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The following file is part of the

James Doyle Sell Mining Collection

Slide 1 Tombstone District, Ag, by B. Devere (1

Location – SE cor Ariz, 65 miles SE
Tucson – 25 miles N. Mexico Border
Production
170,000 oz Au current value
35 million oz Ag $1.3 Billion =
45 million lbs Pb $870 / ton
2.5 million lbs Cu
1 million lbs Zn
ore production, small 1.5 million Tons.

Slide 1 (2

Districts three Areas
Western Igneous
Ajax Hill Horst
Tombstone Basin
—
TKsg & TKsf, TKsg 72 my fresh, Barren, medium gr granite, TKsf 71±2 my slidly welded, flow banded tuff – two closely related spatial & temperally – tuff less mafic & more siliceous than Gd – suggests differentiates of same magma

Slide 1 (3
Ajax Hill Horst
Pe – IP age rocks – fault bounded
Ajax Hill fault – Right-lateral with considerable vertical offset – K faulted against Є & Pe
Horquilla Peak fault –
Prompter fault – system, southerly dipping faults – Left-lateral, offsets Ajax Hill – pushing fault Westward – horizontal offset est 1200'
Vertical offset ?
Faults are pre TKsg & TKsf

Slide 1 (4

Tombstone Basin

Broad syncline - plunges E-SE @ 10°-30°

down faulted into graben - Prompter on South
Highway on North

Truncated by TKsg on west

Slide 2 (5

90% of districts production from Basin.

Broad syncline complicated by NW-SE trending
anticlines & synclines that corrugated Broad syncline

Rock units

Paleozoic on southern limb & to SW

Kb in core

~~Bas~~ lower 100' of Kb important - Replacement deposits

Basal limy, sandy, shaly congl. 60' thick, Novaculite.
overlain by 34' thick Blue Limestone - Remainder
of fm is 2900' of SS, silt & mudstone with thin Ls.

Slide 2 (6

Basin cut by dks of monzonite & syenodiorite
related to TKsg & Andesite por dks
younger than TKsg & TKsf - probably related to
volcanics SW of District.

Fault fissures - Red

Tranquility fault - post-mineral cuts orebodies
on west side - is E dipping with E side down
also Right lateral - strike slip offsets Prompter fault
400 ft. - vertical offset at least 400 ft.

Slide 2 (7

Units of Ajax Hill horst

P€ schist & granite

€ Bolsa quartzite & Abrigo Ls.

D Martin Limestone

M Escabrosa Limestone

IP Horquilla Ls.

Rhyolite dikes & sills - 63 my.

Slide 3 (8

Alteration

Thermal - associated with TKsg.

Skarns - grossularite, diopside & wollastonite.

Coarse Rexlyn marbles grade to fresh Ls.

Baked mud & siltstone of Kb.

AJax Hill & Prompter faults conduits of heat transfer

Kb better heat conductor then Ls. Baking farther from intrusive the Rexlyn Ls.

Slide 3 (9

Hydrothermal

Silicification & hornfelization

"Novaculite" basal Kb unit converted to quartzite & Jasper

Hornfels types

Argillic, chlorite-silica, Epidote-Silica

Hydro Alt in Ls., fn Rexlyn, vns & pods 2nd calcite, pods of Fe Mn oxides with minor Cu, Pb, Zn carbonate

weak to moderate SiO2

Epi-SiO2 zone appears to surround best mineral in breccia & Ls

Slide 3 (10

Dikes — Argillic & Qtz-ser Alt in Menz & Rhy dks & sills — not prevasive.

strongest where fissures cut dks & sills elsewhere very weak.

Slide 3 (11

Mineralization

Orebodies occurs as oreshoots in fissure & replacements in L.S. — most are producded oxides

Limonite		Pyrite
manganese oxide		Galena
Cerargyrite		Tethedrite
bromyrite	oxidized	Sphalerite
Cerussite	from	Alabandite
Smithsonite		Chalcopyrite
malachite	Galena & tethedrite argentiferous as	
+ Native Au & Ag	is some of Pyrite	

Slide 3 (12

Pyrite zone — Limonite / Pyrite — prevasive

Low total sulfide content est 1–2%

occurs as diss grains & discontinuous fracture fillings

Slide 3 (13

Source of mineralization

assumed to b TKsg - Not, TKsg not in slide no Alt, no min -

If barren stock had been source should show in skarns does not, no Fe, No Base metals, no SiO_2

Hydro Alt & Py zone 1500 - 2000' E of Gd.

Largest & Richest orebodies N&NE edge of district

Source located in N & NE - solutions moved upward & southwesterly along fissures - fissures were only channelways of mineral solutions in district -

Slide 4 (14

Types of orebodies,

Ore shoots in fissures -

Westside fissure mined semi continuously for 2600' along strike & to depth of 800 feet near westside shaft.

Skip Shaft fissure - mined for 900' along strike & to depth of 600'

Extension Fissure - mined for 1000' along strike & to depth of 500'

ore shoots varied from 2'-20' in width and averaged about 10'

Slide 4 (15

Tabular replacement ore bodies

Luck Cuss fault -

Where fissures encounter pre-existing faults & dikes at low angles, ie Lucky Cuss Fa & Contention dk, They hook into the pre-existing structure & parallel it for some distance -

created long tabular Replacement orebodies in fault & wallrocks of Lucky Cuss -

In dikes created long - wide shatter zones where the fractures were filled with sulfides thus creating large - low-grade orebodies

Slide 4 (16

Pipelike Replacements associated with Prompter fault -

Where fissures encounter the Prompter fa ~~at~~ high angles they create "pipelike" replacements in the Northern ~~hanging~~ foot side wall of the fault -

Fault like sponge - absorbed movement of fissures

Very few go through - & confined mineral to northern wall, even though southern - hanging wall an favorable Ls. - deposits small & low grade - far from source - localized at fissure - fault intersection

Slide 5 (17

Replacements in Blue Ls below hornfelsic [illegible] mud & siltstone of Kb.

Slide a photo of a section drawn in 1881

Bears NW-SE looking NE through Goodenough orebodies on North side of district - note replacement under hornfels in Blue Ls.

Slide 6 (18

Photo of same group of 1881 drawn sections

Bears NE-SW, looks NW along Westside fissure -

are in crest of anticline & down limb to NE -

Note units -

All large replacement deposits found to date formed in Blue Ls.

Below hf mud & siltstone & in Red below silicified Novaculite -

Slide 7 (19

Show location of Sections A-A' & B-B' plus Drill holes - drilled by Newmont in early 1950s

(20

Slide 8

describe stratigraphy of Tombstone Basin

Note that Ped, Pc, Ph & Me are Massive Limestones with no shale capped members, i.e. less attractive targets for replacement ores -

Favorable replacement Horizons

Earp Formation - 584' Ls, Sh & Ss.
Martin Limestone - 229' Ls & Sh
Abrigo Limestone - 844' Ls & Sh.

(21

Slide 8

Dm & Ɛa most favorable replacement horizons in Southern Ariz - wherever they occur in favorable location for ~~m~~mineralization, in other mining districts they have been extensively replaced by high-grade base metal sulfides -

No Reason why Tombstone should be exception -

Units deep 4500 - 5500 below surface -

(22

Slide 8

Pe (Earp fm) with its shale capped limestones should be just as favorable as the Martin & Abrigo - in Tombstone Basin should be at 2000 - 2600 feet below surface.

Many geologists have proposed that Tombstone ores were shallow - confined to ~~zone~~ area near unconformity between Cretaceous & Paleozoic and do not extend to great depths — That hypothesis is not true

(23

Slide 8

Drill hole - 1995' deep, drilled from 600' level of Westside - Bottom 2450' Below surface.

Hole encountered.

40 ft of	Along dike 14 ft. of
0.60 oz Ag	2.13 oz Ag
1.1% Pb	0.32% Cu
1.6% Zn	6.07% Pb
	5.72% Zn.

Hole Bottom in dike according to logs.

(24

Slide 9

Section similar to previous slide but hole is 1500 ft. NE of hole on other section.

Hole 1650 ft. deep, drilled from 600' level of Silver Thread, Bottom is 2050 below the surface - Hole did not test favorable Earp fm

@ 1290' 5' of	@ 1440' - 15' of
0.015 oz Au	1.5 oz Ag
3.55 oz Ag	4.22 % Pb
0.92% Cu	3.66 % Zn
8.18% Pb	
3.96% Zn	

Slide 9 (25

Between 1500 & 1580' there are 5 one to two foot intercepts of massive sulfides, those intercepts varied from low of. to high of.

2.0 oz Ag	7.9 oz Ag
6.3% Pb	18.7% Pb
9.6% Zn	24.5% Zn.

Intercepts in the two holes do not necessarily represent orebodies in themselves but do prove mineralization at depth and support conclusion that favorable limestone likely contain large replacement deposits below shale caps - Lights - questions.

Talks for ASARCO Newark, N.J. Expl. Meeting Feb. 18-22, 1980.

1) Exploration Guides to Carbonate Hosted Massive Sulfide Deposits in Western Cordilleran, by JDS

2) Superior East Project, Az, by JDS

3) Tombstone District, Az, by Bert Devere

Start Slot 64 Position

Slide 1 (Geologic Map - Tombstone Mining District)

The Tombstone Mining District is in the SE corner of Arizona, 65 miles SE of Tucson and 25 miles west of the Mexican border.

Mines in the district have produced approximately 170,000 oz gold, 35,000,000 oz silver, 45,000,000 pounds lead, 2.5 million pounds of copper and a million pounds of zinc. Total ore production was small about 1 1/2 million tons but if that ore were produced today it would be worth 1.3 Billion dollars or $870 per ton.

The district can be divided into three areas, the igneous rocks in the western half of the district, the Ajax Hill Horst and the Tombstone Basin.

The igneous rocks are two - the Schiefflin granodiorite and the Uncle Sam tuff. The granodiorite is a fresh-barren-medium grained 72 m.y. old stock. While the tuffs are fine grained, slightly welded and have moderately well defined flow structures. They have been dated at 71 ± 2 m.y.

The close releationships of the two rock types both spatially & temporally and the tendency for the tuff to be less mafic & more silikeous than the granodiorite suggests that they are differentiates of the same magma.

The Ajax Hill Horst is a fault bounded mass of precambrian - Pennsylvanian - Permain rocks that are cut by 63 m.y. old rhyolite dikes & sills. The boundry faults predate the granodiorite and tuff and are the Ajax Hill fault, a Rightlaterial strike-slip structure that has a large dip component as here you can see Cretaceous rocks are faulted against Cambrian rocks. The Horquilla Peak fault bounds the horst on the south and southeast and the Prompter fault system this series of structures through here - bound it on the North. The Prompter system is a series of southerly dipping left-laterial strike-slip faults that are younger than the Ajax Hill fault but older than the Uncle Sam Tuff. Where the Prompter & its associated structures cut the Ajax Hill fault they have pushed the Northern extension of the Ajax Hill fault westward - the horizontal displacement is estimated to be about 1200 feet while the vertical displacement is unknown.

The Tombstone Basin is a broad syncline that plunges 10-30° to the E-SE ~~and~~ which has been down-faulted into a graben between the Prompter fault on the South, the Highway fault on the North. The Schieffelin granodiorite truncates the syncline and graben to the west.

Slide 2 - (Geology Central portion Tombstone District)

The Tombstone Basin is the location of about 90% of the districts production - this slide is an enlargement of that area.

The broad downfaulted syncline of the basin has been complicated by a series of small NW-SE trending anticlinal and synclinal folds, shown here, that have corregated the syncline from NE to SW.

Rocks within the Basin are the:

Pennsylvanian-Permain Horquilla Limestone and Earp formation

and the Permain Colina Limestone and Epitaph dolomite.

which are exposed along the southern limb of the syncline and the Cretaceous Bisbee formation that occupies its core.

The Bisbee formation is 3000 feet of sandstones, mud & siltstones, limestone & conglomerates. The lower 100 feet of the formation is important for it is there that the limestone replacement deposits have been found. At the base of the formation is the 60 foot thick "Novaculite" a limy, sandy, shaley conglomerate which is over lain by the 34 foot thick Blue Limestone. The Remaining 2900 feet are mud-silt and sandstone and occassional, thin limestone beds.

The Basin is cut by monzonite and syenodiorite dikes that are probably related to the Schieffelin granodiorite and andesite porphyry dikes that are younger and are probably related to the volcanics that crop out 6-8 miles southwest of the district.

Across the Prompter fault system which is here, to the south is the Ajax Hill Horst and exposed there are Precambrian Schieffelin Granite

Cambrian Bolsa Quartzite & Abrigo Limestone

Devonian Martin Limestone

Mississippian Escabrosa Limestone
and the
Pennsylvanian - Permian Horquilla Limestone

as well as the Rhyolite dikes & sills.

Two other significant features appear on this slide the fault-fissure, shown here in red and this fault system the Tranquility - the fault system is very young and cuts off all mineralization to the east for about 6000 feet — until you get into the Tombstone Extension mine in this area. the intervening 6000 feet is mostly alluvial covered though some upper Bisbee formation rocks do outcrop. The fault is a easterly dipping Right-lateral strike-slip structure that has off set the Prompter fault about 400 feet, in this area in this area. Its eastern side is down dropped at least 400 feet.

Slide 3 (Alteration)

Two general types of alteration occur in the district - Thermal associated with the Schiefflin granodiorite and hydrothermal associated with the mineralization.

The thermal alteration occurs as calc-silicate skarns made up of grossularite, diopside & wollastonite in the limestone adjacent to the granodiorite and as very coarsely recrystalline, snow white marbles that grade into fresh limestone. The mud & siltstone of the Cretaceous Bisbee formation have been baked. It is evident that the large pre-intrusive faults the Ajax Hill and Prompter were conduits of heat transfer as the thermal alteration spreads out along them for some distance away from the granodiorite, Also, the mud & Siltstones were better heat conductors than were the limestones for Baking extends further in those rocks than recrystallization does in the limestones.

Hydrothermal alteration occurs as Silicification and hornfelization. The Novaculite, the Basal member of the Bisbee formation is intensely silicified to quartzites and jaspers. while the mud-silt & sandstones are converted to argillic, chlorite-silica and epidote-silica hornfelses. The Epidote-Silica hornfels appears to surround the area of better mineralization in the fessines and limestones. Hydrothermal alteration in the limestone occurs as fine recrystallization veines & pods of secondary calcite, iron & manganese oxides usually accompanied by minor amounts of copper, lead & zinc carbonate and weak to moderate silicification.

Also shown on this slide is the patchy argillic & qtz-sericite alteration in the monzonite dikes and Rhyolite dikes and sills - strong alteration in these rocks usually occurs when they are cut by fault-fissures.

Surface Evidence of base metal mineralization is found in the fault fissures and what is left of the outcropping replacement ores - the minerals are limonite, manganese oxides, cerargyrite, bromite, cerussite, smithsonite, malachite plus rare native gold and silver, all oxidized from pyrite, galena, tetrahedrite, sphalerite, alabandite and chalcopyrite. The galena and tetrahedrite are both argentiferous as is some of the pyrite.

The Red line here outlines an area of pervasive disseminated limonite after pyrite. The total sulfide content was low

1-2% with the sulfides occuring as fine disseminated grains and in small discontinuous veinlets.

The source of the Tombstone mineralization has always been assumed to be the Schieffelin granodiorite which does not appear on this slide because it contains no alteration or mineralization what so ever. If that barren intrusion had been the mineralizer one would expect to find some evedience of that mineralization in the skarns along its contact - there ~~is~~ is none. The skarns contain no iron, no magnetite or hematite, no base metal sulfides or oxides and no quartz. Also, as you can see here the hydrothermal alteration and area of prevasive pyritization occurs some 1500 - 2000 feet east of the intrusive contact. Also, over 70% of districts production came from this area in the northern and northeastern part of the district.

The mineralizing solutions came from a source to the north or NE and travelled upward and southwesterly along the fault-fissures which appear to be the only conduits of mineral solutions in the district.

Slide 4 (geologic map - Central portion of District)

The fault-fissures contain some sizable oreshoots as well as being the feeders for the limestone replacement deposits - The Westside fissure here, has been mined almost continuously for 2600 feet along strike and to depths of 800 feet near the Westside shaft. The Skip shaft fissure was mined for 900 feet along strike and to 600 feet below the surface.

The oreshoots varied from 2-20 feet in width and averaged about 10 feet.

Where a fissure cut a pre-existing fault or dike as here in the Contention dike and here in the Lucky Cuss fault they made different types of ore bodies.

When a fissure encountered a fault or dike at a low angle they usually hooked into the pre-existing structure and followed it for some distance before crossing.

In the faults they created long tabular oreshoots, that often replaced the entire fault particularly if the fault was in limestone as was the case with the Lucky Cuss. In the dikes they created shattered zones where the fractures were filled with sulfides - thus creating sizable low-grade orebodies, as they did in the Contention dike.

However, when a fissure encountered a fault at a high angle as with the Pumpton fault they formed smaller pipe like orebodies in the Scotwell limestones. The large Pumpton fault seems to have acted like a sponge - it absorbed the momentum of the fault fissures as well as their mineralization. The fissures rarely cross the fault and in only one instance have orebodies been found on the southern hanging ~~wall of the fault~~ though favorable limestones occur in that location. The fault has been prospected for over 10,000 feet along strike.

Slide 5 (photo of map #2)

This slide is a photograph of a section that was drawn in 1881 - The section bears NW-SE and you are looking NE through the Goodenough orebody on the northern edge of the district. Here you can see how the ore formed in the Blue limestone as replacements under ~~the~~ hornfelsic mud and siltstone called Shale

on this section - The quartzite are the silicified

Novaculite - the basal unit ~~of~~ the Bisbee formation.

Slide 6 (map C)

This slide is a photograph of the same

series of 1881 maps and sections and Bears NE-SW

X along the Westside fissure - This is one of the small,

anticlines that corrugated the Basin syncline, the ore

formed at the crest of the anticline and down the

limb to the Northeast - ~~the~~ again the limestone is the

Blue limestone, the quartzite the Novaculite but on this

section the Lower limestone is the Permain Epitaph dolomite.

All of the replacement ores found to date have been

in this location - in the Blue limestone, beneath

hornfelsic mud & siltstone caps ~~near~~ the base of

Bisbee formation and in the top of the Epitaph dolomite - Beneith the silicified Novaculite.

Slide 7 (Geologic Map - Central Portion Tombstone)

I have returned to this slide for a moment to show you the location of the next two slides which are section - Section A-A' is through here along this drill hole and section B-B' is ~~along~~ here along this hole. The holes were drilled by Newmont in the early 1950s.

Slide 8 (Section A-A')

This is a generalized ~~section~~ longitudinal section that shows the Newmont hole and the stratigraphy below of the Tombstone Basin. The units from top to bottom are the Cretaceous Bisbee formation with the replacement ores at their base -

The Permian Epitaph dolomite & Colina Limestone
Pennsylvanian - Permian Earp ~~formation~~ & Horquilla Limestone
Mississippian Escabrosa Limestone
Devonian Martin Limestone
and the
Cambrian Abrigo Limestone & Bolsa Quartzite.

The units of interest are the Pennsylvanian - Permian Earp formation, ~~and~~ the Devonian Martin Limestone & the Cambrian Abrigo Limestones.

The Earp formation is 584 feet of Alternating limestones - shales & sandstones while the Martin is 229 feet of limestones & shales and the Abrigo is 844 feet of limestones and shales.

The Martin and Abrigo limestones are the most productive limestone replacement hosts in southern Arizona - in every southern Arizona mining district where these units occur in areas favorable for replacement orebodies, such as here in this area of the Tombstone Basin, they have been extensively replaced and made large high-grade orebodies. There is no reason why Tombstone should be the exception. However as you can see these limestones are deep estimated to be 4500 to 5500 feet below the surface. But the Earp formation with its shale capped limestone members should be equally productive and they should be much shallower, some 2000 to 2600 feet below the surface.

The two deep holes drilled by Newmont both encountered ore-grade sulfides - ~~in~~ this hole drilled for 1995 feet from the 600 foot level of the Westside mine, to a total depth of about 2,450 feet below the surface - encountered 40 ft. of 0.6 ounce silver, 1.1% lead and 1.6% zinc - here, and here along this dike, in the top of the Earp formation, the hole encountered 14 feet of 2.13 ounces of silver, 0.32% copper, 6.02% lead and 5.72% zinc. This is possibly an orebody. The hole bottomed in the dike.

Slide 9 (Section B-B')

This section is similar to the previous section except this hole is location 1500 feet north of the hole on the other section. The hole is 1650 feet deep, was drilled from the 600 foot level of the Silver Thread mine, and bottom about 2050 feet below the surface. As you can see the hole did not reach the Earp formation but it did cut several short intervals of ore-grade sulfides in the massive Colina Limestone.

Here at 1290 feet is 5 feet of .015 ounces of gold, 3.55 ounces of Silver, 0.92% copper, 8.18% lead and 3.96% zinc. At 1440 feet here, there is 15 feet of 1.15 ounces of Silver, 4.22% lead and 3.66% zinc and between 1500 and 1580 feet, here, there are 5 one to two foot intercepts of sulfides that vary from a low of 2 ounces of silver, 6.3% lead and 9.6% zinc to a high of 7.9 ounces of silver, 18.7% lead and 24.5% zinc.

None of the intercepts in either hole necessarily represent orebodies, however they do prove that high grade mineralization exists at depth in the Tombstone Basin and support the conclusion that high-grade replacement deposits likely exist in the shale capped limestones of the Earp formation.

If the replacement deposits can be proven then
we are looking at more than a single mine —
rather
we are looking at an entirely new - high - grade
limestone replacement mining district.

May I have the lights, please

Are there any questions?

12:22
12:~~40~~ 30
18 min.

The subject of my presentation was to be "Decay Curves" but has been changed to "A Review of the Ground EM Methods" with the subject of decay curves brought in as a screening technique.

INTRODUCTION

The effectiveness of the ground electromagnetic method is well established and documented. Its most successful applications have been in the search for steeply dipping tabular sulfide bodies of volcanogenic massive sulfides. It has found its widest application in glaciated areas of moderate topography where overburden and bedrock weathering are relatively shallow. The physical property here involved is, of course, good electrical conductivity of the target sought in contrast to poor electrical conductivity in the enclosing bedrock. Most techniques utilize two electromagnetic coils: one used as a transmitter of and one a receiver, of an alternating (or pulsating) electromagnetic signal. The transmitted primary field (including the effects of homogeneous earth) is subject to distortions caused by secondary fields which emanate from conductive zones or bodies in the ground. It is these distortions that are sought for and measured with the receiving coil. A wide variety of coil configurations and orientations have been used in the various electromagnetic procedures. The more successful ones commonly in use - in recent years - can be roughly grouped into the following categories:

1. vertical loop methods
2. horizontal loop methods
3. Turam method
4. Other methods or special methods.

VERTICAL LOOP METHODS

Figure 1. Two approaches to the vertical loop method are commonly used. In one a vertically mounted transmitting antenna is used at a fixed station and rotated on a vertical axis in such a way that it is always pointed toward the receiver. The receiving coils move along lines perpendicular to the suspected strike and is tipped from a horizontal attitude until the dip of the null position is determined.

Figure 2. In the second approach the technique is similar except that both transmitter and receiver are moved simultaneously (broadside) along parallel lines running at right angles to the conductors being sought. The latter approach is generally used for reconnaissance surveys while the former slower technique is used to detailed surveys or in detailing an individual conductor.

A further variation of the vertical loop system utilizes two transceivers in which the two coils are used alternately as receivers and transmitters. This approach has successfully lessened one disadvantage to the vertical loop system -- its relatively poor performance in rugged topography.

Figure 3. In the horizontal loop system two horizontally oriented coils with an interconnected cable are used. The cable carries a reference signal to which the complex combination of the primary and secondary fields is compared at the receiver. The coils and connecting cable are moved simultaneously at a fixed separation along one line.

Figure 4. The Turam method utilizes a large fixed wire loop that may be more than a mile on a side as an inductive source or alternately a long grounded wire which energizes both inductively and galvanically. Measurements in the field thus produced are measured with two receiving coils which usually

record ratios of field strength and phase difference.

There are other techniques that do not well fit these categories.

Figure 5. The VLF-EM method uses the horizontally oriented very low frequency ratio transmissions of military communications transmitters that may be hundreds or even thousands of miles away. Dip angle measurements are taken as in the vertical loop method just described. As can be seen here there is a preferred conductor orientation.

Figure 5A. Direct energization of conductive sulfide vodies as in the resistivity-equipotential mise-à-la-masse method has its EM equivalents and the Asarco developed drill hole/surface method can be used in this manner.

In recent years pulse methods in which the decay of a residual magnetic field is measured following the interruption of an electromagnetic pulse have received increasing attention. The pulse systems are particularly attractive because of their potential for detecting targets at greater depths than the popular systems of the past, and their ability to function under severe topographic and overburden conditions.

Figure 6. The choice of an EM technique whether it be for general or reconnaissance applications or for some more specific problem involves the consideration of several factors. The major ones to be considered are:

1. required depth of penetration
2. cost and efficiency
3. suitability of terrain
4. ability to detect significant conductors
5. ability to discriminate between conductors.

The first three items are relatively straight forward to deal with. For example, if geological projections place a favorable massive sulfide rock member at more than 300 feet bedrock depth, most presently available commercial surface methods can be eliminated. On the other extreme we might be dealing with steeply dipping, sub-outcropping, highly conductive massive sulfides under less than 50 feet of moderately to poorly conductive overburden. In this case we would be inclined to use the most cost efficient method available since most standard methods would be equally effective.

Topography must be considered in mountainous areas since all techniques can not equally cope with orientation and coil separation errors that result in extreme topography.

In considering items 4 and 5 we are faced with more complex technical problems. A number of factors are involved. These include:

1. transmitting frequency
2. transmitter-receiver separation
3. conductivity and permeability
4. conductor dimensions.

Theoretical considerations and practical experience have led to the following commonly accepted generalizations concerning the three standard methods.

The horizontal loop method is especially well adapted to areas of low topographic relief and shallow to moderate overburden, in the detection of steeply dipping dike-like conductors. It is discriminating in that large formational conductors and flat overburden conductors are effectively screened and that a degree of conductivity discrimination is possible by comparing the quantities generally measured, the in phase and out of phase components, or by varying the frequency transmitted. The method is efficient where cut lines are available but is subject to increasing background noise as coil separation, and coil attitude errors, become inevitable in increasingly severe topography.

Figure 6A and 6B. The vertical loop method has often been used in air-borne EM survey follow-ups or in surveys where a somewhat greater depth penetration is required. It is also subject to coil orientation errors where visability is poor or topography is extreme. Determination of relative conductivity is also theoretically possible. A factor often overlooked in closely spaced transmitter-receiver systems and in particular in the vertical loop technique, is the rapid drop in the energizing or primary field strength with increasing distances from the transmitter (it varies inversely with the cube of the distance). This becomes critical in such approaches as the vertical loop broadside method where the strike is not at right angles to the lines or in vertical loop fanning with a fixed transmitter positioning. These approaches tend to "see" conductors very selectively. A weak conductor immediately below the transmitter will respond whereas a more distant stronger conductor may respond only weakly or not at all. This consideration is less critical with the horizontal loop since under similar conditions of over-burden depth and conductor attitude, the system "sees" a conductor from a more consistent geometry. I will now show a number of examples of typical expected horizontal loop and vertical loop responses from various conductors. Figures 7, 8, 9, 10 and 11.

The more cumbersome Turam methods are less efficient because of equipment weights and the sometimes difficult transmitter lay outs. The method is, however, considered superior for depth penetration, because it essentially does away with the previously mentioned drawback of moving coil systems, and can be used under severe topographic and overburden conditions.

Figure 12. The rather controversial VLF-EM method has been used successfully under conditions similar to those specified for the horizontal loop system - in the search for massive sulfides under shallow non-conductive overburden. It is perhaps the most efficient of all the ground methods and should be considered where conditions are suitable and low cost coverage of sizeable areas are desirable. I personally feel that it is an often under-rated system and that its limitations are not nearly as serious as some would have us believe. I have here two examples of applications in Newfoundland, neither of which were detected by the more conventional EM systems.

The first is Old Buchans Orebody at Buchans in Central Newfoundland. It is a massive lead-zinc deposit with barite and a poor electrical conductor. The second is the Skidder Prospect, again in Central Newfoundland. It consists of heavy to massive pyrite. It was indicated as a good conductor by VLF-SP and meter checks on hand specimens. Becuase of the high operating frequency and the infinite transmitting source it responds to low grade and large conductors and sometimes finds applications in purely structural mapping. Disadvantages are that a suitably oriented transmitter is not always available, however our office has the capability of setting up and energizing a suitably oriented VLF transmitter. Since it responds to all grades of conductors within depth range, there is generally a problem of discriminating conductors significant to the purpose of the survey from those that are not.

Figure 14. This is an example of a VLF-EM dip angle plot with two conductors (actually conductive structures) intersecting at the top of the illustration.

The Asarco drill hole-surface method falls under the classification of special methods. The method may be used either in directly energizing a conductive body as mentioned earlier or in utilizing a barren drill hole to place a transmitter at depth in a search for conductors remote to the drill hole.

Figures 14 and 15, Overlays a, b, and c. This illustration shows the outline of the West Fork orebody and drill holes used in a series of drill hole EM surveys done over the past several years. The first two overlays indicate that the positive field strengths in general follow the one outline with some minor discrepancies and one major discrepancy around DH-64 for which I have no explanation. The last overlay is an interpretive compilation of all the surveys done to date. From this work it can be concluded that in general results were positive, particularly when it was possible to place the energizing electrodes close to the orebody.

The whole process of selecting an EM system, doing the survey, processing the data, and making recommendations concerning the results brings into play two major considerations. One, we must be reasonably assured that the possible target can indeed be detected and two, once detected it is probable that unwanted responses will appear that must somehow be eliminated and hopefully without the cost of diamond drilling.

On the first point, system design objectives have as their aim instruments and procedures that will focus on targets of the size, attitude, and electrical characteristics of the anticipated sulfide bodies. Successes with the EM method testify well to the success instrument and system designers have had in this regard. Unfortunately not all sulfide bodies can simply be focused in - in fact many can and many have been eliminated along with the nuisance noise conductors. This for a number of reasons - some sulfide occurrences simply do not contain sufficient conductive sulfides to be highly conductive. Even some massive sulfide bodies are low grade conductors for a number of reasons. They may contain a predominance of non- conductive sphalerite as at the Silverhill deposit in North Carolina, or sphalerite and barite gangue as at Buchans, Newfoundland. Intergranular conductivity may be poor even though the individual mineral grains are highly conductive sulfides. Also size and attitude are factors. Valuable sulfide deposits sometimes present surprisingly small targets and even large deposits may act as a series of small conductive lenses without electrical continuity making detection difficult with the standard EM systems.

In theory this dilemma can be resolved to an extent by altering parameters in such a way that targets with a broader conductivity and dimension range will be detected. This, however, will tend to aggravate the second consideration - that of sorting conductors on the basis of the causative sources.

The most common sources of extraneous conductors are carbonaceous beds or shears, fracture zones, faults and of course sub-economic sulfides. The latter I would prefer to ignore at the present time. For the remainder there are a variety of screening possibilities. The EM systems themselves furnish data that can be used for screening; sometimes successfully but sometimes not so successfully judging from the number of carbonaceous conductors that have been drilled over the years. The theoretical factors used for interpretive and design purposes do not always seem to be valid under field conditions. For example, according to theoretical curves the high frequency remote transmitting VLF method should be virtually useless for sulfide prospecting because it would emphasize size and geometry and would be of no value in determining conductivity. Yet in some situations the method can be superior both for detailing and conductivity estimates. Because of the remote transmitter it may tend to "see" conductors more objectively than the moving transmitter systems.

Often other geophysical methods are helpful in screening EM anomalies, particularly when geological evidence can be used to anticipate responses.

Magnetics may be used directly when the search is for magnetic sulfides. In other cases it may be that the sulfides are non-magnetic and that magnetics will be helpful in eliminating magnetic carbonaceous horizons.

In theory, at least, gravity spot checks should be very effective in screening out noise conductors since it would be anticipated that shears and carbonaceous horizons would not produce gravity highs whereas any body or zone with substantial sulphide content would. Gravity is, however, quite sensitive to near surface variations in bedrock depths and care should be taken in shallow overburden areas with the gully and ridge type bedrock topography commonly found on glaciated sedimentary rocks.

Self-potential has been also used in conjunction with EM surveys. It would seem a logical screening technique from the traditional point of view that the source of these potentials is the oxidation of sulfide minerals. Although this may be a contributing factor, it is now believed that these potentials are largely the result of other factors and more closely related to conductivity. This means that the method is of little use in determining the nature of the material in a conductors but can be used in conductivity comparisons and in detailing conductive horizons.

Screening with induced polarization can be effective but only in geological environments where carbonaceous conductors are known not to be involved and background polarization from other sources is low. It also should be remembered that IP responds strongly to minor disseminated sulfides. A large volume of low percentage sulfide material will respond more strongly than a low volume occurrence of heavy or massive sulfides. Nevertheless a conductor within an IP zone judged to be of sulfide origin would seem to be an excellent drilling target.

It is my contention that many sulfide conductors do not fit the text book illustrations. They may range all the way from nonconductive to highly conductive as seen by the methods commonly in use. Screening methods are inadequate in that they are not sufficiently specific for the causative material and at times apply the wrong criteria for the problem at hand. The possibility of identifying conductive material (even to the point of differentiating various types of sulfide bodies) may seem remote indeed and is very likely not completely attainable. Nevertheless I feel the effort should be made and initial steps were taken with this objective in mind in Newfoundland in the fall of 1976. Measurements were made of the decay potentials following the passage of a long direct current pulse across and along EM conductors.

Figure 16. This figure shows the equipment arrangement for the tests. The Wenner electrode configuration was used. The distance between electrodes is adjusted to suit the local circumstances. The objective was to energize the material in suboutcrop between the (inner) potential electrodes. During the energizing period electrical energy is stored somewhat akin to the storage of electrical energy in a capacitor. After the current interruption the energy dissipates in a direction opposite to the flow of the energizing current. Conductive sulfides, carbon, and other minerals are known to store electrical energy in this manner (which is the basis of the induced polarization method). The hope would be that the rate of discharge would somehow be related to the physical or chemical properties of the body being investigated.

Approximately 270 volts were placed across the (outside) current electrodes. The electrometer was automatically placed across the potential electrodes two seconds after the current interruption and potential readings were taken at five second intervals as long as there was detectable potential decay.

Pulse length was varied and it was found that a relatively rapid build up in storage of electrical potential occurred up to about 15 seconds when a saturation point was approached. Reducing pulse length by half resulted in a considerably lower reading level while doubling the pulse length provided little advance in reading level and further work was done with the fixed 15 second pulse. Whether the relationship of time and the saturation point or the character of the build up and consequent decay curves would furnish diagnostic information was not investigated. This could, however, be done relatively easy and should be if decay curve work is pursued further.

The experimental equipment has some of the character of a Rube Goldberg development but nevertheless is simple and offers a versatility not available in commercial equipment. Limited power restricts present use to shallow depths and areas relatively free of electrical noise.

Several conductive targets were tried in the Central Newfoundland area. These included:

The Old Buchans Orebody which consists of massive sphalerite, galena, minor chalcopyrite, and barite gangue.

The Skidder Prospect which at the suboutcrop surface is heavy to massive pyrite.

The No. 1 lens at Tulks Prospect which is a medium grade zinc-lead-copper deposit with pyrite gangue.

A strong carbonaceous conductor, and a set up to record background polarization.

All were tested across strike and two (the Old Buchans Orebody and the carbonaceous conductor) were tested parallel to strike as well.

Figure 17. This plot shows the cross-strike results with a linear time plot against a logarithmic decay rate. The background and carbonaceous decay rates are exponential as opposed to distinctly non-exponential decay in the sulfide cases. There would be little difficulty in identifying the sulfide conductors if these few cases could be relied on for more general applications.

Figure 18. The possibility that physical rather than mineralogical differences might account for the variations in curve character was considered. Anisotropic conductivity or conductivity varying with direction was one such possibility. Carbonaceous material often occurs in fine laminations in thinly bedded sediments and might display a high degree of anisotropic conductivity. On the other hand, the desired massive sulfide targets are often thick-bedded. The idea was tested by measuring potential decay following energization parallel to strike as well as across strike at the Old Buchans Orebody and the carbonaceous conductor. The results were quite spectacular and are shown here as a linear decay against a logarithmic time plot. Again the differences are significant and it would be hoped that they could be demonstrated over a wider range of test cases.

As mentioned earlier, the work here described was done with a long current pulse. Decay was measured after near maximum energy storage. This made possible the use of extremely simple equipment and detailed examination of curves not possible with commercial equipment then available. Earlier work had indicated, however, that when shorter non-saturation pulses were used potential levels were always equal at a time equal to the pulse length after the current interruption. This implied that curve form is probably similar and similar criteria may be examined using the shorter pulse lengths. Modern IP equipment provides for measurements of this kind and Asarco will have this capability with the acquisition of new equipment this year. It is hoped that this area of study will receive further attention and perhaps some progress made toward the more difficult problem of polarizable clays versus disseminated sulfides in the West.

Over the years IP development has followed two separate lines. Time domain IP (related to the data described in this paper) and the variable frequency approach in which conductivities at multiple frequencies are compared. The results are equivalent and proponents of the latter approach are now claiming success at differentiating types of polarizers by comparing phase shifts over a wide range of frequencies. Although I have tended to favor what to me is the more straightforward time domain approach, developments in the frequency domain should be monitored as well.

As for the future of the ground EM methods, more sophisticated instruments, methods, and data collection should increase depth penetration and improve interpretations. There is also room, however, for the time proven methods hopefully with improved screening techniques.

E. W. PERKINS

February 1980

Start Slide 1 Slot

From Morris Tour 1980 Conf.

James D. Sell. SUPERIOR EAST PROJECT, ARIZONA.
Thursday Feb/ 21. 1980. 9.45 - 10.15/

SLIDE 1. SUPERIOR EAST CONCEPT.

SLIDE 2. NE MINERAL TRENDS BASIC TO ARIZONA.
Globe-Ajo Zone. ASARCO reconnaissance along trend----

SLIDE 3. POSTON BUTTE

SLIDE 4. SACATON, as well as a number of altered zones not drilled.

S:ODE 5/ GENERAL SETTING AND MINERAL ZONES OF MIAMI-SUPERIOR ZONE.

MIAMI-INSPIRATION ZONE (18,000 tpd at 0.80 % Cu.)
M prod. 152 million tons ore w/ 1.5 MILLION tons Cu metal
I prod. 287.5 million tons ore w/ 2.5 million tons Cu
I reserve 103.5 million tons ore w/ 1 million tons Cu.

543 Million tons ore with 5 Million tons Cu metal.

COPPER CITIES-PINTO VALLEY (CASTLE DOME). (50,000 tpd at 0.50% Cu).
CC prod. 76.5 million tons ore with 0.45 million tons Cu metal
CD prod. 42 million tons ore with 0.25 million tons Cu metal
PV reserve 400 million tons ore with 1.50 million tons Cu metal

578 million tons ore with 2.2 million tons Cu metal

OLD DOMINION
8 Million tons of ore with 0.42 million tons Cu. metal

MAGMA (3,000 tpd at 4.5% Cu.)
Produced 23 million tons ore w/ 1.1 MILLION tons Cu metal
Reserve 40 million tons ore w/ 1.5 million tons Cu metal

63 million tons ore with 2.6 million tons Cu metal.

SLIDE 6. ???????IS THERE ALSO A PRODUCTIVE PORPHYRY SYSTEM LOCATED UNDER THE VOLCANIC COVER ON THE SW SIDE OF THE INTRUSIVE MASS,??????????

SLIDE 7. EASTWARD ZONING AT MAGMA, PLUS EXPANDED RESERVES IN STACKED REPLACEMENT ORE BODIES ALL SUGGEST A LARGE PORPHYRY SYSTEM POSSIBILITIES.

SLIDE8. EVALUATION.

SLIDE 9. GEOLOGY, ALTERATION-MINERALIZATION OF SE AREA. PRE-1970.
Collection of drill hole data, land status, ASARCO aeromag data (1971), seismic data (1970-1974), Computer modeling (1977)
[76% probability of system being present''', 45% prob. of hitting alteration zone in 5 holes. and 64% prob of hitting ~~mineral~~ alt zone in 10 holes].

SLIDE 10. PRESENT LAND STATUS.
4 by 6 miles Oak Flat.

SLIDE 11. ASARCO DRILLING.

SLIDE 12. DRILL HOLES ON PLATEAU W/ 1976-1979 results.
ASARCO 16 holes (3 incomplete)(4 deepened) 1971-1979.
62 thousand feet (ave 4500).
A-4 = 3rd hole A-2 = 5th hole
competion" 17 holes with 8 left incompleted.
59 thousand feet (ave 3500feet)

SLIDE 13. A-4 DISCOVERY. 3rd hole completion.
Cu^{o} 1060 feet at 0.56%

SLIDE 14. EXPANSION NORTH AND SOUTH.

SLIDE 15. CONJECTURE FROM MAGMA TO A-4. Cu^{o} and REPLACEMENT.

SLIDE 16. SPECULATIVE CU^{O} RESOURCE.

A	137 million tons.
N	175 million tons.
FS	120 million tons.
	432 million tons w/ grade of 0.80% with more speculative of 2 to 5 times as much.

SLIDE 17. A-2 INTERCEPT (5th hole completion).
Joint venture with ICC
AI Hole
Deppening DCA.3.
Evaluation.

SLIDE 18. A-8 intercept 646 feet at 1.57%.
expansion of zone by A-9, A-10. and A-11 offset.

SLIDE 19. CORE BOX SHOWING QTZ-BORNITE.

slide 20. CLOSE UP OF CORE.

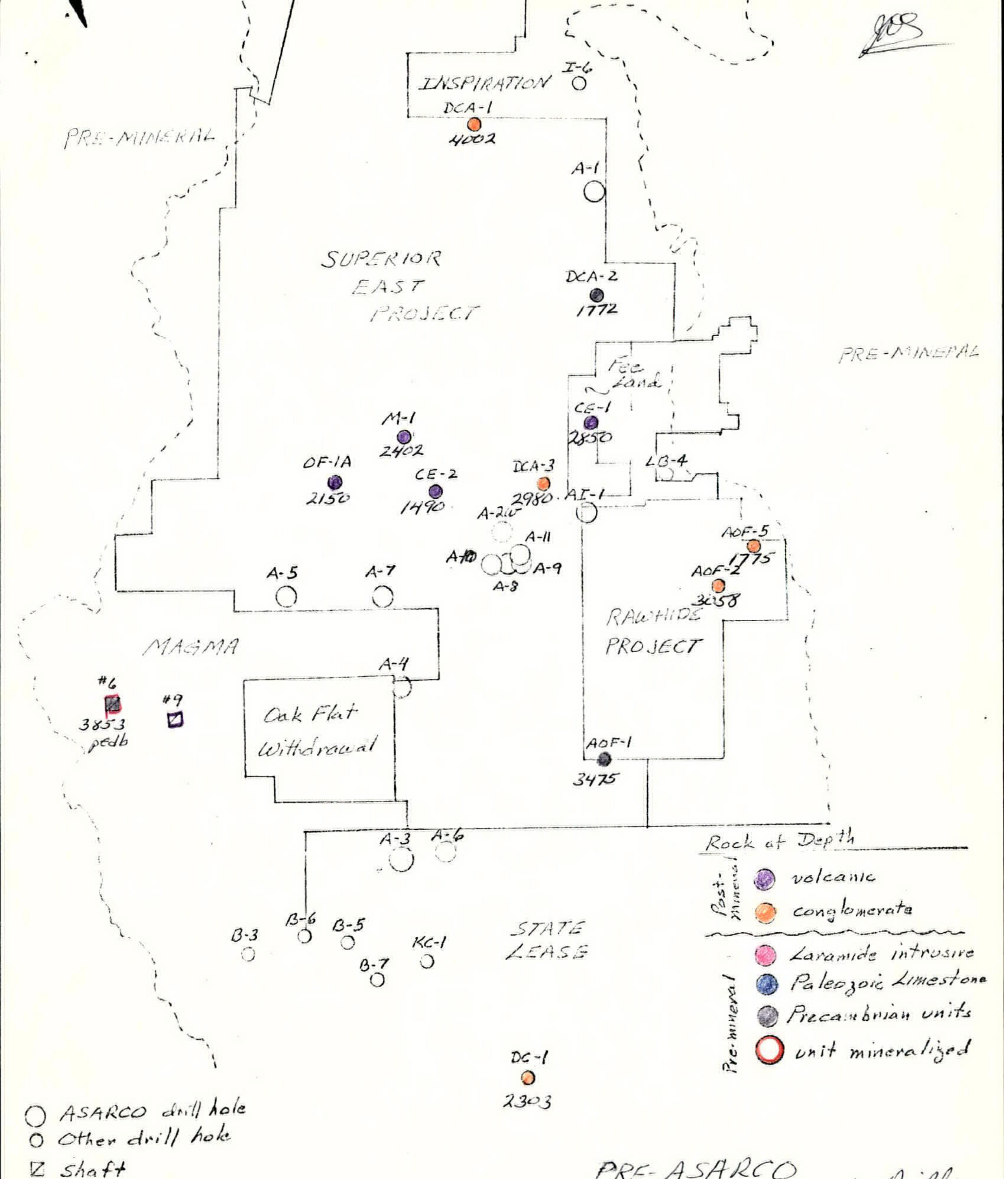
SLIDE 21. IDEALIZED CROSS SECTION
VALUES
PRESENT ESTIMATE TONNAGE MILLION 45.

SLIDE 22. FUTURE.

SLIDES 23, 24 25. Dyna-drill, confirmation

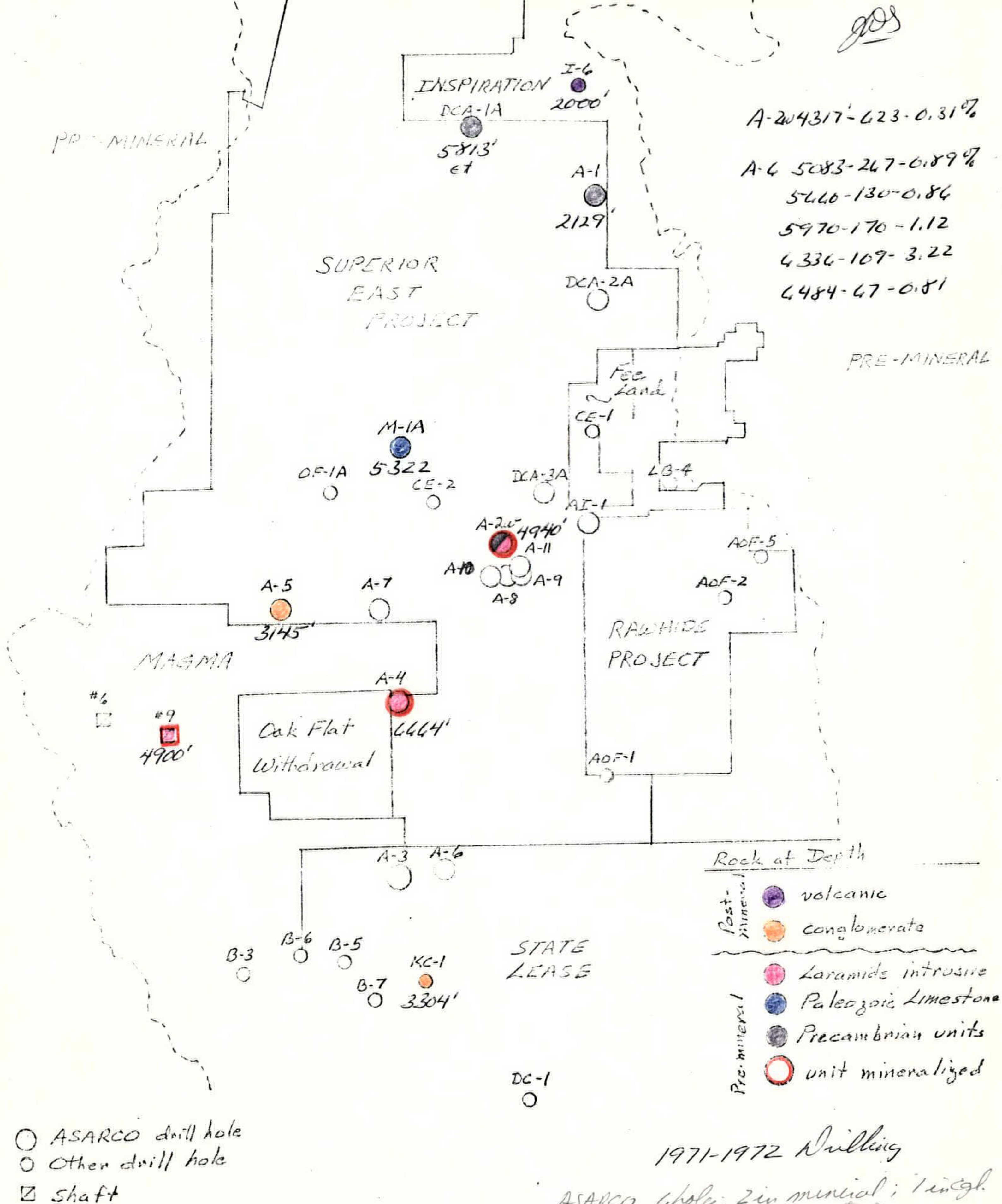
SLIDE 26. OVERVIEW

A. Moved CC and blanket?
B. Main system.
C. Additional Veins
D. Cu^{o}
E. Lms Repl.



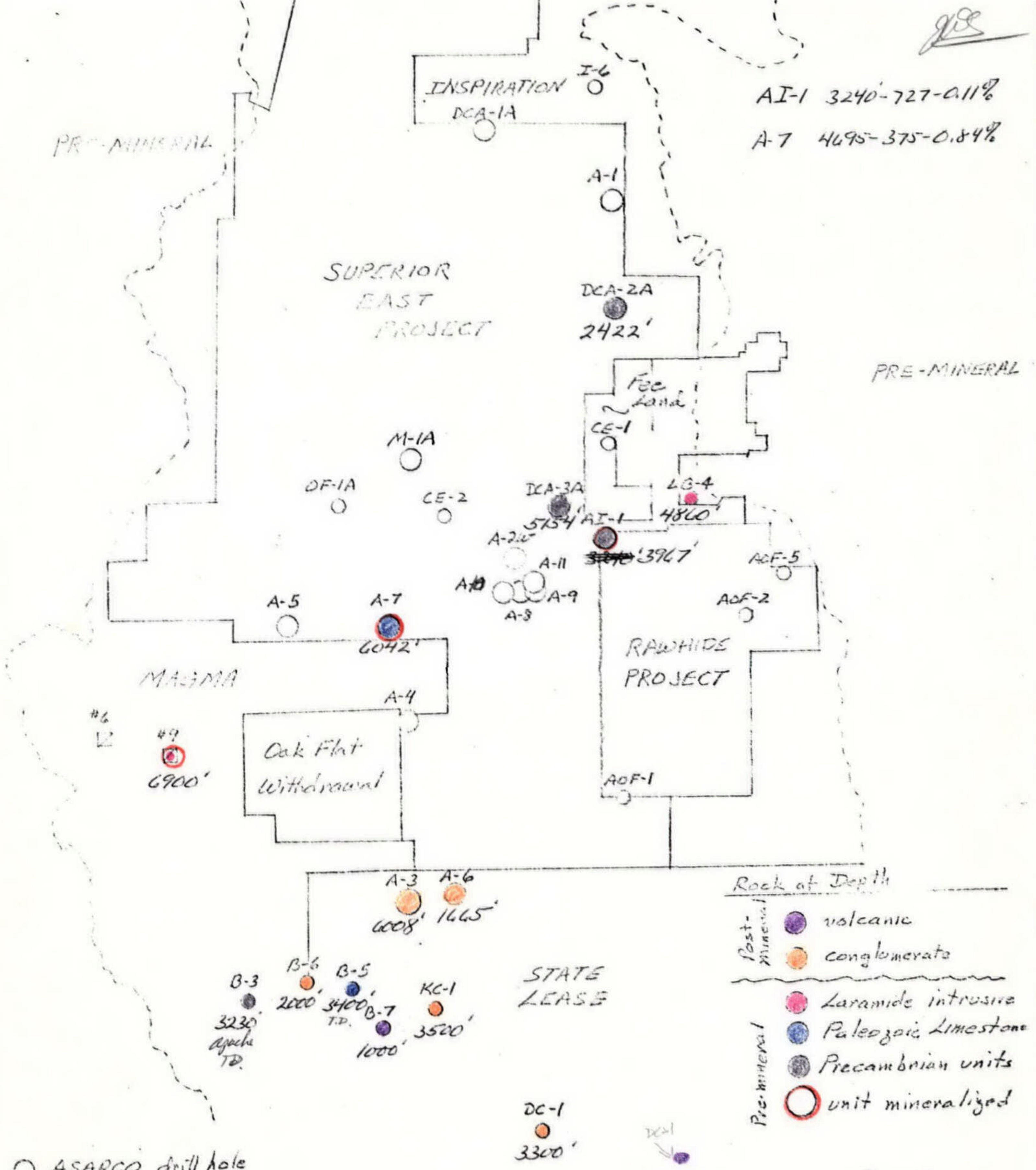
PRE-ASARCO
(thru 1970). Drilling

13 holes; 3 in premineral



1971-1972 Drilling

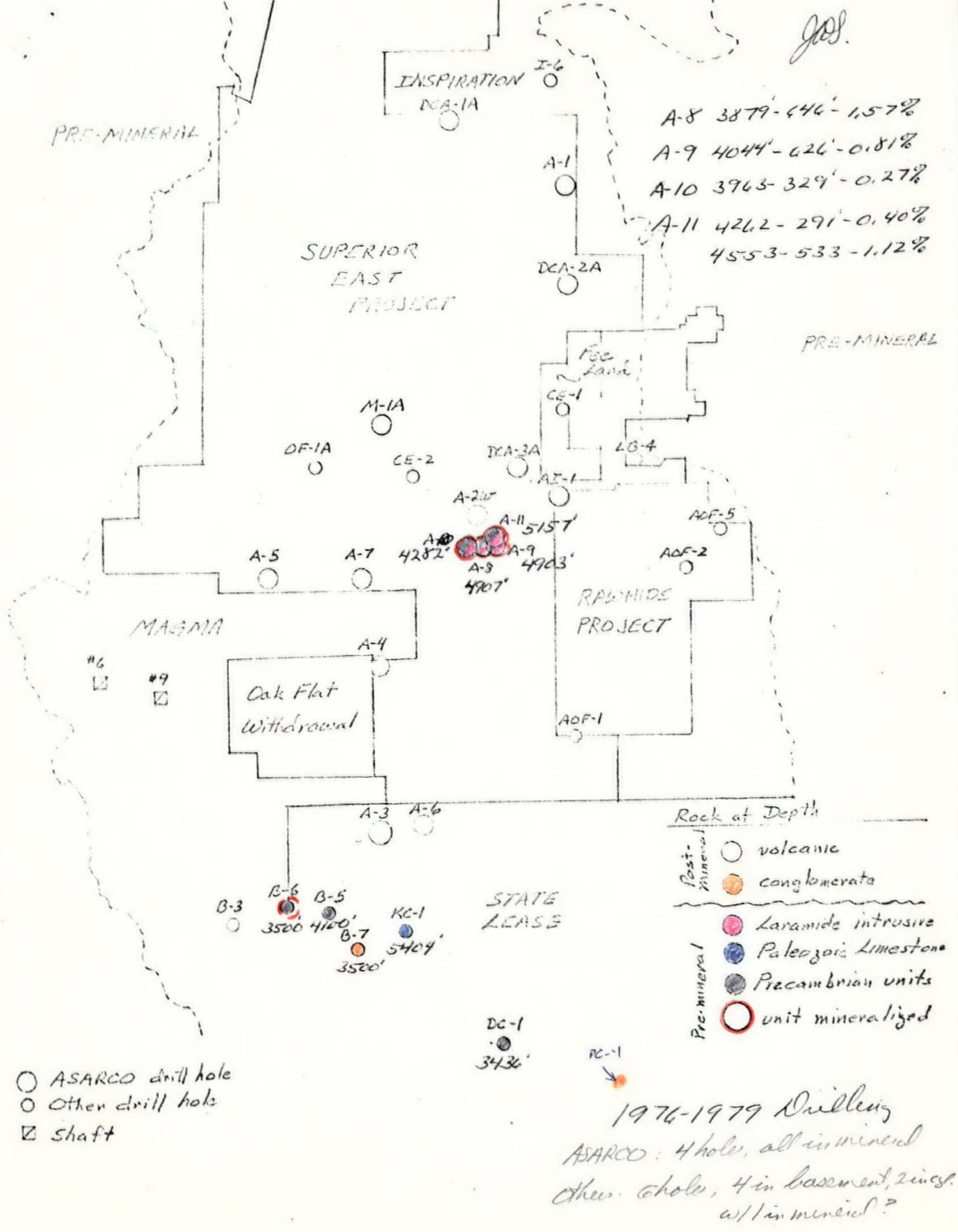
ASARCO 6 holes; 2 in mineral; 1 in cgl.
DCA-1A drill hole recentered
Other. 3 holes; one in mineral bx.

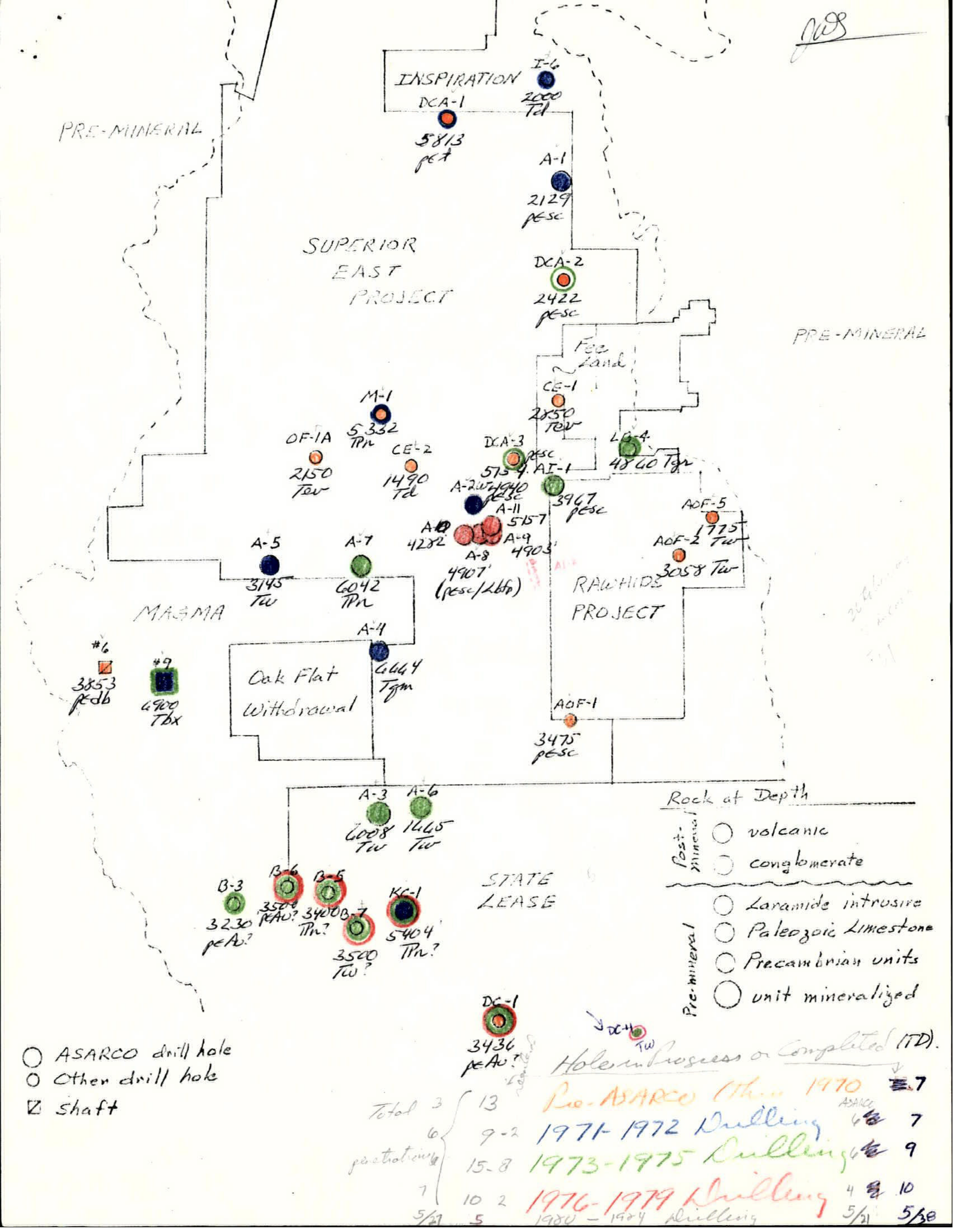


1973-1975 Drilling

ASARCO 6 holes; 2 mineralized, 2 left in cgl.
DCA-2A & 3A redrilled holes.

other 9 holes: 1 in min bx; 4 in basement
4 in postmineral
1 in volc.


JWS.
A-8 3879-646'-1.57%
A-9 4044'-626'-0.81%
A-10 3963-329'-0.27%
A-11 4262-291'-0.40%
4553-533-1.12%
INSPIRATION
I-6
DCA-1A
PRE-MINERAL
A-1
SUPERIOR EAST PROJECT
DCA-2A
PRE-MINERAL
Fee Land
CE-1
M-1A
OF-1A
CE-2
DCA-3A
LB-4
AI-1
A-2W
A-11 5157'
AOF-5
A-10 4282'
A-9 4903'
A-8 4907'
A-5
A-7
AOF-2
RAWHIDE PROJECT
MAGMA
A-4
#6
#9
Oak Flat Withdrawal
AOF-1
A-3
A-6
Rock at Depth
Post-mineral
volcanic
conglomerate
Pre-mineral
Laramide intrusive
Paleozoic Limestone
Precambrian units
unit mineralized
B-3
B-6 3500
B-5 4100'
B-7 3500'
KC-1 5404'
STATE LEASE
DC-1 3436'
DC-1
ASARCO drill hole
Other drill hole
Shaft
1976-1979 Drilling
ASARCO: 4 holes, all in mineral
Other: 6 holes, 4 in basement, 2 in cgl. w/ 1 in mineral?


JWS
PRE-MINERAL
INSPIRATION
I-6
2000 Td
DCA-1
5813 pCt
A-1
2129 pCsc
SUPERIOR EAST PROJECT
DCA-2
2422 pCsc
PRE-MINERAL
Fee Land
CE-1
2850 Tev
M-1
5332 TPn
OF-1A
2150 Tev
CE-2
1490 Td
DCA-3
5154 pCsc
LO-4
4840 Tgr
AI-1
3967 pCsc
A-2W 4940 pCsc
A-11
5157
A-10
4282
A-9
4903'
A-8
4907' (pCsc/Lbp)
AOF-5
1775 Tw
AOF-2
3058 Tw
A-5
3145 Tw
A-7
6042 TPn
RAWHIDE PROJECT
MAGMA
A-4
6664 Tgm
#6
3853 pCdb
#9
6900 Tbx
Oak Flat Withdrawal
AOF-1
3475 pCsc
A-3
6008 Tw
A-6
1665 Tw
STATE LEASE
B-3
3230 pCAu?
B-6
3500 pCAu?
B-5
3400 TPn?
B-7
3500 Tw?
KC-1
5404' TPn?
Rock at Depth
Post-mineral
volcanic
conglomerate
Pre-mineral
Laramide intrusive
Paleozoic Limestone
Precambrian units
unit mineralized
DC-1
3436 pCAu?
DC-4
Tw
ASARCO drill hole
Other drill hole
shaft
Hole in Progress or Completed (TD).
Total
13 Pre-ASARCO Other 1970 7
6 9-2 1971-1972 Drilling 6 7
15-8 1973-1975 Drilling 6 9
7 10 2 1976-1979 Drilling 4 10
5/21 5 1980-1984 Drilling 5/21 5/38

ASARCO ~~Completions~~ Drilling

	Hole Number	Date(s) Drilled		Ft of Rotary pre ASARCO	Ft of Rotary ASARCO	Ft of Core	Total Depth
x	A-1	R: April 9-27, 1971 C: July 15 - Aug 12, 1971	2	—	1309	820	2129
x	A-2	R: Jan 13 - Feb 7, 1972 C: March 4 - 18, 1972	6	—	4076	445	~~(4521)~~
x	A-2 Wedge	C: April 19 - May 17, 1972	(6)	(wedge @ 4230)		710	4940
N	A-3	R: May 22 - June 1, 1973; May 10-19, 1974 C: Sept. 26 - Dec. 1, 1975	12	—	1949	4059	6008
x	A-4	R: May 1 - July 21, 1971 C: Aug 17 - Nov. 4, 1971	4	—	3593	3071	6664
x	A-5	R: July 28 - Aug 28, 1971	3	—	3145	—	3145
N	A-6	R: June 6-16, 1973; May 20-29, 1974	9	—	1665	—	1665
N	A-7	R: Aug 17 - Sept 16, 1973 C: Nov 27, 1973 - Feb 9, 1974	8	—	3150	2892	6042
o	A-8	C: Aug 8 - Dec 29, 1976	13	—	—	4907	4907
o	A-9	C: Jan 7 - May 4, 1977	14	—	—	4903	4903
o	A-10	C: May 5 - Aug 3, 1977; Nov 15 - Dec 28, 1977	15	—	—	4282	4282
	A-11	C: Aug 2, 1978 - June 20, 1979	16	—	—	5175	5175
N	AI-1 (AI-2)	R: July 18 - Aug 12, 1973 C: Oct 1 - Nov. 21, 1973	7	—	2766	1201	3967
✓	M-1	Continental Sept - Oct. 1970		2402	—	—	—
x	M-1A	C: April 11 - July 3, 1971	1	—	—	2920	5322
✓	DCA-1	M-S May 18 - June 26, 1964		4002	—	—	—
x	DCA-1A	C: Nov 17, 1971 - Feb 9, 1972	5	—	—	1811	5813
✓	DCA-2	M-S July 3-12, 1964 June 27 - July 24, 1965		1772	—	—	—
N	DCA-2A	C: Nov. 4 - Dec 19, 1974	11	(wedge @ 1352)		1070	2422
✓	DCA-3	M-S May 7 - June 21, 1965		2980	—	—	
N	DCA-3A	C: July 2 - Oct. 16, 1974	10	—	—	2174	5154
				11,156	21,563	40,440	~~72,538~~

62,003

73,159

ave 4534

(3) left in Precinct

ASARCO Drilling (Continued) 1/12/85

		Rotary	Core	Total Depth of Hole
A-12	out of A-11 @ 2750' Nav. Jan. 14, 1980 – March 5, 1980 2750'-2879	–	129	
	Nav. March 12, 1981 – June 1, 1981 2879-4217	–	1338 (2974)	
	Core June 2, 1981 – Nov. 10, 1981 ~~Dec. 19, 1981~~ 4217-5724 TD	–	1507 ~~868~~	5724
	core A-12 wedge of Nov. 11, 1981 – Dec 19, 1981 4093-4240 = NT	–	147	
A-13	Core March 8, 1980 – Sept. 8, 1980	–	4663	4663
A-14	R. June 20, 1980 – July 2, 1980 Surf-1534	1534	–	
	Core Sept 19, 1980 – March 9, 1981	–	4204	5738
A-15	Core Feb. 16, 1983 – April 6, 1983 Surf-2029	–	2029	
	Core April 2, 1984 – July 6, 1984 2029-4699	–	2670	4699
AI-2	Core April 1, 1980 – Sept. 8, 1980	–	3612 ~~2616~~	3612 ~~2616~~

	FT Rotary pre-ASARCO	FT Rotary ASARCO	FT Core	Total
from above	–	1534	20,299	
page 1	11,156	21,563	40,440	
ASARCO & Predecessors Subtotals	11,156	23,097	60,739	
		83,836		
		94,992		
		R.	C.	
Others		33,273	26,282	
		59,555		
Grand Total		67,526	87,021	
		154,547		

Date of Completion of ASARCO holes.

Rank.	Date	Hole No.	TD type	TD depth.
1.	July 3, 1971	M-1A	TPn	5322
2.	August 12, 1971	A-1	pЄ sc	2129
3.	August 28, 1971	A-5	Tw	3145
4.	November 4, 1971	A-4	Tgm	6664
5.	February 9, 1972	DCA-1A	pЄ t	5813
6.	May 17, 1972	A-2(W)	pЄsc, Tbfp	4940
7.	November 21, 1973	AI-1	pЄsc	3967
8.	February 9, 1974	A-7	TPn	6042
9.	May 29, 1974	A-6	Tw	1665
10.	October 16, 1974	DCA-3A	pЄ sc	5154
11.	December 19, 1974	DCA-2A	pЄ sc	2422
12.	December 1, 1975	A-3	Tw	6008
13.	December 29, 1976	A-8	pЄsc, Tbfp	4907
14.	May 4, 1977	A-9	pЄsc, Tbfp	4903
15.	December 28, 1977	A-10	pЄsc, Tbfp	4282
16.	June 20, 1979	A-11	pЄsc, Tbfp.	5175
				ave 4534
17.	Sept. 8, 1980	AI-2	pЄsc.	~~2616~~ 3612
18	Sept. 8, 1980	A-13	pЄsc & Lmg	4663
19	March 9, 1981	A-14	Lfp	5738
20	Dec. 19, 1981	A-12 (Newdrilled 2750 → ~~5005~~ 5724 & wedge)	pЄ sc	~~[illegible]~~ 5724
21	July 6, 1984	A-15	pЄsc.	4699
				96,974
				ave 4,618

Other Drill Holes on or near Plateau, of Interest.

	Company	Hole No.	Date(s) Drilled	Footage Rotary	Footage Core	Depth TD	TD Type
1	Cibola Expl.	CE-1	1930's	2850	–	2850	Tcv
2	"	CE-2	1930's	1490	–	1490	Td
3	Kerr-McGee	OF-1A	Oct. 27 - Nov. 15, 1964	2150	–	2150	Tcv
4	Kerr-McGee	DC-1	Nov. 27 - Dec. 17, 1964	2303	–		
↓	Magma	reentry	R: Spring '74; C: Spring '74 C: Jan - Feb 1976	497	636	3436	Ao?
5	Inspiration	AOF-1	April 6 - Oct. 27, 1964	–	3475	3475	pЄsc
6	"	AOF-2	Aug 31, 1966 - April 1967	1581	1477	3058	Tcv
7	"	AOF-5	Aug 31 - Nov. 23, 1970	1755	–	1755	Tcv
8	"	I-6	1970 - 1971	–	2000	2000	Td
9	Kaiser	LB-4	R: Nov. 24 - Dec. 24, 1973 C: Jan 28 - July 30, 1974	2362	2498	4860	Tgr
10	Coryell	KC-1	1972	2370	934		
↓	Magma	reentry	Nov. 1975 - Feb. 1976	–	2100?	5404	Tm?
11	Magma	#6 Shaft	1956 (to 3800 Level)	3850	–	3850	pЄdb
12	"	#9 Shaft	1970 - 1973 (to 4100 Level)	4900	–		
↓	"	DDH below shaft.	1975 ?	–	2000	6900	Tbx
13	"	B-3	Nov. 1973 - Jan. 1974	2100	1130	3230	Ao?
14	"	B-5	R: May - July 1974 C: Dec. 1975 - Feb. 1976	720	3380?	4100	Ao?
15	"	B-6	R: July 1975 C: Nov. 75 - Feb '76	1000?	2500?	3500	Ao?
16	"	B-7	Nov. 75 - April 1976	2100	1400?	3500	Tcv?

Continued →

M-5 continued

(17)	Magma Quintana reentry	MJ-Leic	1974 ?	1245	–	} 3997	Tw
		DC-4	Aug. 20 - Dec. 3, 1976	–	2752		
				33,273	24,282	= 59,555	
(8) (left in Quintana)						ave 3,503'	

(12) 21

21 + 17 = 38 Grand Total 156,529

ave ~~[illegible]~~ 4119' or 1256 meters

<u>TABLE ONE</u>

GLOBE SUBDISTRICT

Name of Mine	Discovery Year	Status x Year	Type of Operation	Production: Tons of Ore	Production: Pounds of Copper	Reported Reserves Tons @ % Copper	Additional Estimated Reserves Tons @ % Copper
1. Defiance	1930	Closed 1948	Under-ground	1,500	Minor Pb-Zn-Ag-V Production ($100,000.00?)		
2. Vacey Constance	1886	Closed 1886	Under-ground	250	Minor Ag Production ($100,000.00)		
3. Highland	1929	Closed 1929	Under-ground	2,000	400,000	--	--
4. Irene	1880	Closed 1890	Under-ground	2,000	Minor Pb-Ag Production ($15,000.00)		
5. Superior-Boston	1907	Closed 1926	Under-ground	65,000	19,556,000	(plus 1,343,000 oz.Ag)	--
6. Eureka	1906	Closed 1907	Under-ground	40,000	3,000,000	--	--
7. Iron Cap	1912	Closed 1928	Under-ground	683,000	60,000,000	(plus 1,256,500 oz.Ag)	--
8. Arizona Commerical	1906	Closed 1930	Under-ground	800,000	92,000,000	(plus 580,000 oz. Ag)	--
9. Old Dominion	1882	Closed 1931	Under-ground	8,000,000	850,000,000 JEK 1881-1931 765,000,000	(plus 4,536,000 oz.Ag)	40,000,000 @ 1.0
10. Albert Lea	1944	Closed 1946	Under-ground	1,200	Minor Cu-Pb-Zn-Au-Ag Production $28,500.00)		
Subtotal				9,594,950	939,956,000	--	40,000,000

TABLE ONE - Cont'd.

COPPER CITIES-CACTUS SUBDISTRICT

Name of Mine	Discovery Year	Status x Year	Type of Operation	Production: Tons of Ore	Production: Pounds of Copper	Reported Reserves Tons @ % Copper	Additional Estimated Reserves Tons @ % Copper
11. Porphyry Reserve	1929	Closed 1930	Leaching	Surface Leaching	350,000	--	--
12. Copper Cities thru 1982	1953	Operating 1971	Open Pit	~~56,755,205~~ 77,369,399	~~662,841,497~~ 890,649,066	~~9,000,000 @ 0.5~~ mined out	~~20,000,000 @ 0.5~~
13. Diamond H	1970	Operating 1972	Open Pit	Minor (Included w/Copper Cities)		~~19,000,000 @ 0.55~~	--
14. Altered Zone	--	--	--	--	--	--	300,000,000 @ 0.3
15. Continental	1896	Closed 1929	Under-ground	Development Minor -- May be partially stripped for Pinto Valley.			
16. Castle Dome	1943	Closed 1970	Open Pit	41,442,617	578,183,368	Now site of Pinto Valley Operations.	
17. Pinto Valley 1973-1983	Announced 1973	Under Development	Open Pit	~~--~~ 136,942,304 ~~123,082,304~~	1,173,283,082 ~~[illegible]~~ ~~[illegible]~~	350,000,000 @ 0.45 384,000,000 @ 0.404	300,000,000 @ 0.4
18. Carlota	1929	Closed 1944	Under-ground	5,000	440,000	8,600,000 @ 1.3	7,000,000 @ 1.0
19. Cactus	1908	Closed 1929	Under-ground	Development Minor		20,000,000 @ 0.5	20,000,000 @ 0.5
20. Black Bess	1920	Closed 1935	Under-ground	1,000	Minor Cu-Zn Production ($15,000.00?)		
Subtotal				98,203,822	1,241,814,865	406,600,000	647,000,000

TABLE ONE - Cont'd.

MIAMI-INSPIRATION SUBDISTRICT

Name of Mine	Discovery Year	Status x Year	Type of Operation	Production: Tons of Ore	Production: Pounds of Copper	Reported Reserves Tons @ % Copper	Additional Estimated Reserves Tons @ % Copper
21. Smelter	1969	Drill Holes 1972	Under-ground	--	--	--	Several deep holes in mineral.
22. Miami East	1968	Under Development 1973	Under-ground	--	--	~~80,000,000 @ 1.0~~ 6,000,000 @ 3.14	150,000,000 @ 0.8
23. Occidental	1969	Drilling 1973	Under-ground	--	--	--	100,000,000 @ 1.0
24. Van Dyke	1929	Closed 1945	Under ground	70,000	11,851,700	Part of Occidental-AMAX (22) Operations.	
25. Warrior	1904	Closed 1919	Under-ground	300,000	30,500,000		
26. Miami	1911	Leaching 1971	Leaching 1911-1983	152,702,609	~~2,512,879,221~~ 2,720,545,639	~~28,000,000 @ 0.8~~ 17,500,000 @ 0.8	100,000,000 @ 0.7
27. Red Hill (after 1979 - reported as Inspiration Mines)	1967	Under Development 1972	Open Pit 1971-1979	-- 17,672,409	-- Consolidated under "Inspiration Mines"	~~64,000,000 @ 0.6~~ ~~46,500,000 @ 0.6~~	30,000,000 @ 0.5
28. Inspiration	1914	Operating 1971	Open thru 71 Pit 1914-1983	~~238,843,111~~ 336,876,492	~~4,251,951,861~~ 5,359,082,335	~~85,000,000~~ @ 0.9 190,000,000 @ 0.52	~~100,000,000 @ 0.7~~
29. Blue Bird	1962 1962-1982	Operating 1971	Open Pit	~~13,304,700~~ 48,660,260	~~56,869,467~~ 209,330,368	~~75,000,000~~ @ 0.52 65,000,000 @ 0.53	20,000,000 @ 0.5
30. Barney	1970	Drilled Out 1972	Open Pit	--	--	15,000,000 @ 0.5	--
31. Montezuma	1972	Drilling 1973	Open Pit?	--	--	--	75,000,000 @ 0.7(?)

continued ↓

TABLE ONE - Cont'd.

MIAMI-INSPIRATION DISTRICT - Cont'd.

Name of Mine	Discovery Year	Status x Year	Type of Operation	Production: Tons of Ore	Production: Pounds of Copper	Reported Reserves Tons @ % Copper	Additional Estimated Reserves Tons @ % Copper
32. North Oxhide	1968	Operating 1971	Open Pit	~~11,593,552~~	~~31,174,822~~	~~35,000,000 @ 0.4~~	10,000,000 @ 0.4
22. South Oxhide	1968	Under Development 1973	Open Pit 1947-1983	-- 27,502,807	-- 81,203,812	~~50,000,000 @ 0.4~~ 28,573,000 @ 0.30	35,000,000 @ 0.4
Subtotal			thru '83±	416,813,972 566,112,168 ~~3[illegible]~~	6,895,227,071 8,412,513,854 ~~3,4[illegible] tons~~ or ~~3,4[illegible]~~	432,000,000 ~~[illegible]~~ 322,000,000 @ 0.566	620,000,000

TABLE ONE - Cont'd.

TOTALS

Name of Dist.	Average	Production: Tons of Ore	Production: Pounds of Copper	Reported Reserves Tons @ % Copper	Additional Estimated Reserves Tons @ % Copper
Globe District	97.96# Cu/ton recovered	9,594,950	939,956,000	--	40,000,000
Copper Cities District	12.65# Cu/ton recovered	98,203,822	1,241,814,865	406,600,000	647,000,000
Miami District	16.64# Cu/ton recovered	416,813,972	6,895,227,071	432,000,000	620,000,000
Superior (Magma)	103.57# Cu/ton recovered				
Ray	20.02# Cu/ton recovered				
San Manuel-K	13.16# Cu/ton recovered				
TOTAL		524,612,744	9,076,997,936	838,600,000	1,307,000,000

Name of Mine	Discovery Year	Status X Year	Type of Operation	Tons of Ore	Pounds of Copper	Reported Reserves	Additional Estimated Reserves
OTHER							
Superior (Magma) Thru 1972 Closed Aug 1982	1911	Operating 1971	Underground	16,414,285 +8,443,140	1,700,088,749 700,842,340	~~10,200,000 @ 5.8~~ 4,962,000 @ 5.5	~~10,000,000 @ 5.0~~
Ray Thru 1972 Thru 1984.	1911	Operating 1971	Open Pit	216,656,509 123,993,814	4,337,125,555 1,922,293,579	~~736,310,000 @ 0.82~~ 626,000,000 @ 0.79	~~200,000,000 @ 0.8~~
San Manuel-K	1955	Operating 1971	Underground	189,118,417	2,489,495,468	1,003,000,000 @ 0.7	?

ASARCO

Southwestern Exploration Division

November 27, 1979

Superior East Project
Pinal County, Arizona

70,000 tpy

A pro-forma feasibility study has been made which shows the following after tax internal rates of return:

	Total Project			Project with Property Obligations		
Cu price	$1.00	1.30	1.60	$1.00	1.30	1.60
DCFROR	16.12%	24.33%	30.74%	15.27%	22.96%	27.95%
Payback				4½ years	3 years	2½ years
yearly cash flow				45 mill	70	90 mill/year

after ± 6-8 years

Feasibility was based on the following criteria:

Reserves: Primary orebody - high grade disseminated and fracture vein controlled.

100,000,000 tons @ 1.25% Cu } 90% mined grade,
110,000,000 tons @ 1.14% Cu } 110% mined tons.

Mining: See attached sketch for configuation of orebody (J.D.Sell) with a presumed strike of 4,000', 300' wide and 1,000' thick. Block caving used for a mining system rated at 20,000 tpd with a 16-year life.

Milling: Standard flotation flow sheet for 20,000 tpd producing high grade concentrates.

Capital Costs: See attached estimate by George Percival.

Mine preproduction	$140,300,000
Mill	100,000,000
Engineering	4,000,000
Working Capital	8,700,000
	$253,000,000

NSR: See A.J.Kroha's estimate to adjust for George Percival's comment (chalcopyrite concentrates estimated at 0.33/lb smelting).

Cu price	smelter	Grade	tpd	NSR/lb	Rec'y	NSR/ton
$1.00	.26	1.14 -	200 -	.74 -	.95 =	16.03
1.30	"	"	"	1.04	" =	22.53
1.60	"	"	"	1.34	" =	29.02

>>>

Operating Costs: See attached estimate by George Percival.

	Total Project per ton	Project with with property obligations Cu $1.00	$1.30	$1.60
Direct mining	$3.71	3.71	3.71	3.71
Indirect "	1.48	1.48	1.48	1.48
Direct milling	1.49	1.49	1.49	1.49
Indirect "	0.59	0.59	0.59	0.59
Management fee	--	0.05	0.05	0.05
3% royalty	--	0.48	0.68	0.87
	$7.27	7.80	8.00	8.19

Also attached are print-outs and work sheets for the above six rates of return and a copy of the initial request.

Property obligations include:

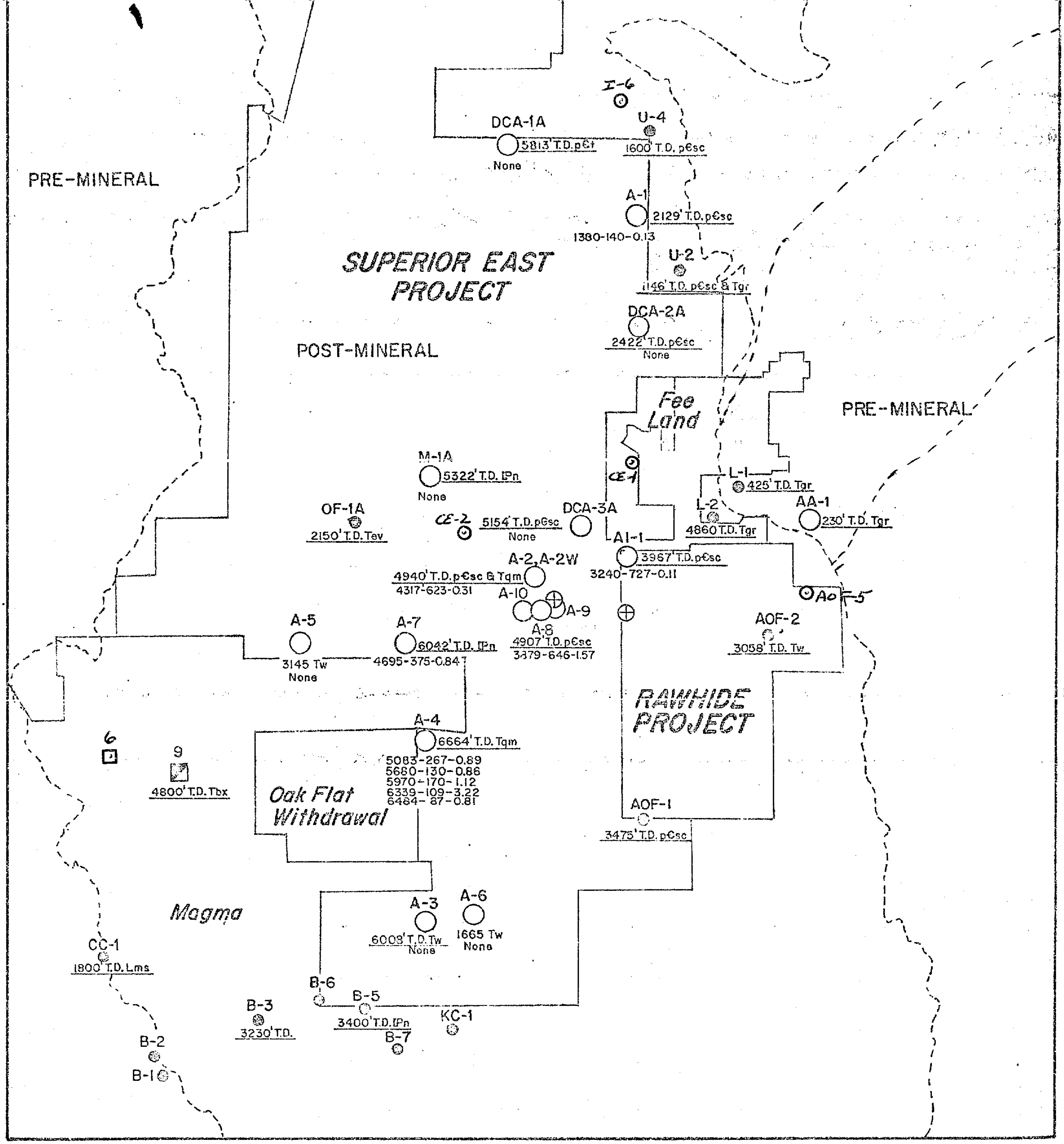
1) 3% NSR to CanUS Ltd upon production until $20,000,000 paid;

2) 0.05 per ton management fee;

3) Mining agreement with Continental Materials based on net profit lease. Net profits shared 80-20% after payback of all pre-mining expenses (including exploration), plus 1% over the prime rate, less $500,000 deductible. This also covers post-mining operation captial costs.

R.B.C.
R. B. Crist.

RBC:jlh
attachment
c.c. W.L.Kurtz
F.T.Graybeal
J.D.Sell
G.Percival



DC-1

EXPLANATION

- ASARCO drill hole
- Other drill hole
- Magma's #9 shaft
- DCA-1 (hole designation)
- 4011 Tw — Rock type; Bottom hole depth
- T.D. — Total Depth
- Proposed drill site

POST-MINERAL ROCK UNIT

Td - Dacite
Tev - Early volcanics
Tw - Whitetail

PRE-MINERAL ROCK UNIT

Tbx - Breccia
Tqm - Quartz Monzonite
Tgr - Granite
Ps - Supai formation
IPn - Naco limestone
Me - Escabrosa limestone
Dm - Martin lms
pЄt - Troy qtz
pЄdb - Diabase
pЄsc - Schist

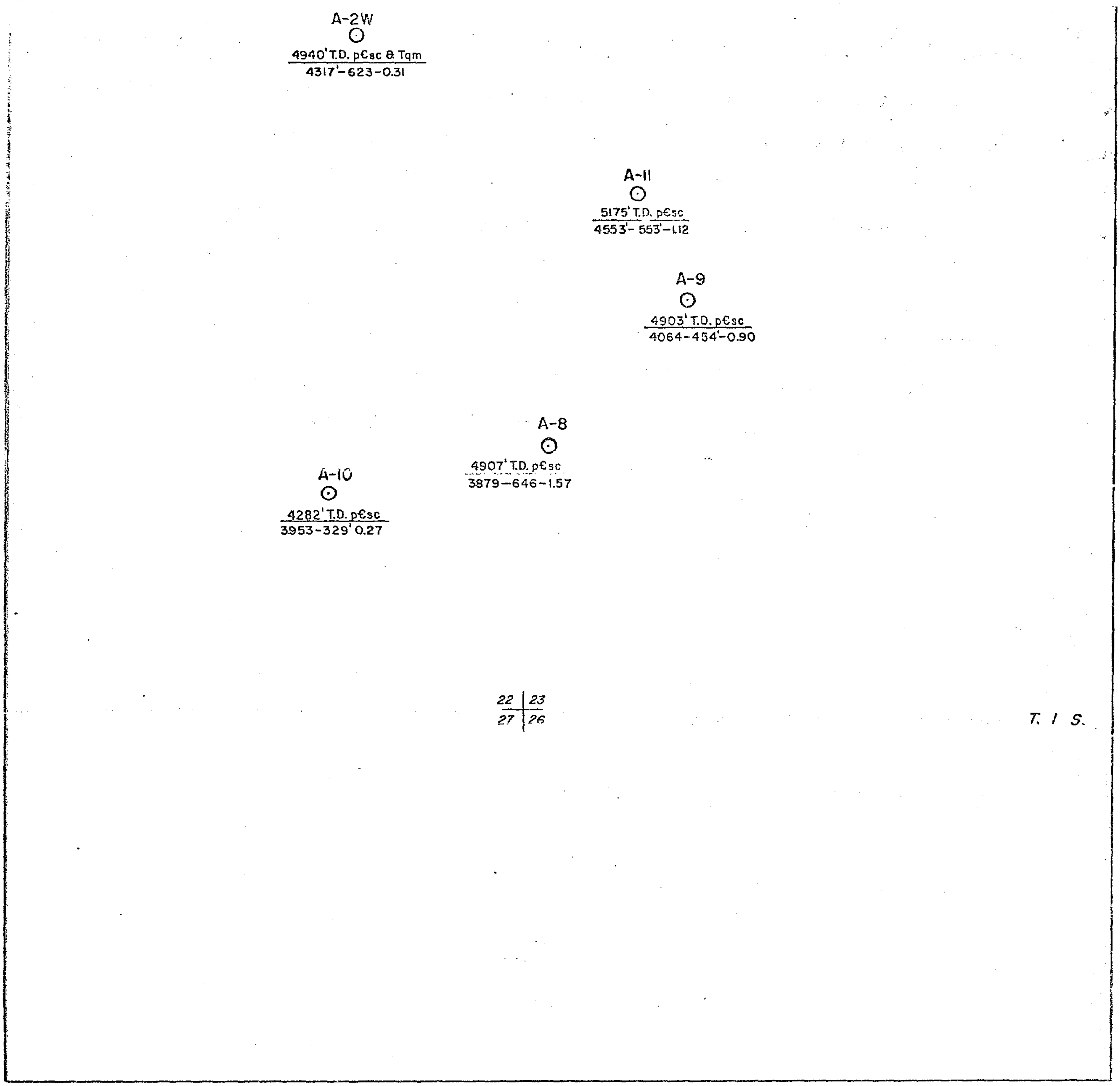
ASSAY DATA KEY

depth-length-%Cu
4317-623-0.31

DRILLING PROGRESS MAP
for the month of ________
SUPERIOR EAST
GILA & PINAL COUNTY, ARIZONA
SCALE: 1" = 1 mile J.D.S.

master

MVK 2463 No.



EXPLANATION

POST-MINERAL ROCK UNIT

- Td–Dacite
- Tev–Early Volcanics
- Tw–Whitetail

PRE-MINERAL ROCK TYPE

- Tbx–Breccio
- Tqm–Quartz Monzonite
- Tgr–Granite
- Pe–Supai Formation
- IPn–Naco Limestone
- Me–Escabrosa Limestone
- Dm–Martin Limestone
- p€t–Troy Quartz
- p€db–Diabase
- p€sc–Schist

A-8 ⊙	ASARCO Hole & Designation
4907' T.D. p€sc / 3879-646-1.57	Total Depth-Rock Type / Depth-Length-% Cu
⊕	Proposed Drill Site

N

DRILLING PROGRESS MAP

For The ______ Quarter, 1979

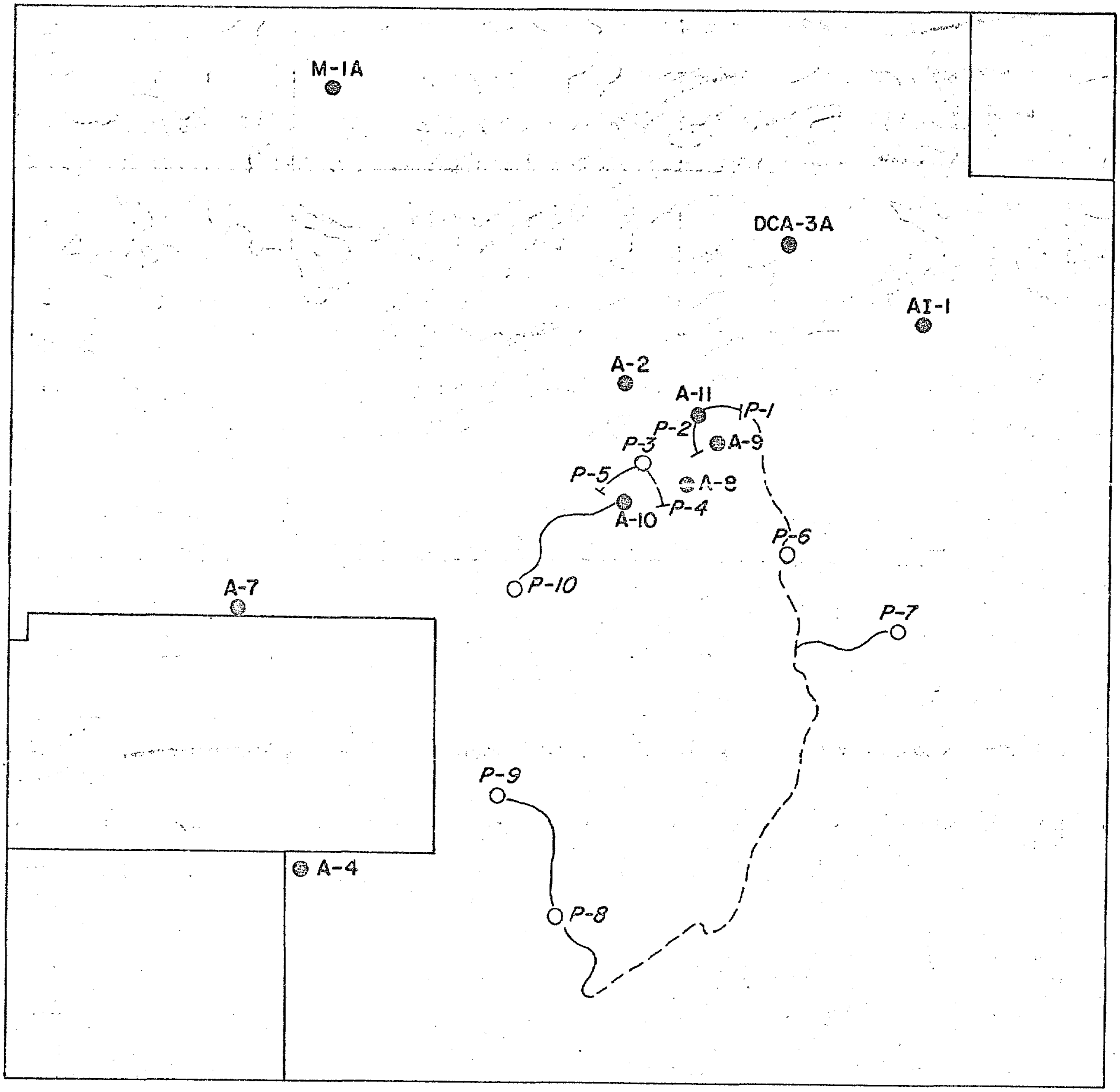
SUPERIOR EAST PROJECT

PINAL COUNTY, ARIZONA

SCALE: 1"=500'

J.D. Sell June 1977

MYK-3041



Base from Superior Az., U.S.G.S. 7.5' Quad.

EXPLANATION

ASARCO

Magma

Oak Flat

A-2 Completed Holes

P-3 Proposed Vertical Holes

P-4 Proposed Inclined Holes

Road To Be Improved

Road To Be Built

Proposed Future Drilling

SUPERIOR EAST PROJECT

PINAL COUNTY, ARIZONA

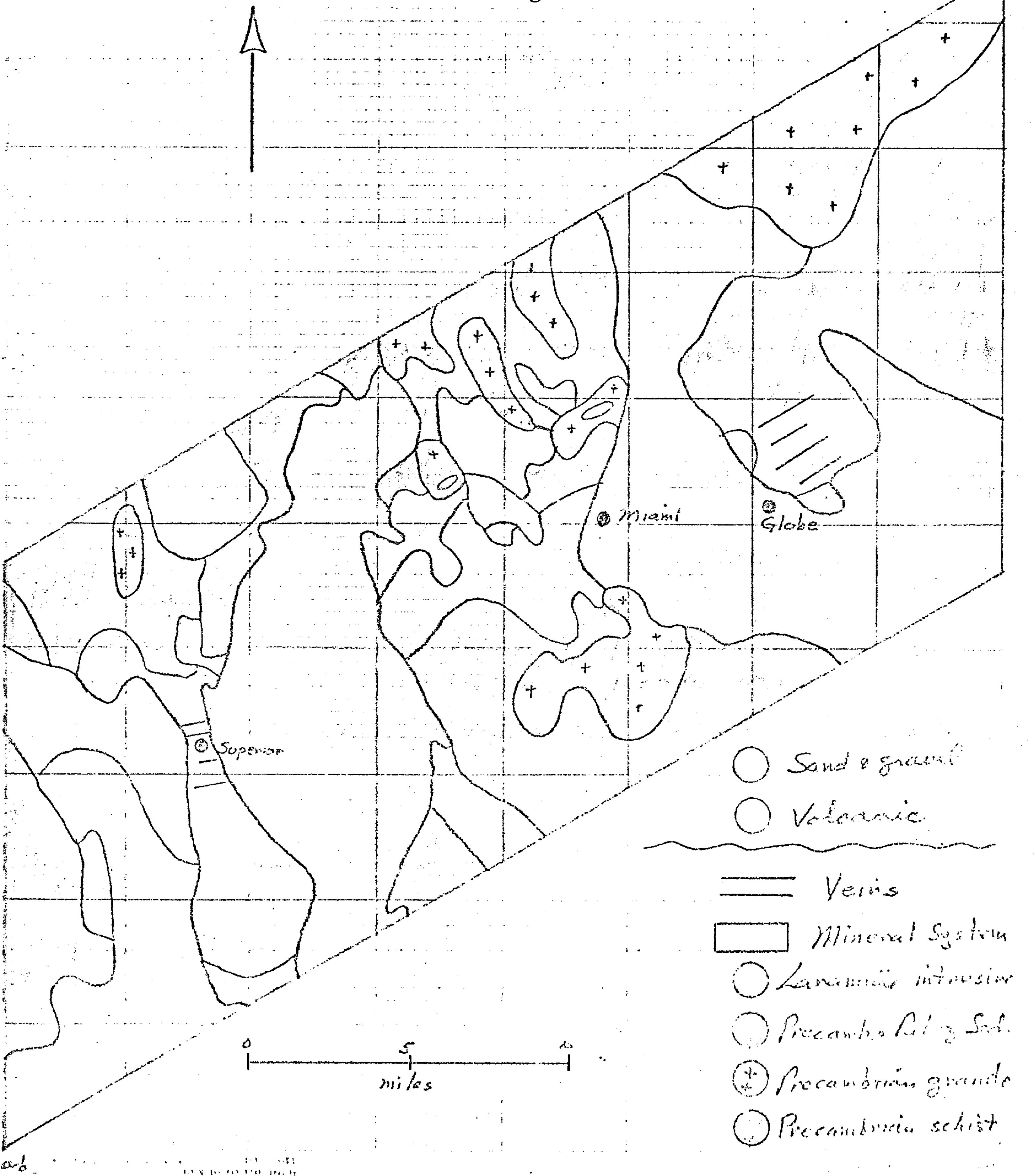
SCALE: 1" = 2000'

F.T. Graybeal

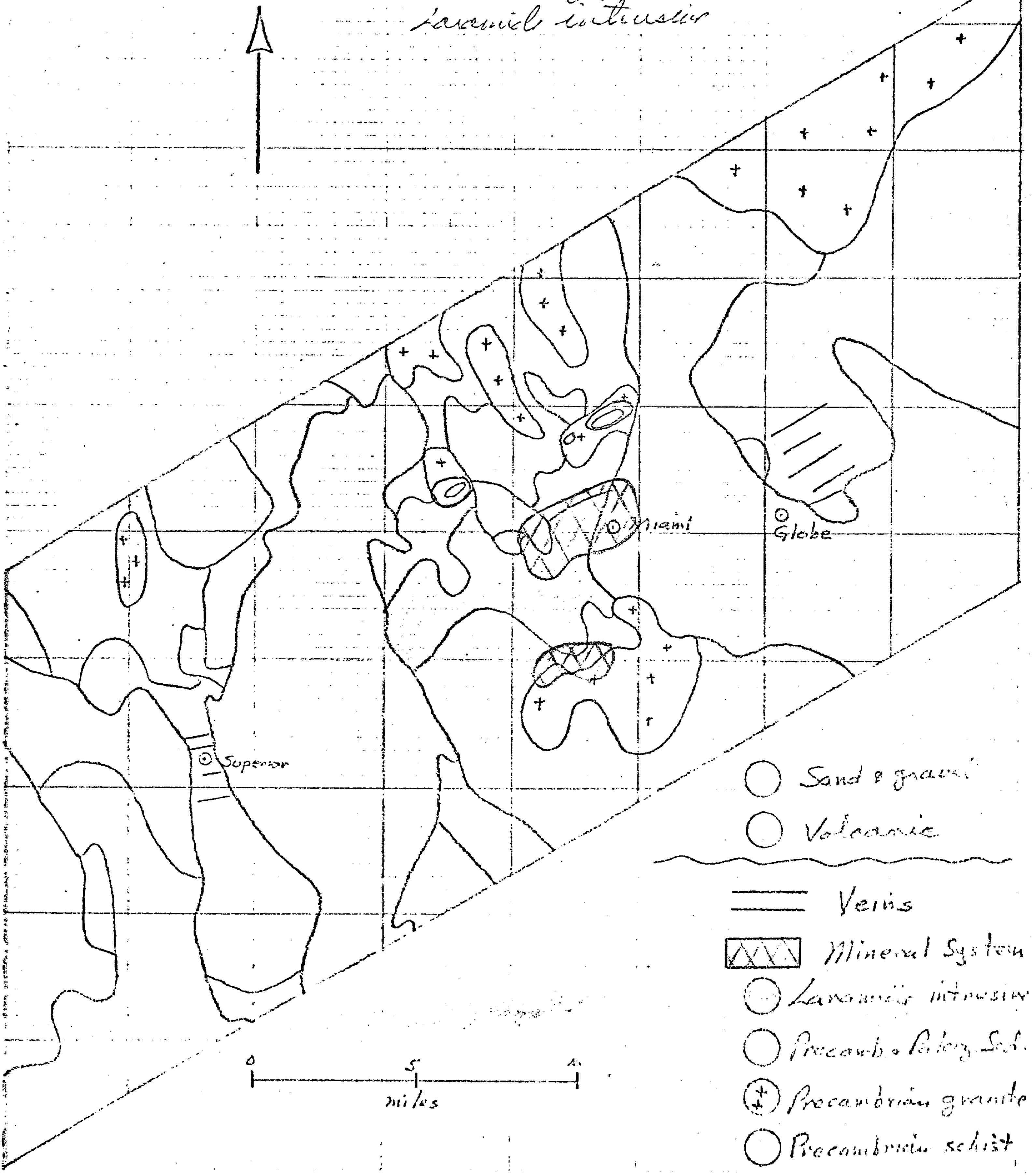
Aug. 1979

MVK-5141

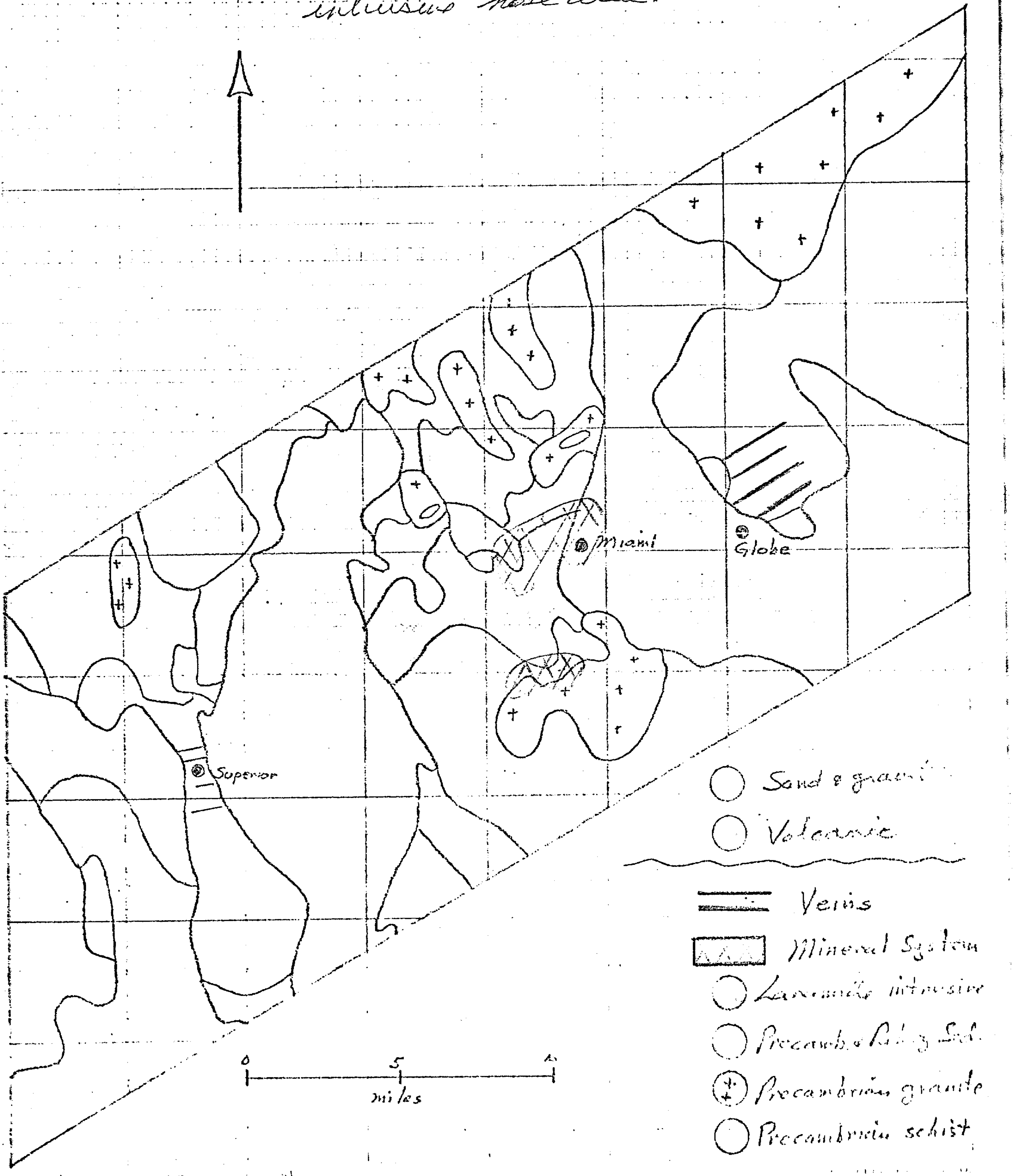
Regional Setting
Basic Geology



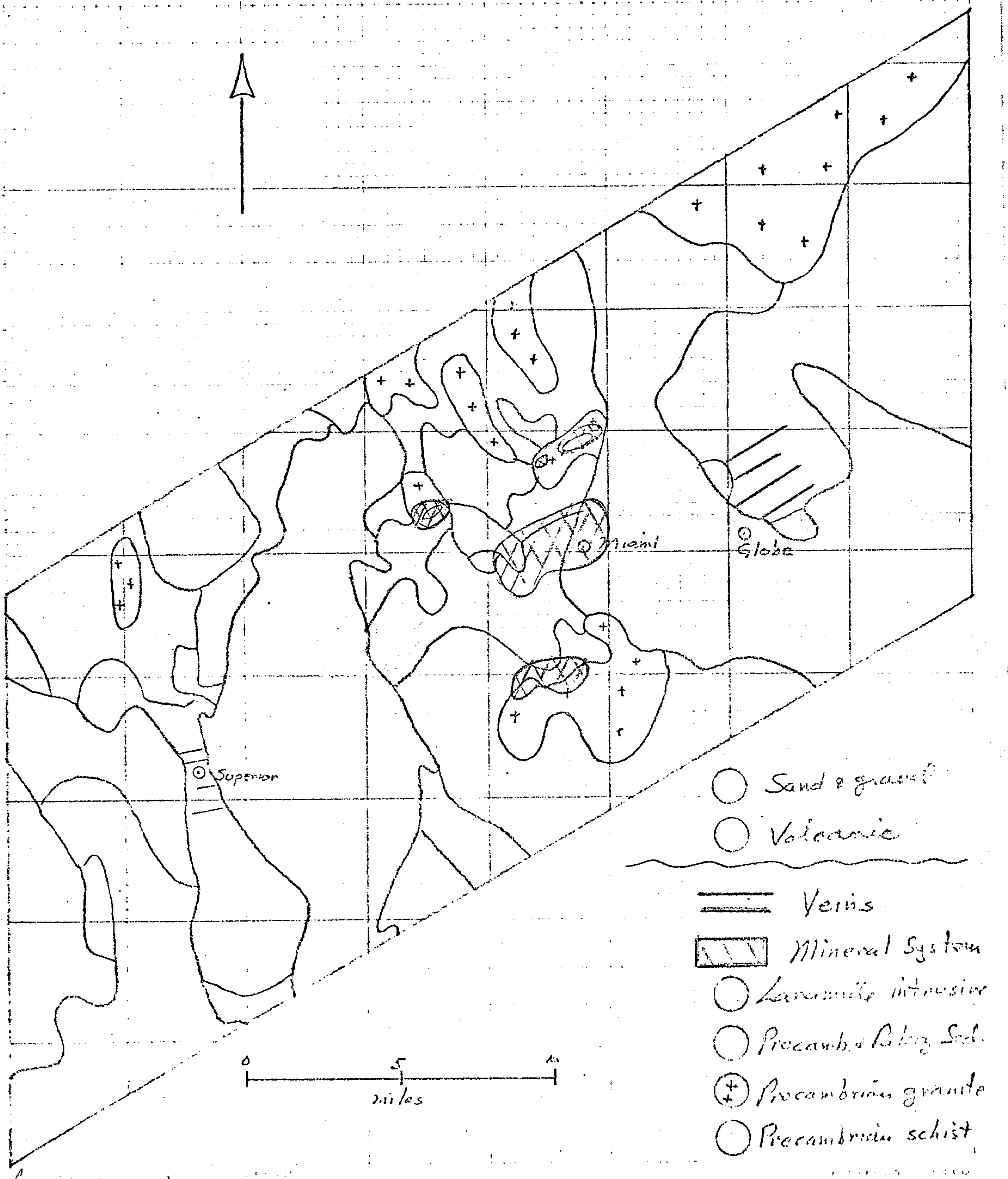
Alteration-Mineral Zones around edge of Laramide intrusive



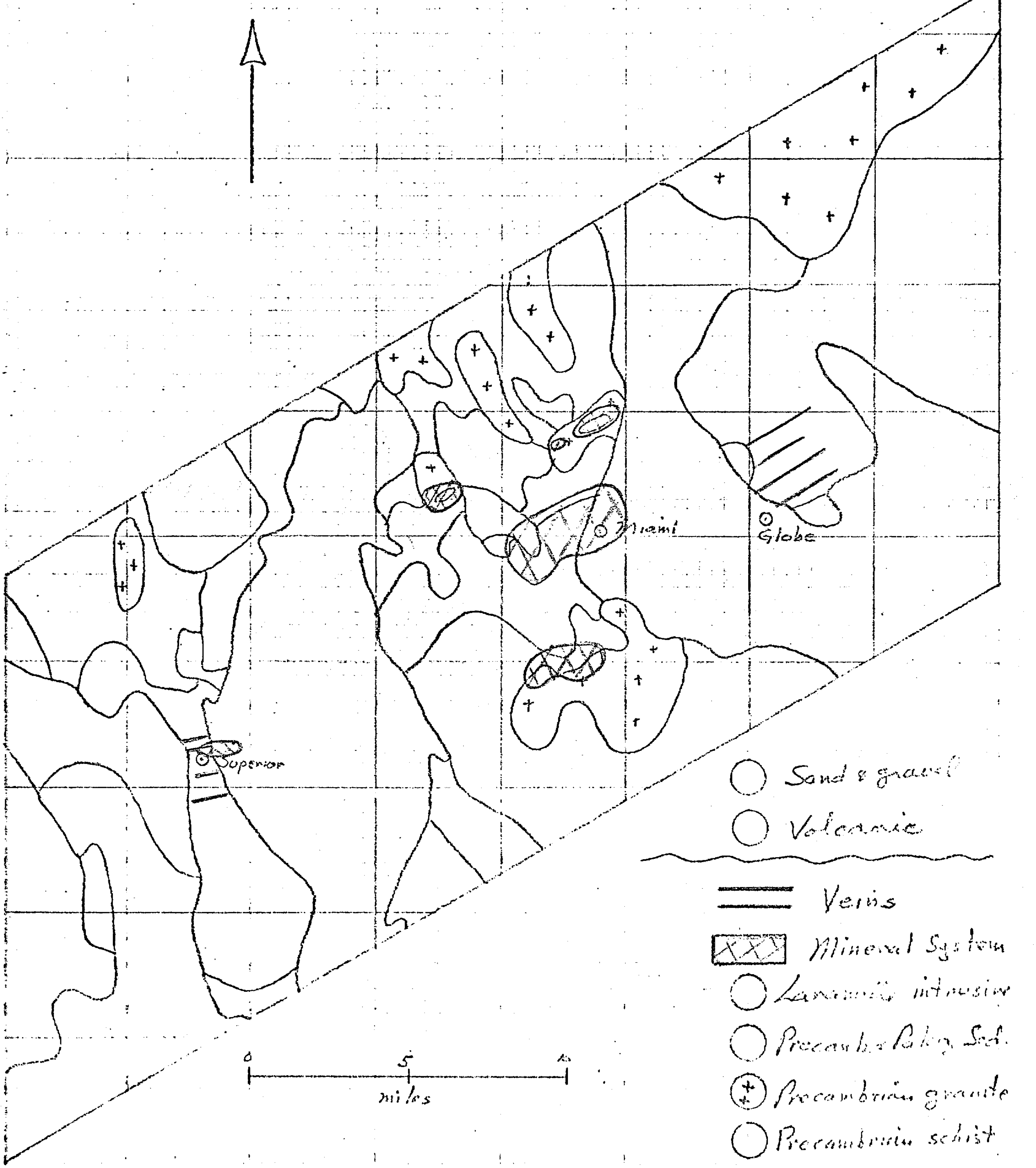
Globe - Old Dominion Vein System
Northeast extension beyond
intrusive nose area.



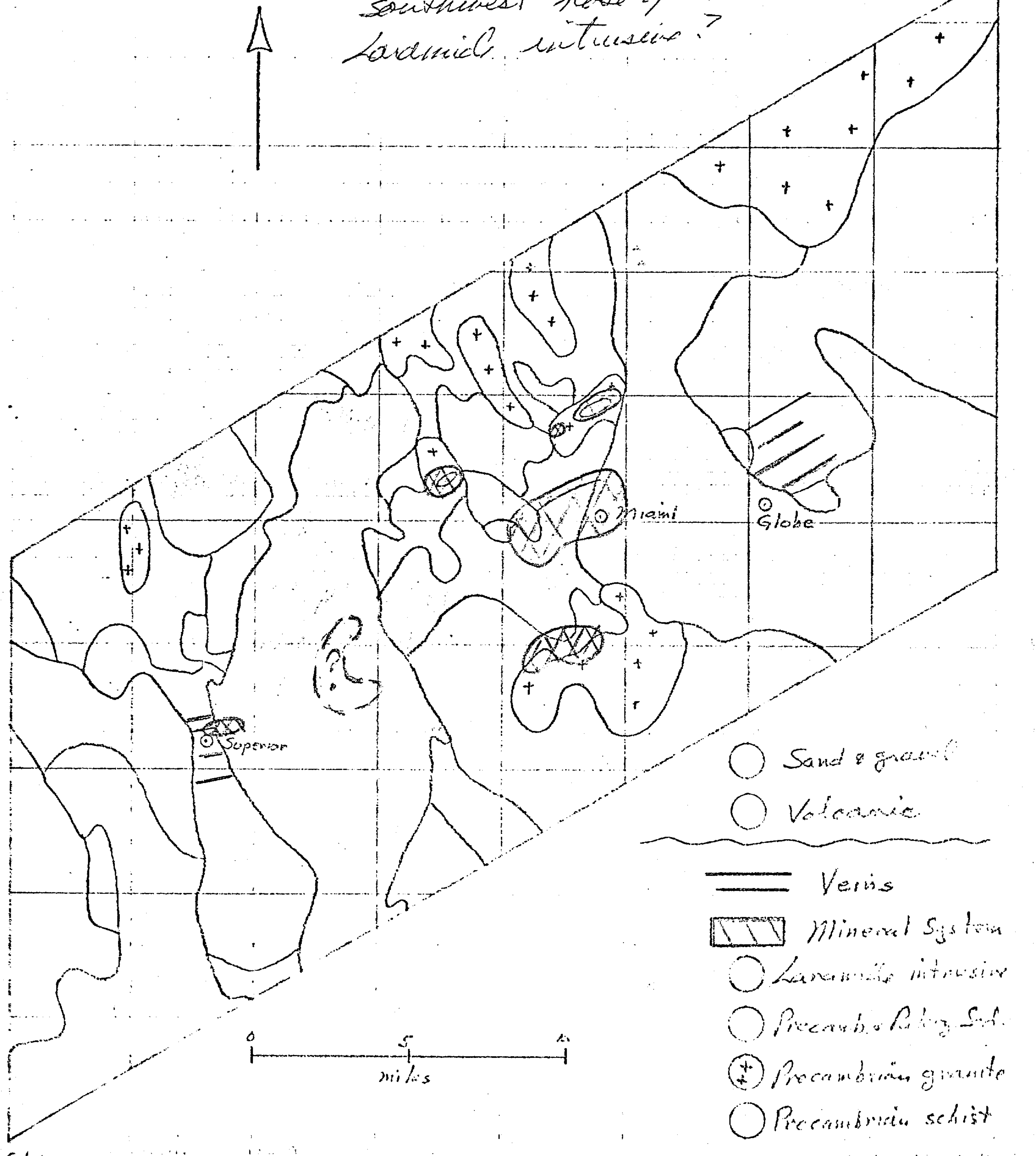
Sub-parallel trend of
Copper Cities - Pinto Valley



Magma Vein System
Southwestern extension beyond
intrusive nose.



Question: Is there a productive porphyry system under the volcanic cover on the southwest nose of the Laramide intrusive?



g-1

J. D. Sell
1-21-71

Superior East: Porphyry Copper Lineament Concepts and Related Whitetail Conglomerate Study

by James D. Sell, Exploration Geologist
Southwest Department
For presentation at Annual Exploration Meeting
Chandler, Arizona March 11-13, 1971

The Superior East project is a study of the geology, structure, and mineralization of an area between Globe and Superior, and north
S-1 of Ray, Arizona. (SLIDE ONE, Please) The project area encompasses some one hundred twenty square miles, of which seventy square miles are covered by post-mineral conglomerates and volcanics.

The drawing of lines or lineaments has long been practiced in Arizona (3, 4, 7, 10, 11, 13, 14, 18, 22, 23, 26) and today the use of the computer for assimilation of the vast amounts of data is being utilized (1,8). The fundamental factor of deep-seated lineament structures as loci for mineral targets was expressed by Billingsley and Locke (4) as:

> "The essence of a mining district is the presence of such competent rocks with long-lived, deep, penetrating breaks re-opened to permit passage of heat and associated products from depths to surface"...

As exhibited in SLIDE ONE, we might express the major porphyry copper mineral deposits of Arizona as four rather broad northwest trending belts From left to right, they are named: (1) the Ajo, (2) the Northwest, (3) the Central, and (4) the Morenci belt.

In general, it is found that the loci for mineralized porphyry copper deposits are where these belts cut northeast-trending structures,
S-2 as expressed by Landwehr (14). (SLIDE TWO, Please) Landwehr has named the major northwest belts in Arizona as: (1) the Colorado, through Jerome-Bagdad; (2) the Globe, through Globe-Ajo; and (3) the Bisbee--Morenci, through Morenci to Pima-Bisbee. As noted, these cover a wide swath. Synopsis of the trend-direction analysis has been reported in publications by Marv Barnes (1) and Lowell and Guilbert (17).

S-3 SLIDE THREE, Please, shows the Silver Bell deposit is a graphic study of the district trends mapped by Courtright (21). Here the mineralized northeast-trending fractures and fissures are enclosed in an overall northwesterly-trending alteration zone.

ASARCO geologist Blucher (5) in 1957 initiated a porphyry copper
S-4 reconnaissance program in the Globe-Superior region. (SLIDE FOUR, Please) Blucher covered the area in some detail and discovered and reported on a number of mineralized areas which had not been previously reported or were little known. These deposits were not of economic importance at the

time of his study, and at present have remained in that status for the most part, although some of the areas have been drilled. Blucher was impressed, as later was N. P. Peterson (20) of the USGS, in the apparent alignment or elongation of the known ore deposits of the Globe-Miami area and the apparent fact that this trend passed under the large post-mineral cover area of our present Superior East project, and the deposits at Magma and Silver King were situated where the trend emerges from under the volcanic cover.

Further investigation verified that the northeastward trend of the older Precambrian grain of the region had been followed by the younger Precambrian diabase intrusives and subsequently by the Tertiary igneous intrusives and many of the dominantly mineralized vein deposits. Thus it was reasonably evident that the northeast trend represented deeply-rooted structures of prime importance.

Later work in the Superior area has also shown the importance of the northeast structures as recurring movement along them is evident in older Precambrian, younger Precambrian, Laramide, early Tertiary volcanic, and late Tertiary volcanic times.

Continued work along this trend to the southwest by Blucher and Kinnison (6) in the Blackwater District also indicated a strong northeast trend to the mineralization and alteration outlines. Expanded reconnaissance in the area resulted in the discovery of the Poston Butte mineralization with a known alteration-mineralization extent of three miles of strike length northeast, by one mile in width. Only a small outcrop of several hundred square feet is known but even here the fracture pattern has a dominant northeasterly to easterly trend.

Next, Kinnison and Blucher extended their reconnaissance to the southwest where the small altered and mineralized hill of the Sacaton deposit was located (12). Drilling blind through the alluvium outlined a strongly oriented northeasternly-trending alteration-mineralization area.

Beck (2) followed up the reconnaissance with more detailed work in the north Sacaton area and found a northeasterly-trending zone in which aplite dikes were cut or bordered by diabase dikes which, in turn, were cut and bordered by a swarm of dioritic-monzonitic dikes and bodies of Laramide age. Outside of this three-mile-wide zone, the Precambrian granite basement rocks are cut by only a few aplitic dikes.

Deep alluvial drilling southwest of the Sacaton deposit outlined a similar northeast-trending alteration-mineralization zone in the Santa Cruz area, as reported by Wojcik (27).

By this time some sixty-five linear miles of exposures had been examined along this apparent productive northeasterly trend, and it was my good fortune to be able to continue the investigation (24, 25) to the southwest for another forty-five linear miles where the study was terminated somewhat inside an active Air Force bombing range. Again it was conclusively demonstrated that the northeast-trending zone was persistent and had been active from older Precambrian through Tertiary time. Several intrusive and altered areas were found but follow-up work was not encouraging.

This one hundred ten mile long zone of northeasterly-trending structures has been active over the entire geologic time span and has influenced sedimentation, intrusive activity, and alteration-mineralization. Its importance as a deep-rooted primary structure is impressive and, as elsewhere in Southern Arizona, where this structure is cut by northwest trending elements mineral concentrations tend to occur.

At present Asarco is supporting further work along this northeasterly productive trend. Compilation and integration of all previous mapping coupled with additional work will be the basis of re-evaluating an accumulation of age-dates and aeromagnetic trends.

In the evaluation of this N 60° E lineament trend and its productive mineral potential, it was readily apparent that a large area of post-mineral cover existed between the mining area at Superior and the productive area of Globe-Miami.

Compilation and integration of all the available information will enforce our hunt for an ore body in this permissive area (Lasky, 15). Drilling targets in the area are of the three known classes: (1) The Miami-Inspiration class of large tonnage of relatively high-grade secondary chalcocite ore bodies located along the Schultze granite-Pinal schist contact, and having substantial oxide copper outside the main zone; (2) the satellitic porphyry intrusive class exemplified by the large Castle Dome-Pinto Valley class which is generally located several miles from the granite-schist contact; and (3) the Magma class of limestone replacement deposit having a possible genetic relationship, with a presently poorly-understood porphyry breccia intrusive.

S-5 The relative position of the known ore bodies and alteration zones are shown on SLIDE FIVE, Please. The importance of the northeast-trending lineament zone has been established, but the productive capacity of the area is even more impressive.

The Miami-Inspiration ore body has produced through 1969 an excess of 375 million tons of ore with a recovered 3-1/4 million tons of copper. Reserves in this block is still substantial and several pit expansions are now underway. Also, the faulted segment of the same ore body, named Miami East, now being drilled by Miami and Occidental, is believed to contain an excess of 130 million tons with a grade of + 1.5% copper.

The Copper Cities deposit (Miami Copper) in fifteen years has produced 52 million tons of ore and recovered 300 thousand tons of copper. Another pit, Diamond H, is ready for production on the southwest end of the same alteration zone, and between the two pits a large reserve of around 0.3% copper is known. Ultimate production from the zone is unknown, but large.

The Bluebird and Oxhide deposits are nonsulfide deposits of reprecipitated values probably leached from the Miami-Inspiration deposit or possibly from an undiscovered deposit lying to the northwest now covered by mid-Tertiary dacite. Production of around 65 million pounds of copper has been made to date and reserves probably amount to at least double this amount.

The Castle Dome area is a "worked out" deposit having produced 41 million tons of ore with a recovered 514 million pounds of copper from 1943-1953. Since that date, 64 million pounds of precipitate copper has been produced from leach dumps over the deposit. Under the Castle Dome area is the newly reported Pinto Valley project with a released figure of 350 million tons of 0.45% copper. Actual reserves are probably nearer 550 million tons at the same grade.

The Cactus-Carlota deposit is primarily a nonsulfide deposit in brecciated Pinal schist and is underlain by a flat, gravity type fault. Little production from the area has been made but reserves probably range between 75 and 100 million tons, half of which is commercial at the present time. The deposit is controlled by Miami and Homestake Production Company. The west end of the deposit (Carlota portion) is entirely covered by dacite.

To the southwest, a zone of nonsulfide copper is found in the schist and is underlain by a flat fault similar to Cactus-Carlota. The exotic mineralization passes under the dacite cover. Several drill holes put down in 1930-1931 were 1000 feet west of the dacite cover and all encountered values of nonsulfide copper. In 1965, a joint venture hole between Superior Oil and Miami Copper was placed some 3000 feet west of the dacite edge. It also encountered nonsulfide copper values.

This zone of exotic copper values will be further evaluated by drilling in search for the continued nonsulfide copper in the upper plate of the gravity slide fault as well as for the source area for this copper.

On the northwest side of the Superior East area are two alteration-mineralization zones. One is a Silver King where $6.5 million in silver had been extracted at the turn of the century from a small pipe-like deposit. The Silver King intrusive is pre-Whitetail in age, and abundant clasts of the Silver King diorite prophyry are found in the conglomerate immediately in the area. An alteration zone separate from the pipe-deposit is known which passes northeasterly under the Whitetail and overlying dacite. Evaluation of this zone is in progress. The Rock House zone, to the north, occurs in both Precambrian Pinal schist and post-dacite intrusive, contains pyrite with minor values, and is probably related to solfataric activity connected with the volcanism.

In the Magma area, a blind mineralized breccia is known in the area of the new No. 9 shaft. This shaft was collared in dacite, and as of last week was at a depth of 2100 feet in Whitetail Conglomerate. The new shaft will increase the air base and hoisting capacity for exploitation of the Magma stacked replacement ore bodies. An announced reserve of ten million tons of 5.8% copper is reported but this is calculated only to the 3900 level. Mineralization in scattered holes is known to the 4300 level but no reserve calculations have been released. Total production at Magma from the vein and replacement deposits has been 15-1/2 million tons of ore with 810 thousand tons of copper recovered. Little is known of the mineralized breccia, and during a recent tour at Magma we were politely refused passage into the area where they are presently diamond drilling an up-hole at the shaft site station in the breccia. All of the replacement limestone ore is totally blind and covered by dacite. ← March 4, 1971

The renewed interest in the Volcanic covered area between Globe and Superior has resulted in the accumulation of data on many facets of the problem. The present Asarco studies in the Superior East area include re-evaluation of the adjacent mineralization around the edge of the plateau, an evaluation of the Whitetail conglomerate of Oligocene age, an evaluation of the mid-Miocene volcanics, and a structural interpretation of the entire region. Dual elevation aero-magnetics has been completed over the area as well as new color photography by the Salt Lake Geophysical Division. A preliminary review of computer statistical drilling target evaluation has also been run.

The Whitetail conglomerate is the first post-mineral unit of the district. Recent age dating of a tuff unit in the conglomerate indicated a 34 m.y. date in the Ray district. Our study is through traverses in the scattered outcrop areas. Altered fragments are sought, and where found they are collected for assay. The tuffaceous silt matrix is also sieved and sampled and being assayed for values. The type of clasts are recorded and, where possible, the transport direction is determined.

The dacite, with a dated age of 20 m.y., was subjected to a study by D. W. Peterson (18) of the USGS. Peterson suggested that the dacite mass is an ignimbrite or ash-flow tuff, and thus equidimensional pumice fragments in the column of tuff would be progressively flattened as the mass cooled and settled. The most deformed or elongated pumice would be at the base, and the least would be at the top. A phase of his study included a study of the flattening ratio. Part of our work has been to verify this method of depth determination and expand the coverage. To date it appears the dacite is more variable than suggested by Peterson, and only gross position can be determined. A photo interpretation of the fracture pattern--intensity and relative age--on the Plateau is also underway. This is being coupled with expansion of a study into the surrounding pre-mineral units and a total evaluation being made of the relative high-low position of blocks.

Thirteen relatively deep drill holes, plus two of Magma's shafts, are known to be on the Plateau. Information on these penetrations is being gathered. Four of the holes penetrated into pre-mineral units; two are reported to have penetrated, but some questions remain; and the remaining seven holes were terminated either in early volcanics or Whitetail conglomerate beneath the dacite cover.

A recent study released by USGS (16) on the trace-element of biotite in granitoid rocks of the Sierrita district points up a further approach. The excellent exposures and biotite content of the Laramide Schultze granite of the Globe-Miami district makes this unit amenable to such a study, and particular care will be taken in the area where the granite passes under the dacite cover. The copper mineralization related to the Schultze granite has recently been studied and released in a thesis by Clary (9).

Asarco is not alone on the plateau (SLIDE SIX, Please) but we have a land position along with Inspiration Consolidated Copper Company, Magma Copper Company, and Continental Materials Corporation. Other companies such as Banner Mining Company have holdings off the Plateau area in the pre-mineral exposure. Negotiations are in progress with Continental Materials Corporation on their holdings.

As mentioned previously, drilling penetrations (SLIDE SEVEN, Please) in the Plateau area is restricted to four holes into pre-mineral rock out of some thirteen attempts. The four completions are near the eastern edge of the Plateau, and three intercepted nonsulfide exotic copper, while the fourth (southern) hole was barren.

In our Superior East drilling project, it is proposed to re-enter and deepen four holes, which presently range in depth from 1500 feet to 3000 feet in depth. Two of these were thought to be in premineral units by the previous operators but re-evaluation of the core by thin-section and with increased knowledge of the geology of the area, it is firmly believed that the holes terminated in post-mineral units. Completion of these holes will provide valuable geologic information as well as testing for the western edge of the Schultze granite where an Inspiration-Miami type body is permissible along the contact in schist and the incidence of rich limestone replacement bodies in the Paleozoic units.

Several new holes are proposed to further test the contact zone and also the continuation and source area of the eastern exotic copper zone. This phase of the high cost drilling area is expected to cost $300,000 with testing of adjacent target areas on a continuing basis to be $150,000 or a total of $450,000 for a two-year program in the Superior East project area.

Thank you.

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SLIDES

ONE:	JHC Ariz.-New Mex. Porp. Map with NW Trend overlay
TWO:	JHC Ariz.-New Mex. Porp. Map with NE Trend overlay
THREE:	KR-JHC Mineral Fissure - Alt. Trend at Silver Bell
FOUR:	JHC Ariz.-New Mex. Porp. Map updated
FIVE:	WES Orebody Map of Globe-Superior Trend updated
SIX:	Land Status of the Plateau area
SEVEN:	Drill hole locations on the Plateau area

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Start Slot 30 Position

Newark, N.J. meeting

James D. Sell EXPLORATION GUIDES TO CARBONATE HOSTED MASSIVE SULFIDE DEPOSITS IN WESTERN CORDILLERAN.

Tuesday, Feb. 19, 1980. 8Xxxxx 9.30-10.15

SLIDE 1. COPPER DISTRICTS OF W. US.

SLIDE 2. LEAD DISTRICTS OF W. US.

SLIDE 3. ZINC DISTRICTS OF W. US.

SLIDE 4. LEADVILLE, COLO, PRODUCTION - VALUE DATA

SLIDE 5. ASPEN, COLO. PRODUCTION - VALUE DATA.

SLIDE 6. TINTIC, UTAH. PRODUCTION - VALUE DATA

SLIDE 7. ALTERATION

1. Changes from the normal.
2. Most favorable bed.
3. Calcium_Magnesium_Silica addition.
4. Increasing unit involvement.
5. Direction of fluid movement.
6. Fracture control.
7. Contact control.=
8. Initial depositional characteristics.

SLIDE 8. LEADVILLE LIMESTONE FROM ASPEN (MISS.).

SLIDE 9. LEADVILLE LIMESTONE FROM LEADVILLE (MISS.).

SLIDE 10. RECRYSTALLIZED LEADVILLE DOLOMITE FROM ASPEN.

SLIDE 11. RECRYSTALLIZED HAMBURG DOLOMITE FROM EUREKA, NV. (CAMBRIAN).

SLIDE 12. RECRYSTALLIZED (PEARLY) FROM LEADVILLE.

SLIDE 13. RECRYSTALLIZED (ZEBRA) FROM LEADVILLE.

SLIDE 14. MINERALIZED PEARLY (EUREKA, NV).

SLIDE 15. MINERALIZED ZEBRA (LEADVILLE,COLO).

SLIDE 16. MINERALIZED BRECCIA (LEADVILLE).

SLIDE 17. CAVE FILL, STRATIFIED.

STRATIGRAPHY

SLIDE 18. CHRISTMAS, ARIZONA.

~~XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX~~

PROD UG & OP 29 MILLION TONS W/ ~~120,000~~ TONS CU METAL.

RESERVES EQUAL OP AND DOUBLE UG 240,000

SLIDE 19. MAGMA (SUPERIOR), ARIZONA.

VN 8 MILLION)
Dm 5 MILLION) with 1.1 MILLION TONS CU.
STACKED 10 MILLION)

RESERVES 40 million tons with 1.5 million tons cu.

FORM

SLIDE 20. GILMAN ORE RUNS.

SLIDE 21. GILMAN X-SECTION.

SLIDE 22. TINTIC ORE RUNS.

SLIDE 23. TINTIC PRODUCTION ZONING.

SLIDE 24. TINTIC GEMINI SECTION.

SLIDE 25. TINTIC IRON BLOSSOM SECTION.

SLIDE 26. TINTIC CHIEF PLAN.

SLIDE 27. TINTIC NORTH-SOUTH SECTION.

SLIDE 28. CHEMICAL CHANGES.

1. OUTSIDE DISTRICT
2. INSIDE DISTRICT.
3. NEAR ORE ZONE.
   A. DOLOMITE
   B. MINERAL JASPEROID
4. ORE ZONE.

Overhead. proj.

SLIDE 29 SPEEDY.