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SELECTED BULK-TONNAGE, LOW-GRADE SILVER DEPOSITS IN WESTERN NORTH AMERICA

		ORE MINERALOGY			GRADE												SPATIALLY ASSOCIATED INTRUSION				
DEPOSIT	HOST ROCK	SILVER-BEARING MINERALS	OTHER MINERALS	ORE MINERAL MODE OF OCCURRENCE	HYPOGENE + SUPERGENE	SUPERGENE	ORE TONNAGE	SHAPE OF DEPOSIT	SIZE OF DEPOSIT (FEET)	STRUCTURAL CONTROLS	OPEN PIT	STRIPPING RATIO	AGE OF DEPOSIT	DOMINANT ALTERATION MINERALS	SUPERGENE ENRICHMENT	DEPTH EXTENT OF PARTIAL OXIDATION	ROCK TYPE	SIZE	GENETIC ASSOCIATION	METALLURGICAL CHARACTERISTICS OF ORE	ADDITIONAL COMMENTS
CANDELARIA, NEVADA	Triassic-Jurassic Candelaria Fm., tuffaceous shales	Secondary silver in limonite and jarosite, some remnant sulfides	Native gold, jamesonite, pyrite, minor chalcopyrite and galena	Disseminated, and in veins parallel to bedding	± 3 oz. Ag	Predominant	10 - 20 million	Tabular	2000 x 500 with fault repeats	Primary not known, secondary by fault offsets	Yes	Approx. 3:1	Jurassic or Tertiary	Clay, dolomite (magnesium metasomatism) manganese oxides	No (dispersion)	600' on dip, 450' vertically	Quartz monzonite, felsite dikes	70' - 180' wide, 400' long	Not known	Refractory -- under investigation	May be syngenetic (Jurassic) or replacement (Tertiary)
DELAMAR, IDAHO	Miocene rhyolite quartz porphyry (ash flow tuff)	Principally naumannite (silver selenide), also argentite	Minor pyrite, free gold	Finely disseminated in quartz	Est. 2 - 6 oz. Ag, ±0.03 oz. Au	--	Est. >8 million	Various shapes from equidimensional blob to long-and-narrow	Range from 100 ft. min. widths to 4000 ft max. lengths	Possibly deep-seated control, combined with more brittle quartz porphyries	3 pit areas	2:1 to 6:1	Miocene	Silica	Possible but minor		Various acid to intermediate volc. rocks, vents	Various	Probable	Nicely amenable to cyanidation. Not refractory (low Fe, Mn)	Deposit is in a volcanic center.
HARDSHELL, ARIZONA	Mesozoic volcanic and volcaniclastic rocks	Native silver? Argentian cryptomelane, cerargyrite, pearceite, argentojarosite	Pyrite, traces galena	Disseminated in associated Mn oxides and silica	Est. 4 - 5 oz. Ag	--	Est. >5 million	Manto-like	1600 x 600	Deep-seated structures, favorable porosity and permeability	Possible open pit, possible underground	If open pit, depends on cutoff grade	Laramide?	Silica, clay, Mn oxides (5-25% Mn)	Minor	At least 500'	Andesite and quartz latite	Irregular dikes and sills	None	Refractory	Underlying Paleozoic carbonate rocks provide the solution channels.
HOG HEAVEN, MONTANA	Two mid-Tertiary horizons, latite tuff breccia and volc. conglomerate	Galena, enargite, matildite	Pyrite, sphalerite, barite	Disseminated	Not established	--	Not established	Strongly warped, lensoid	Not established	Syn- & post-mineral folding	Possibly and partially	Not known	Mid-Tertiary	Silica with macroscale clay envelopes	In upper breccia horizon	To 500'	None known	--	--	Not known	Being explored
LANGTRY, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver?	Barite, pyrite	Finely disseminated	Est. ± 2 oz. Ag	--	± 15 million	Flat-lying	± 700 x 2000 x ± 100 thick	Deep-seated structures, favorable porosity and permeability	Yes	3:1	Miocene or Pliocene	Silica, iron oxides, clay, manganese oxides	None noted	Entire deposit	Pre-ore granitic body	Several square miles	None with granitic body	Refractory	Author considers this deposit an extension of the Waterloo (see below).
REAL DE ANGELES, ZACATECAS, MEXICO	Upper Cretaceous sandstone and siltstone, slightly limey	Argentiferous galena and minor tetrahedrite	Sphalerite, galena, pyrite, arsenopyrite, minor chalcopyrite	Partly disseminated, partly fracture-filling, some veins	2½ oz. Ag, 1% Pb, 1% Zn	Slight silver enrichment in shallow supergene	± 50 million	Roughly circular	At least 1000 x 1000	Bedding, fracturing	Yes	Low	Not known	None in classic sense. Minor calcite, chlorite	Locally at least silver	Up to 125'	None	--	--	Amenable to flotation	Both syngenetic-diagenetic (Cretaceous) and classic hydrothermal origins have been suggested.
ROUND MOUNTAIN, COLORADO	Oligocene rhyolite flows and breccias	Argentian cryptomelane, bromides and chlorides, native silver	Barite, fluorite, iron oxides	Mn oxide veins and veinlets in stockworks	Remnant only	2 - 3 oz. Ag	5 - 12 million	Flat-lying, lensoid	2½ million square feet	Primary not known, secondary by fossil water tables	Yes	Approx. 2:1	Mid-Tertiary still forming(?)	Clay, silica (opal-type), sericite	Redeposition, possible enrichment	200'	None known	--	--	Refractory -- under investigation	Primary grade not known. Deposit is in a volcanic center.
SAM GOOSLY, BRITISH COLUMBIA	Jurassic Hazelton Group, andesitic tuffs and breccias	Tetrahedrite, traces of ruby silver and argentite	Pyrite, chalcopyrite, pyrrhotite, sphalerite, rare galena	Disseminated and veinlet, some massive	Hypogene only. 2.8 oz.Ag, 0.33 % Cu, 0.02 oz.Au	None	43½ million open pit with depth extension	Essentially tabular	4000 x 300, irregular	Possibly position in a theorized volcanic vent	Yes, with depth extension	2.1:1	Eocene or Jurassic	Sericite, clay, chlorite, silica, tourmaline, gypsum, aluminous (scorzalite, andalusite, pyrophyllite, corundum)	None or very minor	Very shallow (glaciated)	Syenomonzonite-alkali gabbro stock	Over a mile square	Not certain but quite possible	Flotation recovery, requires fine grinding	Deposit may be contact or replacement associated with an Eocene stock in a volcanic vent, or syngenetic (Jurassic) remobilized
WATERLOO, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver? Argentiferous pyrite? Also cerargyrite, embolite, argentojarosite	Barite, pyrite	Finely disseminated	Est. 2 - 3 oz. Ag	--	Est. >25 million	Elongate wedge	1000 x 6000	Deep-seated structures, favorable porosity and permeability	Yes	Relatively low	Miocene or Pliocene	Silica, calcite, clay, manganese oxides	Locally in structures	At least 400'	Andesite porphyry	Modest-sized elongate stock	Probable	Refractory	Post-mineral brecciation caused by gravity gliding

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TO	FILE NO. SUBJECT	DATE
Bill Kurtz	Watson talk on bulk-tonnage silver	Oct. 6, '76

Bill – Enclosed is a copy of my ~~the~~ talk to be given in Spokane at the NMA Convention in early December – also a first draft of the master chart to accompany the talk. As a contributor of information, the copies enclosed are yours. If you have any comments, corrections, etc. of the paper or chart, please drop me a line before November 1 (when I plan to finalize it all).

Thanx again for your help.

SIGNED Barry Watson

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TO _____ DATE _____

P.S. It's amazing how little can be said in but 20 minutes time.

Love Fill ~~Gold~~ – Silver

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BULK-TONNAGE, LOW-GRADE SILVER DEPOSITS IN WESTERN NORTH AMERICA
(A talk to be given by Barry N. Watson at the Northwest Mining Association Convention, Spokane, Washington, in December 1976.)

To date, very little information has been published concerning a deposit-type that I choose to call here the "bulk-tonnage, low-grade silver deposits". A major reason for this paucity of available data is that none of the bulk tonnage silver deposits which have been discovered and developed over the last 15 years or so have yet come into production -- although the Delamar start-up will soon rectify that situation.

This paper is a first-attempt at discussing these deposits as a specific deposit type -- which I believe they are in the same sense as the "porphyry coppers" or the "bulk-tonnage, low-grade golds". There is plenty of room for revision and addition to what is presented herein, but, at least for starters, data has been accumulated and organized in chart-form for 9 bulk-tonnage, low-grade silver deposits in western North America. I am deeply grateful to a number of industry friends and contacts who have cleared with their companies much of the information presented in the master chart.

As there are a number of both distinct differences and similarities between a porphyry copper environment and a porphyry molybdenum environment, so the bulk-tonnage silver has both its similarities with, and contradistinctions to, those of bulk-tonnage gold. The latter class of deposit has been fairly effectively split into two groups: 1.) the Carlin-type deposits; and 2.) other bulk-

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tonnage golds, often associated with volcanic piles and/or hypabyssal intrusive phenomena. It is not the purpose herein to compare bulk-tonnage gold and silver deposits, but suffice it to say that the one distinct environment that emerges from the data on bulk-tonnage silver is similar to the second type of gold deposit, that associated with volcanic piles. I will call this type of bulk-tonnage silver the "Waterloo-type" because of a personal working knowledge of this particular California mineralization. A somewhat detailed look at the Waterloo deposit will give insight into the peculiar characteristics of a number of the bulk-tonnage, low-grade silver deposits.

The Waterloo mineralization lies along the southwestern flank of the Calico Mountains east of Barstow, California. The Langtry deposit, also characterized on the master chart, is a continuation of the same mineralization which is separated from the Waterloo by erosion of the connecting mineralized link. The Waterloo deposit is the size of a small porphyry copper and contains somewhere around 3 ounces of silver/ton finely disseminated in silica throughout the basal portion of the Barstow lakebed sediments of Miocene age. In a gross sense, silver values decrease both upsection and laterally in these sediments, while, more specifically, certain bedding horizons contain higher grade values than the surrounding silicified rock.

Most of the Waterloo deposit has been subjected to postmineral brecciation, and the matrix-material of this breccia has been leached of some of its silver values with cerargyrite and

embolite being carried and deposited in relatively open fault structures. Although these secondary silver minerals constituted the ore of the old-timers at the Waterloo and adjacent mines, the preponderance of mineralization in the Waterloo breccia is locked within the silicified fragments. Some studies have indicated that it is in the form of finely divided native silver. Another study has suggested fine-colloidal, argentiferous pyrite. This finely disseminated nature of the siliceous mineralization, coupled with the local presence of strong manganese oxide staining, makes for a refractory ore.

Although a small tonnage of very low grade, disseminated gold mineralization exists adjacent to the Waterloo deposit, very little gold is found within the potential silver ore. Barite is commonly present, however, and either late-mineral or post-mineral carbonate veins are found in the breccia. Silicification and brecciation vary concurrently from weak to intense, but ore grades do not necessarily correspond to the degree of silicification.

The Oligocene(?) to Miocene(?) Pickhandle Formation -- volcanic materials with interbedded detrital sediments -- underlies the nearly 2,000 feet of Barstow fluviatile and lacustrine sedimentary rocks in the Calico area. Intruding both the Pickhandle and Barstow Formations are a number of andesitic, dacitic and rhyolitic intrusive volcanic rocks of irregular cupola-to stock-like shape. Some of these intrusions are elongate in a northwesterly direction. Many show evidence of doming and disruption of the overlying stratified units. The rich silver veins of Wall Street Canyon occur in

both Pickhandle and later intrusive rocks, and thus the principal stage of silver-barite mineralization has followed the emplacement of the intrusive volcanic bodies and is thought to be genetically related to certain of their intrusive phases.

As initially suggested by Harold Weber, Jr. of the old California Division of Mines and Geology, and as later substantiated through detailed study by James Briscoe and the author, the mineralized Barstow sediments have moved southwesterly down the flank of the Calico Mountains to their present position astraddle the northwest-trending, Calico range front fault by the mechanism of imbricate gravity gliding. Brecciation occurred during gravity gliding and continued with post-gliding movement along the Calico fault zone. As no evidence exists for the Calico fault to be considered as the mineralizing channelway, the most logical source of the silver-barite mineralization is one mile upslope to the northeast where lies the northwest-trending Wall Street Canyon vein system. The gravity gliding is merely coincidental to the Waterloo bulk-tonnage silver environment, but recognition of it is essential in piecing together the geologic history and origin of the mineralization.

In late Miocene or Pliocene time, then, intrusive volcanic bodies intruded the Pickhandle rocks in the present area of the Calico Mountains. The doming action was compensated for on the southwest by movement on the nearly vertical Calico fault. Post- and/or syn-intrusive hydrothermal activity gave rise to the Wall Street silver-quartz vein system which paralleled the long axis of the Wall Street intrusion. Mineralization was tightly confined

to steep fractures in the relatively impermeable intrusive and Pickhandle rocks. However, upon reaching the more permeable Barstow sediments, the silver-silica-barite-bearing solutions diffused laterally and upward through a large volume of unconsolidated materials. The doming action of the various intrusive phenomena eventually caused oversteepening, and the silver-silica-laden Barstow sediments slid southwesterly off the northwesterly-elongate "Wall Street dome", coming to rest eventually over the gradient change marked by the Calico fault. Erosion and latter faulting have modified the picture.

The Waterloo mineralization, then, is epithermal. Silver-barite veinlet leakage in upper Barstow sediments elsewhere in the district, coupled with certain structural constraints in the geologic history of the area, eliminate the possibility that the Waterloo mineralization is of a surface, hot spring type.

doesn't have to be at the surface to be hot-spring related

Seven of the 9 deposits characterized in the master chart -- including the Waterloo and Langtry mineralization -- are hosted by volcanic rocks or sediments closely associated with a volcanic environment. The mineralization in all 7 has stratiform aspects. The two exceptions to the volcanic environment -- Candelaria and Real de Angeles -- will be discussed briefly later. Criteria used for inclusion of a deposit on the master chart as a "bulk-tonnage, low-grade silver" were three-fold: 1.) The tonnage must exceed 5 million short tons and the deposit must, thusly, be amenable to bulk mining methods; 2.) Silver must be the most valuable extractable metal or mineral, based on present-day prices; and 3.) Deposit data

must be available. The latter point may seem all too obvious, but unavailability of company data for various reasons has forced the exclusion of two important bulk-tonnage silver deposits of the Waterloo-type -- at Creede, Colorado and Rochester, Nevada -- from the chart. Each will be briefly noted in its proper context in the following comments.

Silver mineralization at Delamar in southwestern Idaho, Round Mountain in south-central Colorado, and Creede in southwestern Colorado is located within known caldera structures.

At Delamar naumannite (a silver-lead selenide) is the principal ore mineral and is found disseminated through quartz veins and silicified rhyolitic ash-flow tuff of Miocene age. The mineralization is relatively iron- and manganese-free and is nicely amenable to cyanidation. Three pits are planned, and the shape, size, stripping ratio and silver and gold contents of the ore bodies varies from pit to pit. Gold is found free here and is more important as a by-product than at any of the other deposits. A dual syngenetic-epigenetic hot spring environment has been proposed for the Delamar mineralization, while deeper-seated, more classically epithermal mineralization is known elsewhere in the district.

The Round Mountain deposit is north of Silver Cliff, Colorado and is found in rhyolitic flows and breccias of Oligocene age. The silver mineralization is entirely secondary and principally tied up with manganese oxides, unfortunately giving rise to a refract-

ory ore. As nothing remains that can definitely be identified as primary mineralization, it is not known whether enrichment has occurred. A horizon of black volcanic glass immediately beneath the ore-bearing flows and breccias has acted as a dam to descending silver-bearing meteoric solutions and has, thusly, been instrumental in creating the presently-known deposit. Very low-grade silver values are said to exist throughout much of the volcanic materials underlying the black glass horizon. Ore genesis is doubtlessly related to the volcanic activity, but erosion has stripped off any evidence that would prove or disprove a surface or very-near surface hot spring environment.

At Creede, Colorado exploration programs are presently underway to delineate silver-bearing tonnages in the upper Oligocene Creede Formation. This thick sequence of tuff, stream and lake sediments, and travertine was deposited following resurgence of the Creede caldera and coincided, in part, with eruptions of quartz latite flows. The mineralization in the Creede Formation is reported to be epithermal. Similarities between the Creede and Waterloo deposits may turn out to be striking.

The Hardshell, Arizona and Hog Heaven, Montana deposits lie in sequences of volcanic and volcaniclastic rocks overlying older shelf sediments and metasediments.

The Hardshell deposit is on the eastern side of the Patagonia Mountains and occurs in Mesozoic volcanic and volcaniclastic rocks once known as the "Chief conglomerate". The finely disseminated

silver is found in associated manganese oxides and silica, and the ore is quite refractory. This manto-like mineralization may be Laramide in age, and solution channels for the mineralization are known to exist in the underlying upper Paleozoic carbonate sediments. Fluid inclusion and other technical data soon to be released are said to indicate a depth of burial of over a mile at the time of formation of the deposit.

The Hog Heaven silver mineralization southwest of Kalispell, Montana has been mined by open-pit methods in the past and is presently undergoing an exploration program aimed at developing bulk-tonnage reserves. Galena, enargite, and matildite (a silver-bismuth sulfide) carry silver disseminated through both an upper latite tuff breccia unit and a separate lower volcanic conglomerate unit in a mid-Tertiary volcanic sequence. These stratified volcanic materials lie upon lower Belt PreCambrian metasediments. Again, silica is the dominant alteration mineral, with macro-? scale clay envelopes, and some enrichment of silver has occurred in the upper breccia horizon. A surface and near-surface hot spring environment of deposition has been proposed.

Both the Sam Goosly, British Columbia and Rochester, Nevada deposits occur in piles of lower Mesozoic volcanic and sedimentary rocks, and though quite dissimilar in some aspects, both are associated directly with silicification.

The Sam Goosly mineralization lies in the middle "pyroclastic division" of the Jurassic Hazelton Group. Eocene plutons

are found both east and west of the roughly north-trending mineralized zone. Tetrahedrite is the principal silver-bearing mineral, but chalcopyrite is also important as an ore-mineral. This sulfide mineralization occurs in disseminated, veinlet, and locally massive form, and the ore requires fine grinding prior to flotation. Silicification and aluminous alteration are most closely tied to mineralization. The Sam Goosly deposit may be 1.) hydrothermal in origin and genetically tied to one of the Eocene plutons, 2.) volcanogenic in origin and thus Jurassic in age, or 3.) Jurassic mineralization remobilized by Laramide thermal events.

The old camp of Rochester, Nevada thrived on silver ores mined from a pile of rhyolite and rhyolitic rocks of Triassic age. Silver-bearing minerals include sulphantimonites, sulpharsenides, argentite and cerargyrite and are disseminated through a large volume of silicified rhyolitic materials. Copper, lead, and gold are also present. The company holding the bulk-tonnage silver mineralization at Rochester may sponsor a paper on their deposit in the not-too-distant future.

no! PGV

At this point it is possible to loosely characterize the Waterloo-type bulk tonnage silver deposit. So far, it occurs in a volcanic environment of Mesozoic or Cenozoic age. It may be hosted by pyroclastic rocks, volcaniclastic rocks, or the fluviatile and lakebed sediments so often intercalated in a volcanic pile. The mineralization can occur as a variety of silver-bearing primary or secondary minerals, usually associated with

silica and often with manganese and/or iron. Primary mineralization is usually finely disseminated, and the ores are often, but not always, refractory. The average deposit may be, depending on cut-off grade, around 20 million short tons in size, grading about 3 oz. Ag and with possible by-produce values in copper, lead, zinc, or gold. Pyrite is ubiquitous but to varying degrees of intensity, and barite and fluorite are frequent gangue (or ore) minerals. Mineralization is stratiform in either a strict or a loose sense and deposits are thusly "manto-like", or "tabular", or "flat-lying", or "lensoid". Permeability of the host rock, or its pre-mineral or syn-mineral structural preparation is often critical.

The Waterloo-type deposit is most probably volcanogenic in the sense that mineralization is related to the volcanic processes that formed the host rocks. It could have formed in a surface or near-surface hot spring environment, or fairly deep in the volcanic sequence of rocks, or at any intermediate level between the surface and "fairly deep."

Like all other models of deposit-types, however, too strick an adherance to the Waterloo-type model will cause the geologist to miss some very real bulk-tonnage silver deposits which fit the general parameters suggested herein. In closing, I would like to briefly describe the two non-Waterloo-type deposits listed in the master chart plus an additional non-Waterloo-type, bulk-tonnage silver district upon which company information could not be made available.

At Candelaria, Nevada a sizeable tonnage of silver is found disseminated through, and in veins parallel bedding of, the tuffaceous shales of the Triassic-Jurassic Candelaria Formation. Some remnant sulfides are left, but most values occur as secondary silver in limonite and jarosite. Dominant alteration minerals are clay, dolomite, and various manganese oxides, and the ore is refractory. Both syngenetic (Triassic-Jurassic) and hydrothermal replacement (Tertiary) origins have been suggested for the mineralization.

The Real de Angeles deposit is located in the State of Zacatecas, Mexico. Some 50 million short tons of silver-zinc-lead ore occur in slightly limey, upper Cretaceous sandstones and siltstones. Argentiferous galena, sphalerite, pyrite, arsenopyrite and minor chalcopyrite and tetrahedrite are found disseminated and as fracture-fillings as well as in major cross-cutting vein structures. There are no dominant alteration minerals in the classic sense -- only minor calcite and chlorite. No intrusive rocks are known in the vicinity of this essentially stratiform deposit. Both syngenetic (Cretaceous) and epigenetic (Tertiary) origins have been proposed for the mineralization.

In the Silver District north of Yuma, Arizona, massive veins up to 125 feet wide carry finely disseminated silver (mineralogical form is not certain) and oxidized lead and zinc values in banded quartz-calcite-fluorspar-barite vein matter. The veins occur in three systems, each up to three miles long, which occupy moderate- to steeply-dipping faults cutting schistose and gneissose

rocks, a Laramide(?) quartz monzonite stock, and Tertiary volcanic materials. The veins seem to be characterized by open-space filling, but their considerable widths and varying dips cause trouble with this observation. Manganese- and iron-oxides are often present, and the ores can be expected to respond variously to metallurgical treatment. A number of relatively small, elongate pits could feed a mill designed for bulk tonnages. The genetic association probably lies with the Tertiary volcanic activity.

Deposit	Host Rock	Ore Mineralogy: Silver-bearing Minerals	Ore Mineralogy: Other Minerals	Ore Mineral Mode of Occurrence	Grade: Hypogene + Supergene	Grade: Supergene	Ore Tonnage	Shape of Deposit	Size of Deposit (ft.)	Structural Controls	Open Pit	Stripping Ratio	Age of Deposit	Dominant Alteration Minerals	Supergene Enrichment	Depth Extent of Partial Oxidation	Spatially Associated Intrusions: Rock Type	Spatially Associated Intrusions: Size	Spatially Associated Intrusions: Genetic Association	Metallurgical Characteristics of Ore	Additional Comments
Candelaria, Nevada	Triassic-Jurassic Candelaria Fm, tuffaceous shales	Secondary silver in limonite and jarosite, some remnant sulfides	Native gold, jamesonite, pyrite, minor chalcopyrite and galena.	Disseminated, and in veins parallel to bedding	±3 oz. Ag	Predominant	10-20 million	Tabular	2000 x 500 with fault repeats	Primary not known, secondary by fault-offsets.	Yes	Approx. 3:1	Jurassic or Tertiary	Clay, dolomite (magnesium metasomatism), manganese oxides.	No (dispersion)	600' on dip, 450' vertically	Quartz monzonite, felsite dikes.	70'-180' wide, 400' long	Not known	Refractory — under investigation	May be syngenetic (Jurassic) or replacement (Tertiary)
Delamar, Idaho	Miocene rhyolite quartz porphyry (ash-flow tuff)	Principally neumannite (selenide, also argentite	Minor pyrite, free gold	Finely disseminated in quartz	Est. 2-6 oz. Ag, ±0.03 oz. Au	—	Est. >8 million	Various shapes from equidimensional blob to long, narrow	Range from 100-4 min. widths to 4000-ft max. length	Possible deep-seated control, combined with more brittle quartz porphyry	3 pit areas	2:1 to 6:1	Miocene	Silica	Possible but minor	Very shallow, 200' maximum	Various acid to intermediate volc. necks, vents	Various	Probable	Nicely amenable to cyanidation. Not refractory (low Fe, Mn).	Deposit is in a volcanic center.
Hardshell, Arizona	Mesozoic volcanic and volcaniclastic rocks	Native silver? Argentite, cryptomelane, cerargyrite, pearceite, argentojarosite	Pyrite, traces galena	Disseminates in associated Mn oxides and silica	Est. 4-5 oz. Ag	—	Est. >5 million	Manto-like	1600 x 600	Deep-seated structures, favorable porosity and permeability	Possible open pit, possible underground	If open pit, depends on cutoff grade	Laramide?	Silica, clay, Mn oxides (5-25% Mn)	Minor	At least 500'	Andesite and quartz latite	Irregular dikes and sills	None	Refractory	Underlying Paleozoic carbonate rocks provide the solution channels
Hog Heaven, Montana	Two mid-Tertiary horizons, latite tuff breccia and volc. conglomerate	Galena, enargite, matildite	Pyrite, sphalerite, barite	Disseminated	Not established	—	Not established	Strongly warped, lensoid	Not established	Post-mineral faulting	Possibly and partially	Not known	Mid-Tertiary	Silica with macro-scale clay envelopes	In upper breccia horizon	To 500'	None known	—	—	Not known	Being explored
Langley, California	Miocene Barstow Fm, lakebed sediments, reworked volcanic ash	Native silver?	Barite, pyrite	Finely disseminated	Est. ±2 oz. Ag	—	±15 million	Flat-lying	±700 x 2000 x ±100 thick	Deep-seated structures, favorable porosity and permeability.	Yes	3:1	Miocene or Pliocene	Silica, iron oxides, clay, manganese oxides	None noted	Entire deposit	Pre-ore granitic body	Several square miles.	None with granitic body	Refractory	Authors considers this deposit an extension of the Waterloo (see below).
Real de Angeles, Zacatecas, Mex.	Upper Cretaceous sandstone and siltstone, slightly limey	Argentiferous galena and minor tetrahedrite	Sphalerite, galena, pyrite, arsenopyrite, minor chalcopyrite	Partly disseminated, partly fracture-filling, some veins.	2½ oz. Ag, 1% Pb, 1% Zn	Slight silver enrichment in shallow supergene	±50 million	Roughly circular	At least 1000 x 1000	Bedding, fracturing	Yes	Low	Not known	None in classic sense. Minor calcite chloride	Locally, at least silver	Up to 125'	None	—	—	Amenable to flotation	Both syngenetic-diagenetic (Cretaceous) and classic hydrothermal origins have been suggested
Round Mountain, Colorado	Oligocene rhyolite flows and breccias	Argentian cryptomelane, bromides and chlorides, native silver	Barite, fluorite, iron oxides.	Mn oxide veins and veinlets in stockworks	Remnant only	2-3 oz. Ag	5-12 million	Flat-lying, lensoid	2½ million square feet	Primary not known, secondary by fossil water tables	Yes	Approx. 2:1	Mid-Tertiary, still continuing	Clay, silica (opal-type), sericite	Se-deposition, possible enrichment	200'	None known	—	—	Refractory — under investigation	Primary grade not known. Deposit is in a volcanic center.
Sam Goosly, British Columbia	Jurassic Hazelton Group andesitic tuffs and tuff breccias	Tetrahedrite, traces of ruby silver and argentite	Pyrite, chalcopyrite, pyrrhotite, sphalerite, rare galena	Disseminated and veinlet, some massive	Hypogene only. 2.8 oz. Ag, 0.33% Cu, 0.02 oz. Au	None	43½ million open pit with depth extension	Essentially tabular	4000 x 300, irregular	Possibly position in a theorized volcanic vent	Yes, with depth extension	2.8:1	Eocene or Jurassic	Sericite, clay, chlorite, albite, tourmaline, gypsum, aluminous (scorzalite, andalusite, pyrophyllite, corundum).	None or very minor	Very shallow (glaciated)	Syenomonzonite-alkalic gabbro stock	Over a mile square	Not certain but quite possible	Flotation recovery requires fine grind	Deposit may be contact or replacement associated with an Eocene stock in a volcanic vent, or syngenetic (Jurassic) remobilized.
Waterloo, California	Miocene Barstow Fm, lakebed sediments, reworked volcanic ash	Native silver? Argentiferous pyrite? Also cerargyrite, embolite, argentojarosite	Barite, pyrite	Finely disseminated	Est. 2-3 oz. Ag	—	Est. 725 million	Elongate wedge	1000 x 6000	Deep-seated structures, favorable porosity and permeability	Yes	Relatively low	Miocene or Pliocene	Silica, calcite, clay, manganese oxides.	Locally in structures	At least 400'	Andesite porphyry	Modest-sized elongate stock	Probable	Refractory	Post-mineral brecciation caused by gravity sliding

"Estimates" are those of the author.

JHG → WLK file
Silver

ASARCO

Southwestern Exploration Division

January 28, 1977

TO: D. M. Smith

FROM: F. T. Graybeal

Nevada Reconnaissance

Past exploration in Nevada by Asarco has emphasized both porphyry copper and precious metal deposits. The general lack of success regarding the porphyry coppers has led us to concentrate on precious metal deposits which would yield to bulk mining techniques. Most of this previous work has involved sampling between outcropping vein structures, with increased emphasis on stratigraphy as an important ore control.

As discussed previously, I would like you to continue our Nevada reconnaissance with emphasis on precious metal deposits. The objective of this program is the discovery of a deposit of sufficient size to be of interest to Asarco. Our preference is for large disseminated deposits which should be your primary effort. In general the disseminated deposits, particularly those amenable to open pit mining, will return a greater profit per exploration dollar than the veins. However, I recognize your expertise in precious metal vein geology and I'm more than willing to discuss unusually attractive targets of this type. This program obviously has no time limit so your investigations in specific areas can be as brief or thorough as you feel is necessary.

The area of responsibility for the SWED is western Nevada, as defined on the attached map, and you should attempt to confine your efforts to this area and adjacent portions of eastern and southeastern California. The general idea has been for the SWED to emphasize exploration for volcanic-associated deposits of the Rochester-Bodie type in the Walker Lane and the Salt Lake Office to emphasize exploration for the Carlin types, although some areal and geologic overlap has and will continue to occur.

One note of caution is required and relates to the roughly 350 separate mining districts in Nevada which include a wide variety of geologic types. Past reconnaissance in this region by relatively inexperienced men has resulted in the tendency to jump from one district to another with no apparent pattern. This no doubt resulted from an inability to zero in on a deposit type or concept and contributed little to our exploration effort. As long as you are clear on what our objective is and I know where you are working this problem should not arise.

There is no single complete reference on Nevada geology or mineral deposits, although I have attached a general reference list you should find useful. The majority of the detailed studies can be found in U.S.G.S. and Nevada Bureau of Mines publications, and University of Nevada theses. Our

files contain a large amount of data and you should become familiar with them. Another important source of information will be G. J. Stathis and W. L. Kurtz, each having spent a number of years in Nevada. As your primary objective will be precious metals I have also included a list of appropriate reports and publications and, for your convenience, copies of articles which are not generally available in the literature. I suggest you concentrate your initial reading to north-central Nevada which includes our Rochester deposit and a potential project at the Golconda W-Mn mine. This region might be considered the western limit of deposits of the Carlin-type with gold deposits in both limestone and clastic rocks.

After completing your review of the files and literature, please initiate field studies along the Getchell Lineament. Although this structure is now a Basin and Range-type fault Mr. Stathis believes it follows a much older structure which may have localized Mesozoic porphyry copper zones, Carlin-type deposits of uncertain age, and Recent hot spring activity. This structure passes through the Getchell, Pinson, Preble, and Golconda deposits north of Interstate 80 and extends to the south on the order of 50 miles. This environment is somewhat different from the Walker Lane epithermal precious metal deposits, but, depending on your genetic model, it may have some similarities to the Calico district in California. If or when this work is completed and no areas are indicated for detailed work, I would tentatively plan, subject to further discussion, to have you study Walker Lane geology. This should give you some experience in the two basic precious metal environments in Nevada and we would proceed from there.

Later this year, possibly following the Volcanic Rock Symposium, I will arrange for formal visits to Yerington, Battle Mtn., Carlin, and McDermitt. At that time you may also wish to meet with L. D. James to discuss various geochemical approaches we have used in Nevada, and to review any appropriate data in the Salt Lake City office. I will keep you advised of significant progress on the Golconda agreement.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Atts.
cc: WLKurtz - w/biblio. only
GJStathis - w/biblio. only

BIBLIOGRAPHY (references marked with * are attached)

General

1) Mining Districts and Mineral Resources of Nevada, F. C. Lincoln -- 1923.
2) Mineral and Water Resources of Nevada -- Nev. Bur. Mines Bull. 65 -- 1964.
3) Metallogenetic Provinces and Mineral Belts in Nevada, R. J. Roberts -- 1966 in Nevada Bur. Mines Report 13, Part A, p. 47-72.
4) Metal Mining Districts of Nevada -- Nev. Bur. Mines Map 37.
5) USGS Bulletins Nos.:
   a) 408 -- A reconnaissance of some mining camps in Elko, Lander, and Eureka Counties, Nev. by W. H. Emmons.
   b) 414 -- Notes on some mining districts in Humboldt County, Nev. by F. L. Ransome.
   c) 594 -- Some mining districts in northeastern Calif. & northwestern Nevada by J. M. Hill.
   d) 648 -- Notes on some mining districts in eastern Nevada by J. M. Hill.
6) U.S. Bureau of Mines Information Circulars Series -- William O. Vanderburg:
   a) IC 6964 -- Reconnaissance of mining districts in Clark County.
   b) IC 7093 -- Reconnaissance of mining districts in Churchill County.
   c) IC 7022 -- Reconnaissance of mining districts in Eureka County.
   d) IC 6995 -- Reconnaissance of mining districts in Humboldt County.
   e) IC 7043 -- Reconnaissance of mining districts in Lander County.
   f) IC 6941 -- Reconnaissance of mining districts in Mineral County.
   g) IC 6902 -- Reconnaissance of mining districts in Pershing County.
7) Memo on Gold-Silver Prospecting by J. H. Courtright -- 1976*.
8) Tabular summary of Bulk-Tonnage Silver Deposits by B. N. Watson -- 1976*.
9) Igneous activity, tectonics, and hydrothermal precious-metal mineralization in the Great Basin during Cenozoic time by Silberman et al -- 1976*.
10) Structural controls and genesis of Carlin-type gold deposits in the evolution of the Basin and Range Province by Radke and Dickson -- 1976*.
11) Gold-Ore Mineralogy and Its Relation to Metallurgical Treatment by Henley -- 1975*.

Gold-Silver

1) Carlin Symposium -- Reno -- 1976 -- eight papers as follows:
   General features of Carlin Deposits -- Radke*.
   Carlin deposit -- Radke* (also several published articles).
   Cortez deposit -- Doherty* (see paper by Wells et al in Econ. Geol.
   Getchell deposit -- Berger* (see extensive ASARCO files).
   Pinson and Preble deposits -- Galli, Livermore, and Reeve*.
   Eureka Windfall deposit -- Wilson*.
   White Caps deposit -- Chapman*.
2) Rochester, Nevada -- see thesis by P. G. Vikre and extensive ASARCO files.
3) Round Mtn., Nevada -- see extensive ASARCO files.
4) Battle Mtn. Gold -- memo by W. L. Kurtz -- 1977*.
5) Hayden Hill, Calif. -- ASARCO file data, particularly summary of drilling by G. J. Stathis.
6) Waterloo deposit, Calif. -- extensive ASARCO file data including two papers published by H. Weber of Calif. Div. Mines/Geol.
7) Hardshell, Ariz. -- extensive ASARCO file data.
8) Delamar, Idaho -- report by J. R. King -- 1976*.
9) Creede, Colo. -- Prof. Paper 487 by Steven and Ratte with special emphasis on disseminated deposits in Creede formation; news release in E.&M.J. -- 1975*.
10) Specogna, B.C. -- paper by Richards -- 1976*.
11) Sam Goosely -- paper by Ney et al -- 1972*.

Other Types

1) McDermitt, Nevada -- paper by McKee on McDermitt caldera -- 1976*; paper by Roper on McDermitt Hg deposit -- 1976*.

case file

Silver

HARDSHELL | Fleetwood Kurtz, S. Tilley, J Cartright, FTG, GJS 12/8/76

S. Tilley. Australian Dexter electrolytic process recovering copper - other metals? from ores and ores might apply to Hardshell mat?

F. Kurtz wt of silver is cryptomelane-coronadite loss 10% chalcopyrite which late arrival

* rhn + qtz always cut the chalcedonic silicification
* Silver + rhn as very fine needles in quartz - probably not recoverable in milling.

ASARCO

.xploration Department

January 23, 1976

Memo for J.C. Balla
M.P. Barnes
R.E. Gale
F.T. Graybeal
L. Montoya
S. Von Fay

GOLD-SILVER PROSPECTING

Although it has been recognized for sometime that important sized deposits of gold and/or silver tend to occur in sedimentary or pyroclastic horizons associated with veins (such as Hardshell, Waterloo and Carlin) our search for new deposits has been largely oriented toward the study and sampling of exposed vein wallrock.

Mr. Kurtz reports that recent work at Rochester indicates that the Weaver formation (tuffs and fragmental volcanics) appears to contain the best silver values and that at Pueblo Viejo in the Dominican Republic open pit gold ore is apparently confined to a sedimentary sequence, ranging from shale to conglomerate. Freeport's recent discovery in the Creede District is another example.

He has proposed, and I agree, that a more effective approach in prospecting should include a search for possibly favorable horizons in precious metal districts, rather than relying entirely on sample results from exposed vein wallrock.

J.H. Courtright

J.H. Courtright

JHC:vh

cc: TCOsborne
WLKurtz

~~JRK / FTG~~ → ~~[illegible]~~ file under Silver

Delamar Idaho

JRK toured property and reports
8-10 MT @ 3-4 oz Ag & .02 Au
4.5:1 w/o ratio. Mineralized stratabound.

assume 90% recovery 3.5 oz Ag .02 gold
$4.50 Ag $140 gold

then .90 x 3.5 x 4.50 = 14.18
.90 x .02 x 140 = 2.52
Gross recoverable $16.70

assume *Mining @ .55 per ton moved
*Milling @ 2.50 per ton
Admin .10 per ton
Retort-Cupell .05 per ton
3.20

* includes indirects

Then direct costs per ton of ore = 5.68
net w/o amortization taxes = 11.02/ton

1700 tpd x 10,000 = 17,000,000 capital costs? = ≈ $2 per ton ore

Should give a very good ROR

JDSell talked to Ben Dickerson - ore apparently in several separate zones + Ben is uncertain whether they can selectively mine to keep mill feed up to reserve estimate. Also some horror tales regarding some cost overruns.

FTG.

Silver

CPI ---> G L K : SILVER

THOMAS E. CONGDON
WILLIAM J. CAREY
DOLF W. FIELDMAN
NILENDU S. MUKHERJEE

1010 DENVER CENTER BUILDING
1776 LINCOLN STREET
DENVER, COLORADO 80203
TELEPHONE 303-861-8140

CONGDON AND CAREY
MINERAL EXPLORATION

RECEIVED
MAR 17 1975
EXPLORATION DEPT.

March 14, 1975

J. H. C.
MAR 19 1975

Mr. James H. Courtright,
Chief Geologist
ASARCO
Box 5747
Tucson, Arizona 85703

Dear Mr. Courtright:

Eleven years ago we embarked on an exploration program to develop large tonnage reserves of disseminated silver ore adaptable to mining by low cost open pit methods.

Today Congdon and Carey has the controlling interest in more than 200 million ounces of silver in the United States and Canada. It is possibly the largest silver position in North America next to that of Texas Gulf Sulphur Company.

The enclosed chart outlines our precious metals projects. Exploration knowledge gained from the management of four partnerships since 1961 contributes to the direction of Congdon and Carey, Ltd. 5, a new partnership fully funded through 1976.

We seek a partner to help with the development of two silver deposits in the United States...Candelaria and Round Mountain. Projected costs over three years to take these projects through final feasibility studies is $2.2 million.

Candelaria Project, Mineral County, Nevada

Underground sampling and 23,500 feet of drilling have established the following reserves available to open pit mining to a depth of 350 feet:

	Tons	Silver Oz./Ton
Mt. Diablo - Indicated	12,000,000	2.99
Northern Belle - Inferred	7,000,000	2.50
	19,000,000	2.81

1/3 ? o/u ratio ?

Additional exploration targets remain to be explored, including the possibility of much larger reserves of lower grade material.

The U.S. Bureau of Mines at Reno and Hazen Research, Inc. in Golden have conducted preliminary tests of a number of different extractive processes. The program is encouraging ? but incomplete; the resolution of this effort is the next step toward the proof of economic feasibility.

Round Mountain Project, Custer County, Colorado

Bulk surface sampling and 22,400 feet of drilling developed the following reserves in the Kate area to a maximum depth of 200 feet:

	Tons	Silver Oz./Ton
Indicated	7,100,000	2.04
Inferred	4,800,000	2.00
	11,900,000	2.02

Growing knowledge of the geologic controls of mineralization encourages additional exploration of this large property. There is strong evidence improvement of grade is probable.

Modest metallurgical tests have been undertaken, including heavy media whereby two-thirds of the weight might be rejected at a loss of only 12% of the silver in a pre-concentration step.

Sam Goosly Project, Omineca Mining Division, British Columbia

This mineralized zone was discovered by Kennecott in 1967. Our program of 34,900 feet of diamond drilling and 580 feet of drifting established the following reserves mineable by open pit methods at a stripping ratio of 2.1:1.

	Tons	Silver Oz./Ton	Copper %	Gold Oz./Ton	Sb %
Main Deposit - proven	33,000,000	2.8	.30	.023	.084
Southern Tail - proven	10,500,000	2.7	.42	.035	.087
	43,500,000	2.78	.33	.026	.085

Deep drilling has shown reserves perhaps as large as the open pit reserves exist below the planned pit floor.

pretty good rock
if recoveries are ok

Metallurgical studies, which included full pilot plant operations by Hazen Research, Inc., are now complete. Wright Engineers will finish the final feasibility report by mid-1975. Development to production will begin when the tax and royalty problems now burdening the mining industry in Canada are resolved.

If you believe, as we do, that the price of silver in a few years will exceed $6.00 relative to today's capital and operating costs and want to establish a silver position, there is good reason for us to meet. We think our silver holding is unique...one that cannot be readily duplicated. But we need help to bring it to production.

Geologic and engineering data relating to reserve estimates are available for study by your staff in our Denver office.

I will be in Tucson on Thursday and Friday, March 20 and 21, and will call at your office to discuss this matter.

Thank you for your courtesy.

Very truly yours,

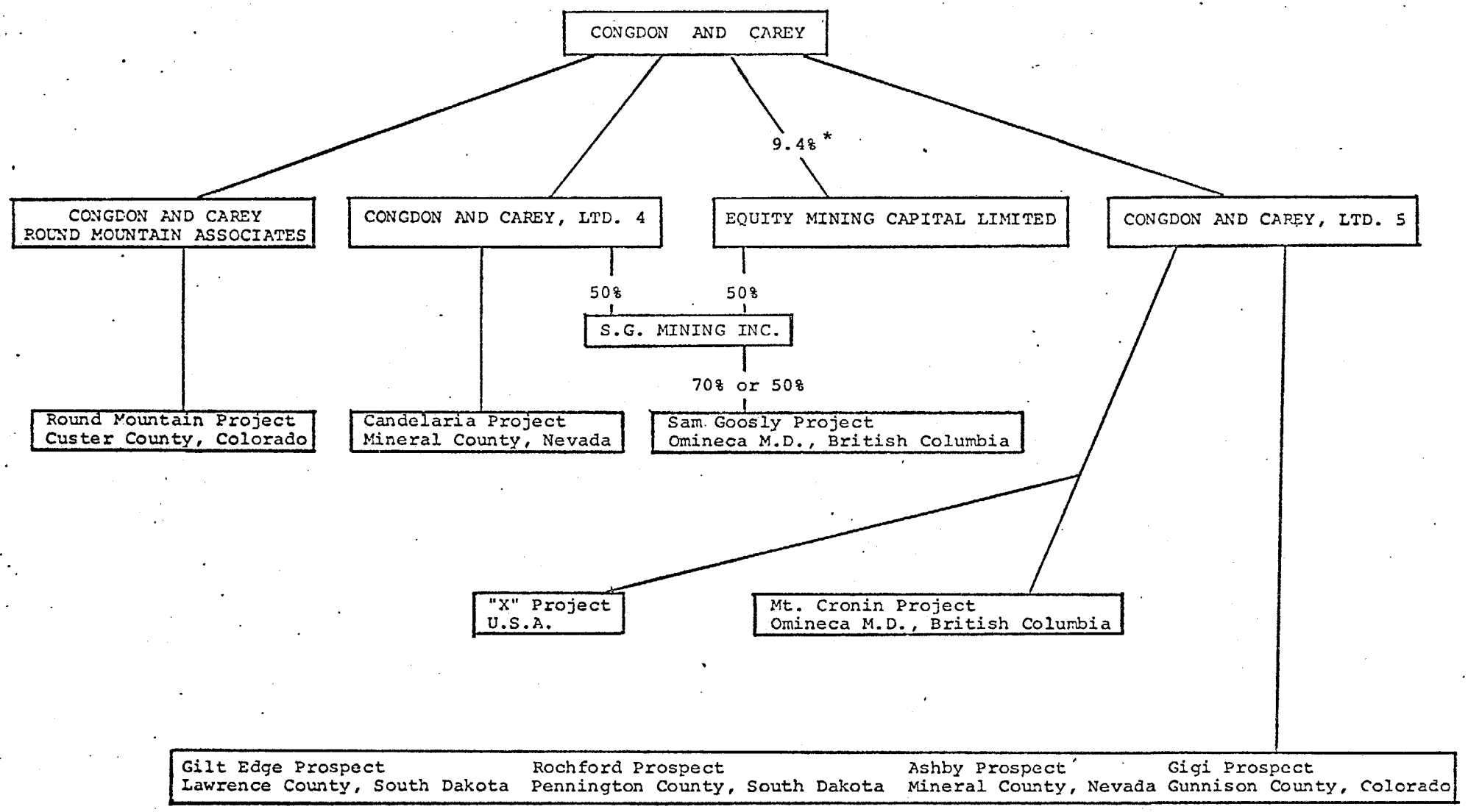
CONGDON AND CAREY

William J. Carey

William J. Carey

/jr
attachment

SILVER PROJECTS



* does not indicate control

Mr. R.B. Meen

MINING DEPT.
MAR 28 1974
TUCSON

NEW YORK OFFICE

March 25, 1974

TO ALL PLANT AND UNIT MANAGERS

SMALL SILVER BARS

In response to the many internal requests for information about our small silver bar sales program, we have attached a copy of our standard response letter and the order form, which answers many of your questions.

To minimize our communication expense, please refer any inquiries received at your office on this subject, to the nearest Federated sales office. They will have a supply of these order forms which will be sent to the customer for transmittal to the Newark Office. Since many of the inquiries ask about the company in general, we are also including a copy of our 1973 Annual Report in our response. We anticipate that any further communication regarding specific orders will be handled directly between Newark and the customer.

There will be an advertizing campaign utilizing space in the financial newspapers of all the major cities across the United States over the next few weeks. All ads will be on a strict "soft-sell" basis. Our policy is simply to offer small silver bars for sale to the ultimate consumer without any reference or guidance as to silver's propriety as a potential hedge against inflation. We are not repurchasing silver bars at this time but instead are referring customers to alternate consumer outlets.

Since this is undoubtedly the first important company product to reach the public at large, every effort is being made to ensure that the quality and appearance of these bars meets the highest standards of ASARCO.

K. Smalberg

K. Smalberg

KS:af

Enclosure

cc:
Advisory Committee, et al

AMERICAN SMELTING AND REFINING COMPANY
150 ST. CHARLES STREET
NEWARK, NEW JERSEY 07101

FEDERATED METALS DIVISION
TEL. NEW YORK: (212) 344-9460
TEL. NEWARK. (201) 589-0500

Dear Sir:

SILVER BAR SALES

In response to your inquiry, ASARCO, Federated Metals Division is offering for sale small Silver Bars, as follows:

Bar Size	New York Refined Silver Price as announced by Handy & Harmon on day order accepted plus Overage of
50 oz. bar - 3" x 3" x 1" thick	$ .70 per troy ounce
100 oz. bar - 6" x 3" x 1" thick	.60 per troy ounce
500 oz. bar - 15" x 3-1/2" x 3-1/4" thick	.45 per troy ounce

Plus packaging, freight and sales tax.

We attach an Order Form which explains our terms of sale. PLEASE READ THIS FORM CAREFULLY. If you have any questions, please write. To enter an order, complete and sign the form and return with your deposit.

Since the Silver price varies each day, you will be billed for orders received before 11:00 a.m. based on that day's Silver price, otherwise the following day's price will apply.

Each bar of Silver is stamped with our brand "ASARCO 999", to indicate 99.9% purity, a serial number and the weight in troy ounces to the closest 0.1 ounce.

Your order will receive our prompt attention.

Very truly yours,

AMERICAN SMELTING AND REFINING CO.
Federated Metals Division

Sales Department

ORDER FORM

FROM:

(Please print name and address to which Billing and Silver is to be sent)

Billing Address:

_____

_____

_____

Shipping Address:

_____

_____

(Please fill in above only if different from Billing Address) .

TO:

ASARCO, Federated Metals Division
150 St. Charles Street
P. O. Box 959
Newark, New Jersey 07101

Please enter my order for Silver as follows:

		Weight
_____	Bars of 50 troy ounce size	_____
_____	Bars of 100 troy ounce size	_____
_____	Bars of 500 troy ounce size	_____
	Total Weight	_____

Enclosed is non-refundable deposit of $1.00 per troy ounce payment by Postal Money Order, Cashier's Check, or Certified Check. Full payment is required within 10 business days after billing and prior to shipment. ASARCO's terms of sale will apply.

I understand that the full price for which I will be billed will be the New York refined Silver price as announced by Handy & Harman plus the applicable overage, handling and shipping charge ($.05 per troy ounce or $25.00 minimum), freight and insurance charges and applicable sales tax.

SIGNED:_____ DATE:_____

Important: Please read carefully the Terms of Sale that follow.

TERMS OF SALE

(Please read carefully)

1. GENERAL. This contract constitutes the entire agreement between Buyer and Seller with respect to the product(s) furnished hereunder. No representation, promise or condition not set forth herein shall be binding on either party hereto and no waiver, alteration or modification of any of the provisions hereof shall be binding unless in writing and signed by an authorized representative of Seller.

2. ORDER SUBJECT TO ACCEPTANCE. Buyer's order is subject to acceptance by ASARCO at its office in Newark, New Jersey.

3. DELIVERY AND RISK OF LOSS. Sales hereunder shall be made f.o.b. ASARCO Plant, Newark, New Jersey. Risk of loss shall pass to Buyer at the f.o.b. point.

4. WARRANTIES. Seller warrants that the product(s) furnished hereunder shall conform to the description stated on the face hereof; that it will convey good title to such product(s); and that such product(s) shall be delivered free from any lawful security interest or lien or encumbrance unknown to Buyer. THE WARRANTIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF, AND SELLER EXPRESSLY DISCLAIMS, ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR PARTICULAR PURPOSE.

5. CLAIMS BY BUYER. Seller shall have no liability on any claim by Buyer with respect to any product furnished hereunder alleged to be defective or otherwise not in conformity with the terms and conditions hereof or with any warranty expressed in these terms and conditions unless written notice specifying such claim shall be received by Seller having been sent by Buyer within ten (10) days after receipt by Buyer of the product(s) furnished hereunder as to which such defect or non-conformity is alleged or promptly after such other date as Buyer can establish as the earliest date on which the basis for such claim could have been discovered by Buyer with reasonable diligence, but in no event shall Seller be liable to Buyer for any claim of which it does not receive written notice within ninety (90) days from date of delivery to Buyer. Failure to so notify Seller shall constitute a waiver of any and all claims with respect to such product(s).

6. BUYER'S REMEDIES. Seller will replace, at the delivery point specified herein, any product furnished hereunder that is found to be defective or otherwise fails to conform to the terms and conditions hereof or to any warranty expressed in these terms and conditions, or, at Seller's option, Seller will repay the contract price herein of such product, plus any transportation charges paid by Buyer in addition to such price. The Buyer's remedies for such defective or non-conforming product(s) shall be limited exclusively to those set forth in this Section 6.

Cont'd...

7. LIMITATION OF LIABILITY. Except as expressly provided otherwise herein, the limit of Seller's liability with respect to any product(s) furnished hereunder, whether in contract, in tort, under any warranty, or otherwise, shall be the contract price herein of the specific product on which such liability is based. In no event shall Seller be liable for any special or consequential damages whatsoever.

8. FORCE MAJEURE. Seller shall not be liable for any damages resulting from delays in delivery or in performance or failure to manufacture or deliver, due to: fires; floods; riots; strikes; freight embargoes or transportation delays; shortgae of labor; inability to secure fuel, material, supplies or power at current prices or on account of shortages thereof; acts of God or of public enemy; any existing or future laws or acts of any government (including specifically but not exclusively any orders, rules or regulations issued by any official or agency of any such government) affecting the conduct of Seller's business with which Seller in its judgment and discretion deems it advisable to comply as a legal or patriotic duty; or to any cause beyond the Seller's reasonable control. Seller may, at its option and without liability, delay performance hereunder or cancel this contract if necessary due to the foregoing. In the event of inability to supply the total amount of quantity of product(s) to be furnished hereunder, Seller may allocate its available supply among any or all customers, as well as departments and divisions of Seller, on such basis as Seller may deem fair and practical without liability for any failure of performance which may result therefrom.

9. TAXES. All sales, use, excise or similar taxes with respect to product(s) furnished hereunder shall be payable by Buyer in addition to the contract price herein of such products and any such tax payments made by Seller shall be for Buyer's account.

10. RIGHT TO CANCEL. If Buyer shall fail, at any time, to make any payment when due hereunder or otherwise to fulfill the terms of this or other contracts between the parties hereto, Seller may, without prejudice to other lawful remedies, cancel this contract.

11. WAIVER. Seller's waiver of any breach or failure to enforce any of the terms and conditions of this contract or other right hereunder shall not be construed as a waiver of any other breach of the same or any other provision hereof or right hereunder.

12. ASSIGNMENT. The rights and obligations hereunder may not be assigned by Buyer without written consent of Seller.

13. SEPARABILITY. In the event any provision of this contract shall be invalid, illegal or unenforceable, the validity, legality and enforceability of the remaining provisions shall not in any way be affected or impaired thereby.

14. GOVERNING LAW. This contract shall be governed by the laws of the State of New York.

AMERICAN SMELTING AND REFINING COMPANY
150 ST. CHARLES STREET
NEWARK, NEW JERSEY 07101

FEDERATED METALS DIVISION
TEL. NEW YORK: (212) 344-9460
TEL. NEWARK: (201) 589-0500

Dear Sir:

Order #_____

SILVER BAR SALES

This will acknowledge receipt and acceptance of your non-refundable deposit and order for Silver Bars.

The balance due under your order has been calculated as follows:

	Pieces	Exact Weight		Amount
50 T.O. Bars	_____	_____	T.O. @ (N.Y. Silver Price + $.70)	_____
100 T.O. Bars	_____	_____	T.O. @ (" " " + .60)	_____
500 T.O. Bars	_____	_____	T.O. @ (" " " + .45)	_____
Total Weight		_____	Sub-Total	_____
Plus Handling and Shipping @ $.05/T.O. ($25.00 minimum)				_____
		Sales Tax		_____
		Freight Charges - Ship via_____		_____
		Total Amount		_____
		Less Deposit		_____
		Balance Due		_____

Upon receipt of your Postal Money Order, Cashier's Check or Certified Check for the above balance due within 10 business days, we will ship your Silver in accordance with the terms as stated on our Order Form.

Very truly yours,

AMERICAN SMELTING AND REFINING COMPANY
Federated Metals Division

Sales Department

don't type

file Silver

5/73

Silver

Congdon + Carey

1) Sam Goosly Property
British Columbia
Canada

10-15 mill 0.53 Cu tetrahedrite, tennantite chalcopyrite

4.00 oz Ag native sulfides - in tetr. tenn

± .03 oz Ag

recovery problems

½ owned by Kennco - maybe related to

30% carried working interest

2) Leadville, Colorado (Silver Cliff) - 3-5 million

3) Candelaria, Nevada

15 million 3 oz 85% recovery by bubbling SO_2 thru

Sulfide brine - require fine grind

THE SILVER INSTITUTE LETTER

INFORMATION ON SILVER FOR INDUSTRY

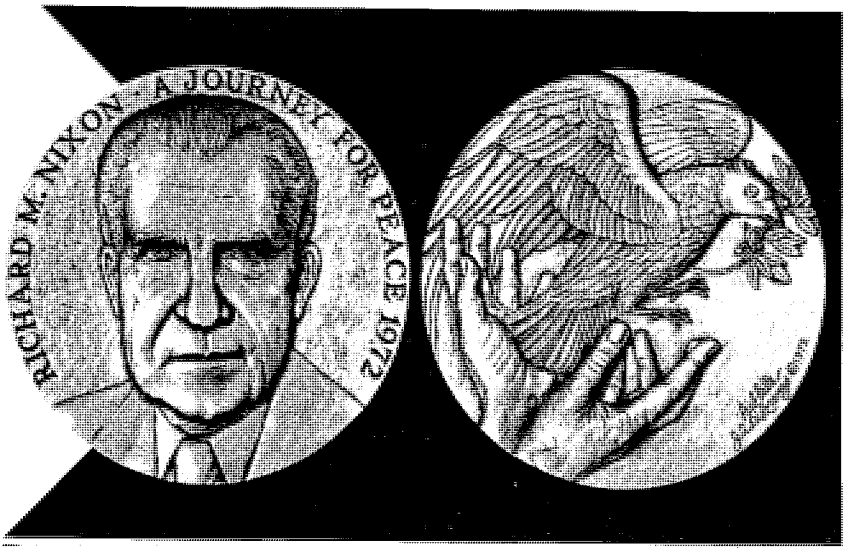
VOLUME II, NUMBER 2 FEBRUARY, 1972

SILVER COMMEMORATES PRESIDENT'S CHINA VISIT

A silver medallion commemorating President Richard M. Nixon's trip to Peking will soon be offered to the public. The Medallic Art Company, one of the finest modern private mints in the United States, is striking the commemorative in .999 Fine silver. The medallion measures 2½ inches (64 mm.) in diameter, contains 5 ounces of silver, and the mintage is limited to 15,000 pieces.

The medallion may be ordered from the International Numismatic Agency, 96 Prince Street, New York, N. Y. 10012. Price: $40 including case and easel.

The President's state visit to the People's Republic of China will be the first ever made by an American President while in office. His purpose is to relax tensions with mainland China and the area in general.



The obverse of the medal portrays the President and the legend reads "Richard M. Nixon—A Journey for Peace—1972." On the reverse is a dove of peace. The medallion was designed by Paul Calle and sculpted by Joseph Di Lorenzo. (Photo: left)

Since the turn of the century, Medallic Art Company has struck many specimens for the White House, the Society of Medalists, the Pulitzer Prize, National Geographic Society, and a host of distinguished clients. It is widely acknowledged to be one of the finest mints for the production of high relief silver medals.

SILVER SHINES IN NATIONAL DEFENSE

The U. S. Department of Defense (DOD) uses silver in more than 5,000 different items. From the 4,161 troy ounces of silver in a naval torpedo to the 23 grams in an electronic relay.

Defense of national security demands that all equipment work accurately, reliably. Silver fits this need in many applications. So an American military report states, "The increase in the use of precious metals in both military and civilian commodities has been phenomenal. Indications are that this use will continue or increase in the coming years."

Silver has been vital to American military missile programs.

Early in the development of the Polaris missile, a problem was posed: When extremely high-temperature flaming gas is forced at explosive pressure through the 5-inch aperture of a missile's nozzle, how do you handle the heat?

Answer: You use a nozzle of tungsten that is impregnated with silver—20% silver by volume, and at one point a single manufacturer was using about 150,000 troy ounces of silver per month for this program.

Specifically, you start with powder metallurgy, sintering a tungsten skeleton of the nozzle component, then infiltrating the pores with pure, molten silver. The nozzle then is assembled into the missile structure. As one scientist explained it, "If you must avoid heat build-up, use silver infiltration of tungsten to combine the conductivity of silver with the resistance of tungsten. To move heat, use silver. For less critical problems you can use pyrolitic graphite as a refractory, but then you can run into fabricating problems and you can risk erosion or cracking if the heating process is repetitive."

Civilian industry uses this technique in resistance spot welding; electrodes are made of the silver-tungsten composite to handle temperatures in the 6,000° F. range which allows welding of such materials as columbium and tantalum. The silver-tungsten conducts heat away from the electrode's point of contact with the material being welded, so the electrode itself does not get welded to the material. An additional advantage is that at 6,000° F. a little of the silver at the hot spot vaporizes and provides protection for the rest of the silver-tungsten component.

Dr. E. F. Baroch, Director of Metallurgical Research, and Mr. Sam Worcester, both at the Wah Chang Division of Teledyne, Inc., P.O. Box 410, Albany, Ore. 97321, are experts in this area of rocketry and welding. P. R. Mallory & Co., Inc., of Indianapolis, and Fansteel, Inc., of North Chicago, Ill., also can help solve high temperature spot welding problems.

The great advantages of using silver infiltration of tungsten for the above problems are these:

Silver-tungsten is more machineable than alternative materials;
It conducts heat faster;
It is ductile;
It has impact strength, resists erosion, deformation, cracking.

(Photo: Polaris A-3 missile, fired from submerged submarine, has a silver-tungsten nozzle as described above.)

The Defense Department uses large amounts of silver in its aircraft, in many jet engines, and in surface vehicles. In the DOD array of various kinds of engines, motors and machines, silver is used in some sparkplugs, distributors, box junctions, switches, magnetos, cable assemblies, point kits, starters, clutches, bearings, shaft gears, pistons and sleeves, bushings, linkpins, casings, seals, rings, shafts, valves, pumps, actuators, wiring assemblies, contacts, connecting rods—and even screws.

The American military services use over 150 different kinds of bearings that contain silver.

A wide variety of silver brazing alloys contain anywhere from 19% to 96% silver.

There are over 100 different kinds of batteries employing anywhere from a few grams to thousands of ounces of silver.

But DOD is far from wasteful. Long before many private enterprises, Defense started its own recycling program. One spring morning in 1970, for example, a semi-truck with trailer sections moved out under armed guard from the U.S. Bullion Depository at West Point, N.Y., with a cargo of 683,990 troy ounces (over 23 tons) of fine silver in bullion bars. It was consigned to Engelhard Industries in New Jersey. The silver was to be used as government furnished material (GFM) for the manufacture of torpedo batteries at a cost saving to the taxpayer of $750,000.

Thanks to the recycling program, in a period of two years over 9 million ounces of silver had been provided to the government's contractors as GFM, with cost savings of about $13 million.

Even with the massive recovery effort, however, officials say that silver utilization has been exceeding recovery to such an extent that Defense Department reserves have declined by approximately 1 million troy ounces.

"The amount of silver utilized in the production of defense items," one manual states, "justifies the statement that as long as ths country has a need for a defense program, there will be a continuing requirement for silver."

MORE COMPANIES JOIN SILVER INSTITUTE

Five more important firms have joined The Silver Institute, Inc., since our report in The Silver Letter of last September. They are: Texas Gulf Sulphur Company, Inc., of Toronto, Canada; Denron Refiners, Inc., of Oak Creek, Wis.; Earth Resources Company, of Dallas, Tex. and Golden, Colo.; American Chemical and Refining Company, of Waterbury, Conn.; and International Recycling Corporation, of Sayreville, N.J. Membership now includes 32 companies active in 7 countries.

ENGELHARD'S ALEXANDRE ELECTED DIRECTOR

At the January 18 board meeting of The Silver Institute, Inc., in Washington, D.C., Mr. DeWitt L. Alexandre was elected as a member of the Board of Directors of the Institute. Mr. Alexandre is a Corporate Vice President of Engelhard Minerals and Chemicals Corporation and head of the Precious Metals Sales Department of Engelhard Industries Division. Since graduating from Harvard in 1939, he has had wide business experience and is a world authority on silver and silver products.

SILVER IN SOLAR POWER

In France, silvered glass mirrors covering the side of a nine-story building reflect the sun's rays into Professor F. Trombe's solar furnace to produce a million watts of power. The nearly perfect reflectivity of silver is fundamental to the efficiency of the operation, and only about 300 troy ounces of pure silver are sufficient for this Megawatt installation.

Now, Professor A. F. Hildebrandt of the University of Houston is directing the exciting development of industrial solar power in the sun-drenched American Southwest. Calculations indicate that a single square mile of mirrors will concentrate enough sunlight to operate a power installation sufficient for a community of 24,000 people; and the aim is to serve millions.

The mirrors could be made of many substances, but the most efficient—and economical—will be silvered glass, requiring only about 150,000 troy ounces of pure silver for each such installation.

MIRROR, MIRROR ON THE WALL

Housing starts in 1971 numbered over 2 million—an all time record—say construction industry sources, and since a house is hardly a home until it has some mirrors in it, 1971 sales of silvered glass mirrors climbed about 10% above 1970 figures.

Mirrors are big with builders, decorators and housewives. Because the cost per cubic foot of building has grown enormously, and if a developer's construction budget forbids the building of big rooms, the next best thing is to create the impression of larger rooms by using mirrored walls. It is good merchandising.

The principle holds true in office buildings as well as residences and when space is at a premium, a good decorator will install a mirrored wall to provide a spacious atmosphere of elegance.

In homes, a wall mirror not only prevents claustrophobia for the lady of the house, it also brings the outdoors indoors—the evening skyline if you are in a city apartment, the garden trees if you're outside the city.

As in so many applications, a little silver does great things and one ounce of pure silver makes possible 200 square feet of perfect mirrors.

* * *

Inquiries on specific problems for which silver could be beneficial may be obtained by writing or telephoning.

THE SILVER INSTITUTE, INC.
Suite 1138 1001 Connecticut Avenue, N.W.
Washington, D. C. Telephone (202) 393-2285

72-B-2,700

A Table showing the Monthly Fluctuations, in London, in the Price of Bar-Silver per Oz. from January 1833 to December 1970.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Avge.	Silver Coined in England.	Amount of Bills and Telegraphic Transfers Drawn in England on Indian Governments.	Export of Silver to the East.	Imports of Silver Bars and Coin.	Average Bank Rate of Discount.	Average Price of Gold s. d.	Years.	Remarks.
1833	58⅞	58¾	58¾	58⅞	58⅞	58⅞	59¼—59⅛	59⅜	59½	59¾	59⅞	59⅞	59 3/16	£145	*£55,510	†£1,895,023	...	From 1784 to May, 1839, the rate never exceeded 5%, nor was less than 4%.	77 9	1833	Continuance of East India Company. Slavery abolished. Compensation to Owners, £20,000,000. Renewal of Bank Charter, Bank Notes a Legal Tender.
1834	59⅞	59⅞	60	59¾	59¾	59¾	60¼—60⅛	60¼	60⅜	59¾	59¾	59⅞—59¾	59 15/16	432,775	398,253	2,146,465	...		77 9	1834	Great Importation of Gold into New York. Substitution of Metallic Currency for Paper in the United States.
1835	59⅞	60	60	59¾	59¾	59¾—59⅝	59¾	59¼	59⅝	59⅝	59½	59⅝	59 11/16	146,665	732,803	2,063,167	...		77 9	1835	Extinction of United States National Debt. Bank of United States wound up, owing to refusal of Congress to re-charter it.
1836	59¾—59⅝	60 —59¾	60⅛—59⅝	59¾—59⅜	60	60⅛	60¼—60	60⅜—60¼	60⅜—60⅛	60¼—60⅛	60⅛	60 —59⅞	60	497,719	2,045,254	2,610,101	...		77 9	1836	Banking and Commercial Embarrassments in United States. Spanish Civil War.
1837	60⅜—60¼	60	60	59⅞—59½	59¾—59½	59¼	59⅝—59¼	59⅝—59	59½—59¼	59¼—59	59½—59¼	59½	59 9/16	75,385	2,042,232	3,010,190	...		77 9	1837	Commencement of Panic in London. Discounts refused. Many houses trading with the United States stop payment. Accession of Queen Victoria. Rebellion in Canada.
1838	59½	59½	59½	59½—59⅜	59⅜	59⅜	59⅜	59⅜	59½	59½	59¾—59½	60⅛—60	59½	174,042	1,706,184	1,945,264			77 9	1838	Resumption of Specie Payments in United States. Famine in various parts of British India. Afghan War.
1839	60⅝—60⅜	60⅝	60⅝—60¼	60¼—60	60⅜—60¼	60⅜	60½—60⅜	60⅜	60½	60½	60½—60¼	60¼	60⅜	390,654	2,346,592	1,786,253	No Statistics of Imports of Silver obtainable prior to 1858.	5½ %	77 9	1839	Banks in United States suspend Payments in Specie. War with China.
1840	60½—60¼	60¼	60⅜—60¼	60½—60¼	60¼—60⅛	60¼	60¼—60⅛	60⅜—60¼	60⅝—60½	60¾—60½	60½	60½—60¼	60⅜	207,900	1,439,525	1,841,335		5 „	77 9	1840	Misunderstanding with France. Treaty of London for settlement of Eastern Question.
1841	60⅜	60⅜	60	60	60¼	60¼—60⅛	60 —59⅞	60⅛	60⅛	59⅞—59¾	59⅞	59¾	60 1/16	89,641	1,174,450	3,143,292		5 „	77 9	1841	Great depression in every branch of Manufacturing Industry.
1842	59⅝	59½—59⅜	59⅜	59⅜—59¼	59½—59⅜	60 —59¾	59¾	59¾—59⅝	59⅝—59⅜	59¼—59⅛	59⅜—59¼	59¼—59⅛	59 7/16	192,852	2,589,283	4,794,678		4 „	77 9	1842	Peace with China. Income Tax Act passed.
1843	59⅝—59⅛	59¼—59	59⅛—59	59⅛	59⅛	59¼—59⅛	59¼	59¼	59¼	59¼	59¼	59¼	59 3/16	239,580	1,917,438	3,752,472		4 „	77 9	1843	Treaty of Commerce opens China to all Nations.
1844	59⅜—59¼	59⅜	59¼	59⅜	59½	59⅝	59¾—59⅝	59¾	59¾	59⅝	59⅝	59½	59½	610,632	2,801,731	2,495,959		4 „	77 9	1844	Bank Charter Act passed. Consols 101¼. Prior to September this year, the Bank never reduced the rate below 4%.
1845	59¼	59¼—59⅛	59⅛—58⅞	58⅞	59¼—58⅞	59¼—59	59¼—59⅛	59⅝—59⅜	59⅜	59⅞—59½	59⅞—59⅜	59¼—59⅛	59¼	647,658	2,516,951	2,939,922		3 „	77 9	1845	Railway Mania. Sikh War.
1846	59¼	59¼	59¼	59	59	59	59⅛	59⅛	59⅛	59⅜—59¼	60⅛	60⅛	59 5/16	559,548	3,065,709	1,973,391		3¼ „	77 9	1846	Commercial and Railway Panic. Repeal of Corn Laws.
1847	60⅜—60⅛	60⅜	60⅜	60⅜—58⅞	59¼—58⅞	59⅞—59	60 —59⅞	60 —59¾	59¾—59⅝	59½—59¼	59⅛	59⅛	59 11/16	125,730	3,097,042	4,204,503		5 „	77 9	1847	Year of Panic. £10,000,000 granted for relief of Famine in Ireland. Gold discovered in California.
1848	59¼—59⅛	59⅜—59¼	59¼—59⅞	59½—58½	60 —59½	59⅝—59½	59⅞—59½	59⅞—59⅝	59⅞	59⅞—59½	59⅝—59½	59½	59½	35,442	1,541,804	3,396,807		3¾ „	77 9	1848	Sikh War.
1849	59¾—59⅝	59¾	60⅛—60	60 —59⅞	59⅞	59⅞—59½	59¾—59⅝	59⅞—59¾	59¾—59½	59½—59⅜	59½	59⅝—59½	59¾	119,592	1,889,195	3,811,809		3 „	77 9	1849	First importation of Californian Gold into England. Annexation of the Punjaub.
1850	59¾—59⅝	59⅝—59½	59¾—59⅜	59⅝	59⅝	59⅝	59⅞—59⅝	59⅞	60⅛—60	60⅜—60⅛	61¼—60⅜	61½	60 1/16	129,096	2,935,118	5,052,059		2½ „	77 9	1850	Average of Consols 96¼.
1851	61⅝	61⅝—61⅛	61½	61½	61½—61⅛	61⅛—60⅞	61 —60¾	61 —60¾	60¾—60½	60⅝—60	60⅜	60¾	61	87,868	3,236,458	1,715,100		3 „	77 9	1851	Discovery of Gold in Australia.
1852	60¾—60½	60½	60⅜	60 —59⅞	59⅞	60¼—59⅞	60⅜	60⅜	60⅜	61⅛—60¾	61⅞—61⅛	61⅜—61¼	60½	189,596	2,777,523	2,447,450	...	2 „	77 9	1852	Consols touched 102, and averaged 99⅝.
1853	61⅜	61⅜	61⅜	61⅜	61⅜—60⅝	61⅛—60⅝	61½—61⅛	61⅞—61⅛	62⅛—61⅞	62⅛—61⅞	62⅜—61⅞	61⅞—61⅝	61½	701,544	3,317,122	3,117,980	...	3½ „	77 9	1853	Australian Mint Established.
1854	61¾—61½	61⅝	61⅞	61⅞—61⅝	61¾—60⅞	61½—61¼	61¼	61¼	61½—61	61⅜—61⅛	61½—61⅛	61⅝	61½	140,580	3,850,565	3,095,490	...	5 „	77 9	1854	Russian War began.
1855	61⅝—61½	61⅝—61½	60⅞	60⅝	61⅜—61¼	61½	61⅝—61½	61¾	61½	61½	61⅜—60	61¾	61 5/16	195,510	3,669,678	6,431,733	...	4¾ „	77 9	1855	Loan of 16 millions. Fall of Sebastopol.
1856	61¼—60⅞	61⅜—61⅛	61 —60½	61 —60½	61⅛—61	61¼—60¾	60⅞	61⅝—61¼	62¼—61⅝	62	62¼	61¾—61½	61 5/16	462,528	1,484,040	12,113,991	...	5¾ „	77 9	1856	Russian War ends.
1857	62¼	61⅞—61½	61¾—61⅜	61¾—61⅜	61½—61	61⅞	61⅞—61½	62 —61¾	61½	61⅞	61⅞—61½	62⅜—62	61¾	373,230	2,819,711	16,731,915	...	6¾ „	77 9	1857	Panic. Suspension of Bank Act. Indian Mutiny. Loan of £1,000,000 to East India Company.
1858	61½	61⅞—61⅜	61⅜	61⅜—61¼	61⅞—61½	61½—61⅜	61⅜—61¼	61 —60¾	60¾	61½—61⅛	61½—61¼	61¾—61¼	61 5/16	445,896	628,499	4,753,933	£6,700,000	3¼ „	77 9	1858	End of Indian Mutiny.
1859	62 —61¾	61¾	62¾—61¾	62⅜—61⅞	62⅜—62¼	62¼—62	62¾—62	62 —61¾	62 —61¾	62 —61⅞	62	62	62 1/16	647,064	25,901	14,828,521	14,772,460	2¾ „	77 9	1859	Loan of £5,216,528 to East India Company.
1860	62⅜—62	62⅛—62	62⅛—61¾	61¾	61⅝	61¾—61⅝	61½	61⅝—61⅜	61⅝	61¾—61⅝	61⅝—61¼	61⅜—61¼	61 11/16	218,403	4,694	8,478,739	10,394,000	4¼ „	77 9	1860	Commercial Treaty with France.
1861	61⅜—61¼	61¼—61⅛	61 —60⅝	61¾—60⅞	60⅞—60¾	60⅝—60⅜	60¼—60⅛	60½—60¼	60⅞—60¼	60¾—60⅝	61⅛—60⅞	61¼—61	60 13/16	209,484	797	6,824,807	6,590,000	5¼ „	77 9	1861	Financial depression in India. American Civil War begins.
1862	61⅝—61	61¾—61½	61⅜—61¼	61¼—61⅛	61⅝—61¼	61⅝—61	61⅛—61	61⅜—61¼	61⅜—61¼	61⅞—61¼	62⅛—61⅞	61¾—61⅝	61 7/16	148,518	1,193,729	10,091,460	10,753,000	2½ „	77 9	1862	Great distress in Cotton Manufacturing Districts. Panic.
1863	61¾—61⅝	61⅝—61½	61½—61⅜	61⅜—61	61⅝—61¼	61⅝—61	61¼—61	61⅛—61	61⅜—61⅛	61⅝—61¼	61¾—61⅜	61¾—61⅝	61⅜	161,172	6,641,576	8,263,011	10,888,130	4½ „	77 9	1863	Large exports of Gold to the Continent to pay for Silver.
1864	62½—61⅞	61⅞—61¼	61¾—61½	61⅞—61¼	61⅛—60⅞	61⅜—61⅛	61 5/16—61⅛	61½—61	61⅝—61⅜	61¼—60⅝	61⅜—60⅞	61⅝	61⅜	535,194	8,979,521	6,254,004	10,827,300	7½ „	77 9	1864	£13,000,000 Silver exported from France.
1865	61⅝—61½	61½—61⅜	61⅜—61	60⅝	60¾—60 9/16	60¾—60½	60¾—60½	60⅞—60¾	61 —60⅝	61¼—61⅛	61¾—61¼	61⅞—61 9/16	61 1/16	501,732	6,789,473	3,598,058	6,980,000	4½ „	77 9	1865	Close of American War.
1866	61¾—61⅜	61½—60⅞	61 —60⅞	61½—61	62 —61	62¼—61⅝	61¾—60⅝	60⅝—60⅜	61 —60¾	61 —60⅞	61 —60⅞	60⅞—60¾	61⅛	493,416	6,998,899	2,365,626	10,778,000	7 „	77 9	1866	Commercial and Joint Stock Companies Panic. Bank declined to sell Bar Gold.
1867	60⅞	60¾	60¾—60⅝	61¼—60¾	60¾—60⅜	60½—60⅜	60½	60½—60⅜	60⅝—60 5/16	60½—60⅜	60½—60⅜	60½—60⅜	60 9/16	193,842	5,613,746	642,912	8,020,000	2½ „	77 9	1867	Great decline in Export of Silver, only £2,500,000 sent from France.
1868	60⅞—60⅜	60½—60⅜	61⅛—60½	60⅝—60½	60⅝—60⅜	60⅜	60 7/16—60⅜	60⅜—60⅛	60¼—60⅛	60½—60¼	60½—60⅜	60⅞—60¾	60½	301,356	4,137,285	1,635,642	7,716,420	2¼ „	77 9	1868	Abyssinian Expedition.
1869	60⅞—60⅝	61 —60¾	60¾—60½	60⅝—60½	60⅜—60	60¼—60	60 5/16—60¼	60⅜—60¼	60½—60⅜	60½—60⅜	60½—60⅜	60⅝—60⅜	60 7/16	76,428	3,705,741	2,362,943	6,730,000	3¼ „	77 9	1869	Distress in Lancashire.
1870	60¾—60½	60½—60⅜	60⅝—60⅜	60½—60⅜	60½—60⅜	60½—60⅜	62 —60½	60⅝—60⅜	60⅜—60¼	60⅝—60⅜	60⅝—60½	60⅝—60½	60 9/16	336,798	6,980,122	1,579,473	10,649,000	3 „	77 9·01	1870	Franco-Prussian War. Panics.
1871	60⅝—60½	60⅝—60½	60½—60⅜	60¼—60 3/16	60¼—60 3/16	60 9/16—60⅜	60⅝—60½	60¾—60⅝	60 13/16—60⅝	60⅝—60¼	61 —60⅝	60⅞—60½	60½	701,514	8,443,509	3,712,473	16,520,000	3¼ „	77 9·01	1871	£8,500,000 Gold exported to Hanse Towns. Peace between France and Germany.
1872	61½—60⅝	61⅛—60¾	60⅞—60¾	60⅞—60¼	60½—60 1/16	60⅛—60	60 3/16—60 1/16	60¼—60	60 7/16—60 5/16	60¼—60	59¾—59¼	59¾—59⅝	60 5/16	1,243,836	10,310,339	5,654,451	11,140,500	4⅛ „	77 9·24	1872	£8,050,000 do. do. Commencement of decline in price of Silver.
1873	59 15/16—59¾	59 15/16—59¾	59⅞—59¾	59¾	59⅞—59⅜	59½—59 5/16	59⅜—59 5/16	59 3/16—58 13/16	59⅛—58 13/16	59 —58½	58⅛—57⅞	58 1/16—58	59¼	1,081,674	13,939,095	2,497,576	12,302,220	5⅜ „	77 9·28	1873	£10,000,000 do. do. German Government announces the demonetization of Silver.
1874	59½—58	59 —58½	59⅜—58½	59¼—58 9/16	58⅞—58½	59 —58½	58½—58¼	58⅛—57⅞	58 —57⅝	57 13/16—57⅝	58¼—57¾	57¾—57¼	58 5/16	890,604	13,285,678	7,092,726	11,797,990	3⅝ „	77 9	1874	Enormous Increase of Bullion in Bank of France, £22,000,000, mostly Gold.
1875	57⅝—57½	57½—57⅜	57¼—57	57⅜—57⅛	57 —56½	55⅞—55½	55⅞—55 11/16	56⅝—56	56¾—56 11/16	57⅛—56¾	56 15/16—56⅝	56⅝—56⅛	56⅞	594,001	10,841,615	3,714,404	9,506,757	3¼ „	77 9·23	1875	Heavy Commercial failures. Large Export of Gold to Germany. Continued decline in price of Silver.
1876	56⅛—54⅞	54⅞—53	54¼—52½	54 —53½	54 —52	52 —50	51½—46¾	53¾—50¼	52 9/16—51⅛	53⅝—52	55 —53⅛	58½—55¼	52¾	222,354	11,513,233	10,914,407	13,585,608	2½ „	77 9·30	1876	Remarkable fluctuations in rates of Indian Exchanges and Bar Silver.
1877	58¼—56⅞	57¾—56	56⅛—53½	55 —53½	54⅝—53⅝	54 —53½	54½—53⅞	54¼—54	55¼—54¼	55⅝—54⅝	55 —54	54¼—53¾	54 13/16	420,948	8,637,530	17,007,458	21,625,652	2⅞ „	77 9·42	1877	Great Famine in India. Russo-Turkish War.
1878	54 —53½	55¼—53 13/16	55 —54⅛	54¼—53⅞	53⅞—53¼	53 7/16—52½	52 13/16—52 5/16	52¾—52⅛	52⅛—51½	51 9/16—49½	50¾—50¾	50 11/16—49½	52 9/16	613,998	13,978,584	5,842,577	11,453,105	3¾ „	77 9·41	1878	General depression in Trade. Large Bank failures. Russo-Turkish War ended.
1879	51 —49⅝	50¼—49½	50¼—48⅞	50⅛—49½	51¾—50	53 —51½	52¼—51	51⅞—51⅛	51⅝—51⅜	53¾—51 9/16	53¾—53	53 —52⅜	51¼	549,054	14,705,700	7,034,967	10,520,012	2½ „	77 9·11	1879	Suspension of Sales by German Government. Marked diminution in production of Californian Mines.
1880	52¾—52¼	52 9/16—52	52½—51¾	52¼—51¾	52¼—52 1/16	52⅞—52 3/16	52⅞—52½	52⅞—52½	52⅝—52⅛	52 5/16—51 13/16	51⅞—51⅝	52 —51⅝	52¼	761,508	15,482,092	6,135,520	6,827,471	2¾ „	77 9·15	1880	Consols touched 100⅝. Reported existence of large quantities of Gold in South India.
1881	51¾—51	52⅞—51¼	52⅞—52	52⅛—52	52 —51½	51 11/16—51	52⅜—50⅞	51⅞—51¼	51 13/16—51⅝	52⅛—51 13/16	52 —51⅞	52 —51¾	51 11/16	997,128	16,273,677	4,288,009	6,902,210	3½ „	77 9·35	1881	Meeting of Conference in Paris respecting Bi-metallism, which adjourned without coming to any practical conclusion.
1882	52⅛—51 13/16	52 1/16—52	52 1/16—51⅞	52 5/16—52 1/16	52 7/16—52⅛	52⅜—51⅞	52 —51⅝	52 1/16—51⅞	52 1/16—51¾	51 15/16—51½	51¾—50⅞	50⅞—50	51⅝	209,880	12,053,665 to 2nd Jan., 1883	6,423,270	9,243,375	4⅛ „	77 9·43	1882	War with Egypt.
1883	50 9/16—50	51 —50⅜	51 3/16—50¾	50 13/16—50⅜	50⅜—50 1/16	50¾—50 1/16	50½—50 5/16	50⅝—50 7/16	50 15/16—50⅝	51 —50⅞	50 15/16—50½	51 —50½	50 9/16	1,274,328	18,909,000	7,125,454	9,468,002	3½ „	77 9·18	1883	Completion of Italian order for Gold. Discovery of Silver at Broken Hill, New South Wales.
1884	51 —50¾	51⅜—51	51 3/16—50 11/16	51 —50½	50 15/16—50¾	50 15/16—50⅝	50⅞—50 11/16	50⅞—50 9/16	50⅞—50⅝	50⅞—50 7/16	50 7/16—49 11/16	49⅞—49½	50⅝	658,548	16,966,112	8,418,522	9,546,496	2 9/16 „	77 9·32	1884	War in Egypt, Income Tax increased. Franco-Chinese Complications.
1885	50 —49⅜	49 9/16—48 13/16	49 3/16—49	49⅞—48⅞	50 —48 15/16	49 3/16—49	49¼—49⅛	49 3/16—48 7/16	48⅜—47¼	47⅝—47¼	47½—47 5/16	47½—46⅞	48⅝	720,918	11,018,000	8,010,925	9,377,601	2⅞ „	77 9·17	1885	Suspension of the Coinage of the Bland Dollar, recommended by the President of the United States. Broken Hill Proprietary Silver Mines opened.
1886	47 —46⅞	46 15/16—46½	46⅞—46 11/16	46 11/16—46	46 —44¾	45⅜—44 11/16	44 9/16—42	42⅝—42	45 —42⅝	45⅞—44½	47 —45⅞	46⅜—45	45⅜	417,384	11,791,000	5,846,222	8,166,249	3 „	77 9·10	1886	Great depression in Trade. The Rand proclaimed a gold field.
1887	47⅛—46¼	47—46 5/16	46 7/16—44 5/16	44 9/16—43½	43¾—43 7/16	44¼—43 11/16	44 7/16—43⅞	45¼—44¼	45 —44 7/16	44¾—43 1/16	43 15/16—43⅝	45⅛—43 13/16	44⅝	861,498	15,394,000	6,327,113	7,471,639	3⅜ „	77 9·01	1887	Depression in Trade continued, assisted by War rumours.
1888	44 9/16—44¼	44 3/16—43 13/16	43¾—43	42⅞—42½	42⅝—41⅝	42¼—42	42 5/16—42	42⅛—41 15/16	44 3/16—42 1/16	43⅜—42⅞	43⅛—42⅞	42⅞—42 5/16	42⅞	756,558	13,964,700	7,807,400	7,825,380	3⅛ „	77 9·21	1888	Deaths of two German Emperors successively caused great uneasiness. War rumours subsided later. Stringency of Money earlier than usual towards close of the year.
1889	42 11/16—42⅜	42¾—42½	42⅝—42¼	42 5/16—42 1/16	42¼—41 15/16	42 3/16—42	42 5/16—42	42 9/16—42¼	42 11/16—42⅜	43½—42⅝	44⅜—43⅝	44⅜—43¾	42 11/16	2,224,926	15,658,000	8,575,713	9,184,940	3½ „	77 9·04	1889	Home Coinage of Silver unusually large.
1890	44⅞—44⅛	44⅝—43 11/16	44⅜—43¾	48 —43⅞	47½—46	49 —46¼	50⅞—47 9/16	54½—50¾	54⅝—50	51½—48⅛	48¾—45	49½—47¼	47 11/16	1,712,161	15,473,323	8,456,709	10,385,659	4½ „	77 9·44	1890	Serious Panics in London and New York. Extension of Silver Legislation in the States.
1891	48¾—46⅞	46¾—44½	45 5/16—44⅝	45 —43⅞	45⅛—44¼	46 —44¼	46⅜—45⅝	46⅛—45 1/16	45 5/16—44¾	45 —44 1/16	44 1/16—43½	44¼—43½	45 1/16	1,057,336	16,891,000	7,082,719	9,316,200	3 5/16 „	77 10·29	1891	Chilean Revolution. Failure of United States Legislation to maintain Silver prices. Large Continental orders.
1892	43¾—41⅜	41 15/16—41⅛	41⅝—39	40⅛—39¼	40⅜—39 11/16	41⅛—40 1/16	40¼—39 1/16	39 1/16—37⅞	38 5/16—38⅛	39⅝—38⅛	39¼—38¾	39 3/16—37 13/16	39 13/16	778,932	16,307,000	11,881,885	10,746,382	2½ „	77 10·17	1892	Further depression in Silver. Inoperative Monetary Conference at Brussels. Discovery of Gold at Coolgardie, Western Australia.
1893	38 9/16—38⅛	38½—38¼	38⅜—37 9/16	38 5/16—38	38 9/16—37⅝	38¾—30½	34¾—32⅛	34⅞—32 11/16	34½—33⅞	34⅛—31½	32¾—31½	32 5/16—31¾	35⅝	1,088,406	10,640,000	11,649,411	11,913,395	3 „	77 10·57	1893	Indian Mints closed to free Coinage of Silver. Repeal of Sherman Act. Australian Bank Crisis. Rupee fixed at 1/4 (June, '93).
1894	31¾—30½	30 11/16—27½	27⅞—27	29⅜—28⅛	29¼—28 1/16	28 15/16—28 5/16	28 15/16—28⅞	30½—28 11/16	30¼—29 3/16	29 9/16—28 15/16	29 5/16—28⅜	28½—27 3/16	28 15/16	822,492	15,335,000	10,041,162	11,005,507	2 1/16 „	77 9·33	1894	Duty of 5% imposed on Silver entering India. War between China and Japan.
1895	27 7/16—27 3/16	27 11/16—27¼	29¾—27⅝	30⅞—29⅞	30⅞—30 3/16	30 11/16—30 3/16	30⅝—30 3/16	30 9/16—30¼	30 9/16—30 7/16	31⅜—30⅝	31 —30⅝	30 11/16—30	29⅞	1,187,010	18,184,400	6,484,933	10,669,682	2 „	77 9·03	1895	Speculation in African Mines. Large indemnity to Japan. Consols touched 108¼. U.S. Currency difficulties.
1896	30⅞—30	31 9/16—30¾	31 9/16—31⅛	31 3/16—30 13/16	31¼—30 15/16	31 9/16—31 3/16	31½—31⅜	31⅜—30⅜	30 11/16—30	30 5/16—29¾	30 3/16—29¾	30 —29 13/16	30¾	1,329,570	16,111,928	6,897,015	14,329,116	2½ „	77 10·16	1896	Consols touched 114. Defeat of Silver party in U.S. Election. Extensive Coinage of Silver by Russia.
1897	29 13/16—29 11/16	29¾—29 11/16	29⅝—28 5/16	28½—28 3/16	28 3/16—27½	27¾—27½	27 11/16—26⅜	26½—23¾	27¼—23¾	27½—25 9/16	27½—26⅜	27¾—25 15/16	27 9/16	941,886	8,405,866	7,223,397	18,032,091	2⅝ „	77 11·23	1897	Turco-Greek War. Famine and Plague in India. Gold Standard adopted by Japan.
1898	26⅞—26⅛	26¼—25⅝	26 1/16—25	26 5/16—25 11/16	26⅞—25⅞	27½—26 11/16	27⅞—27	27 13/16—27⅛	28 5/16—27 11/16	28¼—27 9/16	28 5/16—27½	27⅝—27¼	26 15/16	1,269,180	16,886,809	5,949,285	14,677,799	3¼ „	77 10·46	1898	Spanish-American War. Indian Monetary Conference. European extension in China. Soudan reconquered.
1899	27⅝—27¼	27½—27⅜	27 9/16—27⅜	28⅞—27⅜	28¾—28	28 —27 11/16	27¾—27⅝	27 13/16—27⅛	27⅜—26 15/16	26 15/16—26⅝	27 5/16—26 11/16	27 5/16—26 15/16	27 7/16	1,544,400	19,466,583	7,742,829	12,727,989	3¾ „	77 9·27	1899	Boer War. 6% Bank Rate in December. Consols down to 97⅝.
1900	27 11/16—27	27¾—27 5/16	27 11/16—27 7/16	27½—27 5/16	27⅝—27½	28 9/16—27 9/16	28 9/16—27¾	28 7/16—27 15/16	29¼—28 7/16	30 3/16—29⅛	29 15/16—29 7/16	29⅞—29½	28¼	2,077,020	12,721,580	9,985,642	13,322,300	3 15/16 „	77 9·91	1900	Continuation of Boer War. Large Coinage of Rupees. Boxer rebellion in China.
1901	29 9/16—27¾	28½—27⅞	28 3/16—27 5/16	27 15/16—26 15/16	27⅝—27 3/16	27 9/16—27¼	27¼—26 13/16	27⅛—26¾	27 —26⅞	26⅞—26⅜	26½—25⅝	25¾—24 15/16	27 3/16	860,508	17,262,086	9,018,419	11,501,678	3¾ „	77 9·83	1901	Death of Queen Victoria. Continuation of Boer War. Combination of American Smelters. Commonwealth of Australia established.
1902	26⅛—25 7/16	25½—25 5/16	25 7/16—24 13/16	24⅞—23 5/16	24 —23 5/16	24 7/16—23 15/16	24 9/16—24 3/16	24 7/16—24⅛	24⅛—23 9/16	23 11/16—23¼	23¼—21 11/16	22⅝—21 13/16	24 1/16	1,099,890	18,607,296	7,565,305	9,764,296	3⅜ „	77 9·55	1902	End of Boer War. Heavy fall in Silver. War Indemnity unsettles China Trade.
1903	22⅜—21 11/16	22 5/16—21⅞	22⅞—22⅛	25 1/16—22⅝	25¼—24 15/16	24 9/16—24⅛	25½—24¼	26¾—25 5/16	27 9/16—26¼	28½—27 7/16	27⅝—26¼	26 7/16—25	24¾	538,164	22,150,554	8,051,780	10,310,330	3¾ „	77 10·06	1903	Straits Settlements and Siam adopt Gold Standard. Large purchases by the Indian Government. U.S.A. buy for new Philippine Coinage. Mexican Currency Commission.
1904	27 5/16—25½	27½—25⅝	26 11/16—25½	25½—24 7/16	25 15/16—25⅛	26⅛—25 5/16	27 —26⅜	27 —26 3/16	26⅞—26	26 15/16—26½	27¼—26¾	28 9/16—27⅜	26⅜	623,898	24,766,316	10,038,319	11,687,339	3¼ „	77 9·94	1904	Russo-Japanese War. Monetary Reform in Mexico. Continued buying by Indian Government.
1905	28⅜—27 9/16	28 5/16—27⅝	27 11/16—25 13/16	26⅝—25 7/16	27 5/16—26⅛	27⅛—26 7/16	27 5/16—26⅞	28¾—27¼	28¾—28	28 15/16—28 5/16	30 5/16—28 13/16	30 5/16—29⅜	27 13/16	316,206	26,584,734	8,643,405	12,992,014	3 „	77 9·42	1905	Mexican Mints closed to free Coinage of Silver. End of Russo-Japanese War. Internal troubles in Russia. Continued buying by Indian Government.
1906	30¼—29 11/16	30 13/16—30⅛	30 7/16—29	30 9/16—29⅝	31⅜—30 9/16	31⅛—29 9/16	30 7/16—29 13/16	30 15/16—29⅞	31¾—30 15/16	32 9/16—31 11/16	33⅛—32	32⅜—31 9/16	30⅞	1,821,798	28,664,315	15,565,334	17,288,063	4¼ „	77 9·82	1906	Heavy purchases by Indian Government. Large Exports of $ from Mexico. Resumption of purchases by U.S. Government. Straits Exchange fixed at 2/4 per $.
1907	32 7/16—31 5/16	32⅛—31½	32 1/16—30 7/16	30½—30	31⅛—29 15/16	31 1/16—30⅝	31 15/16—31	32¼—31⅛	31 9/16—31 1/16	30⅞—27 7/16	28 1/16—26½	26¾—24 3/16	30 3/16	2,039,400	21,317,037	12,752,230	15,983,892	4⅞ „	77 9·95	1907	Cessation of Indian buying. Sharp fall in Silver. Financial crisis in U.S.A. Bank Rate 7%. New Zealand becomes a Dominion.
1908	27 —24⅞	26⅝—25⅜	25 13/16—25 7/16	25½—24 5/16	24 13/16—24	25⅜—24¼	24⅞—24 3/16	24⅜—23⅝	24 3/16—23 9/16	24 —23 1/16	23 5/16—22 3/16	23 3/16—22	24⅜	1,009,206	10,668,722	10,243,968	10,326,889	3 „	77 10·19	1908	Large Gold Exports to Paris. General depression of Trade. Political unrest in South Eastern Europe.
1909	24⅜—23 3/16	24⅛—23 5/16	23⅜—23 1/16	24 7/16—23¼	24⅞—24⅛	24½—23 15/16	23⅞—23⅜	24 —23 7/16	23⅞—23⅝	23 13/16—23 1/16	23⅝—23⅛	24 5/16—23 9/16	23 11/16	1,202,256	22,968,515	8,936,715	11,814,889	3 1/16 „	77 9·18	1909	Some improvement in Trade. Good Crops, especially of Cotton, in India.
1910	24¼—24	24⅛—23 5/16	24 3/16—23 3/16	24 15/16—24	24 15/16—24⅝	24¾—24½	25⅝—24½	24⅝—24 3/16	24⅞—24 5/16	26¼—24 13/16	26 —25 5/16	25⅜—24 15/16	24⅝	2,606,670	24,795,590	8,648,443	14,100,310	3 11/16 „	77 9·03	1910	Death of King Edward VII. Indian Import Duty on Silver increased from 5% *ad val.* to 4 annas per ounce. Union of South Africa inaugurated.
1911	25⅜—24⅜	24 7/16—23 11/16	24½—24¼	24 15/16—24 5/16	24 11/16—24 7/16	24⅝—24 5/16	24 7/16—23 15/16	24 3/16—24	24 5/16—24⅛	25 3/16—24 3/16	26⅛—25	25 11/16—25 1/16	24 9/16	2,264,130	25,462,390	9,865,796	14,293,747	3 7/16 „	77 9	1911	Strikes and Labour unrest in England. Rebellion in China. Italian war in Tripoli.
1912	26 13/16—25⅛	27⅞—26¾	27⅛—26 11/16	28 3/16—26¾	28¼—27 11/16	28 9/16—27 15/16	28 3/16—27⅝	29⅛—27 9/16	29 7/16—28 13/16	29⅝—29	29⅜—28 13/16	29 11/16—28¾	28 1/32	2,610,432	27,742,524	14,345,474	16,778,304	3¾ „	77 9	1912	Establishment of Provisional Government in China. Indian Government purchased £6,000,000 Silver. War between Turkey and Balkan States.
1913	29¾—28 5/16	28 13/16—27 1/16	27 7/16—26 1/16	28 1/16—26 7/16	28 3/16—27⅝	27 11/16—26⅝	27½—26 13/16	27 9/16—27 3/16	28 11/16—27 7/16	28 7/16—27½	27 11/16—26 7/16	27¼—25 15/16	27 9/16	1,693,494	27,652,321	10,739,978	14,495,049	4¾ „	77 9	1913	China Loan of £25,000,000. Indian Government bought £5,500,000 Silver. Failure of Indian Specie Bank. Civil War in Mexico.
1914	26¾—26 7/16	26 11/16—26½	27 —26 11/16	27¼—26 13/16	27 3/16—25 15/16	26¼—25 11/16	26⅛—23¾	27¾—23⅞	25 3/16—23 9/16	24⅛—22 3/16	23 —22⅛	23¼—22⅜	25 5/16	6,250,524	2,106,000	5,745,468	11,950,090	4 „	77 9	1914	Outbreak of Great European War and consequent disorganisation of Money and Stock Markets. Record home coinage of Silver. Bank rate reached 10% in August.
1915	22 15/16—22 9/16	23 1/16—22½	24 5/16—23⅛	23 15/16—23½	23 13/16—23 5/16	23½—22⅞	22 15/16—22 5/16	23 1/16—22⅜	23¾—23 3/16	24⅛—23¾	27¼—24⅛	27 1/16—25¾	23 11/16	7,815,437	11,536,256	3,828,168	10,560,161	5 „	77 9	1915	Continuation of Great War. Heavy coinage of Silver, both home and abroad.
1916	27 5/16—26 11/16	27⅛—26 13/16	28 15/16—26 15/16	35⅛—29	37⅛—32⅞	32⅞—30	31 —28⅝	32 —30½	32 15/16—32⅛	32⅞—32⅛	35 15/16—32 7/16	37 —35 13/16	31 5/16	8,378,465	14,121,665	§4,412,000	§12,395,000	5½ „	77 9	1916	
1917	37 7/16—36	38 7/16—37 5/16	37 5/16—35 11/16	37 15/16—36 9/16	38⅛—37¾	39⅞—38	41¼—39½	46 —40⅛	55 —46	48¼—41⅞	45⅜—42¾	43½—42¾	40⅞	4,088,778	37,221,197	‡	‡	5⅛ „	77 9	1917	Continuation of Great War. The United States declares war against Germany.
1918	45⅛—43¼	43¼—42½	46 —42½	49¼—45¼	49¼—48⅞	48⅞	48 13/16	49½—48 13/16	49½	49½	49½—48¾	48¾—48 7/16	47 9/16	9,252,549	16,506,964	‡	‡	5 „	77 9	1918	Armistice with Enemy Countries signed on 11th November. Serious Political unrest in Russia and Germany. Pittman Silver Act passed in the United States.
1919	48 7/16	48 7/16—47¾	50 —47¾	49 9/16—48⅝	58 —48 9/16	54⅞—53	55 9/16—53	61¾—55¾	64 —59	66½—62¾	76 —65½	79⅛—73⅛	57 1/16	3,646,183	26,602,480	‖ 623,728	‖ 2,425,424	5⅛ „	90 1·03	1919	Peace treaties with Central Powers signed. High prices of commodities and wide fluctuations in International Exchanges. Civil war in Russia continues. General political and labour unrest.
1920	85 —75⅞	**89½**—82	84 —65¾	72⅛—64½	65½—57⅝	57⅝—44	56⅝—51⅛	63¾—57	60¾—57⅝	59 —50½	54⅝—43⅞	44¾—38⅞	61 7/16	5,640,679	664,426	8,915,959	9,923,034	6 11/16 „	112 11·52	1920	British subsidiary coinage reduced to ·500 fine. Heavy Continental sales of demonetized silver. Value of Rupee fixed at 11·30016 grains gold. World-wide depression in trade. Indian Silver Import Duty remitted.
1921	42½—35⅛	37¾—31⅜	34⅛—30⅝	36½—32½	35½—33⅛	35¾—33½	39½—35¼	38⅞—36¼	43⅜—37¾	42⅞—39⅛	40½—37⅜	37⅝—34½	36⅞	8,917,023	Nil	9,770,124	10,264,443	6 1/16 „	107 0·50	1921	Continental sales continue. British Mint commences selling surplus silver from debased coinage. Financial crisis in China.
1922	35½—34½	35⅛—32⅛	34⅛—32⅛	35⅞—33¼	37⅜—34⅞	36¼—35¼	36⅝—35	35¼—34½	35⅝—35⅛	35 7/16—33¾	34 1/16—31⅞	32 7/16—30⅜	34 7/16	7,416,208	Nil	10,466,695	10,099,890	3 11/16 „	93 3·80	1922	Sales of Surplus Silver by Mint, and Continental sales continue. Great increase in Indian demand for Gold. German Mark completely valueless owing to inflation. Sterling exchange on New York appreciates. Continued depression in Trade.
1923	32 11/16—31 3/16	31¼—30½	32⅞—31 9/16	33 3/16—31 11/16	32 15/16—32	32 1/16—31 1/16	31⅜—30 11/16	31⅛—30¾	32⅜—30 15/16	32⅜—31 5/16	33⅝—31¾	33 11/16—33	31 15/16	6,644,324	8,116,471	10,863,638	9,611,055	3½ „	90 2·90	1923	Mint and Continental sales continued. Purchases by U.S. Treasury under Pittman Act completed. Great Earthquake in Japan. Political unrest at home and abroad.
1924	34 1/16—32 15/16	34 1/16—33 5/16	33 13/16—33 5/16	33 5/16—32 13/16	35⅛—32 13/16	35¼—34¼	34¾—34¼	34¾—33⅝	35 3/16—34 5/16	36 1/16—34¾	34¾—33 3/16	33⅜—31½	34	4,345,426	5,252,291	4,817,309	13,931,746	4 „	93 8·30	1924	Large Continental purchases for coinage. Recoinage of British Currency suspended whilst Mint coining for Foreign Countries.
1925	32 9/16—31¾	32⅜—32⅛	32 3/16—31 9/16	31 11/16—31 1/16	31½—31 1/16	32½—31⅜	32⅛—31¾	32⅞—31 15/16	33 7/16—32⅝	33 3/16—32⅝	32¾—31 15/16	32 3/16—31½	32⅛	2,556,932	2,651,250	5,939,485	10,612,558	4 11/16 „	85 5·60	1925	Gold Standard, suspended 1914, conditionally restored. Serious disturbances in China.
1926	31 13/16—30 13/16	31⅛—30 9/16	30 9/16—30⅛	30 1/16—29 3/16	30⅝—29 15/16	30 9/16—30 1/16	30 5/16—29⅜	29¼—28½	28 11/16—26⅛	26¾—24⅛	26 —24 9/16	25 1/16—24⅜	28 11/16	3,275,827	Nil	8,016,832	11,198,113	5 „	84 11·10	1926	Disturbances in China continue. Coal strike at home, lasting 7 months with consequent dislocation of Trade. Report of Royal Commission on Indian Currency and Finance published.
1927	27 13/16—24¾	28 —26⅛	26¼—25 3/16	26¾—25 11/16	26 9/16—25¾	26 7/16—25 15/16	26¼—25 13/16	25⅞—24 15/16	25⅞—25⅛	26 1/16—25⅝	26 15/16—26⅛	27 —26⅜	26 1/32	2,409,099	Nil	4,957,472	7,173,051	4⅝ „	84 11·20	1927	Disturbances in China continue. Rupee fixed at 1/6. Indian Government sold 9,000,000 ozs. of surplus silver in London.
1928	26 11/16—26 1/16	26⅜—26 1/16	26½—26⅛	26 15/16—26¼	28⅞—26¾	28 1/16—27⅛	27½—27 1/16	27 5/16—26 11/16	26 11/16—26 1/16	27 —26 5/16	26 13/16—26 9/16	26 9/16—26 3/16	26¾	5,762,892	Nil	6,326,502	10,205,998	4½ „	84 11·20	1928	Stabilization of the French franc. Bank of England takes over Currency Note Issue. Sales of demonetized coin by France, Belgium and India, offset by large purchases by China. Capture of Pekin by Nationalist forces.
1929	26 7/16—26	26 5/16—25⅝	26⅛—25⅞	25 15/16—25 3/16	25½—24 9/16	24½—24	24 13/16—23 15/16	24 7/16—24 3/16	24 3/16—23 3/16	23 5/16—22⅞	22 15/16—22½	22 11/16—21 5/16	24 7/16	5,933,097	Nil	5,109,170	8,330,718	5½ „	84 11·35	1929	Indian Government sales of silver continue. Heavy drain of gold to France and Germany. Financial failures here and abroad.
1930	21⅝—20	20 7/16—19⅛	20 —18⅝	19 13/16—19 3/16	19 9/16—17 7/16	17 3/16—15 7/16	16 7/16—15 9/16	16⅞—15⅞	17 —16⅜	16 13/16—16⅜	16 13/16—16 5/16	16¼—14 7/16	17 11/16	1,953,716	Nil	7,011,585	8,518,353	3⅜ „	84 11·93	1930	World-wide trade depression. Break in silver and China exchanges. Indian Government continue sales and reimpose import duty of 4 annas per ounce. £55,000,000 gold exported to France.
1931	14½—13 3/16	13¼—**12**	14½—12⅝	13½—12⅝	13¼—12⅛	13 13/16—12 3/16	13¾—12 11/16	13⅛—12 9/16	19½—12¾	18 3/16—15 15/16	21 9/16—18	20 11/16—19⅛	14 19/32	3,024,711	Nil	4,086,510	8,405,982	4 „	92 6·23	1931	Continued depression. Indian silver import duty increased to 7½ annas per ounce. Heavy drain of Gold to the Continent (£72,000,000 to France alone), caused Great Britain to abandon gold standard. Large movement of gold from India to England began.
1932	20 7/16—18 15/16	20 —19¼	19¾—17½	17½—16½	17⅜—16 9/16	17 —16⅝	17¼—16⅝	18 15/16—17 3/16	18 13/16—17 9/16	18⅛—17 11/16	18⅜—17 13/16	17¾—16⅜	17 27/32	1,731,570	Nil	2,078,035	7,827,237	3 „	118 0·82	1932	Continued depression. High gold price induced sale of about £15,000,000 gold and sovereigns previously hoarded in Great Britain and Ireland. From September, 1931, to end of 1932 14½ million fine ozs. gold exported from India.
1933	17⅛—16½	17 5/16—16 9/16	18 7/16—17	20 7/16—17¼	20½—18 3/16	19 9/16—18⅜	18 15/16—17⅞	18⅛—17¾	18½—18 1/16	18½—17¾	18⅝—18¼	19 1/16—18 7/16	18 5/32	4,201,520	Nil	616,690	10,391,821	2 „	124 10·40	1933	Banking crisis in U.S.A. in March followed by abandonment of gold standard on April 19th. World Economic Conference met in London, June 12th. Signs of trade revival in Great Britain. Exports of Gold from India about £34,000,000.
1934	19¾—19 1/16	20 11/16—19¼	20¾—19⅞	20¼—18¾	19 13/16—18 3/16	21⅛—19 7/16	21 —20 1/16	21⅞—20 7/16	22 7/16—21⅝	24⅞—22 7/16	25¼—23 7/16	24⅞—23 13/16	21 7/32	2,372,267	Nil	828,237	22,187,021	2 „	137 7·85	1934	U.S.A. returns to gold standard, $ devalued to 59·06%. U.S. Silver Purchase Act passed June 20th. Heavy purchases by U.S. at home and abroad. China forced to divorce exchange from silver. Exports of gold from India £37,000,000. Import duty on silver reduced to 5 annas per ounce.
1935	24¾—24 5/16	25 11/16—24 5/16	28⅞—26 1/16	36¼—28¼	35⅜—32⅜	33¾—31	31 5/16—30 3/16	30 3/16—29	29 9/16—29	29⅝—29 5/16	29½—29 3/16	29¼—20⅞	29	2,707,516	Nil	938,419	40,506,511	2 „	142 1·24	1935	Italo-Abyssinian War. Tension in Europe. Huge purchases of silver in London by U.S. Treasury. Hong Kong and China forced to abandon silver standard. China pegs dollar to sterling at 1/2½. Indian import duty reduced to 2 annas per ounce.
1936	22⅜—19	20 1/16—19 7/16	20 3/16—19 1/16	20⅞—19⅞	20⅞—19¾	20 1/16—19 7/16	19¾—19⅜	19 11/16—19⅛	20 1/16—19 7/16	20 3/16—19 11/16	22 15/16—20	21⅜—20⅞	20 1/16	3,115,864	Nil	9,411,029	17,061,083	2 „	140 3·45	1936	Death of King George V. Devaluation of Currencies by "gold bloc" countries. Large shipment of silver to India. Abdication of King Edward VIII. Civil War in Spain.
1937	21 5/16—20¼	20 3/16—19 15/16	21⅛—20 3/16	21½—20 3/16	20 7/16—20¼	20⅜—19¾	20 3/16—19 13/16	20 —19 3/16	20 —19¾	20 1/16—19 13/16	19 15/16—19 9/16	19 11/16—18 3/16	20 1/16	3,958,529	Nil	3,566,609	20,260,783	2 „	140 8·77	1937	Indian import duty raised to 3 annas per oz. Sino-Japanese War. Chinese Government transfer silver reserve, about 270 million ounces, to Hong Kong and later to London.
1938	20¾—19¼	20⅜—19 15/16	20 9/16—18⅜	19⅛—18 9/16	18 15/16—18⅝	19 1/16—18 11/16	19 13/16—18 15/16	19 9/16—19⅛	19 11/16—18¾	19 13/16—19 5/16	20¼—19½	20¼—19 15/16	19 7/32	2,490,970	Nil	514,555	18,135,050	2 „	142 6·66	1938	Germany annexes Austria, and forces partition of Czechoslovakia. War scare in Europe. Heavy purchases of gold by Continental operators.
1939	21⅛—19 15/16	20¾—19 15/16	20⅝—19⅞	20 3/16—19 15/16	20⅜—19 15/16	20 —17 15/16	18 3/16—16 1/16	20 1/16—16⅝	23½—19¾	23½—21¼	23½—23 1/16	23½—22½	20 13/32	5,964,201	Nil	¶ 1,149,203	¶ 5,751,225	2¼ „	154 4·07	1939	German aggression causes successive crises. Germany invades Poland. Great Britain and France declare war on Germany on 3rd September. Russia invades Poland from the East. Russia attacks Finland.
1940	22⅝—21 1/16	21 13/16—20 3/16	21 5/16—20 1/16	21¼—20⅛	23½—20⅞	23½—21⅛	22⅝—21 11/16	23½—22 5/16	23½—23⅜	23½—23⅜	23½—22⅞	23 5/16—22 13/16	22 9/32	5,616,701	Nil	‡	‡	2 „	168 0	1940	Germany invades Denmark, Norway and the Low Countries. Italy declares war on Allies. France capitulates. Disintegration of Italian African Empire. Indian silver currency reduced to ·500 fine. Italy and Germany attack Balkan countries.
1941	23⅜—23 3/16	23 7/16—23¼	23½—23 5/16	23½	23½—23⅜	23 7/16—23⅜	23½—23¼	23½—23 7/16	23½	23½	23½	23½	23 7/16	5,818,380	Nil	‡	‡	2 „	168 0	1941	Germany attacks Russia. Japan attacks U.S. forces in Pearl Harbour without declaration of war. Great Britain and U.S.A. declare war on Japan. Germany and Italy declare war on U.S.A.
1942	23½	23½	23½	23½—23 7/16	23½	23½	23½	23½	23½	23½	23½	23½	23½	10,208,278	Nil	‡	‡	2 „	168 0	1942	Anglo-Soviet Treaty. British and U.S. forces land in North Africa.
1943	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	6,560,219	Nil	‡	‡	2 „	168 0	1943	Axis forces surrender in Tunisia. Italy surrenders to Allies and declares war on Germany.
1944	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	23½	6,807,041	Nil	‡	‡	2 „	168 0	1944	Allied troops land in France.
1945	25½	25½	25½	25½	25½	25½	25½	25½	44 —25½	44	44	44	30½	7,484,920	Nil	‡	‡	2 „	172 3	1945	Unconditional surrender of all German and Japanese forces ends World War II.
1946	44	44	44	44	44	44	44	55½—44	55½	55½	55½	55½	48 11/16	7,960,696	Nil	§ 4,000,000	‡	2 „	172 3	1946	World-wide shortage of food. Shipments of silver to India recommence. Silver coinage demonetized in Great Britain and cupro-nickel substituted.
1947	55½	47½—44	52—44	46—45	44¾—43	43—37	39¾—37	42½—37	43⅜—41¾	44⅞—43¼	45⅛—45	45	44 7/16	★6,177,371	● £5,599,271	6,509,516	6,800,228	2 „	172 3	1947	Import of silver into India suspended. Partition of India into Dominions of India and Pakistan.
1948	45	45	45	45	45	45	45	45 —44	46½—45	47 —46½	45½—42½	42½	45	22,405,481	2,094,688	185,688	1,640,902	2 „	172 3	1948	Burma becomes a Republic. Ceylon Independence Act. British Mandate for Palestine ended. Newfoundland joins Dominion of Canada. Political unrest in Europe.
1949	42½	43½—42½	43½	43½	43½	43½	43½	44½—43½	64 —44½	64 —63¼	64	64	49 7/32	9,458,019	3,859,654	1,436,218	3,113,847	2 „	172 3	1949	Pound devalued from $4·03 to $2·80. Communist forces over-run China. Terrorism in Malaya.
1950	64	64	64—63	63	63½—63	63½	63½	63½	63½	70 —63½	70	70	64 25/32	8,473,409	5,824,950	506,043	4,087,895	2 „	248 0	1950	India a Republic. United Nations involved in Korean War. General political unrest. French gold reserve revalued. Canadian dollar freed.
1951	78½—70	78½	78½	78½	78½	78½—76½	78½	78½	78½	78½—74	77	77	77 27/32	6,423,392	5,874,879	6,171	3,758,562	2 1/16 „	248 0	1951	Truce talks start in Korea. Anglo-Persian oil dispute. Foreign Exchange market partially reopened in London.
1952	77	77	77	77	77 —72½	72½	73 —72½	73	73	73	73 —72¾	72¾—72½	74 11/32	253,927	4,257,914	86,754	3,218,350	3 11/16 „	248 0	1952	Death of King George VI. Korean War continued. Bank rate raised to 4% March 12th. Ratification of Peace Treaty with Japan.
1953	72⅞—74	74	74	74	74	74	74	74	74	74	74	74 —73¾	73 15/16	7,888,004	3,468,317	25,215	10,315,865	3 13/16 „	248 0	1953	Armistice signed in Korea. Large amounts of Russian gold and silver consigned to London. Bank rate reduced to 3½% September 17th.
1954	73¾	73¾	73¾—73⅝	73⅝—73⅛	73⅜—72¼	73⅛—72¾	73⅛—72	73⅜—72¼	73¾—73	74⅜—73½	74⅜—74¼	74¼	73 15/32	8,243,129	3,215,922	Nil	7,046,181	3 3/16 „	249 4·52	1954	London Gold Market reopened, March 22nd. Bank Rate reduced to 3% May 13th.
1955	74¼—74	74¼—73¾	77½—74¼	77—75½	78½—75½	78¾—77¼	79 —78⅜	79¼—78⅞	79¾—78⅞	80¼—79½	79½—77¾	78¾—77¾	77 17/32	11,951,095	3,139,106	3,370	9,369,378	4 5/16 „	250 11·09	1955	Bank rate increased to 3½% on January 27th and to 4½% on February 24th. Rail and Dock strikes in United Kingdom.
1956	78⅞—77⅜	79½—76⅝	79 —78⅞	79—78⅝	79⅛—78¾	79 —78⅛	78¾—78⅜	79 —78½	79½—78¾	81 —79⅜	81⅜—81¼	81⅜—79¼	79⅛	16,158,383	25,005,705	Nil	6,781,357	5⅜ „	250 3·38	1956	Britain returns 66 million ounces of lend-lease silver to U.S.A. Bank rate raised to 5½% February 16th.
1957	80½—79⅞	80 —79¾	80 —79⅝	80—79½	79⅝—78½	78½—78⅛	78⅛	78⅞—78⅛	78¾—78⅝	78¾—78½	78¾—77⅝	77⅝—77⅛	78 15/16	13,260,265	12,935,246	Nil	4,344,926	5⅝ „	250 2·51	1957	Bank rate Feb. 7th 5%. All lend-lease silver returned to U.S. Surplus Silver sold in London. Bank rate Sept. 19th 7%. Remarkable recovery in sterling.
1958	77⅛—76⅛	76⅝—76⅛	76⅞—76	76⅛—75⅞	76⅛—75⅞	75⅞—74¾	75	75	76½—75	78¾—76½	78 —76¾	76¾—75⅞	76 7/32	8,773,373	4,374,813	2,122	3,993,394	5⅜ „	249 9·51	1958	Recovery in Sterling continued. Bank Rate Mar. 20th 6%, May 22nd 5½%, June 19th 5%, Aug. 4th 4½%, Nov. 20th 4%. Partial convertibility of Sterling, Dec. 29th.
1959	76⅝—75⅞	78—76⅝	79⅜—78¾	79⅜—79⅛	79⅛—78⅞	78½—78¼	78⅝—78	79—78⅝	79—78¾	80¼—79⅛	80¼	80¼	78 13/16	5,886,662	3,850,618	56,394	6,059,016	4 „	249 10·34	1959	More countries return to silver coinage. Labour troubles in the U.S.A lead to temporary shortage of silver both here and abroad.
1960	80¼—79½	79½	79½—79	79¼—79	79⅜—79¼	79¼	79¼	79¼	79¼	79½—79¼	79½	79½—79⅜	79⅜	8,782,789	2,843,879	Nil	9,673,649	5 11/32 „	251 2·33	1960	Credit squeeze. Bank rate 6% 23rd June. Congo chaos. Rumours of devaluation of U.S. dollar cause rush of speculative gold buying. Highest quotation over $40 per ounce (20th October).
1961	79⅝—79⅜	79⅝	79⅝	79⅝ —79⅜	79⅜	79⅜	79¾—79⅜	79¾	79¾	80—79¾	85½—80	88¾—84	80¼	11,920,602	8,975,284	233,988	21,605,272	5 21/32 „	250 11·84	1961	China a large seller of silver. Bank Rate 7% July 26th. U.S. Treasury stops selling silver to industrial users. Sharp price advances in New York and London.
1962	88¼—85½	86½—84½	84⅝—84½	84½—84⅜	84⅜	89—84⅜	88½—86⅛	95¾—88½	103¾—96¾	104¼—100	103—101	103¾—102¼	91½	13,105,320	14,953,036	800,502	15,377,745	4 27/32 „	250 1·03	1962	Bank Rate 4½% 26th April. Mexico stops selling silver in New York, Sept. 24th Record high prices for silver in London and New York in October.
1963	107½—103⅞	107⅝—107½	110—107⅝	109¾—108¾	110⅜—109	110⅛—109⅝	111¼—110¼	111¼—111	111⅝—111¼	111¾—111⅝	111¾—111¾	111¾—111¾	110⅛	11,802,100	12,623,510	213,810	9,807,366	4 „	250 6·90	1963	U.S. Silver Purchase Act repealed. Futures market reopened June 12th. President Kennedy assassinated Nov. 25th. U.S. Treasury sells silver at 129·293 cents per ounce.
1964	111¾	111⅞—111¾	111¾	111¾	111¾—111⅝	111¾—111⅝	112—111¾	112	112¼—112	112¼	112¼—112⅛	112⅛	111 15/16	6,580,400	9,968,093	Nil	29,115,198	5 1/16 „	251 3·82	1964	Heavy sales of U.S. Treasury silver continue. New York price unchanged at 129·3 cents. London prices reach new record levels. Bank Rate 7% 23rd November.
1965	112⅛	112⅛—112	112	112—111⅝	111⅝	111⅝—109¾	111⅝—111½	111⅝	111⅝—110⅞	111⅜—110¾	111⅜	111⅜	111 9/16	13,218,400	9,763,004	221,293	19,316,841	6 7/16 „	251 3·33	1965	Death of Sir Winston Churchill. Rhodesia makes Unilateral Declaration of Independence. U.S.A. Coinage Act 1965 passed. Heavy sales of U.S. Treasury silver continued. Bank Rate 6% June 3rd. U.S.S.R. ships 9 million ozs. Silver to U.K.
1966	111½—111⅜	111½—111⅜	111⅝—111½	111⅝	111¾—111⅝	112—111¾	112¼—112	112⅛	112⅛—112	112—111⅞	111⅞	112—111⅞	111 13/16	18,054,400	19,007,999	389,315	25,510,315	6 15/32 „	251 9	1966	Sales of U.S. Treasury silver continue. New York price unchanged at 129·3 cents. Bank rate 7% 14th July. Credit squeeze. Gold in demand.
1967	111⅞—111¾	111¾	111¾—111⅝	111⅝—111½	133¼—111½	150—137½	161—141¾	160—143½	149—143	164—147	220—161	221—197	141 11/16	6,766,000	9,532,907	306,655	36,031,194	6 5/32 „	256 5·18	1967	Silver sales by U.S. Treasury ceased 18th May; wide fluctuations follow. Heavy buying of gold and silver due to currency fears. Sterling under pressure, devalued to $2·40 17th November. Bank rate 8%. Gold in heavy demand November and December.
1968	222 —195	210 —191	250 —212	240 —210	257 —225	**259**—243½	253 —224	234 —207	229 —218	215 —185	215 —191	205—195½	219 7/16	26,782,435	25,005,781	296,541	113,653,857	7 7/16 „	327 6·63	1968	Distrust of currencies continues. Gold Market closed March 15-31, following exceptional demand. Gold Pool abandoned. Two-tier system operative. French franc under heavy pressure. Free market gold price reaches $42.60 Wide fluctuations in silver due to speculative pressures.
1969	197 —205½	177½—199¾	180¼—193½	177½—184	175¾—186	156½—178	157½—169	160½—172	170 —190½	181½—195	187 —200	172½—192½	180 11/16	128,297,300	35,271,997	103,221	93,620,864	7 13/16 „	343 11·57	1969	Continued fluctuations in gold and silver prices. French franc devalued 9th August. German mark revalued 25th October. Agreement reached by the I.M.F. and South Africa on gold sales at end of year. Free market price touched $35 in December.
1970	180 —192	186 —190½	185¼—192¼	172 —188½	175 —156¾	161 —168½	160½—179	173½—187¾	171 —188	171⅝—180¾	166 —183½	158⅝—167½	176⅞	39,071,000	22,268,784	423,904	49,731,709	7¼ „	300 2·19	1970	South African gold sales to I.M.F. and free market continue. U.S. Treasury withdrew from silver market 10th November. Since 1963, more than 1700 million ounces from their stock were marketed or utilised for U.S. coinage.
Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Avge.	★ Cupro-Nickel Coinage	● Exports of Bar Silver	Export of Silver to the East.	Imports of Silver Bars and Coin.	Average Bank Rate of Discount.	s. d. Average Price of Gold.	Years.	Remarks.

NOTE.—A From 1833–1944 the price of Bar Silver is quoted per oz. standard (·925 fine), thereafter per oz. ·999 fine.

NOTE.—B From 1833–1918 the price of Gold is quoted per oz. standard (·9166 fine), thereafter per fine ounce.

* Including bills on China for this year only. (The East India Company had the monopoly of the trade with China up to 1833.)
† The above totals from 1833 to 1850 include exports from other countries as well as England —from 1851 to 1875 from Southampton only—from 1876, shipments *via* London, Venice and Marseilles.
§ Approximate.
‡ No figures available.
‖ 6 months, July—December.
¶ 8 months, January—August.

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Northwestern Exploration Division
John C. Balla
Manager

April 21, 1983

Mr. Stan H. Huff
Chief Geologist
Northwestern Mining Department
ASARCO Incorporated
P.O. Box 440
Wallace, ID 83873

Road Log-South Adit-Troy Mine
Belt Symposium

Dear Stan:

Enclosed is a copy of Tim Hayes' road log to the south adit, which is to be published in the Belt Symposium guidebook. It may undergo significant editorial change, due to its length.

Very truly yours,

John C. Balla

JCB/dt
Enclosure

cc: R.L. Brown with enclosure
W.L. Kurtz " "
S.A. Anzalone" "
John Breen " "

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Stop 7.

Strata-bound copper-silver mineralization was discovered by Clyde Wetherell of Bear Creek Mining Company (the exploration subsidiary of Kennecott Minerals Corporation) on the north side of Mt. Vernon in 1963, and on the south side of Mt. Vernon, at stop 7, in 1964. From 1964, when the first drill hole was drilled, until 1972 Bear Creek explored and developed the property. In 1973 ASARCO leased the property from Kennecott. The mine began limited production in late 1981 and reached its full production rate of 8,500 tons per day in early 1982. Annual production is 4.2 million troy ounces of silver and 40 million pounds of copper. Ore reserves at the beginning of mining were 64,000,000 tons with a grade of 0.76% Cu and 1.58 troy ounces/ton silver.

At stop 7, the mineralized middle quartzite of the upper Revett formation is exposed. Mineralization consists of bornite, digenite, chalcocite, chalcopyrite, along with various copper oxides (tenorite, chrysocolla, brochanite, malachite, and neotocite). The outcrops are located about 2,300 feet south of the south end of the orebody, and are separated from the orebody by faulting. A stratigraphic rock chip sample of the mineralization assays 52 feet with an average grade of 0.29% Cu and 1.21 troy ounces/ton silver.

At the east end of the outcrop area, the bottom of the middle quartzite is in contact with the top of the lower silty. Further to the east, in the gully, is the east fault, which is not exposed in the road cut.

Stop 8. The South Adit into the Troy orebody, also known as the Spar Lake deposit.

GEOLOGIC BACKGROUND

The strata-bound Troy orebody occurs where Middle Quartzite beds of the Upper Revett Member are coincident with a zone of digenite-bornite-native silver dissemination (Figures 2 and 3). Before faulting the orebody was a map-view "finger" with lateral boundaries curving from southeast to north-northwest (Figure 1). Ore solutions permeated along the beds from southeast to northwest, and probably also upwards, during diagenesis.

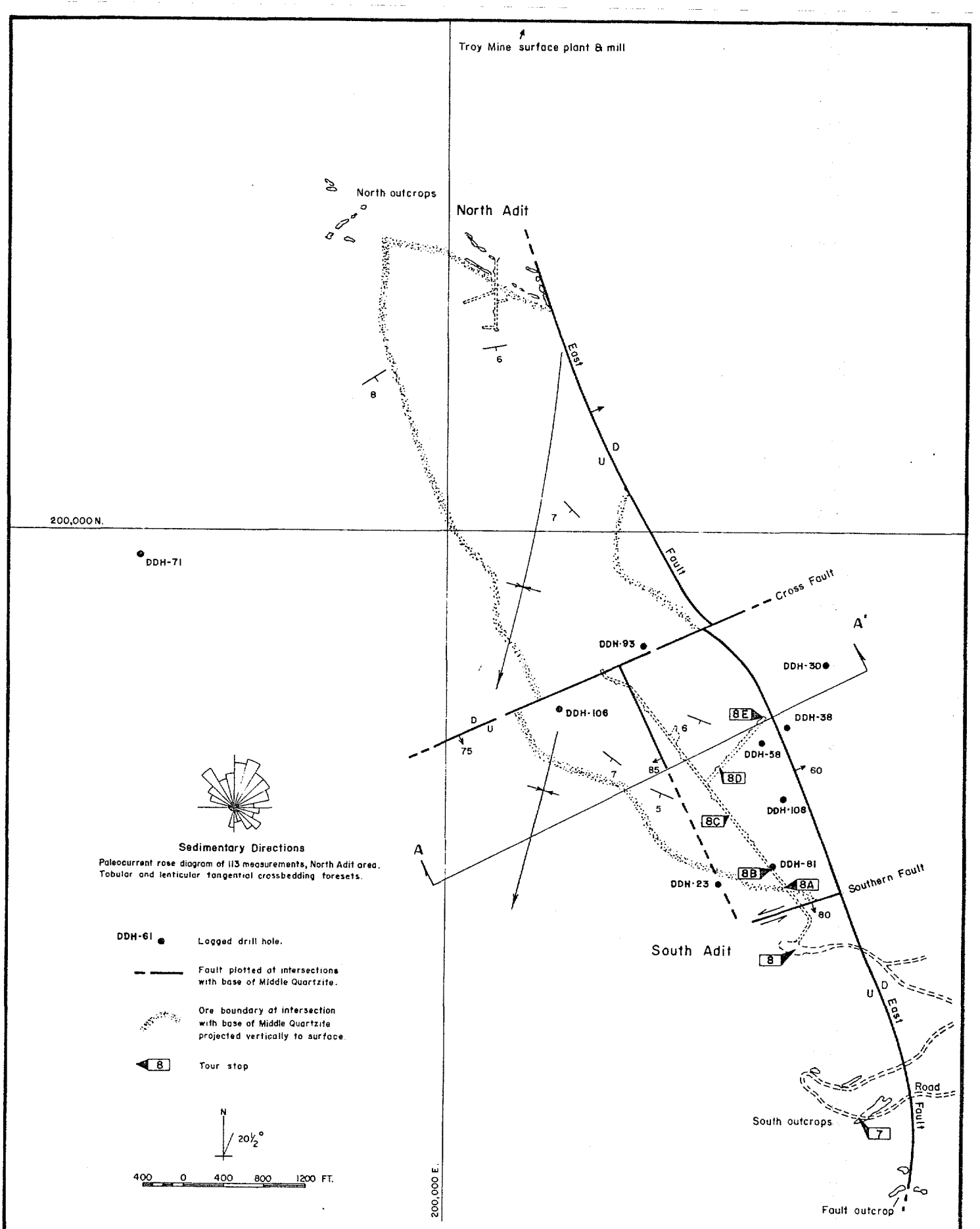
The orebody is eroded on the north and bounded eastward in most areas by the East Fault, a zone of normal faulting, east side down (Figure 1). Mineral zonation boundaries which define the limits of ore within Middle Quartzite are subparallel to, but predate the fault. Both stratigraphy and mineral zonation are offset, so mineralizing solutions did not emanate from the East Fault zone. Vertical stratigraphic throw on the East Fault zone is around 330', with very little strike-slip throw evidenced.

The western ore boundary is a grade cutoff defined in the Middle Quartzite where digenite-bornite-silver (dig-bn-Ag) is zoned westward to chalcopyrite (cpy), and then, in order westward, to galena (gn) and pyrite (py) (Figure 3).

The southern boundary is a post-ore, left-lateral, strike-slip fault which juxtaposes dig-bn-Ag zone on the north, with pyritic Middle Quartzite on the south.

The orebody is broken into two blocks, north and south, by the Cross Fault, a south-dipping reverse fault which displaces the south block 210' vertically above the north.

The Mt. Vernon synclinal axis curves from south to south-westward across the north ore block, plunging at about 7° (Figure 1). Ore in the south block all lies on the southwest-dipping flank of the syncline, where bedding undulates between southwest dips of 5 to 10°.



SPAR LAKE (TROY) OREBODY PLANIMETRIC MAP
PRE-1980 DEVELOPMENT SHOWN

Figure 1.

T. HAYES

SEDIMENTARY GEOLOGY OF THE UPPER REVETT MEMBER FROM DDH-93,

near center of orebody

Scale : 1" = 40'

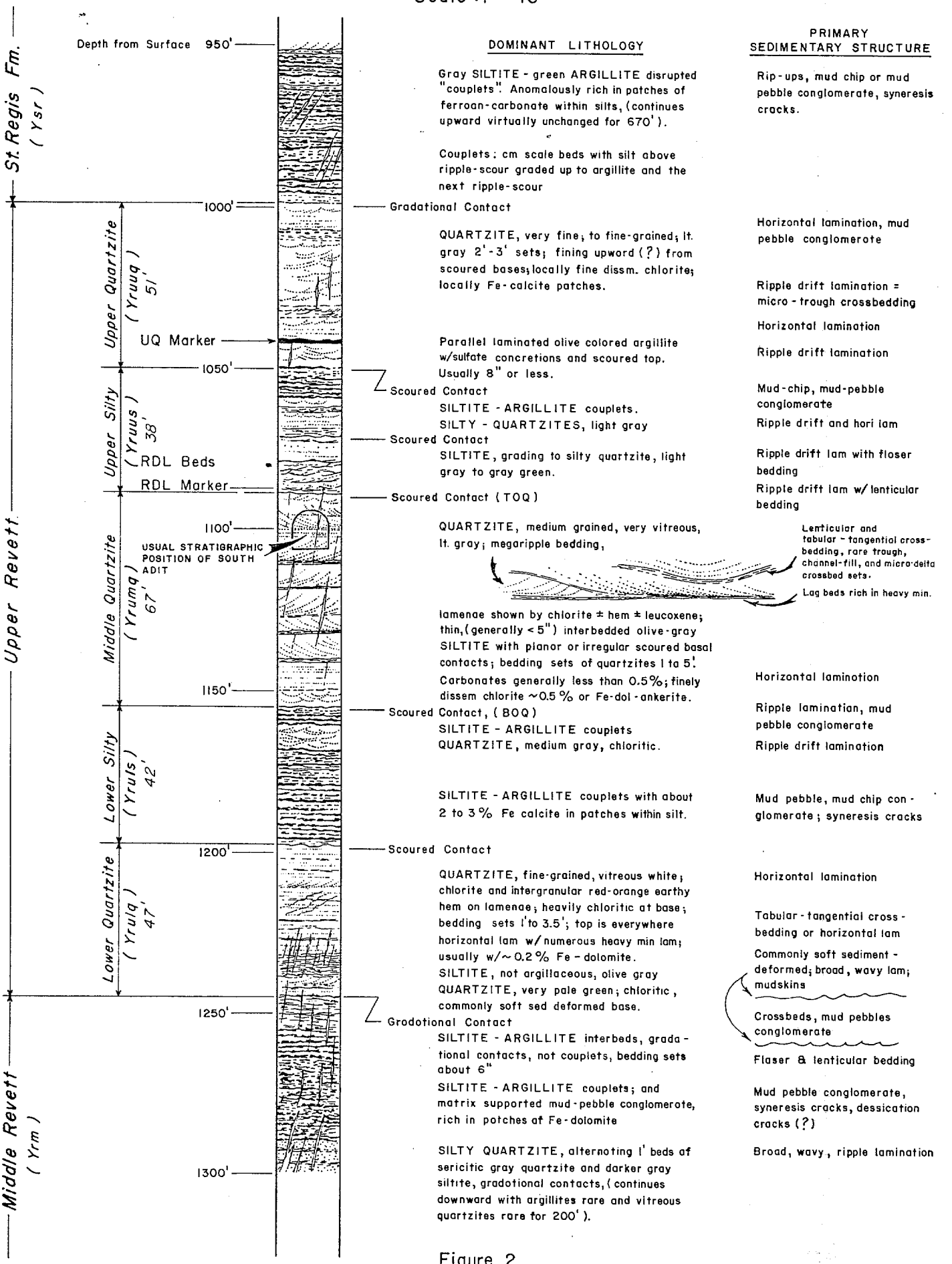
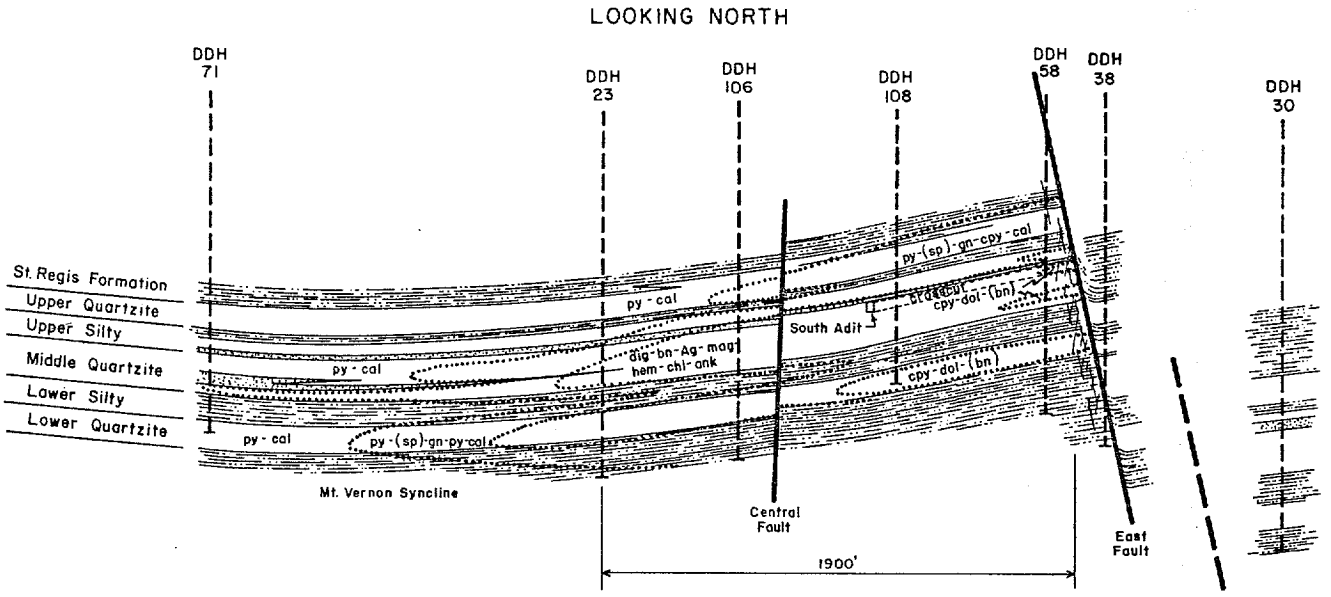


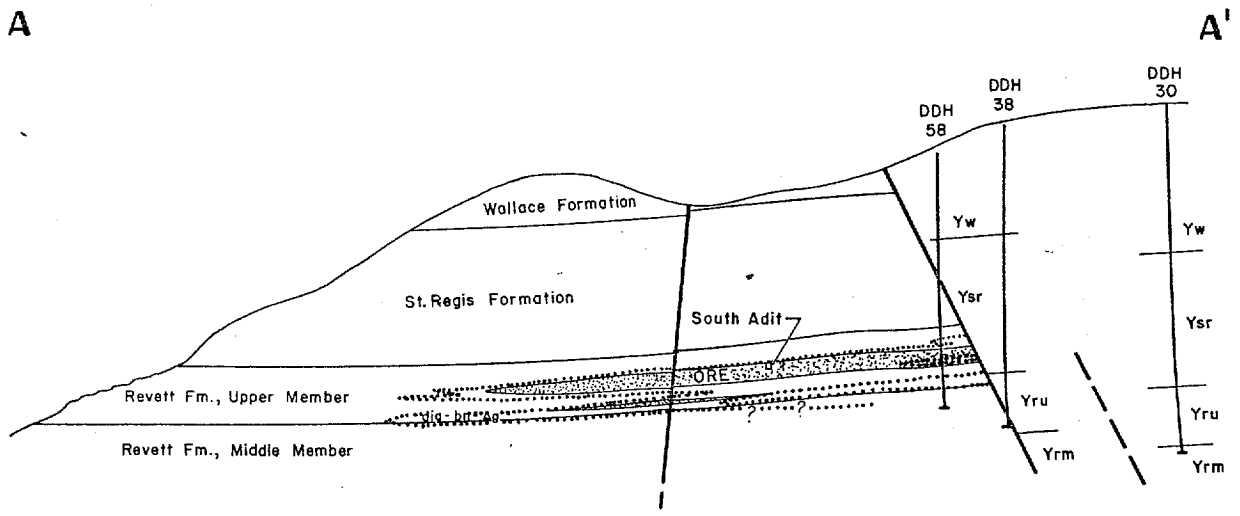
Figure 2.

T. HAYES



ZONATION : 2.5x VERTICAL EXAGGERATION

Thick-bedded, vitreous quartzites | Siltites, medium to thick-bedded | Argillaceous siltite, thin-bedded couplets



UNEXAGGERATED SECTION LOOKING NORTHWEST

0 500 FT.

SPAR LAKE DISSEMINATED MINERAL ZONATION AND ORE DISTRIBUTION

Figure 3.

T. HAYES

The south and north blocks total 64 million tons of 0.76% Cu and 1.58 Tr. oz/T Ag. Bulk grade distribution is remarkably uniform despite many small-scale concentrations of ore minerals.

Principal ore minerals are bornite, digenite ($(Cu, Fe)_9S_5$, usually very close to $Cu_{1.8}Fe_{0.0x}S$), chalcocite, and native silver, occurring mainly as 0.1 to 0.5 mm disseminations with irregular (intergranular?) shapes. Many grains are vermicular exsolutions of dig and bn, or chalcocite and bn, some with trace native Ag as equant, exsolved grains, 5 to 20 microns. Minor minerals are disseminated stromeyerite and chalcopyrite, and veinlet tetrahedrite, bn, cpy, and native Ag. Minor supergene minerals include covellite, chalcocite, native Cu, native Ag, brochantite ($Cu_4SO_4(OH)_6$), malachite, cuprite, and cupriferous goethite (glassy limonite, copper pitch, neotocite), but oxide copper minerals are not recovered.

Mineral Zonation and Paragenesis

The most informative aspect of Spar Lake geology is the exceedingly regular mineral zonation. The spatial sequence of zones (highly generalized) is drawn perpendicular to the inferred major direction of ore solution movement in Figure 3. Zone boundaries are mapped by appearance or disappearance of single mineral phases, vertically within stratigraphy using adjacent drill holes, or continuously along drift ribs. All mineral boundaries are parallel and cross at a low angle through and across beds. Zone boundaries "nose" or "tongue" northwestward in metasandstones and "tail" southeastward across argillites (Figure 3).

The spatial sequence of Spar Lake sulfide and oxide mineral zones is virtually identical to other large red bed-evaporite associated strata-bound copper deposits (Brown, 1980). The same paragenetic sequence of sulfides and oxides is found at every unmetamorphosed deposit (Brown, 1978), i.e. replacement: (1) of pyrite by chalcopyrite, galena or sphalerite; (2) of pyrite or chalcopyrite by bornite + magnetite; and (3) of pyrite, chalcopyrite, or bornite by chalcocite + hematite. In short, pyritic zones were impinged-upon and replaced by lead-zinc zones which were, in turn, impinged-upon and replaced by the bornite and

chalcocite-bearing ore zones. These relations require introduction of a copper-rich, mildly oxidizing solution at the chalcocite side (Rentzsch, 1974).

At Spar Lake, many preserved microtextures are post-ore, load metamorphic -- e.q. magnetite-sulfide intergrowths with euhedral magnetite, porphyroblastic outline (Harrison, 1974, p. 357) and quartz-sulfide-ankerite intergrowths with porphyroblastic rhombohedral outline. Ubiquitous dig-bn exsolution is additional evidence of metamorphism to temperatures above 335° C (Kullerud, 1960).

Because sulfide and oxide zonations of Spar Lake are the same as unmetamorphosed deposits, and because the "nosing" and "tailing" of zone boundaries also suggests solution movement directed from the dig-bn-Ag side into the py zones, it is inferred that the original paragenesis was as in other deposits of this type.

At Spar Lake, gangue mineral zonation of carbonates, chlorite, oxides, and barite parallels the sulfide zonation. Using the same time inferrence as for opaque minerals, the distribution of these gangue minerals is inferred to represent zoned alteration.

Facies Controls of Strata-bound Mineralization

Among the small-scale features displayed underground is the high selectivity of mineralization for one lithology, the vitreous quartzites. The hangingwall for much of the orebody is the base of Upper Silty (Figures 2 and 3). The footwall is the top of Lower Silty. Clark (1971) stated that lateral boundaries of mineralization in quartzite appear to coincide with facies changes where the vitreous quartzites grade laterally to "argillaceous quartzite." Thus, there is confinement of the ore to the coarsest-grained lithology of the Revett Formation laterally, and generally also vertically.

This "facies control" of ore results from two properties of the quartzites: (1) better ingergranular permeability, and (2) the presence of reactive mineral constituents which were replaced to fix the metal sulfides. Metal-fixing reactants may have included early diagenetic pyrite, organic carbon, and, possibly, calcite cements.

This tour will emphasize mineral zonation and its relation to sedimentational facies, and will relate later geologic features to these.

TOUR OF THE SOUTH ADIT, SPAR LAKE (TROY) DEPOSIT

The South Adit explores the top of the orebody and intersects the Southern, the Cross, and the Central Faults. It also intersected the East Fault, but the drift collapsed within the fault zone.

The first 500' of the drift are within surface-oxidized, py-calcite-bearing Middle Quartzite, faulted eastward by the Southern Fault. The drift crosses stratigraphy only very slightly, displaying only the top 30' of Middle Quartzite. However, the ore-defining zonation cuts stratigraphy, so all mineral zones of the deposit are displayed.

Sedimentation and load-compaction features and post-ore veinlets and small faults are the most obvious features; mineral zonation is quite cryptic without hand lens inspection.

The five stops chosen will display both general characteristics and specific relations bearing on the timing of various geologic events.

0 point at the portal. (Stops plotted on Figure 1).

First exposed rocks (160') are 18 to 30' below the top of Middle Quartzite.

275' Adit curves northwest, heads N 38° W from here to the Central Fault, crossing slowly into the zonation.

500' Lagging covers the Southern Fault, with no vertical throw here, but several hundred feet of post-ore, left-lateral throw, displacing pyritic rocks (south) against the margins of bn-bearing zones (north). Notice the first appearance of copper oxides immediately past the lagging. By continuing north we move along stratigraphy but cross from the lateral margins of the dig-bn-Ag zone into ore.

560 to 660' STOP 8. ENTRY INTO ORE.

17 to 29' below the top of Middle Quartzite.

A ripple-laminated, vitreous quartzite bedding set near the sill (map unit 2) grades laterally from cpy-trace bn (0.3 vol-% sulfides, 0.2% Cu, tr. Ag) at 560', to dig-bn-magnetite(mag)-cpy (1 vol-% sulf., over 1% Cu, 2 oz. Ag) at 660'. Some polymineralic clots with magnetite, an increase in calcite, and a coarser disseminated sulfide grain size accompany the change to ore. This is the lateral boundary of ore within this bedding set.

Silicate grain size and bedform (ripple-lamination = small scale trough crossbedding) are continuous, so depostional facies does not control the actual ore boundary at this locality.

The orebody, itself, is the most sulfur-rich rock yet found in the Revett. Sulfur is added in moving from "distal" zones into "ore," and this cannot be explained by sedimentation alone. If py replacement was the only cause of ore fixation, then an abrupt change in the amount of diagenetic, pre-ore pyrite occurred without any change in sedimentary host. If carbonate is the product of organic carbon, in-place organic mats (not transported because the bedform is continuous into poorly mineralized and poorly calcareous rocks) may have provided C_{org} to produce the locally reducing conditions needed to form early diagenetic pyrite concentrations.

Alternatively, both sulfides and carbonate could be products of the ore-fixing reactions, if sulfate was transported with copper, and reduced to sulfide with the coupled oxidation of C_{org} to carbonate.

A third possiblity is reaction between two pore fluids at a solution interface, each solution providing some of the constituents of the ore zone minerals.

660 to 890' Beautiful examples of the characteristic, medium-to thick-bedded sets of tabular-to-lenticular, tangential crossbedding of the Middle Quartzite, usually accentuated by ferroan calcite along certain foresets.

890 to 930'. STOP 8B. MINERALIZATION SELECTIVITY FOR QUARTZITE, MINERAL ZONATION, BEDDING PLANE FAULTS, SULFIDITES, MIDDLE QUARTZITE BEDDING TYPES, AND THE GENERAL NATURE OF "FACIES CONTROL".

12 to 23' beneath the top of Middle Quartzite.

Two units that are finer-grained than average are exposed here, separated by crossbedded quartzites. Near the sill is the "B" unit, a flaser-lenticular bedded quartzite-in-siltite, which shows the favorability of quartzite lithology -- quartzite lenses have much greater vol-% sulfides than the enclosing siltier matrix.

Moving upward from within "B" at 890 is a "normal" vertical zonation: from dig-bn-Ag-mag-(cpy) at the sill upward to cpy-only near the top of "B", and cpy-gn at the top of "B" (and in the crossbedded quartzites above). Calcite is present throughout.

Moving northeastward from the drift into the bay, the uppermost sandy lenses within "B" have changed from the cpy-gn assemblage, to the dig-bn-Ag-mag-(cpy) assemblage, an example of the northeastward rise of zone boundaries across the stratigraphy.

Bedding plane faults with small, post-ore movements which offset zonation are present, at the top of "B" and the base of the "C" silty set, but are not found in all parts of the mine.

Within the "C" are 2 or 3 bed-conformable layers of nearly pure cpy, termed sulfidites. At a few locations these sulfidites appear to be bedding plane veinlets with terminated quartz crystals growing inwards toward their centers. However, at many more locations, sulfidites change thickness laterally to become quartzite lenses with greater vol-% sulfides, identical to that seen in "B". The "B" unit 200' to the SE looks almost exactly as "C" does here. The thickening of sulfidites to sandy lenses and general coarsening of grain sizes was accompanied by a change to a "more proximal" mineralogy. The preferred interpretation is that the origin of sulfidites was as a pinchout of a sandy fluid conduit that became heavily mineralized, the sulfide layers later serving as a weak zonation for dilation to form local bedding plane veinlets.

Sedimentary features are well-displaced here, including the co-set of thickly bedded, tabular-to-lenticular, tangential cross-

stratification sets of medium-grained metasandstones (terminology of McKee and Weir, 1953). Such individual sets may grade laterally through an orderly series of different grain sizes and sedimentary structures, fining to units as represented by "B" and "C", where flaser-lenticular bedding or broad, low amplitude ripple bedding in argillaceous silt are displayed. More commonly, facies changes occur by scour. These are not regional facies changes, as the Middle Quartzite consists of thick-bedded quartzite sets for miles away from the mine area.

The 68-foot thick Middle Quartzite is broken into several, fining-upwards sub-units laterally. Each cycle has a scoured base, crossbedded quartzites, horizontally or ripple-laminated finer-grained vitreous quartzites, and a ripple-laminated silty or argillaceous top. Mineral zone boundaries "nose" into coarser vitreous quartzites of each cycle, and "tail" across the argillaceous silt, indicating probable permeability control of mineralizing fluids. On a more-detailed scale, this facies permeability control is quite imperfect, and there are several examples (the "B" unit here) where a silty, rippled unit within bn-dig-Ag zone is of very good grade.

A tongue of the dig-bn-Ag zone extends to the southwest beneath us within Middle Quartzite, and a tongue of cpy-gn zone extends southwestward into the Upper Quartzite, 60' above us. In the Upper Silty couplets between, is a tail of pyritic dissemination.

1540 to 1610'. STOP 8C. RELATIVE AGE OF VEINLET MINERALIZATION COMPARED WITH THE ZONED DISSEMINATION.

The back is very near the top of Middle Quartzite, and the sill rests atop the "C" silty bed.

At 1540, a bed-conformable layer of densely disseminated dig-bn-Ag-mag is cut by numerous high-angle veinlets. Such layers are more commonly adjacent to silty tops and bottoms of quartzite sets, but may occur "floating" within a set.

The reason for stopping here is to inspect the time relation between veinlets and dissemination. (1) High-angle veinlets in the "9" quartzite begin as virtually barren quartz near the silty

base of the set but become quartz-bn veinlets when they reach the concentrated dissemination in the wallrock. Cu and S for veinlet bornite were derived from the band of dissemination; veinlets do not feed the dissemination.

(2) At 1610, a veinlet intersects a spherical, polymineralic clot of about 2 cm in size composed of dig-bn-Ag-mag-hm. The veinlet mineralogy is barren quartz except within several cm above or below the clot, where there is bn in the veinlet.

These two relations are repeated throughout the adit. Also, (3) depletion envelopes occur adjacent to mineralized veinlets -- for a few cm or less, the wallrock contains less disseminated sulfide, giving the appearance of bleached envelopes, the only differences being a lower % of opaques and coarser quartz in the envelope; (4) veinlet mineralogy changes at, or very close to, and in-parallel-with, wallrock disseminated mineral zone boundaries (755' in the crosscut discussed at stop 8E); and (5) veinlet surfaces appear bedded because constituents mobilized into the veinlet moved so little as to still mimic bedform concentrations of the adjacent wallrock (360' in the crosscut).

2030' Turn northeast into the crosscut which climbs with the dip to near the East Fault.

XC 190'. STOP 8D. MINERAL ZONATION AND ORE RODS.

The "C" silt, here considerably thinned by scour, is 2' above eye level; the sill is 18' below the top of Middle Quartzite.

Note the bed-transgressive nature of mineral zonation. Conformable calcite bands disappear at progressively higher stratigrahic levels from southwest to northeast. A zone boundary between (a) bedform patches of 2% calcite and (b) random, fine dissemination of 0.4% ankerite-ferroan dolomite crosses through stratigraphy, rising to the NE. More cryptic is a magnetite boundary at which mag <u>disappears</u> upwards, paralleling the upward <u>appearance</u> of calcite, rising through the section to the NE. Cpy appears higher up, its boundary also rising through bedding to the NE. Approaching here

from the SW, heavy mineral laminae at the lower "C" contact acquire a very fine, intergranular, red stain (hematite?). Continuing northeastward, the heavy mineral laminae, and the thin lag beds between quartzite sets, become conspicuously reddened.

Continuing to the NE, "ore rods" appear near the sill. The term, "ore rod," is now used for all types of concentrated disseminations of sulfides and oxides which cross bedding at high angles, and includes vertical arrays of clots, vertically elongate clots, sheeted concentrations of dissemination, and the originally named column-like concentrations. In general, ore rods are part of the zonation, restricted entirely to the dig-bn-Ag (ore) zone except for the vertical arrays of sulfide clots. Ore rods can cross between quartzite bedding sets, or end at top or bottom against a lag bed. If they top against a silty bed, they form bed-conformable top concentrations as if they "pooled" against a barrier. Ore rods are a major contributor to the ore grades, do not disrupt the bedding, have been observed only in quartzites, and usually have mineralogy identical with the host quartzite set with more sulfides and oxides. The only exceptions to this rule are those with mineralogies typical of zones below, as will be shown at 8E.

XC 516 A small bench on the SW side of the drift exposes a columnar ore rod. This area also has strongly hematized heavy mineral laminae and lag beds, and is exemplary of the central ore zone, though the ore may have much more chlorite.

XC 830'. STOP 8E. NEAR THE EAST FAULT, END OF THE CROSSCUT.

Bedding plane veinlets related to the East Fault extend SW at least 170' from the fault zone (to about 675' in the crosscut), but densely-spaced veinlets occur only within quartzite wallrocks in a 40'-wide zone parallel to the East Fault. A dense stockwork of veinlets is displayed on the northwest rib. Only within quartzites along the East Fault are veinlets dense enough to produce ore grades within cpy-dominated rock.

Moving NE between XC 650 and here, we have very gradationally entered the chalcopyrite-dolomite-(bornite) zone. At around 755 on

the NW rib, the veinlet mineralogy changed from bn-quartz, to bn-cpy-qz, then to cpy-qz (moving to the NE) in parallel with the wallrock disseminated zonation. Veinlets here cut disseminated cpy-(bn) and are mostly cpy with lesser bn (± qz). Elsewhere, similar density stockwork cuts disseminations without cpy, and the veinlets contain no cpy.

Stockworks along the East Fault are very high-grade but retain the relative Ag/Cu proportions of the disseminated mineral zones they cut. Bornite stockwork ore has higher Ag/Cu (1/90) than chalcopyrite stockwork ore (1/1000), just as disseminated dig-bn-Ag zone has higher Ag/Cu (1/120) than disseminated cpy zone (1/500).

The back here is the top of Middle Quartzite/base of Upper Silty. In contrast to quartzites, silty rocks have fewer veinlets and deform by shear into dragfolds along the East Fault. The dragfold, here, appears reversed to the down-to-the-east throw on the fault. In outcrops on the south of Mt. Vernon, dragfolding is consistent with the throw.

The SE rib, here, has sheeted ore rods of very high grade. Sheeting attitudes in the ore rods can be followed across the drift to more poorly developed ore rods in the same quartzite sets in the NW rib. These ore rods have cpy as the major sulfide, but a central zone of bornite-rich rods with magnetite domes up into the top quartzite set, cutting into a background dissemination with more cpy than bn and with no magnetite. This may be an irregularity in the usual zone boundary between cpy-dol-(bn) and dig-bn-Ag zones, or it may mean that ore rods post-dated and cut the zone boundary and carried the higher metals upwards from below. Remembering the general pattern that ore rods usually appear only within the dig-bn-Ag zone, the conclusion is that ore rod formation was synchronous with, or slightly later than, the formation of the zoned dissemination.

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ASARCO

Southwestern Exploration Division

JDS

February 8, 1983

To: F. T. Graybeal

From: F. R. Koutz

As you requested on February 2 I have collected together a number of silver articles as follows:

* Fischer, 1937, Econ. Geol., V. 32, p 906: Sed. Deposits of Cu, V, U & Ag in SWUS (xerox).

- Proctor, 1953: Geology of the Silver Reef Utah. UGMS Bull. 44.

* Wilson, 1933: Silver District, AZ. AZ Bu. Mine Bull. 134.

* 2 pages from our Silver District files. WLK says he has no other additional notes around. John Teet (N.J. Zn) says he isn't planning a paper for the new AGS Digest and they have found a JV partner-with the lawyers working out details now. We have several inches of old files on the Ag district.

- Robinson, R. W., 1981, Ore Mineralogy & F. I. Study of the S. Amethyst Vein System, Creede (M.S., NMIMT). This is most recent thesis on Creede according to Phil Giudice (Freeport). There is a thesis being done under Tommy Thompson at CSU on the "Silver-Manganese Upper Zone" (your title) by a John Rice - being supported by Paul Eimon @ Pioneer Petroleum. Phil says there isn't really that much MnOx at Creede and thesis is concentrating on sulfide replacement of organic debris-logs in Creede Fm. John Rice was going to do a thesis on World's Fair as of Jan. 1982.

- Kim Howell, 1977, Commonwealth Mine, M.S., U. of AZ.

- The 1927 thesis by Lewis A. Smith on the Commonwealth (E9291-1927-21) was on inter-library loan and I've requested a recall - but it may take several months. The loan copy is missing illustrations and the original closed reserve copy cannot be taken from the library "Treasure Room" nor copied.

* The "field" manual by Norton on one of your favorite mountain ranges tries to be a little too poetic - but is interesting - you can keep up on the 1980's buzz words.

* The "acid mine drainage" by S. A. Dean on Trench tails (from her M.S. thesis) is included for your information.

The xeroxed starred items you should keep - the rest are checked out to me from the Tucson Office Library (I've just obtained the 3 theses). Be sure to read the Barrister article in January 1983 Mining Eng.

F. R. Koutz

FRK/cg

cc: JDS

ASARCO

Northwestern Exploration Division
John C. Balla
Manager

December 22, 1982

Mr. W.L. Kurtz, Manager
Western U.S.A.
ASARCO Incorporated
P.O. Box 5747
Tucson, AZ 85703

Escalante Silver Mine
Utah

Dear Mr. Kurtz:

Mr. David C. Fitch, vice president of Ranchers Exploration and Development Corporation, presented a paper entitled "Geology of the Escalante Silver Mine, Utah," at the Northwest Mining Association Convention in Spokane. Dave was kind enough to send me a copy of his paper, which was an excellent presentation. Since it may be of interest to our various exploration divisions, I am distributing a copy of it.

Very truly yours,

John C Balla

John C. Balla

JCB/dt
Enclosure

cc: R.L. Brown with enclosure
R.E. Gale " "
J.D. Sell " "
D.M. Smith " "
P.G. Vikre " "

ASARCO Incorporated

DEC 27 1982

SW Exploration

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DEC 17 1982
SPOKANE

GEOLOGY OF THE ESCALANTE SILVER MINE, UTAH

David C. Fitch and Michael W. Brady

Ranchers Exploration and Development Corporation
Albuquerque, New Mexico

Presented at the 88th Annual
Northwest Mining Association Convention
Spokane, Washington
Friday, 10 December 1982

INTRODUCTION:

The Escalante Silver Mine, operated by Redco Silver, Inc., a wholly-owned subsidiary of Ranchers Exploration and Development Corporation, is 42 miles west of Cedar City, Utah, on the west side of the Escalante Valley (Fig. 1). The silver deposit is in a relatively wide and continuous quartz vein that outcrops partially and forms a gentle ridge in an area of low, rolling hills.

Knowledge of mineralization on the property dates to 1896 when Heber Holt and Heber J. Grant of Enterprise, Utah, located the original four claims, and subsequently had them patented in 1910. During the following years there was a limited amount of trenching, shaft sinking, and mining, and the first three diamond drill holes were completed in 1929. A small amount of ore was processed in a pilot mill in 1934. The property lay dormant until 1958, when its potential was recognized by Samuel S. Arentz, a prominent mining engineer and consultant. Arentz acquired the property and formed several joint ventures with mining and oil companies that conducted extensive drilling, drifting, mining, and water draw-down tests over a period of 17 years. The deposit remained uneconomic, however, mostly because of low silver prices and significant pumping costs associated with mine dewatering.

In 1975, Ranchers acquired an option on the property because it had significant reserves of relatively continuous silver mineralization with the potential of becoming a successful mine if silver prices improved, and if the mine could be successfully dewatered. A core drilling program was begun in 1979, and as of May 1982, the company had completed 70 core holes, bringing the number of exploratory holes drilled on the property to more than 160 and resulting in significant additions to in-place reserves. At June 30, 1982, the ore reserves within the current mine plan contained approximately 1.7 million tons of ore at an average grade of about 11 ounces silver per ton. Significant quantities of additional geologic reserves are contained both within and ouside the area of the mine covered by the current mine plan. These additional geologic reserves or reserves that may be subsequently deliniated may be incorporated into modified mine plans as necessary, depending on results of drilling and development activities, and economic and market conditions.

Studies were made to develop a method for mine dewatering while preventing adverse effects to the local agricultural irrigation wells, and to select an innovative low-cost mining method. The studies proved successful; a pilot mining and dewatering test began in 1979 as silver prices increased, and full mine development began in 1980. Mill construction began in September 1980, and the mill was operating by August 29, 1981. The mill is currently processing 750 tons per day. A more complete description of the operation is given by Hahne, E. H., this NWMA convention, and Hogan, D. K., and others, 1982.

Acknowledgments:

The authors wish to acknowledge the significant contribution to the geology of the Escalante deposit made by Walt Ashwill, Ranchers Chief Mine Geologist, Tanny Harlin and Don Morrison, mine geologists, and Ed Garrison and Arthur Ehrenberg, staff geologists.

GEOLOGIC SETTING:

There are three principal sequences of rocks in the Escalante Mine area (Fig. 2):

1. A shallow intrusive-extrusive trachyte dome north of the mine;
2. A volcanic sequence that is partly older but mostly younger than the dome;
3. The mine sequence, a dominantly volcaniclastic sequence of rhyolitic composition that hosts the Escalante veins and appears to be younger than the volcanic sequence.

Younger gravel and alluvium cover a large part of the area and obscure the relationship between the volcanic and mine sequences. Because the Utah State Geologic Map is the only published geologic map covering the Escalante Mine area, regional correlation of the above rocks is interpretive at this time. Allen (1979), however, tentatively correlates the mine sequence to the upper part of the Miocene Cove Mountain Formation mapped by Blank (1959) in the Bull Valley area seven miles south of the Escalante.

The mine sequence has been examined in detail over a vertical thickness of more than 700 feet and is dominated by alternating beds of volcanic sandstones, conglomerates with breccias, and ash-flow tuffs. Minor rhyolite porphyry and trachyte outcrop in the upper part of the mine sequence south of the mine. No marker beds are apparent in the mine sequence. Silver mineralization in the Escalante vein appears to be restricted to the thick volcanic sandstone sequence and weakens markedly upward into the overlying flows and extrusive breccias of the upper part of the mine sequence. The host rocks are mostly dusky red-brown and contain 5 to 10 percent hematite. Rounded and angular lithic fragments range up to 8 or 10 inches across and fluvial cross-bedding occurs in places in finer-grained volcanic sandstone. The rock ranges from poorly consolidated to well-cemented, and there is a well-developed envelope of silicification within 50 to 100 feet of the vein that grades outward to a calcite-altered zone.

Rocks in the mine area exhibit only minor structural deformation; and strike N17°E and dip gently 8-10°SW. They are cut by the Escalante vein that strikes N22°E and dips 70°W. The vein outcrops intermittently along a gentle ridge for approximately 2,000 feet until covered on the north by alluvium ranging from 50 to 150 feet thick. Surface drilling has extended the vein an additional 1,500 feet north beneath alluvium. The northernmost extent of the vein has yet to be determined. At the southern part of the deposit, the vein forks into two or three separate veins that again fork to form as many as seven separate veins. Studies are in progress to determine the southern extent of the vein or veins. A low-angle bedding fault cuts and displaces the vein at a depth of about 300 feet. Preliminary data indicates the fault strikes N53°E and dips 8°SW. The fault exhibits an apparent displacement of the upper vein block 40 feet west. At least four other northerly-trending veins cut the volcaniclastic beds southwest of the Escalante vein.

ORE DEPOSITS:

The Escalante deposit occupies the full width of a relatively wide and continous quartz vein with sharp, well-defined walls. Economic silver mineralization extends nearly 3,500 feet along the strike and reaches depths of

more than 800 feet (Figs. 3 and 4). In the deposit, the vein averages 19 feet thick, but locally varies from 5 to a maximum of 45 feet thick. At the outcrop, thickness averages 4 to 6 feet with a gradual increase to 25 or 30 feet at a depth of 200 feet, and then a gradual decrease to 15 or 20 feet thick at depths of approximately 800 feet.

The vein is composed principally of fine-crystalline quartz, with locally significant amounts of calcite, barite, and flourite. Silver minerals are mostly concentrated in the quartz-rich parts in association with finely-disseminated hematite that imparts a dark-gray color to the rock (Figure 5). Silver minerals are not visible in hand specimen and are microcrystalline ranging from less than 10 microns to more than 200 microns in diameter. Dominant silver minerals are argentite and acanthite-jalpaite with moderate amounts of cerargyrite-embolite and rare native silver. There appears to be a correlation between hematite abundance (Fe up to 3%) and silver mineralization. Ore-grade silver mineralization is typically confined to the quartz veins, however, silver values ranging from 2 to 16 ounces per ton locally extend up to 10 feet into silicified wall rock. Although wall rock mineralization is too low-grade and discontinuous to be mined at present, studies of wall-rock potential are being made on a continuing basis.

Cerussite, mimetite, and willemite are common constituents in the ore but there is no direct correlation between silver concentration and lead and zinc values which range up to more than 2%. Malachite, chrysocolla, and a copper silicate have been identified in the ore but are rare. Copper content of the ore is generally less than 500 ppm. Other minor metals include manganese that ranges from 1,000 to 4,000 ppm, and mercury that ranges from 100 to 400 ppb. Trace amounts of gold also occur in the ore. Trace amounts of cadmium, tin, arsenic, nickel, vanadium, molybdenum, and columbium have been detected in several samples. Figure 6 lists minerals identified in the Escalante mine.

Crustification banding across a massive vein is the dominant texture throughout the orebody. The bands roughly parallel vein walls and are composed of finely-crystalline quartz, quartz with hematite inclussions, calcite, or fluorite. Local brecciation of vein material with repeated veining is common. Open vugs lined with drusy quartz are locally present. Individual small bands vary markedly in silver concentration, however, a weighted average grade across the full vein width correlates remarkably well laterally.

The texture and distribution of the ore and gangue minerals indicates that the deposit formed by periodic deposition of vein material, following stages of dilation and fracturing. Preliminary studies suggest an early, black-to-dark-brown, barren-calcite phase that is partially replaced by a later quartz-fluorite phase, then episodic deposition of quartz-sulfide, silver and hematite minerals. There appears to be a late period of clear quartz and calcite deposition lacking silver minerals.

MINERAL DISTRIBUTION:

Although the distribution of minerals is complex on a small scale, a study of mineral variation on a large scale, using total vein analyses, appears to indicate patterns of possible significance for exploration.

Silver mineralization in the deposit ranges from 2 to 4 ounces per ton at the outcrop to an average 5 to 8 ounces per ton in the upper 150 feet of vein. A richer zone, averaging 12 to 18 ounces per ton, extends from 150 feet to about 550 feet deep. This richer zone then grades downward into vein material averaging 8 to 10 ounces per ton at the bottom of the currently defined deposit. The vein contains significant amounts of subeconomic silver mineralization beyond limits of the ore deposit, generally at grades of more than 2 ounces per ton of silver. The distribution of silver averaging more than 10 ounces per ton (Fig. 7) occupies essentially one continuous zone within the vein and extends approximately 3,400 feet along strike, and from a depth of 150 feet to 500 or 600 feet; a vertical interval of some 300 to 500 feet. Although the top of this zone roughly coincides with the present water table and one might invoke a supergene enrichment process, there is a strong possibility that the zone originated as a primary hypogene deposit. For example, oxidized lead minerals occur to the bottom of the zone, indicating a much lower water table at some previous time. Also a major part of the silver is microcrystalline within the quartz and would be unavailable to ground-water solutions; in fact, mill processing requires very fine grinding to recover the silver values.

The distribution of silver mineralization greater than 10 ounces per ton appears closely related to higher silica concentration (Fig. 8), but not to calcite. Most of the higher silver values are in areas containing more than 70% SiO_2, and although ore-grade silver mineralization occurs in areas with greater than 20% $CaCO_3$, this mineralization is not as extensive as with silica.

Fluorite concentration increases to more than 10% towards the base of the high silver zone, somewhat at the expense of calcite and quartz (Fig. 9). Lead concentration increases to more than 2% in the lower parts of the deposit, however, lead distribution is not uniform. Zinc distribution is not shown but roughly follows lead distribution.

Studies are currently being made to determine if there is a uniform pattern of barite distribution which reaches concentrations of more than 10% $BaSO_4$.

EXPLORATION POTENTIAL

A study of the available geologic data and the above distribution of minerals leads one to conclude that favorable criteria for similar deposits are:

1. The presence of a suitable vein host with reasonable continuity along strike and/or dip.
2. Anomalous silver mineralization over a long strike zone in the vein. Values as low as 1 to 2 ounces per ton silver are felt to be significant.
3. Abundant silica rather than calcite or flourite as the dominant gangue mineral.

There are more than 20 prospect pits that expose vein material, yet to be tested by drilling, on the Escalante property, an area of some 17 square miles (Fig. 2). Several of these contain significant silver values ranging up to 8 feet thick averaging 12 ounces per ton of silver. A concentrated program of geologic mapping and sampling is now in progress to determine favorable drill targets which will be core-drilled to test for the presence and extent of silver mineralization at depth. Additional drilling is also

planned to test for ore-grade silver mineralization in the north extension of the Escalante vein and in a new parallel vein on the north end discovered by our previous drilling about 100 feet east of the Escalante vein. Additional drilling is planned to test for a downward extension of the Escalante vein, and to determine the south extent of the Escalante vein.

Based on work to-date, the geologic potential for additional ore deposits is felt to be excellent. The size of the Escalante deposit approaches the rank of a district, and as such, it is likely that there is more than one deposit in the area.

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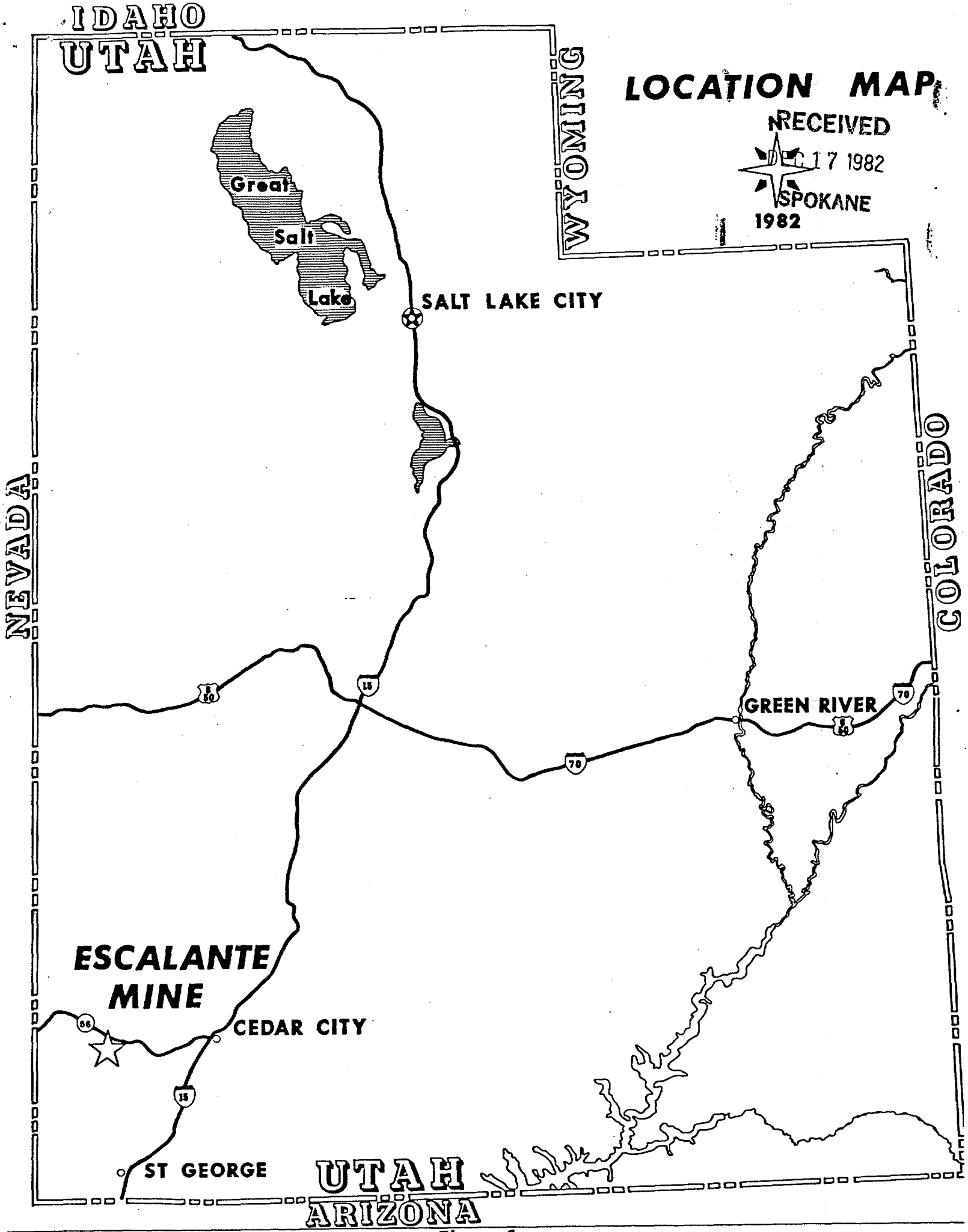
IDAHO
UTAH
WYOMING
LOCATION MAP
RECEIVED
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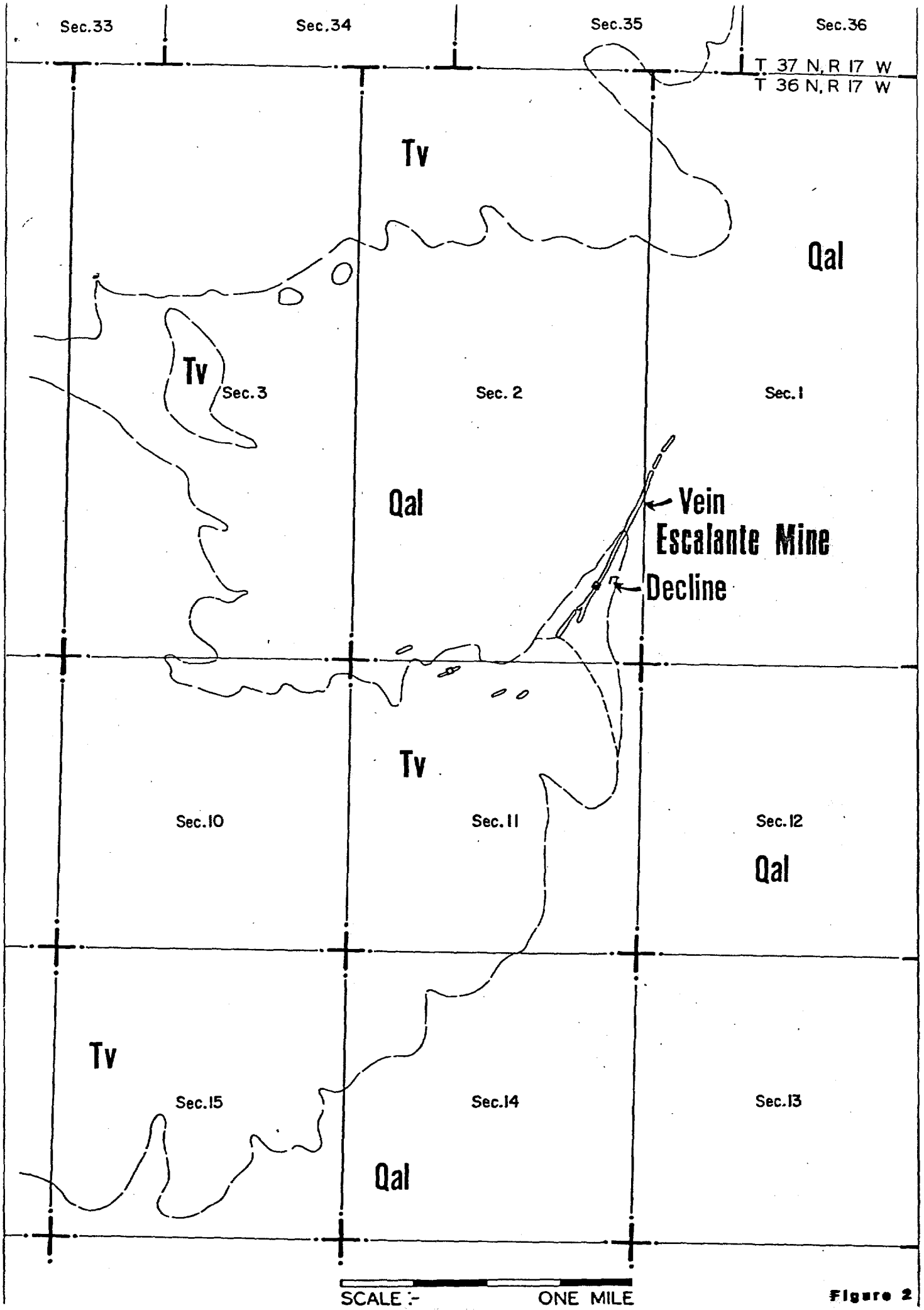
SPOKANE
1982
Great
Salt
Lake
SALT LAKE CITY
NEVADA
COLORADO
15
50
70
GREEN RIVER
ESCALANTE
MINE
56
CEDAR CITY
ST GEORGE
UTAH
ARIZONA

Figure 1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Escalante Mine
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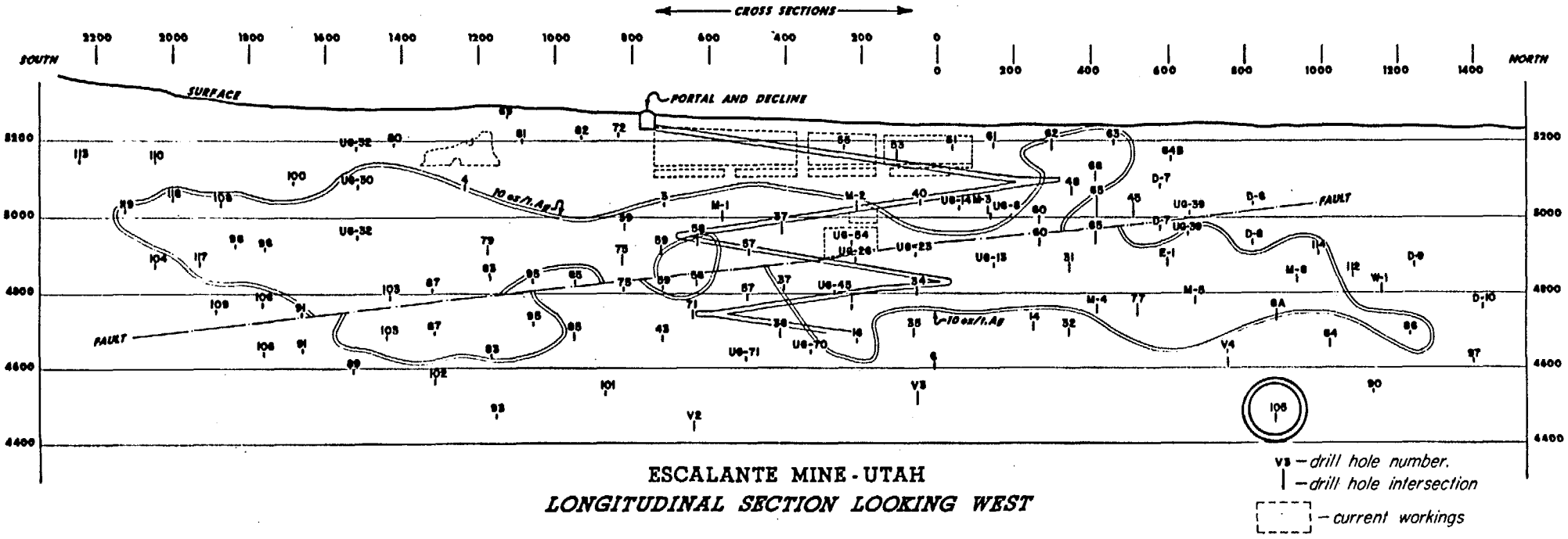
SCALE :-
ONE MILE

Figure 2



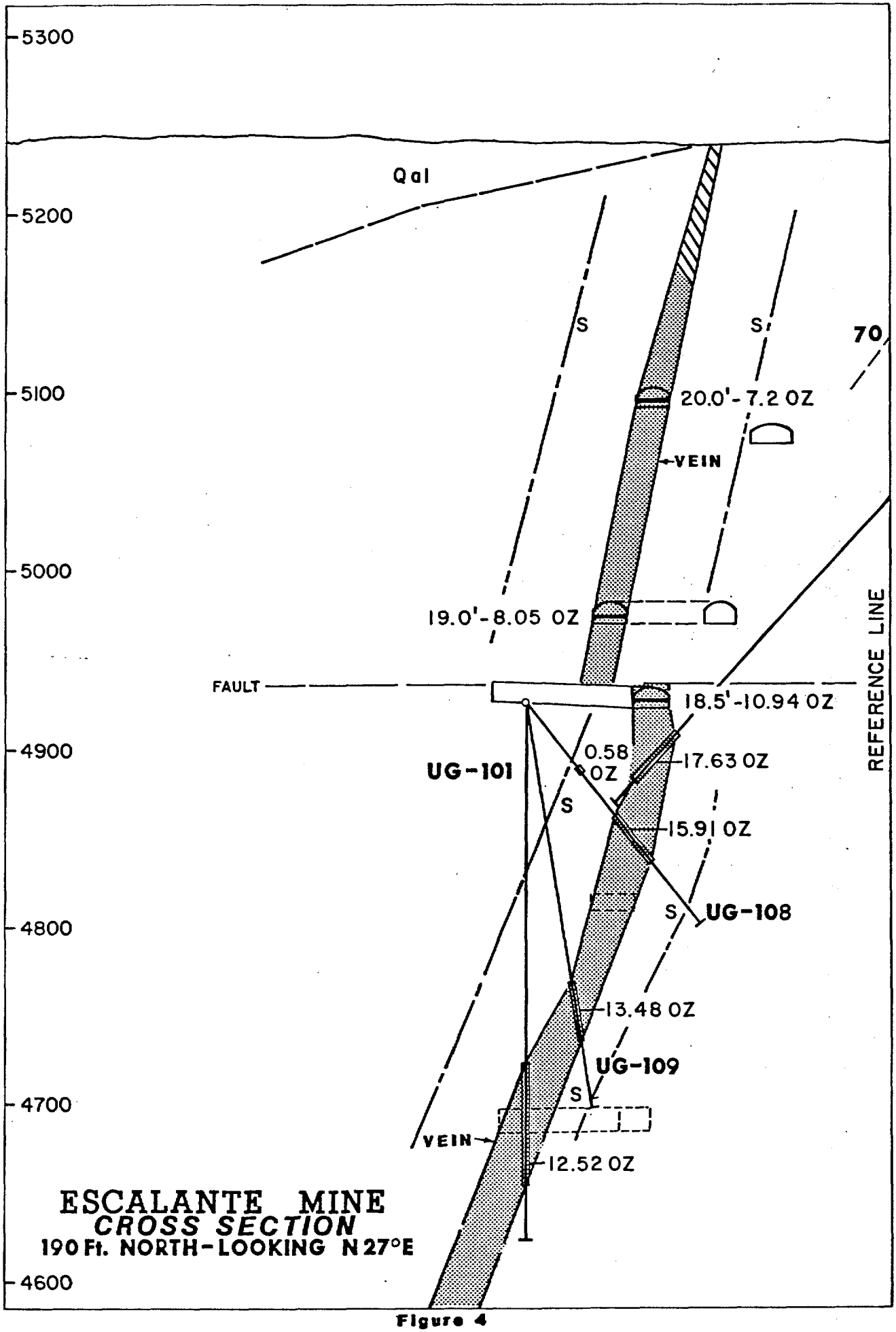
ESCALANTE MINE - UTAH

LONGITUDINAL SECTION LOOKING WEST

V3 — drill hole number.
| — drill hole intersection
[ ] — current workings

Showing distribution of silver and mine workings

Figure 3


5300
5200
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Qal
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70
20.0'-7.2 OZ
VEIN
19.0'-8.05 OZ
FAULT
18.5'-10.94 OZ
REFERENCE LINE
0.58 OZ
17.63 OZ
UG-101
S
15.91 OZ
S
UG-108
13.48 OZ
UG-109
S
VEIN
12.52 OZ
ESCALANTE MINE
CROSS SECTION
190 Ft. NORTH-LOOKING N 27°E

Figure 4

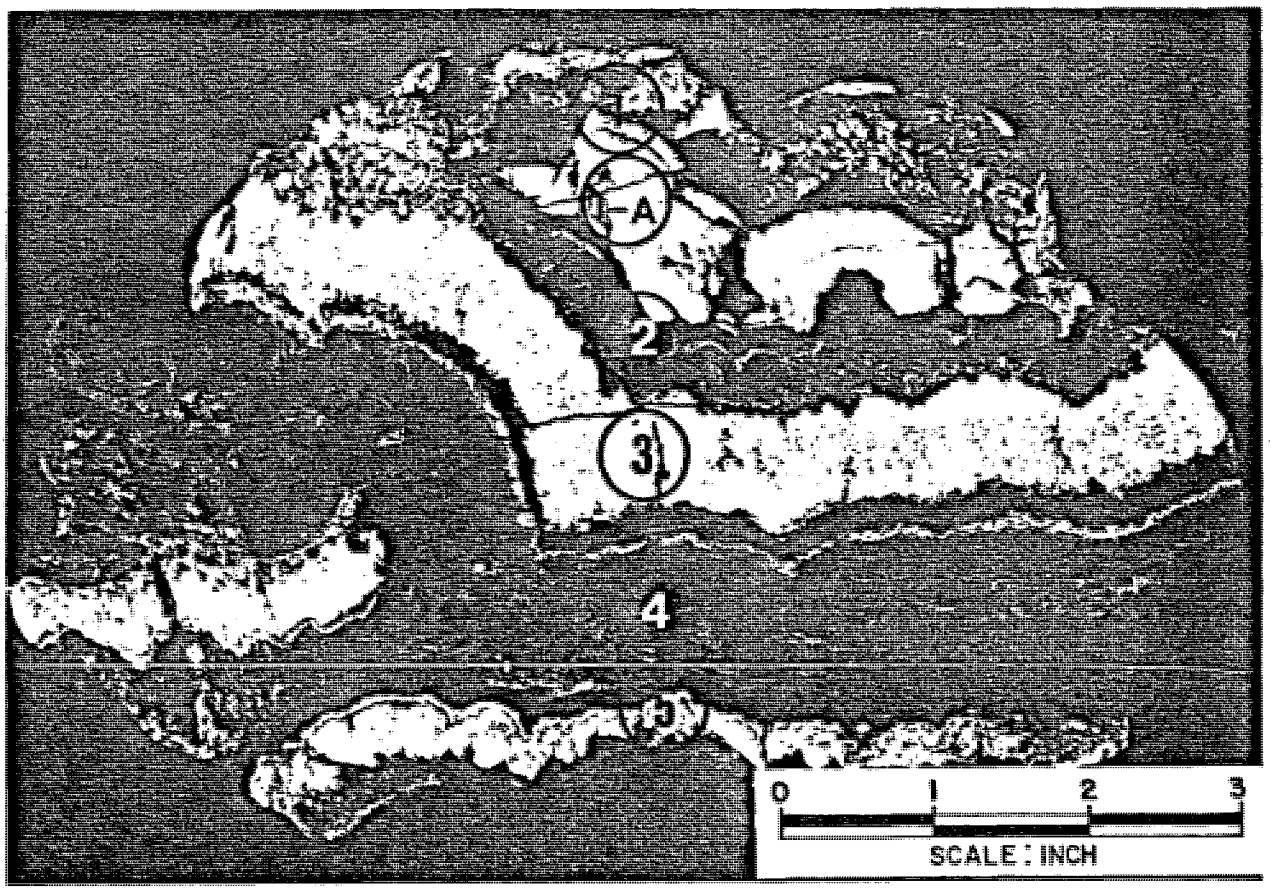

FIGURE 5 Photograph of typical Escalante vein sample from depth of 150 ft. The sample consists of alternating dark and light-gray quartz. Silver mineralization is concentrated in the dark, hematite-rich bands.

Figure 6

ESCALANTE SILVER MINE

Table of Minerals Identified

Ore Minerals	Approximate Abundance
argentite	common
acanthite-jalpaite	common
cerargyrite	common
ambolite (chlorian bromargyrite)	common
native silver	rare
Lead Minerals	
galena	common
cerrussite	common
mimetite	common
leadhillite	rare
Zinc Minerals	
willemite	minor-common
sphalerite	common
hemimorphite	minor
smithsonite	rare
Copper	
copper silicate (unidentified)	minor
malachite	minor
descloizite	minor
chrysocolla	minor
OTHER	
gold	trace
hematite	abundant
geothite	abundant
pyrolusite	rare to common
Gangue Minerals	
quartz	abundant
calcite	locally abundant
barite	locally abundant
fluorite	locally abundant

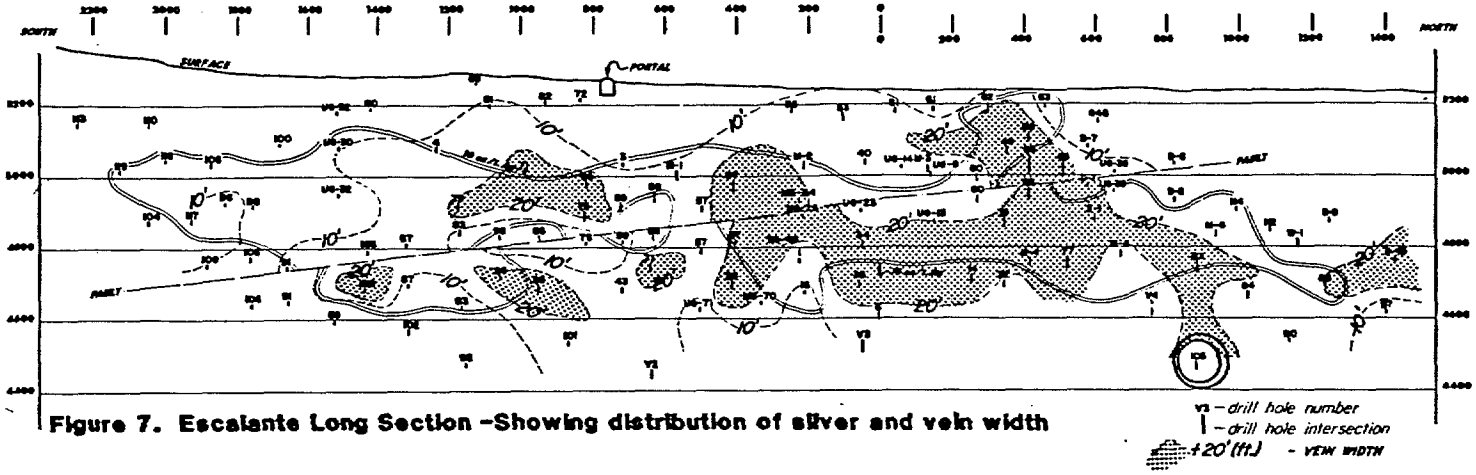

Figure 7. Escalante Long Section –Showing distribution of silver and vein width

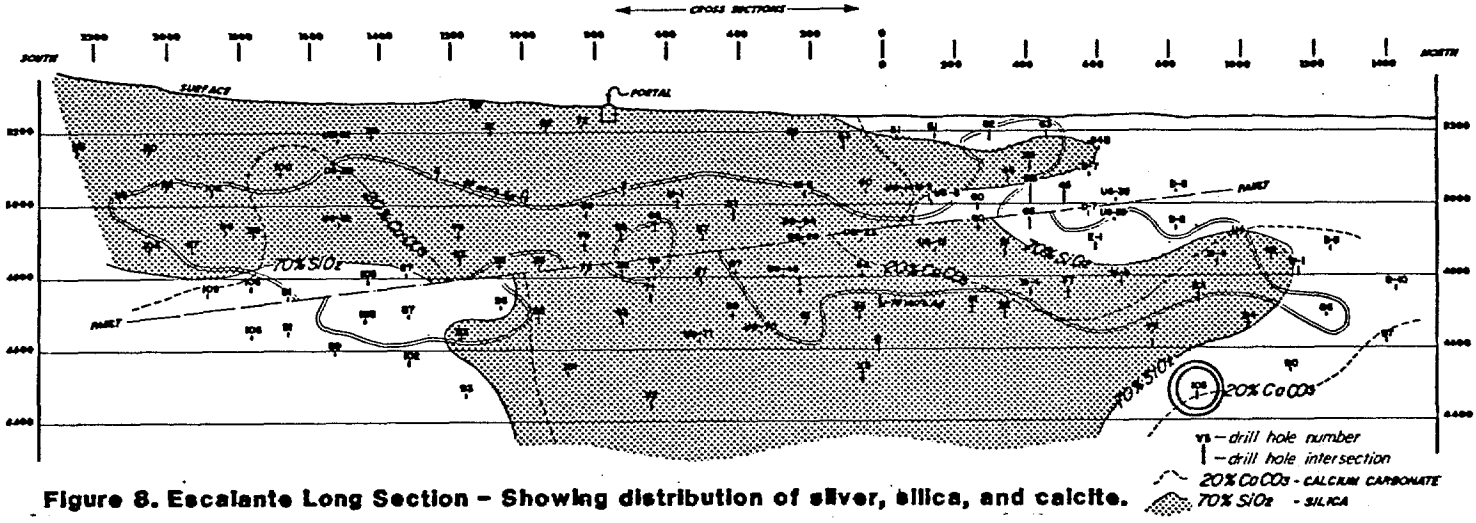

Figure 8. Escalante Long Section – Showing distribution of silver, silica, and calcite.

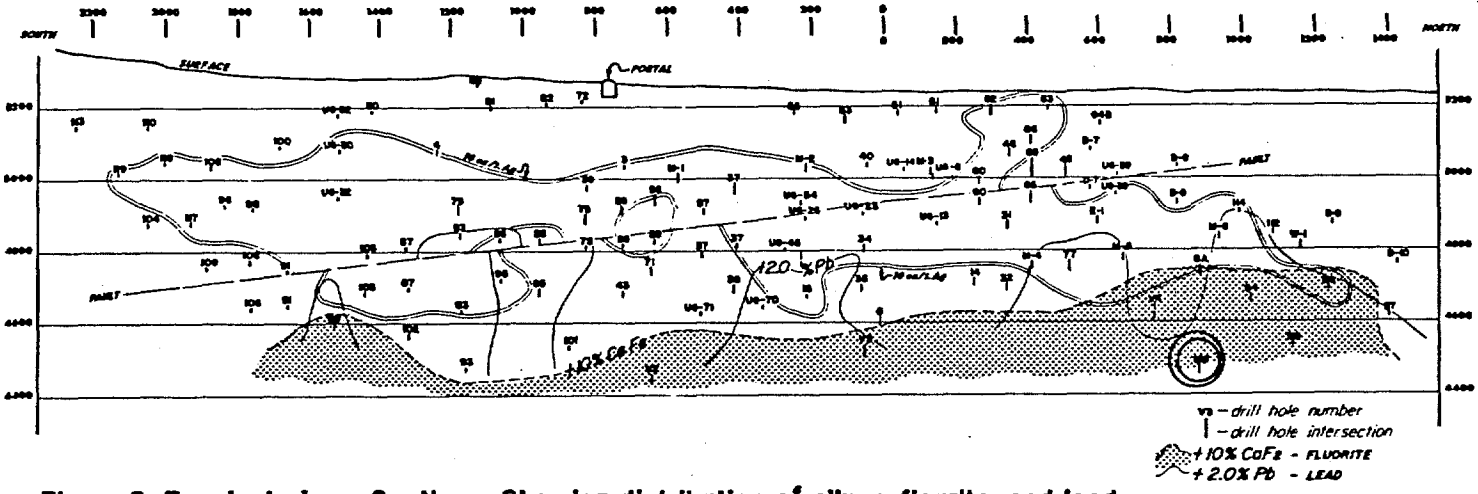

Figure 9. Escalante Long Section – Showing distribution of silver, flourite, and lead.

ASARCO

Southwestern Exploration Division

May 10, 1982

F. R. Koutz
H. G. Kreis
F. A. Michel
G. W. Pickard
G. J. Stathis

The attached paper on Disseminated Silver Deposits by Graybeal should be part of your input into the process of looking for them.

James D. Sell
J. D. Sell

JDS/cg

Attachment

RECEIVED
MAY 22 1981
S. W. U. S. EXPL. DIV.

May 18, 1981

Mr. W. L. Kurtz
Manager, Western Exploration
Tucson Office

Disseminated Silver Deposits

Dear Mr. Kurtz:

I was asked to provide a resume of significant exploration characteristics which was excluded from the attached paper given to the Arizona Geological Society Tectonic Symposium in March 1981.* Easily the most important exploration guide is the close relationship of disseminated deposits to old silver mines. Where the former silver mines aren't veins, such as Round Mountain and Taylor, production was still significant enough to merit comment in the literature. Available data at Santa Fe and Hercules are not sufficient to evaluate the extent of earlier production. Unfortunately, Barry Watson, in his abstract for the April 1981 Precious Metals Symposium in Vancouver, made obvious reference to the relationship between old mining districts and disseminated silver. This relationship does not hold as well for disseminated gold deposits.

In at least two deposits, the veins from which earlier production was derived were parallel to the bedding, leading to the term "bedded veins". At Hardshell the bedded vein, upon close examination, turned out to be a thin zone of stratabound-strataform mineralization in a clay-rich tuff bed which had localized faulting. It looked like a vein in a fault and had the geometry of a vein, but the clues to the stratabound nature of the mineralization were present. Bedded veins are also described at Candelaria. Descriptions of bedded veins should be carefully noted and such occurrences examined in the field because these veins may actually be zones of stratabound mineralization with potential for large tonnage. Stratabound control of mineralization in some of these deposits is unusually well-developed at Tombstone, Hardshell, Langtry, and Bismark (the latter two are not discussed separately in the attached paper).

* Published as AGS Digest Volume XIV, p. 271-281 (1981).

Felsic volcanic or clastic sedimentary rocks were noted as preferred hosts for disseminated silver mineralization. Although the paper mentions that particular structural environments in calderas were not obviously favored, certain lithologic facies may be strongly favored. The Freeport discovery at Creede in the Creede Formation occurs in a very permeable rock which is correlated with the finer-grained moat-filling facies farther south. The Hardshell deposit occurs in a medium-grained clastic unit which occurs at the base of the coarse clastic section beginning about the level of limestone conglomerates; the unit at Hardshell is clearly a lateral facies of the thicker section of volcanics found under the diabase at Trench and these may be moat-filling deposits in a Laramide caldera.

Lipman discussed coarse breccias in the San Juan Mountains several years ago in a G.S.A. paper (I can't recall the date) and concluded they were probably talus or landslide related. He also included the Tucson Mountain chaos in his discussion. Such breccias would probably be especially permeable and, where cut by mineralized veins, would be excellent hosts for disseminated mineralization and should be explored where present. The highly variable continuity of such units makes their thickness difficult to predict, but a rough fix on their possible locations may be possible by locating the inner wall of the old caldera.

Conglomerates not related to caldera moats may also be favorable such as the Telluride Conglomerate in the Idarado Mine near Ouray, Colorado. In the East Tintic District, Morris and Lovering (USGA Professional Paper 1024, p. 98) mention the occurrence of disseminated mineralization in the Apex Conglomerate which lies at the base of the Packard Quartz Latite in the Ballpark area. The distribution of favorable epiclastic-volcanolastic units of regional extent may also be worth field study particularly if these surfaces on which they were deposited can be projected through mining districts.

Alteration most commonly associated with disseminated silver deposits is combined pyrite-quartz, both pervasively distributed. I recently saw a deposit in Chile in which dissemiated pyrite was widespread, but there was very little silica even though disseminated values were present. Pyrite generally appears more widespread than silica, but ore grade mineralization commonly occurs where both overlap. The absence of massive pyrite veins with sericite replacement envelopes, such as are common in porphyry copper deposits, is curious and perhaps not of exploration significance.

Larry Buchanan will also publish a paper in the Proceedings of the AGS Symposium in which he argues that precious metals in veins are separated from underlying base metals by a zone of boiling in the hydrothermal fluid. We have

recognized this as a general phenomenon in porphyry copper systems for the past 10 years and the concept has gained popularity since a paper by Kamilli and Ohmoto (1977, Econ. Geol.) suggested boiling as a panacea for precious metal occurrences. At the Symposium Doug Smith pointed out some inconsistencies in Buchanan's model and I agree with Doug. Hardshell contains mixed silver and base metals even though Fleet Koutz has found evidence of strong boiling. The upshot of this paragraph is that I would be happy to explore for disseminated silver deposits within a base metal zone if the right structural-lithologic environment were present.

On a subject which relates to boiling, you recall the 25 million tons of chalcocite-covellite averaging about 0.4% Cu and 0.3 oz. Ag which is hosted by the quartz feldspar porphyry stock near TM-8 in Alum Canyon (Sunnyside area, Patagonia Mountains). This is the zone which I consider to be hypogene and related to condensation of the vapor from the underlying boiling zone in the diatreme. Giudice's description of chalcocite-covellite with high silver contents at Creede sounds like a similar environment. I suspect that possibilities are remote for similar occurrences elsewhere in the Sunnyside diatreme, particularly as the mineralization appears confined to the porphyry; however, areas where veins project under clastic facies of the diatreme such as south of the World's Fair mine are of more than passing interest.

On a less practical subject for the moment, I took considerable heat from Messrs. Vikre and Smith during the recent Mexico trip because I considered (still do) that Watson's two-fold disseminated and stockwork classification was useless. As you will note in this letter, I am a strong believer in classifications which, to be useful, should contribute to an ordering of chaos and permit modelling. I searched extensively, but was unable to determine that Watson's breakdown reflected an intrinsically important variable worthy of classification. I do admit that the abundance of quartz veins varies between different silver deposits; nevertheless it seems clear that the disseminated-stockwork grouping was a useful attempt to achieve meaningful order which failed and should therefore be abandoned. As the silver values in all the deposits under discussion are distributed more or less evenly throughout, these deposits may be accurately characterized as disseminated until a better term can be found.

Of perhaps more interest is a developing jasperoid association, and Taylor would be the type example. Hardshell, perhaps Santa Fe, and the 2 million ton deposit of 2 oz. Ag at the southeast end of the Winchester Mts. (see Pickard and Beverly reports in your files) would also qualify. The large jasperoid at the north end of the Swissheld Mountain discovered during S. R. Davis Pearce Reconnaissance work may also fit. The Winchester and Swisshelm jasperoids both occur as replacements of limestones - like Taylor. As I recall, the Swisshelm jasperoid

only carried 0.5 oz. Ag, but it was quite extensive and may have been confined to a limited stratigraphic thickness. The Swisshelm zone was not strongly iron stained in the outcrops I saw, but I was only there a few hours. Iron stain, indicative of pyrite mineralization, appears to be a significant feature in all the disseminated silver deposits. The jasperoid association was not mentioned in the paper to avoid drawing attention to the Winchester and Swisshelm occurrences, although I think that any jasperoid would be sampled these days. The strong enrichment in the Taylor jasperoid (I don't remember if the Winchester occurrence was enriched) may lead to anomalously low values in outcrop and this should be recognized. Also, the apparent flat-lying geometry of the Swisshelm jasperoid may suggest stratigraphic control which should be of interest to the field geologist.

The Cu-Ag zone near TM-8 in the Sunnyside area (Arizona) and the Chevron discovery at Creede may also fall into a separate subclass of the high Mn-base metal group. It's interesting that at Sunnyside the Cu-Ag deposit is interior and the Mn-base metal-Ag deposit is exterior in the metal zoning geometry; a similar spatial distribution of the disseminated silver zones occurs at Creede, although distances are different.

To avoid undue attention, several deposits for which data were available were not discussed in the paper including the Swisshelm and Winchester jasperoids, Bismark (Calico District), Tintic-E. Tintic Districts, Lake Valley (New Mexico), and Sulfur District (Nevada). Since this paper was written, Bismark made the front page of the Northern Miner (March 26, 1981.

Florida Canyon was left off the Ag/Au-production graph (Figure 10) intentionally, although we don't yet have a good fix on the Ag content. It would nevertheless probably plot around Ag/Au = 2. Breece Hill (Cumings report dated 1981) was also omitted. The Breece Hill drilling has cut mineralization grading roughly 0.04 oz. Au and 0.30 oz. Ag which occurs largely in porphyry (some in the Weber grits). There may be several million tons of this material which, although not yet demonstrated to have continuity and W:O ratios to be ore, is nevertheless of further interest. It may have geologic characteristics common to other disseminated deposits of similar Ag/Au such as Cinola and Zortman which together constitute a separate geological class lying between Carlin-types and the typical disseminated silver deposits. It's interesting that this intermediate Ag/Au class (Yellow Aster to Landusky on Figure 10) contain the lowest grades of all on the chart and may only be economic if heap leach technologies can be applied successfully.

Extended discussion of the relationship of the high Mn and/or base metal group to base metal-rich systems was also avoided in the paper. As discussed earlier, Tintic-type limestone replacement systems may be good guides to disseminated silver deposits and I don't wish to point this out to those in the general public who were not already aware of this fact, although one question at the Symposium was asked on this general subject. The reverse association may also be true (disseminated silver at Tombstone may be a guide to limestone replacement deposits).

To summarize the above discussion, significant exploration guides to disseminated silver deposits would be:

1. significant prior silver production, with or without associated base metals.

2. permeable felsic volcanic or clastic sedimentary rocks

3. pervasive silicification or quartz veining

4. widespread disseminated pyrite

5. "bedded veins"

6. widespread manganese or barite may also be significant, although they were not discussed earlier, and

7. a heat source.

The exploration geologist should be aware that silver can be leached from altered outcrops and that valid targets may exist where favorable strata can be projected to intersect submarginal hydrothermal systems. I am not yet convinced, however, that disseminated gold deposits will grade downward into disseminated silver deposits. A possible new, as-yet-unrecognized disseminated silver environment may exist in zones of low grade, subeconomic disseminated chalcocite-covellite-tennantite such as at Sunnyside and the Chevron discovery at Creede.

I suspect there may be as many disagreements with the above comments as there were with what was said in the attached manuscript. The lack of a well-defined metallogeny for disseminated deposits makes blanket staking of favorable environments (lithologic or otherwise) difficult, so the geologist is left to generate drill targets on a prospect-by-prospect basis using his creative instincts. For this reason it would be useful to get as much input on the subject of disseminated silver deposits as possible. I have sent copies of this note to various managers as noted below for distribution to their staffs if they wish.

Very truly yours,

F. T. Graybeal

F. T. Graybeal

cc with attachment for:

SAAnzalone
JCBalla
JHCourtright
LMontoya
WDPayne
DMSmith, Jr.

ASARCO

Exploration Department

April 14, 1982

F. T. Graybeal
New York Office

Pueblo Viejo
Dominican Republic

Attached is a poor Xerox of the paper "Geology and geochemistry of the Pueblo Viejo gold-silver oxide ore deposit, Dominican Republic" by Russell et al, Trans. Instn Min. Metall, Nov. 81. This complements the recent Econ.Geology article by Kesler et al. I have marked a few items of interest for the field geologist.

Also, on page 1107 of Kesler's Econ. Geology article is the statement: ..."Jasperoid and pyrophyllite are widespread throughout the Pueblo Viejo and Platanal Members outside the area of known sulfide mineralization..." The obvious point here is you can miss something if you only sample one or two siliceous zones within a widespread alteration zone.

I am routing a copy to those listed below.

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WLK:mek

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Geology and geochemistry of the Pueblo Viejo gold–silver oxide ore deposit, Dominican Republic

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Synopsis
Mining of the Pueblo Viejo Au–Ag oxide deposit in the Dominican Republic began in 1975, with reserves of 27 000 000 t of ore averaging 4.23 g/t Au and 21.6 g/t Ag in two ore zones. Since then approximately 14 000 000 t of ore in a third zone has been added to the reserves. The oxide ore was developed by weathering of a funnel-shaped, gold–quartz–pyrophyllite hot spring deposit that formed in the upper part of a Lower Cretaceous keratophyre–spilite volcanic pile. The sulphide protore is best developed in the upper part of this funnel-shaped zone, where pyrite–sphalerite veins cut carbonaceous sediments that contain chert and thin pyrite layers. Silicification, including massive jasperoid, is closely associated with mineralization and causes the ore zones to form hills with relief of about 200 m. The thickness of ore ranges from nothing in stream valleys to 80 m on hill tops.

Au values increase upwards in the hydrothermal system: consequently, the average Au grade of oxide ore is higher than the average grade of the underlying sulphide protore, whereas Ag abundances in the oxide and sulphide zones are about equal. Ag is depleted in the near-surface parts of the oxide ore and enriched at the oxide–sulphide interface, but Au remained immobile during the oxidation process. Because of this immobility soil samples collected at about 10 cm below surface contain Au values representative of the ore grade and provide a fast and inexpensive method of outlining the surface extent of oxide ore. Precious metals in the oxide ore occur mainly as native Au and as Ag halides. Some sulphides and selenides of Ag and Cu are present in the zone of supergene enrichment. In the sulphide protore precious metal values are in Ag-rich electrum, argentite and tellurides of Au and Ag. Mineralogical and chemical relations indicate that development of the oxide ore by weathering took place at pH values of 1 or less and Eh values of up to 0.7 V, that Ag moved as Ag^+ and that Au was immobile.

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The Pueblo Viejo Au–Ag oxide deposit of Rosario Dominicana, S.A., in the central Dominican Republic (Fig. 1), is one of the world's largest open-pit Au mines. Mining began in April, 1975, with initial reserves of 27 000 000 t at 4.23 g/t Au and 21.6 g/t Ag in the Moore and East Mejita zones (Fig. 2). By the end of 1979 increased daily milling capacity had raised throughput from an initial 6500 t to 9000 t, and the remaining reserves were 15 000 000 t with 3.94 g/t Au and 23.0 g/t Ag above a cutoff grade of 1.00 g/t Au. In 1980 about 14 000 000 t of ore has been proved in a third zone, known as the Monte Negro orebody (Fig. 2).

The oxide ore at Pueblo Viejo was developed by weathering of a gold–quartz–pyrophyllite hot spring deposit. The precious metals are associated with oxidized pyrite–sphalerite veins that are too small to be mined selectively but that are amenable to bulk mining. Oxide ore was formed where weathering removed sulphide minerals and carbon from the host sediments. Because of the association of silicification with precious metal mineralization the oxide ore zones form resistant hills with relief of around 200 m. The ore is mined by drilling and blasting of benches 10 m high and is treated by conventional cyanidation methods. At present the underlying sulphide mineralization[1] is not mined and its economic potential depends on future metal prices and the development of a suitable metallurgical process.

History of Pueblo Viejo

Pueblo Viejo may well have been the first Au mine in the 'New World'. The earliest reference dates from 1505, although Spanish explorers probably found the deposit when it was already being worked by the native population in 1495, when expeditions were organized to the interior of the island during the second visit of Columbus. In 1525 the mine was abandoned in favour of newly discovered deposits on the American mainland. When the mine was reopened in 1975 numerous small excavations dating back to this period were encountered on the upper benches.

After 1525 Pueblo Viejo was largely ignored for more than 400 years until R. Zoppis made an appraisal for the Dominican Government in 1950. Exploration was focused on sulphide veins in stream-bed outcrops of unoxidized sediments. A small pilot plant was built, but Au and Ag could not be recovered from the unoxidized rock in economic quantities.

During the 1960s several companies inspected the property, but no serious exploration was done until Rosario Resources Corporation became interested in 1969. As before, exploration was directed first to the unweathered rock. Where sulphide veins crop out in the stream valley the oxide cap is only a few metres thick and it was not immediately apparent that the cap was of significant tonnage, even though it was known to carry Au and Ag values. As drilling moved out of the stream valley on to higher ground to the east the thickness of oxides increased up to a maximum of 80 m and it quickly became clear that ther[illegible] of oxide ore [illegible]

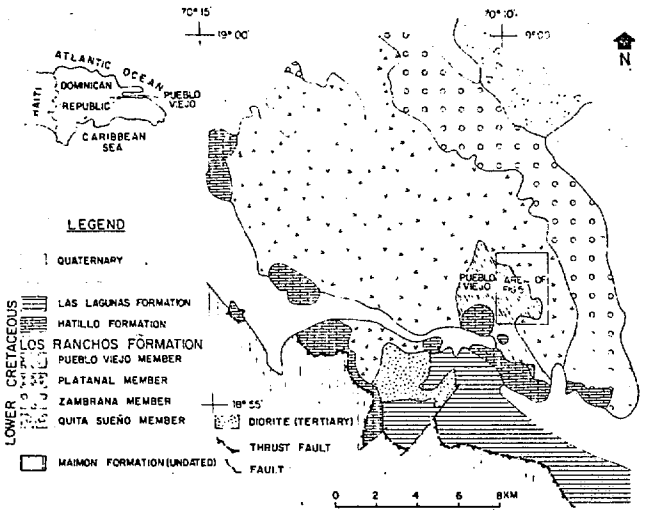


Fig. 1 Location and regional geological setting of Pueblo Viejo mine, Dominican Republic

warrant exploitation. In 1979 the Dominican Government purchased all foreign-held shares in the mine, which is now operated by Rosario Dominicana, S.A., under a management contract with Rosario Resources Corporation, a wholly owned subsidiary of Amax, Inc.

Geological setting

The Pueblo Viejo deposit is in the upper part of the Lower Cretaceous Los Ranchos Formation,[2] which has a regional northwest strike and dips at about 25° to the southwest (Fig. 1). Metamorphic calcite, epidote, chlorite and albite are common throughout the formation and foliation is developed locally. Just south of Pueblo Viejo the Los Ranchos Formation is overlain by the Lower Cretaceous Hatillo Limestone and Las Lagunas Formations,[2] which are overthrust by sericite schists of the undated Maimon Formation (Fig. 1). Locally, stocks of pyroxene diorite have intruded the Hatillo Limestone and produced contact-localized magnetite deposits.

The Los Ranchos Formation, with a thickness of about 1500 m, has been divided into four members[3] (Fig. 1). The lowermost Quita Sueño Member is composed of keratophyre and quartz–keratophyre flows, tuffs and intrusions. The overlying Zambrana Member consists of volcaniclastic sediments derived from the keratophyres. The Platanal Member consists of spilite, volcaniclastic debris derived from spilite and lenses of limestone that contain both marine faunal and terrestrial floral remains. The Pueblo Viejo Member, which hosts the Au–Ag ore, was deposited in a restricted basin. It rests on spilite and spilite conglomerates, but large lenses of spilite are present within the sediments of the Pueblo Viejo Member and, outside the sedimentary basin, spilites of the Platanal Member may have continued to be deposited throughout the time of deposition of the Pueblo Viejo Member.

Stratigraphic relations in the mine area are shown in Fig. 3, which is based on surface mapping and drill core logs. Quartz-eye conglomerate and other units of the Platanal Member are overlain by sandstone, carbonaceous sediment and quartz porphyry agglomerate of the Pueblo Viejo Member. Beneath the Moore orebody the sandstone, which is about 50 m thick, is overlain by a lens of spilite. The sandstone and spilite are overlain by medium- to fine-grained, thinly layered carbonaceous sediment. Graded beds with scour marks and conglomerate lenses are found in the sandstone and carbonaceous sediment and ripple marks and desiccation cracks are present in the carbonaceous sediment.

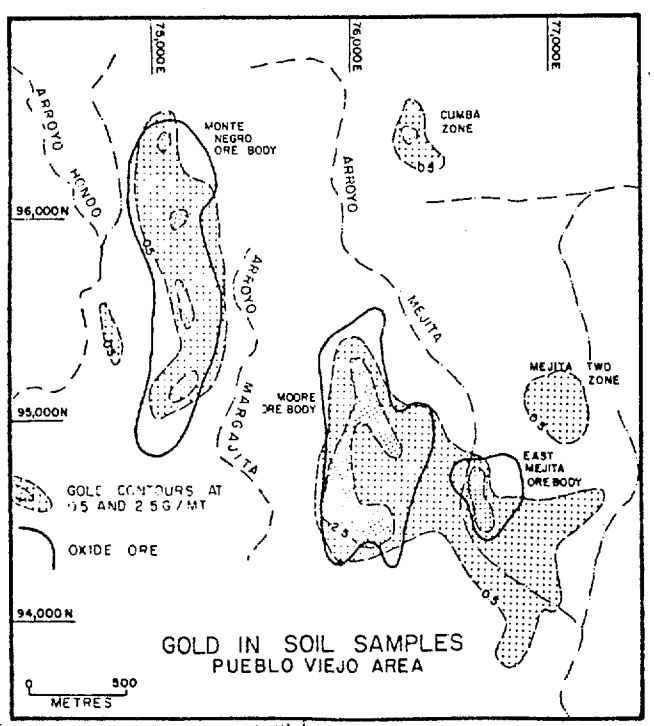


Fig. 2 Locations (by National Grid) of oxide ore zones and soil

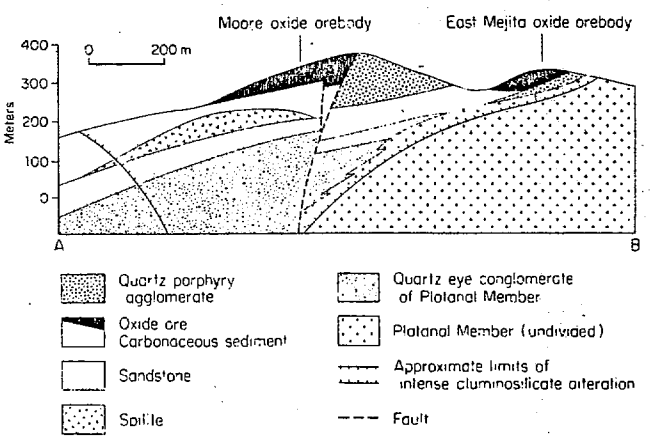


Fig. 3 Cross-section through Moore and East Mejita zones (see Fig. 5 for location of *A–B*)

The presence of thin pyrite layers and carbonaceous chert beds suggests that chemical sedimentation alternated with clastic sedimentation. Smiley[16] has identified *Gleichenites* sp., *Podozamites* sp. and other poorly preserved plant fossils in the sediments and considers them to have been transported from a nearby, well-drained slope into a lagoonal or deltaic environment. Carbon isotope analyses indicate that most of the carbon in the unoxidized sediment is of organic origin,[1] which suggests derivation from the plant debris.

Can actually see twigs, branches

Sulphide protore

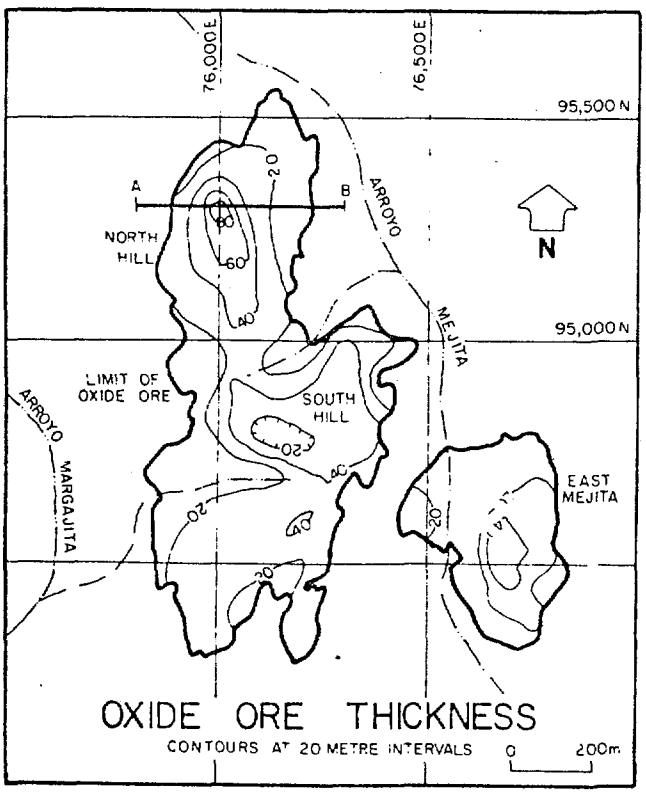
Precious and base-metal mineralization is found within a funnel-shaped zone of aluminosilicate alteration (Fig. 3) that consists mainly of pyrophyllite and quartz. Secondary kaolinite is present in the upper part and alunite and diaspore are found at depth beneath the Moore ore zone. The limits of this alteration zone are marked by a rapid change in mineralogy to a calcite–chlorite assemblage that is typical of the Los Ranchos Formation. Pyrite is by far the most common sulphide mineral, occurring as disseminations, layers, veins. Disseminated pyrite which is present

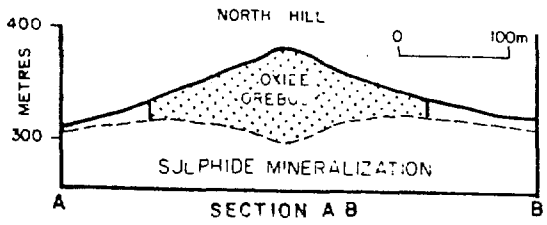
throughout the Los Ranchos Formation, is essentially barren of precious metals. The layers, which are found in the carbonaceous sediments, are 0.1–2.0 cm thick and contain low, but anomalous, precious metal values that probably were introduced hydrothermally. Au and Ag are concentrated in sulphide veins, which are most numerous in the upper part of the system. The veins, with widths of about 15 cm, decrease in size and abundance with depth, until they become irregular stringers in the deeper parts of the alteration zone. The most common vein minerals are pyrite, sphalerite and quartz, with lesser amounts of enargite, barite and pyrophyllite. Trace amounts of galena, argentite, colusite, stibnite, geochronite, tennantite–tetrahedrite and tellurides of Au and Au–Ag have also been detected.[1]

Fluid inclusion studies and mineral stabilities indicate that solutions in the hydrothermal system ranged from about 300°C to less than 115°C, that they were dilute and that they boiled.[1] These observations, as well as the funnel-like configuration of the alteration zone, suggest that the deposit was formed by a hot spring similar to those at Wairakei and Broadlands in New Zealand.[4,5]

Oxide ore geology

Each of the ore zones at Pueblo Viejo is associated with silicified rock and, consequently, occurs on the top and flanks of a resistant topographic high, with a relief of 100–200 m. The Moore zone extends over an area of 1200 m by 500 m and consists of North and South Hills (Fig. 4), which had elevations of 390 m above sea-level at the start of mining. Between the hills is a fault-bounded block of barren pyrophyllitized sediments (Fig. 5). The thickness of oxide ore varies from nil in the stream valleys to a maximum of 80 m on the top of North Hill and 50 m on South Hill and East Mejita (Fig. 4). The thickest oxide ore is developed in intensely silicified, thinly bedded, well-fractured sediments. In contrast, in areas underlain by intensely pyrophyllitized sediments the limits of oxidation are only a few metres below surface. No stripping is necessary because soil cover is negligible over the mineralized zones.





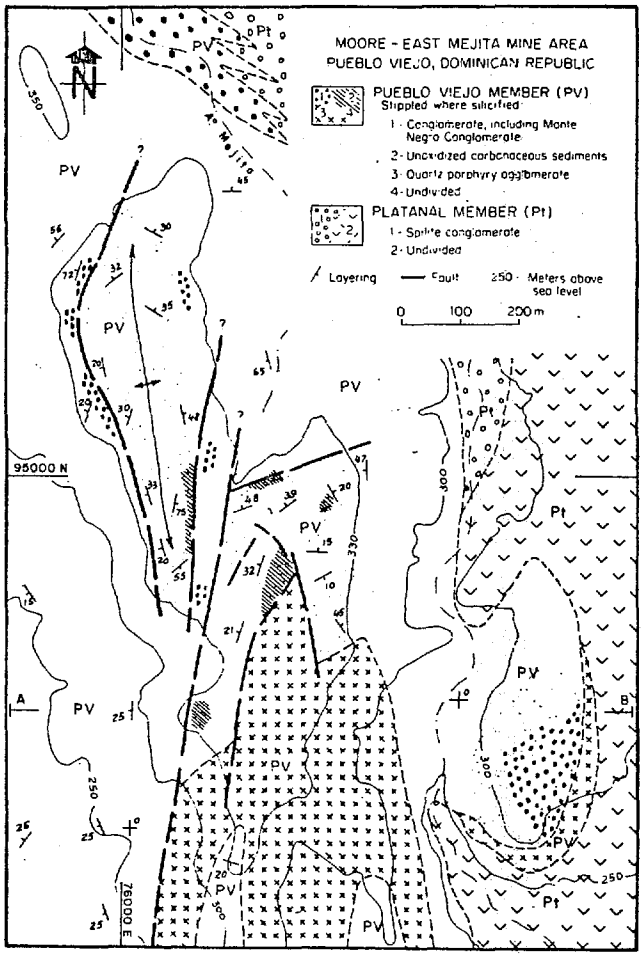


Fig. 5 Geological sketch map of Moore and East Mejita zones (Moore zone shown at 330-m level)

The lower limit of oxide ore (the oxide–sulphide interface) is defined as the depth at which pyrite and/or carbon are observed. The interface can be defined in drill-holes within one 2-m sample in thinly bedded, closely fractured sediments, but in thickly bedded sediments a wider transition interval of partly oxidized sediments is often present.

The geology in and around the Moore and East Mejita ore zones is shown in Fig. 5. For the Moore zone the geology is shown for the 330-m bench level. The only rock types of significant quantity in the ore zones are sediments and quartz porphyry agglomerate. The appearance of the sediments is quite variable. In the northern and western parts of the Moore zone the oxidized sediments retain much of their original textures and bedding is well preserved. In other areas, where intense silicification has produced extremely hard jasperoid masses, the original sedimentary

sediments have been leached of iron oxides and are pale grey to white. Often, the intense surface weathering has destroyed original textures and the ore consists of a very friable mixture of quartz and pyrophyllite.

Quartz porphyry agglomerate outcrops in the East Mejita zone and on the south side of the Moore zone (Fig. 5). The sediments in contact with quartz porphyry agglomerate at East Mejita contain beds up to 1 m thick that consist almost entirely of large quartz grains set in a fine-grained silicified matrix. The quartz grains were almost certainly derived from the quartz porphyry agglomerate, which must have stood partly above sea-level at the eastern edge of the sedimentary basin. This interpretation is supported by the observation that sediments close to the quartz porphyry agglomerate (Fig. 5) contain abundant large plant fragments that appear to be tree roots or branches and these were probably transported for only short distances.

The large body of quartz porphyry agglomerate that outcrops at the south end of the Moore zone overlies, and in places is overlain by, carbonaceous sediments (Figs. 3 and 5). This body has a maximum thickness of 120 m and is composed of 5–10% quartz phenocrysts of about 0.5-cm diameter and 5–10% small cherty or pyrophyllitic fragments in a pyrophyllitized matrix. Although the porphyry body occurs within mineralized sediments, it is barren or only poorly mineralized and in places calcite and chlorite have not been completely destroyed by hydrothermal alteration, as they have in the enclosing sediments. Steeply dipping to vertical faults are common at the edges of the porphyry body and shearing is present along its sharp basal contact. Its emplacement within well-mineralized sediments is therefore probably due to faulting, principal movement taking place along its base.

In the mine area the regional structural trend of the Los Ranchos Formation is overprinted by local folding and faulting. 'Crumple' zones in the pyrophyllitized sediments occur on the west, east and north sides of the Moore orebody. In these zones the sediments are tightly folded and steeply dipping with a well-defined axial plane cleavage. Crumple zones are not present in the silicified sediments, which are horizontal or gently undulating, except close to major faults, where the dips may reach vertical. North Hill of the Moore orebody is formed by a large anticlinal structure with steep to vertical faults on the flanks (Fig. 5).

Ore treatment

Ore is mined by drilling and blasting 10-m high benches. Cuttings from each blast-hole are assayed for Au and Ag. Loaded ore is trucked from the mine to a jaw crusher, after which it is fed to a semi-autogenous mill, where cyanide, water and lime are added.[6] After milling, the pulp is pumped to a leach circuit and then to a series of thickeners, where flocculant is added and the pregnant solutions are decanted off from the solids. At the start of mining only Au and Ag values were recorded on the plans that were used for grade control. As mining progressed it was found that by adding further information to the plans, based on results of laboratory tests on blast-hole cuttings, a better blend of ore could be achieved.

For optimum grinding a blend of hard and soft ore is necessary. An excess of hard ore slows the grinding rate and an excess of soft ore can cause choking of the circuit. The principal factor that determines the hardness of the ore is the ratio of quartz to pyrophyllite, although such other variables as bedding thickness and intensity of weathering OR FRACTURING ALSO HAVE AN EFFECT. A STAMPING TEST WAS DEVISED whereby samples of blast-hole cuttings are rolled in a laboratory ball-mill for 5 min. The weight percentage of material greater than 38 mesh remaining represents a 'grindability index' and is entered on the grade plans for each block of ore. Indices from 0 to 10 indicate soft to medium ore, 10–30 hard ore and > 30 very hard ore. Because the grindability index is closely related to the intensity of silicification it can be used to test the relation between gold mineralization and degree of silicification. A correlation plot of grindability index versus gold grade for 959 samples on the 330-m bench gave a correlation coefficient of only 0.035, which is not significant. A comparison of contour maps of the two parameters (Fig. 6) shows that most of the highest gold grades are in moderately rather than intensely silicified rock.

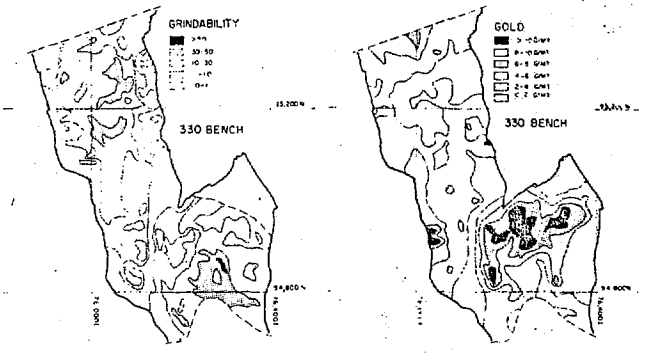


Fig. 6 Contour maps of grindability index and Au grade for 330-m bench of Moore zone (maps prepared from grindability and assay tests on about 2000 and 10 000 blast-hole samples, respectively)

During ore treatment flocculants (synthetic polymers) are added to the cyanided slurry when it enters the thickeners. The rate of flocculation of the slurry depends largely on the amount of pyrophyllite in the ore and the amount of added flocculant must be varied to maintain the flocculation rate at an optimum level. Blast-hole cuttings are tested for rate of flocculation and the results are posted on the grade plans for each block of ore. This information alerts the mill to periods when it is necessary to lower or raise flocculant additions. In the bench tests for flocculation 10 ppm of flocculant is added to 500 cm^3 of a slurry of blast-hole cuttings and water in a 2-in diameter cylinder. After 1 min the height of the column of clear water at the top is measured and each 0.1 in represents an increase of 1 in the flocculation index. Indices of 2–10 are normal at Pueblo Viejo. Any relation between gold mineralization and intensity of pyrophyllization should be evident from a comparison of flocculation indices and gold grade. Correlation plots of 449 samples from the 330-m bench gave a correlation index of 0.231, which is not significant.

When mining approaches the oxide–sulphide interface blast-hole cuttings are also tested for Au and Ag recovery. Au recovery is low if pyrite is present because Au is locked in the pyrite crystals. More seriously, any carbon present can adsorb Au and Ag from solution, causing low recoveries. The recovery problems caused by pyrite and carbon contamination could be solved by stopping mining a safe distance above the oxide–sulphide interface, but this would leave some valuable ore unmined because Ag is enriched close to the interface. Drilling is stopped when the oxide–sulphide interface is intersected in blast-hole drilling and a sample of the oxide interval is taken before the hole is continued to the planned depth and the sulphide INTERVAL IS TAKEN AS A SEPARATE SAMPLE. BOTH SAMPLES ARE

subjected to bench scale 'preg rob' and recovery tests and material that is found to be excessively contaminated can be left unmined.

Metal distribution

The average contents of Au and Ag in the Moore orebody and in the sulphide zone that underlies it are shown in Table 1. The average Au value is significantly higher in the oxide zone, but Ag is almost the same for both zones. The higher average Au content of the oxide zone could be due either to an increase in hypogene Au in the upper part of the mineralized system or to the enrichment of the oxide ore in residual Au derived from rocks that have now been eroded. In areas where the zone of hydrothermal alteration extends downward into the conglomerates beneath the bedded sediments there is a gradual decrease of Au with depth (Fig. 7), but a less marked decrease in Ag. In the upper parts of the mineralized system the Au distribution is erratic. No vertical trend in Au distribution has been observed in the oxide zone and the present distribution is considered to be the original hypogene distribution. Thus, the richest part of the oxide ore in any small area might be close to surface (Fig. 7) or close to the oxide–sulphide interface (Fig. 8). The tendency for Au values to be erratic in the carbonaceous sediments is probably related to the more heterogeneous distribution of large sulphide veins in these rocks.

Table 1 Average Au and Ag abundances* in oxide ore and underlying sulphide protore of Moore zone

Metal, g/t	Oxide ore	Sulphide protore
Au	3.66	2.25
Ag	19.7	17.9

*Abundances represent average grade of all rock within volume limited by cutoff grade of 1.4 g/t Au, including waste. Thus, figures are lower than quoted ore grades, but a truer representation of average amounts of Au and Ag deposited in hydrothermal system.

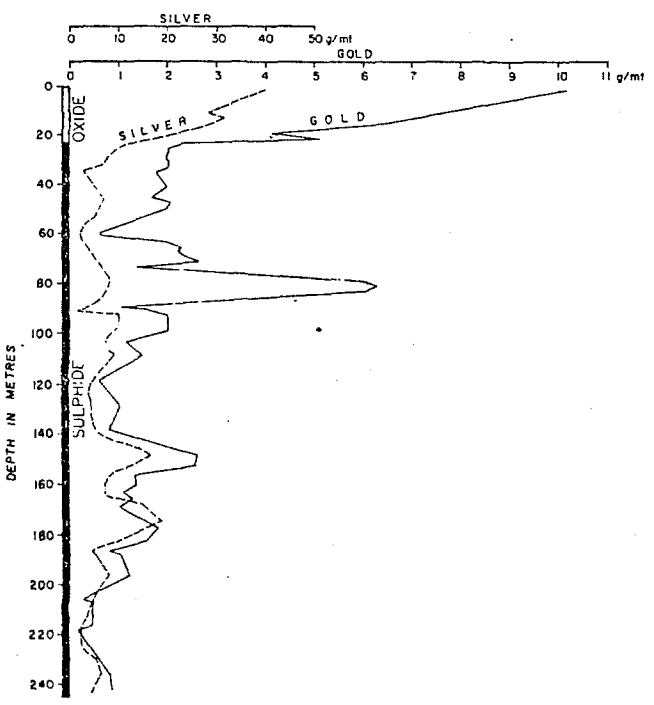


Fig. 7 Au and Ag profiles for drill-hole 159, Moore zone: assay intervals at 2 m smoothed by use of 10-m diameter moving average (note that Au:Ag ratio is much higher than 1:10 in upper part of

Fig. 9(*a*) shows best-fit curves for Au and Ag values in the oxide ore plotted against relative depth from surface to the oxide–sulphide interface. Relative depths were used to detect variations caused by supergene processes, independent of the present oxide thickness. Au decreases slightly with depth and there is no anomalous increase close to surface that could be attributed to the addition of residual Au. The constant slope of the line also suggests that there has been no mobilization of Au within the oxide ore. During the oxidation process Ag has been enriched close to the oxide–sulphide interface. The average value remains fairly constant for half the depth to the interface and, thereafter, increases steadily, reaching a maximum at the interface. This supergene Ag enrichment continues for about 10 m below the oxide–sulphide interface (Fig. 9(*b*)).

Cu and Zn have been leached almost completely from the oxide zone. The Cu and Zn profiles in Fig. 8 show that no Zn is present in the oxide ore, but about 1% is present in the sulphide zone. With the exception of small lenses of massive pyrite–enargite that have been intersected in diamond drilling,[1] Cu values are very low in the sulphide zone (< 0.2%), but a zone of copper enrichment can be detected just below the oxide–sulphide interface.

Soil geochemistry has proved to be an ideal method for detecting oxide ore at Pueblo Viejo. A shallow sampling depth is sufficient to penetrate the thin cover of humic material and the samples collected are essentially of weathered rock *in situ*. In Fig. 2 the areas of soil samples that contain more than 0.5 g/t Au are shown with the limits of the Moore, East Mejita and Monte Negro orebodies. Reserves in the Moore and East Mejita zones had already been outlined by drilling when the geochemical survey began, but the Monte Negro, Mejita Two and Cumba zones were located by this method. The success of the geochemical survey is due to the immobility of Au in the rock during the oxidation process, the sample assays indicating the grade of original hypogene mineralization. Ag assays were also made on the soil samples, but because of the intense leaching of Ag from near surface the assays do not give a good indication of the potential Ag grades in the lower part of the oxide zone.

Mineralogy

Quartz, pyrophyllite and kaolinite are the only common silicate minerals in the ore. Fe oxide, usually in spongy or botryoidal forms, is abundant throughout, except for intensely leached zones near the surface. Minor barite occurs in the oxidized veins.

Au has been observed in only a few samples of very high-grade ore, where it forms spongy native Au grains (Fig. 10). The grains are up to 100 μm across and consist of individual Au blebs about 1 μm in diameter. Some micron-size blebs of silica are found in the Au grains, as are small crystals of barite (Fig. 11). Lloyd[7] has illustrated similar large, spongy Au grains in unoxidized ore in the Witwatersrand district and has attributed their texture to leaching of Ag by nitric acid used to dissolve the rocks and free the grains for study. As was noted by Kesler *et al.*,[1] however, Au in the sulphide zone at Pueblo Viejo has been found only in grains of 1–5 μm in pyrite, even though many more sulphide than oxide samples have been studied microscopically. A possible explanation for the large grains being found only in the oxide zone was suggested by Boyle,[8] who noted that in many Au deposits that show no evidence of enrichment or depletion of Au during oxidation

THE Au IS OFTEN COARSER IN THE OXIDE ZONE. THIS COULD OCCUR.

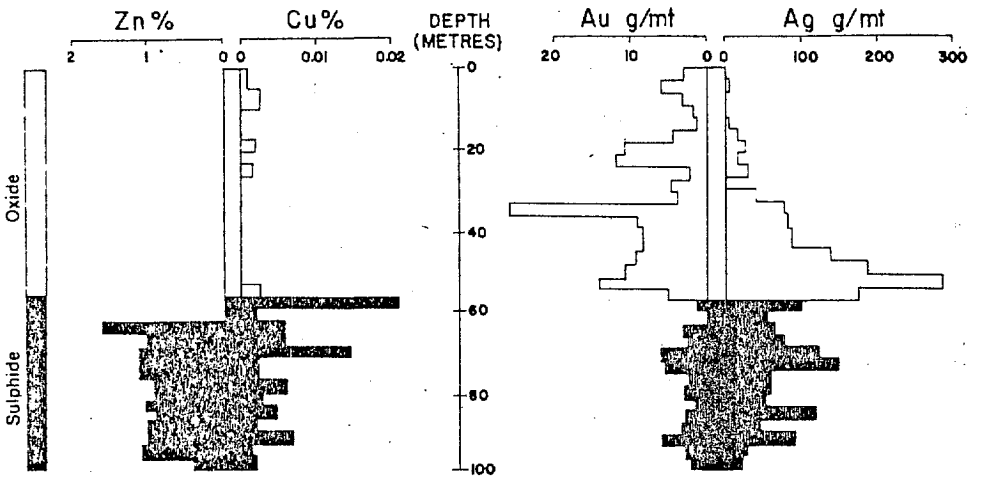
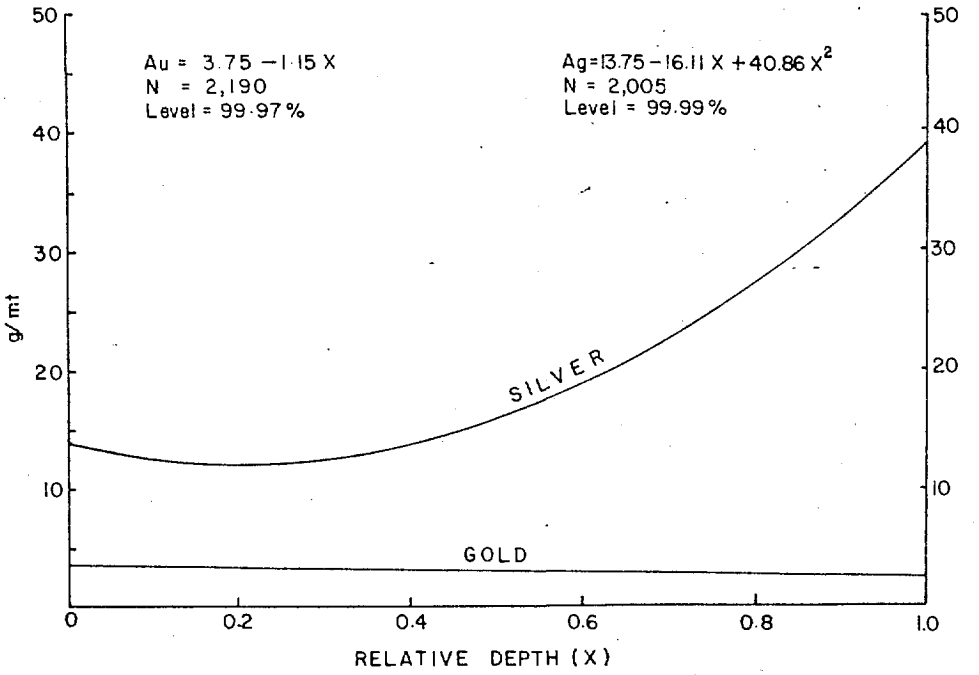


Fig. 8 Au, Ag, Cu and Zn profiles across oxide–sulphide interface in drill-hole 69, Moore zone (note accumulation of Ag and Cu at interface)



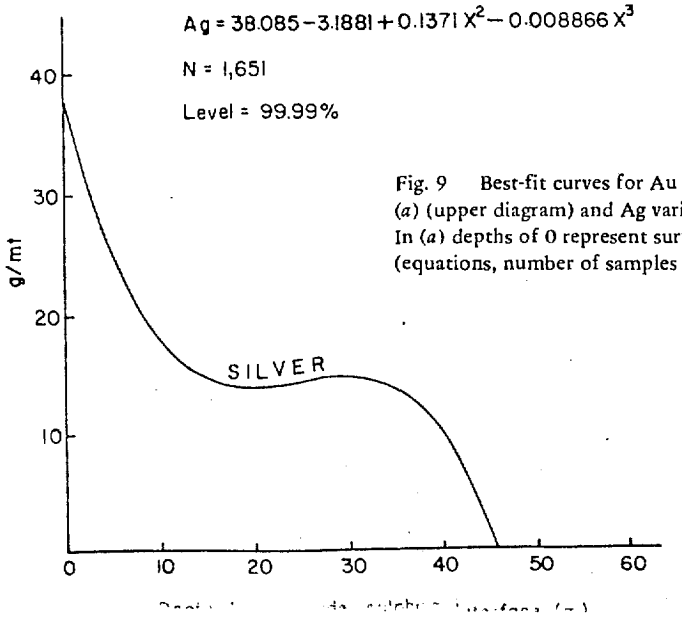


Fig. 9 Best-fit curves for Au and Ag variation with relative depth in oxide zone (*a*) (upper diagram) and Ag variation with depth in sulphide zone (*b*) (lower diagram). In (*a*) depths of 0 represent surface and those of 1 represent oxide–sulphide interface (equations, number of samples and confidence levels given for each curve)

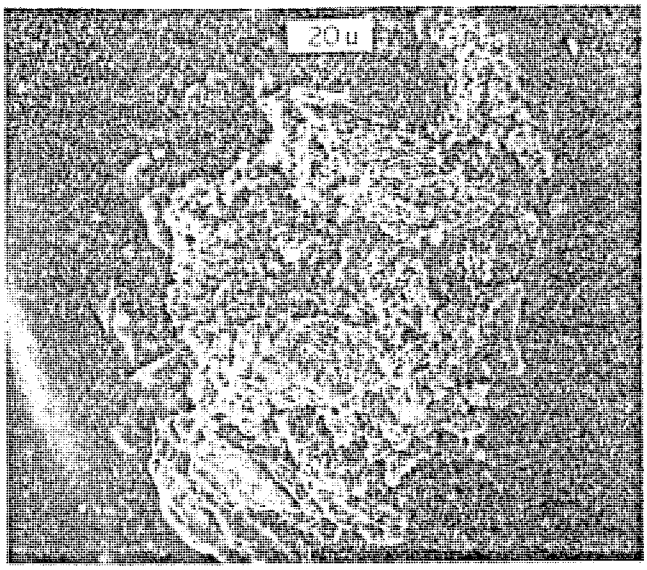


Fig. 10 Scanning electron microscope view of Au grain in oxide ore: no Ag detected in this or other grains

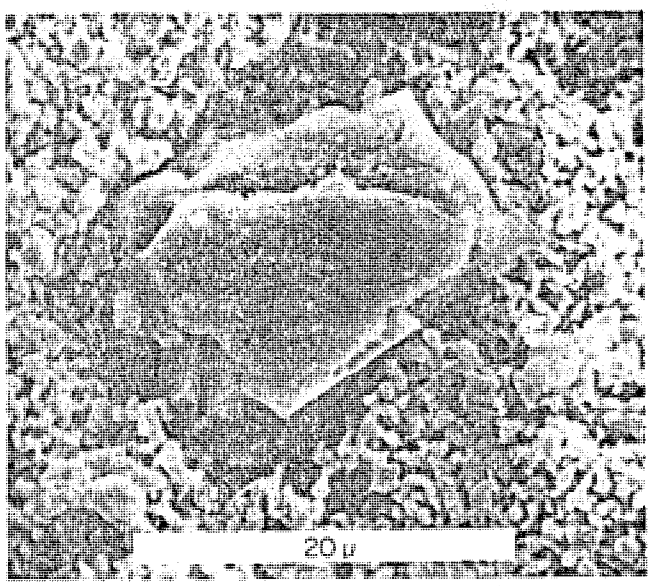
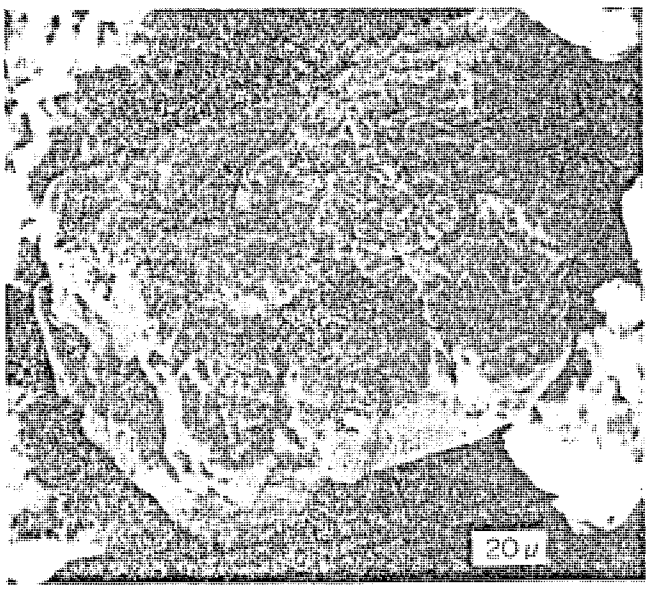
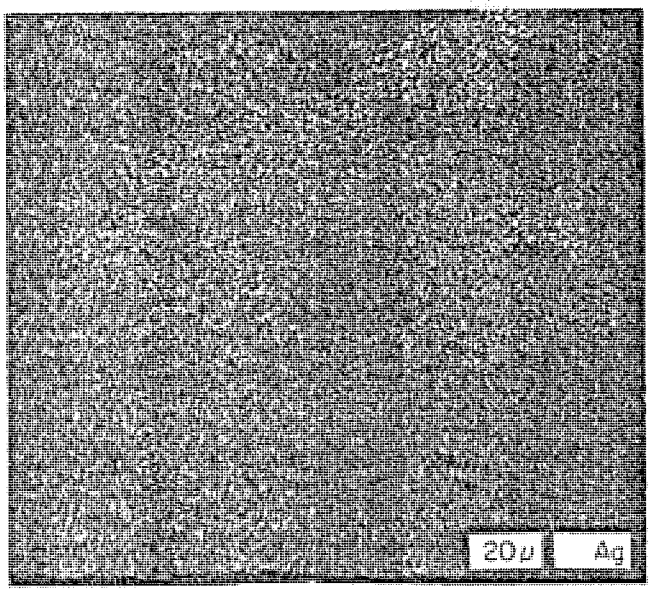
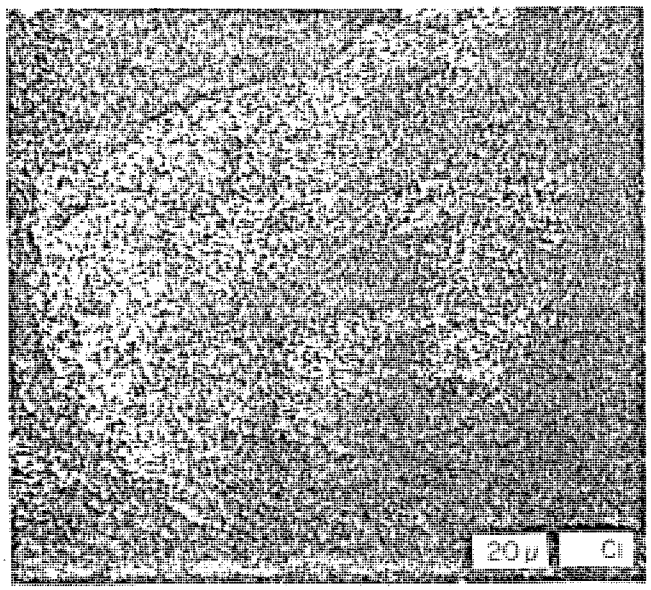
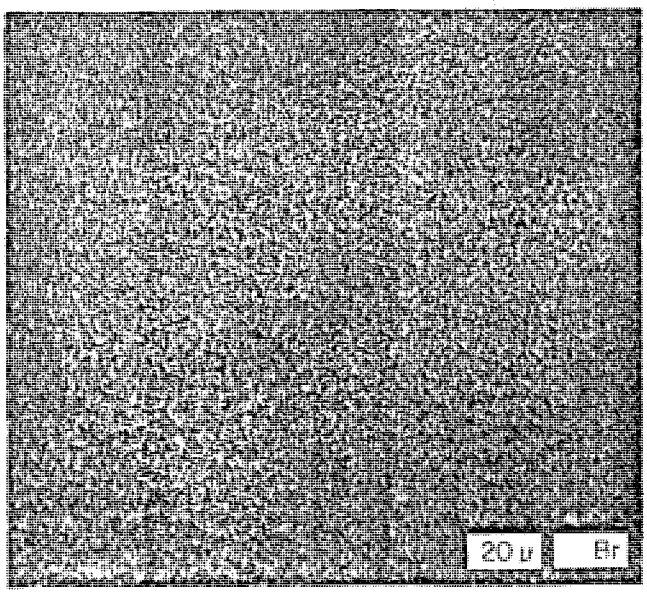


Fig. 11 Scanning electron microscope view of Au grain with embedded barite crystal (note spongy texture of Au)









[illegible] from M[illegible] (top left), and X-ray scans of Ag, Cl and Br

if particles of Au released from enclosing minerals remain *in situ* and accrete any nearby dissolved Au.

Above the oxide–sulphide interface Ag has been detected as cerargyrite (AgCl), embolite (Ag(Br,Cl)) and iodobromite (2AgCl.2AgBr.2AgI) (Fig. 12). Below the interface Ag has been detected in supergene sulphides and selenides, including minerals with the approximate compositions of stromeyerite ($(Ag,Cu)_2S$), aguilarite ($Ag_2(S,Se)$) and argentite (Ag_2S). Native Ag has not been found. Ag selenides could also be present in the lower part of the oxide zone, assays having shown that enough Se is present to tie up all the Ag. Cu is present just below the interface as covellite, which coats pyrite grains. Hg is also present in the oxide ore, apparently as calomel (HgCl). It has a similar distribution to that of Ag, being enriched close to the interface, and is recovered in small quantities as an environmental safeguard rather than an economic by-product.

Secondary deposits of aliphatic hydrocarbons are commonly found in the oxide zone as coatings on bedding and fracture planes. They form a moist brown film on freshly exposed surfaces. Their presence became an important feature of the mine geology when it was determined that even in small quantities they cause a reduction in Au recoveries.

Geochemical conditions of oxidation

Weathering and formation of oxide ore at Pueblo Viejo is controlled by the pH and Eh of groundwater, as well as by its concentrations of Cl and S. We have estimated pH from measurements on water in old tunnels, in streams draining the mine and on rock–water slurries from drill-holes that intersect the oxide–sulphide interface. The tunnels and streams yield pH values as low as 2.5 and the slurries gave pH values as low as 2 in the sulphide zone (Fig. 13). The indirect estimates that we have obtained are probably high – the stream and tunnel values because of volatilization of SO_2 and the slurries because of dilution – AND pH VALUES OF ABOUT 1 ARE PROBABLY ATTAINED IN THE OXIDE ZONE INTO THE SULPHIDE ZONE (PATH BC, FIG. 14)

oxidizing sulphide zone. SO_2 probably accounts for almost all the acidity by forming H_2SO_3 and H_2SO_4, H_2SO_3 probably being the more important constituent. Thus, the pH is an approximate measure of the concentration of S in the system: for example, at a pH of 1 and H_2SO_3 concentration of 0.1 M the total S will be 0.192 M.

The effects of variations in Eh and Cl^- on Au and Ag mineralogy in the weathering zone at pH 1 and Σ S=0.192 M are shown in Fig. 14. We have assumed that solubilities in excess of 10^{-6} M correspond to fields in which aqueous solutions rather than minerals are the dominant hosts for Au or Ag. Alternative choices of 10^{-5} M and 10^{-4} M are shown by dashed lines. The solution field for Ag at low Cl^- activity is dominated by Ag^+ and that at high Cl^- activity by various complexes of Ag and Cl, the distribution of which, at any given Cl^- activity, was shown elsewhere (see Seward[10], Fig. 5). For convenience, in using Seward's data for the $AgCl_4^{-3}$ complex all relations have been calculated at 18°C with data reported by Wagman *et al.*[11,12] and Robie and co-workers.[13] Quantitative relations shift only slightly at temperatures up to 40°C. The field of solubility of native Au occurring as the auric chloride complex at high Eh and high Cl^- activity has been recalculated for 18°C after Cloke and Kelly[14] by use of the more recent data of Wagman *et al.*[11,12]

Fig. 14 shows that Ag is soluble, but Au is immobile at low Cl^- concentrations and high Eh values typical of weathering systems in humid tropical regions (stippled area). An increase in Cl^- concentration causes deposition of cerargyrite (AgCl) and a decrease in Eh causes deposition of acanthite (Ag_2S). At higher pH values and lower H_2SO_3 concentrations a stability field for native Ag separates the Ag^+ and Ag_2S field, but the lack of native Ag at Pueblo Viejo indicates that such conditions did not prevail here. It follows from these observations that deposition of AgCl in the lower part of the oxide zone is due to an increase in Cl^- concentration (path *AB*, Fig. 14) such as would occur during dry periods. Sulphite in solutions moving from the

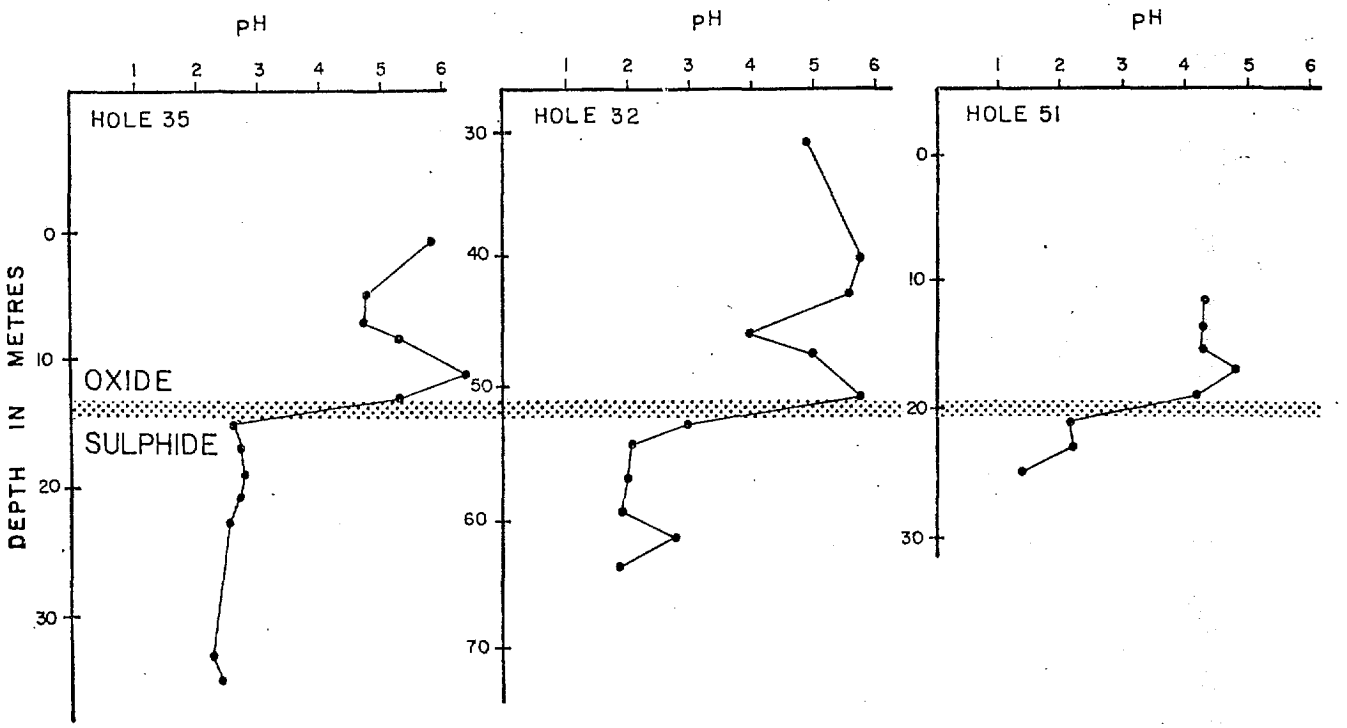


Fig. 13 Variation of pH in rock–water slurries from drill-holes (note that pH of slurries in oxide zone is only slightly lower than local rainwater (6.8–7.4), whereas that in sulphide zone is much lower)

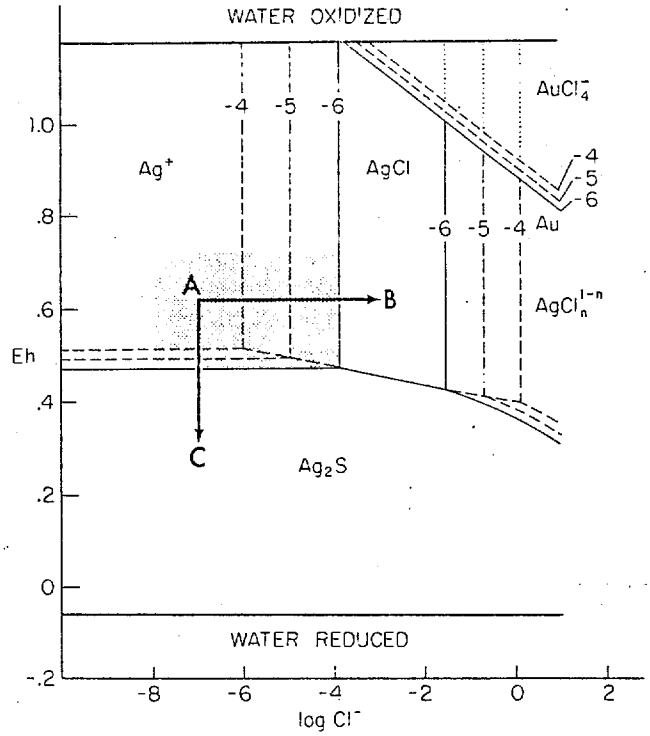


Fig. 14 Eh–pH diagram for Au–Ag–S–H–O–Cl system at 18°C, pH 1, Σ S=0.192 M and H_2SO_3=0.1 M, showing stabilities of phases found in oxide and sulphide zones. Chloride concentrations in rainwater at Pueblo Viejo are below 10^{-8} M and those in tunnel and stream water are below 10^{-4} M, indicating that stippled field represents range of chloride concentrations in oxide ore. Kelly and Goddard[9] produced a similar diagram for system Au–Ag–Te–S–H–O–Cl at pH 4

would be reduced sufficiently to precipitate Ag_2S directly from solution, or the Ag^+ ion could replace Fe in pyrite to form Ag_2S.

This interpretation of Fig. 14 indicates that Au is not dissolved during weathering at Pueblo Viejo – a point of importance to the origin of the observed spongy Au grains (Figs. 10 and 11). All of the calculations for Fig. 14 are, however, based on the thermochemical properties of particles large enough for the extra energy associated with near-surface layers and irregularities, such as edges and corners, not to contribute significantly to the whole. On the other hand, extremely fine particles, such as individual Au atoms or groups of Au and Ag atoms would be oxidized and complexed far more readily than is indicated by Fig. 14. Thus, it seems reasonable to suppose that during oxidation of the Ag in electrum the Au becomes oxidized at least as far as the aurous state and complexed by the Cl^- ion, even though the Cl^- concentration is low.

This complex would be very short-lived and could account for only very short-range transport of Au. Such movement, however, would be sufficient to account for the development of the observed porosity and surface texture of the spongy Au. Other complexing agents, notably thiocyanate, cyanide and probably organic (e.g. humic) materials[8,15] appear viable as supergene transporters of Au in some natural environments, but we have seen no evidence that they were important at Pueblo Viejo.

From these geological and theoretical data we conclude that the supergene dissolution, transport and redeposition of Ag at Pueblo Viejo must occur at pH values of about 1 in the presence of sulphurous and sulphuric acids. Sufficient S for the formation of Ag_2S could be derived from inorganic reduction of sulphurous acid, with possibly important sulphate. Ag is transported almost exclusively as Ag^+ at Eh values of up to 0.7 V. These conditions are well separated from those which permit dissolution of megascopically visible Au and account for the lack of supergene transport of Au at Pueblo Viejo.

Conclusions

The Pueblo Viejo Au–Ag oxide ore was developed by weathering of a base and precious metal-bearing hot spring deposit. The precious metals occur in pyrite–sphalerite veins that are most abundant in the upper part of a funnel-shaped zone of hydrothermal alteration in which quartz and pyrophyllite are the most common alteration products. Mineralization of ore grade is found in intensely silicified zones and in zones where pyrophyllite and quartz coexist. Intensely pyrophyllitized zones are below ore grade or barren.

Au in the sulphide mineralization is present in electrum and tellurides, but has only been observed in oxide ore as native Au. Ag in the sulphide mineralization has been detected in argentite, electrum and tellurides, but has been found only as Ag halides in the oxide ore. Computer plots of precious metal distribution in the oxide ore show that Ag is leached from the near-surface portion and enriched close to the oxide–sulphide interface, whereas Au has remained immobile. This is to be expected under the Eh and chloride concentration conditions considered to exist at Pueblo Viejo. During the oxidation process Ag is transported downwards as the Ag^+ ion and deposited as Ag halides. Under the same conditions Au is not soluble.

Because of the immobility of Au, geochemical surveying is an ideal tool for the location of oxide ore at Pueblo Viejo, where there is negligible soil cover and the mineralized rocks may be sampled at surface. Ag assays of soil samples are less responsive because Ag may be almost completely leached from the upper part of the oxide zone.

Acknowledgement

The authors are grateful to Rosario Dominicana, S.A., for support of this study and for permission to publish this paper. Most of the laboratory work was supported by National Science Foundation Grant GA158284 and the University of Michigan. Work done by previous geologists at Pueblo Viejo, including K. Monster, P. K. Brown, M. Essington and J. Galbraith, contributed important basic field relations in the mine area. The illustrations were drafted by Ignacio Camilo.

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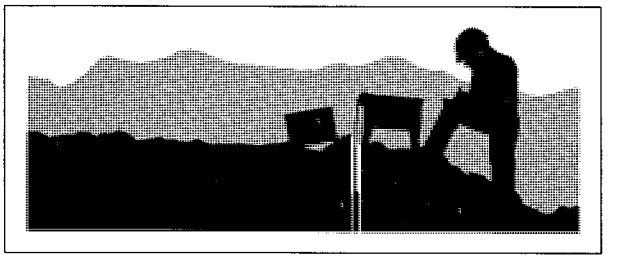

MAP (Metals Analysis Probe)

ON THE MAP

A quarterly newsletter Vol. I, No. 4, October 1983

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SILVER MAP ECONOMICS

What does it mean in total dollars to sample an outcrop, a mine face, a muck pile, a trench, a dump, concentrates, tailings, or a stockpile, and immediately know the assay? This special edition illustrates several field-proven ways the **MAP** pays for itself quickly, and at least partially illustrates **MAP's** tremendous economic benefits.

Too many deserving properties and mines are passed by because of prohibitive time and evaluation costs. Headings turn to low grade unnoticed, trenches and ore trains suffer grade dilution, mill feed is spiked high and low, making process control a nightmare, all because assay sample results lag by hours, shifts, or even days.

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LOWER DRILLING COSTS

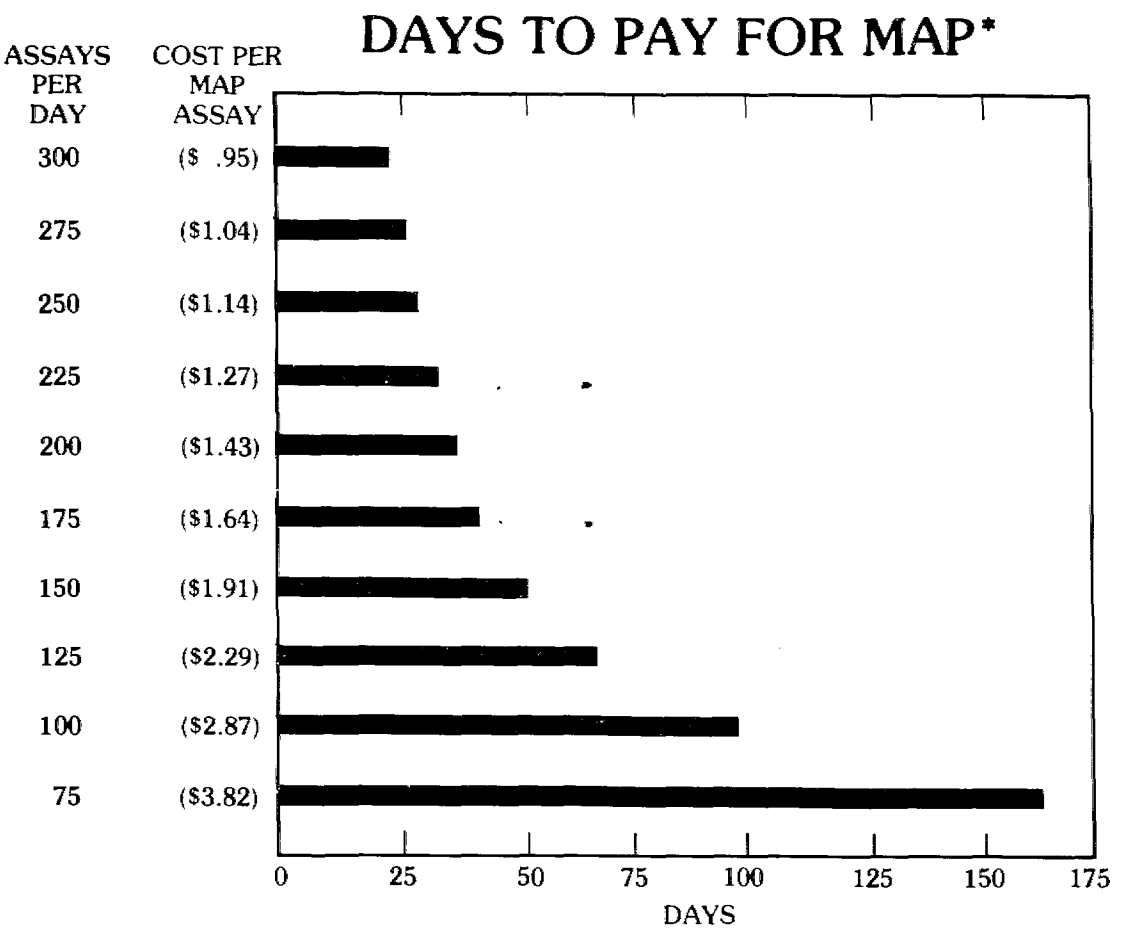
One 10-hole grid pays for MAP or expands to 50 holes for the same budget!

MAP & Rotary Drilling	
10 holes × 250 ft. @$2/ft.	$ 5,000
Assaying *	1,500
Engineering	3,332
Contingencies @15%	1,474
MAP Total	$11,306

Reverse Circulation Drilling (RCD)	
10 holes × 250 ft. @$15/ft.	$37,500
Supervision & Sampling	8,334
Assaying	5,000
Engineering	3,332
Contingencies @15%	8,124
RCD Total	$62,290

* Daily cost of MAP = $287. Operator ($250) + MAP purchase amortized 5 years.

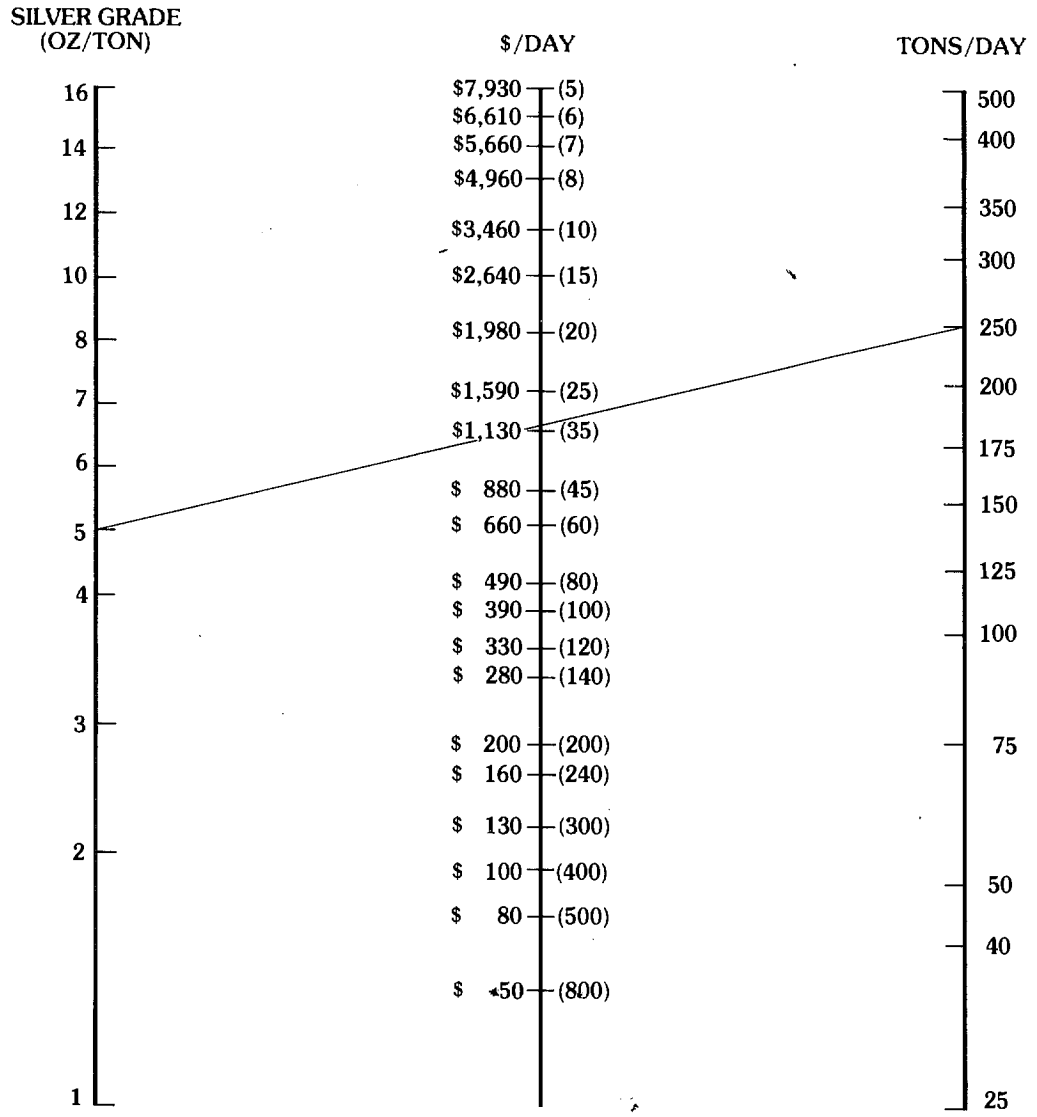
REDUCED ASSAY COSTS



* Based on difference between MAP assay costs and $7 (sampler & lab) conventional assay cost.

GRADE CONTROL PAYS!

Use this graph to determine how quickly your **MAP** system will pay for itself. Draw a line from your average grade to your tons per day. Where it crosses the middle line shows the increased profits and days required to pay for your **MAP**. The example shown earns $1,130/day and recovers the **MAP** purchase price in 35 days.



Graph based on $10 silver price and 10% decrease in dilution using MAP grade control. Both of these assumptions may be conservative. Your payout time may vary.

ON THE MAP

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November 8, 1983

TO: W. L. Kurtz

FROM: D. M. Smith, Jr.

Metallic Mineralization in
Gulf Coast Salt Domes--A
New Exploration Model

Peter E. Price, advanced research geologist with Marathon Research (now that their minerals group is defunct), presented an outstanding talk to the DREGS this month on the referenced topic. The exploration idea grew out of Alden B. Carpenter's discovery in 1973 that hydrocarbons from the Raleigh oil field in central Mississippi contained significant quantities of metals, especially Pb in amounts up to 400 ppm (Econ. Geol., v. 69, p. 1191-1206). The Marathon concept grew to encompass 3 probable stages of evolution for salt-dome-related base-metal deposits if indeed they actually existed:

1. Source - marine black shales
2. Transport - chloride and/or organic complexes
3. Deposition - anaerobic bacteria (sulfate reducing)

They do exist and in addition to Pb and Zn they contain up to 9.5 oz. Ag. My notes from Price's talk follow:

The guinea pig - Hockley dome (12,000 x 10,000 ft.) located 35 mi. NW of Houston. Drilled by Freeport Sulfur as a S° play. Marathon found ZnS and PbS in Freeport cuttings. Review of all available cuttings showed base metals to be concentrated around the periphery of the dome in a strongly reducing environment. Metals were especially abundant at the southern margin of the dome where several fences of drill holes on 200-ft. centers were subsequently drilled.

Cross-section zonation - 5 zones are recognized within the dome.

From the top down they are:
1. Calcite (limestone) caprock, 0 to 200 ft. thick
2. Transition, 0 to 100 ft. thick
3. Anhydrite, 600 to 800 ft. thick
4. Dissolution, now compressed to 0 ft. thick
5. Salt diapir

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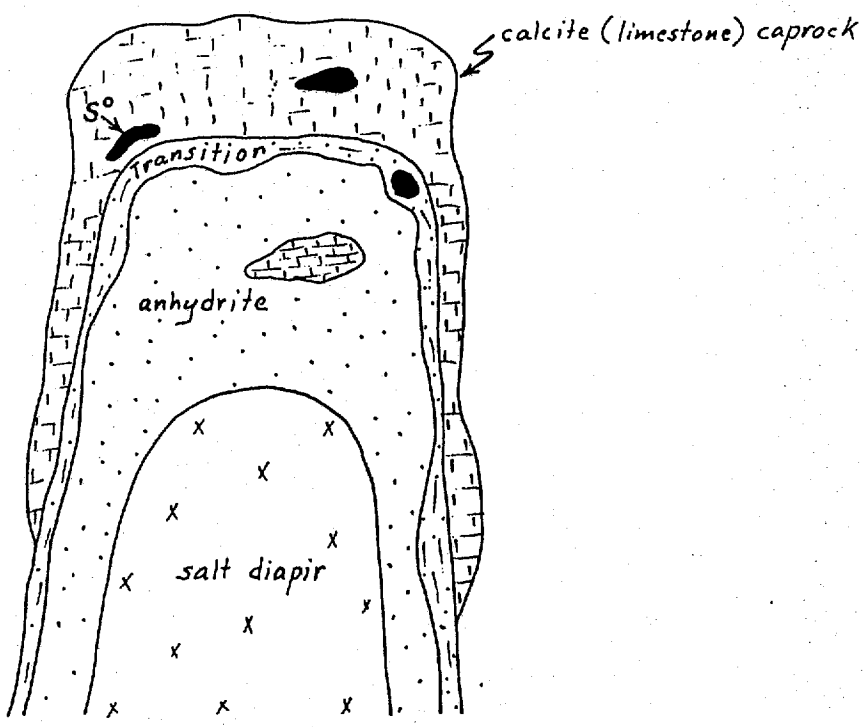


Geologic X-section
Hockley Dome

Mineralogy - Principal minerals: pale sphalerite (replaces anhydrite laths)
galena
pyrite-marcasite

Accessory minerals: hauerite (MnS_2)
S°
acanthite
barite - forms zebra rock identical in form to that of the circum-Sawatch region. White barite zebra bands are often separated from dark limestone layers by bands of marcasite
pyrrhotite
selenite - post sulfide

Textures: Colliform, indicating open-space filling. Opposite walls of filled fractures are often mirror images. Typical rhythm of banding is anhydrite-marcasite-sphalerite-marcasite-sphalerite-marcasite-anhydrite. Sulfides are extremely fine grained (mention was made of 4 micron ZnS).

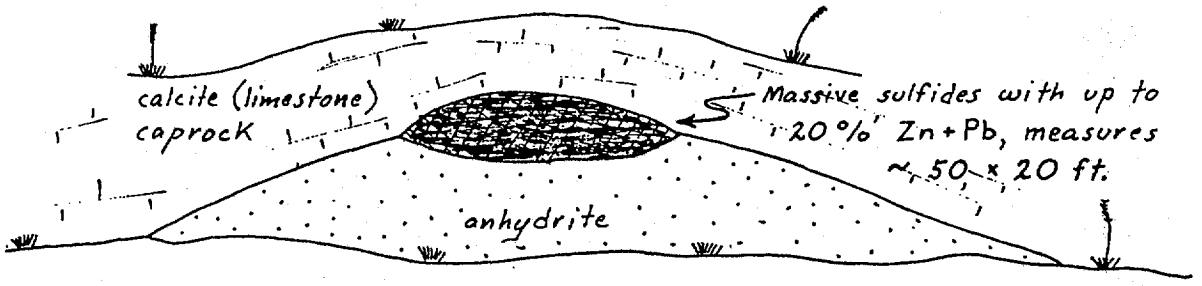
Multiple events of brecciation and mineralization are evident.

Geochemistry - Ti, values "elevated"
Au, 0.04 ppm maximum
Cd, up to 1.5% in ZnS
Ag, up to 1.5% in ZnS
Sr, up to >1%
Mn, up to 2% associated with sulfide mineralization
Hydrocarbons are found bleeding from massive sulfides in core and also stain unmineralized fractures. The hydrocarbons are "fresh" around the rim of the dome and have been almost completely biodegraded near the center.

Ore occurrence - Mineralization of "ore" grade occurs in 3 host types, mostly in tectonic fractures and bedding planes:

1. Calcite (limestone) caprock
2. Anhydrite
3. Interior limestone (bergs "floating" in anhydrite)

Other example: Winfield dome



Road-cut X-section

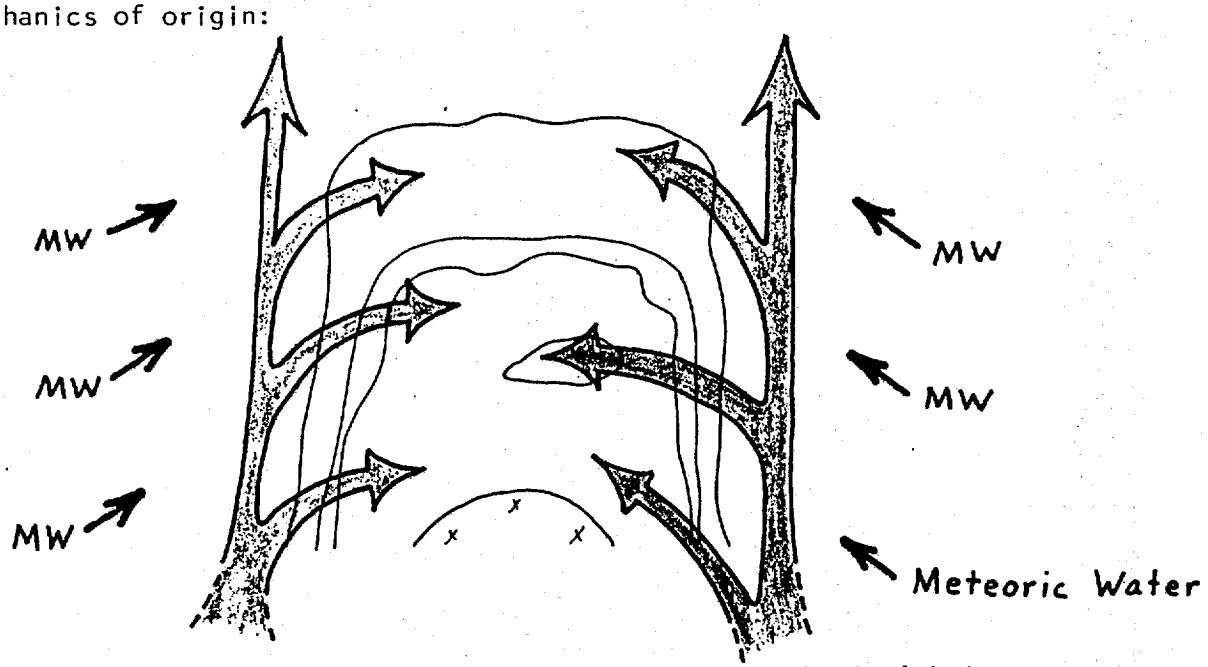
Ore body - Size: 10's of millions of tons
Grade: 6% Zn+Pb in cal (limestone) caprock
4% Zn+Pb in anhydrite
∿1 oz. Ag (estimated from histogram), assays up to ∿2 oz. in Zn-Pb ore
Zn/Pb = 3
Thickness: ∿40 ft. (estimated from sections)
Mining method: room and pillar or solution
Byproducts: barite
limestone
gypsum-anhydrite ballast for oilfield roads (biodegradeable)
gypsum for wallboard (produced by periodically ripping anhydrite tailings for a 10-yr. period which is the expected life of the project)

Second ore body(?) - Almost incidentally some grab samples were taken from a sandy inclusion in the anhydrite well below the main Zn-Pb zone. This material is at least several feet thick and based on more careful sampling has been shown to average 5.5 oz. Ag! The maximum Ag assay obtained was 9.5 oz. Very fine grained acanthite associated with galena is the only Ag mineral present.

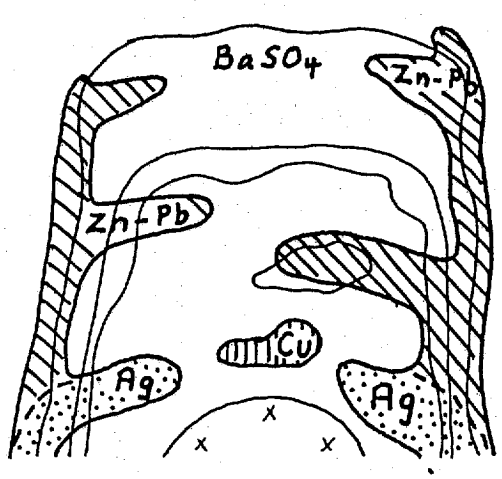
Fluid inclusion data - barite, T_h = 120-130°C
quartz (doubly terminated xls), T_h = 240°C; salinity = 34 wt. % NaCl equiv., probably formed at ∿22,000 ft. in the "mother" salt prior to diapiric rise

Isotopes - Pb, ratios indicate present age. $\delta^{34}S$, early sulfate +12 to +20‰
sulfides -20 to +22‰
late barite >+20‰

Mechanics of origin:



Periodic influx of metal-carrying geopressured basinal brines



Final distribution of metals and minerals

Other areas of interest - Marathon has identified 14 mineralized salt domes in a portion of the Gulf Coast region which coincides with a major reservoir of geopressured basin brines. This association is stressed. Visits to several abandoned drill sites used for S° exploration produced discarded core containing massive sulfides in sections measuring several feet long.

Morocco, Tunisia, and southern Spain all have base-metal mines associated with diapiric salt domes.

End of DREGS Talk

Afterthoughts - The occurrence in sandstone below base metals of Ag as acanthite associated with galena is most intriguing. The sandstone-hosted Pb-Ag deposits of Largentiere (Penarroya, 7.5 million tons of 4.0% Pb, 2.5 oz. Ag, and 0.75% Zn in 1968) immediately come to mind. Is there an Ag-rich equivalent in the sands of the mid-continent region of the U.S. or somewhere stratigraphically below Pine Point? The Paradox basin of Utah-Colorado has black shales, diapiric salt domes, redbed Cu-Ag deposits, and Cu°-Ag° in gangueless fissure fillings. If it also has a nearby reservoir of geo-pressured basinal brines it might be worth a shot. The Delaware basin of Texas-New Mexico lacks the black shales, but has sulfate-reducing bacteria at work. I am told by W. E. Dean that not a trace of sulfide has been found in the tens of thousands of feet of core from the Castile Formation that he and others have logged.

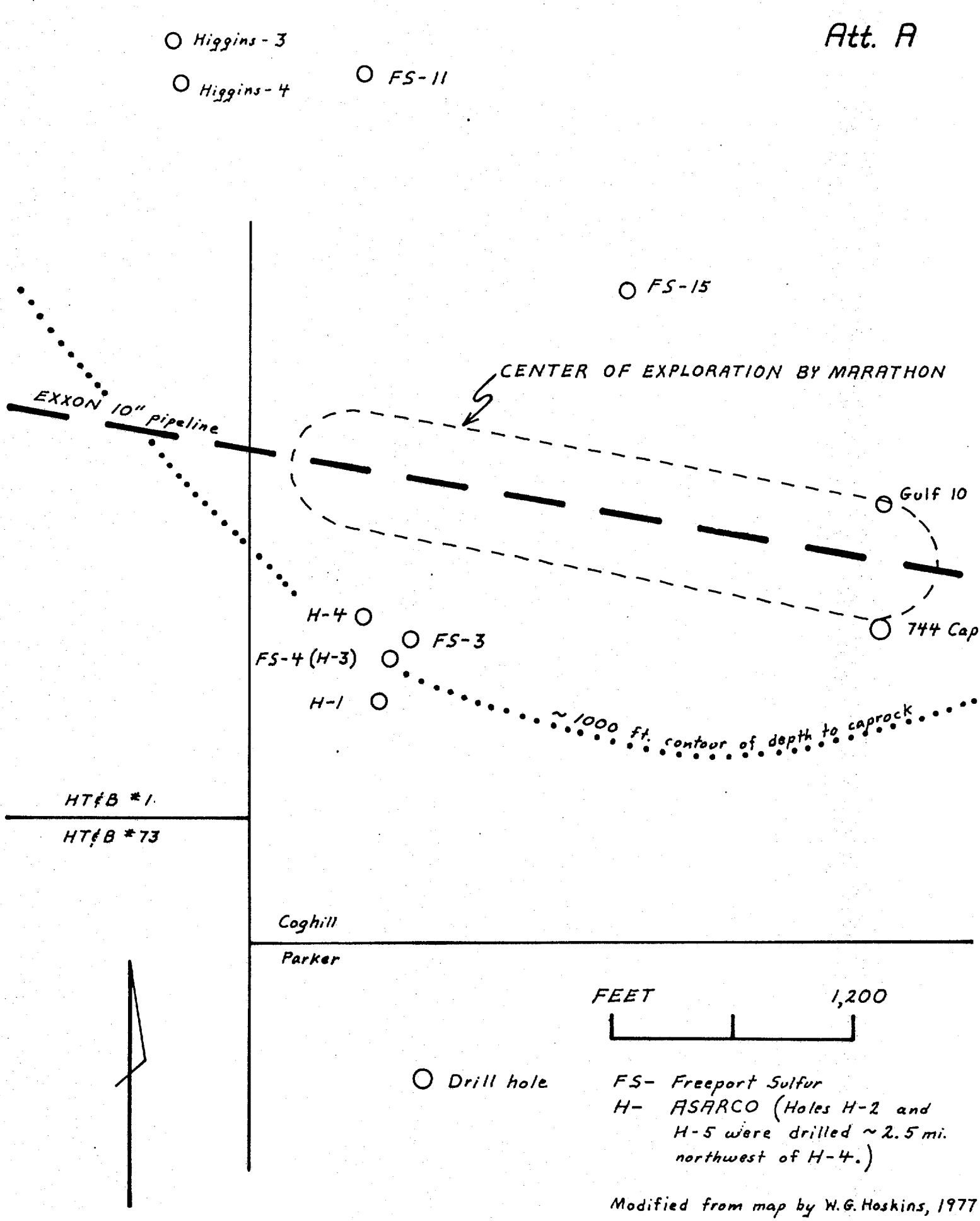
You will no doubt remember that Messrs. Von Fay and Hoskins drilled the Hockley dome in 1976 and although the operation was a success in the sense that Zn-Pb mineralization was encountered, the patient died. The Marathon "ore" body is located approximately 600 ft. north and northeast of the Asarco drill holes (Att. A). Had Asarco used a longer fence-drilling approach they might have found the more intense mineralization.

Douglas M. Smith, Jr.

DMS:lb
Att.

cc: FTGraybeal
PJBartos
DIFletcher - Sometime after the exploration meeting please review the geologic setting of the Paradise basin vis-a-vis the ingredients for salt-dome-related sulfide mineralization as discussed herein.

Att. A



Modified from map by W.G. Hoskins, 1977

Location of mineral exploration efforts at Hockley dome, Harris County, Texas.

Tony early 1984.

JDS → WRK

NW mining department

VALUE vs. COST

Value

Silver Formula: Crude Assay x Percent Recovery = Oz. Ag/Ton Recovered

Oz. Ag/Ton (Recovered) x Metal Price = Value/Ton Crude

1.65 oz. Ag/ton x 90% = 1.49 oz. Ag/Ton (Recovered)

1.49 oz. Ag/ton x $11.44/oz. = $17.05/ton crude

Copper Formula: 2,000 x Crude Assay x Percent Recovery = lbs. Cu/Ton (Recovered)

lbs. Cu/ton (Recovered) x Metal Price = Value/Ton Crude

2,000 x 0.0068 x 90% = $12.24 lbs./ton (Recovered)

12.24 lbs./ton x $0.768/lb. = $9.40/ton crude

Total Value/Ton Crude = $17.05 + $9.40 = $26.45/ton

Cost

	$/ton crude	
Mining	4.02	9.75
Milling	3.41	
General Plant-Indirects	2.32	
Post Concentrator Costs (Smelting, refining, concentrate & bullion freight)	5.79 — 5.79	7.18
Amortization	1.29 — 1.29	
Environmental	0.05	
Rehabilitation/Reclamation	0.05	0.10
Total Cost/Ton Crude =	$16.93/ton	

Margin

$9.52/ton

"The Nevada Prospector"
No. 17, Summer 1984.

New Alpha Silver Process Explained

The recent announcement of successful completion of pilot tests of its new Alpha Silver Process by Haber Inc., has sparked considerable interest on the part of the mining industry in general--southwestern silver miners in particular. If the Alpha Process is successful in the field it will revolutionize the recovery of silver from certain ores that heretofore have been almost impossible to treat economically.

Haber Inc., a high technology research and development firm headed by Norman Haber, president, and located in Montville Township, New Jersey, has entered into a joint venture agreement with Houston Mining & Resources, Inc., a Texas firm with widespread western mining interests. The efficient processing of manganiferous silver ores found on certain of HMR's leaseholdings in the Tombstone (Ariz.) District.

Developed by Norman Haber and John Lee, Ph.D., senior chemist for Haber, Inc., the Alpha Process is a hydrometallurgical technique for sulfide and telluride silver ores. Dr. Lee has been quoted as saying the Alpha Process is "non-toxic and recovery rates; that is, approximately 90 + % of silver, and over 99% of the manganese." The silver content of the ores examined ran as high as 35 oz. per ton and the manganese content as high as 35%.

An article that appeared in the June 1 edition of the (Denver) **Mining Record**, reads, in part:

"HM&R agreed to assign its Tombstone reserves upon third party technical validation by operation of a small pilot of the Alpha Process with ore from values of 23 oz. of silver/ton and 300 lb. manganese/ton in 92 percent and 99 percent yields, respectively, on the first pass. These remarkable results are not unusual for the Alpha Process, although Haber spokesman, Dr. John Lee, claims that the 15 + % manganese figure was rather low, compared to other Tombstone ore samples examined. However, the manganese produced is iron-free and of exceedingly high purity.

"While the reserve contributed by HM&R is substantial, the agreement specifically permits the Alpha Process to be used on any mine in the Tombstone region. Although the Tombstone region has mined $500 million in silver values (at today's prices) 5in the past, it has since resisted extensive mining, due to the manganese content of the deeper silver sites. HM&R and its affiliates invested approximately $2½ million in this property which, along with other Tombstone mines and mills, is nearly at a standstill today."

(Note: The above statement relative to current activity in the Tombstone District is subject to question. Two very substantial mines and mills are producing sizeable amounts of silver—and some gold on a 24-hour, seven-day basis. However, for the most part of the ores they are mining and milling are high in silver chlorides and low in manganese. They cyanide readily.)

The Alpha Silver Process is apparently an outgrowth of Haber's reserach that he claims is a completely new technology dubed electromolecular propulsion, or EMP. Haber's work on EMP began in earnest in 1967, when he left New York University, where he was a part-time researcher, to pursue the technology full time. He holds patents on his process.

Haber and his work have attracted considerable attention in the last decade. The May 14, 1979, issues of BUSINESS WEEK devoted two and one-third pages to the inventor and his processes. One sub-head in the article reads: "EMP starts where Einstein left off."

The BUSINESS WEEK article includes: "By judiciously choosing the medium that will optimize the EMP effect for the molecules of a specific substance, Haber generally can separate that substance quite rapidly into its constituent molecules. For example, in a demonstration with a food dye and two ink samples, a portable EMP instrument suggested the various pigments, carrier fluids, and apparent impurities in

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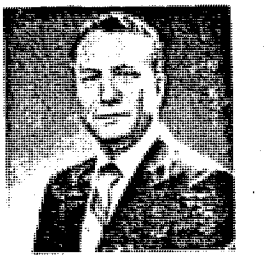

VOTE **Meet The Challenge** VOTE

with

Robert C. "Bob" Lybarger
County Commissioner
For the Future of
Mineral County and Our Mining Industry

less than five seconds."

In the 1979 BUSINESS WEEK article one paragraph was particularly prophetic in light of the recent announcement. It said: "Haber also believes that for refining precious metals, "the potentials are enormous.' He claims that EMP can separate latinum and iridium--often found together in nature--'in one step, in a minute or so,' instead of the multiple processes now needed."

Dr. John Lee, Haber Inc.'s senior chemist, is no newcomer to metallurgy. He is known for the development of a process which recovers molybdenum from ferromanganese nodules.

The occurrence of silver values locked in manganese dioxide has long been a bugaboo in the production of silver in the American West. It did not present a serious problem back in the days when ores were reduced by smelting processes and in some instances prior to the turn of the century smelters actively sought "high manganese" ores, with the manganese and silica content serving as a flux in the reduction process. As recently as 1967 Phelps Dodge Corp., desired these Tombstone ores for their Douglas smelter, offering to purchase ore that they assayed at gold 0.075 oz.; silver 53.74; copper 0.45%, Si02 32.2%; A1203 1.8%; Fe 1.5%; Mn 18.0%; CaO 17.0% and MgO 0.8%.

It was at about this time that silver prices began to look upward and the eyes of the mining industry once again turned on the great Tombstone District. Then that the Brothers Escapule pioneered heap leaching of silver ores with cyanide and perfected the Merrill-Crowe method of precipitating the gold and silver values via zinc dust. The method works well with chlorides and with some of the manganiferous silver ores, but with others the recovery rate of the metals is low, slow and expensive. It often consumes large amounts of sodium cyanide and gives up next to nothing in the values.

Gravity concentration and flotation likewise release little in the way of the precious metals values of these ores. Traditionally, they have responded economically only to smelting. With the significant loss of custom smelting capacity that has taken place in the last quarter century the end result is that it has become next to impossible to get these ores into a smelter.

Considerable effort has been expended in the last 10 years in attempts to treat these ores via hydrometallurgical methods. Some have met with a degree of success but the results have, for the most part, fallen short of an economical recovery. No such process is at this time known to be operating on other than a lab scale.

Heretofore, one of the drawbacks of such processes has been that only the precious metals--silver and gold--have been recovered. The manganese, which in many instances may have more end value than do the precious metals, has gone onto slag dumps and into mill tailings piles. With the Alpha Silver Process as developed by Haber Inc., the manganese content would be saved in the form of an extremely high grade product which, by reason of its quality is expected to be in considerable demand. Thusly, the money value of ores selected to be handled via the Alpha Process should be greatly enhanced in worth.

Many mining firms are watching the progress of the Haber technology with considerable interest. Should their extraction efforts prove successful with a plant of substantial size in the Tombstone District, the way will be paved for a whole new scheme of things in the metals refining industry. "This could", said one mining executive, "be the first light of a bright new day dawning on mining's horizon. It may well be the beginning of true hydrometallurgical extraction of all metals, thusly bringing not only an end to a major portion of the environmental problems that plague the industry, but, hopefully, a relief from some of the high costs of refining metals."

NERCO Acquires All Of Oxy Stock In Mine

NERCO Minerals Company of Fairbanks, Alaska, has acquired all the outstanding common stock of Occidental Mineral Corp. and reopened the historic Candelaria silver mine south of Mina under new ownership. It is the nation's largest open pit silver operation.

-0-0-0-0-

Forest Service Set Mining Claim Rules

The Forest Service recently issued directions for carrying out its responsibilities on unpatented mining claims in wilderness. Approval of a mining plan of operation will be allowed if the claimant has complied with filing-for-record requirements of Federal Land Policy Management Act and discovered a valuable mineal deposit before Jan. 1, 1984.

The Forest Service will require an on-the-ground validity examination to verify discovery and establish a valid existing right.

However, if the sole purpose of operations is annual assessment work and if the operations won't cause significant impact to wilderness values, the Service may waive the validity examination.

Miners and Prospectors.....

Are you interested in belonging to the Nevada Miners and Propectors Association?

For more information and a membership application, write to Box 283, Mina, Nevada 89422

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Nov. 10, 1984 Vol. 73 No. 45

SKILLINGS' Mining Review

Western Mining Rail Excursion Held Sept. 25 to Oct. 5—Page 4

February 27, 1985
Amer. Min. Cong. Journ.

* Exploration managers should think about
Exploration promotion with input
from Company Tax men at or for acquisition
of favorable areas.

2. The experts tell us that this is surplus to U.S. defense needs and that it is the only surplus commodity in the stockpile with any value.

3. The experts also tell us that other commodities are needed more urgently in the strategic stockpile, but that little progress is being made in acquiring them because no funds are available.

4. The current political climate favors strengthening our national defense, but cutting expenditures in an effort to reduce the budgetary deficit.

5. Couple these with the fact that the domestic silver mining industry has little political clout on the national scene; i.e. there are not many voters directly involved.

Any logical person adding up these facts can come to only one conclusion as to what should be done in the best interest of the country—sell the stockpiled silver and use the funds generated to buy more urgently needed commodities.

It may surprise some of you—although it has been said many times before—that the domestic silver mining industry recognizes that such a course of action may be in the best interest of the country *and we are not opposed to it.*

Let me repeat myself—the domestic silver miners do not oppose disposal of surplus silver from the strategic stockpile, *provided it is done properly.* By properly, we mean in such a way as to minimize its impact on world prices, thus bringing maximum benefit to our country and having minimum impact on our industry.

We do object strongly to a repetition of the abortive attempt of 1980-81 to dispose of the silver by auctions of 1000-ounce bars to a limited group of potential customers—a procedure that we are convinced seriously depressed prices and that we know moved very little silver.

Now there are those who would argue that the disposal attempt in 1981 did not depress the silver price—and who will cite figures to prove it. We could argue the point all afternoon to no avail. I think the truth is that none of us is smart enough to quantify and sort out all of the many influences impacting the price of silver over any short term period of time so that believable numerical proof is possible. Those in the business world who are involved day to day in the marketing and trading of silver know that the disposal exercise, and even the anticipation of it, did in fact depress the market. Perhaps the most convincing evidence of that is provided by our friends and customers of the Silver Users Association. The position of this trade association on all political issues is the most consistent and predictable of any group that I have ever seen. If an action will tend to depress the price of silver—they are for it. It is significant that they are in favor of the auction method of stockpile disposal employed in 1981.

There is a procedure for disposing of surplus stockpiled silver that would meet the objectives of our government and our industry. Because it would have minimum impact on the world price, it would maximize dollar return to the stockpile fund for procurement of more urgently needed commodities. At the same time it would have minimum impact on the silver mining industry. That procedure is disposal as coinage.

Disposal as coinage would have minimum impact on price simply because sales would be directed to the largest possible group of potential customers worldwide—the general public. Disposal by this method would have the additional advantage of producing the greatest safety in the event that future national emergency needs cannot be met by imports from foreign countries. Much of the silver would remain in our citizens' savings hoards from which it would be readily available at a price.

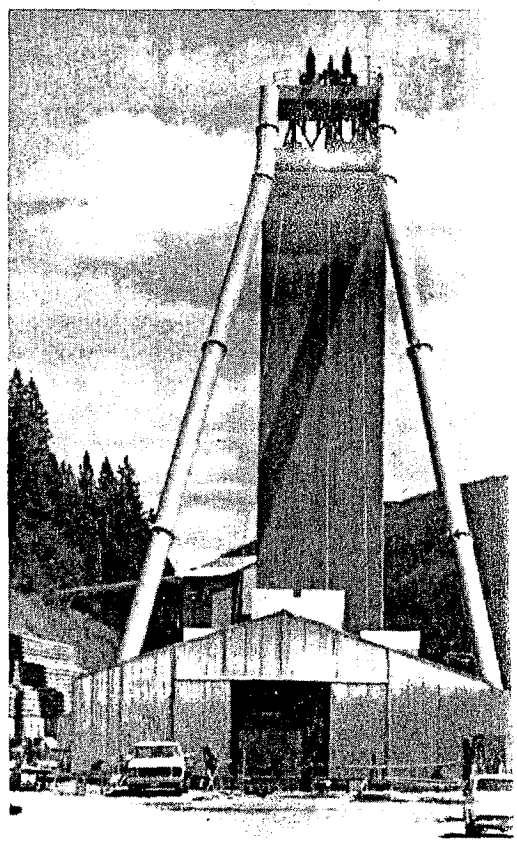
Conclusion

These, then, are two of the silver miner's concerns as he looks at the future—long term:

A concern about foreign competition in the years to come; and

A concern that our federal government act with care in disposing of the excess silver in the strategic stockpile.

We in the industry will continue to do all we can to meet the threats of foreign competition. We ask that government do what it can to avoid tipping the scales against us.



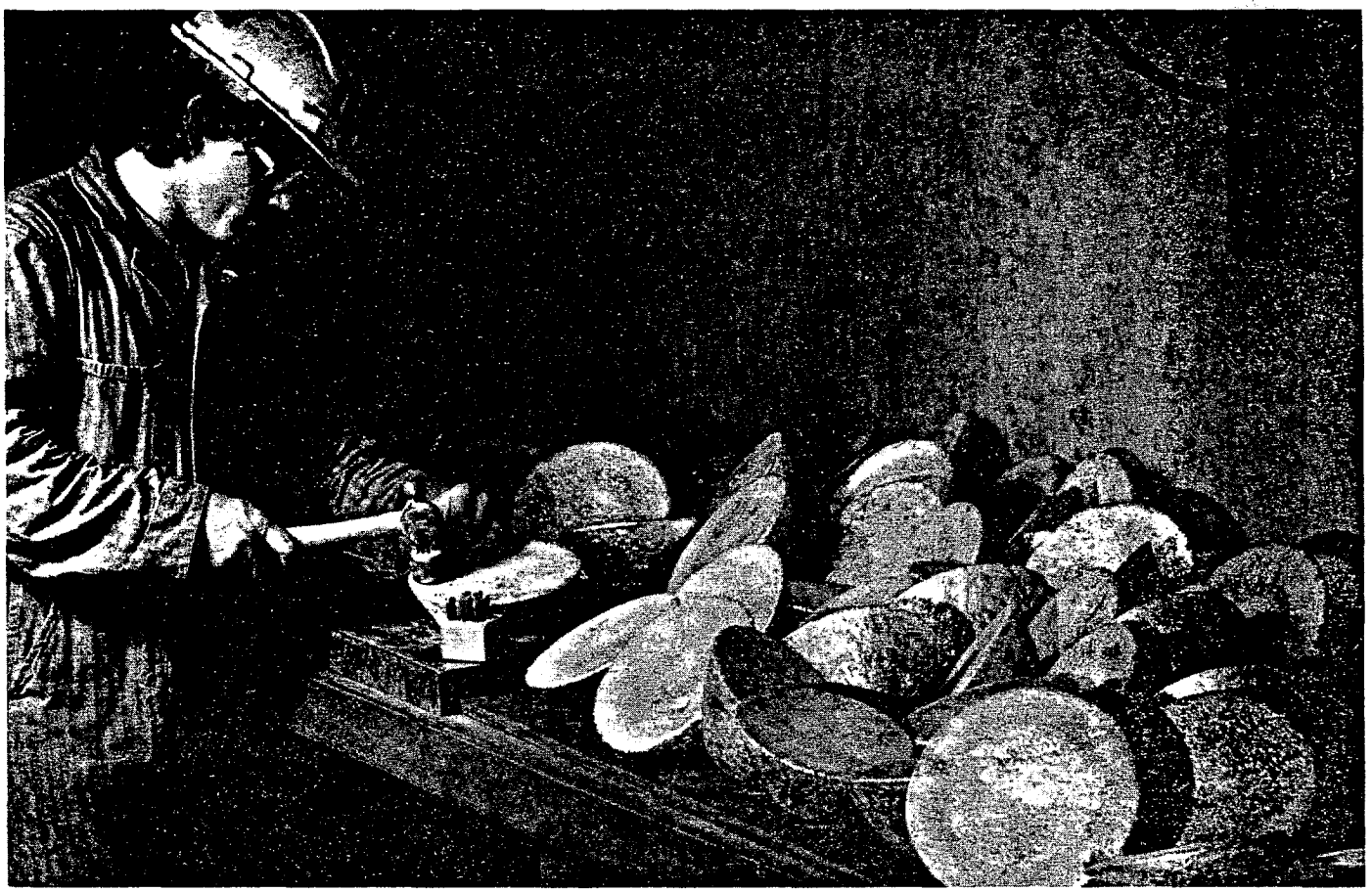
Headframe of the new 6200-ft-deep Silver shaft at Hecla's Lucky Friday mine in Idaho's Coeur d'Alene district.

Commemorative coin bill passes House

The minting of special gold and silver coins would be allowed under a bill passed by the House last week. The coins would commemorate the centennial of the Statue of Liberty and the use of Ellis Island as a gateway for immigrants to America.

Receipts from a surcharge, included in the sale price, would be used to establish an endowment to ensure the continuing upkeep and maintenance of the Statue of Liberty and the immigration facilities on Ellis Island. The Secretary of the Treasury could obtain silver from any federally-owned stock of silver and may obtain gold from any authorized source.

Up to half a million 90-percent gold $5 coins (containing .24 oz of gold) would be minted. And, 10 million 90-percent silver dollars (containing .77 oz of silver) would be allowed. Similar legislation is pending in the Senate. (AMC contact: Keith R. Knoblock, 202/861-2851.)



READY FOR MARKET - A Candelaria Mine refinery worker stamps the final product prior to shipment. The silver and gold doré buttons average 600 troy ounces in weight.

Candelaria Mine pours 10 millionth ounce of silver

THE CANDELARIA MINE in Mineral County, Nevada, has poured its 10 millionth ounce of silver for NERCO. The mine is one of the largest open-pit primary silver mines in the United States.

NERCO acquired the mine from Occidental Minerals Corporation in 1983. Built in 1979, the Candelaria Mine was one of the first large-scale heap leaching operations to recover silver in North America. The site had been mined more than 100 years earlier for underground silver.

According to NERCO President Lawrence E. Heiner, "our strategy at Candelaria has included expanding the ore reserve base, increasing production, and reducing operating costs. The mine has performed extremely well on all three counts, and we consider Candelaria to be one of the model North American precious metal operations."

Between 1985 and 1986, NERCO Minerals Company added 15.8 million ounces of silver and 95,000 ounces of gold to Candelaria's recoverable reserves through minesite exploration. During the last four years, silver production has increased from 1.7 million ounces annually to nearly 3 million ounces. Direct production costs have been reduced 40 percent from approximately $8.08 per ounce in 1983 to $4.84 in 1986.

As of January, 1987, Candelaria's ore reserves stood at 26.14 million tons grading an average 1.164 ounces of silver and 0.005 ounces of gold per ton.

According to Candelaria Mine's general manager, Ralph Van Arsdale, "our employees have accepted the challenge of increasing productivity in order to remain competitive in a volatile economic climate. We're operating more efficiently now than we ever dreamed possible four years ago," said Van Arsdale.

In addition to the Candelaria Mine, NERCO has interests in five other precious metals operations in Idaho, Colorado, Nevada, and Northwest Territories, Canada.

December 13, 1987

TO: R. L. Brown

FROM: D. M. Smith, Jr.

Targets Of Opportunity For Pb-Zn-Ag
Massive Sulfide Ores In The Western U.S.

As per your instructions of November 4th the accompanying tables, maps, and texts describe possible exploration and development targets for Pb-Zn-Ag ores. The selection process involved the application of a basin filter (memos to W. L. Kurtz dated 4-23-84 and 3-10-86) to known prospects as well as to the intrusion-related carbonate-hosted Ag-Pb-Zn districts listed by Graybeal et. al (1986, Tables V and VI) in their monumental treatis on the geology of silver deposits. Western Canada and the Coeur d'Alene district were not included in the review, but doubtless have potential for the discovery of ore deposits containing lead-rich ores. The Metaline district located in extreme northeastern Washington was excluded owing to the absence of precious metals in the ores, however, the possibility that major deposits of MVT Pb-Zn ores could be found in western North America should not be ruled out.

Districts which survived the basin filter or have clearly superior geologic qualifications are listed in the accompanying table. They total 18 in number and are located in Arizona (1, Att. A), California (2, Att. B), Colorado (2, Att. C), Nevada (6, Att. D), New Mexico (3, Att. E), and Utah (4, Att. F).

Douglas M. Smith, Jr.

cc: WLKurtz

11-19-87

ASARCO Incorporated

FROM: DOUGLAS M. SMITH, JR.

NOV 23 1987

TO: J. D. Sell

SW Exploration

Pb-Ag Feed For E. Helena

I've been charged with identifying "targets of opportunity" in the category cited above. No roots of grass allowed.

Your ideas and favorite properties would be a welcome addition to my list which must be on RLB's desk December 15 with drill holes spotted (so send along a map with yours). Thanks.

Cheers,

Doug

ASARCO Incorporated

NOV 23 1987

SW Exploration

LEAD-SILVER TARGETS OF OPPORTUNITY

PROPERTY AND CATEGORY	STATUS	OWNER
PROPERTIES WITH RESERVES		
Eureka, Nevada	water problem	Ruby Hill Mining Co. (Hecla, Cyprus, Sharon)
Shafter, Texas	idle	Gold Fields Mining Corp.
PROPERTIES WHICH MIGHT HAVE RESERVES		
Darwin, California	mined out ?	~~unknown~~ Quintana
East Tintic, Utah	being drilled	Sunshine Mining, Western Mining
PROPERTIES THAT MAY WARRANT EXPLORATION		
Ark, Colorado	idle	Asarco
Cerrillos, New Mexico	idle	B. Gay researching
Cerro Gordo, California	unknown	unknown
Cortez, Nevada	unknown	unknown
Delano, Nevada	unknown	unknown
Kokomo, Colorado	jv sought	Climax
Lake Valley, New Mexico	idle	B. Gay researching
Marysvale, Utah	for sale	Deer Trail Development Corp.
Ophir, Utah	unknown	unknown
Railroad, Nevada	unknown	unknown
Rush Valley, Utah	unknown	unknown
Tombstone, Arizona	unknown	unknown
Tres Hermanas, New Mexico	being drilled	R.L.Berry, R. Chico, Border Mining, Cominco
White Pine, Nevada	unknown	unknown

14112 G.B.

Cyprus Minerals Company
NOV 23 1987
SW Exploration

LEAD-SILVER TARGETS OF OPPORTUNITY

PROPERTY AND CATEGORY	DESCRIPTION OF TARGET	DEPTH TO TARGET
PROPERTIES WITH RESERVES		
Eureka, Nevada	much mineral. @ .15-.2 oz Au, 7-9 oz Ag, 5-7% Pb, 9-12% Zn, .1-.2% Cu	3,000 TO 4,000
Shafter, Texas	20 million oz Ag	unknown
PROPERTIES WHICH MIGHT HAVE RESERVES		
Darwin, California	extent of mining vs ore potential is unknown	unknown
East Tintic, Utah	expansion of existing reserves	1,000 to 2,000
PROPERTIES THAT MAY WARRANT EXPLORATION		
Ark, Colorado	Leadville dolo. not yet tested below zone of most intense alteration	1,500 to 2,500
Cerrillos, New Mexico	Todilto Limestone adjacent to Tertiary stock with Pb-Zn-Ag veins	1,000 to 2,000
Cerro Gordo, California	small district near Darwin, needs study	unknown
Cortez, Nevada	mining may have stopped at oxide-sulfide contact	unknown
Delano, Nevada	sulfide zone beyond post-ore faults	unknown
Kokomo, Colorado	untested geophysical anomaly, Leadville at depth	0 to 4,000
Lake Valley, New Mexico	test hanging wall of stoped area beneath volvanic cover	1,000 to 2,000
Marysvale, Utah	continue driving face in ore and drill underground	2,000 to 4,000
Ophir, Utah	sulfide ore below oxides	1,000 to 3,000
Railroad, Nevada	unstudied	unknown
Rush Valley, Utah	sulfide ore below oxides	1,500 to 3,000
Tombstone, Arizona	B.J.Devere recommendation	1,000 to 2,500
Tres Hermanas, New Mexico	drill West Lime Hills area beneath volcanic cover and Qal	500 to 2,000
White Pine, Nevada	unstudied	unknown

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SABCO Incorporated
NOV 23 1987
Sw Exploration

LEAD-SILVER TARGETS OF OPPORTUNITY

PROPERTY AND CATEGORY	ASSOCIATED BASIN	BASIN POSITION	HISTORIC HOST
PROPERTIES WITH RESERVES			
Eureka, Nevada	unnamed Permian	excellent	Eldorado Dolo, M Cambrian
Shafter, Texas	Marfa	excellent	Presidio Fm, Cretaceous
PROPERTIES WHICH MIGHT HAVE RESERVES			
Darwin, California	unnamed Mississippian	excellent	idoc-gar-wollas rock in lime, Dev-Penn
East Tintic, Utah	Uinta, Oquirrh	excellent	Ophir Fm, M Lime, M Cambrian
PROPERTIES THAT MAY WARRANT EXPLORATION			
Ark, Colorado	Piceance	excellent	Leadville Lime, dolo, U Mississippian
Cerrillos, New Mexico	Estancia	good	none, (Todilto Lime, U Jurassic)
Cerro Gordo, California	unnamed Missippian	excellent	Lost Burro, Devonian
Cortez, Nevada	unnamed Permian	good	Pogonip Grp, Ordovician
Delano, Nevada	unnamed Permian	excellent	Park City Grp, Permian
Kokomo, Colorado	Piceance	excellent	Minturn Fm , limes, Pennsylvanian
Lake Valley, New Mexico	none	bad	Lake Valley Lime, Mississippian
Marysvale, Utah	none	bad	Toroweap Fm, lime & dolo, Permian
Ophir, Utah	Uinta, Oquirrh	excellent	most in various Mississippian limestones
Railroad, Nevada	unnamed Permian	good	Nevada Fm & Devils Gate Lime, L Dev
Rush Valley, Utah	Uinta, Oquirrh	excellent	Oquirrh Fm, limes
Tombstone, Arizona	Pedregosa	good	Bisbee Grp, Cretaceous; Earp Fm, Penn-Perm
Tres Hermanas, New Mexico	Pedregosa	good	Escabrosa Lime, Miss; Fusselman Dolo, Sil
White Pine, Nevada	unnamed Permian	poor	Lone Mtn, Sil; Nevada & Hanson Crk Fms, L Dev

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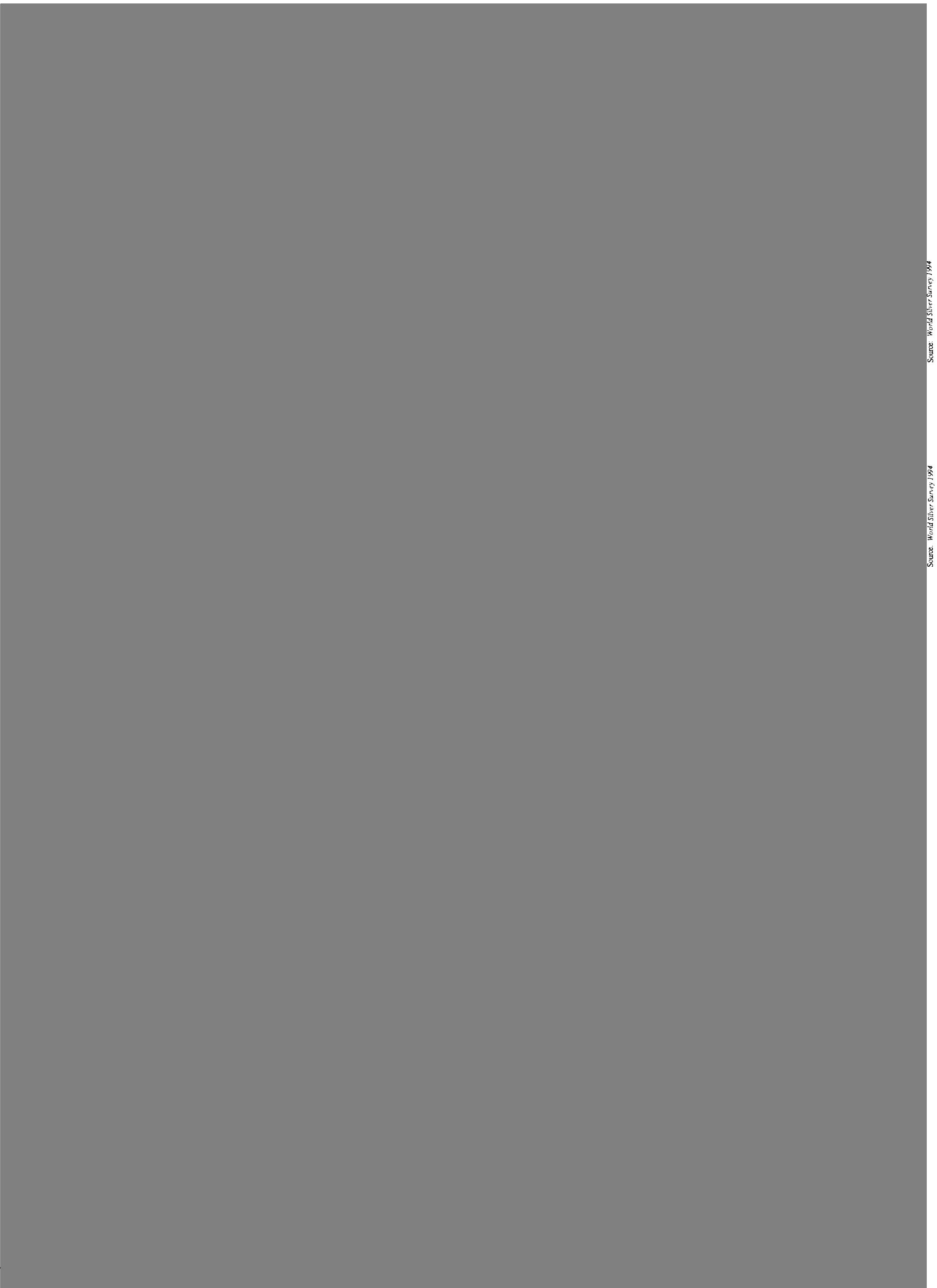
ASARCO Incorporated
NOV 23 1987
SW Exploration

LEAD-SILVER TARGETS OF OPPORTUNITY

PROPERTY AND CATEGORY	CONTROLS	COMMENTS
PROPERTIES WITH RESERVES		
Eureka, Nevada	NS & NE flts	one heading made 27,000 gpm water
Shafter, Texas	ENE flts, dike, reef talus, karst	355 holes, silica encapsulation
PROPERTIES WHICH MIGHT HAVE RESERVES		
Darwin, California	ENE flts close to intrusions	Anaconda may have explored totally
East Tintic, Utah	NE & NNE flts, thrusts	bad ground has hampered mining
PROPERTIES THAT MAY WARRANT EXPLORATION		
Ark, Colorado	EW & NE flts, karst	Au intercepts on adjoining ground
Cerrillos, New Mexico	NE flts	massive sulfide target never tested
Cerro Gordo, California	NW flts, folds, thrusts	
Cortez, Nevada	NE & NW flts	ore zone dips under mountain range
Delano, Nevada	unknown	Noranda mapped but didn't drill
Kokomo, Colorado	NE flts	buried under tailings
Lake Valley, New Mexico	NW & EW flts	hanging wall never tested
Marysvale, Utah	WNW to NW flts, NW anticlinal axis	adit access, dips under mountain
Ophir, Utah	NE & NS flts, folds	
Railroad, Nevada	dikes, joint-controlled chimneys	
Rush Valley, Utah	NNW to NNE flts, folds	
Tombstone, Arizona	NE flts	Newmont cut deep "ore" in 2 ddh
Tres Hermanas, New Mexico	NE flts, karst	Cominco currently drilling (11/87)
White Pine, Nevada	thrusts	

14112 G.B.



Source: World Silver Survey 1994

Source: World Silver Survey 1994

March '86

JHC

REFINED SILVER PRODUCTION FALLS FOR SECOND YEAR IN A ROW

As shown below the total production of refined silver by U.S. and non-U.S. participants in The Silver Institute refining series decreased by 0.1% from 336.3 million troy ounces in 1984 to 335.9 million troy ounces in 1985. This very slight decrease follows last year's 5.6% fall in output.

Production from primary ores was exactly the same as last year. Refining of secondary materials fell 0.3% due to 17.7% reduction on old scrap and coins, which was almost wholly offset by a 10% increase in new scrap refining. Stocks of silver held at U.S. refineries ended the year at an all-time low.

LATEST SILVER INSTITUTE REFINING STATISTICS

Production and Disposition of **999 Silver** by All Known Refiners in the United States

	TROY OUNCES		MILLION TROY OUNCES		
	December 1985	November 1985	Full Year 1985	Full Year 1984	Full Year 1983
			MONTHLY RATE		
THESE REFINERS' PRODUCTION, BY SOURCE					
From Primary (ores & concentrates)	3,865,454	3,891,899	49.6	55.3	52.8
From Coins	0	0	0.0	0.0	0.3
From Old Scrap (used photo film & other products)	2,249,742	2,610,306	30.0	35.2	37.1
From New Scrap (in-plant clippings, waste)*	5,351,561	2,484,922	29.3	25.9	22.0
TOTAL PRODUCTION	11,466,757	8,987,127	109.0	116.4	112.2
DISPOSITION BY THESE REFINERS					
Converted in Plant (consumed in fabricating, etc.)	7,140,723	4,607,726	45.2	43.1	40.0
Shipped Out as 999 Silver	4,929,571	4,637,950	67.6	70.5	72.0
TOTAL DISPOSITION	12,070,294	9,245,676	112.8	113.6	112.0
RESULTING CHANGE OF THESE REFINERS' STOCKS (Production Minus Disposition)	−603,537	−258,549	−3.8	2.8	0.3
THESE REFINERS' STOCKS AT END OF PERIOD	86,798	690,335	0.1	3.9	1.2

Production and Disposition of **999 Silver** by All Known Refiners in Australia, Canada, Mexico, Peru, South Africa, Sweden, and West Germany; and some other Refiners in Europe and Asia.

	TROY OUNCES		MILLION TROY OUNCES		
	December 1985	November 1985	Full Year 1985	Full Year 1984	Full Year 1983
			MONTHLY RATE		
THESE REFINERS' PRODUCTION, BY SOURCE					
From Primary (ores & concentrates)	13,467,628	14,736,691	166.2	160.5	157.4
From Coins	394,493	156,523	1.5	1.2	2.6
From Old Scrap (used photo film & other products)	3,538,647	3,756,928	47.9	47.1	71.5
From New Scrap (in-plant clippings, waste)*	847,410	876,951	11.3	11.0	12.6
TOTAL PRODUCTION	18,248,178	19,527,093	226.9	219.9	244.1
DISPOSITION BY THESE REFINERS					
Converted in Plant (consumed in fabricating, etc.)	1,488,338	1,583,577	17.2	19.8	38.1
Shipped Out as 999 Silver	15,806,871	17,459,080	207.3	200.7	204.9
TOTAL DISPOSITION	17,295,209	19,042,657	224.4	220.5	243.0
RESULTING CHANGE OF THESE REFINERS' STOCKS (Production Minus Disposition)	952,969	484,436	2.4	−0.6	1.2
THESE REFINERS' STOCKS AT END OF PERIOD	7,699,333	6,746,364	7.7	5.3	5.9

Refiner – '85 Prod. 333.6 MM oz or 10,500 Tons — 1X Mohide projection – 13,000 Tons for demand

* PRODUCTION From New Scrap is 999 silver made from in-plant clippings, spillage, sweepings, etc., generated during manufacturing processes.

THE SILVER INSTITUTE

A WORLDWIDE ASSOCIATION OF MINERS, REFINERS, FABRICATORS AND MANUFACTURERS

INCORPORATED 1971

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JHC

ASARCO

Exploration Department

September 27, 1985

FILE MEMO

SILVER
By T.P. Mohide - 1985 - Jan.

This 400 page book contains a wealth of information on virtually all aspects of silver. Some of the more significant observations and conclusions are briefly stated below.

Demand-Supply, Western World

Total supplies exceeded commercial demand in the period 1978 thru 1984 (Att. A)---- varying from 5% in '78 to 74% in '80, and 29% in '84. The projection for '85 is 10%. Increasing consumption is expected to close the gap by 1990.

Att. B shows sources of total supply over the period '78 thru '85 (projected). Mine output increased from 8,250 metric tons to 9,600 in '85; secondary silver peaked at 9,000 metric tons in 1980, falling to 3,200 in '85. Imports from India and southeast Asia rose to 1,711 tons in '83 falling to 850 tons in '85.

Production

Att. C lists mine production by countries during the period '81 thru '83. According to the Silver Institute, World mine production of 12,500 metric tons in '83 will increase 5% in '84 and 2% in '85 (projected). Notably, the U.S.S.R., the next largest producer after Peru, is a net importer of silver.

Consumption Categories

Principal Western World uses in 1983-85:

1.	Photography	40%
2.	Electronics	19-26%
3.	Sterling tableware, jewelry	15-19%

4.	Catalytic converters	8%
5.	Medical	6%
6.	Coinage	5%
7.	Miscellaneous	4%

Seven countries: U.S., Japan, West Germany, Italy, U.K., France and Canada account for some 85% of Western World consumption.

According to the Silver Institute, an expanding list of new end-uses for silver shows no sign of slowing down in electronics, catalytic, medical, decorative and analogous uses, solar power, water purification and in armaments.

Stocks

Att. D shows all 6 types of above-ground silver stocks declining steeply from 1970 to 1980. However, according to CRU, non-government stocks (users inventories, speculative and private coin stocks) were at their highest level in modern history in mid 1983.

Estimated world silver stocks of around 200,000 metric tons equal 16 yrs. mine output (at 12,000 tons/yr.) while world gold stocks of around 65,000 tons equals 46 years mine output (at 1,400 tons/yr.).

At the end of '83 total reported world silver stocks (excluding Soviet Block) were 74,000 tons.

Silver Price

An ounce of silver still had the same purchasing power in 1984 as it had in 1871, 113 years ago. It has maintained its value. Many other materials have not (Professor G. Anders).

The U.S. dollar lost more than half its value in the period 1971 thru 1982, while silver and gold now have a value 5 and 8 times higher than in 1971.

Supplies of scrap fall off below $7.00 per ounce and increase above $10.00 per ounce.

(The author's forecast of the 1985 silver price, $9.00 to $12.00, has thus far this year proven high by 50 to 100%.)

Executive Summary

Under this title there are 23 paragraphs. The most significant of these are quoted below:

17. For about the last thirty years, the amount of silver consumed each year in industry, medicine and the arts has greatly exceeded annual world mine output of silver.

18. The shortfall or gap in supplies has been made up year after year by deliveries of metal recovered from scrap and by draw-downs from stocks held by companies and particularly governments.

19. The bulk of these huge stocks have been sold off in the last twenty five years, so we are now approaching a situation where such silver stock sales will terminate or slow down to a trickle and from then on basically only mine output, plus recoveries from scrap, will be available to attempt to satisfy the growing world demand for silver in the next few years.

20. Remaining surface stocks of refined bullion silver are formidable, but a large part of these stocks will not come onto the market until the silver price is extremely high.

21. This developing constriction of supply in the face of rising demand can only result in much higher prices for silver eventually. As the silver price rises, holders of the remaining silver will be reluctant to sell, hoping for even higher prices.

22. Until that point is reached the short-term outlook for the silver price understandably is unexciting, but, as stated, the longer term will produce a much higher price level for silver.

(Not included in the Executive Summary is the fundamental fact that the demand for silver (and gold) rests primarily on the rate of inflation.)

Explorationists take note:

"During the Boer War, a British Army Officer examined the bullet that had wounded him and found that it contained more silver than lead. Boer prisoners would not reveal the mine source, but later (in 1968) a rich silver deposit was discovered where silver-bearing bullets had been found, near the Hartbeestport-Johannesburg road."

J. H. Courtright

JHC:mek

J. H. Courtright

cc: R.L. Brown
W.L. Kurtz
J.D. Sell
D.M. Smith
J.C. Balla
D.D. Harper
P.G. Vikre
R.S. Gray
H.C. Williamson

1985 consumption does not include small bar sales
'85 ASARCO Rept

Chapter 6 Demand, Consumption and Uses of Silver

1 Metric Ton = 32 000 oz

6.1 DEMAND, CONSUMPTION AND USES OF SILVER

"The barge she sat in .... the oars were (made of) silver."
-Shakespeare, "Antony and Cleopatra"

The wide range of uses of silver in industry, in electricity, electronics and the associated engineering, catalysis etc. sectors has developed largely in the present century and particularly since 1945.

SILVER — DEMAND IN THE WESTERN WORLD AND SUPPLY (estimated)

('000 metric tons)

	1978	1979	1980	1981	1982	1983	1984 est.	1985 proj.
Total Commercial Demand	14.77	14.80 (16.00*)	11.75	11.26	11.75	11.73	12.40 to 12.70 (11.82 Shearson Lehman)	13.00 to 13.50
(Industrial and Coinage ex-including Soviet Bloc)								
Total silver Supplies, including Newly Mined Output, Secondary Silver, Sales by Governments, Silver from India etc.	15.52	15.79	19.06	16.13	14.23	17.47	16.13 to 16.3	14.35 to 14.85

Silver Inst. Refining data 11.1
10.4 10.5 ASARCO
12.00
14.00
450 mil oz

Sources: Metals Analysis and Outlook; T.P. Mohide; J. Aron/Goldman Sachs; Shearson Lehman/American Express, London.

* U.S. Bureau of Mines estimate.

n.b. 1) Total world consumption of silver is believed to have increased by about 1 per cent in 1983, according to the U.S. Bureau of Mines.

2) Total Supplies of Silver exceeded Total Commercial Demand in the period 1978 through 1984. The surplus supply of those years is in stock. This acts as an overhang to the market and is bearish for the price.

3) Free world annual demand for silver should rise to about 15,500 metric tons by the early 1990's, some observers say.

On the face of it, total free world demand for silver has greatly exceeded free world mine production of silver each year for at least the 30 years ending —

over

1984. Consumption of silver in the last few years has surpassed newly mined production in each year by some 3000 metric tons a year, or so.

7.1 WORLD SUPPLY AND DEMAND – SILVER

(metric tons)

Supply	1978	1979	1980	1981	1982	1983 est.	1984 est.	1985 projected
Output (Western)								
Mine output of Western countries-primary silver	8,250	8,400	7,950	8,808	9,166	9,580	9,550	9,600
Secondary (Western) total	5,300	5,692	9,000	5,599	4,050	5,650	5,080 (6,000 -Credit Suisse)	3,200 -3,400
From (to) Communist Bloc	218	450	400	250	(250)	30	150	150
Total Western World Principal Supply	13,868	14,542	17,536	14,696	13,000	15,260	14,780	12,950 -13,450
Imports from India and Southeast Asia	1,400	1,150	1,369	1,306	1,151	1,711	1,200	1,250
Sales by Governments, net (including drawdowns for coinage)	250	100	155	125	345	500	150	150
Overall Silver Supply	15,518	15,792	19,060	16,127	14,226	17,471	16,130 (16,298 -Credit Suisse)	14,350 -14,850

CONSUMPTION IN THE WESTERN WORLD

Industrial	13,561	13,950	11,300	10,950	11,350	11,150	11,500 -11,750 (12,650 -Credit Suisse)	12,250 -12,750
Coinage	1,213	850	450	310	398	578	900	750
Total Demand (excluding exports to the Soviet Bloc)	14,774	14,800	11,750	11,260	11,748	11,728	12,400 -12,700	13,000 -13,500
Net Exports to Communist Bloc countries	n.a.	n.a.	n.a.	0	250	400 to 600	n.a.	n.a.
U.S. Surplus or (Deficit) (included in other categories)	n.a.	n.a.	n.a.	(732)	168	1,191	n.a.	n.a.
U.S. Government Stocks, end-year	n.a.	n.a.	n.a.	5,600	5,475	5,355	n.a.	n.a.
Worldwide Government Stocks	n.a.	n.a.	n.a.	10.265	10,140	10,020	n.a.	n.a.
Estimated Increase in Worldwide Hoards, Private and Commercial (M.A.&.O.)	(1,700)	(350)	5,500	2,900	2,050	2,500	1,000	1,350

Sources: T.P. Mohide, Ontario Ministry of Natural Resources, Mineral Resources Branch; J. Aron/ Goldman Sachs; Conti-Commodity; Metals Analysis and Outlook; Economist; Samuel Montagu; Rudolf Wolff; Handy and Harman; Shearson/American Express; Credit Suisse; Mining Annual Review.

n.b. The "data" currently available must be considered unsatisfactory with flaws large enough to distort conclusions.

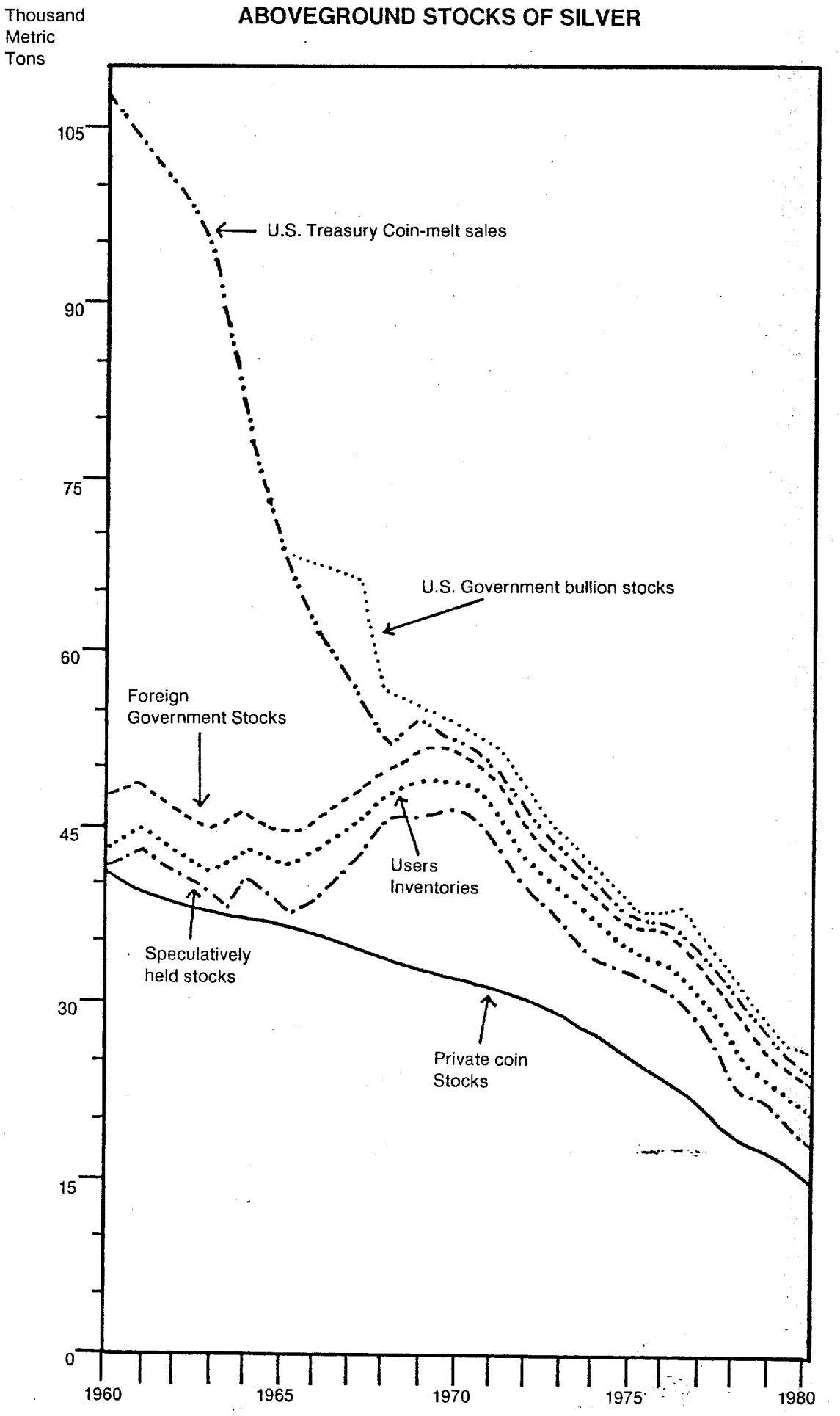
LEADING MINE PRODUCERS OF SILVER

	1981	1982	1983 est.
		(metric tons)	
Peru	1,318	1,692	1,729*
U.S.S.R.	1,580	1,539	1,600**
Mexico	1,640	1,460	1,595***
Canada	1,129	1,204	1,106
U.S.A.	1,265	1,093	1,250
Australia	743	908	1,050
Poland	640	655	675
Chile	361	382	468
Japan	280	306	307
South Africa and Namibia	343	304	283
Bolivia	205	174	187
Sweden	161	168	171
Spain	192	118	185
Yugoslavia	137	105	124
Morocco	100	101	119
Argentina	78	84	76
China, Mainland	65	65	80
Dominican Republic	63	69	39
Honduras	52	64	78
Philippines	63	64	59
Zaire	80	59	39
Italy	55	56	74
Greece	61	49	56
South Korea	41	45	67
Papua-New Guinea	43	43	47
West Germany	39	40	36
Indonesia	26	32	33
France	53	31	21
North Korea	40	30	35
Zimbabwe	27	29	29
Zambia	22	28	29
Finland	38	37	27

* U.S. Bureau of Mines gives 1,680 metric tons. WBMS gives 1,580 tons. Canadian federal government gives 1,654 metric tons for 1982 and 1,387 tons for 1981. Metallgesellschaft gives 1,728 metric tons.

** The figure for the Soviet Union apparently includes refined silver from scrap. U.S. Bureau of Mines gives 1,465 metric tons, including secondary. WMBS gives 1,595 tons. Canadian federal government says 1,579 metric tons for 1981 and 1,539 for 1982. Metallgesellschaft gives 1,600 metric tons. Credit Suisse states that the U.S.S.R. is the world's third largest silver producer, not the second. Silver Institute gives 1,630 metric tons for 1984.

*** U.S. Bureau of Mines gives 1,710 metric tons. WBMS gives 1,846 tons. Mining Annual Review gives 1,900 tons. Canadian federal government says 1,654 metric tons for 1981 and 1,550 tons for 1982. Metallgesellschaft gives 1,911 metric tons smelter production/content of silver concentrates by analysis.


ABOVEGROUND STOCKS OF SILVER
Thousand Metric Tons
105
90
75
60
45
30
15
0
1960
1965
1970
1975
1980
U.S. Treasury Coin-melt sales
U.S. Government bullion stocks
Foreign Government Stocks
Users Inventories
Speculatively held stocks
Private coin Stocks

J. H. C.
JUN 30 1983

MINERAL COMMODITY PROFILES
1983

SILVER

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

MINERAL COMMODITY PROFILES

1983

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

UNITED STATES DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

BUREAU OF MINES

Robert C. Horton, Director

Silver

By Robert G. Reese Jr.[1]

Silver is critical to the production of many manufactured products. It provides high electrical conductivity, resistance to oxidation, and strength at a wide range of temperatures. In addition, the light-sensitive properties of some silver compounds are essential to the manufacture of photographic film for military and civilian applications while other silver compounds find important uses in medicine.

The Nation's net import reliance for silver, calculated as a percentage of apparent consumption, has averaged 41% for the last 5 years. However, the three major source countries are in the Western Hemisphere, and concurrent disruptions in the flow of silver from these countries seems unlikely.

The probable demand for silver in the United States is forecast to be 200 million ounces[2] in the year 2000, while for the rest of the world, it is forecast to be 520 million ounces. The average annual growth rate for demand in the United States is forecast to be 2.2%. For the rest of the world, demand is forecast to grow at an average annual rate of 2.6%. U.S. silver reserves are less than the probable cumulative U.S. demand to 2000; however, world reserves are estimated to be adequate to meet the cumulative demand for the United States and the rest of the world. The United States will probably continue to rely on imports as an important component of supply.

The major domestic end uses for silver in 2000 are forecast to be photographic products and electrical contacts and conductors.

STRATEGIC CONSIDERATIONS

From 1978 through 1982, U.S. import reliance for silver, calculated as a percentage of apparent consumption, has averaged 41%. Principal source countries include Canada, Mexico, and Peru. Any two of these sources are capable of supplying U.S. import needs, and disruption of all three concurrently is unlikely.

U.S. mine production for the past 20 years has remained almost static and is expected to increase at a slower rate than demand. Supply shortfalls in the future could be met, in part, through sales of silver held by individuals, releases of excess material in the National Defense Stockpile, or through sales of other Government stocks. Nevertheless, the United States could become increasing reliant on foreign sources.

Strategic Uses

Silver as a component of manufactured products is extremely important in various defense, transportation, and communication applications.

The largest domestic use of silver is in the production of photographic materials. Image definition using silver-containing film is unsurpassed for clarity, a quality that is critical in some defense applications such as photographic reconnaissance. Other strategic applications include batteries and electrical switches. Batteries incorporating silver are characterized by long shelf life, high surge voltage under load, and temperature stability, all characteristics critical to certain military and aerospace applications. Silver is used in electrical switches because its unique properties allow the switches to function reliably in hostile environments. Silver solders are consumed in a wide range of electrical and electronic products many of which are used for communications and defense purposes. Silver-containing brazing alloys are used in refrigeration equipment, electrical equipment, motor vehicles, some aircraft parts, and in plumbing and heat exchanger equipment, all of which have important defense applications. The important uses of silver in medicine and dentistry are as antiseptics in the treatment of certain infections and as an amalgam for dental fillings.

Unique Properties

The consumption of silver in many of its end uses is based upon the superior performance of the metal or one of its compounds. Silver salts, for example, are unsurpassed for clarity in producing photographic images. Silver used as contact metal in switches is highly reliable owing to its high conductivity and resistance to oxidation at elevated temperatures. Silver improves the wettability, joint strength, and flow properties of some solders, and silver in brazing alloys can wet various base metals at temperatures below their melting points. Silver medicinals have broad consistent antimicrobial action against many common pathogens and very low occurrence of patient sensitization to continued usage of the compounds; in addition, the development of strains of organisms resistant to their action is relatively uncommon.

Grades and Specifications

The purity of silver in bullion, coinage, jewelry, or other items is usually expressed by its fineness or parts per thousand. Pure silver or fine silver is 1,000 parts fine or 100% silver. Sterling silver is 925 fine or 925 parts (92.5%) silver and 75 parts (7.5%) copper. Domes-

[1] Physical scientist, Division of Nonferrous Metals.
[2] The quantities used in this report are in troy ounces unless otherwise specified.

Table 1.—Stockpile status of silver, September 30, 1982

	Troy ounces
Goal	0
Total inventory	137,505,946
Authorized for disposal	103,119,000
Sales (FY 1982)	2,000,000

tic coin silver is an alloy that was used in minting coins until 1964 and contains 900 parts (90%) silver and 100 parts (10%) copper. Commercial silver bullion ranges from a minimum of 999 fine (99.9%) to 999.9 fine (99.99%). For any fineness of silver bullion, the principal impurities are gold or copper. Silver for the National Defense Stockpile is required to be 999 fine, free of slag, dirt, or other foreign material, and in bars of approximately 1,000 troy ounces.

Stockpile

In September 1976, the stockpile goal for silver was reduced to zero, and the approximately 139.5 million ounces in the National Defense Stockpile was declared excess to Government needs. None of the silver was sold, however, until Public Law 97-35, the Omnibus Budget Reconciliation Act of 1981, was passed. This law authorized disposal of 46,537,000 ounces of silver during the year beginning October 1, 1981, 44,682,000 ounces for the year beginning October 1, 1982, and 13,900,000 ounces during the year beginning on October 1, 1983.

The General Services Administration (GSA), acting as the sales agent for the Government under the authority of Public Law 97-35, planned to sell 1,250,000 ounces of the silver per week beginning on October 14, 1981. During the following 2½ months, the GSA sold 2,000,000 ounces of silver. Sales of silver from the stockpile were suspended with the passage on December 29, 1981, of Public Law 97-114, the Defense Appropriation Act of 1982. On December 21, 1982, the amount of silver in the National Defense Stockpile that could be sold annually was limited by Public Law 97-377, Further Continuing Appropriations for 1983. Public Law 97-377 limits the annual sales of silver from the National Defense Stockpile under Public Law 97-35 or any other act to an amount equal to no more than 10% of the production from domestic mines in the preceding 12-month period. Nevertheless, sales of silver remained suspended at the beginning of 1983.

Other silver owned by the Government is held by the U.S. Treasury Department and the Department of Defense. At the end of 1982, the bullion stocks of the U.S. Treasury totaled 36.8 million ounces, and Defense Department stocks were approximately 1.8 million troy ounces.

PROBLEMS

The determination of the quantity of silver that the United States would require for defense purposes in a national emergency such as war is a difficult and controversial problem. Some persons feel that the United States could produce the silver that it required from existing primary and secondary sources or could obtain the material from foreign sources. Other individuals recall the importance of silver during World War II for lend-lease activities and as a substitute material in various applications where other strategic materials were normally consumed. These individuals feel that a strategic stockpile of silver could be an important asset in a conventional war. Many individuals also feel that disposal of excess material in the National Defense Stockpile would harm the primary and secondary silver sources upon which the United States would be relying. This problem and the related issue of how to dispose of any excess material to minimize the impact on the silver market are being studied by agencies of the Federal Government.

World industrial consumption since World War II has been much higher than world primary production. The disparity between supply and consumption has been met through drawdowns of existing stocks and by secondary sources. With the near depletion of some large silver stocks such as the U.S. Treasury's, additional primary or secondary sources may be required to meet expected increases in consumption. A complicating factor in this problem of insuring an adequate supply are the silver holdings of individuals, which are large compared with annual industrial consumption of silver.

TECHNOLOGY TRENDS AND DEVELOPMENT

Recent studies by the Bureau of Mines have dealt with the cyanide heap leaching of low-grade ores having a high clay content. The Bureau's research indicated that percolation of the cyanide leach solution through these ores could be enhanced through particle agglomeration *(3)*[3] Agglomeration was achieved by mixing the ore with portland cement and water and then aging the mixture *(7)*. Among the results obtained using this method were reduced channeling of the heap, higher percolation rates, and increased metal recovery from the ore.

The Bureau has also been active in research efforts to recover silver from various scrap materials. Recent projects have dealt with the silver contained in aircraft scrap *(1)*. Silver was found to be concentrated in silver-brazed stainless steel honeycomb panels distributed throughout the airplane structure. After these panels were shredded the silver could be recovered through electrorefining.

Much of the silver formerly lost each year in the photographic industry from spent developing and fixing solutions is now recovered for recycling through the use of more refined and portable equipment. Improved photographic papers and films, especially X-ray film, have resulted in the use of smaller quantities of silver while retaining an overall good definition

[3] Italicized numbers in parentheses refer to items in the bibliography at the end of the report.

of the desired image. Research into silver-containing film reportedly has resulted in the development of a new high-speed film that makes possible picture taking in some low-light situations without a flash unit. Other recent research has led to improved corrosion-resistant silver dental alloys and the development of antiseptic coatings for protection against certain infections.

RESERVES-RESOURCES

U.S. and World

Estimates of U.S. and world reserves and reserve base are shown in table 2. About two-thirds of the world silver reserves and resources are contained in copper, lead, or zinc deposits. Veins of silver minerals in which silver is the main coproduct component supply the remaining one-third of total world reserves and resources. U.S. and world silver resources are estimated to equal about 6 billion and 25 billion troy ounces, respectively *(5)*.

Silver ores are usually found associated with intermediate felsic igneous rocks such as andesites and rhyolites. The ores occur in veins along fault fissures and shear zones ranging from a few inches to 8 feet in width. Ores from which silver can be produced as a byproduct are usually found in copper porphyries. massive sulfide bodies, or in copper-lead-zinc vein deposits.

The major silver-producing area of the United States is the Coeur d'Alene mining district of Idaho. Silver is produced in all of the Western States, and much of the exploration for new deposits occurs in this part of the country.

Minerals Availability System (MAS)

Recognizing the dynamic nature of the reserve-resource relationship, and the need for minerals information in certain planning activities, the U.S Bureau of Mines is developing the Minerals Availability System as its primary source for worldwide mineral reserve information. By late 1984, MAS is expected to be able to develop worldwide supply curves for silver, showing the impact of changing economic, technologic, institutional, and international factors on minerals availability.

To depict changes in reserves as a commodity's price changes, MAS is accumulating a data base consisting of cost evaluations of major mineral properties worldwide. Standardized engineering assessments and systematic evaluation procedures were designed to assure comparability in the assessment of each deposit. In making a deposit assessment, the following factors are evaluated: Geologic assessments of the quality and quantity of the contained resources; engineering and cost definitions of production technologies and processes; and a financial analysis correlating commodity market prices with production costs, rate-of-return on investment assumptions, taxes, royalties, depletion allowances, and depreciation. Also included are assessments of the economic, physical, environmental, and institutional restraints on minerals availability.

Table 2.—World silver reserves and reserve base[1]
(Million troy ounces)

	Reserves	Reserve base
North America:		
United States	1,510	1,600
Canada	1,600	1,600
Mexico	1,060	1,100
Other	90	95
Total	4,260	4,400
South America:		
Peru	610	630
Other	30	30
Total	640	660
Europe		
U.S.S.R.	1,600	1,600
Other	420	430
Total	2,020	2,100
Africa: Total	450	470
Asia:		
Japan	20	20
Other	10	10
Total	30	30
Oceania:		
Australia	1,020	1,100
Other	5	5
Total	1,030	1,100
World total	8,430	8,700

[1]Includes reserves. Pending establishment of criteria for the reserve base, classification of data is based on a judgmental appraisal of current knowledge and assumptions.

SUPPLY-DEMAND RELATIONSHIP

Components of Supply

Mine Production.—Domestic mine production of silver increased in 1981, reversing the declining production of the previous 2 years. In 1979, domestic production had declined from the previous year in part because the high silver prices allowed producers to process lower grade ores. In 1980, domestic production was again lower because of strikes at some copper mines producing byproduct silver and at some mines producing silver ore. The ending of these strikes and the production from several large new mines resulted in a produciton increase in 1981. Preliminary domestic mine produciton in 1982 showed a production decrease of about 5 million ounces from the 1981 level. The decline was due in part to the low silver and other nonferrous metal prices during the first half of 1982, which resulted in extended shutdowns at some mines. Peak domestic mine production for the last 20 years occurred in 1970 when slightly more than 45 million ounces were produced. Little reliable information on world silver production capacity is available. The capacity data in table 3 are therefore rounded estimates based largely on judgmental factors.

Imports.—In 1981, U.S. imports increased significantly over those of the previous year, but remained near the upper end of the range for imports during the previous decade. Canada, Mexico, and Peru sup-

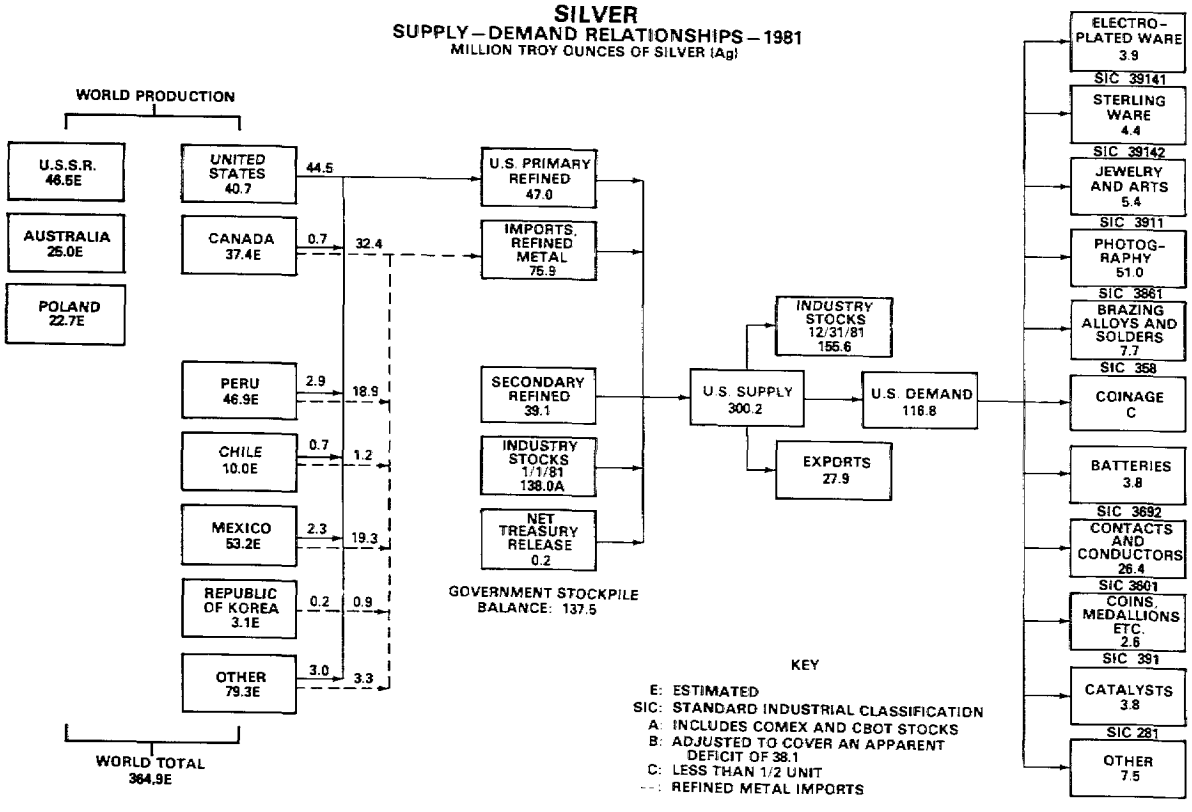


Figure 1. — Supply-demand relationships for silver, 1981.

Table 3.—World silver production 1981 and capacities 1981, 1982, and 1985

(Million troy ounces of silver)

	Production	Capacity		
	1981	1981	1982	1985
North America:				
United States:				
Mine	40.7	60	60	60
Refinery	47.0	160	160	170
Other North America:				
Mine	95.3	130	130	150
Refinery	71.7	110	110	110
Total North America:				
Mine	136.0	190	190	210
Refinery	118.7	270	270	280
South America:				
Mine	66.8	80	80	80
Refinery	27.0	40	40	40
Europe:				
Mine	97.5	120	120	120
Refinery	75.5	100	100	100
Africa:				
Mine	17.3	20	20	20
Refinery	4.0	10	10	10
Asia:				
Mine	20.9	30	30	30
Refinery	50.3	70	70	70
Oceania:				
Mine	26.4	30	30	50
Refinery	10.8	10	10	10
World total:				
Mine	364.9	470	470	500
Refinery	286.3	500	500	510

plied most of the U.S. imports during this period with about 10 other countries supplying the remainder. Imports for consumption in 1982 were the highest of the last 5 years.

Stocks.—Reported stocks of silver at yearend 1981 were almost 300 million ounces. Included in this figure were stocks held by the industry, National Defense Stockpile, the Departments of Treasury and Defense, Commodity Exchange, Inc. (New York), and the Chicago Board of Trade. Unreported stocks of coins and bullion have been estimated at 1.6 billion ounces in the United States*(11)*. Of that amount, nearly 1 billion ounces are believed to be held rather widely among the general populace in the form of coins, while the remainder is probably held by a more limited group of individuals in the form of bullion. In addition to the silver in coins and bullion, individuals also hold an estimated 850 million ounces of silver in the form of sterlingware.

Old Scrap.—Old scrap, consisting of used products such as photographic materials, plating solutions, batteries, coins, sterlingware, jewelry, and electronic scrap, constitutes a major supply source for domestic refiners. Since 1978, old scrap has provided from 38% to 57% of total refinery production. In 1980, the rapid rise in silver prices resulted in many individuals selling their coins, jewelry, and sterlingware. As a result, 57% of domestic refinery production in 1980 came from

Table 4.—Silver supply-demand relationships 1971 – 1981

(Million troy ounces of silver)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
WORLD PRODUCTION											
Mine production:											
United States	41.6	37.2	37.5	33.8	34.9	34.3	38.2	39.4	37.9	32.3	40.7
Rest of world[e]	253.1	264.3	274.4	263.9	268.2	282.1	293.1	306.0	306.7	307.5	324.2
Total	294.7	301.5	311.9	297.7	303.1	316.4	331.3	345.4	344.6	339.8	364.9
COMPONENTS AND DISTRIBUTION OF U.S. SUPPLY											
Refinery production(primary)	68.7	77.5	75.4	63.3	60.1	54.4	45.0	54.4	50.8	39.4	47.0
Imports, refined metal	22.4	25.7	81.2	90.0	61.6	67.2	69.4	61.4	78.4	64.9	75.9
Secondary refined (old scrap)	30.1	31.1	34.6	56.1	51.1	50.2	47.9	37.1	39.7	53.1	39.1
Industry stocks, Jan. 1	82.2	57.1	51.9	38.4	49.3	34.6	30.6	35.9	28.8	16.1	17.0
Commodity trading[1] stocks, Jan. 1	116.4	128.5	100.4	91.7	87.3	124.2	115.8	129.4	118.1	133.1	121.0
Net Treasury release	2.5	2.2	0.7	1.1	3.0	1.3	0.3	0.2	0.2	0.1	0.2
Total	322.3	322.1	344.2	340.6	312.4	331.9	309.0	318.4	316.0	306.7	300.2
Distribution of U.S.supply:											
Indistry stocks,Dec. 31	57.1	51.9	38.4	49.3	34.6	30.6	35.9	28.8	16.1	17.0	20.7
Commodity trading[1] stocks, Dec. 31	128.5	100.4	91.7	87.3	124.2	115.8	129.4	118.1	133.1	121.0	96.5
Exports	12.2	29.7	11.2	18.4	32.6	14.6	22.4	22.4	35.6	80.9	27.9
U.S.demand	131.6	153.9	197.3	177.0	160.4	171.9	153.7	160.2	157.4	124.8	116.8
Apparent surplus (+), deficit (−), supply[2]	−7.1	−13.8	+5.6	+8.6	−39.4	−1.0	−32.4	−11.1	−26.2	−37.0	38.3
U.S. DEMAND PATTERN											
Electroplated ware	10.9	12.7	14.5	13.2	8.7	9.5	6.8	7.3	8.1	4.4	3.9
Sterlingware	22.7	26.5	29.4	22.1	23.7	19.8	16.7	17.9	13.1	9.1	4.4
Jewelry and arts	3.4	4.9	5.8	5.1	12.7	11.0	8.1	6.8	5.4	5.9	5.4
Photography	36.1	38.3	52.0	49.6	46.1	55.5	53.7	64.3	66.0	49.8	51.0
Brazing alloys and solders	12.1	12.2	17.7	14.5	13.6	11.2	12.4	11.0	10.9	8.5	7.7
Coinage	2.5	2.3	0.9	1.0	2.7	1.3	0.1	([3])	0.2	0.1	0.2
Batteries	5.6	6.0	4.2	4.2	4.3	3.5	5.8	6.0	4.6	6.0	3.8
Contacts and conductors	28.0	36.4	40.2	31.3	27.2	32.3	31.3	30.8	33.5	27.8	26.4
Coins, medallions, commemorative objects	—	7.1	20.1	21.4	7.2	8.2	4.3	2.7	4.7	4.7	2.6
Catalysts	1.7	3.4	6.0	7.3	8.8	12.3	8.9	8.2	5.6	3.0	3.8
Other	8.6	4.1	6.5	7.3	5.4	7.3	5.6	5.2	5.3	5.5	7.6
Total U.S. demand	131.6	153.9	197.3	177.0	160.4	171.9	153.7	160.2	157.4	124.8	116.8
Tortal U.S. primary demand (total demand less secondary refined)	101.5	122.8	162.7	120.9	109.3	121.7	105.8	123.1	117.7	71.7	77.7

[e] Estimated.
[1] New York Commodity Exchange and Chicago Board of Trade.
[2] Total U.S. supply less yearend stocks, exports, and industrial demand. Mainly indicates unrecorded changes in stocks, also unreported recovery from old scrap.
[3] Less than ½ unit.

old scrap. The recovery of silver from coins increased significantly, rising from approximately 3.9 million ounces in 1979 to 12.1 million ounces in 1980. As silver prices fell during 1981, the amount of silver recovered from coins fell to only 1.1 million ounces in that year.

Secondary silver plays an important role in the balancing of supply and demand. As indicated above, the amount of secondary silver supplied to the market is subject to sharp changes depending on the relationship between price, demand, and Government policies with respect to its large holdings of silver. A contract study performed for the Bureau of Mines in 1982 found that the amount of secondary silver refined from coins was highly price-elastic, and that the existence of large unreported secondary silver stocks does not necessarily exert downward pressure on the current market price *(11)*. According to the report, the holders of the secondary silver can by their actions serve either as a source of supply to the market or as a source of demand. A generalized flow diagram for silver scrap is shown in figure 2.

U.S. and World Production

World silver production in 1981 increased by nearly 8% from that of the previous year. Production from new projects and expansions at existing operations in response to the silver price increases of 1979-80 were believed to be the primary reasons for the increase. The ending of mining-related strikes in the United States, Canada, and Peru also had a positive effect on production. Prior to 1981, world silver production had been growing at a modest rate.

Mexico, Peru, the U.S.S.R., the United States, and Canada were estimated to have been the five largest mine producers of silver in 1981. Together, they accounted for 62% of the world output with 55 additional countries producing the remainder. Centrally planned economies were estimated to have produced 21% of the world output in 1981, a slight decline from that of a year earlier.

During the first half of 1982, silver prices fell to their lowest level in over 3 years. Peru, in an effort to bolster the price of silver, unilaterally halted new sales of refined silver and provided emergency loans and tax breaks to operators of small- and medium-sized mines. The Government of Peru also attempted to enlist the aid and cooperation of Mexico and Canada to reduce silver sales, but according to reports, no direct Government support was offered by either country. In the

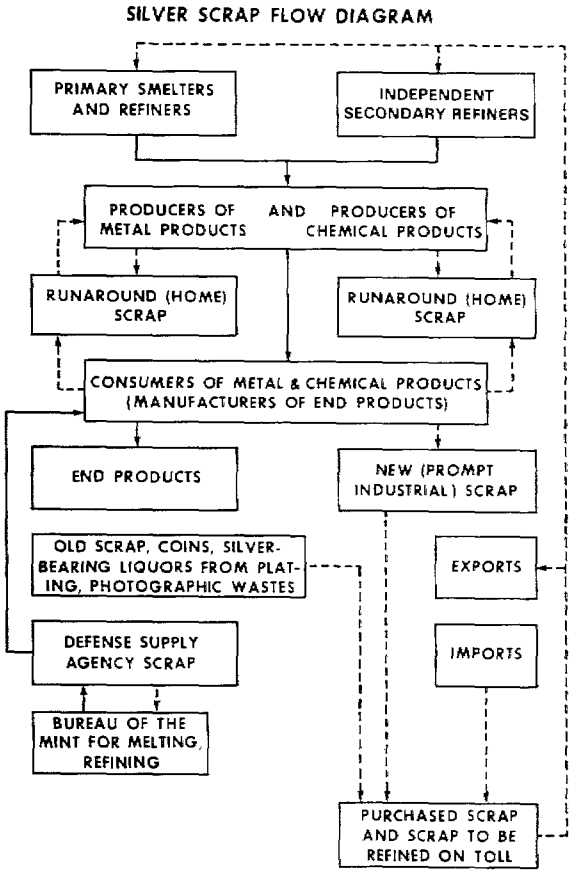


Figure 2. — Silver scrap flow.

United States, a number of mines laid off workers and shut down operations reportedly because of low silver prices. Despite the low prices, several large new mines began production in Mexico during 1982.

In 1981, approximately 50% of the silver mined in the United States was produced by the following five companies, Hecla Mining Co., ASARCO, Incorporated, Anaconda Co., Kennecott Corp., and Sunshine Mining Co. The largest mines operated by Hecla, Asarco, and Sunshine are located in Idaho and mine silver ores. Anaconda's and Kennecott's largest mines produce silver as a byproduct of copper ore processing.

Foreign ownership of major domestic silver mining companies is small, amounting to less than 10% of the estimated mine capacity. Recent years, however, have seen a number of major oil companies acquiring or attempting to acquire mining companies. Some of these acquisitions have been major silver producers. This seems to indicate that given favorable circumstances, U.S. mining companies can be attractive investments, and as a result, there is the potential for further domestic or foreign takeover of these companies.

The United States continued to be the world's largest silver refiner in 1982. U.S. refiners produced 44.5 million ounces from domestic ores and concentrates and 2.5 million ounces from foreign ores and concentrates. Production from old scrap was 39.1 million ounces.

Table 5.—Time-price relationships for silver

Year	Average annual price, dollars per troy ounce	
	Actual prices	Based on constant 1981 dollars
1960	0.91	2.57
1961	0.92	2.57
1962	1.09	2.99
1963	1.28	3.46
1964	1.29	3.43
1965	1.29	3.36
1966	1.29	3.26
1967	1.55	3.80
1968	2.14	5.02
1969	1.79	4.00
1970	1.77	3.75
1971	1.55	3.13
1972	1.69	3.27
1973	2.56	4.69
1974	4.71	7.94
1975	4.42	6.82
1976	4.35	6.38
1977	4.62	6.40
1978	5.40	6.97
1979	11.09	13.20
1980	20.63	22.53
1981	10.52	10.52
1982	7.95	P7.50

P Preliminary.

U.S. and World Consumption

World demand for silver in 1981 was estimated to be 440 million ounces. Traditionally, developing countries such as India are large consumers of silver for jewelry and sterlingware while industrialized countries such as Japan and the Federal Republic of Germany tend to have consumption patterns similar to those of the United States.

Domestic industrial consumption of silver declined during the period 1979-81 owing in part to the rapid price increases in 1979 and 1980 and to two economic recessions since 1979. Preliminary data for 1982 show some improvement over 1981 figures but consumption in 1982 was well below the peak consumption of 197.3 million ounces in 1973. Complicating the supply-demand relationship for silver is its use for monetary purposes and the speculative and investor market for refined silver bars and domestic coins.

The components of domestic silver supply-demand relationships for 1981 are shown in figure 2 and for 1971-81 in table 4.

World Trade

The United States continues to be the leading nation in the world trade of silver. It imposes no restrictions, and levies no duties on the import of silver ores, concentrates, doré, waste and scrap, refined bullion, or coins. An import duty is levied on silver compounds, silver leaf, platinum- and gold-plated silver, and rolled semimanufactured silver.

Table 6.—U.S. import duties[1]

Tariff item	Number	Most favored nation (MFN) Jan. 1. 1982	Most favored nation (MFN) Jan. 1, 1987	Non MFN Jan. 1, 1982
Platinum-plated silver	605.46	12.8% ad val.	7.5% ad val.	65% ad val.
Gold-plated silver	605.47	19.4% ad val.	10.0% ad val.	65% ad val.
Other plated silver	605.48	8.8% ad val.	6.0% ad val.	65% ad val.
Precious metal plates and sheets	605.60	9.9% ad val.	6.5% ad val.	30% ad val.
Rolled silver	605.65	8.8% ad val.	6.0% ad val.	65% ad val.
Other semimanufactured	605.66	20.0% ad val.	0% ad val.	65% ad val.
Silver compounds	420.60	4.5% ad val.	3.7% ad val.	25% ad val.

[1] No duties are imposed on imports of unrefined silver, waste and scrap silver, or bullion.

Except for 1980, the United States since 1970 has been a net importer of silver. U.S. imports are predominantly refined bullion and ores and concentrates, while exports are primarily scrap and refined bullion.

The industrial countries of Western Europe, mainly the United Kingdom, France, the Federal Republic of Germany, Belgium, and the Netherlands rely on imports. The continued industrial growth of Japan has created a large domestic demand for silver, especially in electronics, electrical equipment, and photography. Although traditionally a large importer of silver, India in recent years has exported large quantities and has become an important source of silver in world trade.

Secondary Sources or Recycling

Recovery of silver from scrap is an important component of supply in the United States. In general, refinery production from old scrap nearly equals domestic mine production. For a given year, however, the relationship of these two supply components is determined by factors such as price, the behavior of speculators, the capacity of secondary refiners, and the form in which the scrap is held.

Substitutes

Stainless steel is an alternative to silver in the manufacture of table flatware. Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum is used in place of silver for surgical plates, pins, and sutures. Gold or the platinum-group metals may be substituted for silver in electrical and electronic components to increase the components' resistance to oxidation. Development of new types of batteries may result in the displacement of some silver from this use. New drugs have replaced many of the silver medicinals (although there may be some reverse substitution because of the silver medicinals' reliability and the rapid development of some drug-resistant microbes). Silverless black and white film and xerography have replaced silver-containing film in some applications. Cupronickel, cuprozinc, nickel, and aluminum have replaced silver in coinage in several countries.

OPERATING FACTORS AND PROBLEMS

Costs of mining silver ores vary greatly with depth, problems of ground control, ventilation, width of vein, continuity of ore bodies, location, availability of electricity, water, labor, and equipment. Low-grade deposits can often be mined profitably if sufficient quantities of other metals are contained in the ore.

Silver mining is in general no more hazardous than other mining, but because of the depths reached in the Coeur d'Alene district, rock bursts are relatively common there. Temperatures are uncomfortable at these depths, and air conditioning units must be used in ventilation systems. Gains in productivity are difficult to achieve because the possibilities for mechanization are limited by the relatively narrow veins mined.

Environmental Considerations

The processing of silver-bearing ores after grinding is essentially by flotation or cyanidation. With flotation, pollution of downstream waters by fine solids is a problem that requires adequate ponding and retention of tailings. The resulting tailings disposal problem can be partially solved in those deep mines where ground support is needed by pumping the tailings back into the mine. In cyanidation operations, extreme care must be exercised to avoid contamination of the groundwater, nearby water courses, or surrounding areas through leach solution losses. As a result, the solution collection system for returning the leachant to the storage tanks and monitoring of the water of the surrounding area are important considerations for avoiding pollution.

Achieving adequate air pollution (sulfur dioxide) control and disposing of slag and other wastes (iron and silica) are the problems encountered in smelting silver ores. Refining presents little environmental concern because the bulk of noxious impurities are removed during the smelting step; however, spent solutions from electrolytic refining are a disposal problem because of the other materials in the solution. Currently there is no effluent standard for silver.

Although silver is not a toxic substance in other than very large doses, a standard has been established for worker exposure to airborne silver. The Occupational Safety and Health Administration (OSHA) currently requires that worker exposure to either silver metal or soluble silver compounds be less than 0.01 milligram per cubic meter of ambient air.

OUTLOOK

Demand

End-use consumption of silver in the United States is forecast in table 7. The statistical projections in the

Table 7.,—Projections and forecasts for U.S. silver demand by end use

(Million troy ounces)

End use	1981	2000			
		Statistical projections[1]	Contingency forecasts for United States		
			Forecast range		
			Low	High	Probable
Electroplated ware	3.9				
Sterlingware	4.4	18.3*	0	60	20
Jewelry and arts	5.4				
Photography	51.0	107.0	60	120	90
Brazing alloys and solders	7.7	10.3*	0	20	10
Batteries	3.8	79.5*	30	60	40
Contacts and conductors	26.4				
Coinage	([2])				
Coins, medallions, commemorative objects	2.6	0.0*	10	70	40
Catalysts	3.8				
Other	7.5				
Total[3]	116.8	—	100	330	200

[1] Statistical projections, provided by the Branch of Economic Analysis, are derived from regression analysis based on historical time series data and forecasts of economic indicators such as GNP, FRB Index. Projection equations with a coefficient of determination (R squared) less than 0.70 are indicated by an asterisk(*).
[2] Less than ½ unit.
[3] Data may not add to totals shown because of independent rounding.

table were obtained by relating historical end use consumption to various economic indicators such as the Federal Reserve Board (FRB) Indexes through regression analysis. High, low, and probable forecasts were made by identifying and quantifying factors such as technology development and substitution that could impact on the consumption of silver.

The total U.S. silver demand in the year 2000 is forecast to be in the range of 100 to 330 million ounces. The probable demand in 2000 is estimated to be approximately 200 million ounces closer to the lower end of the range because solid-state switching devices will probably reduce the need for silver in switch contact products, and some substitution of silver is also likely to occur in photography as progress continues with silverless image reproduction. From the trendline value for industrial silver consumption in 1981, U.S. silver demand should grow at an average annual rate of 2.2% between 1981 and 2000.

Although the total U.S. silver demand is forecast to show a positive growth to the end of the century, secondary demand is forecast to decline slightly from the trendline value of 44.7 million ounces in 1981. Less silver is expected to be used per unit in many end uses, and as a result, for many products the silver content will be so small that recovery of the metal will not be feasible.

Overall, the growth in silver demand in the rest of the world is expected to be slightly higher than in the United States. Consumption of silver, particularly in the nonindustrial nations could increase significantly as a result of increases in the consumption of electricity, the use of refrigeration, and a growing interest in photography. Silver use in batteries and plated ware, however, is expected to grow at lower rates than in the United States. The range for rest-of-the-world consumption in the year 2000 is forecast as 340 to 700 million ounces with a probable consumption of 520 million ounces. The annual growth rate for the probable forecast is 2.6% from 1981 to 2000.

Electroplated Ware, Sterlingware, Jewelry and Arts.—Silver consumption in these end uses is forecast to range from 0 to 60 million ounces in 2000. Silver usage in electroplated ware is likely to continue to decline as newer techniques are developed that allow plating with thinner coats and less waste. The rate of decline, however, should be less than that recorded during the recent past. The consumption of silver in both sterlingware and jewelry is dependent on fashion trends and economic conditions. Sterlingware is a prestige item and is likely to remain so. Jewelry is even more responsive to changes in fashion than sterlingware, and changing tastes could result in a resurgence of demand for silver jewelry. Price increases in gold and platinum relative to silver could also increase the demand for silver jewelry. Both sterlingware and jewelry may be used as hedges against inflation, especially when the liquidity of the investment is not an important consideration, because they appear to hold their value. However, the existence of other more liquid investments with high rates of return may reduce the purchase of sterlingware and jewelry for this purpose. The total demand for silver in these end uses should recover from the low levels recorded recently, and probable consumption in 2000 should be about 20 million ounces.

Photography.—The demand for silver in photographic products may reach as high as 120 million ounces in the year 2000. Despite intensive research efforts to develop substitutes for the silver halides, they remain the most light-sensitive materials known. The continuing popularity of amateur photography along with the desire for higher speed, sharper image film should assure continued use of silver-containing film in this sector. However, although there is no apparent replacement for the silver halides, the amount of silver used in these products has been declining. This decrease, along with technological developments such as nonphotographic diagnostic equipment and electronic cameras may result in a low demand of 60 million ounces in 2000. It is believed that the popularity of

Table 8.—Summary of forecasts of U.S. and rest-of-world silver demand

(Million troy ounces)

	1981	2000 Forecast range		Probable		Probable average annual growth rate, 1981-2000 (percent)
		Low	High	1990	2000	
United States:						
Primary	77.7	70	230	130	160	[1]3.2
Secondary	39.1	30	100	50	40	[1]−0.6
Total	116.8	100	330	180	200	[1]2.2
Cumulative (primary)	—	[1]1,480	[1]2,880	[1]990	[1]2,320	—
Rest of world:						
Primary	205.0	240	370	260	300	2.0
Secondary	114.0	100	330	170	220	3.5
Total	319.0	340	700	430	520	2.6
Cumulative (primary)	—	4,220	5,420	2,110	4,780	—
World:						
primary	282.7	310	600	390	460	[1]2.4
Secondary	153.1	130	430	220	260	[1]2.6
Total	435.8	440	1,030	610	720	[1]2.5
Cumulative (primary)	—	[1]5,700	[1]8,300	[1]3,100	[1]7,100	—

[1] Growth rate and cumulative primary demand calculated using a 1981 trend line value of 87.8 for U.S. primary demand, 44.7 for U.S. secondary demand, and 132.5 for U.S. total demand.

Table 9.—Adequacy of U.S. and world silver reserves

(Million troy ounces)

	United States	Rest of world	World total
Reserves	1,510	6,615	8,125
Cumulative primary demand, 1981-2000	2,320	4,780	7,100

amateur photography can overcome the effects of substitution with a resulting probable demand in 2000 of about 90 million ounces.

Brazing Alloys and Solders.—Recovery in the housing industry, combined with an increase in the consumption of appliances such as refrigerators and air conditioning units, could result in consumption of silver in brazing alloys and solders of as much as 20 million ounces in 2000. However, replacement of copper tubing and fittings by aluminum or a metal that could utilize fittings sealed by a nonsilver joint sealant could eliminate the consumption of silver in this end use. With the increasing use of more efficient soldering techniques, the development of nonsilver brazing alloys also capable of wetting some nonferrous metals, and the potential for tubing and fitting substitution, a probable demand of 10 million ounces is expected in the year 2000.

Adequacy of Supply

Forecasts for U.S. and rest-of-the world silver demand in 1990 and 2000 are summarized in table 8. The U.S. cumulative demand for primary silver from 1981 through 2000 is forecast to be 2,320 million ounces based on a 3.2% annual growth rate. The cumulative demand for primary silver in the rest of the world based on a 2.0% annual growth rate is forecast to be 4,780 million ounces. The total world cumulative demand for primary silver to the year 20000 is forecast to be 7,100 million ounces.

Domestic reserves are much less than the probable cumulative demand. As a result, imports will continue to be an important component of supply in the United States. Production from some deposits currently considered resources could contribute to supply if the price of silver increases relative to the cost of production, or if a low-cost method of production is developed. Exploration will also increase reserves. Worldwide, reserves are estimated to be adequate to meet the probable cumulative demand.

Mine production in the United States has fluctuated between 32 and 45 million ounces annually for the past 22 years and has trended upward slightly. Projecting this trend, mine production would be 42 million ounces in the year 2000. Using mine production in 1981 as a base, the average annual growth rate would be 0.2%.

Historically, approximately two-thirds of U.S. silver mine production comes from base metal mines. Copper ore is the major source, but a significant part comes from lead and zinc ores. Silver ores are the predominant source for the remaining one-third of mine production. This ratio has remained relatively constant for the past 22 years and probably will continue during the forecast period. A forecast of 45 million ounces for mine production in the year 2000 was based on a continuation of this ratio and anticipation of the use of new techniques for recovering silver from low-grade deposits and the discovery of new deposits in current producing districts. Other factors considered in making this forecast include the physical location of new and known deposits, and potential legislative impacts.

Table 10.—U.S. mine production forecast

(Million troy ounces)

	1981	2000				
		Projection	Forecast range		Probable	
			Low	High	1990	2000
Mine production	40.7	42	40	60	40	45
Mine production cumulative	—	—	766	958	364	817

Table 11.—Comparison of U.S. silver production and demand 1960 – 81, 1990, and 2000

(Million troy ounces)

Year	U.S. primary demand	U.S. primary production
1960	148.0	30.8
1961	161.4	34.8
1962	187.8	36.8
1963	221.5	35.2
1964	326.0	36.3
1965	457.3	39.8
1966	200.9	43.7
1967	181.3	32.3
1968	124.7	32.7
1969	81.2	41.9
1970	73.1	45.0
1971	101.5	41.6
1972	122.3	37.2
1973	162.8	37.5
1974	121.0	33.8
1975	109.3	34.9
1976	121.6	34.3
1977	105.8	38.2
1978	123.1	39.4
1979	117.7	37.9
1980	71.6	32.3
1981	77.7	40.7
1990	[1]130.0	[2]40.5 [e]40.0
2000	[1]160.0	[2]42.0 [e]45.0

[e] Estimated.
[1] Probable forecasts from table 10.
[2] 22-year trend.

The physical location of ore deposits in most of the United States will probably have little effect on exploitation and productivity; however, some areas of Alaskan terrain are extremely precipitous or uninhabited frontier, and exploitation in these areas could be difficult. The great depth of some of the silver mines in the Coeur d'Alene silver district of Idaho and associated problems of ventilation, temperature, and discontinuity of ore bodies may result in reduced production. Production of silver from lower grade silver and copper ores by leaching is growing as leaching facilities become larger and greater tonnages are processed. Legislation concerning mining, taxes, and the environment could have major impacts on silver mine production. Several copper smelters are experiencing economic difficulty in meeting environmental regulations. Legislation concerning proposed wilderness areas could also have a major impact on silver mining. New lode deposits of silver ore in known silver districts are very likely to be proven as the older deposits become depleted.

Possible Supply-Demand Changes

Changes in speculative interest, as distinguished from industrial consumption, are likely to determine supply-demand relationships in short- to medium-term situations. Industrial demand is likely to be more important in the long term. Speculators and investors act in response to given price levels for silver and the attractiveness of alternative opportunities to act temporarily either as a source of supply or demand for silver. These actions tend to balance the market for silver in the short term. Permanent changes in industrial demand, however, are likely to result in long-term supply changes.

Possible Technological Progress

In electronics, improvements in solid-state switching and in electroplating and cladding technology could extend the life of the equipment while requiring smaller quantities of silver per unit. Newer techniques that might be applicable to leaching and chemical processing of silver ores are under investigation in the laboratory. Such methods could be particularly useful in treating low-grade disseminated ores. Development of new mining and metallurgical processes could lead to exploitation of deposits of marine silver.

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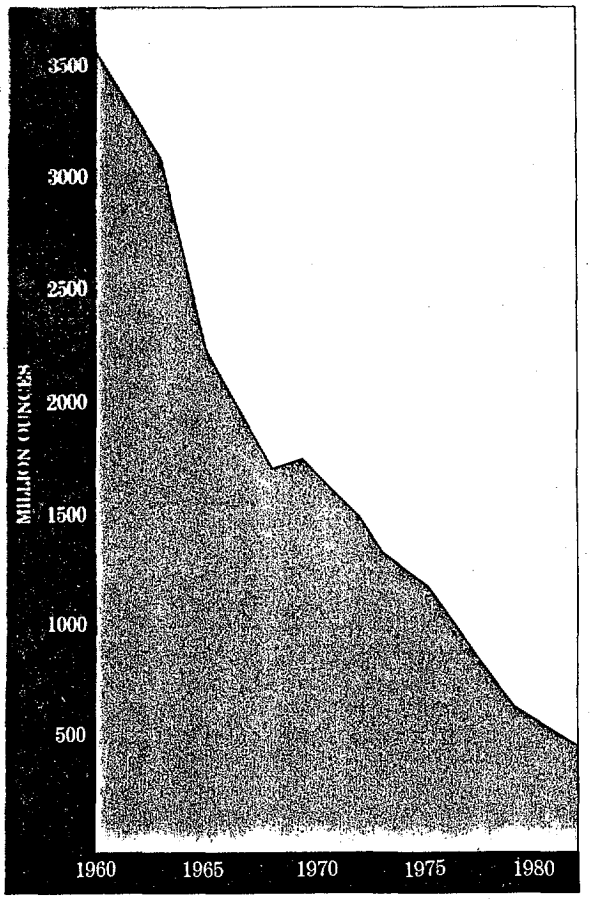
Silver. Ch. in Mineral Commodity Summaries, annual.
Silver. Ch. in Mineral Facts and Problems, quinquennially.
Silver. Ch. in Minerals Yearbook, annual.
Silver (and Gold). Reported monthly, quarterly, and annually in Mineral Industry Surveys.

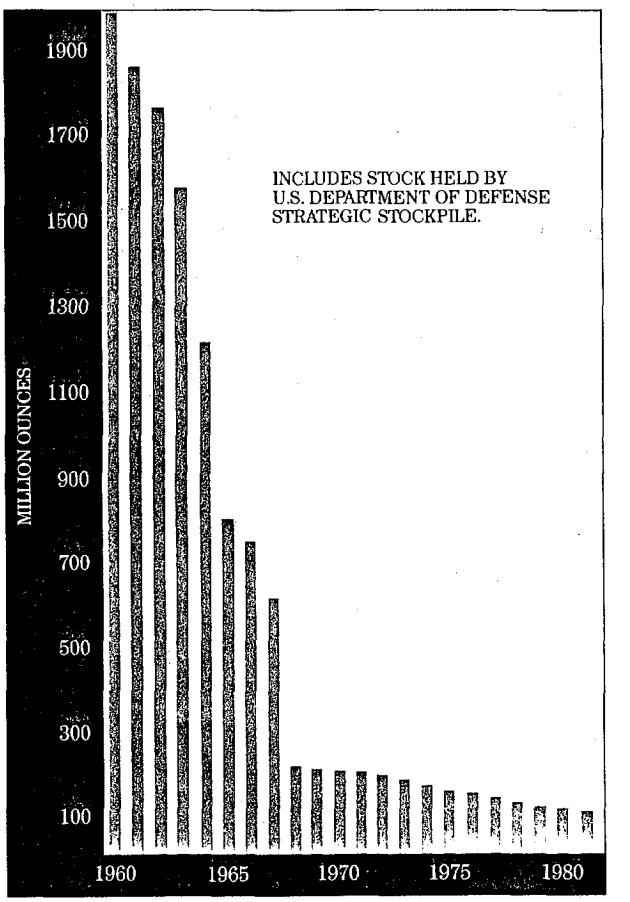
Other sources:

American Metal Market.
Engineering and Mining Journal.
Metals Week.
Mining Journal (London).
The Silver Institute.
World Mining.

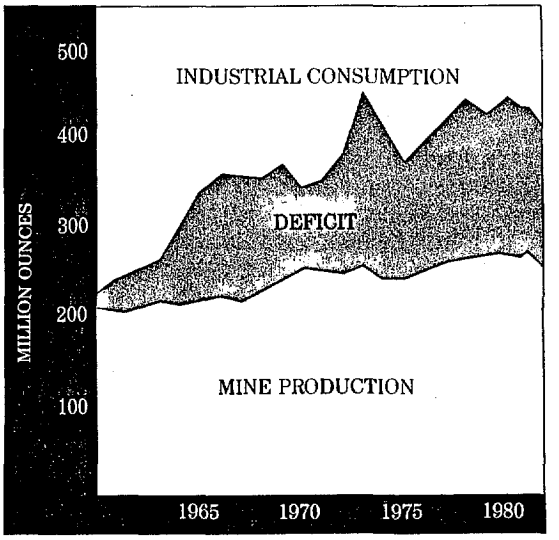
Remaining Aboveground Stocks of Silver



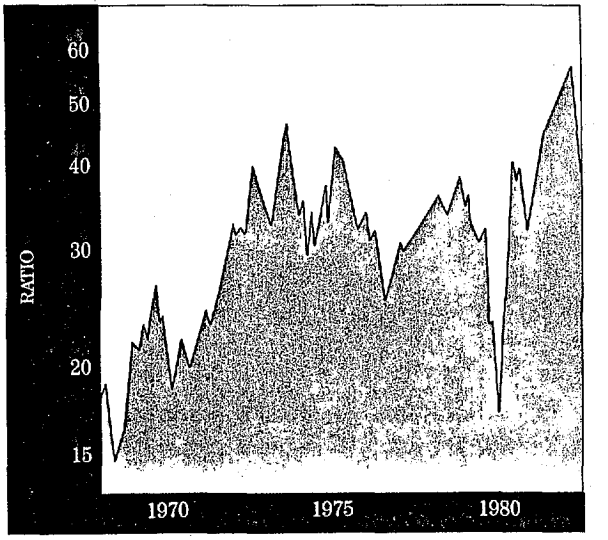
U.S. Government Silver Stocks as of December 31, 1960-1981



Silver Deficit 1960-1981



Gold/Silver Ratio



approximately 10% of the entire world production of silver since 1500. Essentially all of this silver had been sold or placed into coinage, most of which has also been melted to supply industrial demand. Today the only remaining government silver is the approximately 100 million ounces in the strategic stockpile which the administration has determined to sell.

As the economic recovery continues and grows stronger, the upward price pressure on silver should exceed that of gold. Whereas gold has a fairly restricted industrial use (approximately 5.4 million ounces out of an annual production of approximately 40 million ounces), silver is consumed in substantial quantities by the electrical, electronics, chemical and photographic industries. These are all growth industries and although great expense has been directed to reduce the consumption of silver in these industries, the utilization rate is upward—not downward. Hence, unlike gold, silver is a major beneficiary of rising industrial demand.

Historically, gold and silver have tended to trade at relative values—one to the other. This is known as the gold/silver ratio. Each person is entitled to draw his or her own conclusion concerning the significances (or lack thereof) of this historic gold/silver monetary link. However, from the 3rd Century B.C. until 1873 the gold/silver ratio was fairly constant at 16 ounces of silver to one ounce of gold, and from 1873 through modern times the ratio has been considered to normally be 32 to 1.

World Silver Deficit, 1970-1981

(excl. Communist countries; millions of troy ounces)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total 1970s	1980	1981
INDUSTRIAL USE	339	351	377	446	403	368	399	422	438	420	3,963	440	420
OFFICIAL COINAGE USE (EXCL. U.S.A.)	27	27	38	29	28	29	30	23	36	28	295	16	18
PRIVATE COINAGE USE	11	10	11	22	22	7	9	6	6	5	109	4	26
TOTAL USE	377	388	426	497	453	404	438	451	480	453	4,367	460	464
MINE PRODUCTION	252	247	246	254	240	241	251	260	262	268	2,521	270	272
SECONDARY PRODUCTION (SALVAGE SALES; PRIVATE COIN MELT)	30	35	45	60	66	73	86	94	96	81	666	121	100
TOTAL PRODUCTION	282	282	291	314	306	314	337	354	358	349	3,187	391	372
SURPLUS (DEFICIT)	(95)	(106)	(136)	(183)	(147)	(90)	(101)	(97)	(122)	(104)	(1180)	(69)	(92)

Average yrly. deficit for 1970s: 118 mil. troy ozs.

Source: Handy and Harman and authors' estimate for 1980.

Since silver is more significantly affected by industrial demand than is gold, silver prices in mid 1982 were more severely depressed than were gold prices. Last summer's silver prices reflected the severity of the recession in addition to reflecting the downturn in the inflation rate. Last summer silver prices were so low that the gold/silver ratio stood at 50 to 1. Today's prices reflect a gold/silver ratio of approximately 40 to 1. Sunshine believes that as both the price of gold and silver move upward due to the economic-political climate, the gold/silver ratio will narrow and that silver will move substantially higher in relation to gold.

One last factor deserves consideration in any evaluation of the near and intermediate outlook for silver prices. In just the last few years a totally new market demand has developed for silver. If the current trend continues, the volume of silver consumed by this market may rival those of several segments of the traditional industrial demand for silver. This new market demand is the American consumer, the man in the street who is buying very substantial quantities of privately minted silver pieces in one, ten and one hundred ounce coins, ingots or bars. This is the same consumer market that made the Krugerrand such an outstanding success. But it's difficult for the man on the street to buy a coin the size of a quarter for $400 plus. The Krugerrands in denominations smaller than one ounce are really too small, physically, to have great appeal and the premium charged over the spot gold price is fairly steep. Therefore, this vast market of the consumer seeking a convenient way to own bullion is turning to silver. This is not a market that is looking for commemoratives—this is a consumer that wishes to purchase a few hundred or a few thousand dollars of bullion and keep it in his lockbox or under his bed at home. There is a great deal of psychological allure, almost mystical, to everyone wishing to own a little "real money." This mass consumer market is likely to become a real factor in the supply-demand equation for silver in the next few years. There are no reliable figures on the current size of this market, but an educated guess for 1982 consumption would approach 25 to 35 million ounces, and the market is far from developed.

The emergence of this new and growing demand for silver can only serve to place a greater upward pressure on silver prices. It is our opinion that the outlook for silver prices is very positive and that the fundamental factors remain bullish.

US industry's silver consumption declined nearly 11% in first half

Largely as a result of the depressed condition of the US economy, American industry used 10.8% less silver (59.75-million oz) in the first half of this year than it did in the first half of 1982. Statistics released by the US Bureau of Mines last week reveal that the glimmerings of a consumer-led recovery in the US during the first half did not spark any increased industrial offtake.

Silver used in halides for photographic materials fell 2.6% during the first half of this year to 25.4-million oz compared to the same 1982 period. And the 70% increase in the silver price from first-half 1982 to the end of June this year is expected to bite deeply into silver usage by the photographic industry. (At a recent meeting of the American Mining Congress, Charles River Associates' Firoze Katrak said substitution of magnetic tapes for silver halides will be evident by 1985.)

The electronic sector, which used 16.7-million oz of silver in first-half 1982 for contacts and conductors, reduced its consumption this year by 17.8% to 25.4-million oz. The battery business was most adversely affected in the first half, consuming just 1.5-million oz this year, compared with 2.8-million oz in the similar 1982 period.

Sterling ware fabrication declined by 16.6% this year to 3.6-million oz in the first half, compared with 4.4-million oz of silver used in 1982. Industry spokesmen add that this sector has not recovered appreciably so far in the third quarter either.

The US Treasury's silver Olympic commemorative coin program provided a bright side in what was otherwise a depressed six months of silver consumption. The program only began in October 1982, and in the first half of this year, 867,000 oz of silver were used to mint the Olympic coins and a much lesser quantity of George Washington commemorative pieces. The US Mint used only 11,000 oz of silver in coins in first-half 1982.

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JHC

US jewelery manufacturers also increased their silver consumption by 6.7% in the first half this year to 3.5-million oz, as investors bought decorative pieces to take advantage of silver as an appreciating asset.

Private demand for silver rose considerably during the first six months of this year. Net imports grew by 140% to 79.8-million oz, and analysts said most of this metal was taken by investors, since industry stocks fell 29% to 31.8-million oz in the first-half of this year.

Elsewhere in precious metals . . .

New York dealers sold more ruthenium last week than they had in quite some time, reporting quotes of $31-33 per oz, up from $29-31 the previous week. Merchants were lukewarm about the Soviets' $155-per-oz **palladium** option set to expire on Sept. 25; they priced their metal at $151.50-153.50 per oz, up from $149-151. Dealers' **rhodium** offers widened to $334-342 per oz from $335-341, while their **platinum** quotes were unchanged at $428-430 per oz. GSA sought 600 oz of grade **B iridium**.

Sunshine Mining's new gold refining circuit may process 4,000 oz this month into 100-oz industrial bars at its Big Creek, Ida., refinery, according to Sunshine's executive vice president, E. Viet Howard. Sunshine's dore bullion feedstocks for the circuit are coming from its Sixteen-to-One silver-gold mine in Silver Peak, Nev., and from properties situated near the refinery.

An amendment to ban US imports of Soviet gold coins will be introduced by Rep. Frank Annunzio (D-Ill.) once the Export Administration Act reaches the House floor next month. The amendment, offered in retaliation for the Russian downing of a South Korean jetliner, would apply to both the USSR's 1980 half-ounce Olympic coin and to its 0.25-oz chervonetz bullion coin. Statistics released by Rep. Annunzio indicate that the USSR sold nearly $46-million in gold coins to the US during the past five years. Coin dealers believe that figure is exaggerated since most of them stopped selling Soviet gold coins after the US boycott of the Moscow Olympic games in 1979.

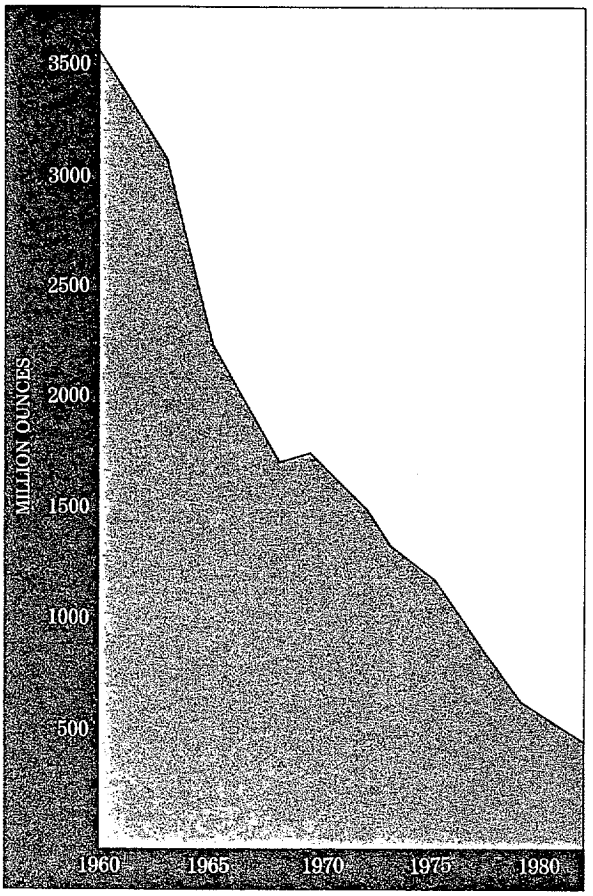
South Africa's Manpower Minister averted a strike by black employees of the Rand gold refinery at the eleventh hour on Sept. 16 by forming a mediation board to review the six-week old dispute between the workers and the Chamber of Mines. The board will try to resolve the wage dispute during the next month. Cyril Ramaphosa, general secretary of the black National Union of Mineworkers, said the Chamber is still unwilling to raise its offer of an 8% pay hike closer to the 40% increase that the union seeks.

A gold nugget weighing 2,003 oz was panned last week at the Serra Pelada alluvial workings in Brazil's Para state. It was bought by the Federal Savings Bank for $981,237 from an independent prospector. Four nuggets exceeding 850 oz have been drawn from the pit in the past four months, leading miners to believe they are nearing a rich gold vein. The 35,000 panners in Serra Pelada will be replaced on Nov. 15, when Cia. Vale do Rio Doce mechanizes operations there. The state minerals enterprise plans to spend $25-million on reinforcing the pit to suit its improved mining methods.

Peruvian silver miners ended a 21-day strike at the Julcani mine owned by Minas Buenaventura on Sept. 22. Company officials said that 200,000 oz of silver were lost as a result of the strike at Julcani and of briefer stoppages at the Orcopampa and Uchucchacua mines, where workers staged sympathy strikes. Buenaventura still expects to produce 7-million oz. of silver this year.

JHC

Remaining Aboveground Stocks of Silver



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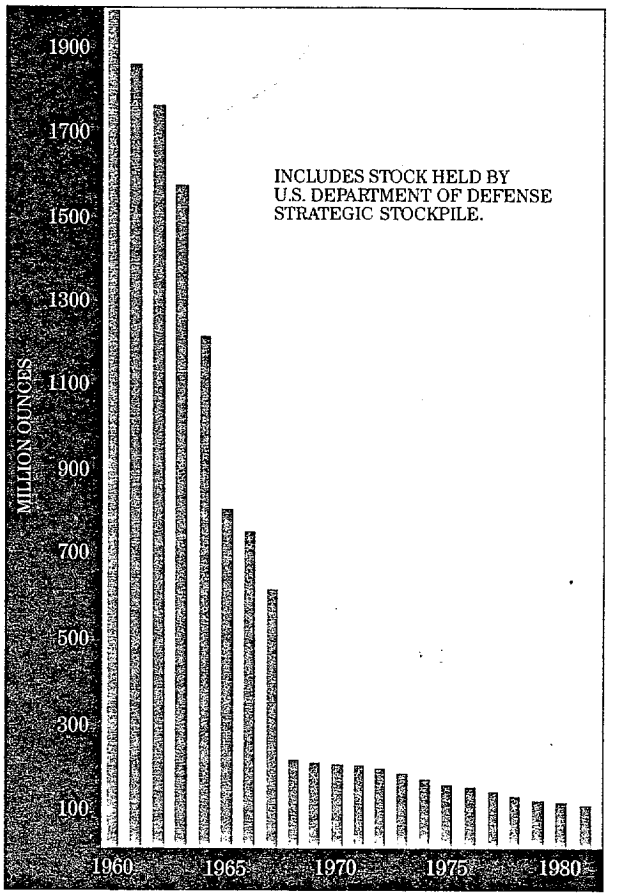

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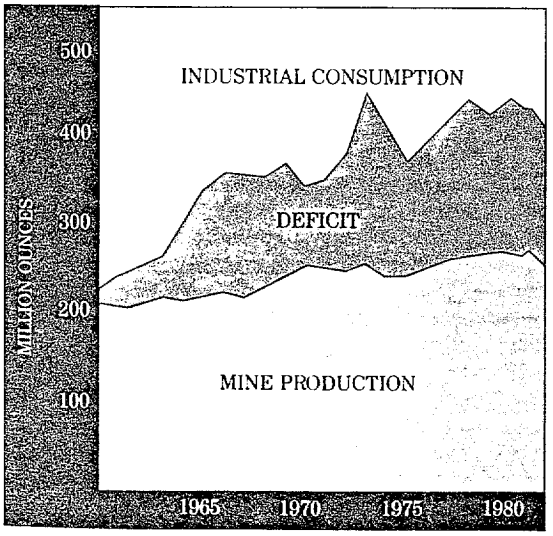
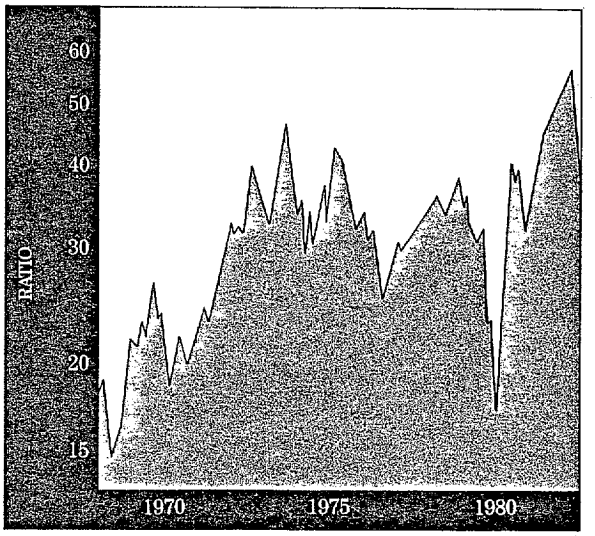


Gold/Silver Ratio



JHC 7

PRECIOUS METALS

The Economic Report

Much of the recent [near 140 percent] run up in palladium prices from $52 to $136 per ounce, basis March, is related to the Bull Market in the other precious metals — about 60 percent of the move by our estimate. The remainder of the advance, however, seems unwarranted based on our analysis. Lacking much quantitative and timely data, the palladium market tends to trade in the short run on anecdotes and rumors. We conclude that in the future palladium should move less strongly than the other metals and could correct back to the $95-100-per-ounce range in the near term should the precious metals complex demonstrate any weakness. (ACLI, February, 1983)

Speculative demand appears to have carried the silver market upward as indicated by the huge increase in volume and open interest. Volume has average between 20,000 and 30,000 lots daily. Open interest has increased by nearly 60 percent since December, 1982. Another factor that helped silver prices gain was an act, passed by the U.S. government, that limits the sale of U.S. government stockpile silver to 10 percent of the annual U.S. production, which would be approximately 4-million ounces per year. For the near term, prices show little sign of slowing the steady upward climb. Support should be found around $13.75 to $14.25 per ounce in lieu of a possible correction. (ACLI, February, 1983)

Because of increased volatility in Comex silver trading, the Exchange increased its silver trading margins in February. Margins on speculative contracts were increased to $4,500 from $4,000, while hedging margins were increased to $3,000 from $2,500. (AMM)

The directors of the Chicago Board of Trade [CBOT] voted to raise initial silver contract margins by half and maintenance margins by two-thirds. For 5,000-troy-ounce contracts, initial margins were upped to $3,750 from $2,500 and maintenance margins rose to $2,500 from $1,500. For 1,000-ounce-contracts, initial margins rose to $750 from $500 and maintenance margins to $500 from $300. (AMM)

The New York Commodity Exchange [Comex] has relaxed rules for silver trading. Prior to January 24th, total contracts were limited to 2,000. Since January 24th, total contracts have been limited to 6,000 net contracts compared with a previous limit of 2,000. The new limit is calculated by the difference between the long and short positions a trader owns. For example, a trader may have 12,000 long contracts and 6,000 short contracts and still meet the exchange's requirements.

The limit for the spot monthly contract was increased to 1,500 contracts from 500 contracts, and this limit applies only to the higher number of either short or long positions. The changes also include a provision that permits "bona fide hedgers" to be granted exemptions from the position limits for both long and short positions. (AMM)

Effective February 1st, Engelhard Industries will publish its silver prices, both for bullion and fabricated metal, at 11 A.M., New York time. The firm will continue to post its gold prices at this same time, 11 A.M.

The silver industry has turned the corner. But even with higher than expected production, I expect to see $15 silver in 1983. — Philip Lindstrom.

Senator James McClure [R, Idaho] recently introduced two bills that would set alternative disposals of silver — as coins and as silver certificates. The coin bill calls for issuing two coins made from stockpiled silver. One coin would contain 0.7734 troy ounces of 900-fine silver. The second coin would contain one troy ounce of 999-fine silver. The other bill calls for the sale of silver certificates which may be redeemed for silver.

Silver consumption in the United States and the Western World increased almost 5 percent in 1982 over 1981, while Western World production of new silver declined 2.4 percent, according to Handy & Harman's annual silver market review.

Industrial silver consumption in the U.S. increased almost 5 percent to 122.3-million troy ounces last year, while total world consumption increased approximately 4.5 percent to 369-million ounces. Western World production of new silver declined to 265-million ounces from 271.6-million ounces the year before.

Walter Franklin, executive director of the Silver Users Association, said that his organization is seriously concerned about the potential for market manipulation in silver trading on Comex where it is now theoretically possible for one large trader to control 20 percent of trading activity in one given day. Franklin indicated that available domestic supply and demand figures on silver for 1982 show approximately 146-million troy ounces of available silver and between 122-million and 123-million ounces of domestic consumption. This is a net surplus of about 23-million ounces. (SUA)

Gold has benefitted from the strength in other, more industrially oriented, precious metals prices, such as silver and platinum. But, in actuality gold has been an underperformer. In relation to silver, the gold/silver ratio has narrowed from a level of 42 to 1 in mid-December to below 35 to 1 by mid February. The gold-platinum spread showed a similar pattern, narrowing from about an $80 gold premium in mid-December to just a $10 premium in early January before widening out to around $30. Thus, the more industrially based precious metals have made the greatest gains, indicating that the strength in the precious metals is at least partly, if not primarily, due to projections of an economic recovery. (ACLI, February, 1983)

Gold has lost its function as a barometer of world political tensions but has instead assumed the role of a hedge against financial uncertainty. Aside from the "very real fear" of a major collapse in the world's financial system, there is no other strong factor in favor of the metal. Any significant improvement in industrial output should favor platinum and silver over gold due to their industrial uses. Hargreaves and Williamson. (SAE)

Hopes are rising of an important new gold find in South Africa. An intensive exploration drilling program is being carried out by Gold Fields of South Africa in the area southwest of Kloof Mine and stretching toward Fouchville. However, any development which might take place in the region is a "long way down the track, perhaps as much as 15 years," according to Colin Fenton, chairman of Kloof and executive director of Gold Fields of South Africa's gold division. (AMM)

ACLI, International Commodity Services/AMM, American Metal Market/SUA, Silver Users Association/SAE, Shearson/American Express

Merrill Lynch Commodities Inc.

Commodity Research Report

Commodity Research

J. H. C.
NOV 29 1982

Silver Situation

Review and Outlook

October 1982

Vincent J. Conway
Assistant Vice President
Metals Product Manager

David G. Linnehan
Assistant Vice President
Sr. Metals Analyst

INTRODUCTION:

The silver market appears to be in the early stages of what could prove to be the next major advancing phase. Many factors that are capable of underscoring a prolonged market upturn seem to be in place, especially supply considerations. For example, the flow of silver from both primary sources (mine production) and above ground (scrap, coin melt, India, hoard liquidation, etc.) has slowed dramatically over the past two years. The total silver supply for 1982 is expected to decline 25 percent from 1980 to the lowest level in 10 years. Moreover, because of the inelastic feature of certain important areas of supply such as mine production, there is scant prospect for a significant increase in supplies through 1983, unless either prices advance substantially or some unforeseen event causes an increased flow of silver from traditional above ground sources.

The silver market also seems to be gradually overcoming the aftershocks of the Hunt affair in the sense that many investors are again considering silver for possible price appreciation; and, there is seemingly less apprehension regarding Hunt family or other speculative hoards keeping a lid on prices indefinitely. Indeed, the summer of 1982 witnessed a rapid silver price advance with no indication that large amounts of hoarded metal had returned to the market. This action suggests that if there is a supply overhang, higher prices than those seen so far this year will be required to draw silver into the marketplace.

A key prerequisite for a sustained silver market upturn - improved demand - is not yet fully in place. However, the recent decline in interest rates suggests an upcoming climate more favorable to economic growth and expansion. If such a climate does unfold, it could lead to a prolonged silver price recovery fueled by increased industrial consumption. In fact, we believe that when consumers begin to seek silver more aggressively, they will find supplies somewhat less than ample; already some tightness has been apparent in the New York dealer market. If increased industrial demand occurs in conjunction with purchases for investment, and supplies remain tight, the silver price response could be substantial.

PRIMARY PRODUCTION DEFICITS ARE PART OF THE SILVER MYSTIQUE:

Silver has been known to mankind since Biblical times, but mostly as a coinage or decorative item. From an investment viewpoint, silver did not become popular until the late 1960's when U.S. government-imposed price ceilings were lifted. A key reason for the sudden interest in silver was the potential for price appreciation because of the existence of the so-called primary production deficit, i.e. shortfalls caused by inability of mine production to meet industrial demand levels. Indeed, primary silver production has failed to fully satisfy industrial requirements every year since 1958.

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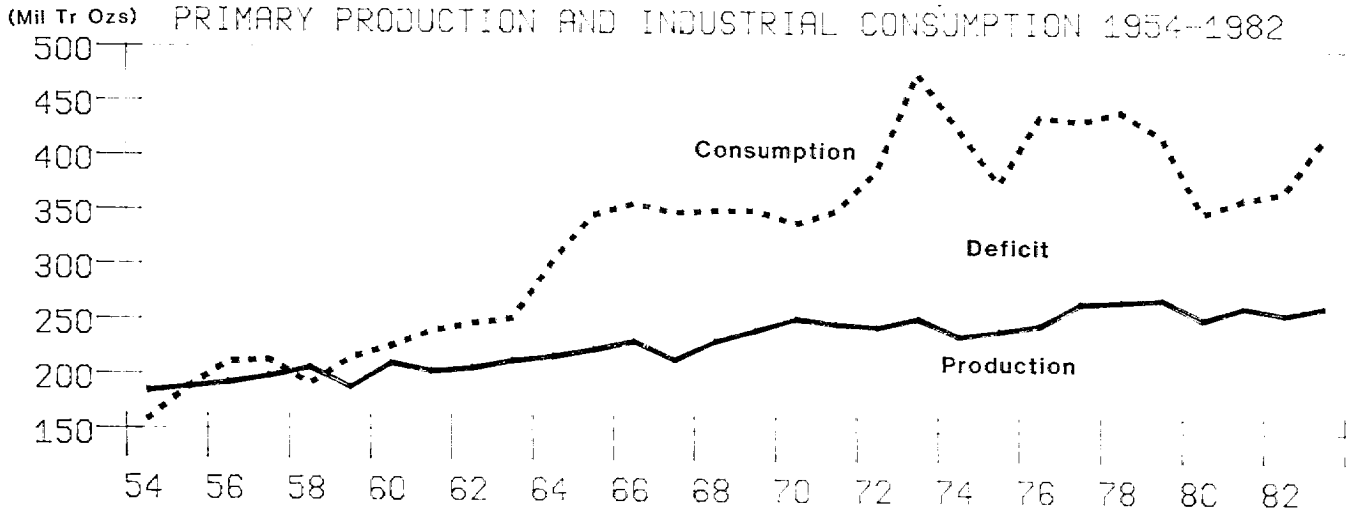

Production deficits caused little concern initially because of a vast reservoir of above ground silver supplies. Sales from a variety of these sources including U.S. Government holdings, which once totaled a staggering 3 billion ounces (the current stockpile holdings of about 140 million ounces seems paltry by comparison), easily filled production shortfalls. However, the cumulative deficits since 1958 have greatly eroded the once-huge above ground supply sources. Today, except for the U.S. Government's 140 million ounce stockpile, there are no major above-ground supply sources that can be mobilized quickly to meet demand surges. Instead, metal will have to come from different sources influenced by various considerations such as the economy, interest rates and, of course, silver prices.

The existence of a primary production deficit is essentially a long run consideration. Indeed, despite an uninterrupted shortfall between primary outturn and industrial usage since 1958, silver prices have experienced both substantial advances and declines. We suspect that this characteristic will continue, with production shortfalls remaining an underlying influence and price action month to month and year to year influenced by the interaction of numerous economic and political factors.

A MAJOR REDUCTION IN SUPPLY DURING 1981 and 1982 SUGGESTS THAT THE PERIOD OF PROLONGED PRICE DECLINES IS ABOUT OVER:

Silver supplies are derived from a variety of different sources that display varying characteristics. Mine production which usually accounts for about 60 percent of total supplies under normal circumstances is the most inelastic component of supply. The other main area of supply is

derived from the flow of silver from various above ground sources such as melted coins, hoard liquidation, scrap production, India, Government sales, etc. This source can vary dramatically from year to year in response to silver prices, interest rates, political considerations and the overall economic climate. Shifts in supply flow have contributed significantly to the ups and downs scored by silver prices since 1967, when the U.S. Government lifted the $1.29 price ceiling (1) and permitted prices to fluctuate freely.

MINE PRODUCTION:

The bulk of primary silver production (mine production) occurs in only a few countries. Most are located in the Western Hemisphere and collectively they account for about 75 percent of world outturn. Mexico was the world's top silver producer last year, with primary output totalling 45.2 million ounces. Peru, Canada and the United States complete the list of major producers. Meanwhile, Australia is the only significant non-communist silver producer outside the Western Hemisphere. Australia produced 27 million ounces of silver last year.

The Soviet Union and Poland are the major Eastern Bloc silver producers, but their metal rarely flows into Western markets in sizable quantities. The Soviets produce an estimated 40 to 45 million ounces of silver annually, while Poland produces about 20 to 25 million ounces. We assume the many problems in Poland will curtail this year's output significantly to perhaps 10-15 million ounces.

About 70 percent of U.S. primary silver production occurs as a by-product of non-ferrous metal mining. Worldwide, the percentage varies from 20 percent to 60 percent, with Mexico acquiring silver from mostly silver-bearing ores. Peru and Canada, like the U.S., obtain a substantial quantity of their silver as a by-product of copper, lead and zinc production.

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(1) In the early 1960's, the U.S. Government imposed a $1.29 price ceiling by selling unlimited quantities of silver at that price. This was done in order to prevent disruptions caused by the large scale melting of domestic coinage which then contained 90 percent silver. The $1.29 figure represented the level whereby the face value of silver dollars equalled bullion value. At higher prices, the silver value of the coin would be worth more than face value and theoretically could be melted. (The theoretical melt point for silver dimes and quarters is a $1.38 silver price).

MAJOR PRIMARY SILVER PRODUCERS 1970 - 1982
(In Million Ounces)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982*
Mexico	43	37	38	39	40	38	43	47	51	49	48	45	45
Canada	44	46	45	48	43	40	36	36	37	42	40	40	40
Peru	40	38	40	42	35	38	41	43	40	37	34	39	36
USA	45	42	37	38	34	35	34	38	40	38	31	36	33
Australia	26	22	23	23	22	23	26	27	25	27	25	27	25
Others	54	62	62	63	63	68	67	76	75	77	75	77	79
TOTAL	252	247	245	253	237	242	247	267	268	271	253	264	258
Average Price	1.77	1.55	1.69	2.56	4.71	4.42	4.35	4.62	5.40	11.09	20.63	10.52	

Source: 1970 - 1981 Handy & Harman Co. 1982 Estimates Merrill Lynch Commodities*

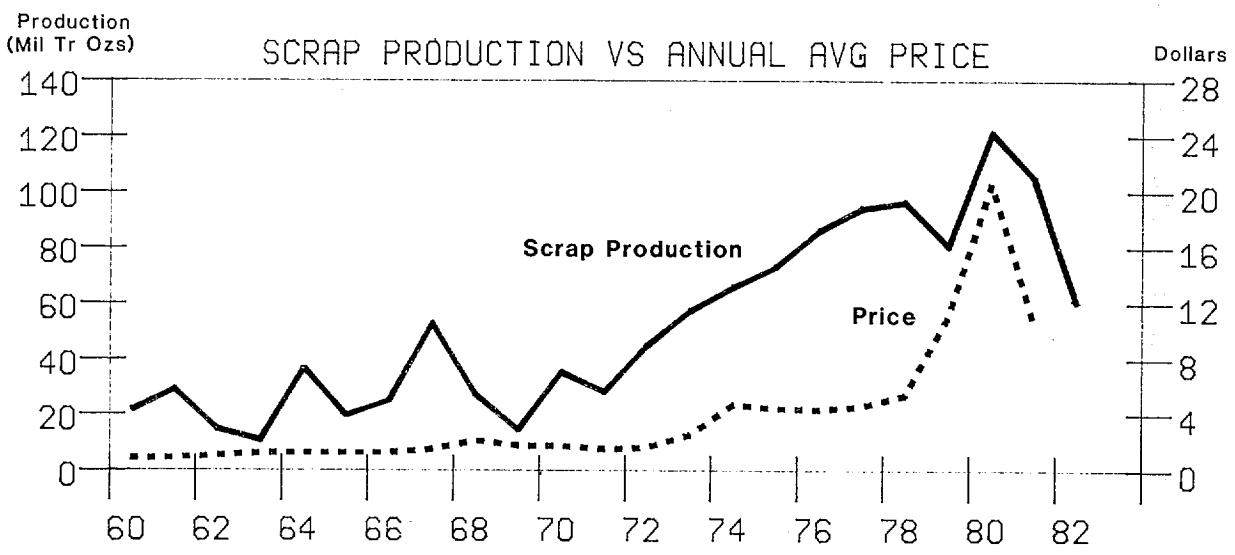
The accompanying table depicts major primary silver producers and free world production levels since 1970 compared with annual average price levels. The figures suggest that year-to-year silver price changes apparently have only a minor impact on primary production levels. For example, a doubling of silver prices in 1979 from the previous year resulted in less than one percent increase free world primary outturn. Another doubling of silver prices in 1980 was actually accompanied by a 7% drop in primary outturn. However, this can be explained by a three month strike at U.S. copper facilities, which, curtailed by-product silver output. Still, even without the strike, silver production would have shown little or no growth in 1980 despite record high prices.

The combination of sharp cuts in copper production in the U.S. and Canada, poor demand and relatively low prices should contribute to an estimated 6 million ounce reduction in primary outturn in 1982 to about 258 million ounces. While we anticipate considerable improvement in both silver demand and prices during 1983, if world economies recover, we doubt there will be much change in primary production from 1982 levels. Indeed, a possible mid-1983 strike at U.S. copper facilities would likely more than offset modest production gains from other regions. Even if a strike failed to occur, total world mine production is not likely to be significantly different from the average level of the past 5 years which approximated 264 million ounces.

THE LIKELIHOOD FOR LITTLE OR NO GROWTH IN PRIMARY SILVER PRODUCTION THROUGH 1983 SUGGESTS THAT INCREASES IN DEMAND WILL HAVE TO BE FILLED FROM ABOVE GROUND SOURCES...BUT ABOVE GROUND SUPPLIES ARE AN ERRATIC SOURCE OF SILVER:

The term "above ground supplies" refers to silver flowing to the market place derived from any source except mine production. The major areas of above ground supplies are:

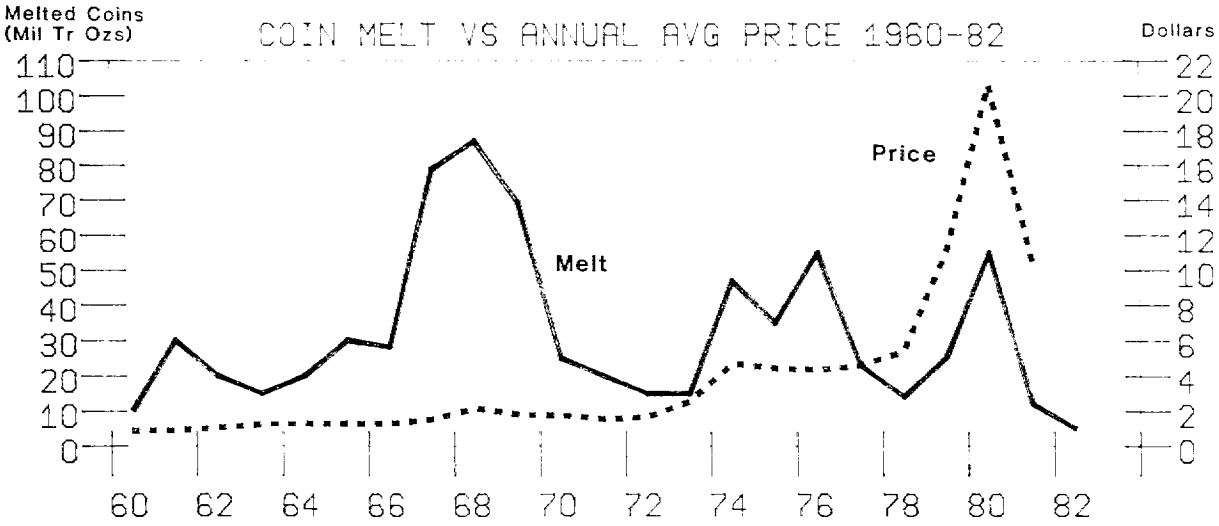
a) Scrap production which has emerged as the largest and most volatile component of above ground supplies. Since 1967, annual scrap supplies have ranged from a low of 15 million ounces in 1969 to an all-time-high 122 million ounces in 1980. This year, we estimate that scrap output will approximate 60 million ounces or about half the 1980 amount and the lowest since 1973.



b) The U.S. Government, which in one year (1968) supplied more silver to the marketplace than the free world's top producers combined. Now, in the absence of stockpile offerings, Government sales are limited to the scant quantities of metal recovered from the federal reclaiming operations. Sales from the 140 million ounces in the stockpile were halted by Congress last year.

c) India's silver hoards which emerged as a major supply source in the early 1960's (see special section discussing India on page 8).

d) Melted coins, which except for U.S. Government sales were once the largest supply source. Today, coin melt represents about 2 percent of the supply picture versus up to 25 percent in the past. Moreover, melted coins as a major supply source are likely gone forever, since many of the coins likely to come back onto the market were melted down during the 1979-1980 silver price boom period. Newly minted silver coins are usually limited quantity commemorative types and they sell substantially above their silver value, and thus cannot be profitably melted except at very high silver prices.



e) Private hoards are only a theoretical supply source in the sense that they can contribute significantly to the above ground supply flow or actually reduce the flow (when investors are net buyers). The acquisition or liquidation of private hoards is a function of world economic and political conditions, interest rates relative to inflation rates and silver price levels.

The year to year changes in total silver supply can be attributed mostly to shifts in the flow of above ground supplies. Since 1967, when price ceilings were lifted, annual flow of silver supplies from non-primary sources has ranged from a low of 88 million ounces in 1971 to a peak of nearly 370 million ounces in 1968 when U.S. Government was selling huge quantities of stockpile silver to meet pent up demand that materalized when price ceilings were lifted.

Over the past five years the above ground flow has ranged from a peak of 226.5 million ounces in 1980 to last year's low of 154.6 million ounces. For 1982, we are estimating above ground supply flows exclusive of net speculative hoard liquidation at 100 million ounces. If so, this will be the lowest level in more than ten years. We anticipate a moderate increase in 1983 if world economies improve and the silver market strengthens as expected. But, we do not envision a dramatic increase in supply flows without an equally dramatic increase in price. The table below depicts above ground supply flow by major category and average yearly silver prices. Unlike primary production, above ground supply flow shows considerable response to silver prices.

THE FLOW OF ABOVE GROUND SUPPLIES * 1960 - 1982
(In Million Troy Ounces)

	US Govt	India	Other Govts	Melted Coins	Scrap	Total	Average Price
1960	21.5		19.7	10.0	21.5	72.7	$0.91
1961	62.6		70.9	30.0	29.0	192.5	$0.92
1962	0.9		29.5	20.0	14.7	65.1	$1.08
1963	25.2		10.0	15.0	10.8	61.0	$1.28
1964	151.0		20.0	20.0	36.6	277.6	$1.29
1965	80.0		26.4	30.0	19.8	156.6	$1.29
1966	142.5	6.9	19.6	28.0	25.2	222.2	$1.29
1967	195.2	20.0	13.0	78.9	52.9	360.0	$1.55
1968	179.5	60.0	15.0	87.0	27.3	368.8	$2.15
1969	89.0	25.0	8.0	61.4	14.6	198.0	$1.79
1970	67.0	16.0	10.0	25.0	35.2	153.2	$1.77
1971	2.5	32.0	5.0	20.0	28.3	87.8	$1.55
1972	2.3	19.0	10.0	15.0	45.0	91.3	$1.69
1973	.9	39.0	52.0	15.0	57.5	164.4	$2.56
1974	1.0	65.7	10.8	47.0	65.7	190.2	$4.71
1975	3.0	66.0	18.4	35.0	73.2	195.6	$4.42
1976	1.3	70.0	7.0	55.0	86.1	219.4	$4.35
1977	0.4	40.6	5.0	23.0	94.2	163.2	$4.62
1978	0.1	45.5	8.4	14.0	96.5	164.4	$5.40
1979	0.1	33.5	3.1	25.5	80.5	142.7	$11.09
1980	0.1	44.7	5.2	55.0	121.5	226.5	$20.63
1981	2.1	33.5	2.0	12.0	105.0	154.6	$10.52
1982E	1.0	30.0	4.0	5.0	60.0	100.0	

* Does not include the liquidation or additions to private hoards.

Source: Handy & Harman Co.

THE FLOW OF SILVER FROM INDIA'S SILVER HOARDS IS LIKELY TO REMAIN AT RELATIVELY LOW LEVELS THROUGH 1983 UNLESS PRICES MOVE SUBSTANTIALLY HIGHER:

India has played a unique role in the flow of silver supplies. This nation has been a major supplier of silver for nearly two decades. For example, since 1967, when silver prices were permitted to fluctuate freely, an estimated 640 million ounces of silver have flowed into the supply pipeline. Yet, India produces a negligible quantity of silver. The ability to become a major supplier exists because of the vast quantities of silver imported into India during the late 1800's and early 1900's. Between 1874 and 1932, nearly 3 billion ounces of silver flowed into India. However, most of this silver is only marginally accessible. It is held by the populus in the form of jewelery and ornamentations; and, it serves both as status symbols and measure of wealth.

Factors influencing the dislodging of this hoard includes both the silver price level as well as economic and agricultural conditions in India. However as time passes, it appears that higher and higher prices are required to dislodge silver holdings. For example, the silver flow from India during the three year silver boom period between 1978-1980 when prices averaged $14.00/oz approximated 40 million ounces annually. This was almost 20 million ounces per year below the average of the three previous years when prices averaged about $5/oz. We estimate the supplies of silver from India in 1982 will approximate 30 million ounces or the lowest level in more than ten years. If silver prices improve as anticipated in 1983, then the supply flow from India could increase to the 35-40 million ounce range.

IMPROVED LEVELS OF DEMAND IS THE KEY TO A SUSTAINED SILVER PRICE RECOVERY:

The demand for silver encompasses three fairly distinct areas: industrial applications, speculative/investment purchases and coinage. The latter has run full cycle. Coinage was the largest source of silver usage in the early 1960's when the U.S. Government attempted to meet shortages via huge levels of coin production. Today, most coinage production is limited to occasional commemorative pieces for collectors. Industrial and investor purchases are now the major areas of silver demand.

Industrial consumption is, of course, influenced by the level of business activity and technological developments that either require silver or substitute for silver. Price is also a consideration when substitutes are available. Speculative and investor purchases have become a potent but erratic demand force as the Hunt affair will attest. Investor demand is influenced by both economic and political considerations with special attention to interest rates and currency relationships.

MAJOR SILVER USAGE CATEGORIES

	1971	1981
Electroplated Ware	8%	5%
Sterling Ware	16%	5%
Jewelery	2%	5%
Photography	28%	38%
Dental & Medical	1%	2%
Brazing Alloys	10%	8%
Electrical	26%	29%
Catalysts	1%	4%
Medallions	5%	3%
Miscellaneous	3%	1%

Source: Handy & Harman Co.

The total range of silver utilized by industry is broad and diverse. Solar energy, medicine, emission control devices, water purification and countless others use silver in varying amounts. However, the major areas of silver usage by industry is confined to a relatively narrow area. Photography has been the largest usage category for decades, accounting for 30 percent to 40 percent of that annual industrial usage. The electrical and electronic industries have enjoyed a rapid growth during the 1960's and the 1970's at this area has replaced the sterling and electroplated ware industries for the second spot. Excellent electrical conductivity and durability are the major reasons why silver is preferred to less expensive substitutes.

Sterling ware was once the largest silver usage category. However, the combination of soaring silver prices and changes in taste have impacted negatively on sterling ware sales. This use category now accounts for about 5 percent to 10 percent of silver consumption. Brazing alloys, medallions and jewelery represent the remaining major usage categories.

The Industrial usage is responsive to both price and to level of economic activity. High prices contributed to declining consumption in 1979, when usage exlusive of coinage fell about 23 million ounces to 420 million ounces. The dramatic 70 million ounce drop in consumption in 1980 reflected the combination of many factors including recession, high interest rates, the Hunt affair and very high silver prices, which averaged about $20/oz for that year. Usage rates improved slightly in 1981, rising about 13 million ounces to 363 million ounces. We are estimating additional modest improvements of 7 million ounces in 1982. The bulk of gains are likely to occur during the second half of the year in response to a possible improved economy, lower interest rates and some inventory accumulation.

More significant usage gains are anticipated for 1983 if the recent fairly sharp drop in interest rates does indeed translate into economic growth. In the past, silver usage rates have displayed an ability to recover quickly from recession. For example, demand rose from 377 to 438 million ounces following the 1975 recession. However, because of the severity of the most recent recession and the likelihood that the recovery will be sluggish, we are estimating a 30 milion ounce increase in industrial usage in 1983 to about 400 million ounces. If so, and if our 1983 primary production estimate of 265 million ounces materializes, then above ground sources will have to supply 135 million ounces of silver to the market place next year.

WORLD SILVER STOCKS:

The prospects for a demand upturn if economies improve focuses attention on inventories of silver world-wide. One cannot argue that ample supplies of silver exist; whether or not they are readily available is another issue. Indeed, the price explosion from 1978 through early 1980 suggest that while ample supplies of silver are held world-wide, they are not always available. The following table depicts estimates world silver stocks as reported by Handy and Harman Co.

SUMMARY OF WORLD STOCKS

	(millions of ounces)		
	1981	1980	Increase (Decrease)
Reported private stocks:			
New York Commodity Exchange	77.6	86.9	(9.3)
Chicago Board of Trade	15.5	34.2	(18.7)
London Metal Exchange	32.2	26.9	5.3
Industry stocks in the U.S.	19.8	19.5	.3
Total	145.1	167.5	(22.4)
U.S. Government stocks:			
U.S. strategic stockpile	137.5	139.5	(2.0)
U.S. Defense Department	3.8	4.5	(.7)
U.S. Treasury (Mint)	38.8	38.9	(.1)
Total	180.1	182.9	(2.8)
Stocks of foreign governments (estimated)	122.0	122.0	--
Conjectural stocks:			
Unreported bullion stocks in U.S. and abroad	250.0	175.0	75.0
U.S. silver coins potentially available	655.0	662.0	(7.0)
Foreign silver coins potentially avail.	25.0	30.0	(5.0)
Total	930.0	867.0	63.0
Total world silver stocks	1,377.2	1,339.4	37.8

CONCLUSION

We believe that the 1980 - 1982 declining market in silver has run its course and silver has entered an advancing phase. This outlook is based upon the following observations and contingencies:

1) A sharp reduction in silver supplies from both primary sources (mine production) and above ground. The inelastic nature of primary production suggests relatively low supply levels through at least 1983.

2) The likelihood of improved industrial usage rates in conjunction with an anticipated economic recovery that could evolve in 1983 and continue through 1984 and longer.

3) The possibility that the recent "flight to quality" prompted by bank failures and the Mexican peso devaluation could result in increased accumulation of crisis assets such as gold and silver.

4) The recent decline in interest rates which makes holding silver less expensive as well as diminishes the attraction of certain paper investments because of lower yields.

The cited influences have already begun to strengthen the silver market; and, recent price gains seem reasonably sustainable unless world economic conditions deteriorate significantly. However, despite emerging price optimism, we also anticipate occasional corrective action and periods of base-building within an overall advancing phase. If so, then the bulk of price activity for the remainder of 1982 could occur mostly within the $8 to $11/ounce area basis spot. Thereafter, the upper boundary could be expanded to the $12 to $14/ounce area, and this could occur within 12 to 18 months.

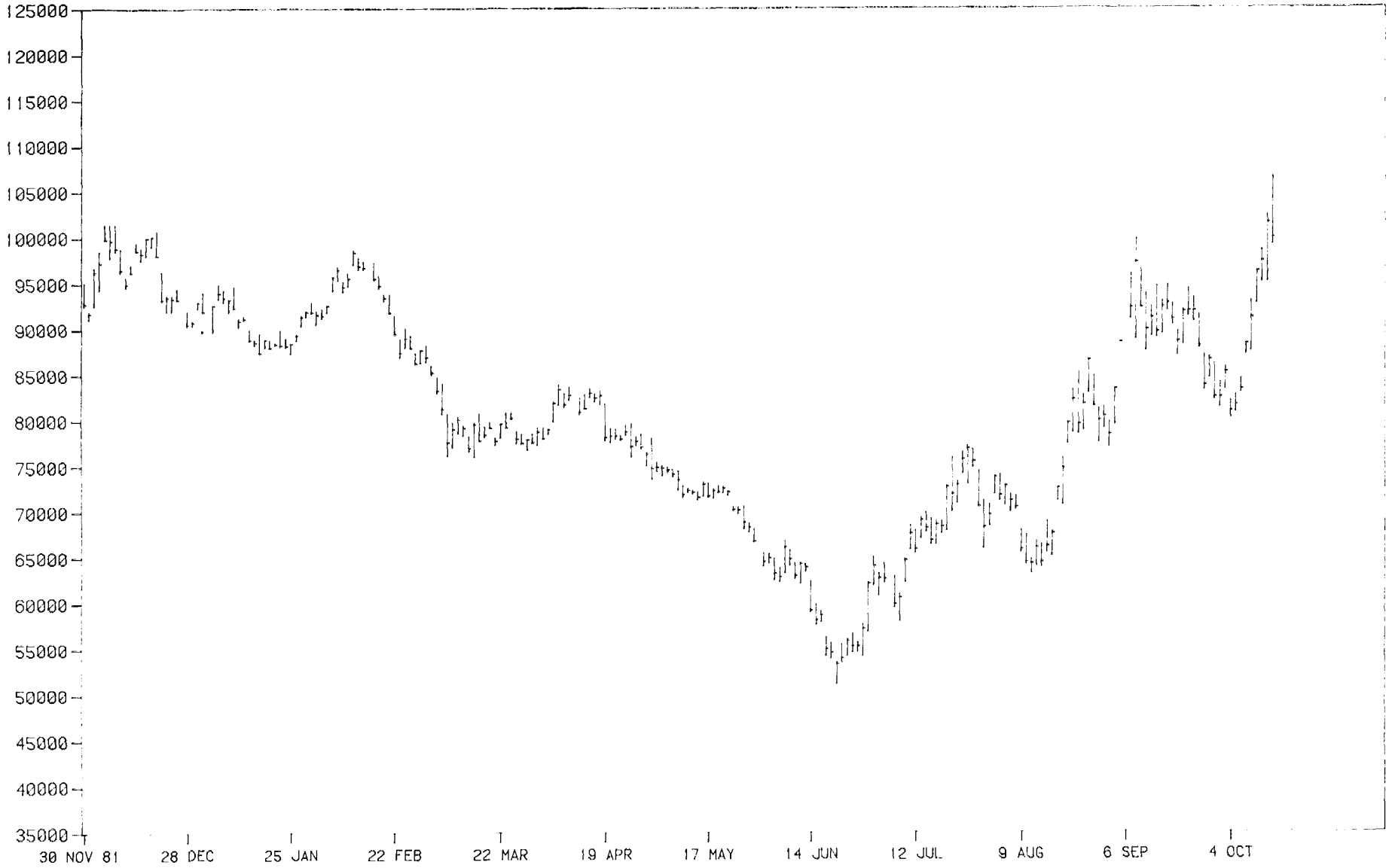
We recognize that upcoming developments may or may not alter the theme and conclusions of this report. In order to maintain a continuous flow of silver market information, Merrill Lynch Commodities issues extensive commentary including daily market reports, bi-weekly research outlooks, trading suggestions when appropriate and other information. We suggest those interested in following silver market developments remain in contact with their Merrill Lynch Account Executive.

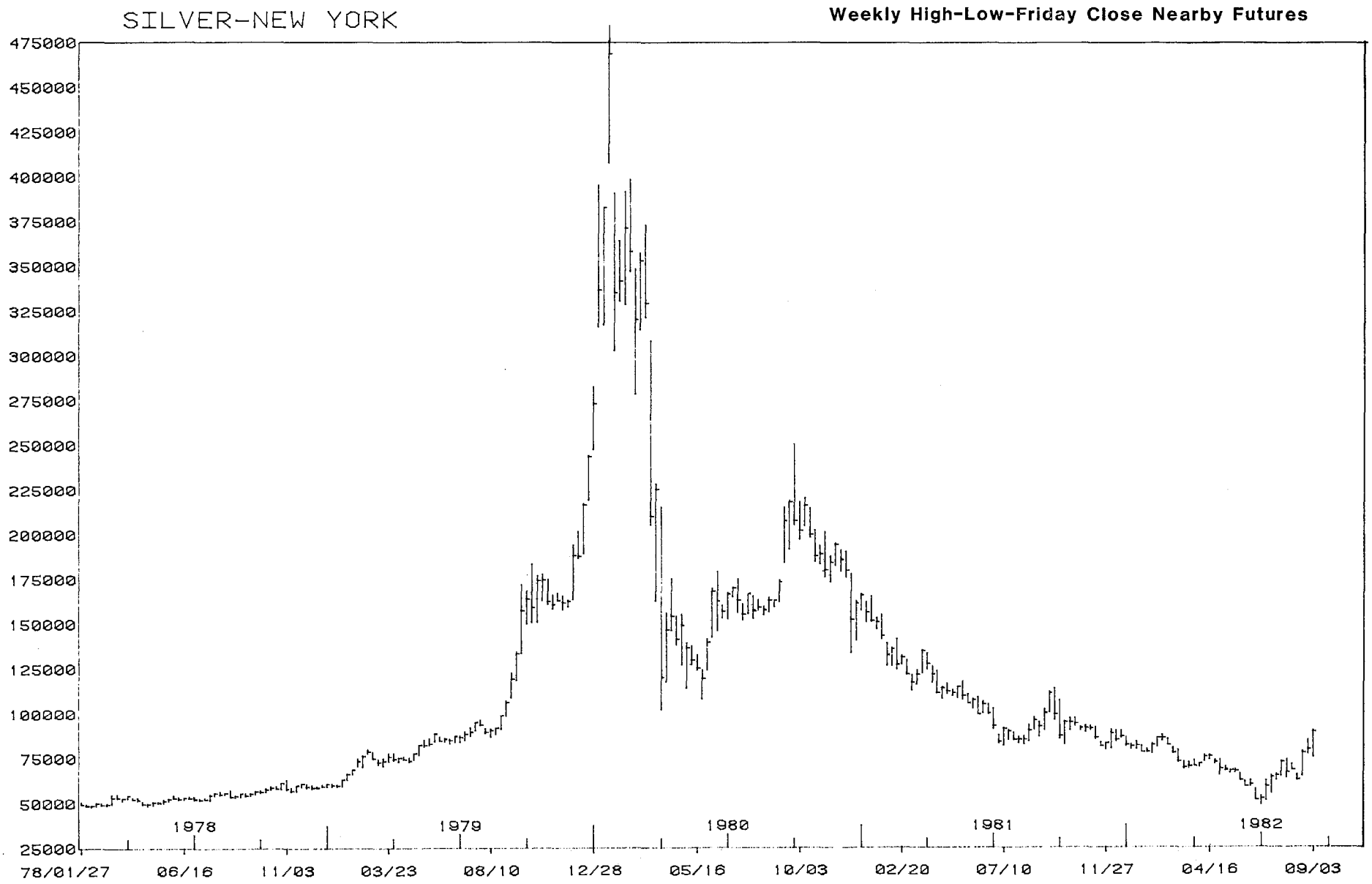
Vincent J. Conway
Assistant Vice President
Metals Product Manager

David G. Linnehan
Assistant Vice President
Senior Metals Analyst

The information set forth herein was obtained from sources which we believe reliable, but we do not guarantee its accuracy. Neither the information, nor any opinion expressed, constitutes a solicitation by us of the purchase or sale of any securities or commodities

DEC82 SILVER-NEW YORK




SILVER-NEW YORK
Weekly High-Low-Friday Close Nearby Futures
475000
450000
425000
400000
375000
350000
325000
300000
275000
250000
225000
200000
175000
150000
125000
100000
75000
50000
25000
1978
1979
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78/01/27
06/16
11/03
03/23
08/10
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JKC

PRECIOUS METALS

The Economic Report

United States platinum consumption is expected to fall to a 10-year low of 662,000 troy ounces this year, a 24-percent decline from last year's level and less than half the annual use in each of the past three years. Platinum use this year will be the lowest since 1973, the year before automakers began using large quantities of the metal in catalytic converters. (PPR&O)

Demand for new platinum will more than double by 1987 to 1.8-million troy ounces, according to Mark Stringfellow, president of Johnson Matthey, Inc. This demand will be fueled by three major factors: increased demand for platinum in the diesel trap oxidizer catalyst; demand for small quantities of platinum as an investment medium; and demand for platinum jewelry.

Refiners of precious metal scrap face a generally bleak future, with the industry burdened by both excessive refining capacity and a potential long-term shortage of scrap supplies, according to Dominick Passaro, president of Refinemet International Company. However, an exception to this, according to Mark Stringfellow, president of Johnson Matthey, Inc. will be supplies of scrap platinum from used automobile catalysts. Between 1975 and 1981, five million ounces of platinum group metals were put in automobile catalysts, and a large amount of scrap platinum should be coming on the market during the next few years from the backlog of older cars on the road.

Rustenburg Platinum Holdings of South Africa, the world's largest platinum producer, has decided to deal directly on the New York Mercantile Exchange in a bid to give it greater protection from sharp fluctuations in the platinum price. (AMM)

The Soviet Union has not reduced its supplies of palladium to the United States, but the perception on the part of some traders that they have may have played a minor role in the price surge. This perception may have resulted from reports of a change in marketing of the metal. This, according to Dominick Passaro, president of Refinemet International, Inc., and Mark Stringfellow, president of Johnson Matthey, Inc.

Russia will reduce its sales of palladium to dealers because Soviet palladium marketing officials believe their revenues have been adversely affected by dealer hedging. They plan to sell directly to customers, but it may take a while to get that level of selling to what it has been to dealers.

The Toronto Stock Exchange will begin trading a 1,000-troy ounce silver options contract on January 12, 1983. Non-securities industry firms will be able to participate as market-makers, trading in silver options for their own accounts on the options floor. (AMM)

Silver use by industry in the United States remains relatively low today, compared with the rate 20 years ago. This, according to Sinclair Weeks, Jr., President of the Silver Users Association. While industrial activity is important as a base for trading in silver, major price moves have been the result of the important influence of the investor demand toward silver. And the dramatic change in investor attitude toward silver resulted in pressure on demand and a turn-around in the price at midyear. However, Mr. Weeks predicts several years of average annual prices not to exceed the $10-11 range posted in both 1979 and 1981. (SUA)

Mexican Central Bank Permission is no longer required for the export of gold and silver from that country. This annuls a decree published September 9th as part of the full exchange controls imposed by former President Jose Lopez Portillo. (AMM)

South African gold producers are seeking agreements with major United States precious metal brokerage houses that would enable the producers to establish an effective floor price on their gold sales. Preliminary plans call for mining companies and brokerage houses to enter an agreement whereby the brokerage house would guarantee it would purchase either all or a portion of a gold mine's output at a level approximating the costs of production if the mining firm exercised its option to sell at that price. The brokerage house's "reward" for such a guarantee would be an agreement that if gold prices increased more than a predetermined level, the brokerage house would reap a significant portion of the profits above that point. The program, as envisioned by mining companies, would cover only high-cost gold mines. (AMM)

Increasing volatility will be a feature of precious metal prices over the coming year, with gold likely to trade in a range of $400 to $550 per troy ounce, according to metal analysts David Hargreaves and David Williamson, of Shearson/American Express Ltd. The analysts also predict that platinum could move into parity with gold. Silver, in turn, is expected to vary between $12 and $18 per ounce.

The silver market is burdened by increasing inventories, but prospects appear bright for some economic recovery and therefore greater silver consumption in 1982. Both production and consumption in the United States have remained weak while warehouse stocks have been growing at a hefty clip. However, further anticipated declines in U.S. interest rates should benefit silver prices. Technically, the market appears to be in the midst of a correction and may undergo a further correction before beginning a new upward trend. (ACLI, December, 1982)

Technically, the gold market remains in an uptrend, but is showing some signs of exhaustion. Gold prices have strengthened on the weakness of the U.S. dollar and the Federal Reserve's easing of interest rates, but fundamentally, the market is in a weak condition. Even if a recovery is underway, inflation rates in the western industrialized nations should remain quite low by recent standards. Thus if the traditional inflation/gold relationship holds, speculative demand for gold may show weakness in the period ahead. (ACLI, December, 1982)

The Bank of Nova Scotia's customers are now able to purchase gold and silver certificates in exact dollar amounts, representing fractional quantities of gold and silver. The fractions apply to sums of one troy ounce or more of gold and 50 ounces or more of silver. (AMM)

United Kingdom silver exports to the Soviet Union totaled approximately 2.61-million troy ounces, in September, valued at $18.4-million, according to British customs and excise figures. Silver dealers speculated that the figures lent weight to market talk earlier that the Soviet Union had recently purchased up to 10-million ounces of silver from the world market. (AMM)

PPR&O, Platinum/Palladium Review and Outlook, J. Aron & Co./AMM, American Metal Market/ACLI, International Commodity Services, Inc./SUA, Silver Users Association

SILVER

8. Events, Trends, and Issues: U.S. mine prodtion of silver declined in 1982 from that of 1981 owing in part to low silver prices early in the year which forced extended shutdowns at a number of mines, and to lower production of byproduct silver from copper mining. This decrease occurred despite production from several new mines and capacity expansions by several other producers. Industrial consumption rose slightly in 1982 with demand being met through imports, and a drawdown of industry stocks.

Silver prices declined steadily throughout the first half of the year reaching a low of $4.88 per ounce in late June. Thereafter prices increased, stabilizing at about $10.00 per ounce late in the year. The average daily price for the year declined from $10.52 in 1981 to $8.00 per ounce in 1982.

In December 1981 Public Law 97-114, the Defense Appropriation Act of 1982 was enacted. The law halted sales of silver from the National Defense Stockpile authorized by Public Law 97-35 until a new study could be performed to determine the amount of silver needed for defense purposes and the best method for disposing of any excess. Silver sales from the stockpile remained suspended through 1982.

The Environmental Protection Agency held hearings on proposed regulations concerning effluent limitations for electroplating and metal-finishing companies. The Securities and Exchange Commission issued a report on its investigations of New York Stock Exchange actions during the runup and subsequent collapse of silver prices in 1979-80.

It is estimated that in 1983 domestic mine production of silver will be 38 million ounces and U.S. apparent consumption will be 144 million ounces. From a 1978 base, demand for silver is expected to increase at an annual rate of about 2.9% through 1990.

The treatment of waste generated in the processing and separation of silver from base metals was controlled to protect ground and surface waters.

9. World Mine Production and Reserve Base:

	Mine Production		Reserve Base 5/
	1981	1982 e/	
United States	40.7	36.0	1,800
Canada	38.7	41.0	1,600
Mexico	53.2	55.0	1,100
Peru	46.9	48.0	600
Other Market Economy Countries	104.2	102.0	1,300
Centrally Planned Economies e/	82.4	82.0	2,000
World Total	366.1	364.0	8,400

10. World Resources: Approximately two-thirds of the world silver resources are associated with copper, lead, and zinc deposits. The remaining one-third is in vein deposits in which silver is the principal metallic component. While recent high prices of silver have led to increased exploration and new discoveries, most significant increases in reserves and resources are expected to come from major base metal discoveries that contain byproduct silver.

11. Substitutes and Alternates: Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware. Some of the batteries being developed may replace silver batteries in some applications. Silverless black and white film, film with reduced silver content, and xerography are alternatives to some uses of silver in photography.

January 1983

RECEIVED

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2-2-82

US BM Silver

world

mine Prod

80	81
342	357

apparently includes communist countries

8 April 81

PRECIOUS METALS

JHC

METALS WEEK®

ASARCO Incorporated
FEB 17 1981
Exploration

February 16, 1981

JHC-WLK-RBC

ASARCO

Exploration Department
Southwestern United States Division

February 20, 1981

F. T. Graybeal
ASARCO Incorporated
New York Office

Dear Fred:

Your paper on disseminated silver deposits returned herewith. Have made only a few suggestions ----- principally in respect to wording ----- leaving scientific aspects and research validity in more capable hands ----- with one exception: production and consumption.

Metals Week 5-5-80	Troy oz.	London M J 2-13-8
1980 Mine production Free World (forecast)	290M (up 6%)	255 M (-5°)
Recycle " " " "	200M (up 20%)	288 M (+100%)
Demand " " " "	420M (down 5%)	- (-20%)
surplus	- 70M	

Metals Week 2-16-81	
1980 Demand - Free World	365M
Surplus " "	180M

USBM - 1979 US consumption breakdown	
Silverware, jewelry	30M
Photographic	65M
Solders, electronic products, catalysts	62M
Coins, medallions, etc.	3M
Miscellaneous	6M
	166M

I should add that your paper will be a most significant contribution to the silver literature ----- how in "the Wall Street world" did you find the time to write it?

Regards,

J.H. Courtright
J. H. Courtright.

JHC:jlh
encls

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703
1150 North 7th Avenue (602) 792-3010

J. H C.

THE FOLLOWING PUBLICATIONS HAVE BEEN ENTERED INTO THE LIBRARY MAY 1981

JUN 4 1981

USGS Professional Papers:

PP 1154 Stratigraphy and structure of the Strawberry Mine Roof Pendant Central Sierra Nevada, California. (2) by Warren J. Nokleberg 1981.

USGS Bulletins:

1501 Studies Related To Wilderness Areas, Mineral Resources of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana, 1981, by J.D.Wells, D.A.Lindsey, and R.E.Van Loenen.

USGS Open-File Reports:

78-942 Hydrothermal Adularia at Bodie, Mono Co., Calif. by R.A.Koski, C.W.Chesterman, M.L.Silberman, and B.P.Fabbi.

80-1234 Where On Earth Is All The Lithium? With a section on Uranium Isotope Studies, Fish Lake Valley, Nevada (2) by James D. Vine. (Microfiche).

80-1245 Exploratory Trench Across The Pleasant Valley Fault, Nevada, by M.G.Bonilla, H.A.Villalobos, and R.E.Wallace.

80-1273 Selected Commodity Occurence Maps for the Ophiolite Belts of the Western U.S. by Jocelyn A. Peterson.

Thesis:

U of A Thesis: Geology and Ore Deposits of the Marble Peak Area, Santa Catalina Mountains, Pima County, Ariz. by Eric R. Braun (1969).

USGS Maps:

Map I-1237 Geologic Map of the Gillis Canyon Quadrangle, Mineral Co., Nevada by Richard F. Hardyman. Scale 1:48,000 (1)

Miscellaneous:

"Map Data Catalog", National Mapping Program U.S. Department of the Interior Geological Survey, (NCIC) 1981.

DOE/ID 12079-8 Geology of the Colado Geothermal Area, Pershing Co., Nevada, (Utah University, Salt Lake City). Earth Science Lab. by Sibbett B.S., and Bullett M.J.

check out for JHC

first nine months of 1979, according to the Silver Institute. By the first two months of this year, by contrast, it had jumped

plant will cost around $17-million.

IMF gold sale: strong bidding, little response

FROM: W. L. KURTZ

WLK
FTG

To: ~~[illegible]~~
RBC
JHC

note "other sources for 1976 etc."

Return to WLK

Bella picked this up in NY while attending Barbara Hamilton's meeting with the security contacts.

SILVER
FREE WORLD MINE PRODUCTION
VS.
FREE WORLD INDUSTRIAL CONSUMPTION

	Mine Production (1)	Other sources	Industrial Consumption (2)	Deficit
	(In million of ounces)			
		(see Metals Week tabulation, Attached)		
1960	207.8		224.6	15.8
1961	203.3		239.5	36.2
1962	208.6		258.5	49.9
1963	214.6		260.7	46.1
1964	210.7		299.2	88.5
1965	218.4		336.6	118.2
1966	221.3		355.1	133.8
1967	214.0		348.7	134.7
1968	231.3		350.8	119.5
1969	241.3		350.6	109.3
1970	251.9		338.9	87.0
1971	246.9		351.4	104.5
1972	244.0		388.9	144.9
1973	253.7		477.8	224.1
1974	237.4		409.0	171.6
1975	240.3		376.8	136.5
1976	246.3	178.0*	418.2	171.9
1977	259.6		387.1	127.5
1978	265.0		388.0	123.0
1979	271.0		410.0	139.0
		Twenty Year Deficit		2,282.0

(1) Published by Handy & Harman annual silver review. Source-Annual report of the Director of the Mint.

(2) Published by Handy & Harman annual silver review.

2/27/80

* Includes "salvage" amounting to 71.6
Therefore actual production deficit 100.3

U.S. Refined Consumption-By Industry
Years 1975-1979 Inclusive

The following represents millions of ounces refined consumption by industry in the U.S. (includes secondary) (1)	1979	1978	1977	1976	1975
1 Silverware	24.2	26.5	23.8	29.3	32.4
Jewelry	5.9	7.2	8.1	11.0	12.7
2 Photographic	64.9	60.0	56.0	55.5	46.1
Brazing Alloys & Solders	11.7	11.0	13.7	11.2	13.6
3 Electrical & Electronic Products	41.8	37.7	38.8	35.8	31.5
Catalysts	8.8	8.8	10.7	12.3	8.8
4 Coins, Medallions & Commemorative Objects	2.6	2.9	4.2	8.2	7.2
5 Miscellaneous	5.7	5.4	5.7	7.2	5.4
TOTAL	165.6	159.5	161.0	170.5	157.7

1 - 30
2 - 65.
3 62
4 3
5. 5
165 -

(1) Bureau of Mines

2/27/80

ASARCO AND ASSOCIATED COMPANIES
Silver Mine Production
1975-1979

	1979			1978			1977			1976			1975		
	Ounces Produced	% Owned by Asarco	Asarco's Net Equity	Ounces Produced	% Owned by Asarco	Asarco's Net Equity	Ounces Produced	% Owned by Asarco	Asarco's Net Equity	Ounces Produced	% Owned by Asarco	Asarco's Net Equity	Ounces Produced	% Owned by Asarco	Asarco's Net Equity
Domestic															
Galena	4,085	37.5%	1,532	3,988	37.5%	1,496	3,702	37.5%	1,388	3,421	37.5%	1,283	3,350	37.5%	1,256
Coeur	2,429	(1)	1,487	2,396	83.3%	1,997	2,381	83.3%	1,984	661	83.3%	551	-	-	-
Leadville	269	50%	135	310	50%	155	310	50%	155	335	50%	168	352	50%	167
Mission	569	100%	569	491	100%	491	290	100%	290	407	100%	407	292	100%	292
Other	323	100%	323	682	100%	682	816	100%	816	919	100%	919	711	100%	711
Total	7,675		4,046	7,867		4,821	7,499		4,633	5,743		3,328	4,705		2,426
Foreign															
Quiruvilca	1,268	100%	1,268	1,281	100%	1,281	1,350	100%	1,350	1,068	100%	1,068	1,134	100%	1,134
Buchans	323	49%	158	523	49%	256	499	49%	245	554	(2)	277	611	50%	306
Total	1,591		1,426	1,804		1,537	1,849		1,595	1,622		1,345	1,745		1,440
Associated Cos.															
Medimsa	10,572	34%	3,594	10,843	34%	3,687	8,357	34%	2,841	7,660	34%	2,604	5,939	34%	2,019
MIM Holdings	14,574	49%	7,141	14,780	49%	7,242	13,168	49%	6,452	11,277	49%	5,526	11,045	49%	5,412
SPCC	2,305	52.3%	1,206	1,843	52.3%	964	1,919	52.3%	1,004	956	52.3%	500	767	51.5%	395
Neptune	27	52.2% (2)	14	38	52%	20	48	52%	25	62	52%	32	98	52%	51
Total	27,478		11,955	27,504		11,913	23,492		10,322	19,955		8,662	17,849		7,877
Total	36,744		17,427	37,175		18,271	32,840		16,550	27,230		13,335	24,299		11,743

(1) Asarco Equity 83 1/3% through April 1979;
50% May-December 1980

(2) Expropriated November 1979

RJO'K
2/27/80

SELECTED MINING COMPANIES

1978 Silver Mine Production

	Equity Mine Production Million Ozs. (Source ABMS Adjusted)	Common Stock Shares in Millions	Ounces per Share
ASARCO	18.1	30.5	0.59
Newmont	2.6	25.0	0.10
Sunshine	3.6	5.7	0.63
Callahan	2.2	3.8	0.58
Hecla	4.1	7.0	0.58
Day	1.5	2.9	0.51
Rosario	6.8	6.1	1.11
Kennecott	3.3	33.2	0.10
Texas Gulf	7.8	34.8	0.22

RJO'K/eob
2/27/80

ASARCO REFINED SILVER PRODUCTION

Thousands of Ounces

	1979	1978	1977	1976	1975
Amarillo	36,101	39,204	33,481	32,997	
Perth Amboy				11,314	44,576
Baltimore					10,679
TOTAL	36,101	39,204	33,481	44,311	55,255
Raw Material from which produced provided by:					
Asarco Mines (1)	4,809	4,654	4,809	4,534	3,226
Custom Material	32,294	34,025	28,533	36,901	41,641
Toll	(282)	525	139	2,876	10,388
TOTAL	36,101	39,204	33,481	44,311	55,255

(1) Includes Asarco's share of production of mines managed by Asarco.

RJO'K/ac
2/27/80

ASARCO AND ASSOCIATED COMPANIES

Gold Mine Production 1978

	Ounces	% Owned By Asarco	Asarco's Net Equity Ounces
Coeur	484	83-1/3% (1)	403
Galena	495	37-1/2	186
Ground Hog	83	100	83
Leadville	8,000	50	4,000
Sacaton	3,691	100	3,691
Buchans	2,995	49	1,468
Granduc	1,822	50	911 (2)
Quiravilca	3,324	100	3,324
Total Asarco	20,894		14,066
Neptune	25,514	52.2	13,318 (3)
IMM	15,207	34	5,170
MIM	13,825 (4)	49	6,774
SPCC	Traces	52.3	-
	54,546		25,262
	75,440		39,328

(1) Reduced to 50% 5/79
(2) Closed
(3) Expropriated 11/79
(4) Gold Content of Products Sold

J.H.C.

Criteria and comparisons of nine selected low grade

Deposit	Host Rock	ORE MINERALOGY: Silver-Bearing Minerals	ORE MINERALOGY: Other Minerals	Ore Mineral Mode of Occurrence	GRADE: Hypogene + Supergene	GRADE: Supergene	Ore Tonnage	Shape of Deposit	Size of Deposit (Feet)
CANDELARIA, NEVADA	Triassic-Jurassic Candelaria Fm., tuffaceous shales	Secondary silver in limonite and jarosite, some remnant sulphides	Native gold, jamesonite, pyrite, minor chalcopyrite and galena	Disseminated, and in veins parallel to bedding	±3 oz. Ag	Predominant	10-20 million	Tabular	2000 x 500 with fault repeats
DELAMAR, IDAHO	Miocene rhyolite quartz porphyry (ash flow tuff)	Principally naumannite (silver selenide), also argentite	Minor pyrite, free gold	Finely disseminated in quartz	Est. 2-6 oz. Ag, ±0.03 oz. Au	—	Est. >8 million	Various shapes from equidimensional blob to long-&-narrow	Range from 100 ft. min. widths to 4000 ft. max. lengths
HARDSHELL, ARIZONA	Mesozoic volcanic and volcaniclastic rocks	Native silver? Argentian cryptomelane, cerargyrite, pearceite, argentojarosite	Pyrite, traces galena	Disseminated in associated Mn oxides and silica	Est. 4-5 oz. Ag	—	Est. >5 million	Manto-like	1600 x 600
HOG HEAVEN, MONTANA	Two mid-Tertiary horizons, latite tuff breccia and volc. conglomerate	Galena, enargite, matildite	Pyrite, sphalerite, barite	Disseminated	Not established	—	Not established	Strongly warped, lensoid	Not established
LANGTRY, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver?	Barite, pyrite	Finely disseminated	Est. ±2 oz. Ag	—	±15 million	Flat-lying	±700 x 2000 x ±100 thick
REAL DE ANGELES, ZACATECAS, MEXICO	Upper Cretaceous sandstone and siltstone, slightly limey	Argentiferous galena and minor tetrahedrite	Sphalerite, galena, pyrite, arsenopyrite, minor chalcopyrite	Partly disseminated, partly fracture-filling, some veins	2½ oz. Ag 1% Pb, 1% Zn	Slight silver enrichment in shallow supergene	±50 million	Roughly circular	At least 1000x 1000
ROUND MOUNTAIN, COLORADO	Oligocene rhyolite flows and breccias	Argentian cryptomelane, bromides and chlorides, native silver	Barite, fluorite, iron oxides	Mn oxide veins and veinlets in stockworks	Remnant only	2-3 oz. Ag	5-12 million	Flat-lying, lensoid	2½ million square feet
SAM GOOSLY, BRITISH COLUMBIA	Jurassic Hazelton Group, andesitic tuffs and breccias	Tetrahedrite, traces of ruby silver and argentite	Pyrite, chalcopyrite, pyrrhotite, sphalerite, rare galena	Disseminated and veiniet, some massive	Hypogene only. 2.8 oz. Ag, 0.33% Cu, 0.02 oz. Au	None	43½ million open pit with depth extension	Essentially tabular	4000 x 300, irregular
WATERLOO, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver? Argentiferous pyrite? Also cerargyrite, embolite, argentojarosite	Barite, pyrite	Finely disseminated	Est. 2-3 oz. Ag	—	Est. >25 million	Elongate wedge	1000 x 6000

1. "Estimates" are those of the author.

bulk tonnage silver deposits in western North America[1]

Structural Controls	Open Pit	Stripping Ratio	Age of Deposit	Dominant Alteration Minerals	Supergene Enrichment	Depth Extent of Partial Oxidation	SPATIALLY ASSOCIATED INTRUSION: Rock Type	SPATIALLY ASSOCIATED INTRUSION: Size	Genetic Association	Metallurgical Characteristics of Ore	Additional Comments
Primary not known, secondary by fault offsets	Yes	Approx. 3:1	Jurassic or Tertiary	Clay, dolomite (magnesium metasomatism) manganese oxides	No (dispersion)	600' on dip, 450' vertically	Quartz monzonite, felsite dikes	70' - 180' wide, 400' long	Not known	Refractory—under investigation	May be syngenetic (Jurassic) or replacement (Tertiary)
Possibly deep-seated control, combined with more brittle quartz porphyries	3 pit areas	2:1 to 6:1	Miocene	Silica	Possible but minor	—	Various acid to intermediate volc. rocks, vents	Various	Probable	Nicely amenable to cyanidation. Not refractory (low Fe, Mn)	Deposit is in a volcanic center
Deep-seated structures, favorable porosity and permeability	Possible open pit, possible underground	If open pit, depends on cutoff grade	Laramide?	Silica, clay, Mn oxides (5-25% Mn)	Minor	At least 500'	Andesite and quartz latite	Irregular dikes and sills	None	Refractory	Underlying Paleozoic carbonate rocks provide the solution channels
Syn- & post-mineral folding	Possibly and partially	Not known	Mid-Tertiary	Silica with macroscale clay envelopes	In upper breccia horizon	To 500'	None known	—	—	Not known	Being explored
Deep-seated structures, favorable porosity and permeability	Yes	3:1	Miocene or Pliocene	Silica, iron oxides, clay, manganese oxides	None noted	Entire deposit	Pre-ore granitic body	Several square miles	None with granitic body	Refractory	Author considers this deposit an extension of the Waterloo (see below)
Bedding, fracturing	Yes	Low	Not known	None in classic sense. Minor calcite, chlorite	Locally at least silver	Up to 125'	None	—	—	Amenable to flotation	Both syngenetic-diagenetic (Cretaceous) and classic hydrothermal origins have been suggested
Primary not known, secondary by fossil water tables	Yes	Approx. 2:1	Mid-Tertiary still forming(?)	Clay, silica (opal-type), sericite	Redeposition, possible enrichment	200'	Not known	—	—	Refractory—under investigation	Primary grade not known. Deposit is in a volcanic center
Possibly position in a theorized volcanic vent	Yes, with depth extension	2.1:1	Eocene or Jurassic	Sericite, clay, chlorite, silica, tourmaline, gypsum, aluminous (scorzalite, andalusite, pyrophyllite, corundum)	None or very minor	Very shallow (glaciated)	Syenomonzonite-alkali gabbro stock	Over a mile square	Not certain but quite possible	Flotation recovery, requires fine grinding	Deposit may be contact or replacement associated with an Eocene stock in a volcanic vent, or syngenetic (Jurassic) remobilized
Deep-seated structures, favorable porosity and permeability	Yes	Relatively low	Miocene or Pliocene	Silica, calcite, clay, manganese oxides	Locally in structures	At least 400'	Andesite porphyry	Modest-sized elongate stock	Probable	Refractory	Post-mineral brecciation caused by gravity gliding

DIAGRAMMATIC INTERPRETATION OF THE HISTORY OF THE WATERLOO DEPOSIT

J. H. C.
JAN 5 1977

SELECTED BULK-TONNAGE, LOW-GRADE SILVER DEPOSITS IN WESTERN NORTH AMERICA

		ORE MINERALOGY			GRADE												SPATIALLY ASSOCIATED INTRUSION				
DEPOSIT	HOST ROCK	SILVER-BEARING MINERALS	OTHER MINERALS	ORE MINERAL MODE OF OCCURRENCE	HYPOGENE + SUPERGENE	SUPERGENE	ORE TONNAGE	SHAPE OF DEPOSIT	SIZE OF DEPOSIT (FEET)	STRUCTURAL CONTROLS	OPEN PIT	STRIPPING RATIO	AGE OF DEPOSIT	DOMINANT ALTERATION MINERALS	SUPERGENE ENRICHMENT	DEPTH EXTENT OF PARTIAL OXIDATION	ROCK TYPE	SIZE	GENETIC ASSOCIATION	METALLURGICAL CHARACTERISTICS OF ORE	ADDITIONAL COMMENTS
CANDELARIA, NEVADA	Triassic-Jurassic Candelaria Fm., tuffaceous shales	Secondary silver in limonite and jarosite, some remnant sulfides	Native gold, jamesonite, pyrite, minor chalcopyrite and galena	Disseminated, and in veins parallel to bedding	± 3 oz. Ag	Predominant	10 - 20 million	Tabular	2000 x 500 with fault repeats	Primary not known, secondary by fault offsets	Yes	Approx. 3:1	Jurassic or Tertiary	Clay, dolomite (magnesium metasomatism) manganese oxides	No (dispersion)	600' on dip, 450' vertically	Quartz monzonite, felsite dikes	70' - 180' wide, 400' long	Not known	Refractory — under investigation	May be syngenetic (Jurassic) or replacement (Tertiary)
DELAMAR, IDAHO	Miocene rhyolite quartz porphyry (ash flow tuff)	Principally naumannite (silver selenide), also argentite	Minor pyrite, free gold	Finely disseminated in quartz	Est. 2 - 6 oz. Ag, ±0.03 oz. Au	—	Est. >8 million	Various shapes from equidimensional blob to long-and-narrow	Range from 100 ft. min.widths to 4000 ft. max. lengths	Possibly deep-seated control, combined with more brittle quartz porphyries	3 pit areas	2:1 to 6:1	Miocene	Silica	Possible but minor		Various acid to intermediate volc. rocks, vents	Various	Probable	Nicely amenable to cyanidation. Not refractory (low Fe, Mn)	Deposit is in a volcanic center.
HARDSHELL, ARIZONA	Mesozoic volcanic and volcaniclastic rocks	Native silver? Argentian cryptomelane, cerargyrite, pearceite, argentojarosite	Pyrite, traces galena	Disseminated in associated Mn oxides and silica	Est. 4 - 5 oz. Ag	—	Est. >5 million	Manto-like	1600 x 600	Deep-seated structures, favorable porosity and permeability	Possible open pit, possible underground	If open pit, depends on cutoff grade	Laramide?	Silica, clay, Mn oxides (5-25% Mn)	Minor	At least 500'	Andesite and quartz latite	Irregular dikes and sills	None	Refractory	Underlying Paleozoic carbonate rocks provide the solution channels.
HOG HEAVEN, MONTANA	Two mid-Tertiary horizons, latite tuff breccia and volc. conglomerate	Galena, enargite, matildite	Pyrite, sphalerite, barite	Disseminated	Not established	—	Not established	Strongly warped, lensoid	Not established	Syn- & post-mineral folding	Possibly and partially	Not known	Mid-Tertiary	Silica with macroscale clay envelopes	In upper breccia horizon	To 500'	None known	—	—	Not known	Being explored
LANGTRY, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver?	Barite, pyrite	Finely disseminated	Est. ± 2 oz. Ag	—	± 15 million	Flat-lying	± 700 x 2000 x ± 100 thick	Deep-seated structures, favorable porosity and permeability	Yes	3:1	Miocene or Pliocene	Silica, iron oxides, clay, manganese oxides	None noted	Entire deposit	Pre-ore granitic body	Several square miles	None with granitic body	Refractory	Author considers this deposit an extension of the Waterloo (see below).
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WATERLOO, CALIFORNIA	Miocene Barstow Fm., lakebed sediments, reworked volcanic ash	Native silver? Argentiferous pyrite? Also cerargyrite, embolite, argentojarosite	Barite, pyrite	Finely disseminated	Est. 2 - 3 oz. Ag	—	Est. >25 million	Elongate wedge	1000 x 6000	Deep-seated structures, favorable porosity and permeability	Yes	Relatively low	Miocene or Pliocene	Silica, calcite, clay, manganese oxides	Locally in structures	At least 400'	Andesite porphyry	Modest-sized elongate stock	Probable	Refractory	Post-mineral brecciation caused by gravity gliding

"ESTIMATES" ARE THOSE OF THE AUTHOR.

Silver has been and is currently recovered from <u>discarded</u> film.

Presumably the new film-making process increases recovery percentage?

Jeff

Analysts View Collapse

San Francisco Chronicle 59
★ Mon., Apr. 28, 1980