PROSPECTING REPORT

on the

TROUT CREEK MINERAL CLAIMS

Similkameen Mining Division
British Columbia

Latitude 49°46'N
Longitude 120°08'W
UTM 0706253E, 5517451N

by

DAVID JAVORSKY
PROSPECTOR AND CLAIM OWNER
818 - 470 Granville Street
Vancouver, B.C.
V6C 1V5

May I, 2007

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INTRODUCTION AND SUMMARY

As follow up to a previous IP Survey, a line of self-potential (SP) readings were taken to try and explain an anomaly from the 2002 IP Survey by Dave Mark.

The self-potential survey showed a very sharp crossover at Trout Creek. Trout Creek follows a Fault Zone. The anomaly was probably caused by graphite in the Fault Zone.

The Fault Zone could also be part of the structure of broken ground that is required for mineralizing solutions to travel into the area. Some epithermal deposits are formed within fault controlled three-sided fracture zone where one side is brecciated. Brecciation does exist along the survey line.

The showing should be further prospected.

Golden Trout Mineral Claim Location Map

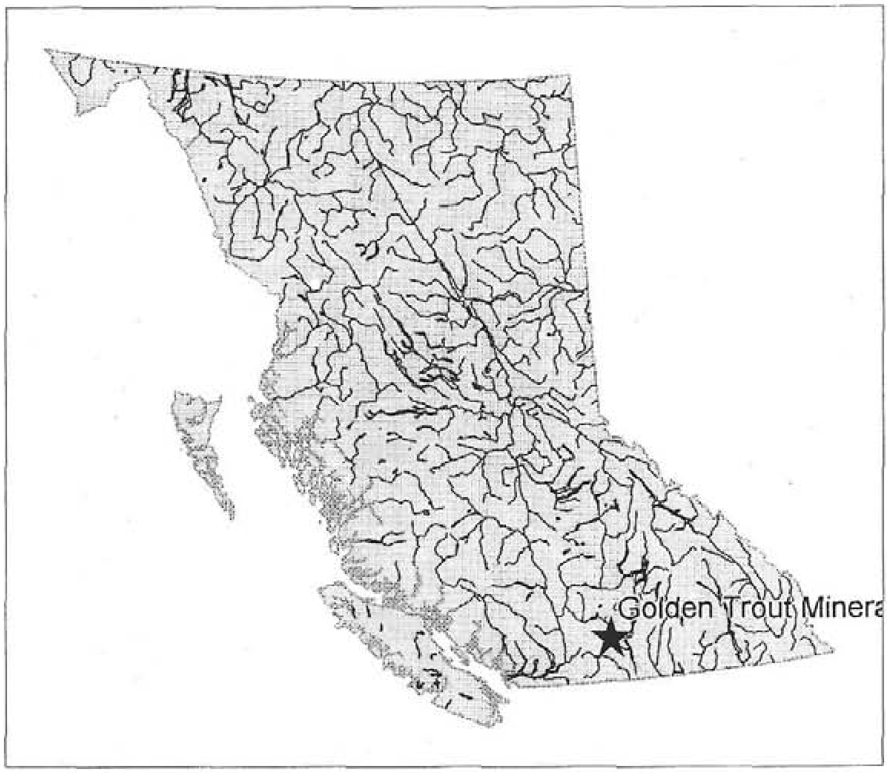
★ **Golden Trout Mineral Claim Location**

Topographic Layers

- **Lakes 1:6M**
- **Rivers 1:6M**

BC Border Layers

- **BC Border 1:6M**



SCALE 1 : 15,204,863

200 0 200 400 600

KILOMETERS

N

Golden Trout Mineral Claim Map

Mineral Titles Layers

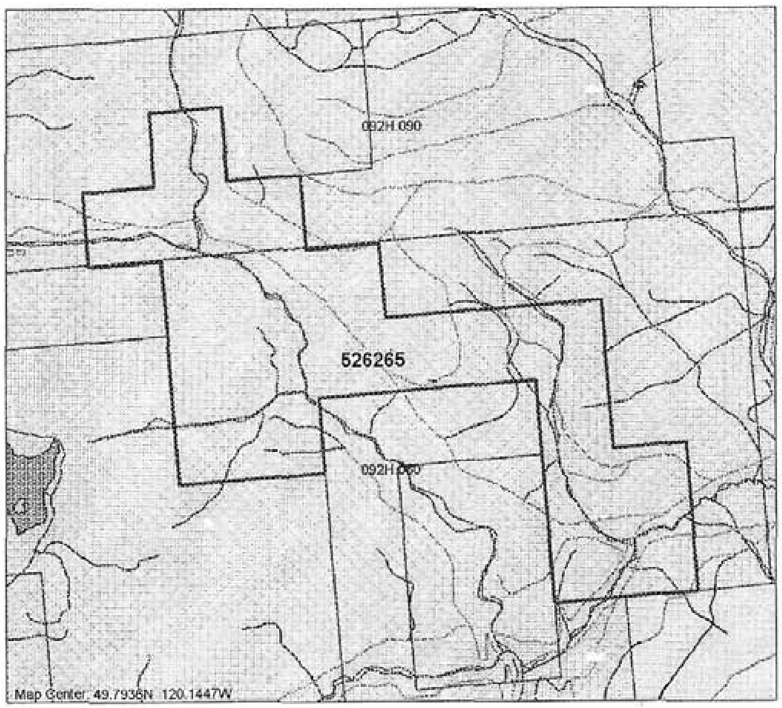
- Golden Trout Mineral Claim Tenure
- All Mineral Tenures

Topographic Layers

- Railways 1:20K
- Roads 1:20K
  - Gravel Road
  - Paved Road
  - Rough Road
- Lakes 1:20K
- Rivers 1:50K
- Rivers 1:20K

Grid Layers

- Grid 1:20K - labels
- Grid 1:20K - outline



SCALE 1 : 46,629

LOCATION AND ACCESS

A good access to the centre of the claim block is provided by the Trout Creek forestry access road. There is active logging in the area. As well, the ranchers have grazing pasture for their range cattle.

The NTS map is 092H-16E and the 1:20,000 trim map is M092H080.

The claims are almost equidistance between the towns of Princeton, Summerland and Paechland. On the claims are a series of old logging roads, placer mining roads, and early pioneer trails. The area is in the interior plateau between the Monashee Mountains to the east and the Coast Mountains to the west.

HISTORY

Trout Creek has a long history of mineral exploration. early gold prospectors were followed by numerous periods of base mineral exploration. The Similkameen Copper Mine was discovered to the southwest; the Brenda Moly-Copper Mine was discovered to the north, and the Elk Gold Mine was discovered to the northwest. Finally, in the early 1980's while doing placer mining, prospector Don Agur uncovered a zone of very altered clay that was identified by Geologist F. Marshall Smith to be epithermally altered and the host of the crystalline gold Don Agur was recovering in his placer operation.

Boomer Resources explored the ground in 1985 and 1986.

In 1986, Golden Pick Resources acquired the ground and, by the end of 1987, had spent approximately $50,000 in exploration. Placer Development acquired the ground and during 1988 and 1989 spent about $500,000.

The ground was restaked by Prospector David Javorsky who has kept various companies working on it over the years. In-Sync Industries explored the ground in 1999 and up to 2004. In-Sync Industries spent $39,000 on the ground during 2002. Their "Geological, Geophysical and Physical Assessment Report on the Spring Property" by Alex Burton and Dave Marx, dated January 2003, is very complete.

In the last few years "on line" computerized staking has seen vast tracks of ground staked instantaneously online, with very little work getting done on the ground.

The finding of epithermal gold-bearing zones in similarly altered rocks to the northwest caused considerable staking around the Spring Creek Claims, Tenure No. 526890. The Golden Trout Claim Tenure No. 526265 was staked January 25, 2006. The claim follows the share bend in North Trout Creek where cross-faulting has influenced the direction of the creek flow. The Cell Acquisition Event Detail follows.

MapPlace.ca

Mineral Titles Online Report

Click on Tenure Numbers for more information.

Click column headings to sort results.

Download to Excel

Tenure Number	Type	Claim Name	Good Until	Area (ha)
526265	Mineral	GOLDEN TROUT	20080125	417.105

Total Area: 417.105 ha

LIBC Metadata

Mineral Title Online
BC Geological Survey
British Columbia Ministry of Energy, Mines and Petroleum Resources
Last updated in April 2007

WORK PROGRAM

On a previous IP Survey conducted in September 2002 by Dave Mark Geophysicist for In-Sync Industries Inc., a high SP anomaly was found along Trout Creek.

Dave Mark is one of the few geophysicists who record the SP channel on their IP Survey.

The SP anomaly went over -444 millivolts. This was very unusual and required follow up.

Two prospectors were mobilized from Vancouver and set up camp where the logging road crosses North Trout Creek.

An SP Survey was conducted using two porous pots filled with saturated copper sulphide solution, a reel of wire, and a digital display high impedance millivoltmeter.

One pot called the tail pot, was established and fixed at one location. The second pot, called the leading pot, was moved at five metre intervals along the survey line. In the Appendices is "A Guide to Prospecting by the Self-Potential Method" by S.V. Burr. 1982 Ontario Geological Survey Miscellaneous Paper 99.

While the survey did not work in the water, it did give indication-readings on the rocks that were sticking out of the water.

A line of SP readings were taken along old line 81+00N. A very low reading was taken right at the east edge of the North Trout Creek followed by a very high reading on the far west side of North Trout Creek.

This very sharp and quick crossover is probably a fault with graphite in it. Usually a sulphide showing will not read greater than 300 millivolts. This crossover read a -481 millivolts and that is a very unusual reading. While the very high +519 millivolts, very sharp positive response is usually associated with graphite. While there could be sulphides in this Fault Zone, they are completely masked by the response to the graphite.

The fault appears to strike N20°E and dip to the east.

There is breccia material along the survey line to the east of the Trout Creek Fault. The breccia material probably represents the ground fracturing above the fault.

The fracturing in the ground along the fault allows mineral bearing solutions to have a pathway to follow through the solid rock. There are some minor specks of base metals in this Breccia Zone.

It must be remembered that gold does not, by itself, have a self-potential response. The main response measured by the self-potential method is decomposing sulphides and graphite.

In effect, the main thing we have measured with the SP Survey is the faulting that could host an epithermal-type deposit. Since crystalline gold has been mined downstream from this unusual Fault Zone and the hillside above this fault zone shows clay alteration and some cooked up rock. All of the indicators are here to indicate an epithermal altered style of gold deposit.

According to Larry Buchanan's model for epithermal gold deposits entitled "Precious Metal Deposits Associated with Volcanic Environments in the Southwest", publihed in 1981 in the Arizona Geological Society Digest Volume XIV, included in the Appendices. When a fault opens up, it creates a breccia zone. This is the heel of the fault where the ground is spreading and breaking up. The faults provide a conduit for hot solutions bearing mineralization to pass through.

In the Arizona Desert, these breccia zones are called Burnt Rock because of their dark colour and burnt texture. The dark stain is due to iron and manganese oxidation. While the breccia zones are not usually hosting the Bonanza Quartz gold zone, the breccia zones do form one of the physical sides to the Bonanza Zone.

On Trout Creek, the river has washed out and filled in the area north of the breccia zone with gravel. This would not be unusual if the area was originally a cooked up clay alteration zone that eroded easily. Also there is alteration on the solid rock to the east side of the gravel and within parts of the Breccia Zone to the south of the Gravel Zone.

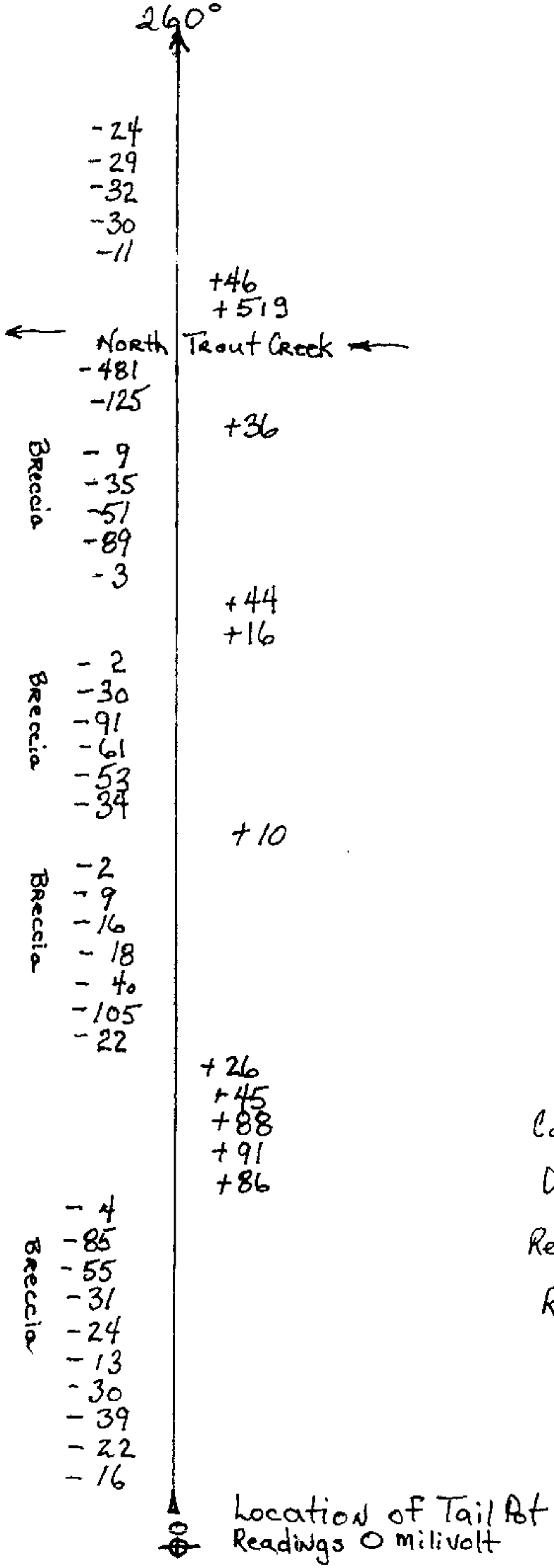
The single line of SP readings were erratic over the Breccia Zone perhaps due to the broken up nature of the rock. The negative readings were probably due to the small amount of mineralization separated by the brecciated pieces of fresh rock.

Further SP work should be done when the ground is not so wet.

The IP Survey showed an "Apparent Resistivity" zone at depth probably coming to surface under Trout Creek in the Fault Zone.

Panning for gold downstream from the Breccia Zone produced numerous "colours" however prospecting failed to locate their source.

Self Potential Survey Map
across North Trout Creek
over GeoTronics IP Line 81+00N
David Javorsky S.P. Operator.
November 2006



Compass and Hip Chain.
Direction of Survey 260°
Readings taken at 5 meter intervals.
Readings are in millivolts D.C.

STATEMENT OF EXPENSES

Camp and Food		$	321.56
Rental of 4x4 PU Truck and Fuel			490.72
Use of SP Equipment			100.00
Dave Javorsky, Prospector - Labour	3 days @ $250/day		750.00
Tom Ash, Prospector - labour	3 days @ $250/day		750.00
Report Preparation - Time, wages, printing			1,000.00
Workers Compensation Insurance			22.50
	Total	$	3,434.78

STATEMENT OF DAVID JAVORSKY

I, David Javorsky, Prospector, state as follows:

That I have completed the work outlined in the forgoing Prospecting Report on the Trout Creek Mineral Claim.

That I graduated from the B.C. and Yukon Chamber of Mines Prospecting School.

That I graduated from B.C. Geological Survey, Advanced Prospecting School.

That I graduated from the B.C. Ministry of Energy, Mines and Petroleum Resources, Petrology for Prospectors course.

That I have actively worked as a Prospector for most of the last 30 years.

That I reside at Stewart, B.C. I receive mail at 818 - 470 Granville Street, Vancouver, B.C. V6C 1V5.

Respectfully submitted,

David Javorsky

David Javorsky
Prospector

May 1, 2007
Vancouver, B.C.

Appendix A

MINFILE 092HNE 108, 284, 285 AND 291

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IINFILE Record Summary

IINFILE No 092HNE108

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Inventory Report

SUMMARY

Summary Help

ame	TC, SPRING, FORK, PO	**Mining Division**	Similkameen
		BCGS Map	092H080
tatus	Prospect	**NTS Map**	092H16E
atitude	49º 46' 40" N	**UTM**	10 (NAD 83)
ongitude	120º 08' 14" W	**Northing**	5517856
		Easting	706097
ommodities	Zinc, Lead, Copper, Silver	**Deposit Types**	L01 : Subvolcanic Cu-Ag-Au (As-Sb) K01 : Cu skarn
ectonic Belt	Intermontane	**Terrane**	Plutonic Rocks

apsule eology

The TC showing comprises a series of mineralized and altered outcrops lying in the vicinity of the confluence of North Trout Creek and Trout Creek, about 3.0 kilometres southeast of Whitehead Lake.

The area south and east of Whitehead Lake is underlain by a granitic stock of the early Tertiary Otter intrusions. The stock trends west-northwest for 3.5 kilometres and is up to 2.5 kilometres wide. It is situated between the Middle Jurassic Osprey Lake batholith to the south, west and north, and the Early Jurassic Pennask batholith to the east.

A zone of strong clay alteration and minor silicification, quartz veining and brecciation is developed in quartz feldspar porphyritic monzonite, along the east bank of North Trout Creek, 240 metres northwest of the creek's confluence with Trout Creek. Drilling indicates the zone dips steeply south and is about 60 metres wide. Surface exposures contain abundant limonite and pyrolusite. Numerous narrow shears, with rusty clay, are developed throughout the zone. The nature of the alteration suggests this occurrence may be of epithermal origin (Assessment Report 14989).

Mineralization consists of disseminated and stringer pyrite, sphalerite, galena and tetrahedrite. One drillhole intersection analysed less than 0.07 gram per tonne gold, 2 grams per tonne silver, 1.49 per cent zinc, 0.07 per cent lead and less than 0.01 per cent copper over 3.0 metres (Assessment Report 14989, hole B85-1, 30.5 to 33.5 metres). A chip sample yielded 0.00073 per cent antimony, 0.0382 per cent zinc and 0.18 per cent lead over 1.5 metres (Assessment Report 19420, page 33, trench TR001E).

Two additional zones of mineralization occur along North Trout Creek, 250 metres north of the main showing. A sheared and clay- altered contact between quartz feldspar porphyry and porphyritic rhyodacite is exposed over a length of 7 metres. Limonite and pyrolusite occur throughout the zone. A chip sample analysed 10 grams per tonne silver and 0.0710 per cent lead over 1.5 metres (Assessment Report 19420, page 22, zone N2). A moderately sericite- altered breccia zone lies 40 metres west-northwest. The breccia is comprised of quartz feldspar porphyry and porphyritic rhyodacite fragments, and is mineralized with up to 5 per cent disseminated pyrite, with associated limonite and pyrolusite. A chip sample yielded 0.101 per cent zinc over 1.5 metres (Assessment Report 19420, page 24, zone P4).

Three blocks of altered and skarnified granodiorite, engulfed in quartz feldspar porphyry, occur up to 750 metres south of the main showing on the west side of Trout and North Trout creeks. The granodiorite blocks are variably mineralized with disseminations and blebs of specular hematite, chalcopyrite, pyrite, sphalerite and galena. Chalcopyrite also occurs in quartz veins in one of the blocks.

This occurrence was first explored by Pan Ocean Oil Ltd. in 1971 and 1972 with the completion of soil, silt, geological and magnetometer surveys. Additional soil sampling was conducted by Brenda Mines Ltd. in 1981. Boomer Resources Inc. drilled three holes totalling 137 metres on the main showing in 1986, after its discovery in 1985. Placer Dome Inc. carried out an extensive program of geological, soil geochemical and geophysical surveying in 1988 and 1989.

ibliography

EMPR ASS RPT 3463, *4335, 9308, 10108, *14989, 17560, 18401, *19420
EMPR EXPL 1979-160; 1980-215; 1981-205; 1988-C108
EMPR GEM 1971-289; 1972-141,142
GSC MAP 888A; 1386A; 41-1989
GSC MEM 243
GSC P 85-1A, pp. 349-358; 91-2, pp. 87-107
Placer Dome File

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IINFILE Record Summary

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by

IINFILE No 092HNE291

SUMMARY

Summary Help

lame	NORTH TROUT CREEK PLACER, SPRING 3	**Mining Division**	Similkameen
		BCGS Map	092H080
tatus	Past Producer	**NTS Map**	092H16E
atitude	49º 47' 06" N	**UTM**	10 (NAD 83)
ongitude	120º 08' 26" W	**Northing**	5518650
		Easting	705826
ommodities	Gold	**Deposit Types**	C01 : Surficial placers
ectonic Belt	Intermontane	**Terrane**	Plutonic Rocks, Overlap Assemblage

apsule ieology

North Trout Creek is a southeastward-flowing tributary of Trout Creek. It initially flows south-southeast for 4.8 kilometres before turning east and continuing for an additional 4.5 kilometres to the mouth of Pintin Creek, north of Whitehead Lake. The creek then flows south-southeast for 3.5 kilometres before entering Trout Creek, 44 kilometres northeast of Princeton.

The uppermost 9 kilometres of the creek runs through a broad, shallow valley. The valley steepens and narrows somewhat in the last 3 to 4 kilometres as the creek descends into Trout Creek.

Placer gold has been recovered from several locations along North Trout Creek, 100 to 1300 metres above the creek's confluence with Trout Creek. Three of the occurrences coincide with structural lineaments (Assessment Report 14989). Gold particles recovered from the stream's gravels have an angular shape, indicating a source nearby (Assessment Report 17560).

The placer deposits of this creek were mined by Don Agur up to the 1980s.

ibliography

EMPR ASS RPT *14989, *17560, 18401
GSC MAP 888A; 1386A; 41-1989
GSC MEM 243
Placer Dome File

IINFILE Record Summary

IINFILE No 092HNE285

Inventory Report

by
by

3UMMARY

ame	BOOMER, SPRING, TC	**Mining Division**	Similkameen
		BCGS Map	092H080
tatus	Showing	**NTS Map**	092H16E
atitude	49º 47' 10" N	**UTM**	10 (NAD 83)
ongitude	120º 07' 49" W	**Northing**	5518802
		Easting	706561
ommodities	Zinc, Lead, Silver	**Deposit Types**	I05 : Polymetallic veins Ag-Pb-Zn+/-Au
ectonic Belt	Intermontane	**Terrane**	Plutonic Rocks

apsule eology

The Boomer showing outcrops along a southeast-flowing tributary of Trout Creek, 600 metres northwest of the tributary's confluence with Trout Creek and 3.2 kilometres east of Whitehead Lake.

The area south and east of Whitehead Lake is underlain by a granitic stock of the early Tertiary Otter intrusions. The stock trends west-northwest for 3.5 kilometres and is up to 2.5 kilometres wide. It is situated between the Middle Jurassic Osprey Lake batholith to the south, west and north, and the Early Jurassic Pennask batholith to the east.

Minor amounts of pyrite, sphalerite and galena occur in quartz veins and along fractures in very altered granodiorite, surrounded by quartz feldspar porphyritic monzonite of the Otter intrusions. Trenching on both banks of the creek intersected quartz feldspar porphyritic monzonite exhibiting moderate to strong silica and sericite alteration, moderate clay alteration and minor to moderate chloritization. The monzonite is occasionally cut by narrow shear zones and is mineralized with up to 8 per cent pyrite, as disseminations and fracture fillings. A sample taken across a clay- altered shear zone, west of the creek, analysed 8.2 grams per tonne silver over 1.5 metres (Assessment Report 19420, page 26). A sample of quartz feldspar porphyry, taken east of the creek, analysed 0.125 per cent zinc over 12 metres (Assessment Report 19420, page 27).

The showing was initially explored by Pan Ocean Oil Ltd. in 1972. Placer Dome Inc. excavated an number of trenches in 1989 after completing geological, geophysical and soil geochemical surveys in 1988 and 1989.

ibliography

EMPR ASS RPT 4335, 18401, *19420
EMPR GEM 1972-141,142
GSC MAP 888A; 1386A; 41-1989

GSC MEM 243
GSC P 85-1A, pp. 349-358; 91-2, pp. 87-107
Placer Dome File

IINFILE Record Summary

IINFILE No 092HNE284

Inventory Report

by
by

SUMMARY

ame	SPRING, ZONE C, TC, FORK, SPRING 3, PO	**Mining Division**	Similkameen
		BCGS Map	092H080
tatus	Showing	**NTS Map**	092H16E
atitude	49° 47' 14" N	**UTM**	10 (NAD 83)
ongitude	120° 08' 36" W	**Northing**	5518889
		Easting	705617
ommodities	Lead, Zinc, Copper, Silver	**Deposit Types**	H05 : Epithermal Au-Ag: low sulphidation I05 : Polymetallic veins Ag-Pb-Zn+/-Au
ectonic Belt	Intermontane	**Terrane**	Plutonic Rocks

apsule eology

The Spring showing occurs on the east bank of North Trout Creek, 1.4 kilometres northwest of the creek's confluence with Trout Creek and 2.3 kilometres east of Whitehead Lake.

The area south and east of Whitehead Lake is underlain by a granitic stock of the early Tertiary Otter intrusions. The stock trends west-northwest for 3.5 kilometres and is up to 2.5 kilometres wide. It is situated between the Middle Jurassic Osprey Lake batholith to the south, west and north, and the Early Jurassic Pennask batholith to the east.

A dike of altered andesite is in contact with an altered tectonic breccia containing fragments of quartz feldspar porphyritic monzonite and quartz diorite. The showing is exposed in outcrop over a length of 50 metres. The dike is partially silicified, chloritized and carbonatized and contains minor disseminated pyrite and galena. The tectonic breccia is sericite altered and mineralized with minor disseminated pyrite and chalcopyrite. The contact between the two units is sheared and intensely clay altered. It strikes 180 degrees and dips 30 to 45 degrees east. The shearing, silica flooding and vuggy texture of the showing suggests a possible epithermal origin for this mineralization (Assessment Report 19420).

Anomalous metal values occur in or near the contact. One chip sample analysed 0.088 gram per tonne gold, 7.6 grams per tonne silver, 0.287 per cent lead and 0.161 per cent zinc over 7.7 metres (Assessment Report 19420, page 21).

The showing was sampled by Placer Dome Inc. in 1989 during a program of geological, soil geochemical and geophysical surveying conducted in 1988 and 1989. Similar surveys were completed by Pan Ocean Oil Ltd. in 1971 and 1972.

ibliography

EMPR ASS RPT 3643, 4335, 10108, 18401, *19420
EMPR EXPL 1979-160; 1980-215; 1981-205
EMPR GEM 1971-289; 1972-141,142
GSC MAP 888A; 1386A; 41-1989
GSC MEM 243
GSC P 85-1A, pp. 349-358; 91-2, pp. 87-107
Placer Dome File

Appendix B

PREVIOUS METAL DEPOSITS, DR. LARRY BUCHANAN

PRECIOUS METAL DEPOSITS ASSOCIATED WITH VOLCANIC ENVIRONMENTS IN THE SOUTHWEST

Larry J. Buchanan
Fischer-Watt Mining Co., Inc., 550 E. Plumb, Suite 203, Reno, Nevada 89502

ABSTRACT

A comparative study of over 60 precious metal vein deposits hosted by volcanics indicates that ubiquitous physico-chemical features relate to the genesis of, and exploration for, these deposits. Host rocks are largely Tertiary calc-alkaline extrusions with hypabyssal intrusions. Andesites are the more common host to ore shoots, however most districts have preore felsic tuffs, volcanogenic sediments, dikes, sills, and plugs. The deposits fill fractures often related to a caldera environment. The veins are vertically zoned from agate and clay near the paleosurface, passing with depth into barren calcite; then quartz and calcite; then quartz, calcite, adularia and precious metals; then in deeper levels to quartz, adularia and base metals. The interface between the upper precious metals and the lower base metals is a level of episodic boiling of the fluids. At this level, CO_2 and H_2S are released to the vapor phase, pH rises in the remaining fluid, temperature drops slightly, and $f(O_2)$ increases. These results of boiling cause first the base metals, then the silver sulfide, and later the gold to deposit in a well-recognized temporal and vertical sequence. Episodic sealing of the fracture system, followed by episodic refracturing causes episodic boiling and mineral deposition at depths greater than hydrostatic conditions would allow, and yields the intra-mineralization brecciation and banded vein fillings so often observed in epithermal deposits. A low pH alteration assemblage, genetically related to the precious metal deposition, is nearly always present. This assemblage extends from the base of the precious metal ore horizon to the paleosurface, thus it serves as an excellent guide to non-outcropping ore shoots.

INTRODUCTION

This paper will present data on epithermal deposits hosted by volcanics and will discuss the metal deposition mechanisms. A model will be presented of a "typical" deposit, describing vertical and horizontal patterns of wall rock alteration, mineralization, levels of ore deposition, and chemical and physical ore controls.

The study will limit itself to only those gold-silver vein deposits in an unmetamorphosed volcanic to subvolcanic environment. These deposits have been called "epithermal", "bonanza ores", "precious metal deposits of volcanic association", and by other names. These names are all slightly misleading in that most of the deposits were formed from solutions hotter than the 200°C limit set by Lindgren (1933) as the upper temperature of "epithermal", certainly only a few districts were "bonanzas", and it is not at all clear just what the association is between the veins and the host volcanics (especially as many ore shoots are in sedimentary rocks below a volcanic cover). As the word "epithermal" is so widely used and is now generally understood to refer more to a genetic-class rather than a temperature-class of deposits, the word "epithermal" will be retained in this report. With the limitation of discussing only deposits in a volcanic environment, some major precious metal districts (Coeuer D'Alene, Carlin, Leadville, Concepcion Del Oro, etc.) will not be discussed, although some of the ideas to be presented may apply equally to these.

DATA BASE FOR THE MODEL

Table 1 gives physical and chemical characteristics of 60 epithermal districts. The compilation reveals several important common characteristics, features too often present to be relegated to mere coincidence:

A. The host is typically an Early to Late Tertiary calc-alkaline volcanic pile commonly containing andesite agglomerates, dikes, breccias and flows; rhyolite tuffs, dikes and small plugs; latite and rare dacite flows and breccias; lake bed and fluvial volcanogenic sandstones and shales. Although andesites are the more common host to ore (Silberman, 1976), most districts have some felsic units. Felsic intrusions are usually late in the volcanic event but are preore. Many field geologists feel a genetic tie exists between the mineralization and the felsic intrusions, with the intrusions acting as a heat source to drive cells of convecting water. Much more study is required to confirm this. Basalts are not known to host significant amounts of ore in any of the districts in Table 1.

B. Sediments or weakly metamorphosed sediments with typically Late Cretaceous to Early Tertiary intrusions often underlie the volcanics. These underlying rocks less commonly host ore shoots, but when ore does occur, it often contains more of a base metal assemblage than the precious metal deposits in overlying volcanics. Limestone replacement deposits adjacent to the deeper veins are not uncommon.

C. Only a few deposits are older than Tertiary: Rochester is believed to be Cretaceous and the Golden Plateau deposits are thought to be Paleozoic. On the other hand, many are younger than Tertiary. There is little geological reason why deposits cannot have formed throughout the Phanerozoic, however the older deposits are commonly either eroded away or metamorphosed to the point they no longer exhibit epithermal characteristics.

D. The deposits fill pre-existing fractures, not necessarily tension fractures, and where studied in detail, most deposits can be placed in a caldron or resurgent caldron setting. The fractures are more complex nearer the paleosurface with numerous bends, cymoids, horsetails, and bifurcations, therefore, stockwork deposits are more likely to exist nearer the paleosurface and should pass to more structurally constricted veins with depth. Numerous intra-mineralization periods of brecciation are reported in most districts.

E. Ore shoots rarely fill the entire vein structure, rather they are isolated zones within the vein enclosed along strike and dip by subore to barren gangue. Normally, the ore-waste contact is formed by a rapid drop in grade, or by a thinning of the pay streak, or both. In almost all districts, very thin and very high grade veinlets may extend outward (into a wall or within the main vein along strike) from the stoped areas, but these veinlets often become subore grade when the necessary mining widths are considered. However, the ore shoots do relate to definite structural features within the veins, such as at dilatant zones in bends concave to the hanging wall (Seven Troughs, Oatman, Comstock), at areas of vein intersection (Hayden Hill, Comstock), and in areas of dip decrease resulting in crushing of the hanging wall (Las Torres at Guanajuato). As these structural features are localized, the ore shoots contained therein are localized within an otherwise subore structure.

F. The precious metal ore zones have a restricted vertical interval of up to 1000 meters, but the typical uneroded deposit averages close to 350 meters. Because of this restricted interval, most districts have a definite elevation which marks the bottoms of the precious metal ore shoots, as well as a definite elevation which marks the tops of ore shoots. These elevations may be evident only if the effects of post-ore faulting are subtracted out of the district geology (Tayoltita, Oatman). At Oatman, Pachuca and Tonopah, the precious metal interval is domed like an inverted saucer. No satisfactory explanation for this doming has yet been offered. If orebodies bottom at a particular elevation and top out at another higher elevation, we must look at the mineralogy of all three levels (above, within, and below precious metal ore shoots) in order to understand the orebody genesis.

G. Above this ore interval, precious metal values drop rapidly. Although the quartz vein filling extends well above the top of the ore zone, the quartz filling of the vein gradually diminishes in width (Guanajuato, Pachuca, Oatman, Gooseberry, Silver Peak), and the crystalline nature of the quartz changes to an agate or chalcedony far above the ore shoot. As quartz and agate diminish in volume toward the vein tops, calcite becomes relatively more common. Higher still in the vein system, calcite begins to diminish often to the point where an empty, paper-thin fracture is all that marks a productive and wide vein at depth (Bulldog Mountain, Guanajuato, Pachuca, Fresnillo, Oatman, San Francisco Del Oro, Kimberly).

H. Going the other way, that is, downward from the base of the precious metal ore shoots, vein fillings often differ from that of the productive horizon by two possible but different manners. These two types of changes appear to be mutually exclusive, thus are discussed separately:

a. The least common way a precious metal ore shoot may terminate with depth is illustrated by Oatman and by the upper ores at Guanajuato. In these districts, the precious metal content rapidly diminishes at the bottom of the ore shoot to anomalous but very subore grade. The quartz vein filling, as well as the strength (width, form, persistence) of the structure, continues downward. There is no appreciable change in vein mineralogy at the base except for a probable diminishing of gangue adularia, a possible increase in pyrite, as well as the near absence of calcite and precious metal minerals.

b. More commonly, the precious metal content gradually diminishes at the base of the precious metal ore interval until a level is reached where ore grade is not maintained. Concomittant with the decrease in precious metal values is an increase in galena, pyrite, sphalerite, and less commonly, chalcopyrite and/or pyrrhotite. Quartz persists downward without appreciable changes, but calcite is greatly reduced in volume, and sericite and adularia are slightly to greatly diminished.

I. Within the precious metal ore horizon, vein mineralogy is a rather simple assemblage of argentite, adularia, quartz, pyrite, electrum, calcite, and ruby silvers. Tetrahedrite, stephanite, polybasite, base metal sulfides, naumannite, fluorite, barite, sericite, chlorite may occur in most deposits in small to large amounts. Even less commonly found are stibnite, realgar, rhodochrosite, rhodonite, bornite, boulangerite and a host of other minerals. The veins show both a repetitively banded filling texture characteristic of open space fillings, as well as textures indicative of replacement of the walls and breccia fragments. Typically, where high precious metal values exist within a vein, the quartz gangue is very fine-grained and contains significant amounts of adularia (Guanajuato, Jarbidge, Oatman, Finlandia, Triunfo, Mogollon), and/or sericite intimately mixed with the precious metals.

J. Gold:silver ratios tend to be larger higher in the vein system, in those districts where ore shoots are not eroded. Oxidation and secondary enrichment of both gold and silver tend to obscure this primary precious metal vertical zonation in the many districts subjected to erosion of ore shoots.

K. The temperature of formation related to the precious metal ore interval is from around 200°C (the lower temperature postulated for Goldfield) to over 300°C, but averages around 240°C. Salinities are generally lower than 3 equivalent weight percent NaCl. Rapid or numerous temperature fluctuations are not noted in deposits studied in detail. The base metals appear to have been deposited at somewhat higher temperatures in all deposits studied in detail, from slightly more saline solutions, and are typically paragenetically earlier than the precious metals.

L. The repetitively banded vein fillings in the ore horizon deserves more description. Banded or crustified textures are so common in precious metal deposits hosted by volcanics that it has been considered a diagnostic feature of epithermal veins. The banded vein filling is little more than a series of layers, each one deposited atop the previous, of gangue and ore minerals. Often, but less often than generally assumed, the bands on each side of the centerline of the vein form mirror images of each other. This feature has led to the probably correct conclusion that each pair of bands deposited at the same time from the same solutions. However, little study has been directed toward answering two fundamental questions:

a. What trigger causes the deposition of certain minerals in one pair of bands but not in the next?

b. Why are many veins characterized by repetitively banded fillings; that is, having numerous bands of the same mineral assemblage separated by numerous bands of a different mineral assemblage? For example, a 4" slab of the Gold Road Vein from Oatman, Arizona, has 41 bands of quartz and chlorite separated by 40 bands of quartz and adularia. What physico-chemical parameter was repeated over and over again to give such repeated bands?

Answers given in the past to explain this feature appear unsatisfactory:

a. An explanation given is that wallrock and solution reactions cause changes in the solution chemistry, causing the bands to form. This is unlikely in that the wall rocks are already reacted with and the solutions are already buffered by the rocks. How could wall rock-solution reactions episodically buffer, then later episodically not buffer, the solutions?

b. A second answer given is that simple cooling of the solution forms the bands. Cooling could lead to bands of specific minerals, but cooling does not explain the repetition of bands of the same mineral. Assuming a mineral precipitates in a particular temperature interval, what causes that temperature interval to be entered and left again repeatedly throughout the vein-forming time span? Also, fluid inclusion studies of ores from Oatman, Pachuca, Tayoltita, Guanajuato, Creede, and others, indicate that rapid or numerous temperature reversals do not exist.

c. A final answer given is that changes in solution chemistry lead to the banding. What is meant by this is that influxes of volatile or dissolved species cause the bands. It is very difficult to imagine a hydrothermal system that can have repeated influxes of volatiles or dissolved species, with each influx so similar to the previous ones, as to cause the same mineral assemblage to deposit scores or hundreds of times within a narrow vein.

M. Evidence of boiling of the ore-forming solutions is common in those districts studied in detail. At Creede, Pachuca, and Tayoltita, vaporization evidence was found at the tops of the base metal ore shoots; at Guanajuato and Tonopah, the vaporization level was at the base of the precious metal ore horizon; and in others such as Lake City and Finlandia, the boiling occurred in discreet zones of high precious metal content within an otherwise base metal assemblage. These seemingly contradictory data may be seen to fit into a pattern if it is remembered that Creede, Pachuca, and Tayoltita are high in base metals, thus the boiling occurred near the top of the base metal horizon. This is the same position as the base of the precious metal horizon, thus boiling occurred at Creede, Pachuca, and Tayoltita at the same level as it did at Guanajuato and Tonopah. Deposits like Lake City and Finlandia are telescoped, but boiling is noted only in those zones of precious metal mineralization, not in the base metal zones.

N. Widespread propylitic alteration (an assemblage of chlorite, pyrite, carbonate, montmorillonite, and illite) is ubiquitous in the districts. Epidote is present in this assemblage at greater depths. The propylitic alteration commonly forms halos hundreds of meters wide around the veins, and usually is wider in the hanging wall than in the footwall. This alteration is often believed to be pre-ore. Silicified vein walls, and less commonly, adularized or albitized walls, often form a thick selvage around the veins at the ore horizon. This selvage may be tens of meters wide, but commonly is on the order of one meter or less. In many districts silicified or feldspathized vein walls have abundant enough precious metal values to constitute ore. The width of the selvage diminishes upward above the ore zones and often disappears completely a few score meters above the ore. Silicification has a much greater vertical extent than do adularization and albitization, often extending above the ore horizon for hundreds of meters, and very commonly extending well below the bottom of the precious metal horizon. Adularized wall rocks occasionally change with depth into adularized and albitized wall rocks. Neither the widespread propylitic alteration nor the more restricted silicification/adularization/albitization serve as very useful ore guides. The former is much too widespread to allow a target to be selected and the latter are usually so narrow as to be found at about the same time as the ore is found. What is needed for the explorationist is an alteration assemblage that is small enough to pinpoint individual targets, is genetically related to the process of ore formation, and extends well above the ore level so that non-outcropping ore shoots can be targeted. Fortunately, such an alteration assemblage exists, as what will be referred to as the low pH assemblage. This assemblage may contain any or all of the following minerals: Alunite, sericite, illite, kaolinite, montmorillonite, or any of the kaolin clay minerals. This alteration, commonly referred to as "bleaching" in the literature, forms a halo around and a cap above individual ore shoots. It is virtually absent below the precious metal horizon (Or, as at Guanajuato, it is absent below the lowest precious metal horizon) and forms a narrow but ever upward-widening halo in the hanging wall around the ore shoot, and expands or "blossoms" above the top of the ore shoot. In those districts studied in detail, the low pH alteration appears to be genetically related to the deposition of the precious metals, but unlike the ore itself, the low pH alteration zone extended to the paleosurface (See Figure 1). At the hot spring orifice on the paleosurface, siliceous sinter and opal are mixed with or forms a cap over alunite and kaolinite (Schoen and others, 1974). These layers often up to scores of meters thick, are believed to be caused by downward percolating sulfuric acid solutions formed by water mixed with oxidized H_2S. Beneath these layers are alteration assemblages of illite, adularia, and celadonite as wide halos around the fractures, formed primarily by the loss of CO_2 (near surface degassing) resulting in a rise in the K^+/H^+ ratio. This assemblage passes with depth and toward the fractures into more well-ordered white micas, often to a sericite structure. Often at the fracture wall, montmorillonite or kaolinite form an inner alteration halo, widest on the hanging wall of the fracture.

THE MODEL

All of these common characteristics must somehow relate to the process of ore formation. The discussion to follow will offer a model which will unify all of these seemingly disconnected characteristics into a simple genetic model. Figure 1 should be consulted while reading this section.

It has long been suggested that epithermal de-

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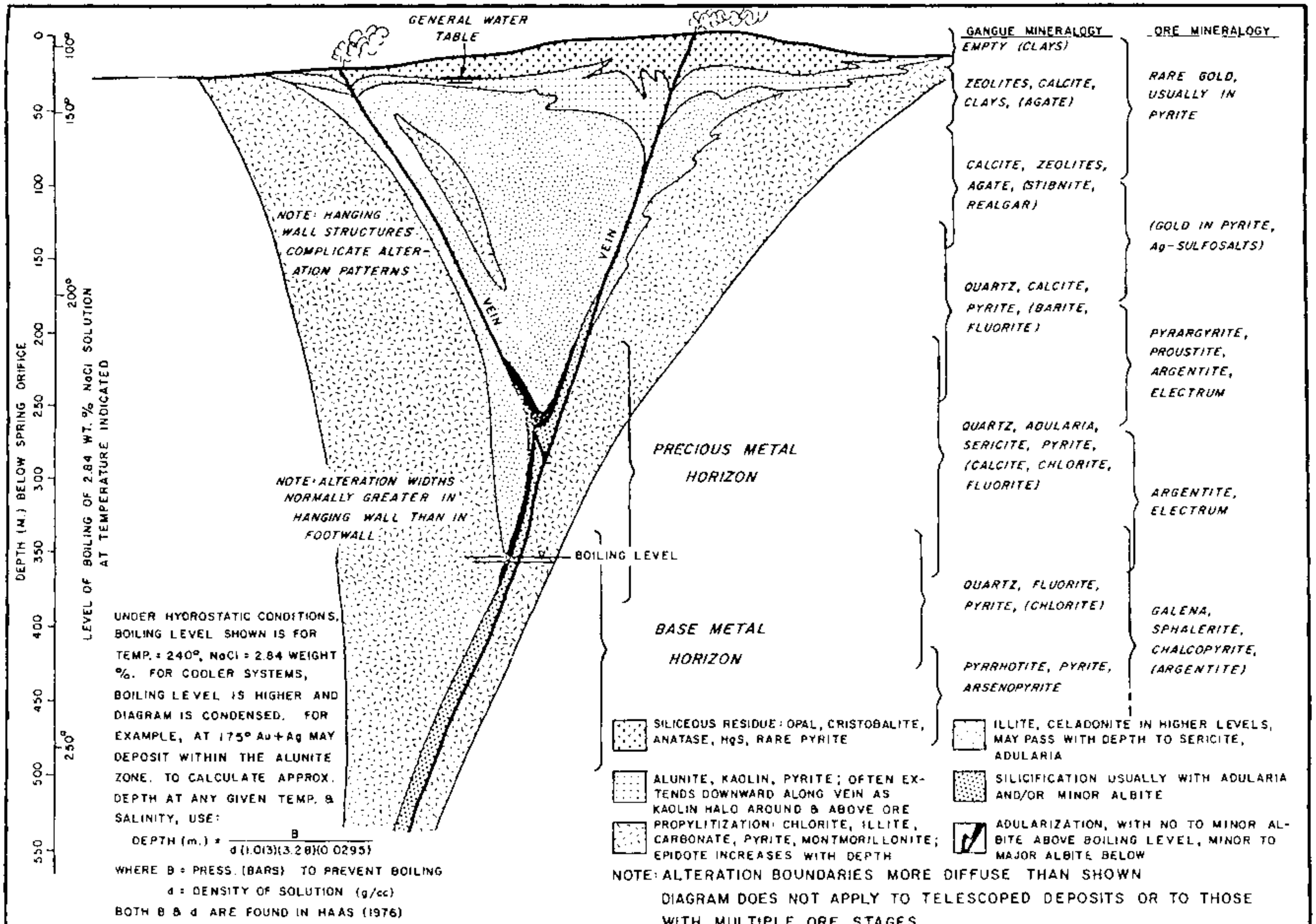

DEPTH (M.) BELOW SPRING ORIFICE
0
50
100
150
200
250
300
350
400
450
500
550
LEVEL OF BOILING OF 2.84 WT. % NaCl SOLUTION AT TEMPERATURE INDICATED
100°
150°
200°
250°
GENERAL WATER TABLE
VEIN
VEIN
NOTE: HANGING WALL STRUCTURES COMPLICATE ALTERATION PATTERNS
NOTE: ALTERATION WIDTHS NORMALLY GREATER IN HANGING WALL THAN IN FOOTWALL
BOILING LEVEL
PRECIOUS METAL HORIZON
BASE METAL HORIZON
GANGUE MINERALOGY
EMPTY (CLAYS)
ZEOLITES, CALCITE, CLAYS, (AGATE)
CALCITE, ZEOLITES, AGATE, (STIBNITE, REALGAR)
QUARTZ, CALCITE, PYRITE, (BARITE, FLUORITE)
QUARTZ, ADULARIA, SERICITE, PYRITE, (CALCITE, CHLORITE, FLUORITE)
QUARTZ, FLUORITE, PYRITE, (CHLORITE)
PYRRHOTITE, PYRITE, ARSENOPYRITE
ORE MINERALOGY
RARE GOLD, USUALLY IN PYRITE
(GOLD IN PYRITE, Ag-SULFOSALTS)
PYRARGYRITE, PROUSTITE, ARGENTITE, ELECTRUM
ARGENTITE, ELECTRUM
GALENA, SPHALERITE, CHALCOPYRITE, (ARGENTITE)
UNDER HYDROSTATIC CONDITIONS, BOILING LEVEL SHOWN IS FOR TEMP. = 240°, NaCl = 2.84 WEIGHT %. FOR COOLER SYSTEMS, BOILING LEVEL IS HIGHER AND DIAGRAM IS CONDENSED. FOR EXAMPLE, AT 175° Au+Ag MAY DEPOSIT WITHIN THE ALUNITE ZONE. TO CALCULATE APPROX. DEPTH AT ANY GIVEN TEMP. & SALINITY, USE:
DEPTH (m.) = B / d (1.013)(3.28)(0.0295)
WHERE B = PRESS. (BARS) TO PREVENT BOILING
d = DENSITY OF SOLUTION (g/cc)
BOTH B & d ARE FOUND IN HAAS (1976)
DEPTH ASSUMES 100% HYDROSTATIC CONDITIONS
SILICEOUS RESIDUE: OPAL, CRISTOBALITE, ANATASE, HgS, RARE PYRITE
ALUNITE, KAOLIN, PYRITE; OFTEN EXTENDS DOWNWARD ALONG VEIN AS KAOLIN HALO AROUND & ABOVE ORE
PROPYLITIZATION: CHLORITE, ILLITE, CARBONATE, PYRITE, MONTMORILLONITE; EPIDOTE INCREASES WITH DEPTH
ILLITE, CELADONITE IN HIGHER LEVELS, MAY PASS WITH DEPTH TO SERICITE, ADULARIA
SILICIFICATION USUALLY WITH ADULARIA AND/OR MINOR ALBITE
ADULARIZATION, WITH NO TO MINOR ALBITE ABOVE BOILING LEVEL, MINOR TO MAJOR ALBITE BELOW
NOTE: ALTERATION BOUNDARIES MORE DIFFUSE THAN SHOWN
DIAGRAM DOES NOT APPLY TO TELESCOPED DEPOSITS OR TO THOSE WITH MULTIPLE ORE STAGES

FIGURE 1

posits form in convecting water cells (White and others, 1971), where water of largely meteoric origin circulates deeply into a volcanic/sedimentary pile, becomes heated, and dissolves metals, alkalies, chlorides, and sulfur species. Eventually, the now heated but low salinity solution rises through a fracture system and deposits ore and gangue minerals as vein fillings.

Broadlands, New Zealand, is part of such a convection cell. Water at 280°C to 160°C (from depths of 1400 m. to 400 m., respectively), rises up a series of fractures, and gangue, precious metal, and base metal minerals are deposited at various elevations within the fractures. Data presented by Ewers and Keays (1977) indicates that the location of metal deposition is in part a function of the level of boiling of the rising fluids. Most base metals deposit at and below the boiling level, whereas precious metals deposit largely at and above that level. Thus, at the level of boiling, a mixed zone of precious and base metal mineralization occurs. The precious metal content decreases at and below the boiling level, and conversely, the base metal content decreases at and above that level.

It appears that boiling at a particular elevation in a vein system must mark that division between the now well-recognized upper precious metal ore horizon and the deeper base metal ore horizon. This elevation is the same as that district wide bottom of ore shoots mentioned previously, and as well, the boiling level marks the flat bottoms of individual precious metal ore shoots within a particular vein. Obviously, the level of boiling cannot remain constant in space or time: 1) Local irregularities in the paleotopography lead to local elevation differences of the boiling fluid; 2) No geothermal system has uniform isotherms (Ellis and Mahon, 1977) in a horizontal plane, thus warmer solutions in some areas will boil at greater depths than cooler solutions in other areas; 3) Similarly, no geothermal system has uniform isobars (Ellis and Mahon, 1977) in a horizontal plane, thus completely preventing boiling in some areas of the system; 4) Deep self-sealing of the fracture system and its later refracturing can allow boiling at depths much greater than allowed under hydrostatic conditions; and 5) Less commonly, episodic fluctuations in temperature and/or volatile content of the solutions can cause fluctuations in the boiling level. These factors, among others, can cause long vertical intervals of mixed base and precious metal mineralization.

Boiling affects profound change in the physical and chemical state of the fluids:

A. Significant amounts of CO_2 and usually lessor amounts of H_2S are partitioned into the vapor phase, according to the simple reactions:

$$HCO_3^- + H^+ \text{ --- } CO_{2(vap.)} + H_2O$$
$$HS^- + H^+ \text{ --- } H_2S_{(vap.)}$$

This release of volatiles results in a pH rise in the remaining solutions. Data of Drummond and Ohmoto (1979) indicate that a 1 mole NaCl solution at 250°C containing 0.10 mole $CO_{2(aq.)}$ (similar to a typical epithermal fluid), will experience a one unit pH rise by the loss to the vapor phase of approximately 3% of the solution mass. By contrast, simple calculations indicate that at Guanajuato, approximately 24% mass loss to the vapor phase occured.

B. The salinity of the remaining solutions will rise, a result of simple concentration of salts by the loss of H_2O steam.

C. Oxygen fugacity in the remaining liquid increases as the ratios of CO_2:CH_4 and SO_2:H_2S increase. CH_4 and H_2S have a greater rate of partitioning into the vapor phase than do CO_2 and SO_2, respectively (Drummond and Ohmoto, 1979).

D. The solution will cool, but much less so than is commonly believed. It is true that the heat of vaporization requires energy to convert water liquid to water steam, but the large thermal reservoir contained by the wall rocks will prevent any major temperature drop in the solutions. As the life of a geothermal system is measured in 10^4 to 10^6 years, the already heated rocks will act to buffer the solution temperature.

E. Major loss of CO_2 and lessor loss of H_2S results in a rise in the activity of $S^=$ and HS^-, thus leading to formation of strong thio complexes with Au, As, Sb, and Hg (Weissberg, 1969). These complexes are stable to near the paleosurface, where the higher oxygen fugacity results in precipitation of the metals.

All of these consequences of boiling combine to promote mineral deposition. Drummond and Ohmoto's study (1979), cited earlier, indicates that most base metals in solution will precipitate after about 5% of the mass of the solution is lost to the vapor phase, but that about 20% of the solution must vaporize before the bulk of the silver will precipitate. As any packet of water will continue to rise as it is boiling, with the water bouyed up by bubbles, the silver will naturally tend to precipitate higher in the vein system than do the base metals. Gold, carried as a thio complex, will not precipitate until nearer the paleosurface in areas of high oxygen fugacity, where the thio complex is destroyed by oxidation to sulfate.

This single phenomena - boiling - explains the vertical zoning of precious metals passing into base metals with depth; as well as explains the early paragenetic position of the base metals so often observed in these deposits. Furthermore, as the pH of the solution rises to the alkaline side, the field of adularia stability is quickly entered, resulting in the association of high precious metal values and high adularia content in the vein. An exception may be those near surface, cool, systems like Goldfield, where the gold is deposited in an acid environment, where clays and/or alunite substitute for the adularia.

But, how can boiling explain the repetitive banding? At Guanajuato, Tayoltita, and Tonopah, studies of fluid inclusion morphology and distribution across individual veins or across individual gangue minerals suggest that the boiling was episodic. There were periods of intense boiling followed by periods of non-boiling or by periods of greatly reduced boiling. Buchanan (1980) has recently documented six major boiling episodes in a single 2.1 cm. wide veinlet at Guanajuato, with each boiling episode accompanied by acanthite and adularia deposition. These boiling episodes were not the result of temperature or chemical fluctuations, and Buchanan (1980) called upon episodic pressure release as the causative mechanism. Episodic drops in the total confining pressure will allow the solutions to boil episodically. This results in the episodic pH rises and precipitation of ore and gangue minerals. As minerals deposit, the thin, near surface veinlets become filled by calcite, zeolites, clays, alunite, and other minerals, effectively forming a sealed cap to the fracture system. Once sealed, the pressure increases (White and others, 1975), boiling at depth stops, and the pH of the solution drops to normal. Tectonism, or more likely hydrofracturing, can break the sealing cap to allow a second episode of boiling and mineralization, and later seal the system again. In this manner, a repetitively banded vein may result with no necessity to call upon a change in solution chemistry or temperature. Such near-surface self-sealing is well documented in modern geothermal systems (Facca and Tonani, 1967; Keith and others, 1978; Anderson and others, 1978).

The low pH alteration assemblage may also be explained using the boiling mechanism. Upon boiling, CO_2 and H_2S were selectively partitioned into the vapor phase. As these vapors, along with steam, rise to cooler regions nearer the paleosurface, the vapors condense and heat the rocks slightly, or mix with cooler groundwaters, to form a solution of low pH. This solution then attacks rock-forming silicates to form the white micas and/or clay minerals. If the solution is of sufficiently low pH, alunite may form.

IMPLICATIONS OF THE MODEL

Figure 1 illustrates the vertical and horizontal mineral zoning in a typical epithermal district, based upon the data of Table 1 and of the previous discussion. A major implication of the model presented is that epithermal vein deposits do not form under simple hydrostatic conditions. If sealed caps episodically develop a pressure on the system in excess of hydrostatic, then when the cap is fractured and the excess pressure is released, the solutions will boil at a depth greater than allowed under strictly hydrostatic conditions. This deep boiling is only momentary, and the boiling level will gradually rise until hydrostatic conditions prevail. Evidence that epithermal deposits do form at greater than hydrostatic depths is gathered from the data of Table 1, where numerous districts (Oatman, Pachuca, Guanajuato, Goldfield, and Bodie) have a greater vertical ore interval than should be allowed under hydrostatic conditions. As an example, the temperature of the solutions at Bodie would allow a low-salinity solution to begin boiling at a depth of about 330 meters, but the known ore interval is 400 meters. At the present time, there is no certain way to precisely calculate the depth in excess of hydrostatic.

Large concentrations of volatiles in the solutions will also allow boiling at depths greatly in excess of hydrostatic conditions, but few systems appear to contain appreciable volatiles (Rochester and Oatman may be notable exceptions).

APPLICATION OF THE MODEL

If the model as presented is largely correct, then exploration for deposits unexposed by erosion will be greatly facilitated by mapping of alteration assemblages along otherwise unfilled and barren, or filled and barren structures. Also, the depth to a suspected ore shoot below the present surface may be estimated by noting type and degree of vein filling, by noting alteration grades and intensities, and by fluid inclusion temperature determinations.

As examples of the application of this model to exploration, Figures 2 through 5 are presented illustrating wall rock alteration patterns at Oatman, Arizona, and Guanajuato, Mexico. Also presented in each figure are longitudinal sections of the major veins with outcrops of the low pH alteration assemblage plotted on the profile, and known ore shoots at depth plotted in section. At Oatman, the low pH assemblage is illite and montmorillonite; at Guanajuato, it is kaolinite and halloysite adjacent to the fractures, passing outward into sericite, illite, and montmorillonite. Note that in both districts only a small percentage of ore shoots cropped out. Also note that the size of the low pH alteration assemblage is crudely proportional to that of the underlying ore shoot.

The data presented in Table 1 suggests that similar maps should be made for many districts in North America, and that many ore discoveries will likely result.

This author does not wish to imply that boiling is the only explanation for many of the features of epithermal deposits, but boiling does offer a genetic mechanism whereby most observable features may be connected. However, as an "orebody" by its very definition is an anomaly, it should not be unexpected that some deposits will vary drastically from this model of a typical system, nor should it be surprising that all deposits will vary in some degree from the model.

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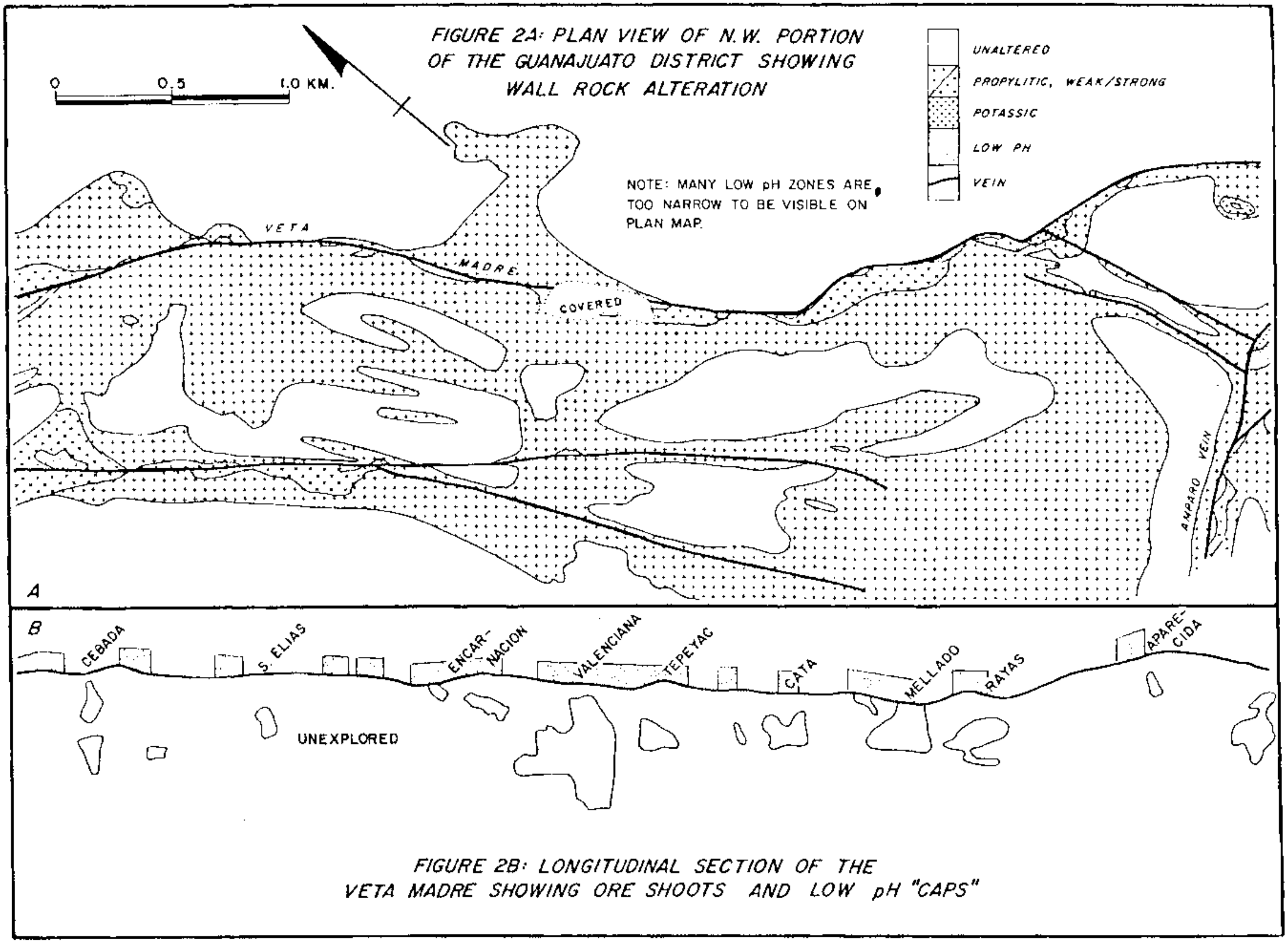

FIGURE 2A: PLAN VIEW OF N.W. PORTION OF THE GUANAJUATO DISTRICT SHOWING WALL ROCK ALTERATION

FIGURE 2B: LONGITUDINAL SECTION OF THE VETA MADRE SHOWING ORE SHOOTS AND LOW pH "CAPS"

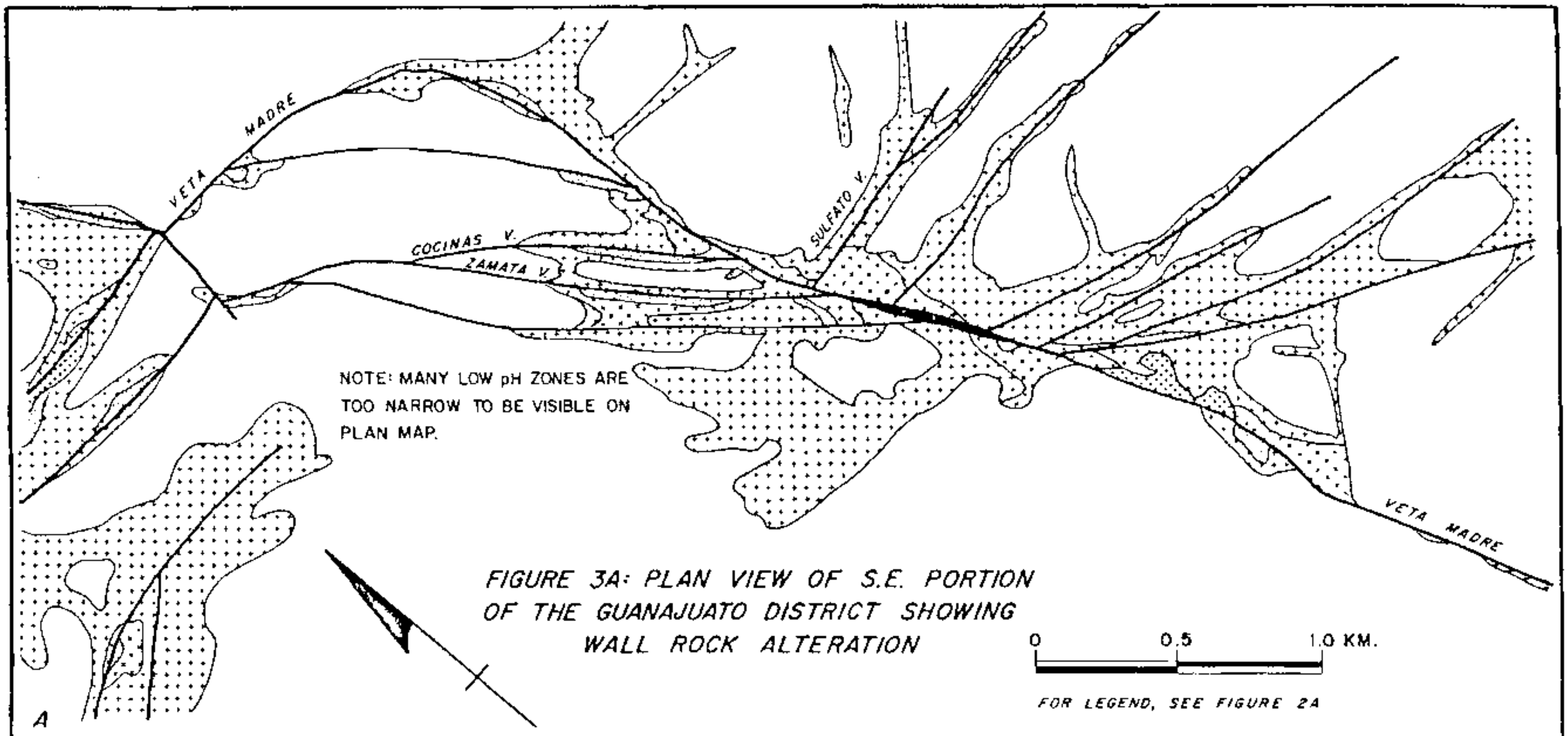

FIGURE 3A: PLAN VIEW OF S.E. PORTION OF THE GUANAJUATO DISTRICT SHOWING WALL ROCK ALTERATION

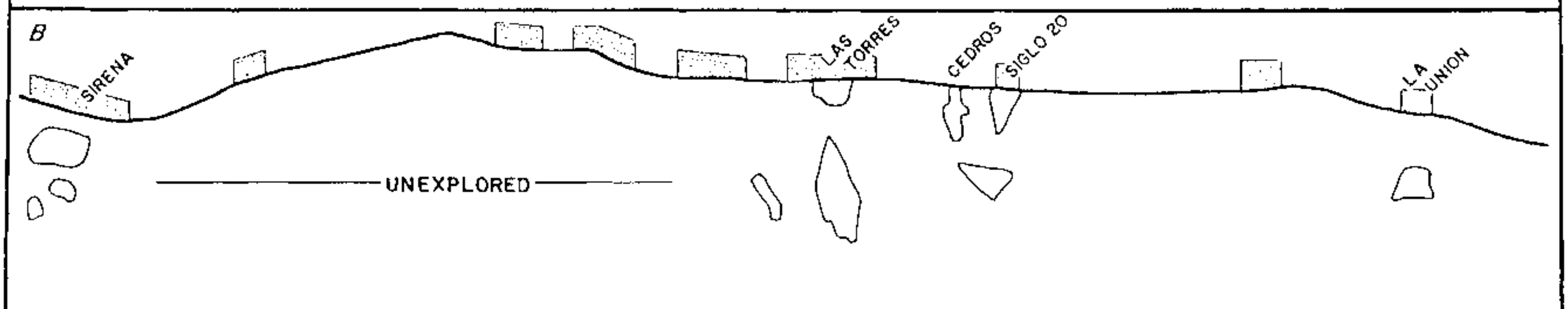

FIGURE 3B: LONGITUDINAL SECTION OF THE VETA MADRE SHOWING ORE SHOOTS AND LOW pH "CAPS"

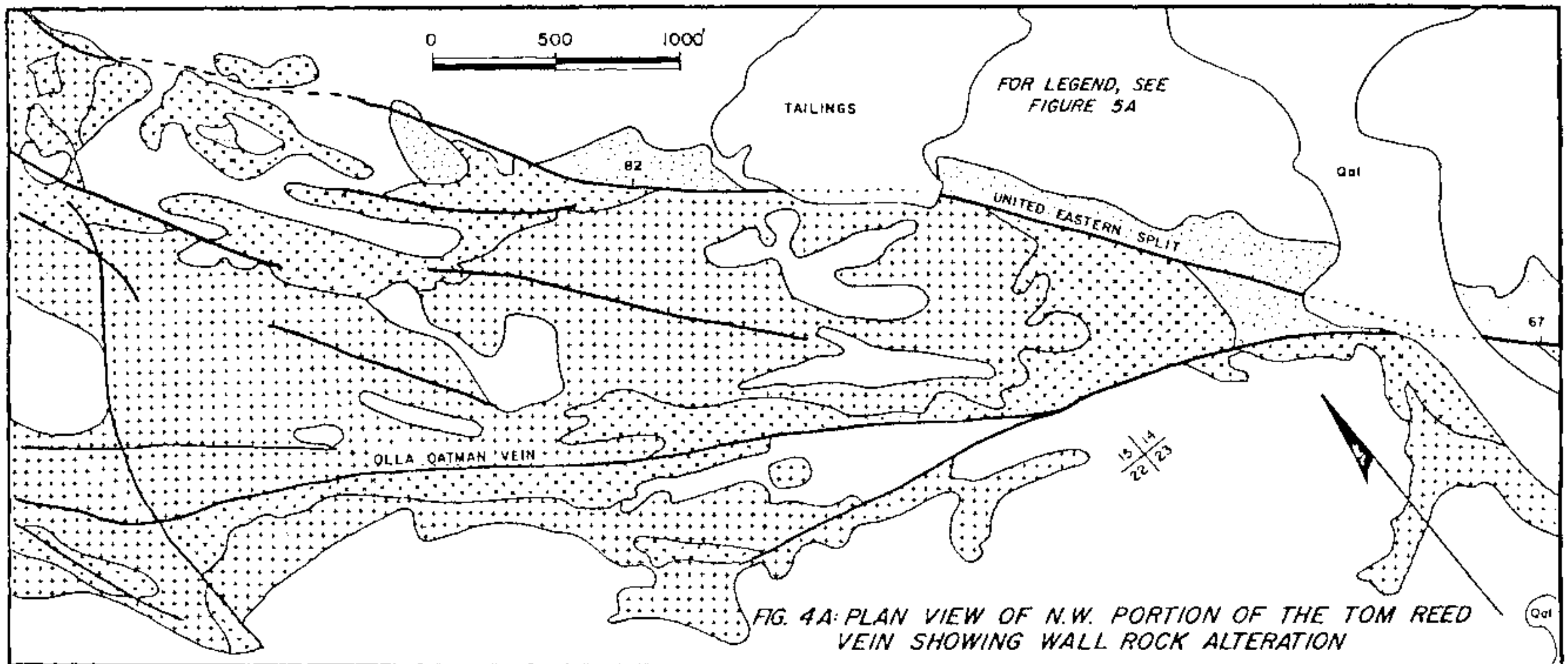

FIG. 4A: PLAN VIEW OF N.W. PORTION OF THE TOM REED VEIN SHOWING WALL ROCK ALTERATION

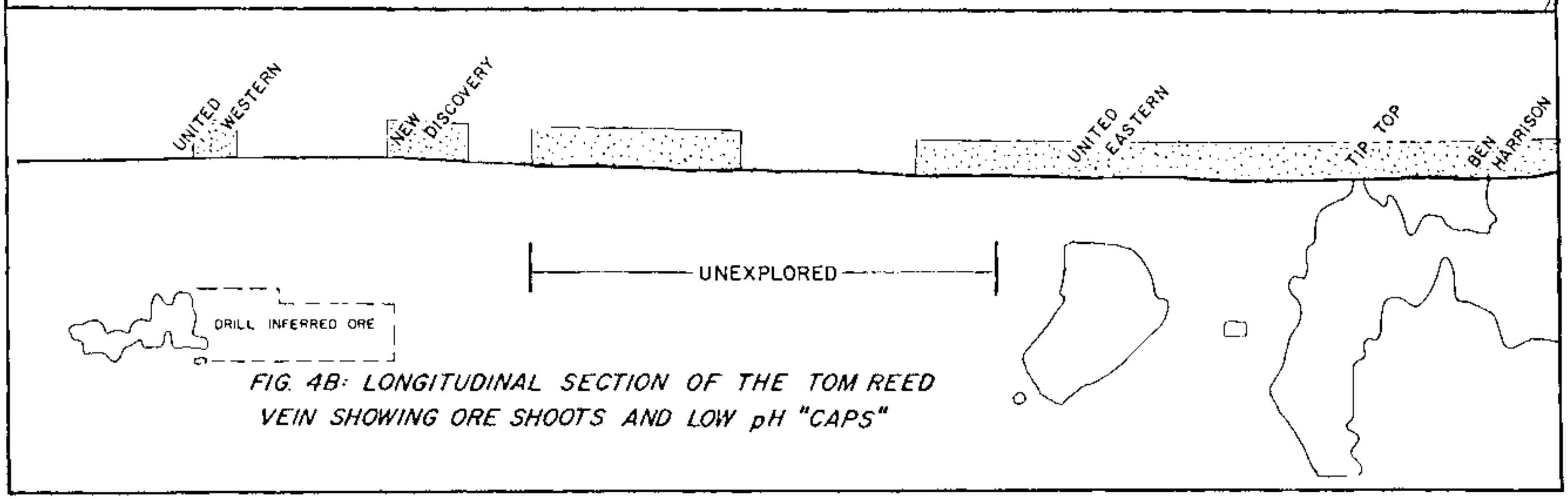

FIG. 4B: LONGITUDINAL SECTION OF THE TOM REED VEIN SHOWING ORE SHOOTS AND LOW pH "CAPS"

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE x10^6	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
OATMAN, MOHAVE CO., ARIZONA	2.2	0.8	0.58	0.17	2.8:1	0	3.8	MIOCENE LATITE, RHY. DIKES & TUFF	MIOCENE	Qt, Ad, Se, El, Ca, rare Py, Ch Fl	X	NO	NO	X illite	X	X	1:2 to 10:1
PACHUCA, HIDALGO, MEXICO	6.2	1500.0	0.06	15.0	1:200	3.5	100.0	MIO.-PLIO. ANDESITE, DACITE, RHYOLITE DIKES	PLIO.?	Ad, Qt, Rb, Rc, Rs, Ca, Se, Ch, El, Ba, Sn, Gn, Sp, Cp, Ar	X	X	X	X	NO	X	2:1 to 4:1
COMSTOCK, STOREY CO., NEVADA	8.3	200.0	0.43	9.9	1:23 to 1:40	UNDER 1	19.3	MIOCENE ANDESITE	13.7 to 12.6 m. y.	Ad, Qt, Ca, Ar, Rb, Au, Py, Cp, Gn, Sp, Rc, Rs, Sn, Pl	X	NO	X	X	X	X	1:2 to 2:1
GUANAJUATO, GUANAJUATO, MEXICO	3.55	815.0	0.05	11.0	1:200	UPPER=0 DEEP=10	APPROX. 70.0	OLIGOCENE ANDES., RHY., LATITE; EOCENE RED BEDS; CRET. SHALES	28.4 m. y.	Ad, Qt, Ca, Py, El, Ag, Ch, Se, Ar, Ai, Ne, Rb, Gn, Cp, Sp	X	X	X	X illite	NO	X	1:1
TONOPAH, NYE CO., NEVADA	1.86	174.0	0.23	20.7	1:80 to 1:110	UNDER 2	8.80	MIOCENE ANDES. FLOWS, RHYOLITE TUFFS	19.1 m. y.	Ad, Qt, Ca, Se, Ar, Rb, Py, Cp, Gn, Sn, Na, As, Ba, Rc, Rs, Pl	X	X	X	X	NO	X	1:1 to 1:3

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
OATMAN, MOHAVE CO., ARIZONA	X illite	X	X	YES, CO_2 RELEASE?		220	NONE	X	310	N40-45W 70-80 N	AVE. 2 MAX. 20	SOME MINERALIZED STRUCTURES DIP SOUTH RARE ALUNITE IN ILLITIC CAPS ORE HORIZON DOMED WITH HIGHER Ag:Au RATIO ON FRINGES OF DISTRICT	SCHRADER (1909) RANSOME (1923) CLIFTON & OTHERS (1980) PERSONAL STUDY (1980)
PACHUCA, HIDALGO, MEXICO	X phyllic	X	X SOME	YES AT VEIN TOPS		200 to 250	BASE METALS INCREASE WITH DEPTH	X	400	N45-90W 40S-90 N00-20E 70W-90 N50E 60S-60N	AVE. 1.1 MAX. 45	VEINS PINCH UPWARD TO CALCITE & QUARTZ STRINGERS AND ARE 50° COOLER THAN THAN IN ORE HORIZON, BASE METALS EARLY IN PARAGENESIS	DREIER (1976) THORNBURG (1951) FRIEDRICH & HAWKES (1966) GEYNE & OTHERS (1963)
COMSTOCK, STOREY CO., NEVADA	X clays	X	X			250 to 300	NONE	X	610	NNE 45E	AVE. 2.5 to 4.2	Th FROM ONE SAMPLE DEEP IN VEIN SYSTEM VEINS ASSOCIATED WITH CALDERA COMPLEX, ZEOLITIZATION OF WALLROCKS REPORTED	WHITEBREAD (1976) BASTIN (1923) ALBERS & KLEINHAMPL (1970) BONHAM (1969) PERSONAL STUDY (1980)
GUANAJUATO, GUANAJUATO, MEXICO	X phyllic	X	SOME	YES	UNDER 1	230	BASE METALS INCREASE WITH DEPTH	X	650	N-S to N45W 45-70W to 45-70E	100	BASE METALS ARE BELOW THE LEVEL OF BOILING WITH PRECIOUS METALS ABOVE, BASE METALS ARE PARAGENETICALLY EARLY	BUCHANAN (1980) CROSS (1975) ANTUNEZ (1964) PERSONAL STUDY (1977-80)
TONOPAH, NYE CO., NEVADA	X phyllic	X	X	YES	UNDER 1	240 and 265	BASE METALS INCREASE WITH DEPTH	X	185	N70E, 70-90N	12	ORE HORIZON DOMED WITH HIGHER Ag:Au RATIO ON FRINGES; Th = 240 FOR PRECIOUS METAL STAGE AND 265 FOR BASE METALS	SPURR (1905) TAYLOR (1973) NOLAN (1935) FAHLEY (ver. comm., 1981) BURGESS (1909) COUCH & CARPENTER (1943)

TABLE 1: COMPARISON OF EPITHERMAL DISTRICTS
SEE LAST PAGE OF TABLE FOR ABBREVIATIONS AND NOTES

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	ALTERATION ASSEMBLAGES POTASSIC	ALTERATION ASSEMBLAGES ARGILLIC	ALTERATION ASSEMBLAGES PHYLLIC	ALTERATION ASSEMBLAGES ALUNITIC	ALTERATION ASSEMBLAGES SILICIC	ORE SHOOT RATIO Hor:Vert
GOLDFIELD, ESMERALDA CO., NEVADA	4.2	1.65	0.79	0.3	3:1	UNDER 1	OVER 5.3	MIOCENE DACITE AND ANDESITE	21.0 m. y.	Qt, Se, Ka, Rb, Au, Py, Fe, Te, Ba, Go, Al, Tl	X	NO	X	X	X	X	
SILVER PEAK, ESMERALDA CO., NEVADA	0.19	36.96	0.03	8.03	1:243	1-4	4.6	MIO.-PLIO. LATITE, RHY-OLITE, TRACHYTE, ANDESITE FLOWS	UNDER 6 m. y.	Ad, Qt, Ca, Rb, Ar, El, Ba, Py, Sp, Cp, Gn, Ag, Sl	X	?	X	X	NO?	X	5:1 FOR 16:1 VEIN
CREEDE, MINERAL CO., COLORADO	0.14	81.8	0.08	25.1	1:400	5	3.3	OLIGOCENE ANDESITE AND RHYOLITE TUFF	OLIG.	Ad, Qt, Ca, Ba, Ch, Se, Ar, An, Fl, Sl, Gn, Sp, Ag, Py, Rc, Te, Pa	X	X	X	X	NO	X	4:1
ROUND MOUNTAIN, NYE CO., NEVADA	0.84	0.26	0.08	0.02	1:0.2	0.01	12.7	MIOCENE LAKE BEDS, RHYO-LITE TUFFS, IGNIMBRITE	25.0 m. y.	Ad, Qt, Au, Fl, Py, As, Re, Ca, Al, Se	X	X weak adularia	X Kaolin	X Sericite	X	X	
EUREKA DIST., SAN JUAN CO., COLORADO	APPROX. 0.15	APPROX. 6.8	0.06	2.8	1:47	7.5	APPROX. 2.5	TERTIARY QUARTZ LATITE TUFF AND LAVAS	13-16 m. y.	Ad, Qt, Au, Rb, Ag, Rc, Ra, Te, Fl, Ag, Sp, Gn, Py, Tl	X	?	X	X	NO	X	1:1 to 1:3

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	EVIDENCE OF BOILING ORE SHOOTS WITH FLAT BOTTOMS (5)	EVIDENCE OF BOILING VERY FINE-GRAINED QUARTZ	EVIDENCE OF BOILING FLUID INCLUSION DATA (6)	SALIN-ITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDO-MORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
GOLDFIELD, ESMERALDA CO., NEVADA	X alunite clays	X	X	Solutions Boiled During Low pH Alteration		200 to 300	BASE METALS INCREASE WITH DEPTH		305	NS TO NW, HORIZ. TO VERT.	55	ALUNITE IS A GANGUE MIN-ERAL, VEINS ASSOC. WITH CALDERA, BOILING IS NOTED TO OVER 330 M. DEPTH, GOLDFIELDITE & TELLURIDES IN ORES	ALBERS & KLEINHAMPL (1970) TAYLOR (1973) RANSOME (1909) TOLMAN & AMBROSE (1934) PERSONAL STUDY (1980) ASHLEY (1981, verb. comm.)
SILVER PEAK, ESMERALDA CO., NEVADA	X Phyllic	X	X	YES			BASE METALS INCREASE WITH DEPTH	X	152	NE, N & S DIP	9	DATA FOR VOLCANIC-HOSTED DEPOSITS ONLY, SILICIFI-CATION DECREASES WITH DEPTH, VEINS ASSOC. WITH CALDERA	ALBERS & KLEINHAMPL (1970) SILBERMAN & MCKEE (1974) ANONYMOUS (1980) PERSONAL STUDY (1980)
CREEDE, MINERAL CO., COLORADO	X illite	X		YES NEAR VEIN TOPS		250	BASE METALS INCREASE WITH DEPTH		310	N-S TO N40W 40-80S AMETHY. 50-60N ALPHA-C.		INCLUDES BULLDOG VEIN, HIGHEST GRADE AREAS ARE STRONGLY ARGILLIZED, TON-NAGE GIVEN IS MINED AND PROBABLE, CHEVRON DEPOSIT NOT INCLUDED, VEINS ASSOC. WITH CALDERA	WETLAUFER & OTHERS (1965) JACKSON (1974)
ROUND MOUNTAIN, NYE CO., NEVADA	X alunite	X		YES BELOW ALUNITE				PRESENT, BUT RARE	125	N60W WNW, HORIZ.		INCLUDES SMOKEY VALLEY RESERVES, VEINS ASSOC. WITH CALDERA, BEST GRADES ASSOC. WITH ADULARIA	FERGUSON (1927) PACKARD (1907) COUCH & CARPENTER (1943) BERGER (1980)
EUREKA DIST., SAN JUAN CO., COLORADO	X	X		NO	0.8	285 to 293	BASE METALS INCREASE WITH DEPTH		610	N50E and N60W	AVE. 1.0	PRODUCTION IS APPROX., PRE-PRECIOUS METAL Th IS 285-290 °C WITH SALINITY OF 0.1-1.5%, ORE IN BENDS IN VEINS AND IN VEIN INTERSECTIONS	LANGSTON (1979) CASADEVALL & OHMOTO (1977) BURBANK & LUEDKE (1969)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	Ag Oz. (1)	GRADE (2) Au Oz/T	Ag Oz/T	Au:Ag	BASE METALS % (3)	TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
AURORA, MINERAL CO., NEVADA	1.53	20.11	2.24	30.0	1:14	UNDER 1	0.83	MIOCENE QUARTZ LATITE, ANDES. FLOWS AND BRECCIAS	10.0 to 12.5 m. y.	Ad, Qt, Au, Ar, Te, Ag, Py, Na, Cp, Ce	X		X	X Sericite		X	
GOLD CIRCLE (MIDAS), ELKO CO., NEVADA	0.13	1.63	0.31	4.6	1:15	UNDER 1	0.4	MIOCENE RHYOLITE FLOWS(?) AND ANDES. FLOWS	15.0 m. y.	Ad, Qt, Au, Ca, Ar, Cp, Rb, Ch, Te, Sp, Py, Ag, Sr, Pl	X		X?	X		X	2:1 to 4:1
CORNUCOPIA, ELKO CO., NEVADA	0.134	0.762	0.43	24.6	1:68	0	0.031	TERTIARY ANDES. PLUG, RHYOLITE	15.0 m. y.	Qt, Ca, Cp, Ar, Rb, Py, Te, Ba, Bo, Sn, Gn, Sp	X	NO	X Close to ore	X Close to ore		X	
BULLFROG, NYE CO., NEVADA	0.12	0.874	0.34	3.0	1:8 to 1:16	UNDER 0.1	0.29	MIOCENE RHYOLITE BRECCIAS AND FLOWS	9.0 m. y.	Ad, Qt, Ca, Cc, Ag, Ag, Py, Cy			X Assoc. w/ ore		X	X	
JARBIDGE, ELKO CO., NEVADA	0.22	1.28	0.49	1.4	1:3	0	0.89	MIOCENE RHYOLITE ASH, FLOWS, BRECCIAS	14.0 m. y.	Ad, Qt, Au, Rb, Ar, Cp, El, Ba, Py, Fl, Na, Se, Ce, Tl	X	X adularia	X	X		X	

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
AURORA, MINERAL CO., NEVADA	YES, "CLAY"		X					X	130?	N40-50E 45-60S N60-80E	24	ASSOCIATED WITH CALDERA COMPLEX, Ag PRODUCTION IS APPROX. SOME ORE SHOOTS WITH FLAT TOPS	ALBERS & KLEINHAMPL (1970) ROSS (1961) SILBERMAN & MCKEE (1974) COUCH & CARPENTER (1943)
GOLD CIRCLE (MIDAS), ELKO CO., NEVADA	X Phyllic	X	SOME					X	183	N30-60W 65N-90	4.6	SAID TO BE CHALKY NEAR ORE SHOOTS	ROBERTS & OTHERS (1971) GRANGER & OTHERS (1957) ROTT (1931) SIRDEVAN (1913)
CORNUCOPIA, ELKO CO., NEVADA	X Sericite Kaolin	X								N78E 83N	0.6	ORE LARGELY OXIDIZED, SOME ORE DISSEMINATED IN HOST ROCKS	GRANGER & OTHERS (1957) ROBERTS & OTHERS (1971)
BULLFROG, NYE CO., NEVADA	X Clays		X					X	OVER 124	N60E 70W N-S N30E	30	GRADES ARE APPROXIMATED, ORES INSIDE ARGILLIC HALO, VEINS ASSOC. WITH CALDERA	ALBERS & KLEINHAMPL (1970) TAYLOR (1973) CORNWALL & KLEINHAMPL (1964) RANSOME & OTHERS (1910)
JARBIDGE, ELKO CO., NEVADA		X	X					X	280	"Northerly" w/ west dips, N to NW, 80E	10	MUCH ADULARIA IN VEINS, GRADES ARE APPROXIMATED	ROBERTS & OTHERS (1971) GRANGER & OTHERS (1957) SCHRADER (1923)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE $\times 10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
ROCHESTER, PERSHING CO., NEVADA	0.078	8.88	0.086	9.74	1:113	0.02	0.911	PERMO-TRIAS. RHYOLITE	72.5 to 78.8 m. y.	Ad, Qt, Ca, Te, Se, Ar, Rb, El, Py, Sp, Cp, Po, As, Al, To	X	X	NO	X Sericite	X MINOR	X	5:3
MOGOLLON, CATRON CO., NEW MEXICO	0.278	13.2	0.22	10.4	1:58	UNDER 1% EXCEPT IN DEEP LEVELS	1.39	TERTIARY ANDESITE & RHY. TUFFS, FLOWS, BRECCIAS & DIKES	MIO.(?)	Ad, Qt, Ca, Ar, Py, Te, Fl, Gn, Sp, Cp, Ho	X	X adularia	X	X	NO	X	1:1 to 1:3
BODIE, MONO CO., CALIFORNIA	1.456	7.28			1:5	VERY LOW		MIOCENE ANDESITE AND DACITE, DACITE PLUGS	8.6 to 7.1	Ad, Qt, Ca, Ar, Rb, El, Sn, Py Sp	X	X	X?			X	
TUSCARORA, ELKO CO., NEVADA	0.162	7.14	0.38	16.8	1:44 to 1:100	0.02	0.425	EOCENE-OLIG. RHY. TUFF, ANDES. FLOW, ANDES. PLUG	38.0 m. y.	Ad, Qt, Ca, Ar, Rb, Py, Sn, En, Bo, Gn, Sp, Cp, Cy, Au, Ag, As	X	X adularia	X	X			
TAYOLTITA, DURANGO, MEXICO	6.24	318.0	0.52	26.5	1:51	1	OVER 12.0	TERTIARY ANDESITE FLOW, EOCENE PLUG, RHYOLITE PORPHYRY	OLIGOCENE	Ad, Qt, Ca, Ch, Ar, Sp, Rb, El, Au, Ag, Py, Cp, Gn, St	X	X				X	2:1 to 4:1

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
ROCHESTER, PERSHING CO., NEVADA	X Phyllic	X	X	YES LOSS OF CO_2	6	270 to 310	SILVER VALUES DECREASE WITH DEPTH		300	N to N30E 30-70W	AVE. 3 MAX. 13	ANDALUSITE-DUMORTIERITE ALTERATION REPORTED, BULK TONNAGE POTENTIAL NOT INCLUDED, SOLUTIONS HAD 15-20% CO_2, BOILING IS CO_2 RELEASE	VIKRE (1978) KNOPH (1924)
MOGOLLON, CATRON CO., NEW MEXICO	NO?	X					BASE METALS INCREASE WITH DEPTH	X	365	N60W 75-89N N10E 70S	10	QT VEINS PASS UPWARD TO CA VEINS	FERGUSON (1921) KAMILLI & OHMOTO (1977) PERSONAL STUDY (1977)
BODIE, MONO CO., CALIFORNIA	SAID TO BE BLEACHED NEAR ORE	X	X			215 to 245	Au, Ag VALUES DECREASE WITH DEPTH		400	N60-70E N10E		ASSOCIATED WITH CALDERA COMPLEX	ALBERS & KLEINHAMPL (1970) WHITE (1974) SAWKINS (1980) PERSONAL STUDY (1980)
TUSCARORA, ELKO CO., NEVADA	X Sericite								110	N80W 50-65W		ADULARIA ASSOCIATED WITH HIGHEST Au VALUES, BULK POTENTIAL NOT INCLUDED, MUCH OF Au PRODUCTION IS FROM PLACERS	GRANGER & OTHERS (1957) ROBERTS & OTHERS (1971)
TAYOLTITA, DURANGO, MEXICO	NO	X WITH POST-ORE TILTING	X	YES	3.3 to 8.4	265	BASE METALS INCREASE WITH DEPTH		600	N10W, 65-85E N40-70E, 40-80W	15	WALLROCKS SAID TO BE ALBITIZED, FLUIDS BOILING ONLY IN AREAS OF HIGHER Au AND Ag VALUES AND AT VEIN TOPS VEINS ASSOC. W/ CALDERA	ALBINSON BROCUM (1971) SAWKINS, 1980, verbal com. SMITH (1974) SMITH & OTHERS (1979) ORDONEZ (1973)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	Ag Oz. (1)	GRADE (2) Au Oz/T	Ag Oz/T	Au:Ag	BASE METALS % (3)	TONNAGE $\times 10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
REPUBLIC, FERRY CO., WASHINGTON	0.86	5.45	0.345	2.18	1:6.3	UNDER 1	2.5	OLIGOCENE RHY. TUFF, ANDESITE TUFF AND QUARTZ LATITE PORPH.	OLIG.	Ad, Qt, Cp, Ca, Na, Au, Te, Ar, Ag, Sn, Py, Al, St, El, La	X	X	X	X		X	1:2
FRESNILLO, ZACATECAS, MEXICO	0.32	20.5			1:646	ABOUT 4		CRETACEOUS SHALE & LIME-STONE CAPPED BY CONGL. & MISC. VOLCAN-ICS	OLIG.?	Ad, Qt, Ca, Rb, Ar, El, Ag, Au, Py, Sp, Cp, Gn, Po, As, Pl	X						1:1 to 3:1
HAYDEN HILL, LASSEN CO., CALIFORNIA	0.09	?	1.0	1.5	1:1.5	0	0.13	OLIG.-MIOCENE DACITIC VOL-CANICLASTIC SHALES & CONGLOMERATE, AND AGGLOM.	MIOCENE	Ad, Qt, El, Au, Sn?, Pr	X	X Adularia	MINOR, IN VEIN FOOTWALL	NO	NO	X	
SEVEN TROUGHS, PERSHING CO., NEVADA	0.16	0.996	1.2	6.5	1:5.4	0	0.152	TERTIARY RHY. PLUGS, FLOWS & TUFFS. BASALT FLOWS	14.0-13.7 m. y.	Ad, Qt, El, Rb, Ca, Py, Au, Ch, Ar	X	X	X Kaolin	X		X	1:1 to 5:8
NATIONAL, HUMBOLDT CO., NEVADA	APPROX. 0.18	APPROX. 0.18	2.8	2.8	1:1	UNDER 1	0.115	MIOCENE RHYOLITE DIKES, LATITE FLOWS	MIOCENE OR YOUNGER	Ad, Qt, Ca, Rb, El, Py, As, Cp, St, Gn, Sp, Se, Bo, Sn	X	X Adularia		X Sericite		X	1:2

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALIN-ITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDO-MORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
REPUBLIC, FERRY CO., WASHINGTON			X	SEE NOTES			Au DE-CREASES, CALCITE INCREASES WITH DEPTH	X	260	N30-60E SE DIP N7E-N30W 45 to 80E DIP	33	MANY FLUID INCLUSIONS WITH 100% VAPOR, AVE. VEIN 1.0 m. WIDE, MAY HAVE STACKED ORE LEVELS, ORE SHOOTS AT BENDS CONCAVE TO FOOTWALL, SILICIF. DECREAS. W/ DEPTH	MUESSIG (1967) FULL & GRANTHAM (1968) BANCROFT (1914) UMPLEBY (1910)
FRESNILLO, ZACATECAS, MEXICO				SEE NOTES			BASE METALS INCREASE WITH DEPTH		1000	E-W N10-45W 45-90S	1.4	SOME STUDIES SHOW BOILING EVIDENCE, OTHERS DO NOT; ALTERATION NOT REPORTED, HAS MANTO REPLACEMENTS IN CRETACEOUS LIMESTONE	PERSONAL STUDY (1977) DE CSERNA (1976) LOWTHER (Verbal Comm., 1977-78) ORDONEZ (1973)
HAYDEN HILL, LASSEN CO., CALIFORNIA	SEE NOTES	X	X				NONE	X	120	N68W 60-80N	MAX. 7 AVE. 0.3	EXCLUDES BULK POTENTIAL OF 390,000 T OF 0.054 Au & 0.45 Ag, DISTRICT APPEARS DEEPLY ERODED, HAS NO LOW pH CAP OR HALO	PERSONAL STUDY (1980-81)
SEVEN TROUGHS, PERSHING CO., NEVADA	X Phyllic		SOME	NO		240 to 318	NONE	X	245	N00-20E	AVE. 0.9	GRADES ARE APPROXIMATED, HAS INTRAVOLCANIC ALTERA-TION, ORE IN CONCAVE BENDS TO HANGING WALL & IN STEEP PARTS OF VEINS, MOST Th READINGS CENTERED ON 260°	BRUCE (Verbal, Comm., 1981) PERSONAL STUDY (1980) KECKLER (1980) RANSOME (1909) SILBERMAN & MCKEE (1974)
NATIONAL, HUMBOLDT CO., NEVADA			X					X	245	N15E-N25W, 50-80W	1.5	ORE IN CONCAVE BENDS TO HANGING WALL, TOP OF ORE IS 18 m. BELOW SURFACE, STIBNITE MOST ABUNDANT SULFIDE	LINDGREN (1915) COUCH & CARPENTER (1943) WINCHELL (1912) ROBERTS & OTHERS (1971)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION		GRADE (2)				TONNAGE $\times 10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES						ORE SHOOT RATIO Hor:Vert
	Au Oz. (1)	Ag Oz. (1)	Au Oz/T	Ag Oz/T	Au:Ag	BASE METALS % (3)					PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	
MONITOR, ALPINE CO., CALIFORNIA	2.5 NOT MINED 0.009 MINED	80.0 NOT MINED 0.75 MINED	0.06	2.0	1:33	NEARLY 0	40.0 NOT MINED	TERTIARY RHYOLITE PLUG AND BRECCIA	5.0 m. y.		X	X adularia	X	X Sericite		X	
GILBERT, ESMERALDA CO., NEVADA	0.005	Nil	1.25	Nil		0	0.004	MIOCENE RHY. ASH & PORPHYRY, ANDESITE	8.0 m. y.	Ad, Qt, Ar, Rb, Au, Cy, Ca, Py, Cp	X		X	X	X	X	
RAMSEY-TALAPOOSA, LYON CO., NEVADA	0.07	6.6	0.89	83.5	1:95	UNDER 1	0.09	MIOCENE ANDESITE FLOWS & DIKES, RHY.	10.0 m. y.	Ad, Qt, Py, Ca, Ar, Cp, Cy, Au	X		X Kaolin	X		X	
CEDAR MTN., MINERAL CO., NEVADA	0.034	APPROX. 0.68	0.04	0.81	1:20	0	0.834	TERTIARY ANDESITE, DACITE TUFF, QUARTZ LATITE		Qt, El, Py			X	X	X?	X	
RAWHIDE, MINERAL CO., NEVADA	0.051	0.697	0.72	9.9	1:14	0.2	0.071	MIOCENE RHY., DACITE, ANDESITE	11.0 to 16.0 m. y.	Ad, Qt, Ar, El, Rb, Cy		X	X	X		X	

DISTRICT	EVIDENCE OF BOILING				SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
	LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)									
MONITOR, ALPINE CO., CALIFORNIA	CLAY HALO		X					MINOR				BULK TONNAGE RESERVES OF ZACA MINE INCLUDED	SILBERMAN & MCKEE (1974) PERSONAL STUDY (1980)
GILBERT, ESMERALDA CO., NEVADA	X		X					X	OVER 100	N45W 60-90W N-S 50W N30E 80W	1 12 1	SAID TO BE "BLEACHED" NEAR ORES, MOST ORE IN ORDOVICIAN LIMESTONE BELOW VOLCANICS, SOME IN ANDESITES	SILBERMAN & MCKEE (1974) ARCHBOLD & BLOMQUIST (1969 FERGUSON (1928)
RAMSEY-TALAPOOSA, LYON CO., NEVADA	X CLAY		SOME	YES		221		X	OVER 213	E-W 55-65S	8.5	Au PRODUCTION IN PART FROM PLACERS, DATA INCLUDES GOOSEBERRY MINE, Th FROM GOOSEBERRY	SILBERMAN & MCKEE (1974) COUCH & CARPENTER (1943) WISSER & LINDSEY (1966) PERSONAL STUDY
CEDAR MTN., MINERAL CO., NEVADA								X				Ag PRODUCTION APPROXIMATE	KNOPF (1922)
RAWHIDE, MINERAL CO., NEVADA	X Kaolin											HIGHEST GRADE ORES ASSOCIATED WITH KAOLIN	SILBERMAN & MCKEE (1974) KOSCHMANN & BERGENDAHL (1968) ROGERS (1911) COUCH & CARPENTER (1943)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE x10⁶	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
BOHEMIA, LANE/DOUGLAS CO. OREGON	0.031	0.035			1:6	9	0.08	MIOCENE DACITE PORPHYRY; ANDESITE FLOW, BRECCIA & TUFF		Ad, Qt, Ca, Au, Py, Gn, Cp, Sp, St, Bm, He	X	X	X Kaolin	X		X	1:1 to 1:3
SEARCHLIGHT, CLARK CO., NEVADA	0.247	0.220	0.44	0.47	1:1	0.3	0.469	TERTIARY QTZ. MONZON. STOCK, ANDESITE		Ad, Qt, Ca, Au, Gn, Py, Ce, Wu, Sc, Cl	X	X Adularia	X	X		X	3:7
MOHAVE, KERN CO., CALIFORNIA					1:2 to 1:12	MINOR		TERTIARY RHY. TUFF & FLOWS	PLIO.?	Ad, Qt, Ca, Ar, Au, Py, Bu, Cp, Sp, Gn, Ja			X	X		X	
CALICO, S. BERNARDINO CO. CALIFORNIA	0.014	17.5			1 to 1200	"MODERATE"		OLIG.-MIOCENE LACUSTRINE TUFFACEOUS SED., VOLC. TUFF & BRECCIA	MIOCENE	Qt, Ba, Ca, Ag, Ar, Rb, Te, St, Si, Cy, Br, Py	X					X	
GREAT BARRIER ISLAND, NEW ZEALAND	41.5	1250.0			1:4 to 1:30	3		EOCENE-MIO. ANDESITE TUFF & BRECCIA, DACITE, RHY.	PLIO.	Qt, Ar, Rb, El, Py, As, Al, Cp, Gn, Sp, Ma, Ca, Ch, Sc, Rc, Ad, Se	X	X Adularia	X	X		X	

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
BOHEMIA, LANE/DOUGLAS CO. OREGON	X		X				BASE METALS INCREASE WITH DEPTH		100	N45-90W 60-70S	AVE. 1	CLAY DECREASES AND SERICITE INCREASES WITH DEPTH IN VEIN WALLS, WALLS SAID "BLEACHED" NEAR ORE	MACDONALD (1908) TABER (1949)
SEARCHLIGHT, CLARK CO., NEVADA		X						X	335	N65W SW DIP	15	MUCH $PbMoO_4$ IN ORES, SOME FLAT VEINS	PERSONAL STUDY (1980) PROCTOR & DORAIBABU (1977) COUCH & CARPENTER (1943) CALLAGHAN (1939)
MOHAVE, KERN CO., CALIFORNIA			X				PYRITE INCREASES WITH DEPTH	X	110	NW, E & W DIPS	2		SCHROTER (1935)
CALICO, S. BERNARDINO C. CALIFORNIA										NW		DATA EXCLUDE 49.0 MILLION TONS OF 2.7 Ag OZ/TON AT WATERLOO & LANGTRY WITH MUCH BARITE GANGUE, THE COMPANY EXPECTS 65% Ag RECOVERY	PERSONAL STUDY (1962-80)
GREAT BARRIER ISLAND, NEW ZEALAND	Sericite Halo		X				BASE METALS INCREASE WITH DEPTH	X	465	N45-80W, DIPS 40-80S AND 80N	10	Ag PRODUCTION APPROXIMATE, ZEOLITIZATION OF WALLROCKS NOTED, Ag DECREASES WITH DEPTH, PHYLLIC POST-DATES POTASSIC ALTERATION AS AT GUANAJUATO	EMMONS (1937) RAMSAY & KOBE (1974) WEISSBERG & WODZICKI (1970)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
GUADALUPE Y CALVO, CHIHUAHUA, MEXICO	APPROX 7.0	APPROX. 28.0	1.18	16.6	1:40	RARE	APPROX. 1.7	TERTIARY ANDESITE FLOWS	OLIG.?	Qt, Ch, Ar, Ag, Au, Py, Gn, Cp, Sp	X		X			X	
OCAMPO, CHIHUAHUA, MEXICO	0.175	6.65	0.25	9.5	1:60	0.03	0.7	EOCENE ANDESITE FLOWS & TUFF, RHYOLITE TUFF	29.0 to 27.0 m. y.	Qt, Ca, Ar, Au, El, Te, Sn, Py, Sp, Cp, Gn	X		X	X		X	1:1
YOQUIVO, CHIHUAHUA, MEXICO	0.052	5.4	0.35	36.0	1:74	"MODER-ATE"	0.150	TERTIARY ANDESITE FLOWS & TUFF, LATITE FLOWS		Ad, Qt, Au, El, Ag, Py, Sn, Gn, Ca, Sp, Cp, Ar, Sr	X	X	X			X	2:1
EL ORO, MEXICO, MEXICO	0.86	APPROX. 20.0	ABOUT 0.4	ABOUT 4.0	1:7	0	OVER 5.0	MIOCENE ANDESITE FLOW ATOP CRETACEOUS(?) SHALE AND SANDSTONE		Qt, Ca, Ka, Ar, Rb, Au, Cp, Py	X		X			X	8:1
GUANACEVI, DURANGO, MEXICO	APPROX. 1.0	APPROX. 440.0	0.17	73.0	1:100 to 1:500	6-12	6.0	TERTIARY ANDESITE FLOWS, REDBED CONGLOMERATE	POST 38.0 m. y.	Ad, Qt, Ca, Py, Ar, Rb, El, Te, Sn, Fl, Ba, Rs, Bo, Tn, Gn, Sp, Cp	X		X	X		X	1:1

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDO-MORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
GUADALUPE Y CALVO, CHIHUAHUA, MEXICO			X				BASE METALS INCREASE WITH DEPTH		400	NW, Dip W	30	Au VALUES DECREASE WITH DEPTH	BAILEY (1931) TURNER (1978) CLARK & OTHERS (1979)
OCAMPO, CHIHUAHUA, MEXICO	X argillic								400	NW & NE, SW DIPS	12	BASE METALS EARLIER THAN PRECIOUS METALS, ORE IS POST-DACITE STOCK EMPLACEMENT	WISSER (1966) KNOWLING (1977) LINTON (1912) CLARK & OTHERS (1979)
YOQUIVO, CHIHUAHUA, MEXICO			X Chalcedony						295	N05-40E, 60-75E N-S to N14E, 75-80E to 75-80W	17	CALCITE IS POST ORE.	WISSER (1966) HALL (1926)
EL ORO, MEXICO, MEXICO	X bleached	X	X				BASE METALS INCREASE WITH DEPTH	X	215	NNW, W Dip N-S, E & W dip	AVE. 3 MAX. 38	Au PRODUCTION APPROXIMATE, TONNAGE APPROXIMATE	EMMONS (1937) LINDGREN (1933) LOCKE (1913)
GUANACEVI, DURANGO, MEXICO		X	X						400	N10W, W dip	40	ADULARIA GANGUE ASSOCIATED WITH HIGHEST GOLD VALUES	DURNING (1978) HALPERN (1939) TERRONES (1922)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	Ag Oz. (1)	GRADE (2) Au Oz/T	Ag Oz/T	Au:Ag	BASE METALS % (3)	TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
SUMMITVILLE, RIO GRANDE CO., COLORADO	APPROX. 0.26	APPROX. 0.50			1:2	57		MIOCENE QUARTZ LATITE PLUG		Qt, Au, Py, Ba, Al, En, Gn, Sp, Cv, rare Cp	X		X	X Illite	X	X	2:1
WONDER, CHURCHILL CO., NEVADA	0.074	6.87	0.17	16.28	1:94	0	0.426	OLIGOCENE-MIOCENE RHY., ANDESITE, LATITE, NEAR RHY. DOME	22.0 m. y.	Ad, Qt, Fl, Ar, El, Cy, Br, Au			X Kaolin	X?		X	
BUCKHORN, EUREKA CO., NEVADA	0.039	0.311	0.182	1.46	1:8		0.214	MIOCENE ANDESITE	15.0 m. y.	Ad, Qt			X Kaolin				
DIVIDE, ESMERALDA CO., NEVADA	0.033	3.27	0.24	24.3	1:101	VERY LOW	0.135	MIOCENE RHY. TUFF, RHY. BRECCIA, ANDESITE, RHY. PLUG	15.0 to 16.5 m. y.	Ad, Qt, Se, Rb?, Ar, Gn, Au, Ag, Py, Cy, Mo, Ba, Cp, Pw	X	X Adularia	X Kaolin	X	X	X	1:1
KATHERINE, MOHAVE CO., ARIZONA	0.175	0.424	0.25	0.75	1:3	0	0.69	PRECAMBRIAN GRANITE, MIOCENE LATITE	MIOCENE	Ad, Qt, El, Ch, post-ore Fl, Py, Se, Ca	X		X	X	NO	X	4:1

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
SUMMITVILLE, RIO GRANDE CO., COLORADO	X Alunite	X	X						305	N30-55W		SOME ORE-BEARING PIPES IN DISTRICT, ORE HORIZON MAY BE DOMED	STEVEN & RATTE (1960)
WONDER, CHURCHILL CO., NEVADA							ZnS INCREASE WITH DEPTH		UNDER 215	N60-70W 75N-90 N25W 72E	6 12	GRADES ARE APPROXIMATE	SILBERMAN & MCKEE (1974) WILLDEN & SPEED (1974) LEWIS (1966?) BURGESS (1914)
BUCKHORN, EUREKA CO., NEVADA	X Argillic								MUCH ERODED 37	N5W 75E		BEST Au VALUES ASSOCIATED W/ ARGILLIC ALTERATION, GRADES ARE APPROXIMATED, "TALC" ALTERATION OF WALLS REPORTED	SILBERMAN & MCKEE (1974) ROBERTS & OTHERS (1967) COUCH & CARPENTER (1943)
DIVIDE, ESMERALDA CO., NEVADA	X Argillic		X				Au VALUES DECREASE WITH DEPTH Ag VALUES INCREASE		300	N05-65E 55E NW vert. dip	6.6	IN LOWER LEVELS Ag IS ASSOC. WITH KAOLINITE, IN UPPER LEVELS WITH SERICITE ORES LARGELY A REPLACEMENT OF RHYOLITE TUFF, OPALIZATION OF RHY. REPORTED	PERSONAL STUDY (1979-80) KNOPF (1921) CARPENTER (1919) BONHAM & GARSIDE (1979) WISSER (1966)
KATHERINE, MOHAVE CO., ARIZONA	X Argillic(?)	X?	X				NONE	X	SEE NOTES	N70-80E 60N (KATH.) N45E near 90 (TYRO)	7.6	DISTRICT MUCH ERODED, VERT. EXTENT AT TYRO IS 65 m., AT KATHERINE IS 170 m., DATA INCLUDES UNMINED RESERVES AT PORTLAND MINE (157,000 TONS OF 0.18)	PERSONAL STUDY (1980) GARDNER (1936) JORALEMON (1925) HENDERSON (1923)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION		GRADE (2)				TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES						ORE SHOOT RATIO Hor:Vert
	Au Oz. (1)	Ag Oz. (1)	Au Oz/T	Ag Oz/T	Au:Ag	BASE METALS % (3)					PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	
PIZ PIZ, NICARAGUA	0.1	0.2	0.25	0.50	1:2	2	0.4	TERTIARY ANDESITE & DACITE, RHYOLITE PLUG		Ad, Qt, Py, El, Rc, Sp, Cp, Gn, Bo, Sc	X			X		X	10:1
COLQUI, (FINLANDIA) PERU	0.388	10.24	0.97	25.6	1:26	17.4	OVER 0.4	TERTIARY ANDESITIC SANDSTONE, TUFF, & FLOWS	10.3 m. y.	Qt, Si, Se, Ac, Rb, El, Py, Te, Gn, Sp, Ba, Ka	X		X	X		X	7:4
NAMIQUIPA, CHIHUAHUA, MEXICO	0.000	26.13	0.00	29.03	1: 450000	8.5	0.9	EOCENE-OLIG. LATITE, ANDESITE FLOWS & TUFF, AGGLOMERATE	OLIG.?	Qt, Ar, Au, Py, Fl, Ba, Gn, Sp, Cp	X			X		X	8:1
TEMASCALTEPEC, MEXICO, MEXICO	0.059	16.0	0.06	16.0	1:267	"Low"	OVER 1.0	TRIASSIC SHALE CAPPED BY TERTIARY ANDESITE & RHYOLITE BRECCIA		Ad, Qt, Ca, Ch, Ar, Rb, El, Py, Gn, Sp, Cp		X	X				3:1
EL TIGRE, SONORA, MEXICO	0.175	27.3	0.25	39.0	1:162	3	OVER 0.7	OLIGOCENE RHY. TUFF & FLOWS. LATITE BRECCIA	OLIG.(?)	Qt, Ca, Ar, Te, Au, Py, Cp, Sp, Gn, Sr	X		X Kaolin			X	6:1

DISTRICT	EVIDENCE OF BOILING				SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
	LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)									
PIZ PIZ, NICARAGUA			X							N45E 35-50NW	73	ORES SECONDARILY ENRICHED ESPECIALLY IN Ag	HAWXHURST (1921) SPURR (1913)
COLQUI, (FINLANDIA) PERU	X Phyllic	X	X	YES	2-10	270 ±20			130	N60-75E	2.5	BASE METALS ARE POST-Ag VEINS AVE. 1 METER WIDE	KAMILLI & OHMOTO (1977)
NAMIQUIPA, CHIHUAHUA, MEXICO	X		X				ZnS INCREASE WITH DEPTH		250	N25 to 40E 70E N05-20W		Ag VALUES DECREASE WITH DEPTH, WALLROCKS AROUND ORE SHOOTS SAID "BLEACHED"	SHEFELBINE (1957) DOUGLAS (1951)
TEMASCALTEPEC, MEXICO, MEXICO		X					Zn & Pb INCREASE WITH DEPTH		250	N40-90W 65N MANY DIPS APPROACH 90°	AVE. 10	GALENA AND PYRITE INCREASE WITH DEPTH AND Ag VALUES DECREASE	CARDENAS & MARTINEZ (1947) WILSON (1959)
EL TIGRE, SONORA, MEXICO							ZnS INCREASE WITH DEPTH		300	N05E to N10W 60W Dip	AVE. 1	ORE IN CYMOID LOOPS, SILICIFICATION INTENSE ABOVE ORE, PYRITIZATION INTENSE BELOW	MISHLER (1920) WISSER (1966)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE x10^6	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	POTASSIC	ARGILLIC	PHYLLIC	ALUNITIC	SILICIC	ORE SHOOT RATIO Hor:Vert
ZACUALPAN, MEXICO, MEXICO	Nil	8.423	Nil	4.9		1.4	1.72	TRIASSIC ANDESITE AND SHALES		Qt, Ca, Ar, Rb, Py, Te, Rc, Cp, Gn, Sp	X			X		X	
STATELINE, TOOELE CO., UTAH	0.0024	0.0084	ABOUT 0.1	ABOUT 0.4		VERY LOW	APPROX. 0.02	TERTIARY LATITE FLOW, RHY. FLOW & TUFF		Ad, Qt, Ca, El, Py, Fl, Mo, Tl	X	X	X	X Sericite		X	
CINCO MINAS, JALISCO, MEXICO	0.100	15.3	0.10	15.3	1:153		OVER 1.0	TERTIARY RHY. TUFF, ANDESITE		Qt, Ca, Ar, El, Au, Py, Gn, Sp, Cp							1:2
GOLDEN PLATEAU, AUSTRALIA	0.484	0.363	0.44	0.33	1:0.8	"minor"	1.1	PALEOZOIC DACITE, RHY., RHYODACITE, TRACHYTE	PALEOZ?	Ad, Qt, Ar, Au, El, Gn, Cp, Sp, As, Hs	X					X	1:1
SILVER CITY & DELAMAR, OWYHEE CO., IDAHO	0.9	27.0			1:30	UNDER 1%		TERTIARY ANDESITE, RHYOLITE	14.8-15.2 m. y.	Ad, Qt, Fl, Cp, Ca, Se, Gn, Ar, Rb, Ba, Py, Pl, El, Na, Ja, Ml	X		X	X		X	5:3

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	ORE SHOOTS WITH FLAT BOTTOMS (5)	VERY FINE-GRAINED QUARTZ	FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
ZACUALPAN, MEXICO, MEXICO			X				Ag/Pb, Ag/Zn, Zn/Pb DECREASE WITH DEPTH			N65W 80N DIP	35		FRANCISCO (1979)
STATELINE, TOOELE CO., UTAH			X					X	155	E-W, N DIP N-S, 50-70E	AVE. 1	HIGHEST GOLD VALUES ARE ASSOCIATED W/ ADULARIA IN VEIN, INCLUDES GOLD SPRINGS & ESCALANTE DISTS.	EMMONS (1937) BUTLER & OTHERS (1920)
CINCO MINAS, JALISCO, MEXICO							BASE METALS INCREASE WITH DEPTH		650	N45-90W, S DIP		CALCITE VEIN ON SURFACE CHANGES TO QUARTZ WITH OEPTH	OJEDA & MAPES (1963)
GOLDEN PLATEAU, AUSTRALIA		X							OVER 215			MAY HAVE VERTICALLY STACKED OREBODIES AS AT GUANAJUATO, UPPER IS 0-120 M. BELOW SURFACE, LOWER IS 120-215 M.	BROOKS (1970)
SILVER CITY & DELAMAR, OWYHEE CO., IDAHO	X Phyllic	X						X	460	N25-62W 25-80S	10	VEINS AVERAGE 1.0 METER WIDE, PRODUCTION LISTED IS FOR 1863-1923. ARGILLIC ALTERATION SAID ASSOCIATED WITH ORE	LINDGREN (1933) PIPER & LANEY (1926) PANSZE (1971)

TABLE 1, CONTINUED

DISTRICT	PRODUCTION Au Oz. (1)	PRODUCTION Ag Oz. (1)	GRADE (2) Au Oz/T	GRADE (2) Ag Oz/T	GRADE (2) Au:Ag	GRADE (2) BASE METALS % (3)	TONNAGE $x10^6$	MAJOR HOSTS	ORE AGE	MINERALOGY OF VEIN (4)	ALTERATION ASSEMBLAGES PROPYLITIC	ALTERATION ASSEMBLAGES POTASSIC	ALTERATION ASSEMBLAGES ARGILLIC	ALTERATION ASSEMBLAGES PHYLLIC	ALTERATION ASSEMBLAGES ALUNITIC	ALTERATION ASSEMBLAGES SILICIC	ORE SHOOT RATIO Hor:Vert
SILVERBOW, NYE CO., NEVADA					1:8			TERTIARY RHY. FLOW		Py, Qt, Rb, Au, Sn			X Kaolin	X		X	
TOVAR, DURANGO, MEXICO			0.06	2.89	1:45	10		OLIGOCENE ANDESITE PORPHYRY. QUARTZ MONZ. PLUG	POST 31 m. y.	Qt, Ar, Rb, He, Py, Gn, Sp, Cp, Ba, Ha	X		X			X	
PARRAL, CHIHUAHUA, MEXICO	0.02	115.1	0.002	8.9	1:150	4 to 20	OVER 13	TERTIARY VOLCANICS CAPPING CRETACEOUS LIMESTONE & SHALE	POST 35 m. y.	Qt, Ar, Rb, El, Py, Fl, Ba, Gn, Sp, Te	X		?			X	?:1
LAKE CITY, HINSDALE CO., COLORADO	0.071		0.12			OVER 5	OVER 0.6	TERTIARY QTZ. LATITE TUFF & BRECCIA, RHY., ANDESITE	22.5 m. y.	Qt, Ca, Rb, Sp, Cp, Gn, Ba, Tl, Te, Rc, Se	X		X Kaolin Dickite	X Sericite	X Higher elevation	X	
JULCANI, PERU							OVER 6	TERTIARY DACITIC FLOW, RHY. PLUG, RHY. BRECCIA, RHY. TUFF	10 m. y.	Qr, Si, Te, Py, Tn, Sp, Cp, Sm	X	X	X	X	X		

DISTRICT	EVIDENCE OF BOILING LOW pH CAP TO ORE	EVIDENCE OF BOILING ORE SHOOTS WITH FLAT BOTTOMS (5)	EVIDENCE OF BOILING VERY FINE-GRAINED QUARTZ	EVIDENCE OF BOILING FLUID INCLUSION DATA (6)	SALINITY (7)	Th °C (8)	VERTICAL ZONATION	QT PSEUDOMORPHS AFTER CALCITE	VERTICAL ORE EXTENT m.	VEIN ATTITUDES	MAX. VEIN WIDTHS m.	COMMENTS	REFERENCES
SILVERBOW, NYE CO., NEVADA	X Kaolin		MUCH AGATE							NW	1.5		BALL (1906)
TOVAR, DURANGO, MEXICO							BASE METALS INCREASE WITH DEPTH			NW, 70-80E NNE	6 1		CLARK & OTHERS (1979) DOW (1978)
PARRAL, CHIHUAHUA, MEXICO		X					Pb + Cu INCREASE TO 20% WITH DEPTH		600	N00-07W 53E N06W 75W	40	Ag DECREASES FROM 600 TO 50 GRAMS WITH DEPTH, DATA INCLUDES UNMINED RESERVES	SCHMITT (1929) PICKARD (1970)
LAKE CITY, HINSDALE CO., COLORADO	?		SOME	YES	3	250	Ag DECREASES BASE METALS INCREASE WITH DEPTH		460	N45E 70E N30E	6	VEINS AVE. 1.0 M. WIDE, FLUIDS BOILED DURING Au-Ag DUE TO PRESSURE RELEASES, NO BOILING IN BASE METAL STAGES, BASE METALS EARLY PARAGENETICALLY	SLACK & LIPMAN (1978) SLACK (1980)
JULCANI, PERU	X Phyllic									N45-60W 50-90N and 50-90S N30-60E		ORES IN ZONES OF ADULARIA ALTERATION OF WALLROCKS	PETERSEN & OTHERS (1977) SCHERKENBACH & NOBLE (1978)

TABLE 1, CONTINUED

NOTES FOR TABLE 1

Footnotes:

1) In millions of troy ounces. Most production figures are from the literature; several are calculated from tonnage and grade figures assuming 100% recoveries.
2) In some cases, grade is recovered oz./ton; in others it is assay oz./ton. Most grade figures are from the literature; several are calculated from production and tonnage figures assuming 100% recoveries.
3) Combined Pb + Zn + Cu. In rare cases is as percentage of metal; in most is as percentage of sulfide.
4) Abbreviations are:

Aa	Altaite	Do	Dolomite	Pw	Powellite
Ad	Adularia	El	Electrum	Py	Pyrite
Ag	Silver	En	Enargite	Qt	Quartz
Ai	Aguilarite	Fa	Famantite	Rb	"Ruby Silvers"
Al	Alunite	Fl	Fluorite	Rc	Rhodochrosite
An	Ankerite	Go	Goldfieldite	Re	Realgar
Ar	Argentite	Gn	Galena	Rs	Rhodonite
As	Arsenopyrite	He	Hematite	Sc	Specularite
Au	Gold	Hs	Hessite	Se	Sericite
Ba	Barite	Ja	Jamesonite	Si	Siderite
Bo	Bornite	Ka	Kaolin, Kaolinite	Sm	Semseyite
Br	Bromeyerite	La	Laumontite	Sn	Stephanite
Bu	Bournonite	Ma	Marcasite	Sp	Sphalerite
Ca	Calcite	Mi	Miargyrite	Sr	Stromeyerite
Cc	Chalcocite	Mo	Molybdenite	St	Stibnite
Ce	Cerussite	Na	Naumannite	Te	Tetrahedrite
Ch	Chlorite	Pa	Pyrargyrite	Tl	"Tellurides"
Cl	"Clay"	Pl	Polybasite	Tn	Tenantite
Cp	Chalcopyrite	Po	Pyrrhotite	To	Tourmaline
Cv	Covellite	Pr	Pyrolusite	Wu	Wulfenite
Cy	Cerargyrite	Pu	Proustite		

5) Shape of ore shoots is based on bottom of stopes, not on bottom of all mineralization.
6) For list of boiling criteria, see references listed for each district.
7) Expressed as equivalent weight percent NaCl.
8) Th = Temperature of homogenization of fluid inclusions with no pressure corrections.

General Notes:

X = Evidence present
NO = No evidence present
blank = Insufficient information
Alteration assemblages as listed do not imply they are related to the ore-forming event; however, deuteric propylitization and/or zeolitization have been ignored.

Appendix C

PROSPECTING BY SELF-POTENTIAL METHOD, S.V. BURR

Ontario Geological Survey
Miscellaneous Paper 99

A Guide to Prospecting by the Self-Potential Method

by
S.V. Burr

1982

Ministry of
Natural
Resources
Ontario

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A Guide to Prospecting by the Self-Potential Method

by
S.V. Burr[1]

INTRODUCTION

The author has used the self-potential or spontaneous polarization (SP) prospecting method extensively for 35 years in surveying mining claims, and considers it the best of the electrical geophysical methods.

Recently, interest in the method has revived, probably due to renewed gold exploration. Most gold deposits are not good conductors, but do contain some sulphides which can be detected by the SP method.

The few available textbooks which mention the SP method are brief in their descriptions of field prospecting methods, and some prospectors, who have tried the method with insufficient understanding of the technique, have become discouraged and added to the misconceptions about it. Good practical descriptions of the SP method are contained in "Prospecting in Canada" by Lang (1970) and in "Mining Geophysics, Second Edition" by Parasnis (1975).

This guide incorporates and updates information from a previous paper by the author (Burr 1960) and is intended to instruct the layperson in the routine prospecting use of the method and to encourage more geophysical research of the SP phenomenon. Much of the material presented is unavailable elsewhere and was derived by experience through field applications.

IMPORTANT FACTS

Although the author has endeavoured to dispell some misconceptions, and to add some new facts on the SP method in the body of this guide, some isolated facts could be emphasized at the beginning:

1) Hydro and telephone lines, which plague some of the other electrical methods, do not affect SP

2) Iron formation, which acts as a "good conductor" with some of the other electrical methods, does not affect SP unless sulphides or graphite are associated with it. One major iron formation at the Sherman Iron Mine, Temagami, Ontario, contains graphite. The SP method begins to detect this anomaly at least two miles away. On the basis of one long north-south traverse conducted by the author, a peak of 4000 mv (4 volts) was obtained over or near this iron formation.

3) Buried or grounded metal objects can produce spurious SP "spot anomalies". A buried long metal pipe can produce a linear and sometimes genuine-looking (pseudo)anomaly. Graphite cathodes are used beside gas pipe lines to prevent corrosion and can produce an abnormally high negative SP anomaly. Similarly, it can be demonstrated that an axe, pick or knife driven into the ground beside the forward pot (an SP ground electrode) produces a high negative reading in the instrument.

4) Several years ago in Northern Quebec, the author discovered a graphite SP anomaly of 1 volt at a pot separation of 300 feet. An unsuccessful experiment was conducted to try and achieve a 6 volt potential and power a radio. An additional pot merely cut the potential to .05 volts. Apparently the current strength or "ground amperage" in a near-surface self-potential electrical field is not proportional to the number of pots used.

5) Natural SP anomalies of a few hundred to over a thousand millivolts, and of negative sign by convention, are caused by the iron sulphides pyrite and pyrrhotite, the copper sulphide chalcopyrite, and the native element graphite. Graphite gives the strongest SP reaction, followed by pyrrhotite, pyrite, and chalcopyrite. Strong negative anomalies have also been reported over chalcocite, covellite and anthracite (Sato and Mooney 1960). Because of the many other factors influencing the strength of an SP response, it is not possible to predict which type of sulphide is responsible for the anomaly. A magnetometer or dip needle survey may help to determine whether the magnetic

[1]Consulting geologist-geophysicist, 2111 Carlton Plaza, 140 Carlton St., Toronto, Ontario M5A 3W7

Manuscript approved for publication (March 15, 1981) and published with the permission of E. G. Pye, Director, Ontario Geological Survey.

iron sulphide pyrrhotite is present or not.

6) Magnetic storms, dealt with in the "Instructions" section of this guide, are a natural phenomenon which can be detected by the SP instrument. It has been suggested that approaching earthquakes, or an atomic explosion anywhere in the world could be detected by a monitoring SP instrument. In California, the method is used to locate water leaks in pipelines; in Australia, to detect salt springs; and it can also be used in geothermal exploration and in structural studies. Other applications are also possible but await further research of the SP method.

7) Manganese oxides (psilomelane and pyrolusite wads) have been observed to give positive SP anomalies. In Jamaica, the author detected high grade manganese "veins" or "dykes" which gave strong positive anomalies. The sedimentary Sibley Formation in the District of Thunder Bay, Ontario contains a manganese oxide unit which produces alternating high positive and high negative readings which the author interprets as a possible indication of the presence of graphite.

8) Finally, the peak of an SP anomaly is detected with the measuring pot positioned directly above the source. This is in contrast to other electrical methods which can be responsive to the dip of the anomalous source, and through misinterpretation have led to some drill holes that have overshot, or have been spotted too far from or too near the target.

BRIEF HISTORY

The SP method is the earliest electrical geophysical method to be discovered or invented. It was first applied in England by Robert Fox (1830) who conducted SP research around the tin mines of Cornwall, and later by Carl Barus (1882) who applied the method at the Comestock Lode in Nevada. The first sulphide orebody discovered by an electrical method was detected by SP at Nautenen, Lapland, Sweden in 1907 (Lundberg 1948).

BRIEF THEORY

Most explanations of the SP phenomenon propose that a "wet" sulphide (or graphite) body develops negative and positive electrical potentials at its top and bottom, resulting in a both metallically and electrolytically mediated "flow" of electrochemically generated current around and through the body as shown in Figure 1.

It is possible that sulphide and graphite bodies in contact with ground water electrolytes induce a "spontaneous" DC flow of current, but local ground currents are not solely related to potential differences arising from spontaneous polarization of a conducting body. The author considers that the natural telluric fields and currents encircling the earth provide a natural applied electrical

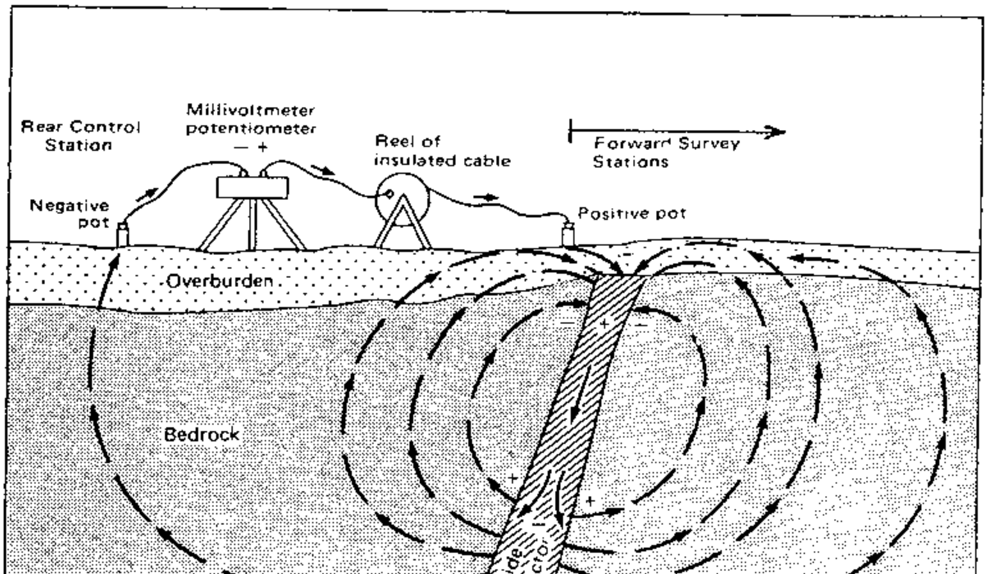

Figure 1—Schematic representation of spontaneously generated electric current flow near a sulphide body, showing current paths through the ground and the SP apparatus (after Lang 1970).

field which—close to an electrolyte-bathed SP body—can give rise to a "conductive" spontaneous polarization effect which distorts the local primary geosymmetry of natural electrical fields near the earth's surface.

For example, if these ground currents are flowing through an electrically isotropic and homogeneous rock type, they are like the parallel, equispaced strings of a harp, and a uniform potential difference field is developed (see A in Figure 2). If they are passing through different rock types with different conductivities, some of the nearbv "harp strings" will converge slightly to take advantage of a better conducting rock unit, resulting in a "resistivity" map which differentiates between different conductivities of the rock types (see B in Figure 2). If the currents come upon sulphides or graphite they will be drawn towards such bodies in an attempt to flow through them, resulting in a high potential or anomaly (see C in Figure 2). Finally, in a strong magnetic storm, the harp strings will quiver as if they were being stroked (see D in Figure 2). The effect of a magnetic storm will be discussed at greater length in the "Instructions" section.

COMPARISON OF ELECTRICAL GEOPHYSICAL METHODS

Although the SP method was extensively and routinely used during the 1930's and 40's by many well-known professional geophysicists, currently, it is generally misunderstood or overlooked as a useful and economical geophysical prospecting method.

The first orebody found in Canada by electrical methods was surveyed by Hans Lundberg (1928) at the Buchan's Mine in Newfoundland, where conductive ore was detected using the SP method. At least one orebody was found in the Noranda area and Lundberg (1948, p.179) reports: "...a lead-zinc-copper orebody was found in the Eastern Townships of Quebec. This survey was carried out by A.R. Clark and H.G. Honeyman, and the results were well confirmed by subsequent drilling." He also states: "The outlining of the Flin Flon orebody in Manitoba is perhaps the best known example of his [Sherwin Kelly's] surveys."

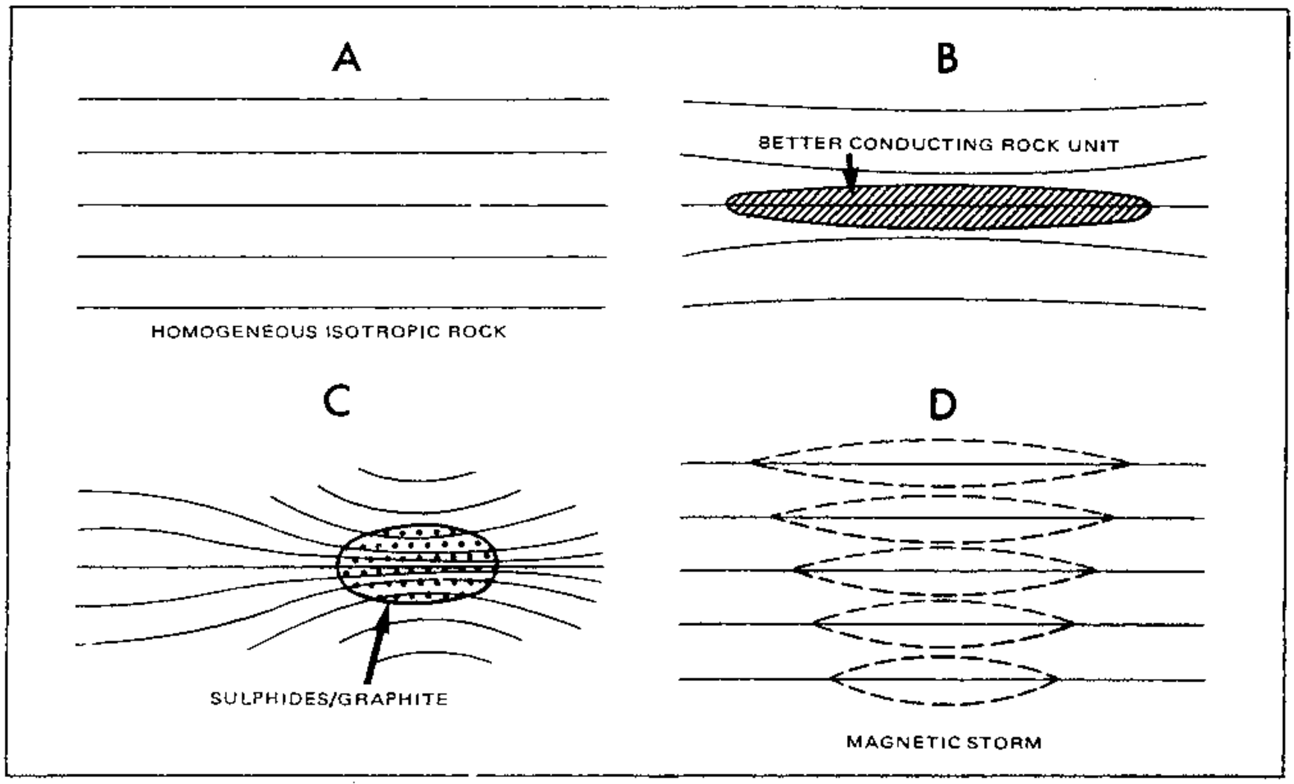

Figure 2—Schematic representation of various naturally occurring configurations of electrical equipotential fields.

The author was involved in early field surveying experiments with the resistivity method, using formulae developed by Dr. Arthur Brant, University of Toronto. This method requires the "pushing" of alternating current into the ground and can provide an excellent interpretive model of the geological stratigraphy and structure. Resistivity surveying can also detect conducting anomalies which may correlate with buried sulphides or graphite. However, the method was found to be cumbersome and slow, and soon gave way to the faster, more portable, but less informative electromagnetic (EM) methods. More recently the induced polarization (IP) method has been developed and applied. It also "pushes" current [as DC pulses which naturally decay] into the ground but is much more cumbersome than the resistivity method, and much more expensive than most of the EM methods. It is considered to be a composite of the resistivity and SP methods and is capable of detecting low resistivity "good" conductors and disseminated sulphides (including oxidized orebodies).

Unfortunately, the interpretation procedure is complicated and the method will equally well detect iron oxides and other semimetallic uneconomic minerals. A drawback with the resistivity, EM and IP methods is that they measure secondary electrical fields which are sometimes difficult to interpret. They also respond to unmineralized wet shears, faults, and fissure zones. Perhaps the most common cause of "false" anomalies with these methods is the variable depth of overburden over the rock surface. If there is a subsurface valley buried by overburden, all the above methods will yield a "psuedoanomaly" similar to an anomaly observable over a massive sulphide zone.

Alternatively, the SP method does not determine secondary fields, so survey results are much easier to interpret. It does not respond to subsurface valleys, wet clay, shears, or faults; and, in the author's experience, the SP method does not provide results which could lead to a false anomaly. In over 500 SP anomalies which were stripped or drilled, the author always found the source of the SP anomaly to be sulphides and/or graphite in the underlying rock.

The SP method responds to good conducting sulphides (both oxidized and unoxidized bodies), graphite, and nonconducting (disseminated) sulphides if these sulphides are oxidizing. The author has encountered only two cases where disseminated sulphides were not detected by the SP method. In one case, an exposure of disseminated pyrite showed no oxidation "rust" (gossan) whatsoever; in another, sulphides of a pyrite-chalcopyrite-bearing copper orebody were also fresh, and the pH of the ground water was found to be 10.0, too basic to oxidize the pyrite. According to Lundberg (1948, p.179): "The self-potential method must be used with some caution....and many orebodies may not cause any anomalies at all, owing to certain ground-water or overburden conditions." The proportion of nonoxidizing, nonconducting sulphide bodies is unknown, but the author expects that the number in Canada is probably very small. It is this small percentage of nonconducting sulphide bodies which prevents one from saying the SP is a "Yes" or "No" method in geophysical prospecting for sulphide ores. It is a Yes or No method for the detection of good conductors only, but not necessarily for disseminated sulphides.

Another feature of the SP method is its ability to differentiate between anomalies caused by sulphides and anomalies caused by graphite. Sulphides produce a range of up to 350 millivolts between the most positive and most negative SP readings, graphite has a higher range. The SP method also has the ability to "smell" an anomaly some distance away and can smell graphite at a greater distance than sulphides.

One of the popular misconceptions about the SP method is that it is limited to shallow depths as its detecting ability is dependent on the presence of oxidizing sulphides which usually occur close to surface of the earth. Lundberg (1948, p.179) states: "The self-potential method is based on the fact that slowly proceeding weathering in the upper portion of a sulphide body is accompanied by electrical potential differences between the surficial oxidiation zone and the deeper nonoxidized portions of the orebody". Lang (1970, p.162) contends this idea by noting that graphite is not oxidizing. The author has located disseminated sulphides under 25 m of sand (including a quicksand layer), and a weak conductor under 36 m of overburden. Lang (1970, p.162) also states: "...reactions at the surface may become too weak to interpret when the overburden is more than about 300 feet [91 m] thick." The author has located "heavy" sulphides capped by 7.6 m of barren rock, with no apparent indications of oxidation.

Another misconception is that one can derive a formula to determine the percentage of sulphides in an SP anomaly based on the strength of the readings. Lang (1970, p.162) states: "The strength of the potential generated depends largely on the concentration of sulphides." One cannot, however, determine any variations in the strength of anomalies as dependent on the concentration of sulphides. For example, the strongest SP value along the strike of an anomaly does not occur where the sulphides are most highly concentrated, but where the source of the anomaly is closest to surface. With a little practice, one can determine whether the source of the anomaly is close enough to the surface to be exposed by stripping. Details are given in the section "Mineral Prospecting with the SP Method".

Although the author has stated that the SP method does not give false anomalies, certain operator errors can produce them. To help operators avoid such errors is one of the objectives of this guide.

LIMITATIONS OF THE SELF-POTENTIAL METHOD

As no one geophysical method is all-embracing, the following limitations of the SP method should be borne in mind when planning surveys:

1) The SP method cannot be used over water. How

ever, Lang (1970, p.162) states: "Where sulphide deposits lie beneath lake waters, the method is not usually applicable *except over the ice in the winter*". Further research is needed to refine this technique.

2) Winter surveys are now possible through snow cover using high impedance voltmeters, but dampness can short-circuit the instrument, extreme cold can weaken the batteries, and ice can encrust the pots and prevent ground contact. Preventive measures include addition of glycerine to the pots, and carefully planned quick checks over target areas, to maximize surveying before prolonged frigid temperatures can affect the equipment.

3) An SP anomaly does not indicate whether conducting sulphides are disseminated or massive. Accordingly, the anomaly could be tested by another electrical method such as VLF (very low frequency) to determine whether it is a good conductor. At the same time, the anomaly could be checked with a magnetometer to determine whether the magnetic iron sulphide pyrrhotite is present.

4) As mentioned in the section "Important Facts", the SP method responds to pyrrhotite, pyrite, and chalcopyrite. It does not respond to zinc, lead, gold, or silver minerals. However, some iron or copper sulphides are generally present with these other metals and, if oxidizing, will result in an SP anomaly.

5) In the case of a strong and obvious graphite SP anomaly, the method cannot indicate the presence or absence of associated sulphides. Presently, only one instrument, the RONKA EM-15, can resolve associated sulphides, but only if the anomalous source is shallow, and if any associated sulphides are good conductors. For reasons not fully understood, this instrument only responds to good conducting sulphides, but not to graphite.

SELF-POTENTIAL EQUIPMENT

A millivoltmeter-potentiometer is used to take SP readings by a needle and scale, digital readout, or an adjustable dial which brings a needle or audio signal to a null position. The operator will likely make fewer mistakes in recording with a digital readout. Readings should be double-checked for precision, particularly at established control stations.

A basic requirement is a reel of wire. In most cases, more than 600 m of wire is desirable. Another useful and timesaving item in conjunction with the use of a long wire is a pair of walkie-talkies. Lastly, the most important items are the porous pots. If these do not function properly, the survey becomes a wasted endeavour. Occasionally the millivoltmeter may get wet and short-circuited. This condition is easy to detect if not to rectify. Also, the wire may develop a bare spot which may make contact with the wet ground and give a sudden strong negative reading. This is also easily identified, though of infrequent occurrence. In some circumstances, an unmonitored pot may change its potential along a survey line and produce false anomalous readings. The pots are crucial to the successful operation of the SP equipment, and accordingly, will be discussed first in the "Instructions" section.

INSTRUCTIONS

(1) Operation of SP Equipment

The Pots

The two pots are generally made of porcelain ceramic in hollow cylindrical forms with porous bottoms. From the caps, copper electrodes are suspended down into the pots. A saturated copper sulphate solution is used as the medium to connect the porous pot contact with the ground, which establishes a mediated electrical contact with the copper electrodes suspended in solution. If two bare metal electrodes made contact with the ground, there would be an instantaneous surge in polarization between them which would then drop quickly to zero. With the copper sulphate solution as the mediator of the ground contact, no net polarization effect involving a discharge of current takes place and the relative potential difference between two survey stations can be measured with considerable accuracy.

Occasionally, the two pots will have, or may develop an inherent potential difference between them. If this is only a few millivolts, no harm is done in running survey lines with the reel and not correcting the individual readings. An error of a few millivolts will not result in false or obscured anomalies. However, a high pot potential difference can be very critical in some situations as discussed below.

The reason for an original pot difference is probably due to slight variations in construction making one pot more porous than the other, and thereby, of a slightly different conductive response. This is usually a fixed and unchanging condition which does not hamper the SP survey. However, a sudden change in pot difference may be caused by a crack, by contact of the porous part of the pot with metal or sulphides, by the drying out of one pot, or by the solution in one or both pots becoming undersaturated in copper sulphate. The pot difference should be checked often; for example, at the start of the day, at noon, at the end of the day, and at each control station and tie-in point.

The filling of the pots must be carried out with care, the level of the solution checked often, and additional crystals or powder added frequently as required. Without ample copper sulphate solids in contact with the solution, a rise in temperature of one or both pots may result in undersaturation. This is because of the increased solubility of copper sulphate at higher temperatures. To make the saturated copper sulphate solution, it is advisable to heat the water as the crystals are being added, until the solution is hot and solid crystals are still present. A pyrex bowl is recommended, as the solution is corrosive, and a wooden spoon or stick is useful for stirring.

Jellying the Pots

If the pots are to be used for a week or more, it is timesaving to make a jelly of the solution. Only enough jellied solution to fill the two pots is required. The operation is similar to making any jelly, except it is advisable to add two or three times as much gelatin to the water to make a good set. The hot water plus gelatin solution should be well stirred as the copper sulphate crystals are added. After the solution has cooled, a few crystals should be added to each pot. The jelly solution can then be poured into the pots, capped, and allowed to set. One set of jellied pots should last an entire prospecting season of 3 or 4 months.

However, the pots should always be stored under moist conditions away from excessive heat to prevent evaporation and danger of drying out.

Pot Difference

Once the pots have been filled and allowed to cool it is possible to determine by a simple procedure whether there is any inherent pot difference:

(1) The pots are placed on or in the ground, close together, with one pot connected to wire running from the positive ("far") connection of the millivoltmeter, and the other pot connected by wire to the negative ("near") connection. A first reading is taken.

(2) The pots are now reversed leaving the same wires attached to the positive and negative connections of the millivoltmeter, and a second reading is taken.

(3) The formula for calculating the pot difference is: (1st Reading + 2nd Reading)/2.

For example, if the *1st Reading* is -8 millivolts and the *2nd Reading* is +10 millivolts, the pot difference is ((-8) + (+10))/2 = +1 mv. These relatively high readings indicate that the potential difference between the ground and each pot is 9 millivolts, suggesting that the pot difference was measured in an anomalous area. However, as long as the correct procedure is followed, the true pot difference is obtainable anywhere. Once the magnitude of the pot difference is established, the positive and negative pots should not be interchanged during the course of SP survey readings. An alligator clamp on the "forward" positive pot is ample identification, and is useful for engaging and disengaging the end of the wire. The pot difference should be regularly monitored and carefully measured at each control station and tie-in point.

The Millivoltmeter-Potentiometer

Most voltmeters are accompanied by full operating instructions which describe how to read the instrument. It is important to emphasize that by convention the *forward* advancing pot should be linked to the positive or *far* instrument connection and the stationary or *rear* control station pot should linked to the negative *near* connection (Figure 1). With the positive pot moving "ahead", anomalies are negative after the traditional Carl Barus method which is the currently accepted convention. If the negative pot is inadvertently sent ahead, strong positive readings would be anomalous.

The Reel of Wire

Wire used in SP prospecting should be strong, thin, light, flexible, and well-insulated with a smooth surface. Depending on the roughness of the terrain, thickness of underbush, and straightness of the traverse line, a 0.8 km length of wire can be pulled off a reel to its end. Wire should be attached to the forward pot by a clove hitch knot, with a bared end connected to the copper electrode which protrudes above the pot cap. The connection should be made with a short piece of insulated wire securely attached at one end to the pot electrode, and to an alligator clamp at the other end in order to make contact with the reel wire. With this arrangement, an SP surveyor can pull the wire and the forward pot with one hand without danger of disengagement of the pot connection.

Theoretically, the potential difference due to the SP effect could be measured with the two pots several kilometers apart. Although impracticable, a longer wire is preferable as more readings can be taken with the millivoltmeter and rear pot set up at a single control station, and fewer control stations are needed as discussed below.

A reel with only 244 m (800 ft) of wire should not be spliced onto an extra length of wire. Regardless of how well the wire is spliced and insulated, it will come apart or become entangled under most field conditions. The time gained from avoiding such survey delays will more than compensate for the cost of an appropriate length (e.g. 610 m (2000 ft.) of wire.

The positive wire from the millivoltmeter should have an alligator clamp to attach to the reel wire, as it is generally necessary to disengage the clamp before the reel unwinds.

The Walkie-Talkies

Although the two SP operators can shout for a few hundred meters and then send messages by tugs on the taut wire, a faster and more reliable survey can result from use of walkie-talkies for voice communication. The forward operator can describe the topography (e.g. swamps, creeks, up-hill, down-hill, etc.) to the note-taker operating the millivoltmeter, and can notify when the forward pot is in ground contact and ready for a reading. Often, the reel will stop, the instrument operator will attach the millivoltmeter at the rear control station wire, and then the reel will suddenly move forward, resulting in possible damage. The instrument operator can also inform the forward operator of the trend of the readings, and, if "smelling" an anomaly, to cut down the readings from, for example, 20 m intervals to 10 m or less for a preliminary detailed survey of the anomaly.

The walkie-talkies should not be so powerful as to interfere with nearby citizens bands.

(2) Conducting an SP Survey

After the pots have been prepared and the initial pot difference measured, they may be combined with the millivoltmeter, the reel of wire, the walkie-talkies, and weatherproof note-taking materials in preparation for an SP survey along a predetermined line grid. The starting procedure will depend on the size of the grid and the length of wire on the reel. For example, the grid shown in Figure 3 is oriented with a base line (BL) parallel to the structure or strike of rock units and cross lines at right angles.

With 610 m (2000 ft) of wire a survey moving from east to west could effectively cover the area as follows: (1) The first control station is established on the base line at cross line 4W. This station is given a *tentative value* of 0 mv. (2) The pot difference is recorded, and (3) SP survey measurements are recorded along with pot locations and other notes, north and south on lines 0, 4W and 8W, as well as readings along the base line between line 0 and line 8W. Readings should never be taken at forward pot spacing intervals of over 15 m (50 ft), except possibly along the base line. In exploration for narrow vein deposits, the intervals should be shortened to define the peak. Bends in the wire of 90 degrees or even 360-degree loops do not affect the readings.

After line 8W has been traversed, readings are taken along the base line to line 16W where a careful measurement is taken and added to the inverse of the pot difference. Next, the second control station at BL,16W is established. If the tentative value of the second control station is +5 mv, then all readings taken from the second control station set-up—along lines 12W, 16W, 20W, and

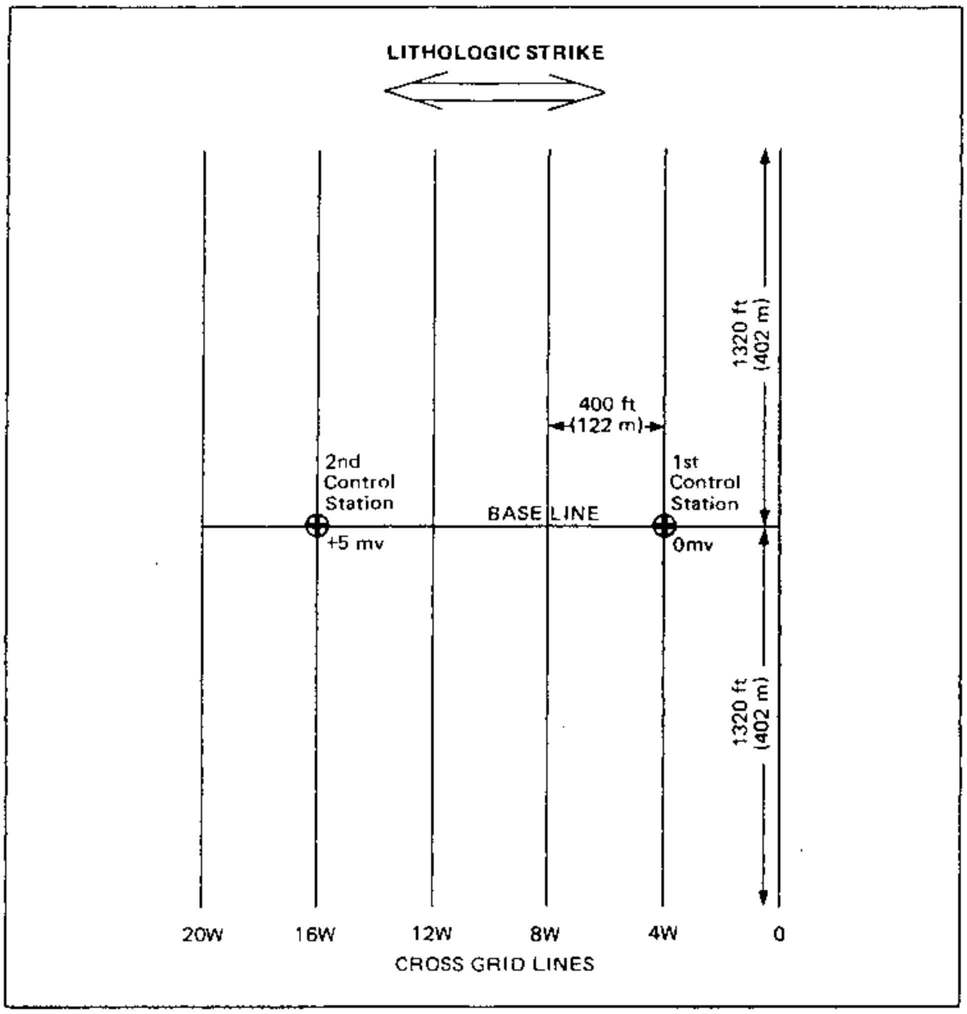

Figure 3—An example of logistical details for an SP survey conducted with 610 m (2000 ft) of wire (see also Table 1).

the rest of the base line—are relative to a value of +5 mv. For example, a reading of -25 mv gives a tentative value for that point, or survey station, of -20 mv. All readings or final adjusted values may be plotted on suitably scaled maps beside the appropriate survey stations.

With only 244 m (800 ft) of wire, an SP survey conducted over the same grid would require more set-ups, or control stations (Figure 4). In such a situation the first control station is set up at 7+00N on line 0 (tentative value 0 mv), and readings taken north, and south to the base line. Along the base line the pot positions should be carefully marked for tie-in with other control stations south of the base line. After the northern part of line 0 has been run, a reading is taken at 4W,7+00N and the inverse of pot difference is added. After this, the rear operator traverses over to 4W,7+00N where a second control station is established. The rest of the northern part of line 4W, including the base line, is surveyed and the procedure is repeated across the northern section of the grid to control station 20W, 7+00N. Next the pots, millivoltmeter, and reel of wire are moved to 20W,7+00S. The southern section of line 20W is traversed, tieing-in at the base line station. Assuming the value at BL,20W had been given as -23 mv from the control station at line 20W,7 + 00N; then, if the reading (including pot difference) from the new control station at 20W,7+00S is +10 mv, it follows that the new control station is 10 mv more negative than the base line at line 20W— thus -33 mv. The survey is continued eastward in the same fashion as the north section. It is unlikely that the rest of the base line tie-ins will check as the potential will have changed somewhat because of moisture and temperature variations. Any discrepancies should not produce or hide anomalies. Nevertheless, it is obvious from the above examples that a longer wire provides better control of background SP variations over a larger area (2 control stations versus 12 control stations and 6 tie-ins), and allows a faster and more efficient survey to be run.

When following the normal procedure of placing the pots on or in the ground, it is possible to obtain variations of up to 110 mv due to the varying acidity and bioelectric activity of soils. Wet swamps tend to give positive SP values, and dry hills negative ones. In areas where there is a more uniform type of soil cover, the background range is

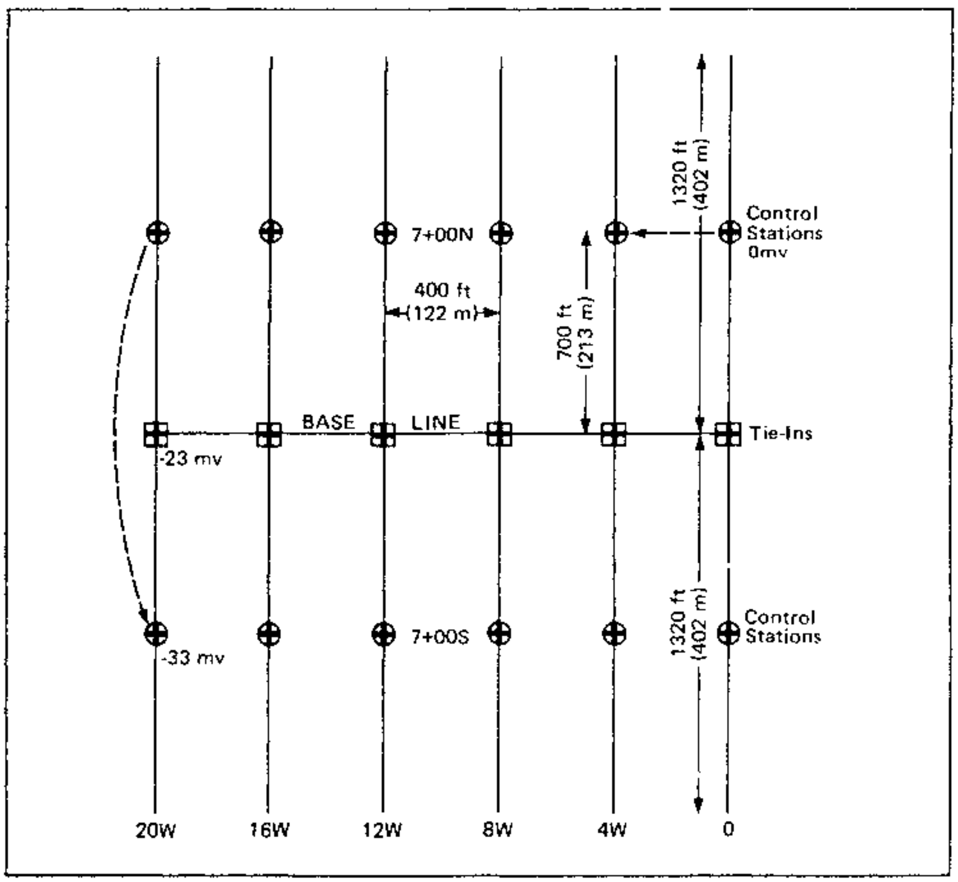

Figure 4—An example of logistical details for an SP survey conducted with 244 m (800 ft) of wire.

much less. As an extreme example of this, a detailed traverse across a 244 m (800 ft) wide tailings pond may give a range in readings from +1 to -1 mv, probably due to the uniform acidity of the tailings. The author observed similar small variations in the residual soils of Jamaica. Lang (1970, p.162) states: "Pronounced slopes... sometimes introduce a topographic effect..." Fortunately, in Canada this potential variation of the background agrees with the topography, and, in nonanomalous areas of swamps and hills, the SP contours correlate to topographic features. This is one reason why the topography at each station should be noted. Another important reason is shown in Figure 5.

Figure 5 represents hypothetical SP values along one line. In example **A** SP measurements occur on a "flat" map showing no topography, such that the weak negatives opposite the **?** would normally be ignored. Example **B** shows a small rise which would explain the negative readings in terms of normal background topographic variation. However, if there is a swamp, as in example **C**, these weak negatives would definitely be anomalous.

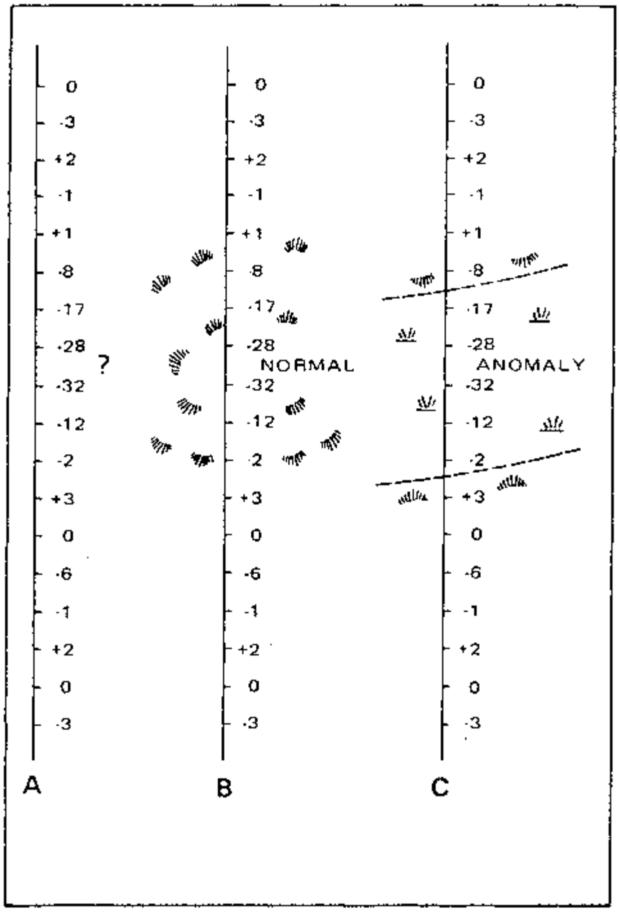

Figure 5—Theoretical SP readings showing the effects of topography.

Under favourable conditions an SP survey such as that depicted by Figure 3 could cover the area with a few hundred readings in one or two days, traversing approximately 4 km of grid. If an SP survey detects strong anomalous negatives and has also covered a few swampy areas, it is likely that the greatest positive and negative values of the survey have been encountered. As an example, SP survey notes might read as shown in Table 1.

If the range of values is of the order of 250-300 mv, or more, about one third of that range is probably background variation due to the varying acidity of the soils. In this case, if the most positive tentative value is near +100 mv, or near +10 mv, it should be given an adjusted value of +50 mv and the other tentative values adjusted accordingly. For example, if the most positive tentative value is +75 mv, it is adjusted to +50 mv, and it follows that a *normalizer* of -25 mv must be added to all the tentative values, as in Table 1, to yield the *final adjusted value.*

If the most positive tentative value is between +40 and +60 mv, no adjustment is necessary. In most cases the most positive value is over a swamp or low wet ground.

In some localized anomalous areas the range from most positive to most negative readings may be 150 mv, or less, and is probably due to a more uniform soil cover. In such a case, the most positive tentative value should be adjusted to about +25 mv. In most circumstances, one does not know at the time when the first control station is set-up, what anomalous conditions will occur. On more than one occasion, the author has unknowingly set-up a first control station over an anomaly and all the subsequent readings were positive to high positive.

The purpose of the adjustment is to attain a final balanced background range about the zero value, such that the anomalous signals are more readily recognized and interpreted. The background is the range of electrical self-potential which is due mostly to variations in topography or soil pH. For example, a final adjusted value of -50 mv on top of a hill would not necessarily be anomalous. A value of -70 mv, or more negative, would be. In the second case above, with a background range of 50 mv or less, an adjusted value of -25 mv on top of a hill would not necessarily be anomalous. A value of -40 mv would be. It should be stressed that over a swamp, as illustrated above, an anomaly due to buried sulphides might be much less negative, or in some cases, a low positive. SP anomalies under swamps and deep overburden are much weaker than on hills and shallow overburden. Thus, topographic information is needed in this type of electrical survey. Below, in the section on "Alternative Field Methods", a simple technique which minimizes the topographic effect is discussed.

Magnetic Storms

Solar flares produce geomagnetic disturbances which are related to the phenomenon of the aurora borealis and can cause magnetic storms of several days duration.

TABLE 1 | AN EXAMPLE OF SP SURVEY NOTES FOR A SURVEY CONDUCTED WITH A REEL OF WIRE 610 METERS (2000 ft.) LONG ON A 400 ft. – SPACED GRID (see Figure 3).

Control Station	Survey Station	Reading	Tentative Value	+(-25) (Normalizer) =	Final Adjusted Value
			(Millivolts)		
BL, 4W	—	—	0		-25
	BL,3W	+3	+3		-22
	BL,2W	-8	-8		-33
	BL,1W	-12	-12		-37
	BL,O	-7	-7		-32
	O+50N	-2	-2		-27
	:				
	etc.		(a "quiet" area)		
	:				
	BL,16W	+5	+5		-20
BL,16W	—	—	+5		-20
	BL,15W	-25	-20		-45
	:				
	etc.		(probably anomalous)		
	:				
	BL,12W	-70	-65		-90
	O+50N	-44	-39		-64

The intensity and effects of magnetic storms in northern areas are enhanced near strongly magnetic iron formation. During a magnetic storm, SP readings fluctuate in an unpredictable and random fashion similar to fluctuations observable on a magnetometer under the same conditions. Generally, the magnetic storm has no effect on the SP readings until the two pots are more than about 100 metres apart; and increased pot separations increase the violence of the fluctuations. Magnetic storms may start suddenly and last only a few minutes, or they may last a few days. Except for short traverses, an SP survey with a reel of wire is not possible under storm conditions. Below, an alternative field method will be discussed which can avoid the effects of a magnetic storm.

(3) Alternative Field Methods

Topographic Problems

Although the influence of topography on SP readings may be interpreted and anomalies recognized, the problems can be confusing to the inexperienced operator. For several years, the author has used a technique which effectively inhibits the topographic effect and gives better ground contacts, even on rubble and bare outcrops.

First, two porous canvas sample bags are filled with material which will stay wet for several hours, such as black muck, loam, or sawdust. Second, a pot is inserted in each sample bag and tied on. Both pots are then in contact with a medium of constant pH, and the influence of varying acidity is strongly attenuated. As a result, readings become more uniform, the background displays a narrower range, anomalies in swamps are better defined, and anomalies on hills are less negative and less exaggerated. A final adjusted value of +10 mv for the most positive value is adequate, and a -25 mv value may be anomalous.

Magnetic Storm Problems

A magnetic storm can hamper or preclude an SP survey conducted with a reel of wire. However, by moving both pots at a constant separation along a survey line, it is possible to overcome the effects of a magnetic storm. Only on rare occasions such as in northern latitudes near strongly magnetic iron formation, could there be any fluctuation with a pot separation of about 15 metres (50 ft) or so.

There are two alternative methods by which two operators can move aong a survey line without the reel, but linked together by about 20 m of wire, to allow for 15 metre-spaced (50 ft) readings in rugged topography. Both methods are much faster than a survey conducted with a reel since it is not necessary to walk back along a line and reel the wire in. From the base line the operators can survey along the longest lines, traverse across along a tie-line or through the bush to an adjoining line, and survey along it back to the base line, and over to the starting station to tie in—similar to magnetic surveying methods.

One method requires that the rear negative pot be moved up to the same ground contact location on which the forward positive pot was positioned. Under field survey conditions this method is impracticable due to the difficulty of placing the rear pot on the exact ground contact position of the forward pot, such that every station becomes an uncontrolled "control station".

A preferable alternative for SP surveying during magnetic storms is the "leapfrog method" shown in Figure 6.

This method solves the problem of uncontrolled control stations, but adds to the arithmetic computations of the operator taking notes since each station has to be evaluated before the next station is "read". Both of the methods involve adding the inverse pot difference to each reading.

For example, the leapfrog pattern can be started from an established control station on the base line with an assigned tentative value of 0 mv. An example of typical survey notes is shown in Table 2.

The control station, with a tentative value of 0 mv, reads the positive pot at 0+50N. The reading is +5 mv; thus, with a pot difference (P.D.) of -1 mv, the corrected reading is +6 mv and the tentative value is 0+6 = +6 mv. Next, the negative pot is moved to 1+00N and reads station 0+50N. The corrected reading is -9 mv. Thus, 0+50N is 9 mv more negative than 1+00N; or 1+00N is 9 mv more positive than 0+50N. Thus 1+00N has a transposed reading of +9 mv (see Table 2), and the tentative value at 1+00N is (+6) + (+9) = +15 mv. The positive pot is then moved from 0+50N to 1+50N. Station 1+50N has a tentative value of +31 mv. The negative pot is then moved to 2+00N and reads 1+50N. If the corrected reading is +36 mv, then the transposed reading of -36 mv means that 2+00N is 36 mv more negative than 1+50N and thus has a tentative value of -5 mv.

To ensure that results are meaningful, it is important to keep a careful record of each reading and calculation for later rechecking. On returning to the base line, the readings should be tied-in to the control station from which the traverse started. An exact tie-in or equivalence of starting and finishing readings at the control station is unlikely, but depending on the number of stations read, one can treat the tie-in error as one would treat corrections for magnetic diurnal variation during a magnetic survey. For example if the tie-in reading is +50 mv after 50 readings, then working backwards one would distribute the discrepancy by adding -50 to the last reading, -49 to the second last, and so on. However, if the change in readings at the control station is several hundred milli-

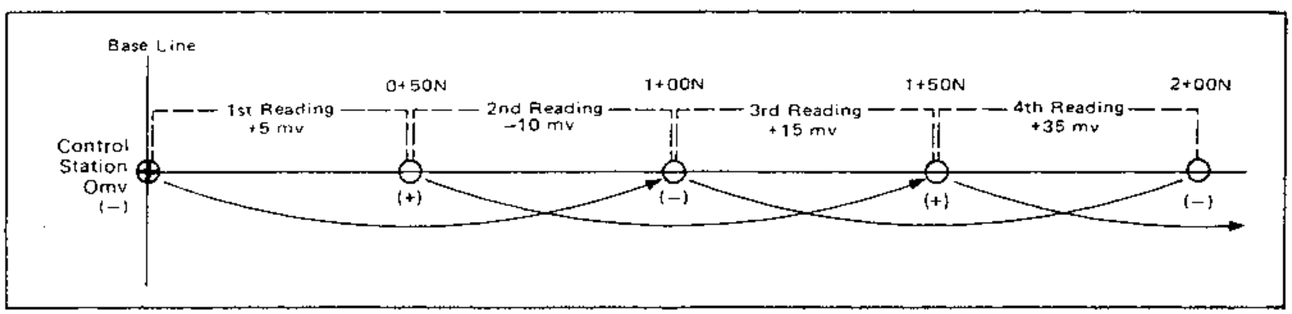

Figure 6—An example of the "leapfrog" method of SP surveying with a fixed length of wire (see also Table 2).

TABLE 2 | **AN EXAMPLE OF SP SURVEY NOTES FOR A SURVEY CONDUCTED USING THE "LEAPFROG" METHOD WITH A FIXED LENGTH OF WIRE** (see Figure 6).

Control Station	Survey Station	Pot	Reading plus inverse Pot Difference P.D. = (−1)	Transposed Reading at Negative Pot	Tentative Value	Final Adjusted Value
				(Millivolts)		
BL,O	0+00	(-)	–	–	0	....
	0+50N	(+)	+5+(+1)=+6	+(+6)	+6	....
	1+00N	(-)	-10+(+1)=-9	-(-9)	+15	....
	1+50N	(+)	+15+(+1)=+16	+(+16)	+31	....
	2+00N	(-)	+35+(+1)=+36	-(+36)	-5	....

volts it is necessary to recheck calculations or resurvey the lines.

Although faster, this alternative method is somewhat complicated, requires careful arithmetic, and usually involves an adjustment to bring the relative values into reasonable perspective for interpretation. Despite savings in time, it is not recommended unless one is obliged to use it due to magnetic storms or a shortage of wire.

(4) Notes on the Interpretation of SP Survey Results

The results of an SP survey can be effectively represented and interpreted by using maps on which the final adjusted values are shown along with SP line profiles, or more preferably, SP contours of appropriate intervals. If a good background range is established, most anomalies are well delineated as more negative areas.

Anomalies of -450 mv, or more negative, are due to graphite, but anomalies of -350 to -400 mv can occur in a variety of lithologic or mineralized conditions. Generally, detailed follow-up readings along the strike of the anomaly can resolve some of the possibilites.

Another situation sometimes encountered during an SP survey is a line of values which are more negative than the values along the adjacent lines on each side. This means that the anomalous SP contours run along the line at right angles to the base line and also to the regional strike. This condition may either be due to a loss of control, or the presence of a crosscutting conducting body which may contain sulphides. Loss of control may be due to a sudden change in pot difference, an erroneous reading (value) of the control station, or location of the control station over an anomaly. Similar to magnetic surveys, SP surveys are better controlled from nonanomalous control stations. If control stations are to be set up on the base line, it is preferable to first survey the base line, back and forth if necessary, to establish reliable values. Then, if some parts of the base line are anomalous, these should be avoided as control stations if possible. Since slight variations in moisture or temperature can change the electrical potential of any station, it is likely that in an anomalous area the change will be greater. To determine the cause of an anomalous line of values, the readings along it should be repeated. Repeated surveys of SP anomalies due to buried conductors are generally replicative; although, they may change in strength due mainly to variations in the level of the water table. A low water table produces stronger negatives than a high water table.

If duplicate readings should substantiate that an anomaly follows along a survey line, some follow-up cross traverses perpendicular to the line may be required in order to detail the anomaly as depicted in Figure 7.

In some cases the line profiles or contours of SP values may be used to approximately indicate the direction of dip of a conducting body (see Figure 8). This is particularly so in level areas of no topographical effect or when using the canvas sample-bag method (see "Alternative Field Methods")

(5) Mineral Prospecting with the SP Method

The main procedures of the SP method are described under the heading "Conducting an SP Survey" SP prospecting may be conducted with a reel of wire; or, at a constant pot separation, depending on which is more

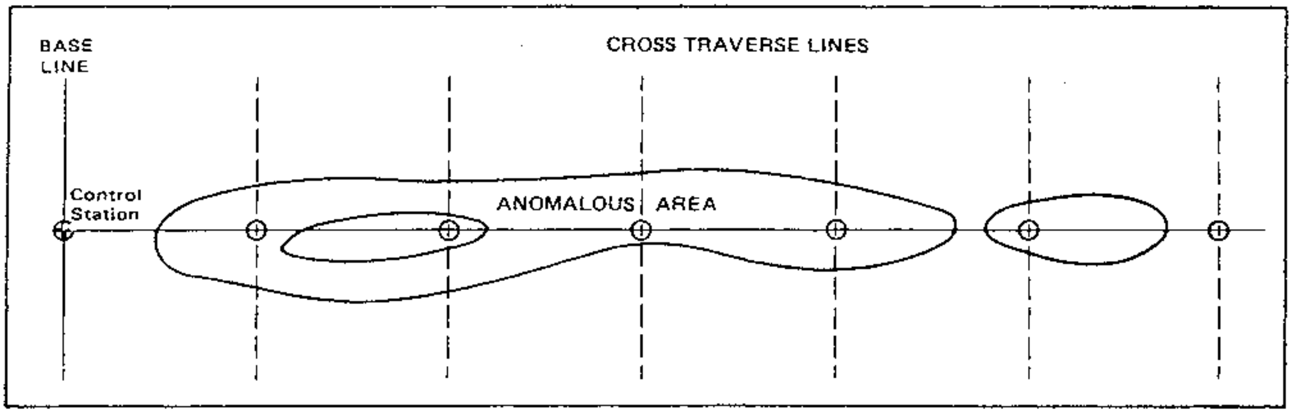

Figure 7—An example of an SP anomaly (arbitrary contour values) detailed by cross traverse lines.

convenient. Normally, it is not necessary to cut picketed grid lines for prospecting, as pace-and-compass traverses provide sufficient control over location of anomalies.

When an anomaly has been detected it should be "peaked up". This means that the forward pot is moved back along the survey line until the highest reading on that traverse line is accurately located. This may require moving the pot only a few centimetres along the line. Next, the rear pot and millivoltmeter are moved up close to the anomaly, preferably at or near a surveyed station so that the new control station can be tied-in to the rest of the survey values. As an example, the peak on the survey line in Figure 9 is -225 mv; since somewhere along strike the peak could rise to a "graphite" level, it is necessary to maintain some control over the relative magnitude of SP values. Assuming the new control station is found to be valued at -125 mv, it is possible to do a further check perpendicular to the traverse line to establish the location of the anomaly peak more accurately. If there is higher ground to the right and lower ground to the left, it is preferable to test the higher ground first by a detailed parallel traverse line some 5 to 10 m from the original survey line, as shown in Figure 9.

If a second peak of -285 mv is located to the right, this means that the best direction was chosen, and another detailed traverse line should be surveyed farther to the right. The third peak may be only -105 mv. Thus the strongest vaule is near -285 mv. Next, it is possible to pinpoint the SP target by "potting" along strike until the maxi-

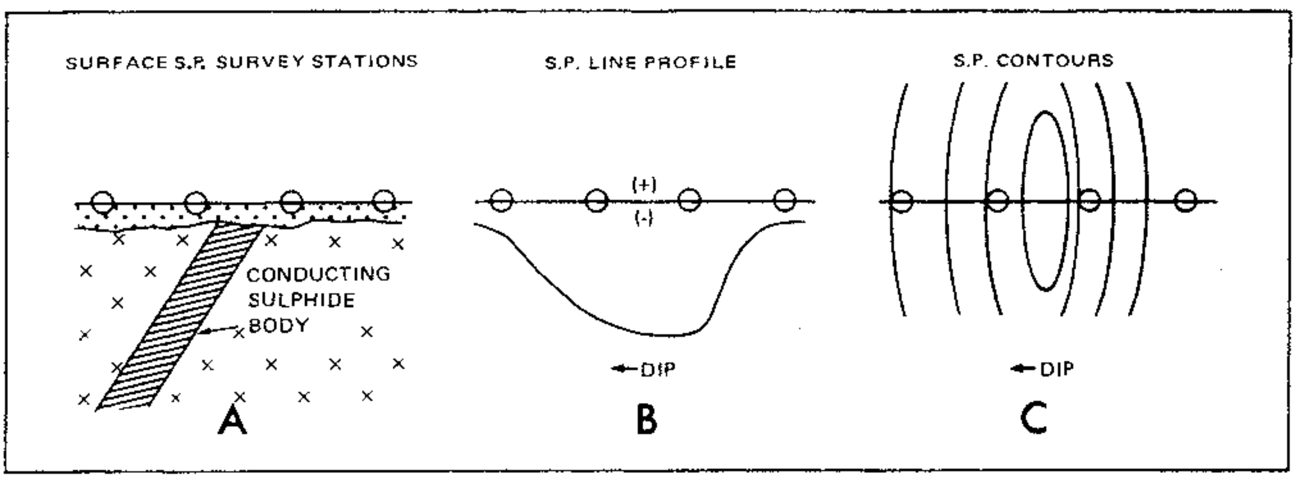

Figure 8—An example of dip determination using SP data.

*(**A**)—cross-section of a dipping sulphide body.*

*(**B**)—line profile of SP readings over (A) showing smooth gentle slope on the down-dip side and steep abrupt slope on the up-dip side.*

*(**C**)—contours of SP readings over (A) showing wider spacing interval down-dip and a closer interval up-dip.*

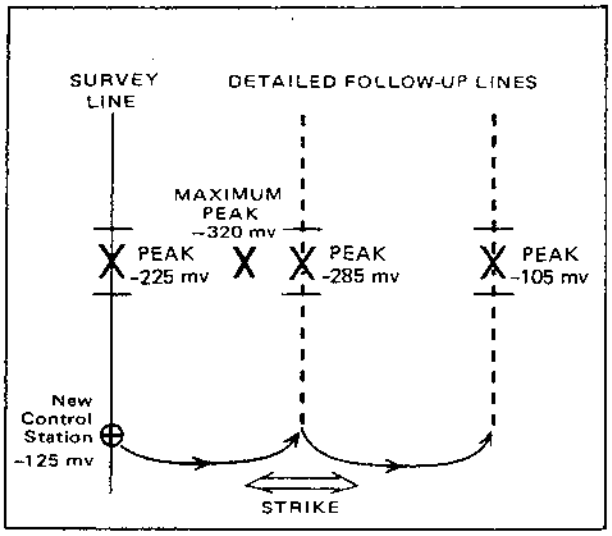

Figure 9—An example of detailed follow-up surveying used to locate a maximum SP peak.

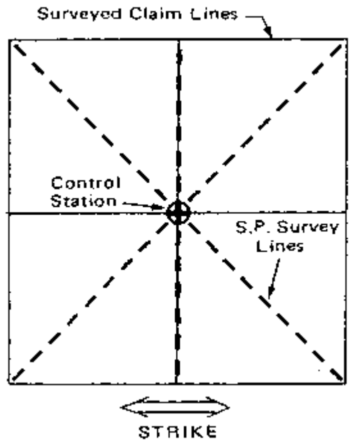

Figure 10—The "spiderweb" method of SP surveying.

mum peak is located, probably between the original traverse line and the -285 mv value for the above example. Assuming the highest peak value is -320 mv, this is where the source of the anomaly is closest to surface. To evaluate whether the anomaly can be exposed by stripping, it is necessary to "pot" around the highest peak by taking a dozen or so readings over an area of about 30x30 cm^2 (1 ft^2).

If the readings around the peak vary by only 1 to 5 mv within the square area, then the source of the anomaly is probably below the water table and inaccessible by ordinary overburden stripping. If the readings vary by 5 to 15 mv or more, the anomaly is above the water table and probably may be exposed by stripping off the overburden with a shovel and pick. If the peak area varies by 25 to 50 mv or more, the source of the anomaly is probably graphite which may, or may not, be above the water table.

An alternative to the grid prospecting method for surveying well-staked contiguous claims is the "spiderweb" technique illustrated in Figure 10.

Four claims can be covered from a single control station. This method is recommended for base metal prospecting in areas where only large sulphide bodies are of interest. It is not recommended for gold prospecting.

CONCLUSIONS

Lang (1970, p.162) states: "Of all the geophysical methods applicable to the search for sulphides, the spontaneous polarization technique provides the quickest field procedure and also furnishes highly definite information as to the occurrence or absence of sulphide mineralization...With the exception of graphite there are but few insignificant factors to lead the geophysicist astray when interpreting the spontaneous polarization results."

Nevertheless, because varying concentrations of iron sulphide are common near the surface of the earth's crust, and are readily detected by the SP method, there may be a considerable number of SP anomalies which are due to uneconomic mineralization. Thus SP should be combined with other prospecting methods when the nature of mineralization is in doubt. Also, laboratory and field research into several important aspects of the SP method are lacking. For example, the feasibility and effectiveness of SP surveys over ice are not well established. Other areas of possible investigation include the effects of magnetic storms, the extra intensity of these storms near major iron formations, the effect of hydrothermal alteration on SP anomalies, improvement of the canvas sample-bag technique (see "Alternative Field Methods") to eliminate potentials due to varying soil acidity, derivation and refinement of topographic correction techniques, and use of the SP method to monitor earthquakes or atomic explosions.

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