,'' which Kral (1951, p. 216) described as the only fluorite producer in the district (with a production of 200 tons of high-grade ore). Kral's location for the Rainbow, however, best fits that of some properties labeled Rainbow(?) on plate 1.

The Rainbow(?) properties lie about 4½ miles west-southwest of the Nyco mine, and include shallow prospects, bulldozer strippings, and adits in welded tuff and rhyolitic to latitic flows(?). At one of these workings, irregular veinlets of fluorspar strike N. 10° E., have a vertical dip, and cut welded tuff that has an attitude of N. 65° W., 20° SW. In a cut 8 feet wide about 1½ miles to the north, fluorspar veins strike N. 75° E. and cut latite.

At the mine labeled Nyco on plate 1, two adits in Water Canyon (area 5, southwestern part of the map, pl. 1) were driven along steeply west-dipping veins in gently southwest-dipping altered dense welded tuff. The wallrocks of the veins are moderately to intensely altered to clay within a few feet of the veins and are bleached to greater distances. Minute cubes of pyrite occur in the bleached and altered rocks and are disseminated in the densely welded rocks beyond the bleached zones. Breccia zones along normal faults that cut the veins dip moderately northwest. The fluorite fills fissures and forms pure crystalline lenses as much as 4 feet thick. Several such lenses have been stoped, and several remain. Most of the fluorite is deep apple green, but colorless fluorite is common. The presence of stopes suggests that this was the main producer of the district.

Areas 6, 7, and 8 — Cottonwood and Barton Creek areas

Fluorite in these areas is associated with irregular alteration zones in tuffaceous quartz-rich volcanic rocks. The zones of alteration consist of bleached, jasperized, and iron-stained rock locally cut by veins and veinlets of quartz and fluorite. The alteration zones are as much as 4,000 feet long and 500 feet wide; however, the fluorite is usually restricted to the central parts of the altered areas. The individual alteration zones generally lie parallel to fault zones that strike north and northeast. However, the distribution of the alteration zones in a northwest-trending band that extends from the Shannon Queen on the southeast to the Davis claim (area 6) on the northwest suggests that all may be alined along an inferred major fault or fracture zone in the pre-Tertiary strata presently concealed beneath the volcanic rocks. It is also inferred that a suitable host rock of limestone for fluorite deposits is abundant here in the pre-Tertiary because nearby pre-Tertiary outcrops commonly expose carbonate strata.

At the Davis claim (area 6), fluorite fills a vein trending N. 70° E. and dipping 70° SE. The vein as exposed in two pits 100 feet apart is 6–18 inches wide. About 200 yards east of the vein, a bleached and silicified zone in volcanic rock is explored by pits for 100 yards; fluorite is closely associated with fine-grained silica and is in discontinuous veins.

On the El Cortez group of claims (area 6), fluorite is distributed along an iron-stained, bleached, and silicified zone for about 3,500 feet. The altered zone strikes about N. 40° E. and contains a discontinuous central vein of fine-grained silica; the central vein is brecciated and cemented by fluorite and dips 65°–75° SE. In places pure fluorite forms lenses as much as 5 feet wide. Even though the altered zone contains pods and veinlets of fluorite and disseminated fluorite, continuous minable bodies are not exposed at the surface.

At the Sunbeam claims (area 7) fluorite occurs in an altered, iron-stained, and veined zone in volcanic rocks. The zone trends N. 30°–50° E. and dips 50°–60° SE. The altered rock locally is 500 feet wide, but appreciable amounts of fluorite are restricted to the central part, where brecciated silicified rock is cemented by the mineral.

A 6-inch-wide vein of fluorite is exposed on the Davis claim (area 7) southeast of the Sunbeam claims.

At area 8, three groups of claims known as the Emerald, Steele, and Shannon Queen are staked on two altered zones in volcanic rocks. The

Emerald claim contains veins and veinlets of fluorite similar to those in the altered areas described for areas 6 and 7. At the Steele and Shannon Queen claims, relatively discontinuous veins of white quartz and fluorite as much as several hundred feet long are localized within an altered and iron-stained zone in the volcanic rock (fig. 8). The Steel claim covers a vein, striking about north and dipping 70°–80° W., which locally thickens to 4 feet and contains at least 50 percent fluorite, some of which is coarsely crystalline.

The Shannon Queen claims cover the south part of the altered zone, and the relations of the veins are illustrated in figure 8. At least five

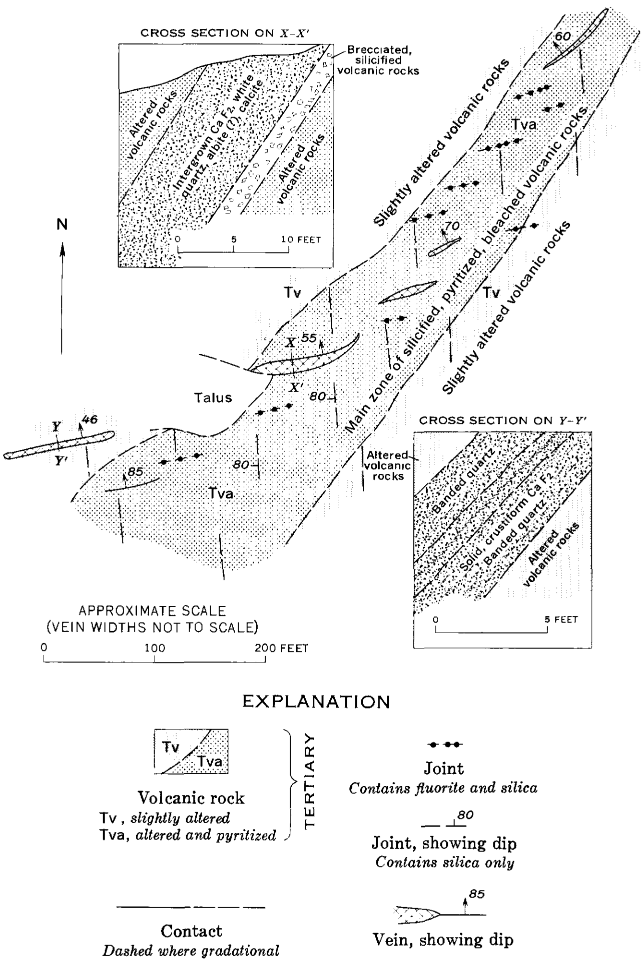

FIGURE 8.—Geologic sketch map of the Shannon Queen fluorite deposits.

quartz veins, ranging from 25 to 100 feet in length and 6 inches to 8 feet in thickness, lie en echelon along the altered area; they strike N. 60°–70° E., transverse to the altered zone. Fluorite is erratically distributed in the veins, and the content ranges from a trace to as much as 50 percent of the vein material. In some veins the fluorite forms a distinct crustiform center surrounded by vein quartz; in others, the fluorite is intergrown with quartz, chalcedony, albite(?), and calcite.

SUGGESTIONS FOR EXPLORATION OF FLUORITE DEPOSITS

The best commercial fluorite deposits are more likely to occur in a limestone host than in a volcanic one.

The deposits in altered volcanic rocks probably are too low in grade to support large-scale mining under 1969 prices, and veins rich enough to warrant selective mining are small. However, richer replacement bodies in Paleozoic limestone may have formed beneath the volcanic cover approximately coincident with the extensive altered zones of areas 5 through 8 and along the northwest alinement of the zones. This depth may approximate 1,000 feet in areas 5 and 6.

Deposits in limestone contain the best grade ore, locally 90 percent CaF_2 by weight. In some of the deposits, fluorite completely replaces limestone, but it rarely if ever replaces silicified fragments of limestone, quartzite, or rhyolite. Hence the grade of ore in the silicified breccias will never be as good as that possible in the limestone; also, a penalty is incurred for silica in fluorspar ore. However, because most of the fluorite in the brecciated jasperized limestone coats and cements breccia fragments, the bulk of the fluorite can be recovered by crushing to half-inch grain size and screening out the undersize, which contains the fluorite. Standard flotation methods can be used to separate fluorite and silica to produce acid-grade (97 percent CaF_2) fluorspar, and since metallurgical grade spar need only have an effective CaF_2 content of 60 percent, the deposits in silicified breccias should not be neglected. To separate calcite from fluorite by flotation requires expensive heating of the flotation feed, and the cost of this, in particular, somewhat offsets the higher grade of the known replacement deposits in limestone.

The possible importance of the deposits in limestone is supported by the striking resemblance of the Hi-Grade and Mammoth deposits to very rich, important pipelike deposits seen by Sainsbury in the Rio Verde in Mexico; at both places fluorite forms fine-grained, colloformly banded, vuggy ore in limestone near the contact between limestone and volcanic rocks. The drab color and fine grain of the fluorite make visual recognition of the fluorite difficult; confidence in recognition of deposits during prospecting is gained only after considerable familiarity with known deposits.

Physical exploration for fluorspar should be based upon a consideration of the following factors:

1. The diversity in structural control of ore deposition leads to ore shoots of different shapes and sizes. Minable ore bodies might be discontinuous and separated from each other by stringers or "leads," as is common at the Daisy mine, near Beatty, Nev.
2. Where ore occurs in flat-lying jasperoid breccias related to faults, the fluorite-bearing solutions probably moved long distances along the breccia from the "feeder," and ore may not extend into the limestone beneath.
3. Ore localized at dike walls may be expected to continue to depth, but in irregular outline.

BASE-METAL DEPOSITS

The known base-metal deposits of the Quinn Canyon Range consist of veins of argentiferous galena that locally contain tetrahedrite, arsenopyrite, and manganese and iron oxides. Descriptions of some of the veins are given by Hill (1916, p. 144–151) and by Kral (1951, p. 212–217), and the writers can add nothing to these descriptions beyond showing the location on the map of several undescribed prospects.

GOLD-QUARTZ DEPOSITS

The gold-quartz deposits of the Quinn Canyon Range have had past production (Kral, 1951, p. 212–214), but are now inactive. The veins are localized on the west side of the range near Willow Creek, and most are confined to the outcrop area of a Middle Cambrian(?) shaly limestone. A quartz-monzonite stock intrudes the limestone near the mouth of Willow Creek and is cut by some of the gold-quartz veins. The writers did not study the gold deposits and can add nothing to the descriptions by Kral (1951, p. 212–214) and Hill (1916, p. 144–151). The general geologic setting, however, is similar to that at the Getchell gold mine near Winnemucca, Nev., where ore bodies lie along a range-front fault cutting a granitic stock. The similarity suggests that geochemical studies should be made along the fault that probably cuts the quartz-monzonite stock in Willow Creek. The locations of the other deposits noted during fieldwork are shown on the map.

REFERENCES CITED

Armstrong, R. L., 1963, Geochronology and geology of the eastern Great Basin: New Haven, Conn., Yale Univ., unpub. Ph. D. thesis, 290 p.

Hill, James M., 1916, Notes on some mining districts in eastern Nevada: U.S. Geol. Survey Bull. 648, 214 p.

Horton, R. C., 1961, An inventory of fluorspar occurrences in Nevada: Nevada Bur. Mines Report 1, 31 p.

Huttrer, G. W., and Hyde, J. H., 1964, Pre-Tertiary structure of the central Grant Range, Nevada [abs.]: Geol. Soc. America Spec. Paper 76, p. 206.

Kleinhampl, F. J., and Ziony, J. I., 1967, Preliminary geologic map of northern Nye County, Nevada: U.S. Geol. Survey Open-file map, 1:200,000.

Kral, V. E., 1951, Mineral resources of Nye County, Nevada: Nevada Univ. Bull., Geology and Mining ser., no. 50, 223 p.

Lumsden, W. W., Jr., 1964, Geology of the southern White Pine Range and northern Horse Range, Nye and White Pine Counties, Nevada: Los Angeles, California Univ. Ph. D. thesis, 355 p.

Moores, E. M., Scott, R. B., and Lumsden, W. W., 1968, Tertiary tectonics of the White Pine–Grant Range region, east-central Nevada, and some regional implications: Geol. Soc. America Bull., v. 79, no. 12, p. 1703–1726.

Scott, R. B., III, 1965, The Tertiary geology and ignimbrite petrology of the Grant Range, east-central Nevada: Houston, Tex., Rice Univ., unpub. Ph. D. thesis, 241 p.

Winfrey, W. M., Jr., 1960, Stratigraphy, correlation, and oil potential of the Sheep Pass Formation, east-central Nevada, *in* Guidebook to the geology of east-central Nevada: Intermountain Assoc. Petroleum Geologists – Eastern Nevada Geol. Soc., 11th Ann. Field Conf., Salt Lake City, Utah, 1960, p. 126–133.

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