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ANTIMONY DEPOSITS OF THE WILDROSE CANYON AREA INYO COUNTY, CALIFORNIA

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ANTIMONY DEPOSITS OF THE WILDROSE CANYON AREA, INYO COUNTY, CALIFORNIA

By Donald E. White

ABSTRACT

The antimony deposits of the Wildrose Canyon area, Inyo County, Calif., are in chlorite schist and amphibolite of probable pre-Cambrian age. All but two of the large deposits lie within a small area of close folds, striking about north-northeast, near Antimony Ridge on the south side of the canyon and were deposited in zones of fracture and shearing along the limbs and crests of the anticlines. Fracturing favorable to the reception of the ores is commonest in the amphibolite--a tough rock competent to hold open spaces.

The antimony minerals of the deposits are stibnite and several oxides. The chief gangue mineral is quartz, which encloses fragments of country rock; gypsum is rather common, and fluorite is rather abundant in one deposit. It is believed that the stibnite and associated primary minerals were deposited at low temperature and shallow depth in Tertiary or Quaternary time. They are probably not directly related in origin to the dikes of aplite and pegmatite, the only igneous rocks exposed in the region, though like these dikes, they may have come from a magmatic source.

The reserves are estimated to be about 50,000 tons of ore, containing 1½ to 5 percent of antimony. They may be somewhat greater, but they can hardly be much greater unless the ore goes deeper than now appears probable. A price for antimony of 20 to 30 cents a pound would be required to assure a profit on the mining of most of this ore.

INTRODUCTION

The Wildrose Canyon area is on the west slope of the Panamint Range, 7 miles northwest of Telescope Peak. It is easily accessible by road from Death Valley and Lone Pine, and by both road and railroad from Trona, the nearest railway station, which is 45 miles to the southwest.

The precise date at which the deposit was discovered is not known, but apparently it was several years before 1915, when the earliest recorded production was made by the Western Metals Co. The company at first shipped the ore to its smelter at San Pedro, Calif., and later attempted to treat it at a plant built in Wildrose Canyon. The company patented four claims--the Monarch, Combination, and Monopoly claims on the south side of the canyon and the Kennedy Quartz claim on the north side.

No record of annual production is obtainable, but during the period of active production--1915 to 1917--according to Tucker and Sampson [1] the Western Metals Co. mined about 4,000 tons of ore, reported to contain 42 percent of metallic antimony. The recovery, however, at least from the Wildrose smelter, was low, and the actual production of metallic antimony was probably less than 1,000 tons.

No ore was mined from the area during the period 1918-36. Small-scale operations were attempted in 1937 and 1938 by E. B. Spitzer, who screened some of the Monarch dump and mined some high-grade ore from the Kennedy vein, on the north side of the area. Treatment of the low-grade ore and dump material, which contains less than 5 percent of antimony, is being considered by A. C. MacClure and A. G. Barnes, of Los Angeles, the present owners of the mine.

The writer, assisted by D. T. McMillan and W. R. Wagner, spent from November 1 to December 15, 1939, in field work in the district. Two areas were mapped topographically and geologically on a scale of 500 feet to the inch, with a contour interval of 50 feet. The one area, somewhat more than 3 square miles in extent, is mainly on the south side of Wildrose Canyon but extends over the ridge into Tuber Canyon. (See pl. 45.)

1/ Tucker, W. B., and Sampson, R. J., Mineral resources of Inyo County, Calif.: California Jour. Mines and Geology, vol. 34, No. 4, p. 378, October 1938.

This area contains the Monarch, Combination, and Monopoly patented claims and several unpatented claims. The second area, a little more than half a square mile in extent, is on the north side of Wildrose Canyon. It contains the Kennedy Quartz pat-

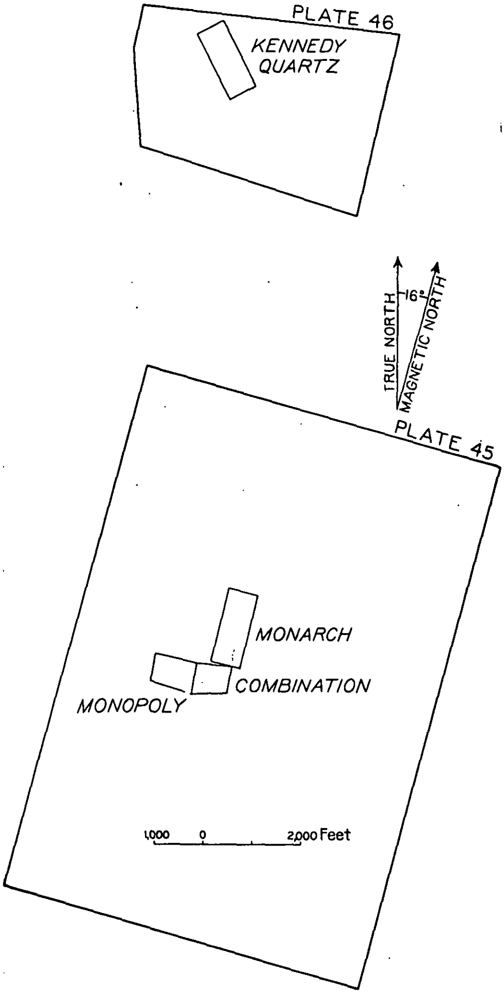

Figure 45.--Index map showing the relative positions of the patented claims in the two areas mapped geologically.

ented claim. (See pl. 46.) The relative positions of the patented claims and the two mapped areas are shown on figure 45.

The writer is indebted to the employees of the National Park Service at the Death Valley Monument and to the Civilian Conservation Corps at Death Valley for their generous cooperation.

GEOLOGY

The geology of this region has been described by Murphy,[2/] who named the stratigraphic units. The descriptions in this report, however, are based on the writer's own observations, and general descriptive terms are used rather than formal stratigraphic names because no detailed stratigraphic study was made in connection with the study of the ore deposits and no correlation with surrounding areas was attempted.

The dominant country rocks of the region are metamorphic and are probably pre-Cambrian. The oldest are dark schists and gneisses of considerable total thickness. They are overlain by 200 feet or more of blue-gray dolomitic limestone, which is probably unconformable on the older rocks and is unconformably overlain by the younger schists of Murphy's Surprise formation. The Surprise formation has been subdivided on differences in metamorphism. It is overlain by dark schistose conglomerate, in which a stratum of white limestone is interbedded, and this in turn is overlain by a buff-colored limestone. No angular unconformities are known to occur in the series above the Surprise formation, but there may be disconformities at the top and base of the white limestone. These metamorphic rocks are complexly folded and faulted.

Abundant small aplite and pegmatite dikes, generally containing tourmaline, suggest an underlying granite body.

Several remnants of once extensive Recent or Pleistocene hot-spring deposits consisting of rubble cemented by travertine are shown on plate 45. The travertine may be a product of the last stages of the activity that produced the antimony deposits.

The valley alluvium was deposited in an earlier erosion cycle and is now being dissected.

2/ Murphy, F. M., Geology of a part of the Panamint Range, California: California Jour. Mines and Geology, vol. 28, pp. 344-347, 1932.

Stratigraphy

Metamorphic complex.--The name "metamorphic complex" has been adopted from the work of Murphy 3/ for the oldest rocks in the area. They are found only in its southern part. The complex consists of dark gneisses and schists, which are believed to have been derived from shaly sedimentary rocks. Its metamorphism is in general of higher grade than that of the younger rocks. The complex could locally be subdivided--in the southwest corner of the mapped area, for example, mica schists are overlain by massive dark schists and gneisses--but it is mapped as a unit. Its dominant minerals are mica, quartz, and intermediate plagioclase; it also contains much tourmaline and rutile and some staurolite and chloritoid.

Dolomitic limestone.--The formation that overlies the complex consists of crystalline, banded blue-gray dolomitic limestone containing subordinate muscovite, quartz, and pyrite. This unit was named by Murphy 4/ the Marvel dolomitic limestone. The light bands effervesce more readily than the dark in dilute hydrochloric acid and therefore probably contain more calcite in proportion to dolomite.

The contact with the underlying metamorphic complex is thought to be unconformable, because of the great lateral variation in thickness of the uppermost unit of the complex. In some places the limestone lies between Murphy's Surprise formation and the complex, but elsewhere it is completely absent or is separated from the Surprise formation by massive dark gneiss. This erratic distribution may be due to a combination of complex folding, original lenticular form of the limestone bodies, superposition of the dark gneiss by thrust faulting or overturning, and pseudo-intrusion of the limestone as it flowed

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3/ Murphy, F. M., op. cit., pp. 337-343.
4/ Murphy, F. M., idem, p. 343.

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under tremendous pressure. A small tongue of blue dolomitic limestone indistinguishable from Murphy's Marvel occurs within the Surprise formation on the western border of the mapped area, and, although it may be a calcareous bed in the Surprise formation, it is thought to be Marvel dolomitic limestone that has reached its present position by plastic intrusion.

Younger schists.--The most extensive formation in the district, consisting mainly of schists, but including mica gneiss and amphibolite, is Murphy's Surprise formation. It is believed originally to have consisted mainly of sandy shales, but conglomerate with boulders as much as 5 inches in diameter is abundant near the base. The formation has been strongly metamorphosed, principally to schists, which are composed mainly of quartz, mica, chlorite, and actinolite but which contain also tourmaline, zoisite, chloritoid, and rutile. The mica gneiss and massive amphibolite are both partly garnetiferous. The amphibolite is the country rock of most of the antimony deposits. Aplite and pegmatite dikes cut the younger schists, but there is correlation between abundance of dikes and intensity of metamorphism.

The four lithologic units into which the formation has been divided for mapping are regarded as metamorphic facies rather than as stratigraphic members. Their boundaries do not seem to follow bedding planes, and their differences, though obviously in part original, are thought to be due in large part to metamorphism. The four facies, which intergrade, are distinguished on the map as chlorite schist, biotitic rocks, light-colored mica schist, and amphibolite.

The chlorite schist, which is dark and without striking features, is the most abundant rock in the formation. The biotitic rocks, which are in part schists but in part rather massive gneisses resembling parts of the complex beneath, form two small areas south of Wildrose Canyon and one larger area north of it.

The light-colored mica schist is soft and commonly contains jarosite and a greenish mica. It is thought to have been formed by hydrothermal alteration of chlorite and biotite schists, during which iron was leached from the biotite and chlorite was precipitated as jarosite. Hydrothermal origin is indicated by gradual transition from the chlorite schist to the sericite schist, which still contains small patches of the chlorite schist. Some jarosite-stained muscovite schist on the Tuber Canyon side of the main ridge is reported to contain a trace of gold.

The amphibolite is in general massive, though a little of it is schistose. It is nearly black where fresh and reddish brown where weathered. Several areas mapped as amphibolite, especially the largest one, contain patches of dark chlorite schist.

Schistose conglomerate with white limestone member.--The Surprise formation of Murphy is overlain concordantly by several hundred feet of schistose conglomerate, in which a stratum of white limestone is interbedded about 500 feet above its base. The conglomerate contains abundant stretched pebbles and boulders of quartzite and dolomite and a few of granite in a groundmass of dark chlorite-biotite-actinolite schist resembling some of the schist in the Surprise formation. The largest of the stretched boulders are only a few inches in thickness, but the boulders and pebbles are commonly so much elongated that their length is several times their thickness. Although the whole formation is dominantly conglomeratic, it contains some beds that are free from pebbles; beds of red-brown arkosic quartzite are conspicuous in the part above the limestone.

The white limestone member is most prominent on the north side of Wildrose Canyon, where it forms cliffs and is about 100 feet thick. On the south side of the canyon the limestone is only locally present and is nowhere more than a few feet thick. The limestone is almost a pure carbonate rock, and its contacts with the conglomerate are abrupt. Its upper contact, at least, is probably a disconformity or a low-angle unconformity.

North of Wildrose Canyon the conglomerate above the limestone is about 200 feet thick, but apparently thins out southward.

Buff limestone.--The youngest of the pre-Cambrian formations consists of several hundred feet of impure buff-colored crystalline limestone. Muscovite and quartz, which are its principal impurities, are concentrated in laminae that have been greatly contorted during metamorphism.

Dikes.--Small aplite and pegmatite dikes, nearly everywhere tourmaline-bearing, are abundant throughout much of the area, particularly in the dark schists of the Surprise formation and in the underlying metamorphic complex.

Hot-spring deposits.--The five small masses mapped as hot-spring deposits consist of alluvial material cemented by travertine. They were originally much more extensive, but they have been greatly reduced by erosion. Many smaller masses of travertine were not mapped. The fact that antimony minerals occur near hot springs suggests that both the travertine and the antimony may have been deposited by solutions that rose through the same openings, though the solution that deposited the antimony minerals was the earlier.

Alluvium.--In the bottom of Wildrose Canyon is a rather thick deposit of alluvium, which has been partly removed by recently rejuvenated drainage.

Structure

The structure of the pre-Cambrian rocks throughout the region is complex. In the southern part of the southern area (see pl. 45) the planes of stratification and schistosity dip consistently northeastward; in the eastern part the dips are prevailingly east and southeast; north of the Monarch deposit they are mainly southwest but vary considerably; and the closely folded rocks near Antimony Ridge that contain most of the known deposits dip eastward and westward.

The structure of the northern area (see pl. 46) is so complex that a comprehensive study of the whole region is probably essential to its complete understanding. It is marked by thrusting, overturning, and normal faulting.

The folds within an area half a mile square, traversed by Antimony Ridge, on the south side of Wildrose Canyon, contain all but two of the principal antimony deposits. The four synclines and three anticlines in this area, with one exception, trend north-northeastward. Each is about half a mile long, and the average distance from an anticlinal crest to a synclinal crest is about 350 feet. The dark schists have been closely folded. Where the anticlines have been abruptly flexed their crests have been broken or faulted. Shearing parallel to the schistosity is pronounced in some places. This group of folds dies out gradually to the south and abuts on the north against an ill-defined syncline, which for the most part trends N. 60° W. but swings to the south near its east end.

The competent amphibolite has controlled in part the localization of shearing and brecciation.

The synclines in general are topographically expressed as ridges and the anticlines as gulleys, probably because fracturing, which decreased resistance to erosion, occurred mainly along the crests of the anticlines.

Ore bodies

Distribution and general character

The area contains many individual deposits and prospects. Of the five largest, the Kennedy deposit, formerly known as the Wildrose mine, is on the north side of Wildrose Canyon, the Mohawk deposit is on the Tuber Canyon side of the ridge south of Wildrose Canyon, and the remaining three, as well as most of the prospects, are on and near Antimony Ridge, on the south side of Wildrose Canyon.

Most of the reserves consist of low-grade ore, generally containing less than 5 percent of antimony. Crystals and small pockets of the antimony minerals are either irregularly distributed in vein quartz or disseminated in brecciated amphibolite. High-grade ore--that which can be hand-picked to a concentrate containing at least 40 percent of antimony--is also present in most of the deposits and was selectively mined while the district was active from 1915 to 1917.

The mineral composition of the deposits is rather simple. The primary minerals are quartz, stibnite, a little pyrite, and fluorite; the principal oxidation products are gypsum, oxides of antimony, and a little jarosite. Some very fine grained native sulphur is believed to be intimately mixed with the stibnite in places.

Minerals

Pyrite.--Pyrite (FeS_2) is present in very small amounts.

Stibnite.--Stibnite (Sb_2S_3) is the only primary ore mineral of the antimony deposits; the antimony oxides, which contain a large part of the antimony in the ore, have been formed by weathering of stibnite. Most of the stibnite in the low-grade ore is fine-grained and is intimately associated with fine-grained quartz, but the stibnite in the high-grade ore is generally in bladed crystals, more than 2 millimeters in diameter, which fill vugs outlined by coarse-grained milky quartz. Stibnite is the latest of the primary minerals, having been deposited after quartz and pyrite. When the flame of a carbide lamp is directed against "high-grade" stibnite the mineral fuses more easily than stibnite from other localities, a sulphurous odor is given off, and a blue flame is seen for several seconds after the lamp is withdrawn.

Antimony oxides.--Oxides of antimony are probably more abundant than stibnite in the near-surface ore, which is all that has been mined up to the present time. A brownish oxide, probably valentinite (Sb_2O_3), commonly forms irregular shells around stibnite and is the earliest oxidation product. Some senarmontite (Sb_2O_3) may be present. Commonly a zone of white or light-yellow oxide, probably cervantite ($Sb_2O_3 \cdot Sb_2O_5$), borders the brown oxide, or, where that is absent, borders stibnite. A bright-yellow or orange-yellow hydrous oxide, stibiconite ($Sb_2O_4 \cdot xH_2O$), forms the outer zone where the zonal arrangement is complete and also occurs rather abundantly in some places where the other oxides are not all present.

Quartz.--Quartz forms definite veins, as much as 4 feet thick, and breccia fillings; more rarely it replaces breccia fragments and wall rock, being then accompanied by sericite. The vein quartz is medium-grained to flintlike in texture.

Fluorite.--Fluorite (CaF_2), most of it purple but much of it white, is rather abundant in the Kennedy vein, on the north side of the canyon, but none has been identified in the other deposits.

Gypsum.--Gypsum ($CaSO_4 \cdot 2H_2O$) is common in the district. Its sulphate radicle presumably was formed by oxidation of the sulphides.

Jarosite.--Jarosite ($K_2Fe_6(OH)_{12}(SO_4)_4$) is not commonly associated with the antimony ores, but it is abundant in other parts of the area and is a characteristic mineral of the light-colored mica schist.

Structural relations

With two exceptions the ore deposits occur in zones of shearing and fracture that are related to the series of small sharply flexed folds striking north-northeast, near Antimony Ridge. The mineralized zones are divisible into two groups on

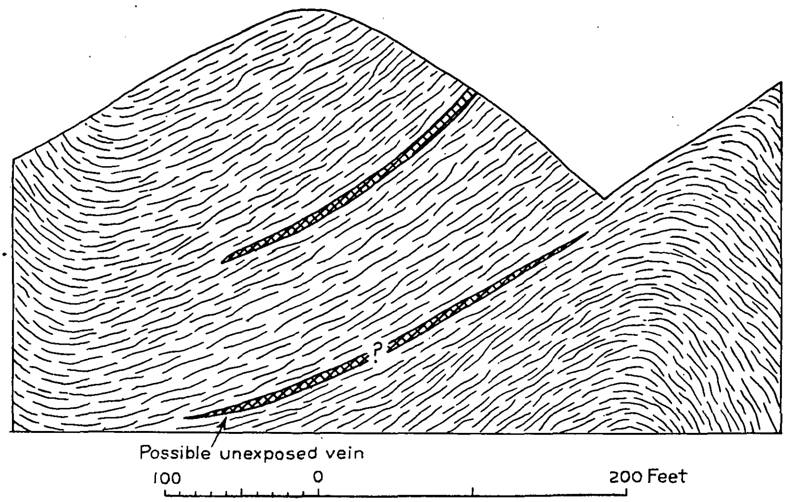
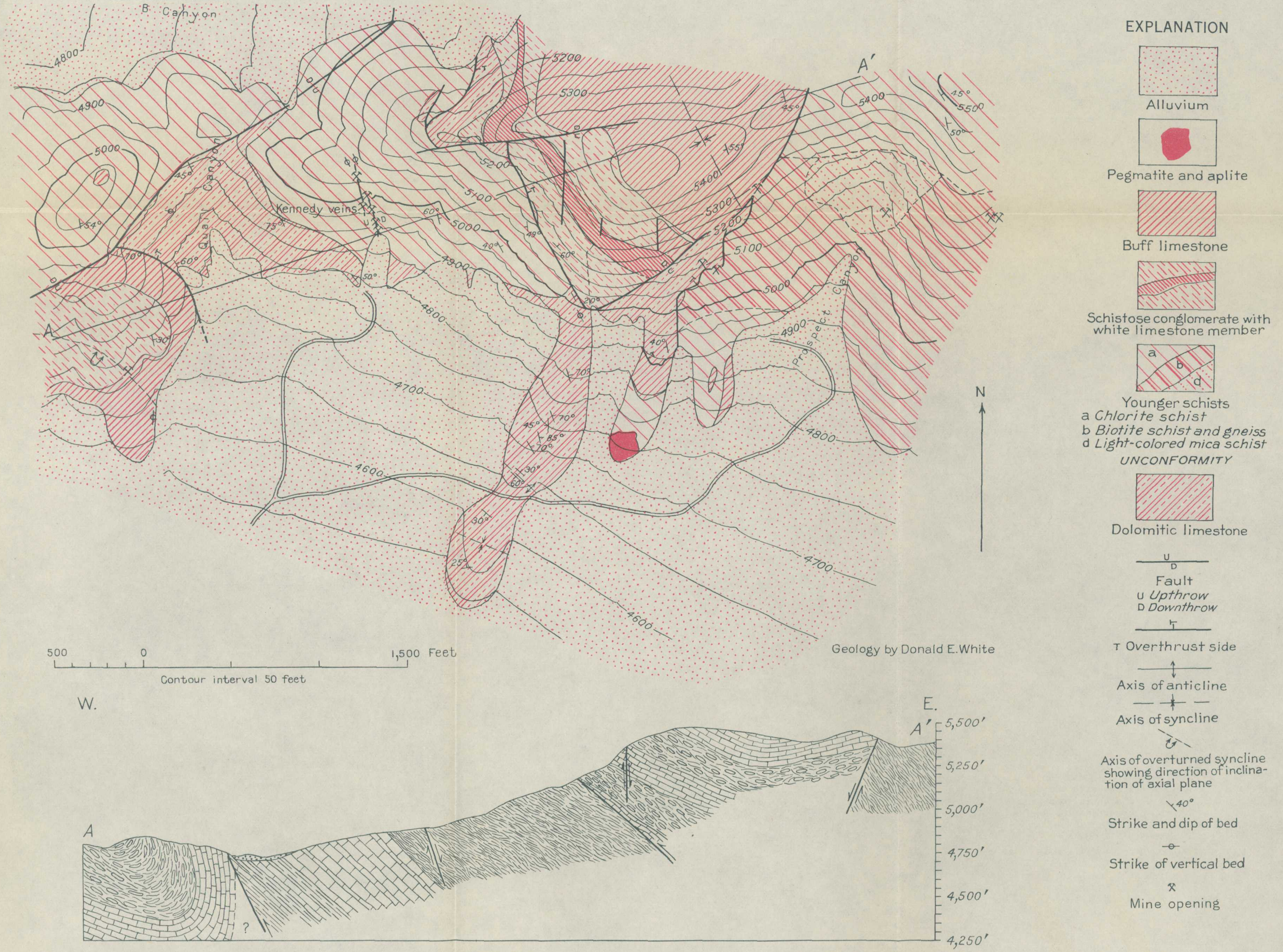


Figure 46.--Diagrammatic section showing the relation of a known vein to an anticline and a syncline, with the vein on the flank of the fold, in a shear plane or a breccia zone parallel to the schistosity. Veins that do not crop out at the surface may occur at a greater depth.

the basis of their relation to the folds. Those of the first group occur on the flanks of the folds, in places where there has been pronounced movement parallel to the schistosity. The zones of the second group extend along the broken axes of anticlines.

Figure 46 shows the relation of veins of the mineralized zones of the first group to the folds. It also illustrates the possible occurrence of veins that do not crop out at the surface



GEOLOGIC MAP AND CROSS SECTION OF THE NORTH SIDE OF WILDROSE CANYON, PANAMINT RANGE, INYO COUNTY, CALIF.

and it suggests that no single vein of this character is likely to persist to a very great depth, because, if subject throughout to the same structural control, it would become nearly horizontal and thin out near the axis of the syncline. Some of the fissures crosscut the schistosity at low angles, and a few irregular breccia zones seem only slightly related to the folds.

The principal example of the second type of mineralization, along broken-crested anticlines, is on the first anticline west of Antimony Ridge. It has given rise to the deposit in the Monarch mine, originally called the Wildrose Antimony mine, from which much of the past production has come. The mine is in the northeast corner of the area of north-northeast-trending folds near Antimony Ridge, where deformation was most intense. The syncline striking N. 60° W., which bounds this area on the north, swings abruptly to the south near the Monarch deposit. The fracture zone that localized the deposition of the ore of the Monarch deposit is apparently a result of the especially complex forces that were active there.

The two principal occurrences of antimony outside the area of close folding near Antimony Ridge are the Mohawk deposit, several thousand feet to the south, and the Kennedy deposit, on the north side of Wildrose Canyon. Each fills a fissure along a small fault.

Origin

The ore bodies probably were deposited at relatively low temperature and pressure by aqueous solutions ascending from deep-seated igneous sources. No igneous rocks that bear close genetic relationship to the ores are exposed in the area. The tourmaline-bearing dikes may be differentiates from the same magma that supposedly was the source of the antimony, but, as these dikes are believed to have been intruded at relatively high temperature and pressure, a long time may have intervened between the intrusion of the dikes and the deposition of the veins. The antimony ores are localized in shear zones and fractures associated with folds in the dark schists. Evidence of post-mineral movement is prominent in several of the deposits, and wherever the direction of movement was ascertainable it was consistently similar to that which produced the earlier deformation, suggesting that the antimony ores may have been deposited during the very late stages of the folding. Sufficient time for considerable erosion and for development of a subsequent drainage pattern in the small folded area elapsed between deposition of the ores and the formation of the hot-spring deposits, which are closely related to the present topographic surface.

Principal ore bodies

General features.--The ores of the Wildrose Canyon district are of two types, the breccia type and the vein type. The breccia type consists of brecciated dark schist or amphibolite containing from 1 to 2 percent of antimony. The vein type consists of vein quartz containing from 5 to 10 percent of antimony with an occasional lens, a few cubic feet or yards in volume, of high-grade ore containing about 40 percent of antimony. Because of the irregular distribution of these lenses, reserves of the vein type of ore cannot be estimated far in advance of mining. Nearly all of the discovered lenses have now been mined out, but more undoubtedly remain to be discovered. Nor can the tonnage of low-grade breccia ore be closely estimated, because most of the past operations have extended only a few feet below the surface. Predictions regarding low-grade breccia ore at depth should be deferred until persistence in depth is actually proved by underground exploration. Such ore has "assay walls" and must be carefully sampled in order to define the limits of each ore body.

Monarch deposit (Wildrose Antimony mine).--The extent, either laterally or in depth, of the low-grade ore in the Monarch deposit has not been fully determined. A few high-grade lenses were mined from an open cut and several tunnels. The lowest, or haulage, tunnel apparently tapped one of the largest lenses near its base, 25 feet below the open cut. This tunnel contains 200 feet of workings, over half of which is in massive amphibolite; the remainder is in brecciated amphibolite, which, though it contains no visible antimony minerals, is said to assay from 1 to 2 percent of antimony.

The vertical face of the open cut exhibits a breccia zone showing pseudo-stratification and abundant gouge; the zone dips very gently to the north. In the inner workings, 20 feet south of the face of the open cut, the breccia zone curves into a fault dipping 30°-40° N. or is cut by it. High-grade lenses of stibnite and quartz were found in both the breccia and the fault.

It is estimated that the ore body contains at least 10,000 tons of 1½- to 5-percent ore and that the old dump contains an equal amount of ore of similar grade. A much greater tonnage may be present if the ore body persists far below the haulage tunnel, but the gentle dip of the breccia zone suggests that the ore body is bottomed not far below the tunnel.

Monarch-Combination vein system.--The veins in the Monarch and Combination mines constitute a system, the north end of which is about 500 feet south of the Monarch deposit. It extends southward along Antimony Ridge for a distance of 1,200 feet. The veins average 1 to 2 feet in thickness, and individual veins range in thickness from less than an inch to 5 feet. The ore consists of fine-grained quartz with 5 to 10 percent of antimony, plus an occasional high-grade lens of stibnite and antimony oxides. The veins are fissure fillings containing many schist inclusions.

The northern vein where it crops out on the crest of the ridge is 4 feet wide, strikes N. 16° W., and dips 75° E. Southward the strike becomes northeasterly and the dip becomes flatter. About 150 feet from its north end this vein is joined near the surface by another, which dips more gently to the east and is the wider of the two for a short distance. Three shafts have been sunk on the main vein, near the middle of its course, to depths as great as 50 feet. In all three shafts the dip of the vein decreases downward. The vein becomes narrower and leaner with depth in two of the shafts but shows 6 inches of good ore at the bottom of the third. The southern 400 feet of the vein has not been developed, but it shows 2 to 4 feet of quartz and contains a little antimony. The southern end of the main vein swings abruptly to a strike of N. 60° E. and a dip of 45° SE.

About 35 feet west of the central part of the main vein a shaft 70 feet deep has been sunk on the intersection of a short vein that strikes N. 20° E. and dips 50° E. with an irregular fracture zone that strikes N. 75° E. and dips 45° S. The dip of the vein decreases downward to 20°, and both the vein and the fracture zone pinch out near the bottom of the shaft.

If 700 feet of the vein, with an average width of $2\frac{1}{2}$ feet, is minable to a depth of 50 feet, 7,300 tons of ore, with an antimony content ranging from 5 to 10 percent, might be taken from it.

Monopoly deposit.--The ore deposit of the Monopoly mine, which is in the south-central part of the area of closely folded schists near Antimony Ridge, is in brecciated and mineralized dark schist, which forms a sheet dipping eastward, roughly parallel to the surface of the ground. Some of the fractures in it dip 45° NW., nearly parallel to the schistosity. Most of the ore is in an area about 100 feet square. Lenses of high-grade antimony ore occur in the breccia, and the deposit was worked for these high-grade lenses, only a few of which are now exposed. Further exploration might reveal new lenses, but the deposit is not expected to persist far downward.

Several thousand tons of ore assaying less than 5 percent of antimony is probably present in the deposit and on the old dumps. A closer estimate is impossible without further exploration and sampling to determine the extent and tenor of the ore body.

Mohawk deposit.--The Mohawk deposit is exceptional in respect to location, being about 2,000 feet south of the Antimony Ridge area of folded schists, which contains most of the antimony prospects of the region. Two tunnels, one at an elevation of 6,357 feet and the other at 6,372 feet, have been driven about 50 feet into the hillside along a quartz-stibnite-antimony-oxide vein, which follows a fault of small displacement striking N. 5° E. and dipping 38° E. The vein is about 4 feet thick except at the entrance to the upper tunnel, where an offshoot from the main vein extends for a short distance into the footwall. Several high-grade lenses of stibnite-antimony-oxide ore are exposed in the vein, but most of the ore is of low grade. The vein has not been sufficiently explored to prove more than a few hundred tons of ore, assaying 10 percent or less in antimony. Inasmuch as the vein can be traced on the surface for only a short distance from the tunnels in each direction, it may be lenticular and short. However, more high-grade ore is exposed in the Mohawk workings than in any other deposit in the area with the exception of the main Kennedy vein.

Kennedy veins.--The Kennedy veins are on the north side of Wildrose Canyon (pl. 46), about 2 miles north of the Monarch deposit. The main vein, which is traceable on the surface for a distance of 200 feet, strikes N. 10° W. and dips about 70° E. It narrows considerably at both ends of its outcrop, but midway between, where three short tunnels have been driven into the hillside, it averages about 2 feet in thickness.

A second vein, parallel to the main vein and 30 feet from it, is traceable for 200 feet southeastward from the crest of the ridge. It seems to be much narrower and poorer than the main vein.

The ore consists of fine-grained quartz containing fluorite, stibnite, and oxides of antimony, with abundant inclusions of dark schist unevenly distributed. The antimony minerals are mainly in high-grade lenses or pockets. Several lenses, each probably containing a few tons of ore, are now exposed in the tunnel; others undoubtedly will be discovered by further exploration, but the present exposures do not indicate the presence of a large deposit with a dependable grade of antimony.

Other deposits.--There are many other prospects in the area, most of them near Antimony Ridge. In the aggregate they probably indicate many tons of low-grade ore and some lenses of high-grade ore; but most if not all of the exposures are so small as to make their exploitation very difficult.

RESERVES

The ore reserves of the area cannot be closely estimated. They must amount to some tens of thousands of tons--possibly to a hundred thousand tons or more. The average grade of the ultimate reserve is probably less than 5 percent of antimony and possibly as low as 2 percent. An estimate of 50,000 tons of ore containing between 1½ and 5 percent of antimony is probably justified. A larger tonnage may be available but could be proved only by further exploration and sampling.

Except for small tonnages of high-grade ore that might be mined selectively, the deposits probably cannot be profitably mined at current prices for antimony, for the following reasons: 1, The deposits are widely scattered, and no one of them is large enough to be mined on a large scale and at low cost; 2, the average ore is too lean to yield a profit unless low-cost methods of treating it can be developed; 3, recovery of antimony oxides from low-grade ore is difficult, and, apparently because of the presence of several oxide minerals, antimony is not easily recovered by flotation; 4, the area is so rugged and the deposits are so scattered that the costs of local transportation would be high; 5, there is no large, dependable, conveniently located water supply. Although the water from springs near Telescope Peak was at one time piped to the old Skidoo mining camp, 20 miles to the north, the volume and dependability of this supply are unknown.

No reliable estimate can be made of the lowest price at which the antimony in the area could be profitably mined, but even if large tonnages of ore were proved the price per ton might have to be nearer \$10 than \$5. Prices of \$5 and \$10 per ton for ore with 1½ percent of recoverable antimony would mean, respectively, prices of 16 2/3 cents and 33 1/3 cents per pound of metallic antimony. The average price for metallic antimony during the period 1919-38 was 9.97 cents per pound, and the average for the war years 1915-18 was 22.06 cents per pound. Little of the antimony ore of Wildrose Canyon, therefore, could be profitably mined at ordinary prices.

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