Selenium in Some Epithermal Deposits of Antimony, Mercury and Silver and Gold

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By D. F. DAVIDSON

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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Deposits of silver and antimony are commonly highly seleniferous in contrast to similar deposits of gold and mercury

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SELENIUM IN SOME EPITHERMAL DEPOSITS OF ANTIMONY, MERCURY, AND SILVER AND GOLD

By D. F. Davidson

ABSTRACT

The presence of selenium in some epithermal ores of silver, gold, and mercury has long been known. Recent work indicates that epithermal silver and antimony deposits are commonly highly seleniferous, and that gold and mercury deposits are only rarely so.

Selenium in silver and antimony deposits is associated with these metals in ore minerals and is not found in other minerals of the deposits. This relation with ore minerals also occurs in the few gold and mercury deposits which contain selenium.

Most published reports suggest that silver and antimony deposits are related genetically to crystalline igneous rocks. Selenium in silver and antimony deposits may have been liberated from crystallizing magma as a part of the process of crystallization and thus have been made available for deposition with the ore metals.

INTRODUCTION

Epithermal deposits have been described by Lindgren (1933, p. 444) as "metalliferous deposits formed near the surface by ascending thermal waters and in genetic connection with igneous rocks." They are commonly in the form of fissure veins, and generally occur in igneous flow rocks, particularly in andesite, latite, trachyte, or rhyolite, but rarely in basalt. They are usually in regions of late igneous activity, near Tertiary intrusive masses and, are for the most part of simple sulfide mineralogy. These epithermal deposits constitute the source of a large part of the world's production of gold, silver, and quicksilver. Most of the bonanzas of the cordilleran region, for example, Virginia City, Cripple Creek, Pachuca, and Guanajuato, are epithermal ore deposits.

Discussed in this report is the selenium content of some epithermal deposits of precious metals, antimony, and mercury. Similar deposits are well described in Lindgren's (1933), and Emmons' (1940) texts on mineral deposits.

The presence of selenium in many epithermal ores has long been known. At a few deposits, such as the DeLamar mine at Silver City, Idaho, the ore minerals are selenides. Typically, however, the sele-

nium is in either sparsely disseminated selenide minerals, or in some form in which it is not easily recognized.

Epithermal deposits, on the basis of present knowledge, contain higher concentrations of selenium than most other types of hydrothermal deposits, although the total selenium content of any given deposit is not large.

Most epithermal deposits of the United States are in, or near the cordillera, and most seleniferous rocks described by workers with seleniferous soils and plants occur in this same area. However the rocks, which have been the parent materials for the seleniferous soils, are with few exceptions Cretaceous in age, and deposits of the type described in this report are usually Tertiary; thus there can be no direct relation. Still the juxtaposition of these areas is suggestive.

In the course of a continuing study of the geology and geochemistry of selenium, examinations of ores, rocks, and minerals from several epithermal deposits have been made, and it is desirable to report the new data at this time. Some published data concerning the occurrence of selenium in epithermal deposits are also presented here in tabular form.

ACKNOWLEDGMENTS

The information in table 5 has been contributed by Fred H. Dakin, Burlingame, Calif., and the writer is grateful to Mr. Dakin for permitting its publication. The writer was aided in the field by T. J. Mosher.

SELENIUM MINERALOGY IN EPITHERMAL DEPOSITS

Epithermal deposits as a class are noted for their simple mineralogy, and the deposits discussed in this report, of precious metals, antimony, and mercury, are not exceptions. Table 1 lists the minerals sometimes present in such deposits which contain appreciable amounts of selenium. Descriptions of the minerals can be found in any standard textbook of mineralogy.

Two groups, of three minerals each, listed in table 1 are of particular interest in a discussion of selenium mineralogy, because they may indicate isomorphous substitution of selenium for sulfur in sulfide minerals of silver and mercury. They are the naumannite-aguilarite-argentite group, and the tiemannite-metacinnabar-cinnabar group.

Diadochic substitution of selenium for sulfur takes place readily because selenium and sulfur have like valence (-2), and because the difference between the ionic and covalent radii is so small. Coleman and Delevaux (1957, p. 522) suggested the possibility that the isomorphous series FeS_2–$FeSe_2$ may be complete at moderately high temperatures and pressures. Earley (1950, p. 356) has synthesized

TABLE I.—*Selenium-bearing minerals and their selenium content*[1]

Type of deposit (grouped according to principal product)	*Maximum reported selenium content (percent)*
Silver and gold deposits:	
Naumannite(Ag_2Se)	30. 2
Aguilarite(Ag_4SeS)	14. 8
Argentite(Ag_2S)	. 0010
Berzelianite(Cu_2Se)	40. 0
Eucairite($CuAgSe$)	32. 5
Umangite(Cu_3Se_2)	45. 1
Clausthalite($PbSe$)	31. 4
Klockmannite($CuSe$)	[2] 55. 4
Guanajuatite(Bi_2Se_3)	[2] 34. 33
Paraguanajuatite(Bi_2Se_3)	[2] 36. 2
Mercury deposits:	
Tiemannite($HgSe$)	29. 2
Metacinnabar, var. onofrite($Hg(S,Se)$)	8. 4
Cinnabar(HgS)	. 0001
Antimony deposits:	
Stibnite(Sb_2S_3)	[3] . 0009

[1] Modified from Michael Fleischer (written communication, 1956).
[2] Theoretical maximums, meaningful values from natural material not available.
[3] Selenium contents, in excess of 1.00 percent are given on p. 12.

the series PbS–PbSe, and Coleman (1958, p. 1679) has demonstrated the natural occurrence of the series. There is little reason a similar system may not exist for silver, and it has been demonstrated that such a system exists for mercury (Earley, 1950, p. 358–360; Nikolskaya and Regal, 1956). Bethke (1956) has shown that metacinnabar, "onofrite" (selenian metacinnabar) and tiemannite form a complete series in samples from Marysvale, Utah, but he suggested that the structure of cinnabar is such that only trace amounts of selenium may substitute for sulfur in the mineral.

Stibnite containing more than 1.00 percent selenium is reported in table 5 of this report, although the highest selenium content in stibnite reported by Fleischer (table 1) is only 0.0009 percent. Further work is being done with this material, and it seems probable that selenium is substituting for sulfur in stibnite in a partial series: Sb_2S_3–$Sb_2(S_2Se)$.

FIELD TESTING FOR SELENIUM

Qualitative field tests for selenium were used in fieldwork and were found very helpful in determining the distribution of selenium in ores and rocks. The methods used were primarily those described by Peterson, Jensen, and Anderson (1957).

In the present report the methods have been called simply "pyrosulfate," "caustic fusion," and "heated tube." The pyrosulfate and caustic fusion tests are based upon the facts that selenium occurs in nature as selenides, elemental selenium, selenites, and selenates, and that these compounds can be oxidized, or reduced, to form ele-

mental selenium, which can in turn be volatilized, and condensed, to form a visible elemental selenium mirror.

The pyrosulfate test consists of heating a finely ground sample in a test tube with potassium pyrosulfate and tartaric acid. Selenium, if present, will coat the tube walls. The caustic fusion method, used for samples containing much carbon or sulfur, comprises heating a ground sample with sodium peroxide, and sodium hydroxide, then heating the product of this reaction with potassium pyrosulfate, and tartaric acid. As in the pyrosulfate test, selenium, if present, will form a mirror. In the writer's experience, these methods are simple and reasonably fast and reliable, although selenium often will not be detected if present in concentrations below 50 ppm (parts per million).

If selenium is in selenide or elemental form, it is possible to test for it by simply heating a ground sample and watching for formation of a selenium mirror, or testing for odor (heated tube test). However, this method of testing is somewhat unreliable.

EPITHERMAL DEPOSITS OF SILVER AND GOLD

No attempt is made to refer to all of the geologic literature describing epithermal deposits of silver and gold for such completeness is not needed to serve the purpose of this report.

Nolan (1933), however, has presented a useful summary of the characteristics of epithermal silver and gold deposits and much of the following information is taken from his compilation. He indicates that epithermal deposits of precious metals in the Western United States are a part of a great circum-Pacific zone characterized by the occurrence of these deposits, and that they are found in regions of Tertiary volcanism.

Nolan discusses a classification of precious metal epithermal deposits proposed by Ferguson (1929) by which these deposits are divided into two types according to the ratio by weight, of gold to silver in hypogene ore. The first class, called the silver-gold class includes deposits in which silver equals or exceeds gold, and the second class, gold-silver, comprises deposits in which gold exceeds silver.

Silver-gold deposits are commonly found in well-defined fault fissures that may extend for long distances both horizontally and vertically. In most localities the faults seem to be of tectonic origin, cut the volcanic country rock, and have no direct connection with the extrusion of the volcanics. Silver-gold deposits probably are derived from large deep-seated igneous sources, and they commonly contain selenium, but little tellurium.

Unlike silver-gold deposits, gold-silver deposits are commonly

localized by fractures which in many places seem to be genetically related to the emplacement of the igneous rocks with which they are associated. These fractures are generally discontinuous, and rarely have measurable displacements. Gold-silver deposits are probably derived from small shallow, rapidly cooling (thus probably fine-grained) igneous sources, and commonly contain tellurium, but little selenium.

SELENIUM IN EPITHERMAL DEPOSITS OF SILVER AND GOLD

Seleniferous epithermal deposits of silver and gold are widespread, and well known. Lindgren (1933) and Nolan (1933) have published short descriptions of some of them and the listing of deposits composing table 2 is compiled from these descriptions. There are other such deposits.

Of the 12 deposits listed, 11 are silver-gold deposits. At only 1 deposit, in the Hauraki district of New Zealand, does gold content of ore exceed silver.

TABLE 2.—*Some seleniferous epithermal deposits of silver and gold described in geologic literature*

Geographic location	District	Principal product	Mode of selenium occurrence	Reference
United States:				
Idaho	Silver City, Owyhee County.	Silver-gold	Naumannite	Lindgren, 1933, p. 485, 496; Nolan, 1933, p. 624, 625, 633.
	Yankee Fork, Custer County.	do	Gold and silver selenides(?)	Nolan, 1933, p. 633.
Nevada	Jarbidge, Elko County.	do	Naumannite	Lindgren, 1933, p. 485; Nolan, 1933, p. 635.
	Tonopah, Nye, and Esmeralda Counties.	do	Naumannite(?)	Lindgren, 1933, p. 488, 496.
			Up to 2 percent selenium in silver concentrates.	Nolan, 1933, p. 624, 625, 634.
	Aurora, Mineral County.	do	Undetermined selenides	Nolan, 1933, p. 635.
Utah	Gold Mountain, Piute and Sevier Counties.	do	Silver-selenium-tellurium mineral.	Nolan, 1933, p. 639.
Washington	Republic, Ferry County	do	Naumannite	Thompson, 1954.
			Gold-selenide(?)	Lindgren, 1933, p. 497.
			Up to 2 percent selenium reported in ore.	Nolan, 1933, p. 625, 640.
Argentina	Cerro de Cachueta	Silver	Naumannite(?), clausthalite, berzelianite "zorgite" (a mixture of clausthalite and umangite).	Lindgren, 1933, p. 496.
	Sierra de Umango	do	Umangite, tiemannite, clausthalite eucairite, klockmannite.	Do.
Mexico	Guanajuato	do	Naummanite, clausthalite, aguilarite, guanajuatite, paraguanajuatite.	Do.
New Zealand	Hauraki	Gold	Seleniferous pyrite	Lindgren, 1933, p. 481, 496.
Sumatra	Radjang-Lebong	Silver-gold	Gold and silver selenides(?)	Lindgren, 1933, p. 498.
			Up to 4.35 percent selenium reported in bullion.	

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RESULTS OF FIELD TESTS FOR SELENIUM AT A SILVER-GOLD DEPOSIT

Field tests for selenium were made during the summer of 1957 at two mines of the Silver City district, Owyhee County, Idaho. This district is one of the few in the United States at which selenium minerals comprised a substantial part of the ore. At the DeLamar mine, virtually all silver was recovered from silver selenide (naumannite), and R. G. Coleman (written communication, 1957) reports that 1 sample of pure pyrite from DeLamar may contain 0.90 percent selenium. The district has long been dormant and sampling for selenium was restricted to material on mine dumps. Location of the district is shown on figure 1 (locality 9). Table 3 presents the results of field testing for selenium six samples from the dumps of the Trade Dollar mine at Silver City, and one sample from the DeLamar millsite, at DeLamar. None of the samples contained detectable amounts of selenium. Four samples from the Trade Dollar mine were of vein material, and two of mineralized wallrock. Selenium may have accompanied only silver in the veins for the dumps represent material from which silver minerals have been carefully removed.

The dumps of the DeLamar mine have been remilled in recent years and no samples of seleniferous silver ore could be found on the property.

TABLE 3.—*Results of field tests for selenium of grab samples from silver deposits*

Locality	No. (fig. 1)	Sample description	Test method	Result of test [1]
Idaho:				
Silver City district, Owyhee County	9			
Trade Dollar mine dumps		Pyritic rhyolite	Pyrosulfate	Negative.
			Caustic fusion	Do.
Do		Pyritic quartz	do	Do.
Do		Quartz, pyrite, and argentite (?).	do	Do.
Do		"Hydrocarbon"	do	Do.
Do		Vuggy rhyolite, quartz, pyrite.	Pyrosulfate	Do.
			Caustic fusion	Do.
Do		Quartz and argentite (?)	do	Do.
DeLamar mine		Cyanide tailings, DeLamar mill.	Pyrosulfate	Do.
			Caustic fusion	Do.

[1] Negative result indicates selenium content less than 50 ppm.

EPITHERMAL MERCURY DEPOSITS

A useful compilation by Ross (1933) of information relating to epithermal mercury deposits indicates that the deposits are widespread in the Western United States and that only two, in Arkansas and Texas, are known outside the cordilleran region. Most deposits are probably related to volcanic rocks, or hot springs of Tertiary or later age. Some deposits, not obviously related to late volcanism, are

classified with the others because of their structural relations and mineralogy. Ross does not, in most of his district descriptions, attempt to relate mercury deposits to source materials from which the mercury was derived. Where Ross has drawn this relation, for example in the Copper Basin district near Prescott, Ariz., mercury deposits probably occur in association with fine-grained intrusive rocks.

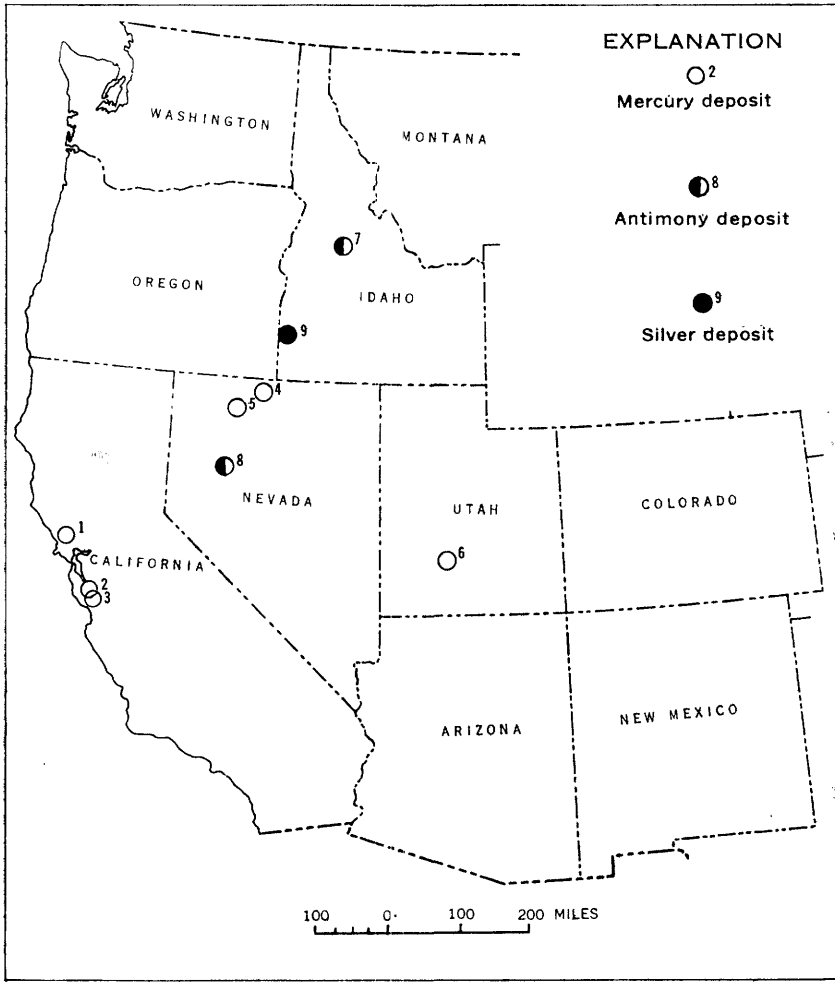

FIGURE 1.—Map of the Western United States (exclusive of Alaska and Hawaii) showing the location of mercury, antimony, and silver deposits sampled for selenium. Numbers refer to locality and sample descriptions in table 4 (mercury), table 6 (antimony), and table 3 (silver).

SELENIUM IN MERCURY DEPOSITS

Selenium has long been known in mercury deposits, and selenium minerals have been reported from many mercury mines in the United States. For example, Becker (1888, p. 375) mentions seleniferous mercury deposits in California, Roberts (1940), and Lindgren (1915) in Nevada, and Butler and others (1920, p. 551–552), have described the Lucky Boy mine near Marysvale, Utah, at which the ore was principally mercury selenide. In spite of this widespread occurrence of selenium minerals in mercury deposits, highly seleniferous mercury ores are rare, and the Lucky Boy mine is the only deposit of its kind in the United States. Tiemannite is probably the most common selenium mineral in the mercury deposits.

RESULTS OF FIELD TEST FOR SELENIUM AT MERCURY DEPOSITS

During the summer of 1957, six mercury deposits were visited by the writer and 38 field tests for selenium were made of a total of 24 samples. Sample localities and descriptions, and results of field tests are reported in table 4. Locations of the deposits are shown on figure 1. Selenium was recognized only in samples from the Lucky Boy mine, Piute County, Utah. Selenium, if present in any of the samples tested at other localities, was in concentrations too low to be recognized by field testing and it is concluded that neither cinnabar nor the other sulfide minerals tested at these properties contain much selenium.

Field tests at the Lucky Boy mine indicate, within the limitation of the test, that selenium is present only in the mercury-bearing minerals, for samples of limestone in direct contact with masses of tiemannite contain no identifiable selenium.

EPITHERMAL ANTIMONY DEPOSITS

F. C. Schrader (1933) in a summary of the distribution and geology of epithermal antimony deposits has written that the principal (and primary) ore mineral of antimony is the sulfide, stibnite, and that the mineral occurs chiefly in quartz veins, which in turn are found in many kinds of rocks. He suggests (p. 659) that the deposits were formed near the surface, at low temperatures by "hot hypogene solutions emanating from rocks ranging from diorite to granite." Nearly all of the deposits described in his report are supposedly genetically related to crystalline (by this is meant relatively coarse-grained) igneous rocks. Thus in Nevada, deposits in Pershing and Humboldt Counties are probably genetically connected with "granular intrusives of Cretaceous age;" and in Lander County, deposits are probably connected with Late Cretaceous granitic intrusives.

According to Schrader (1933, p. 662), antimony deposits in Idaho are "genetically connected with later Cretaceous or Tertiary granites * * * and * * * are mostly associated with gold and sil-

TABLE 4.—*Results of field tests for selenium of grab samples from mercury deposits*

Locality	No. (fig. 1)	Sample description	Test method	Results of field test [1]
California:				
Corona mine, Mayacmas district, Lake County.	1	Highly pyritiferous cinnabar.	Caustic fusion	Negative.
		do	do	Do.
		Cinnabar	do	Do.
		Iron sulfate	do	Do.
		Pyrite from dump	do	Do.
Guadalupe mine, New Alamaden district, Santa Clara County.	2	Millerite	Pyrosulfate	Do.
		Arsenopyrite and pyrite	Caustic fusion	Do.
		Pyrite	Heated tube	Do.
		do	Pyrosulfate	Do.
		do	Caustic fusion	Do.
		do	Heated tube	Dc
		do	Caustic fusion	Do.
		Cinnabar	do	Do.
New Almaden mine, New Almaden district, Santa Clara County.	3	do	do	Do.
		do	do	Do.
		"Asphalt"	do	Do.
Nevada:				
Buckskin Peak, National district Humboldt County.	4	Cinnabar	Heated tube	Do.
			Pyrosulfate	Do.
			Caustic fusion	Do.
		do	Heated tube	Do.
			Pyrosulfate	Do.
			Caustic fusion	Do.
Bottle Creek district. Humboldt County.	5	Cinnabar	Heated tube	Negative.
			Pyrosulfate	Do.
			Caustic fusion	Do.
		do	Heated tube	Do.
			Pyrosulfate	Do.
		Tuff, overlying ore zone	Heated tube	Do.
			Pyrosulfate	Do.
		Pyrite in quartz	Caustic fusion	Do.
Utah:				
Lucky Boy mine, Marysvale district, Piute County.	6	Fines on waste pile at retort site	Heated tube	Strong positive.
			Pyrosulfate	Do.
			Caustic fusion	Do.
		Limestone coated with tiemannite crystals at retort site.	Heated tube	Do.
		Tiemannite at mine opening	do	Do.
		Limestone in contact with tiemannite.	do	Negative.
			Pyrosulfate	Do.
		do	do	Do.

[1] Negative result indicates selenium content less than 50 ppm.

ver," but D. E. White (written communication, 1958) states that the deposits are probably related to Tertiary volcanics. Deposits in California are not so thoroughly described, and Schrader states only that stibnite, cinnabar, and sometimes gold, and silver occur in quartz veins in different kinds of rocks. In the Stayton district, San Benito and Merced Counties, antimony deposits may be related to Tertiary andesite; in other districts, in Kern County for example, deposits may be related to granites.

Deposits in Utah are probably related to eruptive andesitic rocks. The deposits of Montana are not described, but those of Oregon and Washington are probably related to late Mesozoic and Tertiary granitic intrusive rocks.

SELENIFEROUS EPITHERMAL ANTIMONY DEPOSITS

Little published information is available on the selenium content of epithermal antimony deposits. This is somewhat surprising because selenium is widespread in these deposits, and in relatively large concentrations as is shown by the data in table 5. The table lists the selenium and antimony contents, and sample localities of 79 selected samples of antimony ores from the Western United States. These data were collected by F. H. Dakin of Burlingame, Calif. Sample localities are shown on figure 2.

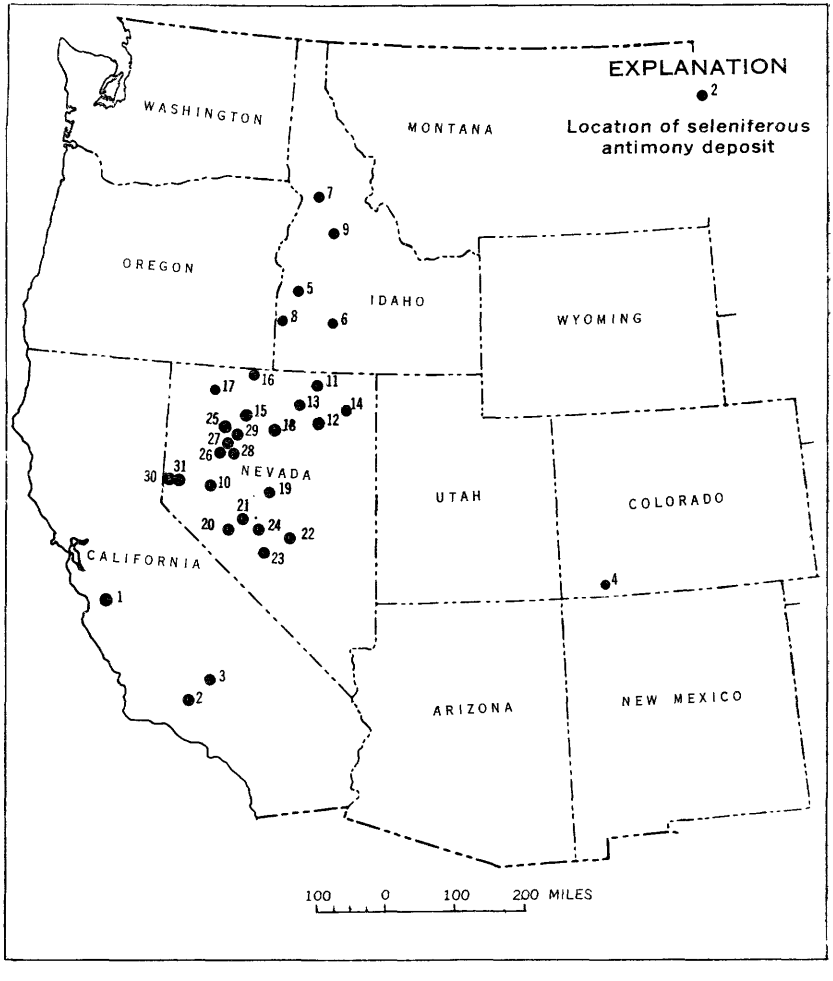

FIGURE 2.—Map of the Western United States (exclusive of Alaska and Hawaii) showing location of seleniferous antimony deposits. Numbers refer to descriptions in table 5.

Selenium content of the sample ranges from a trace to 1.06 percent, and antimony content ranges from 14.8 to 81.7 percent. Selenium and antimony contents in these ores are not correlative. The ore samples listed in table 5 are part of a group of 298 from British Columbia (1), Honduras (4), Japan (1), Mexico (5), United States, including Alaska (285), and the Yukon Territory (2). Only 1 sample containing detectable selenium is not listed in table 5; it is from the vicinity of Nome, Alaska, and contains a "trace." Two hundred five samples from the United States contain no detectable selenium, and among these are samples from the following states not listed in table 5: Alaska (7), Arkansas (1), Arizona (4), Montana (18), Oregon (14) and Washington (12).

There is an apparent regionalization of high selenium content, for the antimony ores from a block of 4 states—California, Nevada, Utah, and Idaho—are more seleniferous than those from other areas of the United States, or from areas outside the United States.

TABLE 5.—*Selenium and antimony content of selected antimony ore samples from the Western United States* [1]

Locality	No. (fig. 2)	Sample description [2]	Selenium content [3] (percent)	Antimony content [3] (percent)
California:				
Near Stayton mine, Hollister, San Benito County.	1	Ore	0.11	37.4
Near Frazier Park, Kern County	2	do	Trace	34.7
		do	Trace	22.7
Near Caliente, Kern County	3	do	.15	55.8
		do	.15	35.1
Colorado:				
Near Durango, La Plata County	4	do	Trace	14.8
Idaho:				
Near Meridian, Ada County	5	do	Trace	60.7
Near Glenns Ferry, Elmore County	6	do	.20	50.6
Near Elk City, Idaho County	7	do	.05	52.5
Near Silver City, Owyhee County	8	do	.07	52.7
Near Stibnite, Valley County	9	do	.08	58.8
		do	.03	37.0
		do	.06	56.6
		do	.04	59.7
		do	.03	55.8
		do	.04	56.6
		do	.04	60.6
		do	.05	69.0
		Antimony (stibnite) concentrate.	.08	55.9
		do	.02	51.3
		do	.03	54.3
		do	.03	48.2
		do	.04	50.6
		do	.04	50.8
		do	.03	47.5
		do	.03	48.2
		do	.05	50.4

See footnotes at end of table.

TABLE 5.—*Selenium and antimony content of selected antimony ore samples from the Western United States* [1]—Continued

Locality	No. (fig. 2)	Sample description [2]	Selenium content [3] (percent)	Antimony content [3] (percent)
Nevada:				
Near Fallon, Churchill County	10	Ore	0.08	44.2
		do	Trace	19.1
65 miles north of Elko, Elko County	11	do	.10	68.0
		do	Trace	52.5
Near Elko, Elko County	12	do	.46	36.5
Near Tuscarora, Elko County	13	do	.08	60.7
Near Wells, Elko County	14	do	Trace	49.0
Near Winnemucca, Humboldt County	15	do	Trace	39.6
Near National. Humboldt County	16	do	.03	23.1
Near Leonard Creek, Humboldt County	17	do	.03	37.7
Near Battle Mountain, Lander County	18	do	.10	51.2
		do	.08	41.9
		do	.07	29.3
		do	.03	32.2
		do	.05	53.3
		do	.07	57.9
		do	.05	54.6
		do	.08	68.0
		do	.03	40.7
Near Austin, Lander County	19	do	.05	61.9
		do	.05	66.9
		do	.03	30.9
		do	.15	46.1
		do	.10	45.1
		do	.07	60.3
		do	1.00	68.5
		do	.05	37.6
Near Luning, Mineral County	20	do	Trace	36.7
Near Berlin, Nye County	21	do	Trace	60.6
		do	Trace	47.9
Near Hot Creek, Nye County	22	do	.07	44.9
Near Tonopah, Nye County	23	do	.80	65.7
Near Manhattan, Nye County	24	do	.05	41.2
Near Rye Patch, Pershing County	25	do	Trace	52.5
Near Lovelock, Pershing County	26	do	Trace	41.0
		do	Trace	53.6
		do	.10	34.6
		do	Trace	40.8
		do	Trace	40.5
		do	1.06	58.4
		do	.03	40.9
		do	Trace	53.6
		do	.05	34.9
		do	.11	19.7
Near Bloody Canyon, Pershing County	27	Antimony oxide	.02	80.8
		do	Trace	81.7
Near Rosal mine, Pershing County	28	Ore	Trace	47.5
		do	.10	34.1
Near Unionville, Pershing County	29	do	Trace	39.7
Near Reno, Storey County	30	do	.08	53.5
Near Sparks, Storey County	31	do	.06	42.9
		do	.06	48.7

[1] Data collected by F. H. Dakin, Burlingame, Calif., published by permission.
[2] Stibnite ores unless otherwise identified.
[3] Sensitivity of selenium assays not known.

RESULTS OF FIELD TESTS FOR SELENIUM AT ANTIMONY DEPOSITS

From 2 localities (1 in Idaho and 1 in Nevada) 18 samples have been tested by field methods for selenium content. The localities are shown on figure 1 and the localities, sample descriptions, and methods and results of field testing are listed in table 6.

Selenium in these deposits occurs in the antimony mineral (usually stibnite) to the exclusion of any other mineral of the antimony deposit, as shown by the results of field testing. The writer has been

unable to detect inclusions of selenium minerals in seleniferous stibnite under the microscope and concludes that such inclusions either are too small to be seen, or do not exist. Where such inclusions do not exist, the selenium content of the stibnite presumably is substituting for sulfur in the stibnite crystal lattice.

TABLE 6.—*Results of field tests for selenium of samples from antimony deposits and a mill*

Locality	No. (fig. 1)	Sample		Test method	Result of test [1]
		Type	Description		
Idaho:					
Stibnite, Yellow Pine district, Valley County.	7	Grab	Stibnite	Caustic fusion	Strong positive.
		do	Pyritic quartz	do	Negative.
		do	do	do	Do.
		do	Stibnite	do	Weak positive.
		do	Stibnite concentrate (slime).	do	Do.
		Composite grab	Stibnite	do	Do.
		do	do	do	Moderate positive.
		do	do	do	Weak positive.
		do	do	do	Do.
		do	Flue dust, antimony reduction furnace.	Pyrosulfate	Strong positive.
		do	Flue dust, antimony oxide production unit.	do	Negative.
		Grab	Brick, antimony reduction furnace.	Caustic fusion	Moderate positive.
		do	Electric furnace slag	Pyrosulfate	Negative.
				Caustic fusion	Do.
		do	Gold roaster cyclone dust	do	Do.
		do	Antimony roaster cyclone dust.	do	Moderate positive.
		do	Arsenic roaster cyclone dust.	do	Do.
Nevada:					
Southerland mine, Pershing County.	8	do	Antimony oxide	Pyrosulfate	Negative.
		do	do	Caustic fusion	Do.

[1] Negative result indicates selenium content less than 50 ppm.

DISCUSSION

The information presented in this report suggests that selenium is common in epithermal silver-gold and antimony deposits, but less common in gold-silver and mercury deposits. Evidence cited from Ross (1933), Nolan (1933), and Schrader (1933) indicates that silver-gold and antimony deposits are genetically related to coarse-grained intrusive rocks, whereas gold-silver and mercury deposits are related to finer-grained intrusive rocks.

A recent study by D. F. Davidson and H. A. Powers (1959) of selenium analyses of extrusive volcanic rocks suggests that crystalline volcanic rocks are only rarely seleniferous, and that noncrystalline volcanics are more commonly seleniferous. These workers believe

that this distribution of selenium can be accounted for if selenium is lost by molten extrusive rocks during crystallization. Rocks which cool without crystallizing presumably retain their selenium content. If these presumptions are the explanation of the apparent difference in selenium content of the two types of volcanic rocks, the same or a similar mechanism may account in part for the difference in selenium content between silver-gold and antimony deposits, and gold-silver and mercury deposits.

The deep-seated magmas from which silver-gold and antimony deposits are formed crystallize slowly and in the process give up their selenium content. Selenium is thus available for movement to the site of ore deposition, along with other constituents of the magma. The igneous material from which gold-silver and mercury deposits are derived cools and crystallizes rapidly and in some way this material retains its selenium content. Selenium is therefore not available for transport and deposition with ore minerals. At the site of ore deposition the composition of the ore fluids, and pressure-temperature conditions undoubtedly affect the deposition of selenium. Conditions favorable for the deposition of silver-gold and antimony deposits probably allow selenium in the ore fluids to enter sulfide mineral structures readily, and those conditions favorable for the formation of gold-silver and mercury deposits are unfavorable for such a substitution of selenium for sulfur.

An alternative hypothesis which applies equally well to seleniferous vitrophyres, nonseleniferous crystalline volcanic rocks, seleniferous silver-gold and antimony deposits, and nonseleniferous gold-silver and mercury deposits, is that the magmas which produced the vitrophyres and silver-gold and antimony deposits were seleniferous, and those which produced the crystalline volcanics and the gold-silver and mercury deposits were not. This hypothesis lacks any known support, and in the writer's opinion must be discarded.

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