RECONNAISSANCE OF TELLURIUM RESOURCES IN ARIZONA, COLORADO, NEW MEXICO, AND UTAH

Including Selected Data From Other Western States and Mexico

By F. D. Everett

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RECONNAISSANCE OF TELLURIUM RESOURCES IN ARIZONA, COLORADO, NEW MEXICO, AND UTAH

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by

F. D. Everett[1]

ABSTRACT

Thermoelectric and metal alloying applications have changed the status of tellurium from oversupply to undersupply. In a search for new sources of this element in Arizona, Colorado, New Mexico, Utah, and neighboring states, the Bureau of Mines analyzed more than 200 samples and obtained the results of tellurium determinations by private companies on more than 500 samples from a wide variety of mineral-bearing deposits.

About 40 minerals containing tellurium have been reported, mainly tellurides of gold, silver, bismuth, mercury, lead, copper, iron, and nickel. The minerals usually occur in small quantities and identification in ores is extremely difficult.

Samples containing more than 0.1 percent tellurium were taken from the Hilltop and Memphis properties in Dona Ana County, N. Mex., and the Silver King property in White Pine County, Nev., where development was chiefly for base metals. The Lone Pine mine in Catron County, N. Mex., and the Bambolla mine near Moctezuma, Sonora, Mexico are potential sources of native tellurium occurring in small but high-grade pods.

Much of the production of tellurium has come as a byproduct of electrolytic refining of copper and lead-zinc ores in Arizona, Colorado, New Mexico, and Utah. Base-metal ore deposits will continue to be the most important primary source of tellurium, although the concentration in ores is nearly always less than 10 parts per million. Any significant increase in output of tellurium probably will be related to production and improved efficiency in smelting and refining base-metal ores.

INTRODUCTION

Interest in tellurium has been increasing since World War II, and especially since 1958, because of technical developments in metal alloys and

[1]Mining engineer, Bureau of Mines, Denver, Colo.

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thermoelectric devices. The addition of small amounts of tellurium to some metals and metal alloys results in special desirable physical properties. Thermoelectric components using tellurium have favorable characteristics in applications for power generation, heating, and refrigeration. Considerable research is being done in design and application of metal alloys and thermoelectric devices, and industry probably will require much more tellurium than is presently being produced. Future supply will be governed partially by price, which in early 1962 was triple that of 1958. An accelerated demand for tellurium could result in apportioning supply by natural price adjustment according to the value of the uses.

This paper presents the results of a search for possible new sources of tellurium. The investigation was generally confined to the area designated by the Bureau of Mines as Region III, comprising the States of Arizona, Colorado, Nebraska, New Mexico, North Dakota, South Dakota, Utah, and Wyoming, but data available from adjoining areas are included. Mineral deposits investigated for possible new sources of tellurium included copper, lead, zinc, gold, silver, iron ore and pyrite, uranium, sulfur, arsenic, alunite, phosphate rock, vanadiferous shale, lignite, and native tellurium. Pulp samples in the Bureau of Mines sample files at the Salt Lake City Metallurgy Research Center, together with many samples collected by field investigations, were analyzed for tellurium. Where known, the content of selenium is reported because selenium is frequently associated with tellurium.

ACKNOWLEDGMENTS

Officials of American Smelting and Refining Company, United States Smelting, Refining and Mining Co., International Smelting & Refining Co., Kennecott Copper Corp., The Anaconda Company, American Metal Climax, Inc., Phelps Dodge Corp., and San Manuel Copper Corp. contributed useful information relative to tellurium production and ore deposits.

Acknowledgment is made to S. R. Zimmerly, Director of Research, Kennecott Copper Corp.; J. G. Lecke, General Superintendent of copper refineries, and D. J. Pope, Assistant to the Vice President, mining department, American Smelting and Refining Company; and M. C. Goldsmith, geologist, Minnesota Mining and Manufacturing Co., for special data on tellurium in copper refining and mineral deposits.

HISTORICAL BACKGROUND

Data on historical background, production, uses, and physical characteristics of tellurium have been published.[2-4] Some of the pertinent data from these publications are repeated here.

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[2] Santmyers, R. M. Selenium and Tellurium. BuMines Inf. Circ. 6317, 1930, 23 pp.

[3] Fisher, Frank L. Tellurium. Ch. in BuMines Bull. 585, 1960, pp. 851-856.

[4] Hampel, Clifford A. (Ed.), John R. Stone, and Peter E. Caron. Tellurium. Ch. 28 in Rare Metals Handbook. Reinhold Publishing Co., New York, N.Y., 2d ed., 1961, pp. 519-528.

Tellurium was discovered by Muller von Reichenstein in 1872 while studying a gold-bearing mineral from the Transylvania Mountains in Romania. Klaproth confirmed the presence of the new element and named it tellurium in 1898.

For many years tellurium was a nuisance element in the base-metal smelting and refining industry, but recently the element has acquired new strategic significance because of special thermoelectric characteristics. Tellurium has been produced commercially since 1918 as a byproduct of electrolytic refining of copper and lead. The demand for tellurium was less than 1,000 pounds a year before 1928; annual consumption increased to 22,600 pounds in 1935, to 89,000 pounds in 1940, and since 1950, to more than 100,000 pounds. The price ranged from $1.50 to $3.00 a pound between 1918 and 1930, but remained at $1.75 between 1930 and 1958. The quotation for commercial-grade tellurium in February 1962 was $6.00 a pound.

Three principal grades of tellurium have been produced--commercial (99.5 plus percent Te), high-purity (99.99 plus percent Te), and semiconductor high-purity (99.999 plus percent Te). Increasing quantities of high-purity tellurium are being used, especially in research on thermoelectricity.

Production

All current tellurium production is derived from the base-metal refining industry. Anode slimes or mud residues contain the gold, silver, platinum, selenium, and tellurium that are carried through concentration, smelting, and electrolytic refining processes. Refineries in the United States recover tellurium--six copper, one lead, and one minor-metal. Copper, nickel-copper, and lead refineries in Canada, and a lead refinery in Peru, recover the major portion of the remaining free-world supply. The U.S.S.R. is known to have a large output of tellurium from the electrolytic refining of metals.

Most base-metal smelters in the United States contribute to the tellurium supply; however, this is accomplished by a system of circulating copper anode slime, copper matte, soda and nitre slags, Cottrell flue dust, baghouse dust, speiss, zinc-leach residue, and lead bullion between smelters and refineries. Base-metal ores, copper concentrates, smelter dusts, and anode slimes from foreign operations, are shipped to plants in the United States for final processing, and these products contribute large but unaccountable quantities of tellurium to the domestic production.

Table 1 lists the production of tellurium in the United States from 1940 through 1961.

Tellurium has been recovered in the past mainly because of its close association with gold, silver, selenium, and platinum in anode muds from electrolytic refining processes. The cost of producing tellurium probably has exceeded its value, especially during the years prior to 1959, when the price for the commercial grade remained virtually stable at $1.75 a pound.

TABLE 1. - Production statistics of elemental tellurium in the United States, 1940-62, in pounds[1]

Year	Production	Primary producers shipments	Primary producers stocks at end of year[2]	Price per pound
1940...........	85,600	89,000	33,400	$1.75
1941...........	224,600	237,700	29,300	1.75
1942...........	225,000	123,100	134,500	1.75
1943...........	54,300	48,700	140,900	1.75
1944...........	61,900	29,600	172,900	1.75
1945...........	33,500	29,100	176,900	1.75
1946...........	11,600	48,500	142,100	1.75
1947...........	60,400	68,300	132,600	1.75
1948...........	56,900	74,700	114,400	1.75
1949...........	120,700	68,400	166,600	1.75
1950...........	107,400	129,900	134,400	1.75
1951...........	187,100	110,200	147,300	1.75
1952...........	189,100	94,600	181,100	1.75
1953...........	70,400	141,200	128,000	1.75
1954...........	97,100	121,000	103,600	1.75
1955...........	137,400	166,000	77,000	1.75
1956...........	223,100	226,100	126,000	1.50-1.75
1957...........	251,900	210,700	166,000	1.50-1.75
1958...........	123,200	159,200	131,000	1.65-1.75
1959...........	176,700	256,900	58,000	[3]1.65-3.00
1960...........	270,600	227,700	126,000	[3]3.00-4.00
1961...........	204,500	230,900	64,000	[4]4.00-5.25
1962...........	264,000	233,000	87,000	[5]5.25-6.00

[1] Bureau of Mines Minerals Yearbooks 1940-62.
[2] Beginning and closing stocks coupled with production and shipments do not balance because imports and exports are not included in table.
[3] High purity (99.99 plus percent tellurium), $25.00 per pound.
[4] High-purity tellurium, $30.00 per pound.
[5] Eng. and Min. J., January-June 1962.

Companies producing tellurium in 1962 are listed in table 2.

Most of the electrolytic copper and lead refineries contribute to tellurium production by distributing anode slimes or doré furnace slags to refineries equipped to recover tellurium. Copper and lead smelters also provide flue dusts, baghouse dusts, Cottrell products, or copper matte that are recycled in copper smelting or are distributed to other smelters and refineries where the tellurium and other minor metals are recovered. Leach residue from a zinc refining plant in the midwest contains tellurium which is recovered in a lead refinery.

Some copper and lead smelting and refining companies do not produce tellurium because the recovery costs exceed the value. The recent rise in price should stimulate new interest, and companies may try to improve efficiency in tellurium recovery.

TABLE 2. - Electrolytic copper and lead refineries in the free world that process tellurium from anode slimes

Country	Company	Location	Refinery product
United States	American Metal Climax, Inc..	Carteret, N.J....	Copper.
Do......	American Smelting and Refining Co.	Baltimore, Md....	Do.
Do......	International Smelting & Refining Co.	Perth Amboy, N.J.	Do.
Do......	Phelps Dodge Refining Corp.	Laurel Hill, N.Y.	Do.
Do......	United States Smelting Refining and Mining Co.	East Chicago, Ind.	Lead.
Do......	Penn Rare Metals, Inc.......	Revere, Pa.......	Minor metals.
Canada.......	Canadian Copper Refiners, Ltd.	Montreal East, Quebec.	Copper.
Do......	International Nickel Co. of Canada, Ltd.	Copper Cliff, Ontario.	Copper-nickel.
Peru.........	Cerro Corp.................	Oroya............	Copper-lead.
West Germany.	Norddeutsche Affinerie......	Hamburg..........	Copper.
Belgium......	Society Generale Metalurgie de Hoboken.	Amsterdam........	Do.
Japan........	Mitsui Mining and Smelting Co.	Takahara.........	Do.
Do......	Mitsubishi Metal Mining Co., Ltd.	Osaka............	Do.
Do......	Nippon Mining Co............	Saganoseki.......	Do.
Do......	do.................	Hitachi..........	Do.

Uses

Industry has made little use of tellurium. Before 1930 small quantities were used as crystal detectors in radio sets, as a coloring agent in ceramic and glass products, for photographic tinting, and in chemical products. Presently small quantities are used in alloys of lead, steel, aluminum, tin, copper, and manganese; as a secondary vulcanizing agent in processing rubber; and in insecticides, germicides, and fungicides. Selenium, sulfur, cadmium, and mercury can be substituted for tellurium in some of these applications.

More tellurium will probably be consumed for thermoelectric semiconductors than for all other uses, although in 1960, purchase of tellurium for thermoelectric applications was less than 10 percent of the total consumption. Research has found many uses for thermoelectric devices, based on the Seebeck and Peltier principles. In the Seebeck effect, heat on a junction of special dissimilar materials can be converted into electrical energy, and in the Peltier effect, electric current from an external source passing through such a junction causes heating or cooling, depending on the direction of current through the junction. Additional explanation of these principles is given in appendix A. A good thermoelement must have capacity for high-thermoelectric power, low thermoconductivity, and low-electrical resistivity. A measure of these factors is called the figure of merit, and some of the compounds that show a high figure of merit are PbTe, Bi_2Te_3, and Bi_2Se_3.[5]

Thermoelectric devices based on these principles have been made to generate small quantities of electricity or to effect refrigeration without moving parts. Efficiency of small electrical generating plants compares favorably to steam or gasoline engines. Efficiency of the electrical-thermo properties is about half that of other popular devices, but the small space requirements and convenience factors are much more attractive. Special applications for thermoelectric devices are numerous, and many are in the research stage.

Possibly nearly all tellurium produced in the future may be consumed in making thermoelectric devices, but because of an apparent limit in output, manufacturers are hesitant to begin making appliances requiring large quantities of tellurium. Several producing companies have formed a research committee to study new applications and promote the consumption of both tellurium and selenium.[6] If tellurium supply remains adequate and the price does not increase greatly, large quantities probably would be used in metal alloys. A small amount of tellurium improves the machinability of some metals and alloys, especially steel.

Special handling procedures must be followed in utilizing tellurium. Workmen exposed to an atmosphere containing as little as 0.001 to 0.01 mg of tellurium per cubic meter of air, have developed obnoxious breaths. This characteristic has deterred several manufactures from using tellurium. Good ventilation, proper use of fume hoods and respirators, and careful handling to avoid contact with dust and materials, are necessary precautions to avoid any disagreeable effects.

SOURCES OF TELLURIUM

The sources of ores contributing to the byproduct tellurium supply cannot always be determined because refineries frequently receive tellurium-bearing products from other refineries and smelters. Ore processors seldom assay for tellurium, and consequently do not know the tellurium content of the crude ores. A general assumption is that most of the tellurium in base-metal ores and in many of the gold-silver ores mined may be recovered. Efforts to improve recoveries have been limited because of the low price. Tellurium has been recovered mainly because its extraction influences the recovery of the higher priced or more-available metals.

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[5] Shilliday, Theodore S. Performance of Composite Peltier Junctions of Bi_2Te_3. J. Appl. Phys., v. 28, 1957, pp. 1035-1042.

[6] The following companies are members of the Selenium and Tellurium Development Committee (1961): American Metal Climax, Inc.; American Smelting and Refining Company; The Canadian Copper Refiners, Ltd.; International Nickel Co., Inc.; The Anaconda Company; Kennecott Copper Corp.; and United States Smelting, Refining and Mining Co.

Copper Ores

Sulfide copper ores currently yield an estimated 80 to 85 percent of the total tellurium production. One company official estimated tellurium recovery from copper processing to be about 50 percent. Calculations based on grade and tonnage of anode residues, and assuming 50 percent recovery, indicate copper ores from several deposits in the United States average between 0.5 and 5 ppm of tellurium (0.00005 to 0.0005 percent).

Lead Ores

Base-metal ores containing lead as the principal metal yield an estimated 15 to 20 percent of the recovered tellurium. Ores from lead-zinc deposits contain as much as 1 pound of tellurium per ton, but the average tellurium content of the lead ores, estimated from production and assuming a 50 percent recovery, is between 0.5 and 1.0 ppm (0.00005 to 0.0001 percent).

Gold-Silver Ores

The only tellurium known to be recovered from ores containing gold (and/or silver) is a product of base-metal smelting and refining. Gold ores processed by amalgamation, cyanidation, or gravity concentration are not known to have yielded commercial production of tellurium except where tailings may have been shipped to base-metal smelters. Tellurium in gold ores must be volatilized by roasting before the gold fraction can be recovered by amalgamation or cyanidation. Frequently the dusts and Cottrell precipitates from the roasting operations are returned to the concentrating circuit to prevent pollution of the atmosphere.

Silver tellurides are found alone with gold, and associated with base-metal deposits; only silver tellurides processed with base metals have contributed to the commercial supply.

SOME ECONOMIC ASPECTS OF TELLURIUM PRODUCTION

In the past, production of tellurium has exceeded demand. With the prospect of new applications, demand should exceed production. According to production specialists of American Smelting and Refining Co.,[7] the maximum production that could be achieved by improving the efficiency in the copper- and lead-refining industries in the Western Hemisphere is between 500,000 and 750,000 pounds of tellurium a year. Any additional needs must be acquired from new sources. The most likely source for new supply will be base-metal processing plants not contributing, at least to full potential, to the present production.

Two native tellurium prospects were being explored in 1961--one in Sonora, Mexico, and the other in New Mexico. It appears probable that the two properties could contribute 10,000 to 20,000 pounds of tellurium a year, with exploration and mining comprising the major costs. However, it is unlikely

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[7] Page 520 of work cited in footnote 4.

that either property will become an important contributor to the tellurium supply unless the price for tellurium rises above $20 per pound for commercial grade. At this price a small operation producing 10 to 20 tons of ore a day probably could make a profit on ore containing 2 to 3 pounds of native tellurium per ton (0.1 to 0.15 percent Te).

Ores containing gold and silver tellurides were mined in Colorado during 1961 in the Cripple Creek and Gold Hill districts in Teller and Boulder Counties, respectively. The Golden Cycle Corp. processed the Cripple Creek ores in the Carlton mill by flotation and cyanidation, until the mill was closed in January 1962 because of inadequate supply of ores from the mines. The mill was designed for a capacity of about 1,000 tons of ore a day, but the rate of milling in 1961 was below 300 tons a day. About 90 percent of the gold was recovered in a flotation concentrate representing 5 percent of the mill feed. A sample of the flotation concentrate assayed 0.07 percent; a sample of the flotation tailing, 0.003 percent Te. The flotation concentrate was passed through a fluosolids reactor, where the ore was roasted and most of the tellurium was volatilized. The tellurium-bearing gases and dust were scrubbed, and the resulting solids returned to the processing circuit. The tellurium ultimately was discarded in the tailing. A company official estimated that at 300 tons a day (12 to 15 tons of flotation concentrates), the operation could recover about 8 pounds of tellurium. As the rate of gold mining and the price of tellurium has been low in the past years, the company was unable to justify tellurium-recovery facilities. Custom processing charges for gold ores scaled upward from $3.00 a ton. Apparently profitable recovery of tellurium at the Carlton mill would require a much higher price for tellurium and an assured ore supply much greater than 300 tons a day.

TELLURIUM MINERALS

Tellurium is the sixth rarest of the 92 elements found in nature, and the average content in surface rocks is about 0.002 ppm. The physical appearance of tellurium is more metallic than other members of the oxygen family, to which it belongs, but chemically, tellurium resembles selenium and sulfur.

Tellurium most commonly occurs in combination with gold, silver, bismuth, lead, mercury, or copper. Microscopic and chemical determinations are required to identify many of the tellurium minerals. Most of the minerals containing tellurium are listed in table 3.

Telluride minerals range in appearance from silvery white with columnar prismatic cleavage to dark, massive grains. Hardness ranges between 2 and 3.5 Mohs, and specific gravity is 6.2.

Tellurium is a poor conductor of electricity. It has a metallic appearance and melts at 450° C to a dark liquid resembling lead, and boils at 990° C. Chemically, tellurium is similar to sulfur and selenium. Bivalent tellurium ion forms compounds with active metals, and covalent tellurium forms compounds with other elements. Tellurium minerals are mainly stable. Some compounds of tellurium are toxic but generally are harmless to the human body, being absorbed through the skin and by ingestion and inhalation of dust, fumes, and vapors. Some forms of tellurium are characterized by an offensive odor similar to garlic. No toxic effects resulting from mining tellurium-bearing ores have been reported.

TABLE 3. - Tellurium-bearing minerals[1]

Mineral	Approximate composition	Te, percent
Native tellurium	Te	92-100
Tellurite	TeO_2	78-80
Paratellurite[2]	TeO_2	78-80
Calaverite	$AuTe_2$	56-58
Petzite	$AuAg_3Te_2$	32-35
Sylvanite	$(Au,Ag)Te_2$	60-63
Krennerite	$(Au,Ag)Te_2$	56-59
Muthmannite	$(Ag,Au)Te$	39-48
Hessite	Ag_2Te	35-38
Stuetzite	Ag_4Te(?)	22-23
Empressite	$AgTe$	53-55
Rickardite	Cu_4Te_3	59-60
Weissite	Cu_5Te_3	53-55
Vulcanite	$CuTe$	65-67
Nagyagite	$Pb_5Au(Te,Sb)_4S_{5-8}$	17-19
Altaite	$PbTe$	37-39
Tapalpite	$Ag_3Bi(S,Te)_3$	20-24
Tetradymite	$Bi_2(Te_2,S)_3$	33-37
Tellurobismuthite	Bi_2Te_3	45-49
Gruenlingite (also Grunlingite)	Bi_4TeS_3	12-13
Joseite	Bi_3TeS(?)	14-16
Wehrlite	Bi_3Te_2(?)	29-35
Montanite	$Bi_2O_3TeO_3 \cdot 2H_2O$	17-20
Oruetite	Bi_8TeS_4	-
Coloradoite	$HgTe$	38-40
Melonite	$NiTe_2$	80-82
Emmonsite	Iron hydrated telluride	59-60
Durdenite	$Fe_2(TeO_3)_4H_2O$	42-57
Mackayite	$Fe(TeO_3)_3 \cdot xH_2O$	-
Blakeite	Ferric telluride	-

See footnotes at end of table.

TABLE 3. - Tellurium-bearing minerals[1] (Con.)

Mineral	Approximate composition	Te, percent
Niggliite	$PtTe_3$(?)	65(?)
Colusite	$Cu_3(Sn,Te,V,As)S_4$	0.4-1.3
Goldfieldite	$5Cu_2S.(Sb,As,Bi)_2(S,Te)_3$	-
Teineite	$Cu(Te,SO_4)_2H_2O$	-
Arsenotellurite[3]	$Te_2As_2S_7$	29.6-40.7
Deinkamite[3]	$PbTeO_3$	-
Hedleyite[3]	Bi_7Te_3	17.6-20.7
Chicolovaite[3]	Bi_2TeS_2	-
Rubisite[3]	$(Te,Se)_3$	-
Frobergite[3]	$FeTe_2$	-
Goldschmidtite[3]	$(Au,Ag)_2Te_5$	65-97
Tellurium selenide[3]	SeTe	-
Tellurous hydrogen[3]	H_2Te	-

[1] Except as otherwise noted, taken from C. Palache, H. Berman, and C. Frondel. Dana's System of Mineralogy, John Wiley & Sons, Inc., New York, 7th ed., v. 1, 1944, and v. 2, 1951.

[2] Switzer, George. Paratellurite, a New Mineral From Mexico. Am. Mineralogist, v. 45, November-December 1960, p. 1272.

[3] Sindeyeva, N. D. Mineralogy, Types of Deposits and Basic Features of Selenium and Tellurium Geochemistry. Acad. of Sci. of U.S.S.R., Inst. of Miner., Geochem. and Crystallochem. of Rare Elements, Acad. of Sci., U.S.S.R. Press, Moscow, 1959, 444 pp.

INVESTIGATION OF TELLURIUM PROPERTIES

A search for potential new sources of tellurium was undertaken in Arizona, Colorado, New Mexico, North Dakota, South Dakota, Wyoming, Utah, and Nevada. Field samples were collected from mineral prospects, mines, mills, smelters, and refineries, and were analyzed for tellurium (appendix B). Data provided by an international mining, smelting, and refining company, involving analysis of several hundred samples from properties in the United States, also were studied (appendix C).

Varieties of mineral occurrences were sampled, with the objective of finding deposits of tellurium. Tellurium minerals mentioned in publications were reviewed for information on sources (appendix D). Samples from mineral deposits containing copper, lead, zinc, gold, silver, iron, uranium, sulfur, arsenic, alunite, phosphate rock, vanadiferous shales, fluorite, and other elements and mineral commodities were analyzed for tellurium. Samples representative of a large mineral production were taken where feasible. High-grade ores or highly mineralized rocks were selected from some deposits with the view of finding indications of tellurium. Samples of concentrates and smelter products also were collected. Smelting companies disclosed the origin of shipments known to contain tellurium-bearing ores processed at their plants.

Some base-metal shipments from mines in northern Mexico to smelters in Arizona and Texas contained relatively high tellurium contents.

Tellurium assaying is laborious and costly, and sensitivities lower than 100 ppm are difficult to attain. Experiments at the Bureau of Mines, Salt Lake City Research Center, resulted in development of a method for determining tellurium in amounts between 0.5 and 1.0 ppm Te.[8] Quantitative results can be estimated by spectrographic and X-ray methods. One company has used the spectrograph to determine the tellurium content of more than 1,500 samples, having a low-sensitivity range of 10 to 100 ppm. A new sensitive test for tellurium based on the induced precipitation of elemental gold was published in 1963.[9]

The Bureau of Mines published the description of a field test for tellurium and selenium[10] which can be performed by nonanalytical personnel. A simple qualitative test for native tellurium and tellurium in some telluride minerals, including gold, silver, lead, and bismuth, but not including mercury or selenium, is as follows: Drop a few grains of the mineral in a test tube containing 2 or 3 cc of hot but not fuming concentrated sulfuric acid. Tellurium is indicated by the presence of a crimson-colored trail following the mineral grains.

Summary of Sample Results

The present tellurium investigation included analysis of more than 200 samples by the Bureau of Mines (fig. 1). Approximately 62 percent of the samples contained less than 0.001 percent Te (10 ppm); 19 percent, between 0.001 and 0.01 percent; 11 percent, between 0.01 and 0.1 percent; 5 percent, between 0.1 and 1 percent; and 3 percent contained more than 1 percent Te. All samples containing more than 0.1 percent Te represent ores with native tellurium or gold, silver, bismuth, and lead tellurides. Samples containing 0.001 to 0.01 percent tellurium were obtained from deposits whose chief minerals contain lead-zinc, copper, or bismuth. Tellurium in ores from deposits of this type probably would be recovered as a byproduct of copper or lead refining. Samples containing alunite, antimony, coal and lignite, fluorite, pyrite, manganese, mercury, molybdenum, phosphate, sulfur, vanadium, titanium, or uranium, showed no significant quantity of tellurium.

Samples from the Hilltop, Memphis, Lone, Pine, Banbolla, and Silver King properties contained more than 1 percent tellurium.

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[8] Anderson, W. L., and H. E. Peterson. Determination of Tellurium. BuMines Rept. of Inv. 6201, 1963, 9 pp.

[9] Lakin, H. W., and C. E. Thompson. Tellurium: A New Sensitive Test. Sci., July 5, 1963, v. 141, No. 3575, pp. 42-43.

[10] Niebuhr, Philip E., and Allan H. Macmillan. Field Test for Tellurium and Selenium. BuMines Rept. of Inv. 6006, 1962, 6 pp.

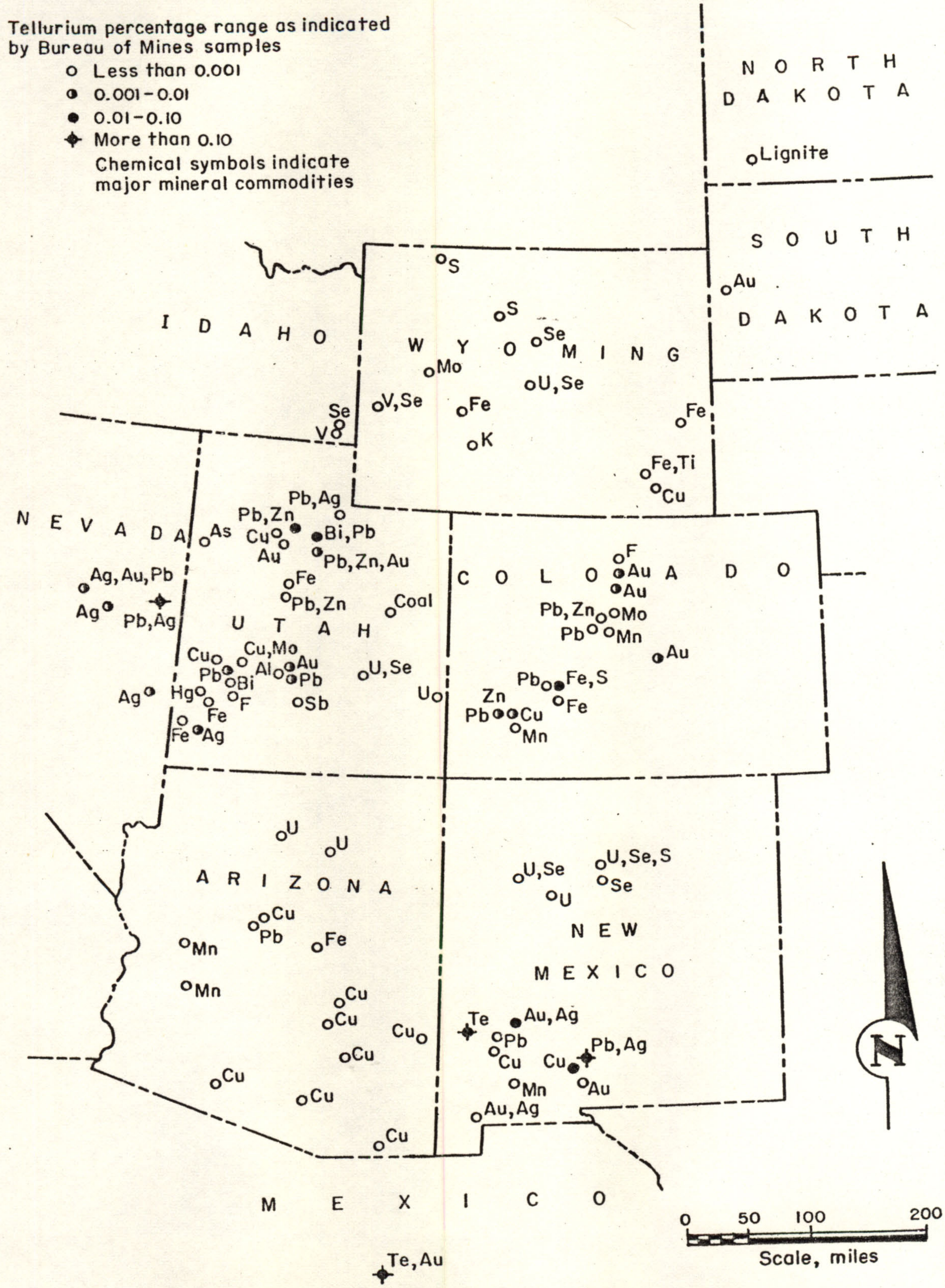

FIGURE 1. - Map Showing Principal Areas of Tellurium Investigations.

Description of Properties

Hilltop Mine

One sample from the Hilltop mine in the Organ Mountains, Dona Ana County, N. Mex.,[11] consisted principally of galena with tellurium present as altaite, the lead telluride. Other samples from the Hilltop contained less tellurium. Sulfide minerals can be found in several working places, but generally occur in thin seams. The property is within the White Sands Military Reservation and currently is restricted from mining development.

Memphis Mine

An oxide sample from the bismuth cut at the Memphis copper mine, also in the Organ Mountains of New Mexico, assayed more than 1 percent tellurium. The mineral tetradymite had previously been reported from this location.[12] However, additional sampling of the bismuth cut indicated that most of the zone contains less than 10 ppm tellurium.

Lone Pine Mine

The Lone Pine mine, formerly known as the Tommy Knocker, Lausen, and Swartz, is part of a property comprising six claims in the Wilcox district, Catron County, N. Mex., which was under lease and option to the Minnesota Mining & Manufacturing Co. in 1961 and 1962. The property is 8 miles east of the intersection of Little Dry Creek and U.S. Highway 260, 13 miles south of Glenwood. Two miles of rough, winding road was constructed to the mine in 1960 over the steep front of the Mogollon Range. The property has been developed by more than 1,000 feet of workings, comprising several shallow shafts and one principal adit and shaft. The workings are in a zone of altered and pyritized Tertiary quartz latite porphyry, underlain by andesite.[13] The principal development consists of a 200-foot shaft (partly sunk as a winze) at an incline of about 80° and approximately 700 feet of adit. The adit intersects the shaft 135 feet from the portal. The shaft was sunk 200 feet below the adit level. About 20 feet of drift has been driven at the 45-foot level and about 70 feet at the 160-foot level of the shaft. The project conducted by Minnesota Mining & Manufacturing Co. consisted of road building; surface mapping; diamond drilling from the surface; shaft rehabilitation; drifting at the 45- and 160-foot levels; underground diamond drilling from the adit, 45-, and 160-foot levels; underground diamond drilling from the adit, 45-, and 160-foot levels; and sampling (fig. 2).

First work on the Lone Pine property was probably done during the early 1930's, reportedly some gold ore was shipped. Approximately 3 tons of high-grade ore containing native tellurium was sorted and piled on the dump. Most

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[11] Dunham, K. C. The Geology of the Organ Mountains, Dona Ana County, N. Mex. New Mexico Sch. Mines and State Bur. Mines and Miner. Res., Bull. 11, 1935, 272 pp.

[12] Work cited in footnote 10.

[13] Ferguson, H. G. Geology and Ore Deposits of the Mogollon Mining District, N. Mex. Geol. Survey Bull. 787, 1927, 100 pp.

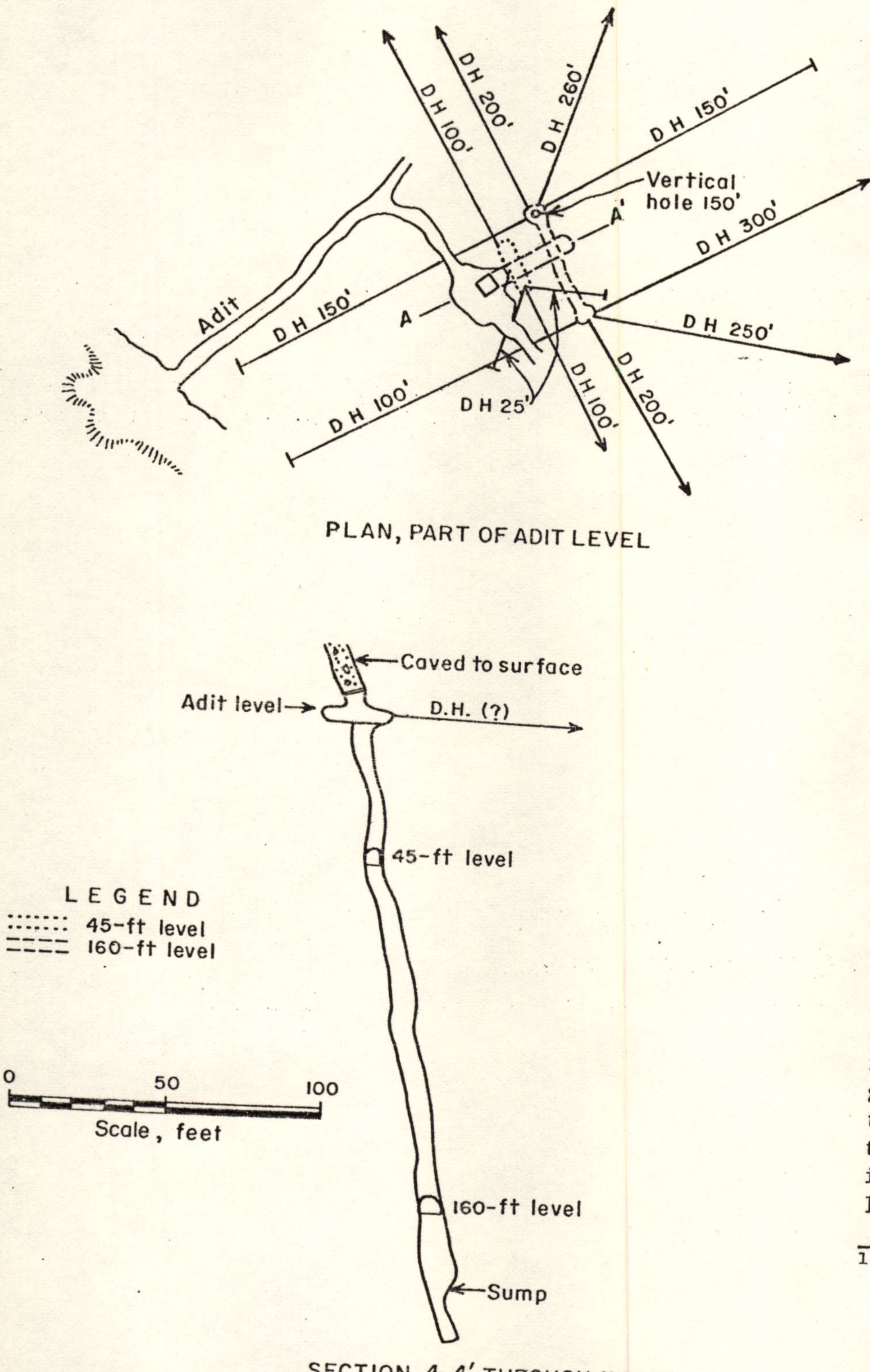

FIGURE 2. - Sketch of Workings Showing Several Drill Holes, Lone Pine Mine, Catron County, N. Mex.

of this ore has been carried away by specimen collectors. Reportedly, the tellurium ore was mined from a quartz-fluorite-pyrite-filled fissure 12 inches wide[14] encountered in sinking the shaft.

Little evidence of a significant fissure was noted in examining the property. It appears probable that the tellurium occurs in an erratically fractured zone in pockets or filled vugs. Relatively high concentrations of pyrite were found with the tellurium, and fluorite was observed randomly both near and away from the high concentrations of tellurium. Much of the latest work consisted of core drilling to probe for new ore or a geologic structure that may indicate trends of mineralization. During 1961 approximately

[14]Ballmer, Gerald J. Native Tellurium From Northwest of Silver City, N. Mex. Am. Mineralogist, v. 17, 1932, pp. 491-492.

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2 tons of high-grade native tellurium ore was recovered by scavenging work in the shaft about 100 feet below the adit. Numerous faults were exposed in the workings. Apparently most of the faults are not related to tellurium deposition. Native tellurium is easily identified as a dark gray to silvery-white, heavy metallic mineral, usually in granular form. Pyrite, and frequently coarse, crystalline fluorite, are associated with tellurium. Two samples cut across the end of the shaft assayed 0.04 and 0.06 percent tellurium.

Bambolla Mine

Native tellurium, paratellurite, emmonsite, and mackayite occur at the Bambolla mine, 11 miles southwest of Moctezuma, Sonora, Mexico. The tellurium minerals are erratically distributed throughout seven veins ranging from 3 to 6 feet in width. The veins are in a layered, welded tuff formation of Tertiary age. Quartz is the principal gangue mineral. Rehabilitation, surface, and underground mapping and diamond drilling were done by a prominent company in 1962. Reportedly, about 10,000 tons of ore containing 30,000 pounds of tellurium was developed above the 290-foot level. The ore averages 0.15 percent Te and 0.37 ounces of gold per ton. Fifty-six samples taken from the mine dump, representing about 7,000 tons, averaged 0.107 percent Te.

Silver King Property

Tellurium has been found in the ores of the Silver King property in the Ward district, White Pine County, Nev., 16 miles south of Ely. Lead, zinc, and copper sulfides, having some silver and gold, occur in replacement deposits in relatively narrow beds of limestone. Tellurium minerals hessite and altaite have been identified in the ore. Mineralization appears to be related to quartz monzonite dikes and narrow fault fissures cutting the limestone beds. The ore is found in several contiguous beds of limestone. One mine sample assayed 3.5 percent Te, and two sample pulps, each representing about 100-ton shipments, contained 0.15 percent Te. Ores with high-silver content have the greatest percentage of tellurium. About 2,000 tons of ore recently shipped from the property averaged 30 ounces of silver and 0.05 ounce of gold per ton, 0.65 percent copper, 3.8 percent lead, and 4.8 percent zinc. The tellurium content of this ore, assuming that most of the tellurium is in the mineral hessite, was estimated at 0.06 percent or 0.01 percent tellurium for every 5 ounces of silver. The ore was shipped to a company purchasing base-metal ores, and most of the tellurium was reportedly recovered in the refining process.

OUTLOOK FOR INCREASED PRODUCTION

The possibility of increasing tellurium production above that of 1961 appears favorable. Most of any increase probably would result from greater production and improved efficiency in recovery methods in the electrolytic base-metal refining industry. In 1961, United States Smelting, Refining and Mining Co. increased production capacity at its Indiana refinery from 17,000 to 60,000 pounds of tellurium a year. A tellurium pilot-plant project was started in 1962 by Kennecott Copper Corp. at Garfield, Utah. The Consolidated Mining & Smelting Co. of Canada may program tellurium recovery as a byproduct from its smelting and refining operations.

New properties, such as the American Smelting and Refining Company Mission (copper) project, and increased activity at mines presently yeilding complex base-metal ores will result in additional tellurium production. Some ores might be developed from mines and dumps in districts virtually abandoned; however, as no credit presently is allowed for tellurium by custom smelting companies, little increase in production can be expected from this source.

Base-metal ores from several areas were sampled by the Bureau of Mines. Samples containing tellurium were obtained from the Jerome district in Yavapai County, Ariz.; Cebolla district (Vulcan-Good Hope mines) in Gunnison County, Gold Hill district in Boulder County, and the Sneffels and Telluride districts in Ouray and San Miguel Counties, Colo.; Ward district in White Pine County, Nev.; the Organ Mountains in Dona Ana County, N. Mex.; and the Stateline district in Iron County, the Marysvale district, Piute County, the Tintic district, Juab and Utah Counties, the Cottonwood and West Mountain (Bingham) districts in Salt Lake County, and the Ophir district, Tooele County, in Utah.

Minor production may come from native tellurium occurrences under investigation in western New Mexico and central Sonora, Mexico. The extent of prospecting and developing native tellurium deposits will depend on an increase in price and demand.

Tellurium recovery from gold-telluride ores has not been economically feasible. However, if the Carlton mill of The Golden Cycle Corp. at Cripple Creek, Colo., resumed operations at a capacity of 1,000 tons of ore a day, tellurium recovery might be profitable.

Concentrating and refining tellurium are not considered difficult metallurgical processes. Improved efficiency can be expected at base-metal smelters and refineries as demand and price for tellurium increase. Recovery of tellurium from gold-telluride ores and ores containing native tellurium has not been practiced commercially. Any potential producer of high-grade tellurium ores or concentrates probably could make arrangements for processing with one of the electrolytic refining companies. United States Smelting, Refining and Mining Co. purchases special smelter and refinery slags and residues containing tellurium and associated elements for recovery in its electrolytic refining plant at East Chicago, Ind.

APPENDIX A. - BRIEF DESCRIPTION OF THE ROLE OF THE SEMICONDUCTOR IN THERMOELECTRICITY[1]

"In a metal each atom contributes at least one electron able to move freely within the metal. In semiconductors, on the other hand, only a few atoms release such free electrons. The number of electrons available for current flow in a semiconductor is hundreds or thousands of times less than in a metal, and this accounts for the low conductivity of these substances.

"When one end of a semiconductor--or a conductor, for that matter--is hotter than the other, electrons leave the hot end more often than they do the cold end. They tend to flow toward the cold end, and since all are negatively charged, the cold end soon becomes charged negatively with respect to the hot end .... After a short time the flow of electrons from the hot end reaches equilibrium with the return flow from the cold end. The charges no longer accumulate, but the cold end remains negatively charged. The fewer the electrons available for the return flow, the higher will be the voltage attained at the cold end before equilibrium is reached. Since the number of free electrons is much smaller in a semiconductor, a temperature difference in a semiconductor will produce a much greater voltage than in a conductor. This is the essence of the thermoelectric advantage possessed by semiconductors.

"Different conductors develop greater or lesser voltages. In all semiconductors the voltage increases with the difference in temperature between the hot and cold ends. The voltage across a given semiconductor when one of its ends is warmer than the other is the measure of its characteristic thermoelectric power, which is expressed in volts per degree centigrade ... .

"Semiconductors possess still another thermoelectric advantage not found in metals at all. In some types of semiconductor material the voltage differential between the hot and the cold end is set up not by the flow of negatively charged electrons but by the flow of positively charged "holes" vacated by electrons. As a result, the cold end in such a semiconductor becomes positively charged. The two types of semiconductors are designated as "n-type" (hot end positive) and "p-type" (cold end positive). In both types, of course, the direction of the current (electron flow) is from the positive to the negative end." (Fig. 3.)

An example of a simple thermoelectric generator is shown on figure 4.[2]

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[1] Excerpts from Joffe, Abram F. The Revival of Thermoelectricity. Sci. Am., v. 199, No. 5, Nov. 1958, pp. 31-37. (Reprinted with permission. Copyright 1958 by Scientific American, Inc. All rights reserved.)

[2] Abel, Edward O. Thermoelectric Power From Lead--What's Practical? What's Possible? Pres. at 34th Ann. Meeting, Lead Ind. Assoc., Inc., St. Louis, Mo. April 11, 1962.

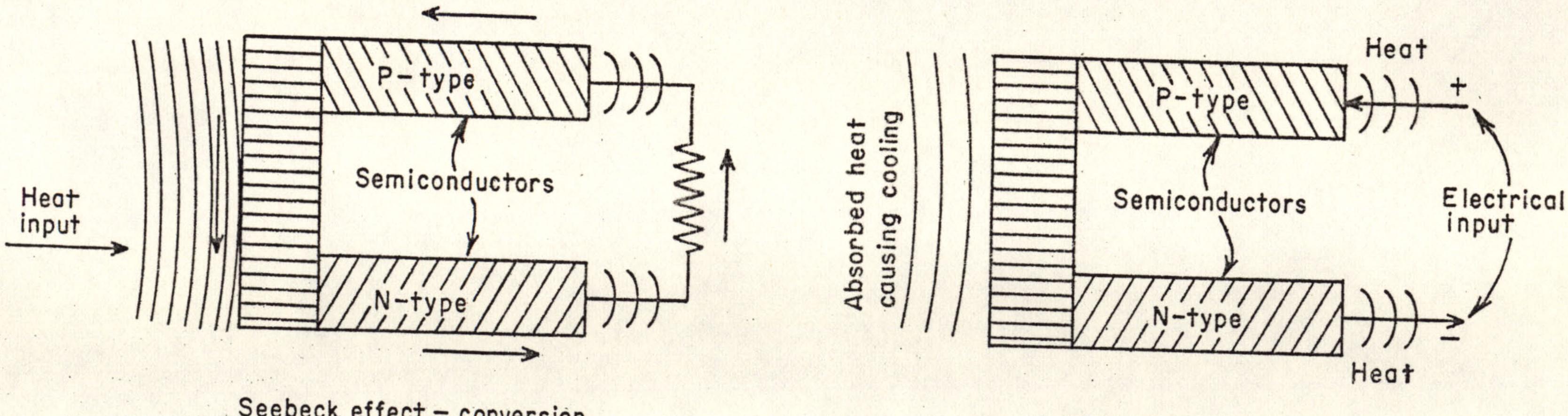

FIGURE 3. - Sketch Illustrating Seebeck and Peltier Thermoelectric Effects.

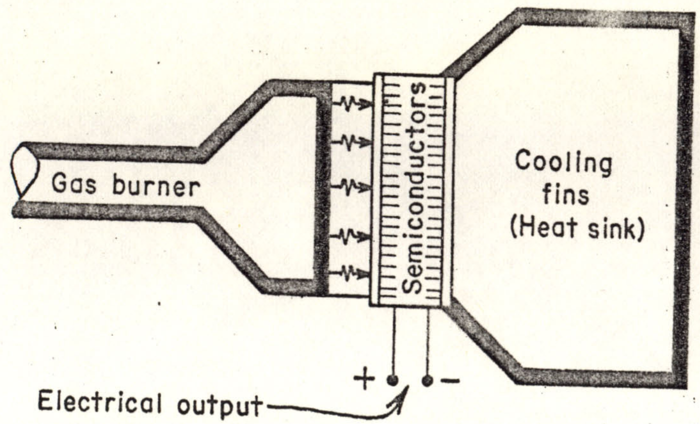

FIGURE 4. - Simple Thermoelectric Generator Housed in a Heat Exchanger.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
Arizona					
Douglas Reduction Works	Cu	Cochise	D	-	Lavender pit ore concentrates.
Do	Cu	do	D	-	Reverberatory matte.
Do	Cu	do	E	-	Reverberatory slag.
Do	Cu	do	D	-	Cu.
Orphan Boy	U_3O_8	Coconino	E	E	Composite of 6 shipments.
Rare Metals Mill	U_3O_8	do	E	E	Composite of U ores.
Pig Iron claims	Fe	Gila	E	-	Low-grade magnetite.
Do	Fe	do	E	-	Do.
Inspiration Consolidated Copper Co.	Cu	do	E	-	Cu ore concentrate.
Do	Cu	do	E	-	Reverberatory slag.
Do	Cu	do	E	-	Cu matte.
Do	Cu	do	E	-	Blister Cu.
Copper Cities	Cu	do	E	-	Cu ore concentrate.
Phelps Dodge Morenci	Cu	Greenlee	D	-	Flotation concentrate.
Do	Cu	do	E	-	Smelter reverberatory slag.
Do	Cu	do	E	-	Cu matte.
Do	Cu	do	D	-	Anode Cu.
Artillery Peak	Mn	Mohave	E	-	Maggie Canyon ore.
Wendon Stockpile	Mn	do	E	-	Mn ore from Arizona.
Banner	Cu	Pima	E	C	Cu concentrate.
Phelps Dodge-Ajo	Cu	do	E	-	Flotation concentrate.
Do	Cu	do	E	-	Reverberatory slag.
Do	Cu	do	E	-	Cu matte.
Do	Cu	do	E	-	Anode Cu.
Johnson's Camp mine	Cu	do	E	-	Concentrate composite.
San Manuel	Cu	Pinal	E	C	Cu concentrate.
Do	Cu	do	E	C	MoS_2 concentrate.
Iron King	Cu	Yavapai	E	-	Cu concentrate.
Do	Cu	do	E	C	Pyrite sample.
United Verde	Cu	do	E	C	Cu 3.08 percent 300 level.
Do	Cu	do	D	C	Cu 1.05 percent 300 level.
Do	Cu	do	E	D	Cu 3.8 percent 4500 level.
Do	Cu	do	D	B	Cu 0.5 percent 700 level.
Colorado					
Burlington	CaF_2	Boulder	E	-	Composite of ore.
Kekionga	Au	do	C	-	Mineral sample.
Do	Au	do	E	-	Dump sample.
Poorman	Au	do	D	-	Do.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		Colorado (Con.)			
Cash	Au,Ag	Boulder	B	-	Au 13.48, Ag 214.0 oz/ton.
Rex	Au,Ag	do	B	-	Au 39.22, Ag 197.7 oz/ton.
Vulcan	Au,Ag,Cu, Pb	Gunnison	D	-	S dump, Au 0.06, Ag 2.0 oz/ton.
Do	Au,Ag,Cu, Pb	do	C	-	Vulcan dump.
Do	Au,Ag,Cu, Pb	do	E	-	Pyrite nodule.
Cebolla Creek	Fe,Ti	do	E	-	Titaniferous Fe.
Hayden shaft	Pb,Zn	Lake	E	-	Pb 2 percent, Mn 9 percent.
Leadville	Mn	do	E	-	Mn ore.
Red Mountain mill	Pb	Ouray	D	D	Pb concentrate.
Do	Zn	do	E	D	Zn concentrate.
Do	Cu	do	C	C	Cu concentrate.
Do		do	E	D	Composite of ore.
Do		do	E	E	Mill tailing.
Sunnyside	Mn,SiO_2	San Juan	E	-	Rhodonite deposit.
Pandora mill	Zn	San Miguel	E	D	Zn concentrate.
Do	Cu	do	D	D	Cu concentrate.
Do		do	E	E	Composite of ore.
Do	Pb	do	D	C	Pb concentrate.
Do		do	E	E	Mill tailing.
Lucky Strike	Pb,Zn	Summit	E	-	
Wilfley	Pb,Zn	do	E	-	
Kokomo	Pb,Zn	do	E	-	Bureau of Mines project.
Climax		do	E	-	Pyrite concentrate.
The Golden Cycle Corp	Au	Teller	D	-	Au ore.
Do	Au	do	C	-	Au flotation concentrate.
		Idaho			
Bloomington Canyon	V_2O_5	Bear Lake	E	D	Vanadiferous shale.
Paris Canyon	V_2O_5	do	E	C	Metals Reserve stockpile.
		Nevada			
Consolidated Eureka	Cu,Pb,Zn, Ag	Eureka	C	-	Ore shipments to smelter.
Bristol Silver	Ag	Lincoln	C	E	Do.
Silver King	Ag,Pb,Zn, Cu	White Pine	C	D	Ore sample.
Do	Ag,Pb,Zn	do	C	C	Do.
Do	Pb	do	A	C	Galena.
Do	Ag,Pb,Zn Cu	do	C	E	Oxide ore.

[1]A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		Nevada (Con.)			
Silver King	Ag,Pb,Zn, Cu	White Pine.	C	-	Ore bin.
Do	Ag,Pb,Zn, Cu	do	B	-	Ore in Quinn stope.
Do	Ag,Pb,Zn, Cu	do	C	-	Ore in Quinn stope 20 feet higher than above.
Do	Ag,Pb,Zn	do	D	-	Drill hole 1, 94 to 96 feet.
Do	Ag,Pb,Zn	do	D	-	Drill hole 1, 160 to 172 feet.
Do	Ag,Pb,Zn	do	D	-	Drill hole 1, 194 to 196 feet.
Do	Ag,Pb,Zn, Cu	do	C	-	High-grade Pb-Zn, Quinn stope.
Do	Ag,Pb,Zn, Cu	do	C	-	Five-foot cut, Quinn stope.
Hamilton Mining Co	Ag-Pb	do	D	-	Ore shipments to smelter.
		New Mexico			
Lone Pine	Te	Catron	A	C	Pyritized rock.
Do	Te	do	B	-	Do.
Do	Te	do	C	-	Do.
Do	Te	do	B	-	Two-ton ore pile on dump.
Do	Te	do	B	-	Adit station chip sample.
Do	Te	do	B	-	Do.
Do	Te	do	E	-	Quartz latite porphyry 145-foot level of shaft.
Do	Te	do	C	-	Site of shaft, 100-foot level.
Do	Te	do	E	E	Surface latite porphyry.
Do	Te	do	E	E	Do.
Do	Te	do	B	E	Pyritized porphyry.
Do	Te	do	C	D	Do.
Do	Te	do	A	C	Pyrite and native Te.
Do	Te	do	B	C	Do.
Do	Te	do	C	-	Dump sample.
Do	Te	do	C	-	Mud in 1/2-inch fault in shaft.
Do	Te	do	A	-	Native Te and pyrite, Bi 0.05 percent, Au 4.00 oz, Ag 0.6 oz/ton.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
New Mexico (Con.)					
Texas Main	Au,Ag,Pb	Dona Ana.	E	-	Mine dump near crest.
Do	Au,Ag,Pb	do	E	-	Third mine dump from crest.
Do	Au,Ag,Pb	do	E	-	Fifth mine dump from crest.
Do	Au,Ag,Pb	do	E	-	Five-foot cut in adit of principal workings.
Do	Au,Ag,Pb	do	D	-	One-foot cut on fissure in adit.
Do	Au,Ag,Pb	do	D	-	Lead ore on dump.
Do	Au,Ag,Pb	do	E	-	Dump sample (4,000 tons).
Do	Au,Ag,Pb	do	E	-	Galena and sphalerite pieces.
Do	Au,Ag,Pb	do	E	-	Hematite sample.
Do	Au,Ag,Pb	do	E	-	Cross fissure dump.
Memphis	Au,Ag,Pb, Zn,Cu	do	A	-	Oxidized mineral in bismuth cut.
Do	Au,Ag,Pb, Zn,Cu	do	E	-	Large sample iron and copper oxidized material.
Do	Au,Ag,Pb,	do	E	-	Cut sample, lower end zinc shaft.
Do	Au,Ag,Pb, Zn,Cu	do	D	-	South dump near highway.
Do	Au,Ag,Pb, Zn,Cu	do	E	-	Roos shaft dump.
Do	Au,Ag,Pb, Zn,Cu	do	D	-	South end of bismuth pit.
Do	Au,Ag,Pb, Zn,Cu	do	D	-	Bismuth ore, representative grab sample.
Big Three	Au,Ag,Cu	Dona Ana.	D	-	Pyrite and limonite ore.
Lady Hopkins	Au,Ag,Cu	do	E	-	Dump.
Hilltop	Au,Ag,Pb	do	D	-	Claim 8, thin vein of galena.
Do	Au,Ag,Pb	do	D	-	Claim 5, thin vein of galena.
Do	Au,Ag,Pb	do	B	-	Claim 3, up raise.
Do	Au,Ag,Pb	do	C	-	Do.
Do	Au,Ag,Pb	do	C	-	Claim 1, adit, thin vein.
Do	Au,Ag,Pb	do	D	-	Claim 4, sulfides.
Do	Au,Ag,Pb	do	A	-	Claim 8, galena.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		New Mexico (Con.)			
Cactus Flats, south of Dry Creek.	Au	Grant......	E	-	Quartz.
Ground Hog..............	Pb,Cu	do.......	E	-	Ore sample.
Clemney mine, Hachita Mts.	Au,Ag	Hidalgo....	E	-	Quartz vein filling.
Creeper mine, Hachita Mts.	Au,Ag	do.......	D	-	Ore sample.
Do..............	Au,Ag	do.......	D	-	Do.
Demming.................	Mn	Luna.......	E	-	Mn stockpile.
Phillips Petroleum Ann Lee shaft.	U_3O_8	McKinley...	E	C	U_3O_8 0.201 percent.
Calumet and Hecla.......	U_3O_8	do.......	E	B	Ore stockpile.
Homestake Sec. 15 drill hole.	U_3O_8	do.......	E	C	Uranium ore sample.
La Bajada...............	U_3O_8	Sandoval...	E	-	Dump sample.
Dial property:					
Drill hole 64.........	Se	do.......	E	-	Sandstone and siltstone with 0.4 oz Ag and about 0.003 percent Se.
Drill hole 81.........	Se	do.......	E	D	Sandstone and siltstone with 0.4 oz Ag.
Drill hole 82.........	Se	do.......	E	-	Do.
Silver Tail.............	Au,Ag	Sierra.....	C	-	Small quartz fissure.
		North Dakota			
Lignite beds............	U_3O_8	Bowman.....	E	C	
		South Dakota			
Homestake...............	Au	Lawrence...	E	E	Minus 3/4-inch mill head.
Do..................	Au	do......	E	D	Slag from cyanide precipitate.
Do..................	Au	do......	E	D	Spiral concentrator sulfide concentrate.
Do..................	Au	do......	E	E	Sand charge to spiral concentrator.
Do..................	Au	do......	E	E	Slime fraction.
Do..................	Au	do......	E	E	Iron-stained schist ore.
Do..................	Au	do......	E	E	Schist rock cut near Yates shaft.
		Utah			
Creole..................	Ag,Pb	Beaver.....	E	D	Ore sample.
Do..................	Ag,Pb	do.......	E	-	Bi 0.3 percent.
Cactus..................	Cu	do.......	E	E	Copper ore.
OK mine.................	Cu	do.......	E	E	Do.
Copper King.............	Cu	do.......	E	D	Chalcopyrite in dump ore.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		Utah (Con.)			
Moscow	Zn	Beaver	E	-	Zinc ore.
Horn Silver	Au,Ag,Pb, Zn	do	D	-	Ore sample.
Staats Fluorite	CaF_2	do	E	E	U_3O_8 and CaF_2 in ore.
Do	CaF_2	do	E	E	Composite CaF_2.
Utah Western Antimony	Sb	Garfield	E	E	Ore grab.
AEC No. 8	U_3O_8	Grand	E	B	U_3O_8 0.327 percent.
Do	U_3O_8	do	E	E	Mainly pyrite.
Cina	Hg	Iron	E	E	Pit sample.
Do	Hg	do	E	E	Hg ore.
Iron Mountain	Fe	do	E	E	Iron ore.
Chief Consolidated	Pb,Zn	Juab	E	-	Fe 42.8 percent.
Deer Trail	Au,Pb,Zn	Piute	D	C	Tailings.
Do	Au,Pb,Zn	do	D	C	Dump sample.
Lucky Boy	Au	do	D	A	Sample of tiemannite (HgSe).
Goldstrike	Au	do	D	D	Grab of ore.
Cascade	Au	do	D	D	Do.
Shamrock	Au	do	D	D	Do.
Bully Boy	Au	do	E	D	Do.
Do	Au	do	D	E	Mill tailing.
Iris	Au	do	D	D	Grab of dump.
Great Western	Au	do	D	D	Grab of ore.
Packard	Au	do	E	E	Dump.
Tate	Au	do	E	E	Composite of 4 cuts.
Blue Bird	Au	do	E	E	Dump grab.
Kimberly	Au	do	E	E	Do.
Do	Au	do	E	E	Ore-bin grab.
Do	Au	do	E	E	Tailing pond.
Annie Laurie	Au	do	E	E	Do.
Do	Au	do	E	E	Ore-bin grab.
Winkleman	Alunite	do	E	-	Pit grab.
White Horse	Alunite	do	E	-	Do.
South Hecla	Pb,Zn,Au	Salt Lake	D	-	Ore sample.
Do	Pb,Bi	do	C	-	Bi winze ore.
Utah Copper mine	Cu	do	D	-	Cu ore concentrate.
Do	Cu	do	E	-	Reverberatory slag.
Do	Cu	do	D	-	Cu matte.
Do	Cu	do	C	-	Converter Cottrell dust.
Do	Cu	do	D	-	Anode Cu.
U.S. and Lark mine	Cu,Pb,Zn, Ag	do	D	D	Pb concentrate.
Do	Pb	do	C	E	Pb bullion.
Keetley unit, United Park City Mines.	Pb,Zn	Summit	E	E	Ore sample.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		Utah (Con.)			
Mayflower New Park......	Pb,Zn	Summit.....	E	E	Ore sample.
Sacramento pit..........	Au	Tooele.....	E	E	Black shale.
Consolidated Mercur.....	Au	do......	E	E	Au ore tailings.
Do...............	Au	do......	E	E	Do.
Manning Canyon..........	Au	do......	E	-	Do.
Mercur Dome.............	Au	do......	E	-	Au ore.
Ophir Hill..............	Pb,Zn	do......	D	D	Shale between Blue and Green veins.
Do.................	Pb,Zn	do......	D	D	W stope.
Do.................	Pb,Zn	do......	C	D	Grab from Pb-Zn stope, 1600 level.
Do.................	Pb,Zn	do......	D	D	Cu ore, Green vein, 1400 level.
Gold Hill mine..........	As	do......	E	-	Arsenopyrite ore.
U.S. mine...............	As	do......	E	-	Do.
International Smelting and Refining Co., Tooele plant.	Pb	do......	E	D	Pb blast-furnace slag.
Do............	Pb	do......	B	B	Cottrell dust.
Do............	Pb	do......	B	B	Blast furnace bag-house fumes.
Do............	Cd	do......	C	B	Cd plant calcine.
Do............	Cu	do......	C	C	Dross reverberatory matte.
Do............	Cu	do......	C	C	Dross reverberatory speiss.
Do............	Pb	do......	C	E	Pb bullion.
Columbia-Geneva Steel Plant.	Fe	Utah.......	E	E	Coal to furnace.
Do............	Fe	do......	E	-	Blast-furnace flue dust.
Do............	Fe	do......	E	-	Pig iron.
Do............	Fe	do......	E	-	Open-hearth flue dust.
Silver Reef.............	Au,U_3O_8	Washington.	B	-	Au ore sample.
		Wyoming			
Iron Mountain...........	Fe,Ti	Albany.....	E	-	Titaniferous magnetite.
Lysite Poison Butte.....	Se	Fremont....	E	C	Sample contains 0.049 percent Se.
Lucky Mc................	U_3O_8	do......	E	B	U_3O_8 0.023 percent, Se 0.825 percent.
Do.................	U_3O_8	do......	E	C	Unoxidized ore, U_3O_8 0.45 percent.
Frazier-Lamac...........	U_3O_8	do......	E	C	Ore with pyrite.
Vitro Sateco mine.......	U_3O_8	do......	E	C	Do.
Atlantic City iron mine.	FeO	do......	E	-	Taconite ore.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX B. - PROPERTIES SAMPLED AND TELLURIUM AND SELENIUM DETERMINATIONS BY THE BUREAU OF MINES (Con.)

Property	Principal commodity	County	Te,[1] percent	Se,[1] percent	Remarks
		Wyoming (Con.)			
Brutch Sulfur...........	S	Hot Springs	E	B	Sulfur ore.
Copper King.............	Cu,Au	Laramie....	E	-	Drill-hole sample.
Dry Canyon..............	V_2O_5	Lincoln....	E	C	Vanadiferous shale.
Do..................	V_2O_5	do......	E	C	Do.
Sunrise.................	FeO	Platte.....	E	-	Hematite ore.
Sunlight Basin..........	S	Park.......	E	-	S ore.
Fremont Lake............	MoS_2	Sublette...	E	-	Cut sample.
Wyomingite rock.........	K_2O	Sweetwater.	E	-	Leucite mineral high in potash.

[1] A = Te or Se above 1 percent; B = Te or Se between 0.1 and 1.0 percent; C = Te or Se between 0.01 and 0.1 percent; D = Te or Se between 0.001 and 0.01 percent; and E = Te or Se of less than 0.001 percent.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY

(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
		California		
Calaveras County:				
Carson Hill	Tailings	Au	8	ND
Melones	Dump and outcrop	Au	4	ND
Ford No. 1	Dumps and float	Au	4	ND
Ford No. 2	Dump	Au	4	ND
Melones-Morgan	Float	Au	9	ND
Calaveras vein	do	Au	1	ND
Stanislaus	Outcrop	Au	1	ND
Keystone	Ore bin and dump	Au	3	ND
Union	Dump and float	Au	2	ND
Empire	Outcrop	Au	1	ND
Eldorado County:				
Darling	Dump	-	7	ND
Fresno County:				
Sheridan	Outcrop	-	1	ND
Dinky Creek	Ore sacks	WO_3	1	L
Garnet Dike	Dump, tailing, and underground samples.	-	8	ND
Inyo County:				
Susquehanna	Outcrop	-	1	L
Do	do	-	5	ND
Bendiro Iron	do	-	1	ND
Sampson-Ella	Underground and dump	-	4	ND
Do	do	-	1	L
Cerro Gordo	Underground	Pb	1	ND
Do	Concentrate	Pb	1	L
Do	Dumps	Pb	16	ND
Coso Hot Springs	Outcrop	-	2	ND
Devil's Kitchen	do	-	5	ND
Golden Treasure	Dump	-	1	ND
Big Horn	Underground	-	1	ND
Imperial County:				
Coyote Mountains	Outcrop	-	4	ND
Los Angeles County:				
Platinum	Pulp	-	1	ND
Mono County:				
Comanche	Dumps	-	2	ND
Nevada County:				
Providence	do	-	2	ND
Plumas County:				
Thunderbird	Outcrop and stockpile	-	15	ND
Butte Bar	Outcrop	-	4	ND
Do	Stockpile	-	1	L
Little Nell	Outcrop	-	3	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
	California (Con.)			
Riverside County:				
Calzona	Outcrop and dump	-	8	ND
Lost Horse	Dump, tailing, and outcrop.	-	6	ND
San Bernardino County:				
Stateline	Outcrop	-	2	ND
Calico Mountains	do	Au	3	ND
Atkinson	Sorted ore	-	2	L
Do	Dump	-	2	ND
New Trail	do	-	3	ND
Blue Bell	Ore bin	-	2	L
Shasta County:				
Deep Pit	Outcrop	-	2	ND
Wallis	do	-	4	ND
Yankee John	do	-	1	ND
Do	Concentrate	-	2	L
Do	do	-	2	M
Do	do	-	2	ND
Eureka	Outcrop	-	2	ND
Sierra County:				
Plumbago	Concentrate	-	2	ND
Siskiyou County:				
Yellow Rose	Dump	-	2	ND
Sonoma County:				
Geyers	Outcrop	-	2	ND
Mercury mine	do	Hg	1	ND
Trinity County:				
Golden Jubilee	do	-	2	L
Dorleska	Concentrate, dumps and cuts.	-	15	ND
Tulare County:				
Beasley claims	Dump and outcrop	-	9	ND
Tuolumne County:				
Jumper mine	Outcrop	-	4	ND
Ashley	Gold, outcrop	-	4	ND
Atlas	Dumps and underground	-	8	ND
Chilana	Outcrops and dump	-	7	ND
Jackass Hill	Underground and outcrop	-	2	ND
Eagle Shawmut	Dump, underground, and tailing.	Cu,Zn	11	ND
Norwegian	Dumps and outcrop	-	7	ND
Hiway cut	Outcrop	-	1	ND
Ryan mine	Underground	-	1	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
California (Con.)				
Yuba County:				
Liberty-Red Cross.......	Ore bin................	-	1	ND
Red Raven...............	Float and dump.........	-	2	ND
Colorado				
Boulder County:				
John Jay................	Ore....................	CaF_2,Au	1	L
Smuggler................	Underground sample.....	Au	3	ND
Ozark-Mahoney...........	Ore....................	CaF_2	1	ND
Mountain Lion...........	Underground............	Au	1	L
Mountain Lion No. 2.....	do.....................	Au	1	ND
Kekionga................	Ore....................	Au	1	ND
Alamakee................	do.....................	Au	1	ND
Winona..................	do.....................	Au	1	ND
Slide...................	do.....................	Au	1	ND
Do....................	do.....................	Au	1	M
Nederland...............	Mine tailing...........	WO_3	1	ND
Clyde...................	Dump...................	WO_3	1	ND
Wolf Tongue.............	Mill tailing...........	WO_3	1	ND
Mountain Top............	....	Au	3	ND
Do....................	....	Au	1	L
White Raven.............	Underground............	Au	1	ND
Do....................	Ore (6 tons)...........	Au	1	L
Do....................	Ore (3 tons)...........	Au	1	ND
Rex.....................	Ore (7 tons)...........	Au	1	M
Do....................	do.....................	Au	1	L
Golden Age..............	Ore....................	Au	1	L
Nevo....................	do.....................	Au	1	L
Chaffee County:				
Sedalia.................	do.....................	Cu,Pb,Ag	2	ND
Stonewall...............	do.....................	Cu,Pb,Zn	1	ND
Mary Murphy.............	do.....................	Pb,Zn	1	ND
Do....................	Mill tailing...........	Pb,Zn	1	ND
Banker..................	Underground............	Pb,Zn	1	ND
Lilly...................	do.....................	Pb,Ag	1	ND
Clear Creek County:				
Bald Eagle..............	Ore....................	Ag,Au	5	ND
Front Range.............	Tailing................	Ag,Au	1	ND
Terrible Dunderberg.....	Ore....................	Ag,Au	1	ND
Central.................	do.....................	Ag,Au	1	ND
Empire..................	Dump...................	Ag,Au	1	ND
Gem.....................	Ore....................	Ag,Au	1	ND
Do....................	Dump...................	Ag,Au	1	ND
Komo....................	Ore....................	Ag,Au	1	L
Forge Hill..............	do.....................	Ag,Au	1	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
	Colorado (Con.)			
Clear Creek County (Con.):				
Franklin-Silver Age.....	Ore....................	Ag,Au	2	ND
Do..............	do....................	Ag,Au	2	L
Do..............	do....................	Ag,Au	2	M
Custer County:				
Bassick................	Tailing................	Au	1	ND
Bull Domingo...........	Ore....................	Au,Ag,Pb	1	ND
Silver Cliff...........	do....................	Au,Ag	2	ND
Eagle County:				
New Jersey Zinc........	Pb concentrate.........	Pb	6	L
El Pase County:				
The Golden Cycle Corp. (at Colorado Springs).	Mill tailing...........	Au	2	ND
Gilpin County:				
Miscellaneous..........	Mine samples...........	Au	7	ND
Miscellaneous..........	Ore shipments..........	Au	4	ND
Gunnison County:				
Little Darling.........	Ore....................	-	1	S
Sylvanite..............	do....................	Au	4	ND
Vulcan.................	do....................	Au,Ag,Cu,Pb	7	ND
Do..............	do....................	Au,Ag,Cu,Pb	1	M
Do..............	do....................	Au,Ag,Cu,Pb	1	S
Ruby...................	do....................	Au	2	ND
Akron-White Pine.......	do....................	Pb,Ag	2	ND
Crested Butte..........	do....................	Pb,Ag	1	ND
Hinsdale County:				
Ute-Utlay..............	do....................	Au,Pb	1	ND
Golden Fleece..........	do....................	Au,Pb	2	ND
Do..............	do....................	Au,Pb	1	M
Lake County:				
AS&R...................	Mill tailing...........	-	1	ND
Dinero.................	Ore....................	-	1	ND
Sugar Loaf.............	do....................	-	1	ND
Bartlett...............	do....................	-	1	ND
Kostelic, shipper......	....	Pb,Ag	1	ND
Kastrina, shipper......	....	Pb,Ag	1	ND
Webster, shipper.......	....	Pb,Ag	1	ND
La Platta County:				
Mt. Lilly..............	Ore....................	Au,Ag,Cu,Pb	1	L
Do..............	do....................	Au,Ag,Cu,Pb	2	ND
May Day................	do....................	Au,Ag,Cu,Pb	1	ND
Bessie G...............	do....................	Au,Ag,Cu,Pb	4	ND
Gold King..............	do....................	Au,Ag,Cu,Pb	3	ND
Copper Hill............	do....................	Au,Ag,Cu,Pb	1	ND
Zodomak Hill...........	....	Au,Ag,Cu,Pb	1	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
		Colorado (Con.)		
Mineral County:				
Empress	Ore	Au,Ag,Pb,Zn	6	ND
Do	do	Au,Ag,Pb,Zn	1	L
Do	Tailing	Au,Ag,Pb,Zn	1	ND
Amethyst	Dump	Au,Ag,Pb,Zn	1	ND
Sublet Mining Co	Ore	Au,Ag,Pb,Zn	2	ND
Mexico	Mine dump	Au,Ag,Pb,Zn	1	L
Montezuma County:				
Doyle	Ore	Pb,Zn,Au,Ag	1	ND
Minerals Consolidated	do	Pb,Zn,Au,Ag	1	ND
Do	do	Pb,Zn,Au,Ag	1	L
Ouray County:				
Midnight	do	Pb,Zn,Au,Ag	1	ND
Genessee	do	Pb,Zn,Au,Ag	2	ND
Camp Bird	Concentrate	Pb,Zn,Au,Ag	3	L
Do	do	Pb,Zn,Au,Ag	1	ND
Hough	Ore	Pb,Zn,Au,Ag	1	L
Park County:				
Hall Valley prospect		Pb,Zn,Au,Ag	1	ND
Buckskin Joe	Ore	Pb,Zn,Au,Ag	1	ND
Hock Hocking	do	Pb,Zn,Au,Ag	1	ND
Hilltop		Pb,Zn,Au,Ag	1	ND
W. G. Mines, Inc		Pb,Zn,Au,Ag	1	ND
Saguache County:				
Rowley	Ore	Au,Ag	3	ND
St. Louis	do	Au,Ag	2	ND
Empress Josephine	do	Au,Ag	1	ND
Do	do	Au,Ag	1	L
Bonanza	do	Au,Ag	1	ND
National Mines	Concentrate	Pb,Zn	1	L
Johnson Mining Co	(10 tons)	Pb,Zn	1	ND
San Juan County:				
Lead Carbonate	Ore	Pb,Zn,Cu,Au,Ag	1	L
Lucy	do	Pb,Zn,Cu,Au,Ag	1	ND
Lost Hope	do	Pb,Zn,Cu,Au,Ag	4	ND
Little Dora	do	Pb,Zn,Cu,Au,Ag	1	ND
Lettie	do	Pb,Zn,Cu,Au,Ag	1	ND
Shenandoah Dives	Zn concentrate	Pb,Zn,Cu,Au,Ag	1	M
Do	Pb concentrate	Pb,Zn,Cu,Au,Ag	1	M
Gold Prince	Ore	Pb,Zn,Cu,Au,Ag	1	ND
Engineer Mountain	do	Pb,Zn,Cu,Au,Ag	1	ND
Idarado Mining Co	Pb concentrate	Pb	1	M
Do	Cd concentrate	Cd	1	M
Do	Cu concentrate	Cu	5	L

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
	Colorado (Con.)			
Summit County:				
Wellington	Ore	Pb,Au,Ag	1	ND
Country Boy	do	Pb,Au,Ag	1	ND
Lucky Strike	do	Pb,Zn	1	ND
Monte Cristo	do	Pb,Zn	3	ND
Chautauqua	do	Pb,Zn	1	ND
Teller County:				
Carlton mill	Tailing	Au	1	ND
Mabel M.	Dump	Au	1	ND
Grass Creek	Tailing	Au	1	ND
School Section mine	do	Au	1	ND
Empire	Dump	Au	3	ND
Vindicator	do	Au	1	ND
Victor	Mill tailing	Au	1	ND
Callee	Tailing and dump	Au	2	ND
Orphan May	Ore bin and dump	Au	2	ND
	Nevada			
Esmeralda County:				
Goldfield	Dumps	Au	([2])	ND
Goldfield Consolidated	Dump, 1 million tons		([2])	L
Lander County:				
Battle Mountain	Crude ore	Cu	([2])	ND
Lincoln County:				
Delamar	Ore bin and tailing dump.	Au	2	L
Bristol Silver	Crude ore	Pb,Zn,Ag	([2])	L
	Utah			
Beaver County:				
Creole	Underground sample	Pb,Zn,Bi	3	ND
Sulphurdale	Sulfur ore	S	2	ND
Sheep Rock mine	Dump	Au,Ag	1	ND
Rob Roy	do	Au,Ag	1	ND
Carbonate		Pb,Zn	1	ND
Golden Reef		Pb,Zn	1	M
Karla mine	Rock	Pb,Zn	1	L
Harrington Hickory		Pb,Zn	1	ND
Inspiration		Pb,Zn	1	ND
Duchesne County:				
Myton Blackbird mine	Outcrop	Mn	1	ND
Murray	do	Mn	1	ND
Emery County:				
Pike-Globe mine	Ore	Cu	1	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

[2] Several samples.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
		Utah (Con.)		
Grand County:				
Lewis & Walling property	....	U_3O_8	1	ND
Climax Uranium property	....	U_3O_8	1	ND
Iron County:				
Stateline district:				
Ophir mine............	Dump....................	Au	1	M
Johnny................	do......................	Au	1	ND
Gold Spring district:				
Talisman..............	do......................	Au	1	ND
Snowflake.............	do......................	Au	1	ND
Jumbo.................	do......................	Au	1	L
Escalante district:				
Holt mine.............	do......................	Au	2	ND
Juab County:				
Bullion Beck............	Ore.....................	Pb,Zn,Ag	1	ND
Grand Central...........	do......................	Pb,Zn,Ag	1	ND
Mammoth.................	Ore and dump............	Au	2	ND
Colorado Consolidated...	Crude ore...............	Pb,Zn,Ag	1	L
Swansea.................	do......................	Pb,Zn,Ag	1	ND
Knight smelter..........	Dump....................	-	1	L
Piute County:				
Yellow Jacket...........	Alunite.................	Al,K	1	ND
Copper Belt.............	Crude ore...............	Au,Ag,Pb,Zn,Cu	1	S
Shamrock................	Dump....................	Au,Ag,Pb,Zn,Cu	1	L
Cascade.................	Dump ore................	Au,Ag,Pb,Zn,Cu	1	ND
Bully Boy...............	do......................	Au,Pb	1	ND
Webster.................	do......................	Au,Pb	1	ND
Iris....................	do......................	Au,Pb	1	L
Lucky Boy...............	do......................	Au,Pb	1	M
Dalton..................	Ore specimen............	Au,Pb	1	S
Deer Horn...............	Oxide ore...............	Au,Pb	1	ND
Deer Trail..............	Sulfide ore.............	Pb,Zn,Au	1	ND
Do..................	do......................	Pb,Zn,Au	1	L
Salt Lake County:				
Scott mine, Big Cottonwood.	Ore.....................	Pb,Zn	1	ND
Cardiff.................	do......................	Pb,Zn	1	ND
Highland Boy............	Ore shipment............	Pb,Zn	1	ND
U.S. and Lark mine......	Ore.....................	Pb,Zn	1	ND
Do..................	Pyrite..................	Pb,Zn	1	ND
Do..................	Pb concentrate..........	-	1	L
Do..................	Zn concentrate..........	-	1	L
Utah Copper mine........	Cu ore sample...........	Cu	1	ND
Do..................	Cu oxide precipitate...	Cu	2	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX C. - SOME SPECTROGRAPHIC ANALYSES FOR TELLURIUM FROM AN INVESTIGATION BY A PRIVATE COMPANY (Con.)
(Mine Locations are Listed According to State and County)

Property	Type sample	Principal elements	Number of samples	Percentage Te, spectrographic analysis[1]
	Utah (Con.)			
Salt Lake County (Con.):				
Utah Copper Mine........	Tailing................	Cu	1	ND
Do................	Cu sulfide concentrate.	Cu	1	ND
San Juan County:				
Happy Jack..............	Copper concentrate.....	U_3O_8	1	ND
Summit County:				
Daly West..............	Sulfide ore............	Pb,Zn,Ag	2	ND
Gilmore................	Tailing................	Pb,Zn,Ag	1	ND
Atkinson...............	do..................	Pb,Zn,Ag	1	ND
Daly No. 2.............	Ore....................	Pb,Zn,Ag	1	ND
Ontario................	do..................	Pb,Zn,Ag	2	ND
Pacific Bridge mill.....	Tailing................	Pb,Zn,Ag	11	ND
Tooele County:				
Gold Hill district, Western Utah Copper mine.	Outcrop................	-	1	ND
Do................	Cu oxide...............	-	1	ND
Do................	Fe oxide...............	-	1	ND
Do................	Underground............	-	1	ND
Do................	AsS_2 ore...............	-	1	ND
Kerry Dee..............	....	-	1	ND
Frisbee prospect.......	....	-	1	ND
Argent.................	....	Pb,Zn	1	ND
Uintah County:				
Dyer mine, Brush Creek area.	....	-	1	ND
Utah County:				
Eureka Standard.........	Sulfide dump sample....	Au,Pb,Ag	1	ND
Iron Blossom No. 3......	Dump...................	Pb,Zn,Cu,Ag	1	ND
Iron Blossom No. 1......	do..................	Pb,Zn,Cu,Ag	-	ND
Do................	Ore shipment...........	Pb,Zn,Cu,Ag	-	L
Apex Standard...........	Dump and ore...........	Pb,Zn,Cu,Ag	2	ND
Yankee Consolidated.....	Dump...................	Pb,Zn,Cu,Ag	-	ND
Do................	do..................	Pb,Zn,Cu,Ag	-	L
Eureka Lilly............	Ore....................	Pb,Zn,Cu,Ag	-	ND
Mountain View...........	do..................	Pb,Zn,Cu,Ag	-	ND
Tintic Standard.........	do..................	Pb,Zn,Cu,Ag	-	ND
Washington County:				
Silver Reef............	Sulfide concentrate....	Au,U_3O_8	-	ND

[1] S = 0.1 to 1.0 percent; M = 0.01 to 0.1 percent; L = 0.001 to 0.01 percent; and ND = none detected.

APPENDIX D. - PUBLISHED REFERENCES OF TELLURIUM MINERALS WITHIN THE AREA COVERED BY THIS REPORT

Property or district	County	Tellurium minerals
Arizona		
Tombstone district (14)[1]	Coshise...	Native Te.
Bisbee-Warren district (13)	do......	Rickardite.
Hassayampa district, Montgomery mine (13)	Yavapai...	Tetradymite.
Groom Creek district (14)	do......	Native Te.
Colorado		
Magnolia district: Keystone, Eclipse, Logan, and Kekionga mines (19).	Boulder...	Sylvanite, calaverite, hessite, petzite, coloradoite, altaite.
Gold Hill district:		
Red Cloud mine (13, 14)	do......	Petzite, tetradymite, sylvanite, calaverite.
Uncle Sam mine (12)	do......	Altaite, hessite, Native Tw.
Buena mine (12)	do......	Native Te.
Jamestown district:		
John Jay mine (13, 14)	do......	Petzite.
Golden Age (14)	do......	Do.
Sentinel (14)	do......	Do.
Tierney (14)	do......	Do.
Smuggler (6)	do......	Do.
Eldora district: Enterprise mine (12)	do......	Sylvanite, petzite, other tellurides.
Rico district: Johnny Bull mine (17)	Delores...	Tellurides.
Whitehaven district (13)	Fremont...	Do.
Central City district:		
Gregory mine (12)	Gilpin	Do.
Jewelry Shop (12)	do......	Krennerite, petzite, sylvanite, altaite.
War Dance (12)	do......	Coloradoite.
Lake City district:		
Golden Fleece mine (7)	Hinsdale..	Petzite.
Galic mine (9)	do......	Native Te.
Vulcan mine (9)	do......	Weissite, rickardite.
Leadville district: Eagle and Louisville mines (14).	Lake......	Tellurides.
La Plate district: Gold King, Lucky Discovery, Bessie G, Neglected, Idaho, Durango Girl, and May Day mines (5).	La Plata..	Sylvanite, calaverite.
Ouray district:		
Jonathan mine (6)	Ouray.....	Hessite.
American Nettie (6)	do......	Tellurides.
Bonanza district:		
Empress Josephine mine (1)	Saguache..	Native Te, rickardite, sylvanite, krennerite, empressite, hessite, petzite, altaite.
Copper Gulch (1)	do......	Tellurides.

[1] Underlined numbers in parentheses refer to items in the list of references at the end of this appendix.

APPENDIX D. - PUBLISHED REFERENCES OF TELLURIUM MINERALS WITHIN THE AREA COVERED BY THIS REPORT (Con.)

Property or district	County	Tellurium minerals
Colorado (Con.)		
Silverton district:		
Barstow mine (16)	San Juan	Tellurides.
Camp Bird (16)	do	Do.
Silver Ledge mine (16)	do	Hessite.
Magnet mine (16)	do	Do.
Bear Creek district (15)	do	Petzite.
Breckenridge district: Ontario mine (14)	Summit	Bismuth, tellurides.
Cripple Creek district: Gold King, Mable M, Little May, Independence, Portland, Moon-Anchor, Anchoria-Island, Elkton, Bluebird, West Point, Moose, Deadwood, and Gold Sovereign (10, 11).	Teller	Calaverite, sylvanite, krennerite, petzite.
New Mexico		
Ute Creek district: Aztec mine (3)	Colfax	Native Fe, tetradymite.
Organ Mountains district: Ben Nevis, Crested Butte, Texas Main, Memphis, Hilltop, Little Buck, Gonzales Eureka, and Rickardite mines (3, 4).	Dona Ana	Altaite, tetradymite, hessite, petzite.
Little Burro Mountains (3)	Grant	Tetradymite.
Sylvanite district: Hand Car, Golden Eagle, Gold Hill, Ridgewood, Little Mildred, and Pearl claims (3).	Hidalgo	Tetradymite, hessite.
Red River district: Sampson, Memphis, and Independence mines (3).	Taos	Petzite.
South Dakota		
Blacktail district: Double Standard mine (8).	Lawrence	Tellurides.
Ragged Top district: Dacy Group (8)	do	Do.
Lead-Deadwood district: Homestake mines (18).	do	Do.
Utah		
Stateline district (2)	Iron	Tellurides.
Ohio district: Bully Boy and Webster mines (2).	Piute	Do.
Dry Canyon district: Kearsarge mine (14)	Tooele	Hessite.
Mercur district: Golden Gate (2)	do	Tellurides.

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