COMPLEX SILVER ORES FROM MOREY, NEVADA

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Abstract

Silver ores at Morey, Nevada occur as kryptothermal fracture fillings cutting a nevadite intrusive. Gangue minerals are rhodochrosite, quartz, pyrite, and arsenopyrite. The major silver minerals are diaphorite, owyheeite, andorite, pyrargyrite, and stephanite. Jamesonite and sphalerite are also abundant.

Owyheeite is the most important silver mineral and has formed at the expense of andorite via a complex series of replacements with fizelyite, diaphorite, or rarely freieslebenite as intermediate products.

Single crystals of diaphorite, fizelyite, and owyheeite have been studied goniometrically. Diaphorite has been confirmed as monoclinic $2/m$ with $\beta = 90°5'$, $a{:}b{:}c = 2.6900{:}1{:}5.4024$ or, after transformation to new axes, $\beta = 116°27.5'$, $a{:}b{:}c = 2.6900{:}1{:}3.0172$. The transformation (Zepharovich to Hellner) is $100/001/\bar{\frac{1}{2}}\frac{1}{2}0$.

Ten forms are reported for owyheeite and the axial ratio is $a{:}b{:}c = 0.840{:}1{:}0.312$. One fizelyite crystal showed eight forms and gave $a{:}b{:}c = 0.703{:}1{:}0.458$.

Introduction

The Morey district is a small silver camp in the Hot Creek range in northeastern Nye County, Nevada. The district is about 28 miles by dirt road north of Warm Springs. The first recorded production was in 1867 (Couch & Carpenter 1943).

Ores occur as kryptothermal fracture fillings which vary from a fraction of an inch to several feet in width. High grade ores occur in vertical shoots separated by lean or utterly barren vein matter. Three vertical east-west veins account for most of the district's production. They may be distinguished on the basis of their mineralogy and abundance of certain gangue minerals. Each of the veins is irregular and branching; satellitic veins which deviate from the east-west trend are apt to be barren or narrow.

The host rock is a nevadite (Richthofen 1868; Cross 1884) composed of invariably cracked or broken phenocrysts of quartz, orthoclase (or rarely sanidine), biotite, and oligoclase in a microcrystalline paste of quartz and orthoclase. The nevadite comprises an intrusive mass several miles in diameter flanked on the east by cognate flows. These flows may be traced to the west where they grade imperceptibly into the intrusive mass. Farther to the east they become progressively more glassy and the sanidine/orthoclase ratio increases. Cognate xenoliths, almost invisible in the intrusive mass, become progressively more conspicuous in flows to the east.

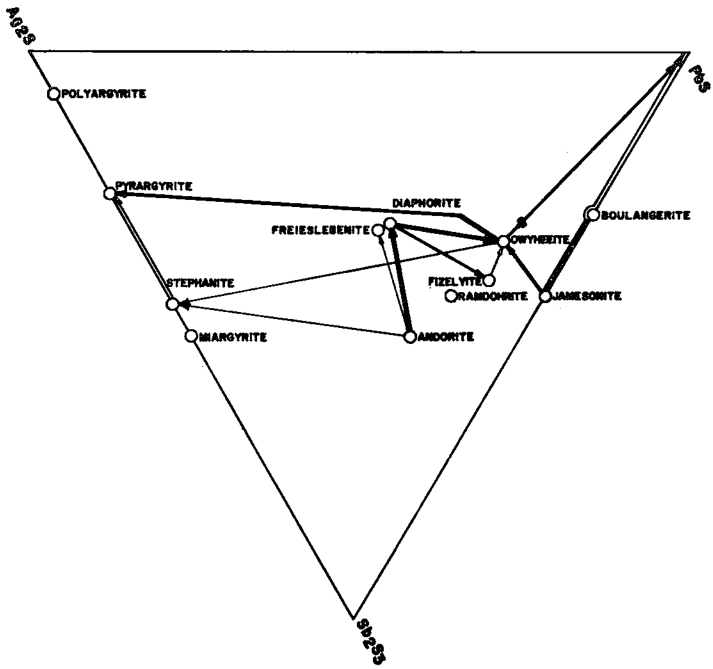

FIG. 1. Paragenesis in the system Ag_2S-PbS-Sb_2S_3. Arrows indicate the direction in which replacements occur and the width of the lines indicates the relative importance of the changes.

THE VEINS

The veins consist largely of rhodochrosite and quartz and show sharp contacts with their walls. Tiny pyrite, arsenopyrite, and very rare cassiterite euhedrons typically line the veins and indent the host rock. Pyrite and arsenopyrite are generally disseminated in the walls an inch or so from the vein. Commonly they are concentrated about previously sericitized xenoliths.

Mild sericitization of the walls and the introduction of pyrite and arsenopyrite was followed by copious amounts of rhodochrosite which fills the veins or lines them as coarse euhedrons. Tiny veinlets normal to the vein walls also are filled with rhodochrosite. Broken crystals of jamesonite and sphalerite are perched on the rhodochrosite or embedded in outer zones of the crystals. Sphalerite and jamesonite continued to crystallize after completion of rhodochrosite deposition and during the onset of quartz deposition. Broken and healed crystal fragments of these two sulfides occur in quartz which veins fractured rhodochrosite.

Andorite and owyheeite follow jamesonite and were essentially contemporaneous with the bulk of the quartz. Following crystallization of andorite was a period of severe brecciation. All earlier minerals were fragmented and are enclosed by new quartz containing a contemporaneous generation of owyheeite. During the crystallization of this later owyheeite andorite was replaced by diaphorite and then either owyheeite directly or with fizelyite as an intermediate step.

Much of the newly-formed diaphorite was redistributed as tiny euhedrons in quartz vugs with pyrargyrite and very rare canfieldite.

A final stage of deposition was the replacement of owyheeite by galena; other sulfosalts are replaced variously by bournonite, pyrargyrite, and stephanite.

The paragenesis is shown in Fig. 1 where the width of the lines indicates the relative importance of the changes.

Oxidation of the veins is limited to about 50 feet owing to the relief in the area and the relative lack of pyrite. At the surface the veins are replaced by porous oxides of manganese and bindheimite. Below this is a thin zone of native silver and chlorargyrite which gives way at greater depth to pyrargyrite and gypsum. Rozenite is a post-mine mineral.

Other species noted are wurtzite, boulangerite, freieslebenite, and tetrahedrite.

Diaphorite

Diaphorite occurs in vugs in comby quartz with corroded sphalerite crystals. The crystals seldom exceed 2 mm in length but are highly complex and ideally suited for goniometric study. Most crystals are brilliant black but some are tarnished metallic blue or bronze.

Seventeen crystals were measured. Data from several had to be rejected since the crystals may be composed of lamellar intergrowths with andorite. These intergrowths are the result of *in situ* replacement of andorite.

The remaining 13 crystals were examined to see if their monoclinic symmetry reported by Hellner (1958) could be verified. The mineral has long been considered orthorhombic and has been subjected to morphological study by several workers (Palache 1938, 1941; Schaller 1937; Prior & Spencer 1897).

Orientation with the classical c as the axis of adjustment provided good angular measurements for {110}, {130}, {150}, {221}, {621}, and {531} (orthorhombic indexing). Faces of these forms were then grouped into odd and even quadrants on the basis of the largest ϕ obtained for any of the faces of {110}. Values were then "smoothed" (Terpstra & Codd 1961, chapter VII). The bias introduced by selecting the highest ϕ for the faces of {110} was justified by the appearance of quadrant groups for faces of the other forms. Using the ϕ values for {110} a value for μ was obtained from the following relation:

$$\frac{\tan \phi_{hk_0}}{\tan \phi_{\bar{h}ko}} = \frac{kq_0 - hp_0 \cos \mu}{kq_0 + hp_0 \cos \mu}$$

in which p_0 and q_0 are elements determined on the assumption that the species is orthorhombic (i.e.—using ϕ values averaged from odd and even quadrants for all forms providing reliable angular measurements). Using the value for ϕ obtained from faces of {110} to solve for values of ϕ for faces of other forms, good matches between measured and calculated values were obtained. For ($\bar{1}\bar{1}0$) and (110) the values of 180° − ϕ and ϕ are 63°32.5′; for ($\bar{1}10$) and ($1\bar{1}0$) they are 63°41′. This gives a value of μ of 89°55′.

The crystals were then reoriented according to the transformation (Zepharovich to Hellner) $100/001/\bar{\tfrac{1}{2}}\tfrac{1}{2}0$. The crystallographic data for this new orientation are presented in Table 1.

TABLE 1. CRYSTALLOGRAPHIC DATA FOR DIAPHORITE

$a:b:c = 2.6900:1:3.1072$ $\beta = 116°27'$ $p_0:q_0:r_0 = 1.1216:2.7012:1$
$r_2:p_2:q_2 = 0.3702:0.4152:1$ $\mu = 63°33'$ $p_0' = 1.2529$
$q_0' = 3.0172$ $x_0' = 0.4977$ Monoclinic $2/m$

	old	new	ϕ	ρ	ϕ_2	B	C	A
b	010	001	90°00′	26°27′	63°32′	90°00′	.....	63°32′
c	001	010	0 00	90 00	.....	0 00	90°00′	90 00
m	110	100	90 00	90 00	0 00	90 00	63 32	90 00
y	221	210	50 17	90 00	0 00	50 17	69 57	39 42
w	081	014	33 35	42 06	63 27	56 03	34 01	63 27
π	130	101	90 00	60 16	29 44	90 00	33 48	29 44
π	$\bar{1}30$	$\bar{1}02$	−90 00	7 20	97 20	90 00	33 47	97 20
m	$\bar{1}10$	$\bar{1}01$	−90 00	37 14	127 04	90 00	63 41	127 04
a	$\bar{1}00$	$\bar{2}01$	−90 00	63 27	153 32	90 00	89 55	153 32
	531	$51\bar{1}$	65 57	82 18	8 25	70 55	61 59	25 11
y	$\bar{2}21$	$\bar{2}12$	−26 35	59 20	127 04	39 43	74 02	112 39
	$\bar{4}01$	$\bar{4}12$	−53 05	68 17	143 32	56 05	81 42	137 54

A total of 79 forms were found on these remarkable crystals but, of these, 42 were noted only once. The forms noted most frequently are as follows in order of decreasing frequency of occurrence: {100}, {$\bar{1}01$}, {101}, {$\bar{1}02$}, {100}, {014}, {210}, {$\bar{2}12$}, {$\bar{6}12$}, {$\bar{6}14$}, {001}, {012}, {511}, {$\bar{5}14$}, {102}, {$\bar{2}11$}, {$\bar{1}03$}, and {$\bar{4}12$}. No appreciable difference of frequency of occurrence was noted among faces of each form in the old orientation. The typical crystal, shown in Fig. 2, is drawn and lettered in the classical orientation.

FIZELYITE

Fizelyite occurs as a replacement product of andorite in some of the ores. The crystals are deeply striated or fluted prisms which closely

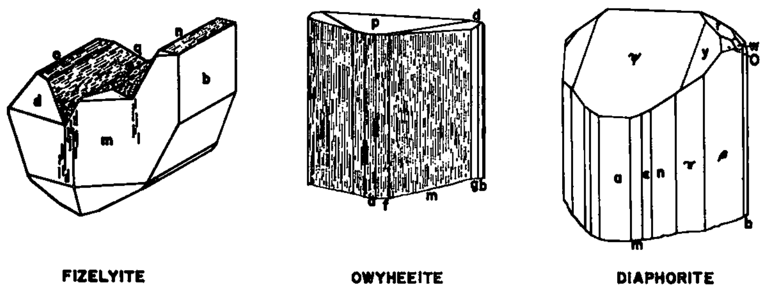

FIG. 2. Forms shown as follows: Fizelyite: *b* {010}, *m* {110}, *n* {012}, *q* {041}, *d* {221}. Owyheeite: *b* {010}, *a* {100}, *g* {160}, *m* {110}, *f* {610}, *p* {106}, *d* {112}. Diaphorite: (in the new setting) *b* {001}, *β* {103}, *π* {101}, *n* {201}, *ε* {401}, *m* {100}, *a* {201}, *ψ* {211}, *y* {210}, *r* {012}, *O* {113}, *w* {014}.

resemble the andorite they replace. Replacement typically begins by selective replacement of every other lamella of andorite by oriented diaphorite. When this is complete, the diaphorite lamellae are replaced by fizelyite and then the same process begins on the other set of andorite lamellae remaining. Silver and antimony are continuously lost during the replacement process (which produces single fizelyite crystals upon completion) so that a volume reduction is evident upon completion:

$$\underset{\text{andorite}}{5AgPbSb_3S_6 \text{ (815.67 cc)}} \rightarrow \underset{\text{fizelyite}}{Pb_5Ag_2Sb_8S_{18} \text{ (540.09 cc)}}$$

At completion, hollow, cavernous crystals of fizelyite up to 4 by 12 mm occupy the cavity originally filled with andorite. These crystals show deep red internal reflections and have a specific gravity of 5.19 ± .008. One crystal suitable for measurement was found; data derived from it are given in Table 2.

The axial ratio is in fair agreement with the value $a{:}b{:}c = 0.683{:}1{:}0.454$ determined by Nuffield (in Berry & Thompson, 1962) on the basis of *x*-ray study. The ratio is also similar to that of andorite. However, the

TABLE 2. CRYSTALLOGRAPHIC DATA FOR FIZELYITE

Orthorhombic $2/m\ 2/m\ 2/m$ $a{:}b{:}c = 0.703{:}1{:}0.458$ $p_0{:}q_0{:}r_0 = 0.651{:}0.458{:}1$
$q_1{:}r_1{:}p_1 = 0.703{:}1.535{:}1$ $r_2{:}p_2{:}q_2 = 2.184{:}1.423{:}1$

form	ϕ	ρ	ϕ_1	ρ_1	ϕ_2	ρ_2
c 001	.....	0°00′	0°00′	90°00′	90°00′	90°00′
b 010	0°00′	90 00	90 00	90°00	.....	0 00
m 110	54 54	90 00	90 00	35 06	0 00	54 54
n 012	0 00	12 54	12 54	90 00	90 00	77 06
o 011	0 00	24 36	24 36	90 00	90 00	65 24
p 021	0 00	42 29	42 29	90 00	90 00	47 31
q 041	0 00	61 22	61 22	90 00	90 00	28 38
d 221	54 54	57 52	42 29	46 09	37 31	60 51

morphological aspect is quite different. The crystal (Fig. 2) is elongate on [100] and deeply striated on that axis. A poor cleavage on {021} was noted.

Owyheeite

Owyheeite is the most abundant silver mineral in the veins. It occurs as acicular prisms which may be curled [001] about [010], sometimes in perfect circles, or twisted 22.5°/mm about [001]. Some crystals have been deflected by the opposing sides of vugs and are twisted into fantastic shapes.

A few specimens containing fairly stout measurable crystals were found. The data in Table 3 are based on seven measured crystals.

The crystals are elongated on [001] and striated in that direction. The dominant form is {110}. The axial ratio is in fair agreement with that reported by Robinson (1949) from Weissenberg photographs ($a:b:c$ = 0.839:1:0.301. The morphology is suggestive of the layer line he found for $c/2$.

The value of $a:b$ is superior to $b:c$ owing to the poor development of forms intersecting [001]. Of note is the fact that all seven crystals examined showed {106} only once. Monoclinic symmetry ($2/m$) with β near 90° is possible. A typical crystal termination is shown in Fig. 2.

Table 3. Crystallographic Data for Owyheeite

Orthorhombic $2/m\ 2/m\ 2/m$ (?) $a:b:c = 0.840:1:0.312$ $p_0:q_0:r_0 = 0.372:0.312:1$
$q_1:r_1:p_1 = 0.840:2.695:1$ $r_2:p_2:q_2 = 3.205:1.190:1$

form	ϕ	ρ	ϕ_1	ρ_1	ϕ_2	ρ_2
b 010	0°00′	90°00′	90°00′	90°00′	.....	0°00′
a 100	90 00	90 00	.....	0 00	0°00′	90 00
g 160	11 13	90 00	90 00	78 47	0 00	11 13
h 130	21 38	90 00	90 00	68 22	0 00	21 38
m 110	49 58	90 00	90 00	40 02	0 00	49 58
i 210	67 13	90 00	90 00	22 47	0 00	67 13
k 310	74 21	90 00	90 00	15 39	0 00	74 21
f 610	82 02	90 00	90 00	7 58	0 00	82 02
p 106	90 00	3 33	0 00	86 27	86 27	90 00
d 112	49 58	13 40	8 53	79 35	79 27	81 15

Shannon (1922) gives an excellent description of the Morey ores based on examination of a single specimen. However, the analysis he cites as evidence of a possible new mineral is probably based on a mixture of owyheeite and galena. The point enclosed by a small rectangle on the galena-owyheeite join in Fig. 1 represents this analysis. His conclusion that the material represented totally altered andorite is essentially correct; andorite is the first silver sulphosalt to form in the Ag-Pb-Sb system. As has been noted, however, owyheeite is only an intermediate step in the paragenesis, and contamination of his sample by excess galena is not only probable but explains the high lead in the analysis.

Conclusions

Two points seem worthy of note. One is that the ores are strikingly similar to the early-mined silver ores in Bolivia which turned to tin ores with depth. A similar deposit has also been described in the USSR (Indolev 1962). The other point concerns diaphorite. After analysis of data from the four quadrants about [001] has shown monoclinic symmetry one might wonder how many other species would succumb to this sort of treatment and reveal lower symmetry!

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