CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

Sacaton Mine

History of Discovery

by

Kenyon Richard

The discovery of the Sacaton orebodies has been reported in industry trade journals (1974-1977) in a manner suggestive (a) that it was only a simple matter of 2 Asarco exploration geologists tripping over a small mineralized outcrop (300' diam.--30' high), essentially devoid of copper staining, in a large, alluvium-covered area,---and (b) that the subsequent actual ore discovery and drilling of a couple of orebodies was an unremarkable consequence of the recognition of the outcrop's significance.

These implications are partially correct. However, the Sacaton discovery was only *one episode* in a continuing and fairly systematic Asarco program. A limited commentary on the nature of Asarco's program *prior* to the Sacaton discovery will, therefore, be germane. Actually, 2 discoveries in addition to Sacaton are involved.

That specific por. Cu program consisted of "re-prospecting" large areas of the SW.-US., (among other regions). This re-prospecting effort had two aspects: (1) the mechanical procedures which comprised airplanes, autos and, mostly, boots, in search of outcrops of disseminated alteration/mineralization; and (2) the geological techniques which narrowed the fields of mechanical search.

As to item (2) above, the following principal geological techniques are generalized:

(a) Large portions of the alt./min. outcrops over orebodies carry no Cu-stain. This is a standard condition in most productive por. Cu districts; however, *that* fact had been *overlooked* by the various generations of prospectors, prospector/engineers and even most geologists of the first half of the 20th Century. Also, the pioneering work of Blanchard (1968) and Locke (1926) carried the implication that the interpretation of leached outcrops was a guide to ore only in the known por. Cu districts.

(b) Literature Research: This included search for and study of very old as well as then-modern and -current scientific papers and maps. A *few* of the scientific papers (mostly USGS) of the first half of this century were particularly helpful in defining detailed geology within and close around the major known por. Cu districts. Articles in state and local geological publications (both regional and local subjects) and, surprisingly, articles in old trade journals too, were often helpful because the author would describe, say, clay-sericite and/or silicification all with Fe oxides---typical por. Cu-type alt./min.---but he would *not attach that* appellation because little if any Cu-stain was noted. These clues, sometimes only a few sentences in obscure, old publications, were enticing leads, indeed, for field checking.

(c) Asarco Files (1912-1950): Many clues similar to these described in the state and local publications noted under paragraph (b) above were found in files, both modern and ancient. An example: In 1912 AS&R (Asarco's original acronym) opened an "exploration" office in Tucson. The search for orebodies then consisted of individual mine and prospect examinations, those which "walked through the door" of the local mine manager, Richard (1978). Many of those old files were particularly useful 25-35 yrs. later.

(d) So-called "lineaments", which implies "lines" at the surface or, their real geological connotation, "structural planes" (particularly their intersections) were early hypothesized mostly, but not entirely, by academic geologists, as having controlled the positions of then-known por. Cu districts. Regardless of a paucity of demonstrable examples of *pre*-mineral structural control (only 4 districts, Bisbee, Miami, Silver Bell and Bagdad, Bryant and Metz (1966), Simmons and Fowells (1966), Richard and Courtright (1966), Anderson (1949), might have been classed as having then-known structurally controlled positions), the rather old hypothesis was revived during the mid- to late-'50s, particularly in the SW. where it became a favorite indoor sport of the exploration/academic geological fraternity. "Ruled" lines were drawn (by *al*most everyone) connecting everything with everything. These exercises were not regarded as practical and drawing lineament "lines" as representing structural planes connecting por. Cu systems was not part of Asarco's research efforts.

Asarco *did*, however, use the lineament idea in its por. Cu program in the distinctive sense that *broad* "trends" or "belts" marked either or both by roughly aligned successions (a) of small stocks of porphyries (not cupolas of single granitoid batholiths, necessarily, and *not* by connecting structural planes), and (b) of large or small zones of alt./min. (sometimes only leached pyrite in outcrops with indicated *very* small amounts of original Cu sulfides). This is noted farther along.

Partly to provide a record of areas covered by prospecting and partly to insure more-careful coverage, sketch/recon. geological maps were sometimes made. While doing that kind of mapping in the area SW. from Superior---a little more carefully than usual because he was trying to sort the volcaniclastic sequence in that area---John Kinnison discovered, in '60, a tiny sliver (about 10' x 200') of por. Cu alt./min. at the base of a hill of post-mineral basalt surrounded by Qal in all directions. That was the *only* surface expression of the Poston Butte por. Cu deposit. Asarco subsequently drilled 22 holes which, it was thought, defined a por. Cu system 1 mi. by 2.5 mi. in area. Although 3 holes cut "ore-grade" intercepts, altogether the results seemed too meager (as of then-projectable economics) to justify further work. (Asarco files; 1960-'63.)

The Poston Butte discovery is described herein (a) because it was a valid Asarco discovery of a por. Cu system, (later, discovered *again* by Conoco---Nason, et al. (1980)), (b) because the clue to its existence was indeed obscure, and (c) because it was a blaze on the trail to the Sacaton discovery.

Following (literally and "on trend") on Asarco's Poston Butte discovery, Art Blucher had just begun re-prospecting and sketch mapping in the wide-spaced ranges around Casa Grande. About the same time John Kinnison (Asarco files, 2/9/61) came up with a pencilled sketch approximately like Figure (1). The importance of this sketch is that it displays continuity of por. Cu systems within lengthy belts without known, long-trending, interconnecting structural planes. The projected triple intersection of belts a few miles west of Casa Grande was particularly intriguing, even though it was about 50 mi. from Ray and 40 mi. from Silver Bell, the nearest productive Cu mines. Obviously, that area of intersections should promptly be traversed.

It didn't take Kinnison and Blucher long. On Feb. 10, '61 after leaving the highway about 5 mi. W. of Casa Grande and circling around over the flat Qal terrain for an hour or so, they spotted the small hill, drove up to it and stepped out onto the outcrop of a por. Cu deposit. The hill (see Fig. 2) was unprepossessing inasmuch as it showed only a faint trace of Cu-stain in a couple of spots---not enough to have attracted any digging or sampling by prospectors. It consisted of granite and a thin dike of por., all altered to quartz-sericite-clay with weak but pervasive jarosite-goethite and a few specks of hematite-after-chalcocite, particularly in the dike. This was an outcrop which one would expect to have originally contained about 2% sulfides as pyrite/chalcocite/chalcopyrite assaying, say, .1-.2 Cu. However, what with nearest outcrops being the Sacaton Mts. 1.5 mi. N. which contain only a couple of very small, wide-spaced, Cu-stained spots, the hill was certainly an inviting exploration lead.

The Asarco Geophysical Dept. then appeared on the scene, and significant parts of an 11/61 report of their work and conclusions are excerpted:

"Geophysical surveys.....on the Sacaton Prospect include the usual recon. methods, I.P., resistivity and magnetics.....a total of 18 square miles was covered.....a new I.P. technique.....called "travelling depth profile".....to improve interpretations in the Sacaton area.....a seismic reflection survey.....to determine bed-rock depths.....Four anomalous zones were indicated by I.P...... travelling depth profiles.....Zone A [KR. note: See I.P. anomaly, Fig. 2].....indicated.....sulfides have rather *abrupt lateral* limits.....[KR. note: See Fig. (2)].....The geophysical target area was interpreted as the *boundary* of *significant sulfides*. [KR. note: Refer to the West Orebody outline on Fig. 2.]

Mostly because Asarco's N.Y. office was impressed with the geophysicists' view that the sulfide zone was small (laterally), only $30,000. was granted for 6 exploration holes. [KR. note: Along with this meager sum, a firm unwritten message was delivered by a high Asarco official that that was *all* we would get.]

The 1st 5 holes cut sulfides, but only a few short runs of ore-grade rock. Positioning the 6th hole (Fig. 2), obviously, was critical. Fortunately, during an informal meeting of several Asarco geologists, J. H. Courtright's insistence prevailed. If some of the other opinions (including the writer's) had been accepted, the 2 orebodies might not have been found. The 6th hole (potentially the last one) became the 1st hole within the West Orebody. (This, then, is a perfect example of the old exploration quip, "Always drill the last hole first.")

The Sacaton discovery illustrates 2 factors which are operative in almost every orebody discovery in new territory; (1) finding the mineral deposit (the simple conclusion of a long but systematic exploration trail), and (2) finding the orebody within the deposit (the early selection of the right set of practical geological facts from a large number of misleading geological impressions which often can be mistaken for facts). The real significance of either of these 2 factors is seldom evident until many holes have subsequently been drilled.

Except for some features of unusual pertinence, the general geology will not be described, herein. Instead the reader is referred to the fine article by Cummings (1982) for the geological details.

Reference is made to the longitudinal (ENE) sketch section Fig. 3, by Kinnison. This was compiled rather early in the drilling program and may be slightly distorted in some details, but it is adequate insofar as it displays some of the following important geological features, as follows:

(a) The bottom of the entire Sacaton hydroth. alt./min system is abruptly terminated by the near-flat, post-mineral Basement Fault at depths of 1800-2200'.

(b) A N-S. section would show the NNW. side of the Basement Flt. to be a steep (almost vert.), sharply curved up-turn. The SSW. side, as indicated particularly by the intercept in the Shaft (Fig. 2), dips 45° NNW.

(c) Thus, this "gravity sliding block", Cummings (1982), is shaped like a lopsided, flat-bottom boat. The approximate outline of this "boat" is the Basement Flt. where it defines the sub-outcrop of pre-mineral formations, as shown on Fig. 2.

(d) A number of post-conglomerate flts. having vert. separations of as much as 1500' have been mapped in the open pit on the

West Orebody or have been deciphered by vert. drillhole analyses. None of these flts. is known to have displaced the Basement Flt. It is to be noted that these faults *and* the Basement Flt. both cut the chalcocite blanket. The latter condition was of interest in regard to future exploration.

(e) Cummings (1982) states that the gravity sliding block moved N40-45E.

> [KR note: If so, it may have moved about 6(?) mi. from the large, rather deeply buried "ore" body described by J. David Lowell in his lecture, Dec. 5, '82, AIME Arizona Conference and named the Casa Grande West. It is suggested that that ore zone at one time was at an appreciably higher elevation, relatively. The Sacaton gravity block slid down from the top of that zone.]

(f) As is evident on Fig. 2, the 2 Sacaton orebodies are small:

West Orebody: (Open pit---high w/o ratio---largely mined out)

33. mil. T. @ .76 Cu

East Orebody: (Cave mine planned)

13.4 mil. T. @ 1.45 Cu

In '63 Asarco explored extensively for the root of the Sacaton por. Cu system. Courtright spotted and drilled a number of wide-spaced holes in an area extending 2 to 7 mi. SW. of Sacaton. Several of these showed *deep, short* intercepts of "ore-grade" rock; and two of them closely straddled what later became Getty/Hanna's Casa Grande West. Only one of these holes showed cc. of "ore-grade." Most intercepts were of oxidized Cu.

Asarco then regarded that area as being the root of the Sacaton system. The relative high proportion, however, of oxidized Cu at depths of 1000 to 2000' (anomalous, certainly) discouraged further exploration in that immediate area under then-extant economic conditions.

As noted above, this represented a valid discovery, but in only half the full sense---that is, (1) the deposit was found, (2) but not the orebody.

Although connected with Asarco's exploration programs from '45 to '67, it has been necessary for the writer, in order to revive and correct memories as to dates, numbers and sequence of activities, to discuss Sacaton with Asarco geologists who are acquainted with it currently and historically. These discussions were beneficial and are appreciated. Special thanks is expressed for the valuable help of J. H. Courtright. Some data which have been supplied have been used either to copy or compile the 3 Figures, or are directly quoted, or specified (Asarco files: approx. 1949-1980) where feasible. Thanks are due Asarco for permission to publish this paper.

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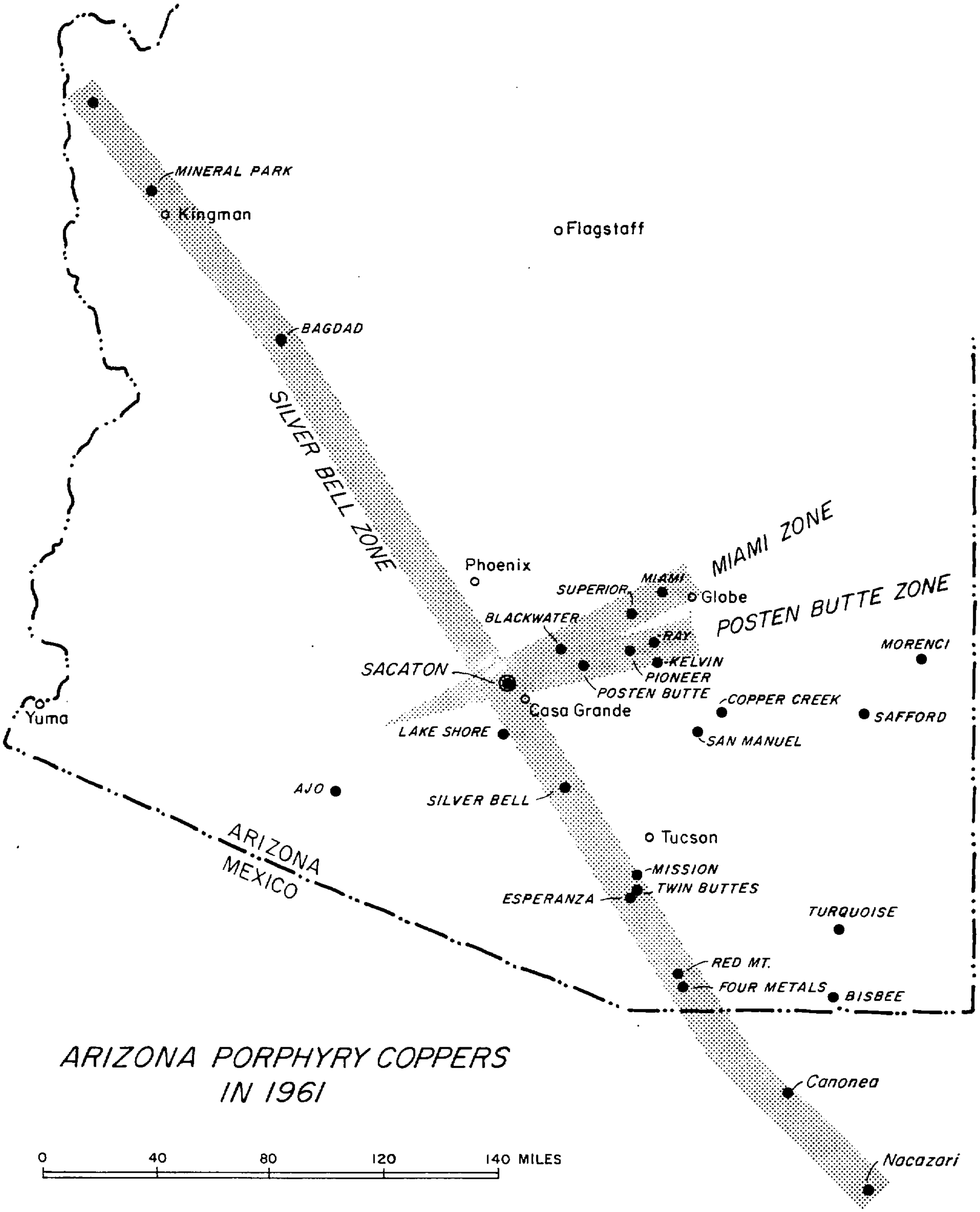
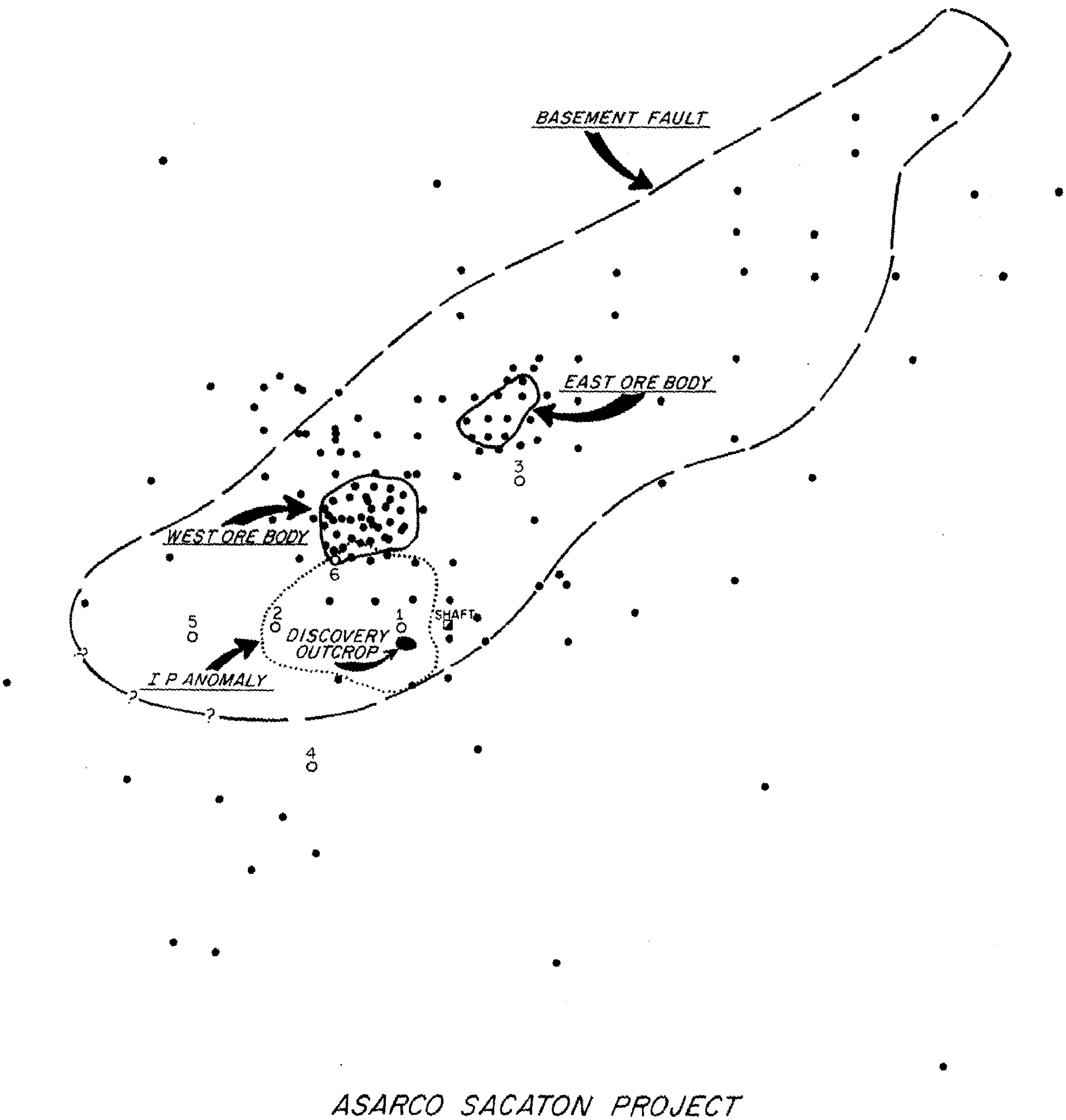
	"Mining Magazine"	2/1975
	"World Mining"	12/1975
	"Engineering and Mining Journal"	6/1977



ARIZONA PORPHYRY COPPERS
IN 1961

FIGURE I



ASARCO SACATON PROJECT
Pinal County, Arizona

FIGURE 2

JANUARY, 1973

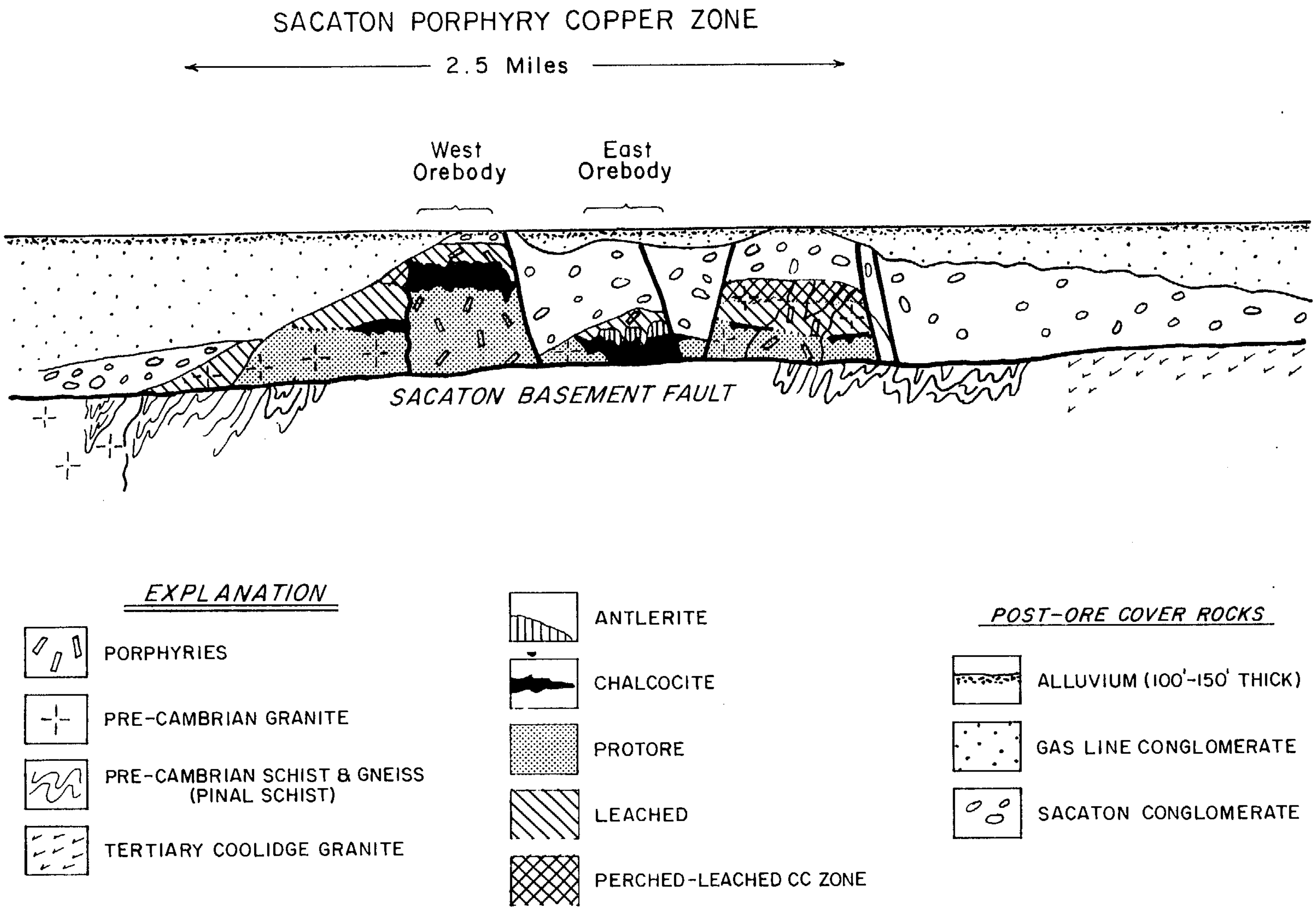


FIGURE 3 *SACATON DIAGRAMMATIC CROSS SECTION*

NOT TO SCALE

JANUARY, 1964

KENYON RICHARD
Mining Geologist
11 EAST ORANGE GROVE ROAD—APT. 535
TUCSON, ARIZONA 85704

602-297-5733

November 17, 1983

Note to Asarco personnel and other editors of this manuscript:

I've used my own style which, to some extent, violates a few rules.

Certain acronyms and abbreviations are used in order that the fast reader can read faster. However, some extra punctuation, such as commas, dashes, and parentheses (and italics) are used to make the fast reader slow down and pay attention. It is hoped that these features will not be changed much just to produce conformance.

Otherwise, thanks are extended to those who may have occasion to study and critically improve this manuscript.

It should be noted that Courtright already has gone over this material carefully and removed (sensibly) quite a few of my favorite bits of inappropriate though interesting information.

Kenyon Richard

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN EXPLORATION DIVISION
P. O. BOX 5747, TUCSON, ARIZONA 85703

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

July 10, 1972

Mr. Dave Beck
1725 East 4620 South St.
Salt Lake City, Utah 84117

Dear Dave:

I am returning to you, via mailing tube, the copies of the work sheets of the Sacaton Mountains which you had loaned Mr. John Balla for his use in the area. Thanks to your good work Dr. Balla is now well on the road to completing a large-sized map of the Table Top-Mineral Mountain area which is his Dissertation Figure 2. As soon as it is complete and published, within the next few + weeks, I will send you one with John's compliments and hearty thanks.

His praise for your mapping and observations is good for at least two drinks any time you are in Tucson or Spokane (where John will soon be stationed).

John's product is:

Balla, John C., 1972, The Relationship of Laramide Stocks to Regional Structure in Central Arizona: Univ. of Arizona, PhD Dissertation, 132 pages.

The ice is about to go out of the Santa Cruz, so better get this in the mail.

Regards,

Jim

J. D. Sell

JDS:lad

N.C.

J. H.

JAN 28 1974

HISTORY AND GEOLOGY OF THE SACATON MINE

The story of the Sacaton Mine begins in early 1961. At that time, two members of the ASARCO exploration staff from the Tucson Office were doing geologic reconnaissance on a mineralized belt trending west-southwest from the Miami-Superior area. On February 9, 1961, the two geologists came onto a small granite outcrop just off the southwest flank of the Sacaton Mountains about 6 miles northwest of Casa Grande. It was an inconspicuous low hill about 300' in diameter and surrounded by alluvial cover with the nearest bedrock exposures a mile and a half to the north. The hill, composed of granite cut by a monzonite porphyry dike, contained pervasive sericitic and argillic alteration. Both rock types exhibited limonite derived from the oxidation of pyrite and traces of "live" limonite derived from the oxidation and leaching of chalcocite (a copper ore mineral). The original sulfide content of this leached outcrop was about 2% by volume. It was not considered that this capping was directly underlain by ore grade copper mineralization; but the outcrop was regarded as a good exploration lead because of its porphyry copper type alteration in an area where a major sized ore body might be concealed beneath shallow alluvial cover.

After investigation of land status, options were obtained on private property and prospecting permits secured on the State land. A number of geophysical surveys were conducted, including induced polarization, seismic, gravity, and magnetics. On September 26, 1961 the first drill hole was put down on the north side of the discovery outcrop. Only thin intercepts of ore grade mineralization were encountered. The next four holes encountered similar results, but the sixth hole northwest of the outcrop cut a significant intercept of ore grade chalcocite. From this point on, drilling proceeded on a wide-spaced grid with the intent of finding the limits of the alteration zone. During the course of this drilling, two ore grade zones were encountered. The first drilling program was terminated on November 1, 1962 with a total of 65 holes, amounting to 73,609 feet. At that time the results of an economic analysis did not warrant further work.

In February, 1968, coincident with rising copper prices, a second drilling program was initiated in order to further delineate the two ore zones. The program was completed in January, 1969, after 38 additional holes had been completed, amounting to 46,937 feet of drilling. This data, combined with that of the first program, were used to calculate the ore reserves.

In order to further verify the feasibility of bringing the two deposits into production, metallurgical tests were run on six-inch diamond drill cores. A total of 38.2 tons of samples was collected from 15 holes. To obtain additional information beneath the planned location of surface structures, ten drill holes totaling 15,017 feet were drilled from November, 1970 to May, 1971. In addition, studies of environment, soil, and geohydrologic conditions were made in the mine area. The formal announcement of the decision to bring the mine into production was made on April 6, 1972.

GEOLOGY

Formations outcropping near the mine include the Older Precambrian Pinal Schist and Oracle Granite and the Younger Precambrian Sacaton Granite. The Precambrian rocks are intruded by the Laramide Three Peaks Monzonite which has been dated at 71.3 million years old. The Three Peaks Monzonite is located north of the mine area and is in the form of a zoned stock elongated in a northeast direction. In places, the above rocks are covered by Tertiary conglomerates and Quaternary alluvium.

Predominant pre-mineral rock types at the mine are Precambrian granite and a monzonite porphyry intrusive of Laramide age. Drill hole information suggests that the monzonite porphyry is in the form of an irregular stock centered near the southwest side of the west deposit. Geologic mapping in the open pit indicates that in detail a complex intrusive relationship exists between the granite and the monzonite porphyry. Post-mineral andesite porphyry dikes intrude the above rocks and post-mineral conglomerate and alluvium completely cover both deposits and all but a small portion of the altered zone. The alluvium varies from 60' to 100' thick and the conglomerate ranges from 0' to 600' thick over the west deposit and 700' to 1500' thick over the east deposit.

STRUCTURE

On a regional scale, the Sacaton deposits are located on a major northeasterly trending zone which contains a number of Laramide stocks and several producing copper mines. In the area of the mine this zone is evidenced by a N60°-70°E elongation of the alteration zone which contains the Sacaton deposits. If this trend is traced out to the northeast, it passes through or close to copper deposits at Superior and Miami.

The structure of the deposit itself is quite complex. The rocks are intensely fractured and faulted with mineralized and unmineralized fractures of all orientations present. The most common mineralized fractures strike N50°-70°E and are nearly vertical. The most common unmineralized fractures strike N5°-20°W and are vertical. Brecciation of both rock types is common and is often of sufficient intensity to produce a thorough mixing of the rock types.

A major normal fault (the Sacaton Fault) striking N20°W and dipping 60° to 70° to the east cuts off the west deposit on its east side. East of the Sacaton Fault bedrock was downdropped between 1000 and 1800 feet. The East Deposit is located on the downthrown side of the fault.

MINERALIZATION AND ALTERATION

The economic grade of the mineralization in both deposits is dependent on the process of supergene enrichment. At some time during the later stages of intrusion of the monzonite porphyry, primary sulfide mineralization of marginal grade was introduced into both the monzonite porphyry and the granite. Later erosion, oxidation, and enrichment formed two somewhat tabular shaped bodies of chalcocite ore.

Stripping of the west deposit, which contains 33 million tons of 0.76% copper started in the spring of 1972. The east deposit, with 14.5 million tons of 1.36% copper, will be mined by underground methods. The west deposit is about 1200' in diameter and varies in thickness from less than 100' to more than 700' in the center. The east deposit, lying at a depth of 1500', is about 600' by 1200' in plan, and around 300' thick.

Primary sulfide minealization in both deposits consists mainly of pyrite and chalcopyrite. In the better part of the primary zone these sulfides occur in a volume proportion of about 1.5 parts pyrite to 1 part chalcopyrite. The total sulfide content (by volume) averages between 1.5% and 3.0%. The primary sulfides occur both as thin veinlets and as discrete grains in roughly equal proportions. Chalcocite and minor covellite occur as supergene replacements of both pyrite and chalcopyrite. Chalcocite predominates in the upper portion of the ore zones and chalcopyrite in the lower parts. In addition to copper, the ore contains minor amounts of molybdenum and traces of gold and silver.

Leached capping, varying in thickness from 100' to 500' overlies both deposits. The capping is characterized by the presence of "live" limonites derived from the oxidation and leaching of chalcocite. Copper values in the capping average less than 0.1% copper, except where appreciable amounts of perched sulfides or oxidized copper minerals are present. Deep post-enrichment oxidation and leaching has destroyed portions of the chalcocite blanket. Oxidized copper minerals including antlerite, brochantite, azurite, malachite, and chrysocolla are found in varying quantities in the capping and below where second stage oxidation has penetrated the sulphides.

The ore bodies lie within a zone of hydrothermal alteration measuring 2.5 miles in length by up to one mile in width. Phyllic and argillic are the principal types with stronger alteration generally coinciding with more abundant sulphide mineralization. Notable features include a paucity of quartz veining (generally less than 1% of the rock) and an abundance of specular hematite (up to 3% or 4% of the rock). The intensity of the alteration is observed to decrease outward from the ore bodies.

RBC

Loading + Hauling only — 22¢/ton — George Percival

Sacaton —
1-24-77

Visit with RBS — FTG —

± 11000 tpd — 4/1 strip — 2/1 next yr.
Grade now .70 % Cu — recov - 88% —
" for remaining 6 yr - ± .60 Cu
" will will gradually drop to ± .5
Shaft operation still dormant —
Pit - Bottom drop cut about 420' from surface
Pockets of leaching decreasing but some still present near bottom — general reddish brown color due mainly to transported (?) hematite — or limonite after specularite —
Breccia (tight) mixture of angular rock frags — occ. blob of suls., but in general no better than average grade
Breccia occurs in roughly circular pattern, but not distinct pipe — narrow fluidized (?) zones — breccia: no rounding, but frags probably rotated some —
Origin: probable shatter bx associated with explosive action — fluidization. Contrasts with "normal" intrusive bx — in absence of rock flour matrix — and lack of stronger mineralization than in wall rock —
Cost of refined Cu — 64.0¢ /lb.
" " fr. smelt - ref 24.
40 ¢ prod

clean gray sul in patches — all the way down to pit bottom —

resemble "chewing gum gouge" at Kimberly. Nev

JHC

10/17/72

FROM: J. H. COURTRIGHT

TO: J.J. Collins

Re our discussion of 6" coring for Sacaton metallurgical samples:

Holes drilled	15
Core recovered	2,551'
Wt. per ft.	30 lbs.
Total	38.2 tons
Cost per ft. (direct)	$23.80

Your copy of report May 28, 1970 transmitted by Saegart June 11, 1970

JHC

J.H. Courtright

Sacaton 12-11-73

S-136 Shaft site

900 - shearing - gouge - starts mainly gr
1230-33 - st shear
33-35 - blk gouge ← Basement Fault
35-39 - chlorite
— foliated gr. firm rock with large pink feldspars — secondary ? " meta - granite - Pre €
1460 - slight to mod fol gr - traces ?

S-120
1840' - Base Fault
strong shearing to 1900 (end of core)

S-105
1960 - Fault
2015 - dark porphyry with white phenox - but part of Basement complex (mod gr - granitic Texture - set al of feldspars

Review of other penetrations suggest fault is coming upward to SE
- Basement complex at bedrock in some holes - farther ~~SE the~~ ~~east~~ and S of 136
also shallower on NW -
probable canoe shaped mass -

ASARCO

Mining Department
S. A. Anzalone
Chief Geologist

September 14, 1976

Mr. C. W. Campbell, General Manager
Western Mining Department
Tucson Office

Dear Mr. Campbell:

Sacaton Unit
East Ore Body
Verification Drilling

The Sacaton East verification drilling program was completed on August 20, 1976. Four drill holes totaling 7746.5 feet of rotary and diamond drilling plus the directional surveying of ten holes were completed under budget.

Summary of Results

The following information was provided by the verification drilling program.

(1) No significant dikelike areas of waste or low grade rock were encountered within the ore body that might diminish the ore reserve potential.

(2) Correlation of mineralization between diamond drill holes in the ore zone was established, providing continuity of ore values within the ore body.

(3) It was determined that zones or fingers of oxidation do not penetrate into the main mass of sulfide mineralization to any significant extent.

(4) Confidence in geological ore reserve has been improved. The following is a summary of ore reserves based on surface drilling. Reserves were calculated by the polygonal method with boundaries adjusted utilizing geological information obtained by drilling.

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

Summary of Reserves
(See Plate 1)

I. Sulfide Ore

1.	Sulfide "core zone"	13,783,000 tons @ 1.45% Cu
2.	Total sulfide ore	21,117,000 tons @ 1.26% Cu

II. Oxide Ore

1.	Oxide overlying sulfide "core zone"	2,234,000 tons @ 1.22% Cu
2.	Total oxide overlying sulfide ore	5,388,000 tons @ 1.15% Cu

(5) The oxide-sulfide mineral interface was found to extend to greater depth over the eastern portion of the ore body and a blanket of higher grade oxide copper mineralization overlies this area. The bulk of this mineralization is composed of copper carbonates and copper sulphates and may be amenable to flotation, thereby adding measurably to the ore reserve. (If a 70 percent recovery can be achieved on this oxide material, this will add to the mineable ore reserves. The Sacaton Unit already has a sulfidization circuit, and metallurgical tests to determent the material's reaction in the circuit are currently underway. Initial results are encouraging.)

(6) In addition to the sulfide ore summarized in (4) I. above, a substantial tonnage of Leachable Mineralization (chalcocite and copper oxides) has been delineated. Depending on the mining plan, portions or all of this material will remain after mining has been completed and will be available for leaching.

Summary of Leachable Mineralization
Based on Surface Drilling
Through August 20, 1976

A.	If only sulfide "core zone" mined	22,541,000 tons @ 1.03% Cu
B.	All possible sulfide ore mined	17,848,000 tons @ 1.02% Cu

(7) Drilling and surveying of holes provided supplemental information on the geometry and structural environment of

the mineralized area. All holes available for surveying were found to have deviated from the vertical, one by up to 230 feet at the bottom of the hole. Plotting the corrected positions of geological contacts, mineralization and structural features provided a more accurate picture of the size, configuration and grade of the potential ore body.

(8) Rock strength tests and geotechnical logging of core indicates that the caving characteristics of rock within the ore body will be favorable. Caving characteristics of the overlying conglomerate have not yet been established.

Recommendations

The modest size of the Sacaton East Ore Body minimizes production flexibility and leaves little room for miscalculation during the planning stage. It is imperative, therefore, that care be taken to thoroughly evaluate all potential problem areas before a commitment to final development is made. Also, every effort should be directed toward developing realistic, updated cost figures and escalation rates.

Preliminary DCFROI calculations based on the ore reserve developed to date suggest that under present economic conditions and current cost estimates, the Sacaton East ore body could support a profitable mining venture.

DCFROI Calculations

Mining the sulfide "core zone" only:

1.	Ore Reserve (undiluted)	13,783,000 tons @ 1.45% Cu
2.	Ore Reserve, diluted 15% @ .20% Cu	15,850,000 tons @ 1.29% Cu
3.	Recovery	90%
4.	Life of operation	10.57 years
5.	Production - 5,000 tpd for 300 days/year	1,500,000 tons per year
6.	Mining costs	$5.00/ton
7.	Milling costs	$2.00/ton
8.	Taxes	50%
9.	Copper price	75¢
10.	Estimated investment	$26,000,000

DCFROI Calculations
(Continued)

A. DCFROI If Total Investment Capitalized

Before Taxes	18.40%
After Taxes	15.00%

B. DCFROI If $20,000,000 of Investment is Expensed, Remainder Capitalized

Before Taxes	27.71%
After Taxes	20.50%

The information utilized in this preliminary DCFROI evaluation was based upon rough estimates of capital requirements, development costs, mining costs and future forecast values for copper. In addition, a dilution grade of 0.20% copper has been used in the above calculations. This is a conservative estimate. A considerable portion of the dilution grade will more than likely be nearer 0.80% copper when the higher grade sulfide "core zone" is mined. Also, no credit was given for precious metals or molybdenum (on the average approximately 0.004 oz. Au, 0.027 oz. Ag and 0.028% Mo) or copper obtained from an in-place leach operation.

In order to establish reliable updated figures on costs, a firm measurement of the mineable tonnage and grade must be established along with the final location and configuration of cave panels, undercut levels, haulage drifts and ventilation system. In addition, realistic tonnage capabilities must be established for both caving and hoisting. The mining rate will have a significant effect on the rate of return from an ore body the size of Sacaton East. It is equally important to establish whether the current design capacity of the underground unit will be able to supply sufficient tonnage to the mill in the event the open pit is exhausted early in the life of the underground operation and what effect increasing the presently anticipated production rate might have on the DCFROI. In this connection, any final economic evaluation should consider the possible effect of mining the additional tonnage available in extensions to the ore body - for example, areas B, C, and D, Plate 1; mineralization below the -320 elevation; and potential mineralization in unexplored areas near or adjacent to regions of known mineralization.

As suggested by Mr. J. H. Courtright in his memorandum dated April 4, 1969, geological and engineering data required to accurately establish the above criteria and develop the final mineable ore reserve can most effectively and economically be obtained by diamond drilling from underground drilling stations.

This will require completion of the Sacaton shaft plus approximately 3600 feet of crosscut from the shaft through the ore zone. Following the drilling program and evaluation of all data, a mineable ore reserve can be established and a detailed mining plan and economic evaluation provided by the Southwestern Mining Department.

Based on preliminary evaluation, under present economic conditions, the ore reserves outlined at the Sacaton East ore body are sufficient to support a profitable mining venture. The anticipated higher grade underground production will augment and ultimately replace ore from the open pit, thereby extending the life of the existing unit and improving its overall economic performance. Preliminary data suggests the cost per pound of copper will be competitive with current open pit copper production at Sacaton. Add to this the further potential of long term copper production from in-place leaching of mineralization remaining in the cave pattern after mining is completed, and the economic potential of the Sacaton East ore body is considerably enhanced.

On the basis of geological data obtained during the 1976 verification drilling program plus earlier exploration work conducted under the direction of J. H. Courtright (report dated April 4, 1969), further development of the Sacaton East ore body is justified and final detailed underground evaluation is warranted. In order to expedite this phase of development, it is recommended that the Sacaton underground program be re-established and that approximately 20,000 feet of underground definition diamond drilling be completed. (See Plate 2)

The estimated cost for 20,000 feet of underground diamond drilling is $225,000 distributed as follows:

20,000 feet of drilling @ $10.00/ft.	$200,000
Assaying and surveying	5,000
Contingencies	20,000
	$225,000

The preliminary locations of the proposed crosscut and diamond drill holes are illustrated on the attached plan maps and cross sections. Updated shaft sinking and drifting cost estimates, along with the selection of the final crosscut location will be submitted by the Southwestern Mining Department following review of this report.

Objectives and Procedures

A detailed review of available geological data by Mr. C. W. Campbell in mid-1975 called attention to a number of potential problems concerning the reliability of the East Sacaton geological ore reserve. Principal areas of concern were as follows:

(1) The possible existence of significant dikelike sections of waste or barren material within the potential ore body as portrayed on geological cross sections.

(2) The accuracy of the geometry of the mineralization as illustrated in the geological reserve and its possible adaptation to block caving.

(3) The necessity to more accurately define the mineable limits of mineralization.

If sufficient of these negative features did exist, doubt would be raised as to whether the mineralization at East Sacaton could be mined at a profit under present economic conditions. It was apparent that additional geological information was required prior to proceeding with further development of the underground operation.

In order to obtain answers to the questions raised by Mr. Campbell, a surface drilling program was proposed. R. B. Cummings in his memo dated March 17, 1976, outlined a two-phase, eight-drill hole program designed to provide information and possible answers to the questions of concern. At the request of R. B. Meen, the Cummings memo was reviewed by S. A. Anzalone and a decision was made to proceed with phase one of the Cummings program. The writer, in a memo dated April 13, 1976, recommended that phase one of a verification drilling program be implemented and an appropriation totaling $120,000 to cover the cost of this work was recommended.

The East Sacaton verification drilling program was completed on August 20, 1976. Four drill holes totaling 7,746.5 feet of rotary and diamond drilling plus the directional surveying of ten holes were completed. Overburden drilling was conducted by C. & W. Drilling Company utilizing a truck-mounted Failings 1500 rig. Diamond drilling was handled by Joy Drilling Company utilizing a truck-mounted Joy 22 rig. All diamond drilling was completed with N.C. wire line tools. An average of 94 percent core recovery was achieved.

Field operations were supervised by Mr. R. B. Cummings, who is to be commended for conducting an efficient, safe operation and bringing the program to completion under budget.

Drill Hole Surveying and Verification of Mineral Intercept Location

Following the completion of the first hole drilled during the 1976 verification program, difficulty was encountered in correlating the geology displayed in this hole with the geology developed from earlier drilling in the area. A decision was made to survey the hole in order to provide an accurate location of the mineralization encountered.

Directional drill hole surveying was handled by Mollen-Hauer Surveying Company utilizing a Humphreys gyroscopic down-the-hole surveying unit, enabling the surveyor to obtain dips and direction through the steel casing. Hole No. 145 was found to have deflected a considerable distance to the northeast. Additional holes were then surveyed, and it was discovered that virtually all holes had deviated from the vertical, some up to 230 feet.

The modest size of the Sacaton East ore body requires that very accurate definition of the geometry of the mineralized zone be obtained prior to laying out a final mine plan and calculating a mineable ore reserve. As a result, as many of the old drill holes as possible were resurveyed utilizing the newer, more accurate instrument. Gyroscopic survey instruments sufficiently small to fit within the drill rod utilized in the earlier Sacaton drilling would have been of considerable assistance in calculating the original ore reserve. Regrettably, small instruments of this quality did not come into common use until quite recently.

Having established the correct location of the mineral intercepts, a new series of polygons was drafted and ore reserves calculated based on the corrected survey locations. The procedures and results are described in the Ore Reserves section of this report. The shift in mineralization observed in the surveyed holes did not diminish the ore reserve. It actually widened the mineral zone and increased the ore reserve. The survey trace of the surveyed holes within the ore body is shown on Plate 11.

Geology and Ore Continuity

With regard to the possible existence of dikelike sections of waste or barren material within the ore body, the diamond drilling revealed that no such areas of significance were likely to occur. A number of short runs of lower grade quartz monzonite porphyry were encountered, but little or no barren dike material was encountered. Relogging of earlier diamond drill core indicates that quartz monzonite porphyry dikes are, in fact, mineralized and reasonably well altered. There appears to be little doubt that the quartz monzonite porphyry will serve as a suitable host rock for copper mineralization within the East Sacaton ore zone. The quartz monzonite porphyry was found to be somewhat harder than the other rock types encountered due to silicification; however, it does not appear that it will be significantly more difficult to break or grind.

The verification drilling provided additional information to assist in the correlation of mineralization between diamond drill holes in the ore zone. As can be seen on the attached cross sections (Plates 3-10), continuity of ore values within the ore body is well established.

As a result of experience gained in the open pit operation, considerable concern was expressed about the possibility of fingers or zones of oxidation penetrating into the ore reserve area, thereby diminishing the tonnage potential and anticipated grade. A detailed review of the earlier drilling plus the information provided by the 1976 verification drilling program indicates that fingers of oxidation do not penetrate into the main mass of sulfide mineralization to any significant extent. A careful review of all drill core in the ore zone indicates that oxidation within the ore body will not be a significant problem. As a consequence, confidence in the geological ore reserve has been improved.

Ore Reserve

To avoid being influenced by previous ore reserve calculations, a new ore reserve was calculated by the author incorporating the new information provided by the 1976 verification drilling and drill hole surveys. The polygonal method was used, adjusting ore boundaries with geological information obtained by the verification drilling program. The ore reserves based on the new calculations are summarized at the top of Page 2.

The ore reserve tonnages and grades presented herein do not include dilution. The current figures represent an estimate of the potential tonnage and grade that should be amenable to block caving. The final diluted grade will depend to some extent on the recoveries achieved in metallurgical tests being conducted on copper oxide material that overlies the sulfide ore zone.

A detailed breakdown of the distribution and grade of the various ore types is provided in Appendixes A - C. A plan map illustrating the location of the various compenents constituting the total ore reserve is provided on Plate 1. The ore reserves were calculated by measuring the area in each polygon, calculating the potential tons per vertical foot and then multiplying that figure by the length of the column of ore grade material encountered in the particular drill hole involved. The ore reserves calculated by this method compare reasonably well with earlier ore reserve calculations by S. E. Zelenkov (memo to J. H. Courtright, February 28, 1969) and Carl Williams (memo to J. H. Courtright, March 6, 1969).

	Tons	% Cu
Carl Williams	14,558,002	1.37
S. E. Zelenkov	12,503,040	1.39
Current Study	13,783,000	1.45 (higher grade core zone)

If the north extension and east extension (Areas B and C on Plate 1) are added to the current reserve calculation, a total of 17,921,000 tons averaging 1.31% copper is obtained. Portions of these areas were included in the Williams and Zelenkov studies. Recent drilling has enlarged and modified the configuration of the mineralized body since their work, with the result that if Areas A, B and C are added together, the tonnage is increased by 23.1 percent and the grade decreased by only 4.4 percent, resulting in an increase in the total pounds of recoverable copper.

Oxide Copper - Metallurgical Tests

During examination of diamond drill core by the writer and R. B. Cummings, it was observed that little or no chrysocolla occurred in the oxide mineralization capping the sulfide zone. The bulk of the mineralization proved to be composed of copper carbonates and sulfates (azurite, malachite, brochantite and antlerite) and it was thought that this material might be amenable to flotation, thereby adding to the ore reserve. Arrangements were made with the Mineral Beneficiation Department to run flotation tests on this material at the Sacaton Unit. Metallurgical tests to date are encouraging. The final test results on this work will be provided by the Southwestern Mining Department.

Possible Leach Ore

In addition to the potential sulfide ore encountered in the drilling summarized at the top of Page 2, a sizeable tonnage of leachable copper mineralization composed of chalcocite and copper oxides was delineated. Depending on the final mining plan, a considerable amount of this material will remain within and adjacent to the cave area after the mining has been completed. This material will be available for leaching by solutions introduced from above. Pregnant solution can be collected in the lower workings of the mine and pumped via the main shaft to the surface for utilization in a leach plant. As can be seen by the following figures, a considerable number of pounds of recoverable copper will remain in the ground after mining is completed.

a. Leach Material Remaining if Only Sulfide "Core Zone" Mined:

   17,154,000 @ .99% Cu = 339,649,000 lbs.
   50% recov. = 169,824,000 lbs Cu recovered

b. Leach Material Remaining if All Possible Ore Mined:

   9,306,000 @ .91% Cu = 169,369,000 lbs.
   50% recov. = 84,684,000 lbs. Cu recovered

It is of interest to note that if the entire East Sacaton ore reserve were considered strictly as an in-place leaching operation utilizing the underground development crosscuts as collection basins for pregnant solutions and pumping them out through the shaft, a potential recovery of approximately 400 million pounds of copper is theoretically possible assuming a 50 percent recovery. While current plans do not call for the East Sacaton ore body to be operated as an in-situ leach operation, this is nonetheless an option to be considered should the underground mining plans be further delayed or be proven uneconomical by rapidly escalating mining costs.

Geotechnical Data

With the assistance of members of the Sacaton Engineering Department, all of the drill core obtained during the verification drilling program was logged in detail to obtain geotechnical data to be utilized in ascertaining whether the characteristics of the rock within the ore body were suitable to block caving. A point load tester was obtained and rock strength index tests were carried out on suitable segments of core throughout each of the drill runs. In addition, all core was photographed for future study. A preliminary evaluation of the geotechnical data indicates that the caving characteristics of the rock are favorable.

A number of core runs in the eastern sector of the ore zone were found to be highly broken and brecciated with sections containing considerable fault gauge and clay. The possibility that this material might pack in some of the cave panels if allowed to stand for any length of time was pointed out by the Sacaton Mining Department. This problem can be avoided if a caving schedule can be developed that will not allow the broken ore to sit in any one panel for any extended length of time. The total amount of material susceptible to packing does not appear to be great. Attempts will be made to obtain additional data regarding the caving characteristics of the mineralized rocks and possible problems relating to packing in the areas of severe brecciation and fault gauge. The geotechnical testing to date indicates that the rocks, while competent, are not very hard and should break quite readily. Some problems may develop with regard to holding the backs in isolated gaugy areas, but these can be handled if sufficient care is taken.

In general, the rock should cave well and mining problems should not be severe.

DCFROI Calculations

Preliminary DCFROI calculations were made to ascertain whether the East Sacaton ore body might be developed to achieve an acceptable rate of return. As can be observed by the calculations illustrated on the next page, the East Sacaton ore body does, under present economic conditions, and utilizing current cost-price estimates, show an acceptable rate of return.

Two DCFROI cases are presented. Case A illustrates the standard calculation assuming that the total amount to be invested will be capitalized. Case B makes the alternative assumption that $20,000,000 of the investment can be expensed. Case B is presented to show the potentially favorable effect on the Sacaton ROI if a significant portion of the investment can be expensed. It must be re-emphasized that all of the above calculations are based upon present economic conditions and utilize current cost estimates. A final economic evaluation will be presented by the Southwestern Mining Department utilizing updated figures following the completion of the underground drilling program.

DCFROI CALCULATIONS

Mining the sulfide "core zone" only:

1.	Ore Reserve (undiluted)	13,783,000 tons @ 1.45% Cu
2.	Ore Reserve, diluted 15% @ .20% Cu	15,850,000 tons @ 1.29% Cu
3.	Recovery	90%
4.	Life of operation	10.57 years
5.	Production - 5,000 tpd for 300 days/year	1,500,000 tons per year
6.	Mining costs	$5.00/ton
7.	Milling costs	$2.00/ton
8.	Taxes	50%
9.	Copper price	75¢
10.	Estimated investment	$26,000,000

	A. Total Investment Capitalized	B. $20,000,000 Expensed, $6,000,000 Capitalized
Net smelter value/year	$18,048,000	$18,048,000
Mining costs	7,500,000	7,500,000
Milling costs	3,000,000	3,000,000
Net cash before taxes	$ 7,548,000	$ 7,548,000
DCFROI BEFORE TAXES	18.41%	27.71%
Depreciation (St. Line)	$ 2,460,000	$ 568,000
Depletion (50% Net Cash)	2,544,000	
Depletion (15% N.S.V.)		2,707,000
Taxable income	$ 2,544,000	$ 4,273,000
Tax at 50%	1,272,000	2,136,000
	$ 1,272,000	$ 2,136,000
Depreciation	2,460,000	568,000
Depletion	2,544,000	2,707,000
Net cash after taxes	$ 6,276,000	$ 5,412,000
DCFROI AFTER TAXES	15.00%	20.50%

In summary, having reviewed the results of the 1976 surface verification drilling program and re-evaluated previous drilling, it is the opinion of the writer that phase one of the verification drilling program has provided sufficient geological data to recommend that the East Sacaton underground program be re-established and that approximately 20,000 feet of underground definition diamond drilling be completed. The detailed information obtained from the underground drilling program will be utilized by the Southwestern Mining Department to provide a final updated economic evaluation of the Sacaton East project.

Additional information regarding the proposed underground program will be provided by the Southwestern Mining Department.

Very truly yours,

S. A. Anzalone

S. A. Anzalone

SAA:ka

Encls. - Plates 1-11
Appendixes A-D

cc: NVisnes
TEScartaccini
TREdwards
RBCummings

APPENDIX A

I. SULFIDE ORE

Above -320' Elevation
Undercut Level

Area		Tons	Grade % Cu
A	Sulfide "core zone"	13,783,000	1.45
B	North extension	2,960,000	0.70
C	East extension	1,178,800	1.27
D	Possible west extension	3,196,000	0.95
E	Possible southeast extension - caved for oxide only	--	--
	TOTAL SULFIDE ORE	21,117,000	1.26

RECEIVED
JUN 10 1975
EXPLORATION DEPT.

J.H.C.
JUN 11 1975

ASARCO Incorporated
Casa Grande Arizona
Sacaton Unit

June 9, 1975

Memorandum To: T. R. Edwards

From: R. B. Cummings

Subject: Exploration Possibilities Northeast of the East Orebody

Summary

Drill hole data from the general area northeast of the east orebody suggests that an attractive underground exploration target is present. Geology in the target area is similar to that from the east orebody. Mineable thicknesses of sulfide mineralization averaging 0.50% copper were intersected in 2 drill holes which are separated by a distance of 2,000'. This and other data suggest that the northeastern end of the Sacaton alteration zone might contain mineralization similar in grade and tonnage to the east orebody. A five hole drilling program costing $ 140,000. is recommended to test this target.

Introduction

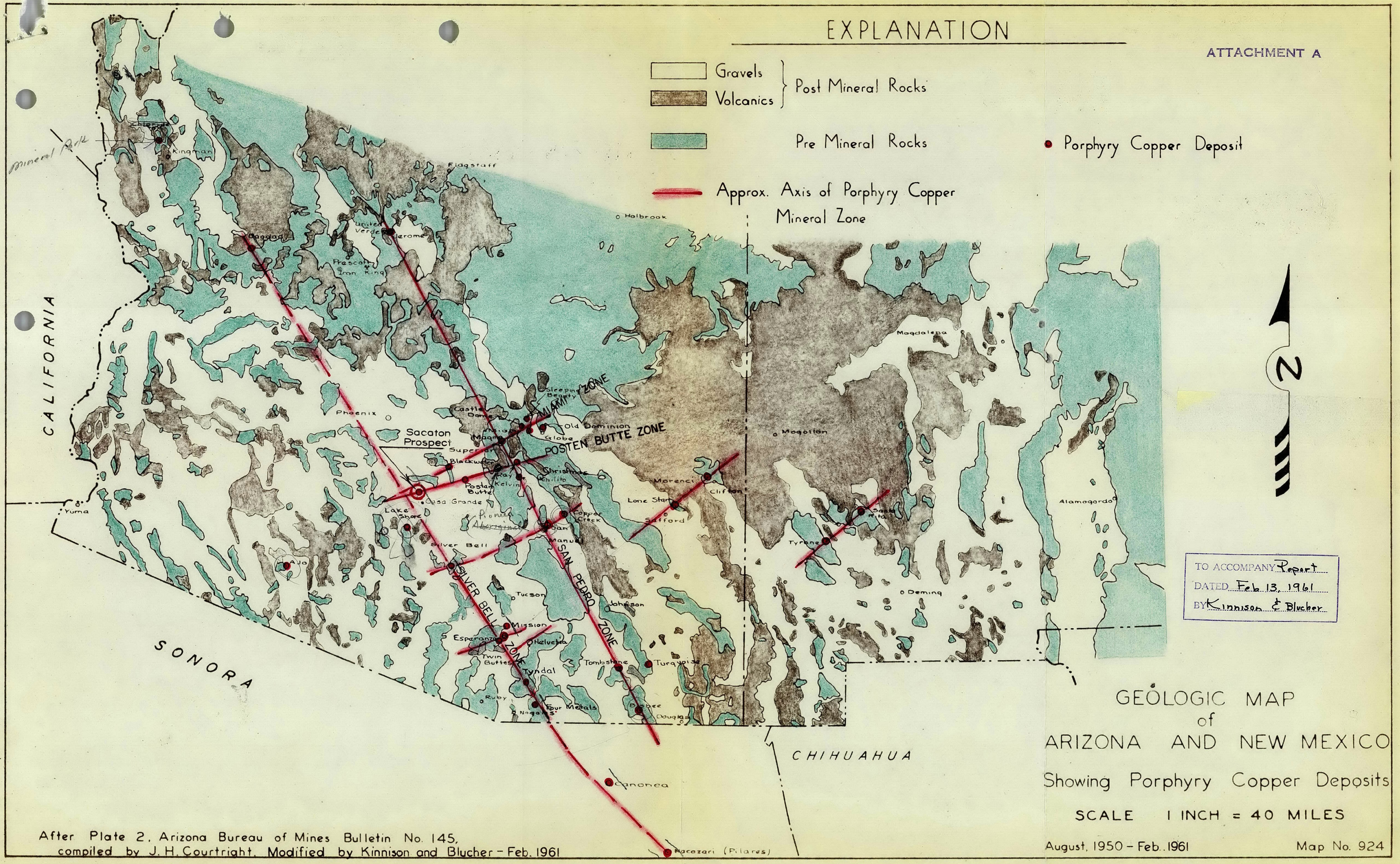
Recent examination of drill hole data along the Sacaton alteration trend suggests that a residual exploration target is present northeast of the east (underground) orebody. Drawing SAC-11-G3 is a drill hole location map showing the outline of the east orebody, the open pit, and three sections drawn parallel to the alteration zone. Drawing SAC-11-G2 shows the three sections looking northwesterly through the west orebody, east orebody, and the area of interest.

The drill hole location map shows that the exploration drill spacing northeast of the east orebody is about 2,000' in a direction parellel to the trend, and 500' in a direction at right angles to the trend. The maximum dimension of the east orebody is approximately 1,100' parallel to the alteration trend and 650' at right angles to the trend. Thus, the exploration drilling did not totally eliminate the possibility of finding an underground orebody similar in size to the east orebody. For the purpose of this study the area of interest is considered to be the N 1/2 of Sec. 25 and part of the S 1/2 of Sec. 24 between drill holes S-56 and S-78.

Harold,

Sacaton Shaft Making 560 gpm
at shutdown

2 DeWatering wells making ≈ 800 gpm



EXPLANATION
ATTACHMENT A
Gravels
Volcanics
Post Mineral Rocks
Pre Mineral Rocks
Porphyry Copper Deposit
Approx. Axis of Porphyry Copper Mineral Zone
CALIFORNIA
SONORA
CHIHUAHUA
Kingman
Flagstaff
Holbrook
Jerome
Bagdad
Phoenix
Sacaton Prospect
Globe
Old Dominion
MIAMI ZONE
POSTEN BUTTE ZONE
Christmas
Casa Grande
Lake Shore
Silver Bell
SILVER BELL ZONE
SAN PEDRO ZONE
Tucson
Mission
Esperanza
Twin Buttes
Tyndall
Ruby
Nogales
Four Metals
Tombstone
Turquoise
Bisbee
Douglas
Johnson
Copper Creek
Safford
Lone Star
Morenci
Clifton
Mogollon
Magdalena
Tyrone
Santa Rita
Deming
Alamogordo
Ajo
Yuma
Cananea
Nacozari (Pilares)
TO ACCOMPANY Report
DATED Feb. 13, 1961
BY Kinnison & Blucher
GEOLOGIC MAP of ARIZONA AND NEW MEXICO
Showing Porphyry Copper Deposits
SCALE 1 INCH = 40 MILES
August, 1950 - Feb. 1961
Map No. 924
After Plate 2, Arizona Bureau of Mines Bulletin No. 145, compiled by J. H. Courtright. Modified by Kinnison and Blucher - Feb. 1961

← These ↑ 3 lines only

MIAMI ZONE
Globe, Miami & Superior
Blackwater, Sacaton

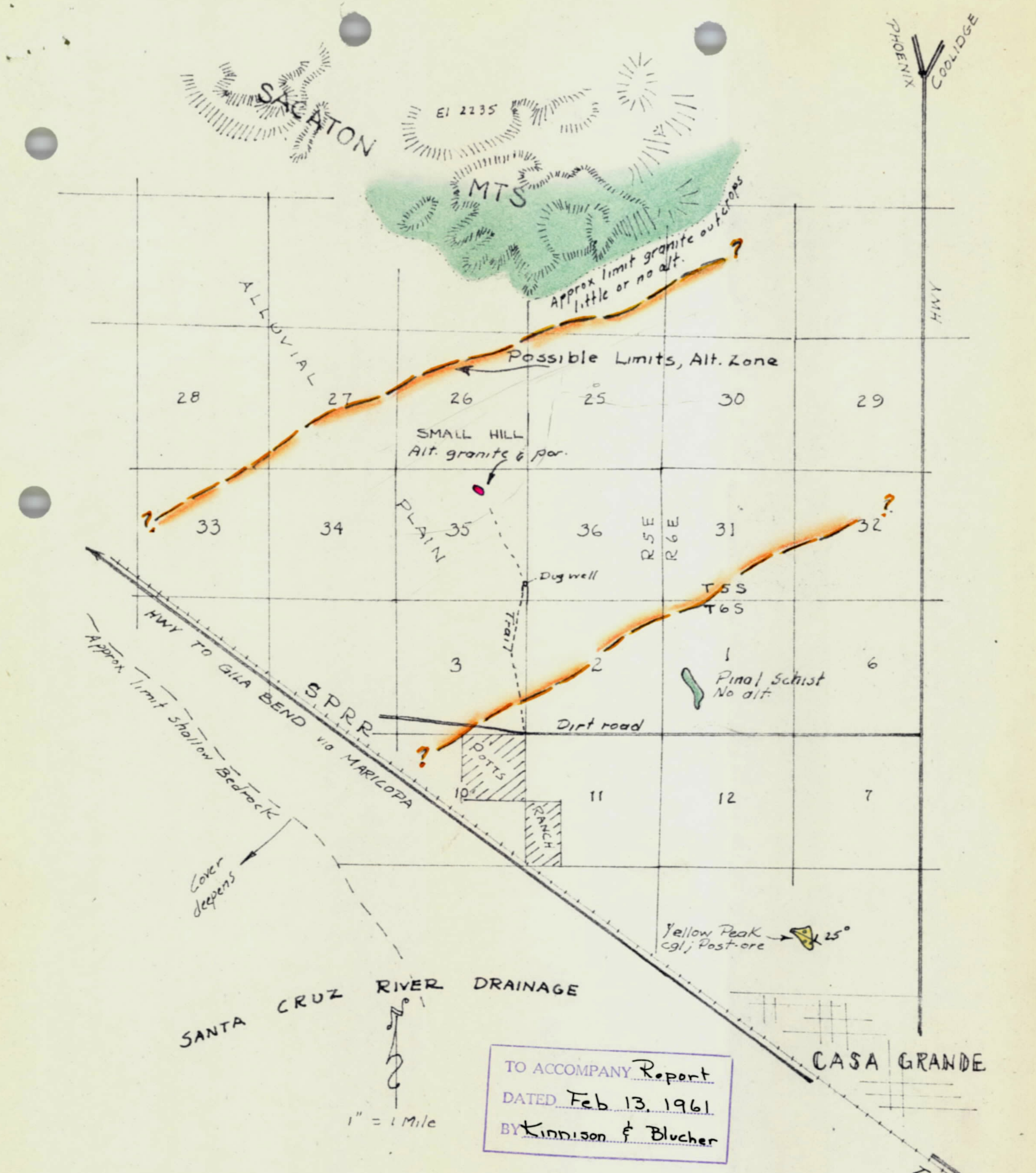
P.B. ZONE
(Kelvin as a dot.)
Pioneer, Ray, P.B.

Town of C.G.

Zones $\frac{1}{4}$" wide

Kingman, Phoenix & Tucson
Casa Grande

SAFFORD
MORENCI



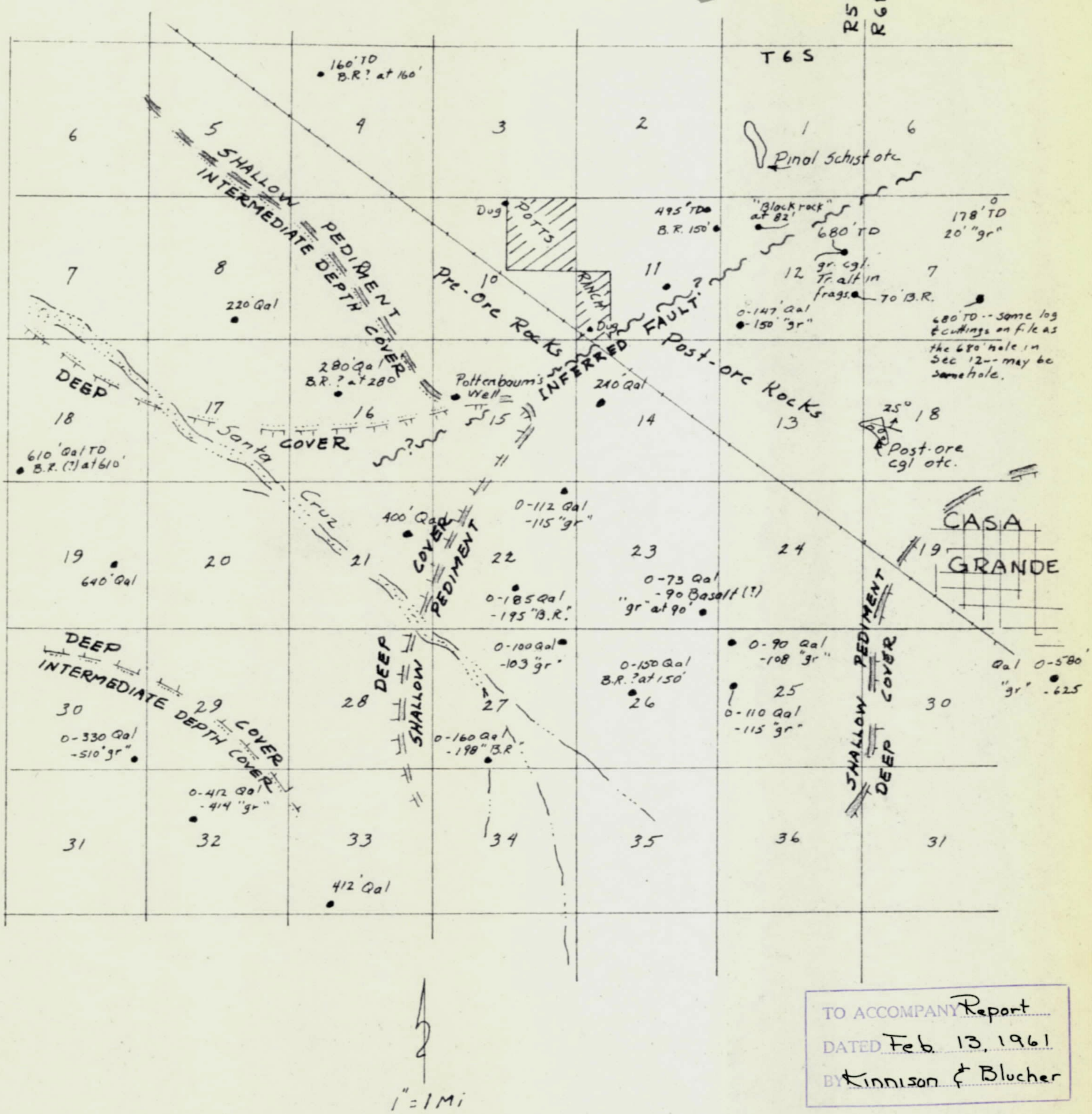
GEOLOGIC SKETCH

SACATON PORPHRY COPPER PROSPECT

A. G. Blucher
J. E. Kinnison

Feb 13, 1961

ATTACHMENT B



TO ACCOMPANY Report
DATED Feb. 13, 1961
BY Kinnison & Blucher

CASA GRANDE AREA
Well Data Collected to Feb, 1961
Source: U.S.G.S. Tucson

Porphyries

pre-Cambrian granite

pre-Cambrian schist and gneiss (Pinal schist)

Tertiary Coolidge granite

Screens

Antlerite

Chalcocite

Protore

Leached

Perched-leached Cc zone

Post-Ore Cover Rocks

Alluvium (100-150' thick)

Clay

Gas Line conglomerate

Sacaton conglomerate

~~"Pebblestone" (w/native Cu)~~

SACATON
DIA. Cross Sect.
Not To Scale

DIAGRAMMATIC CROSS SECTION
Looking NW
SACATON
NOT TO SCALE

J.E.K. 1/29/64

Re-place at bottom
of UHC files

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 15, 1961

Mr. C.P.Pollock, Exploration Manager
American Smelting and Refining Company
120 Broadway
New York 5, New York

DRILLING RECOMMENDATIONS
Sacaton Prospect
Pinal County, Arizona

Dear sir:

Reference is made to Mr. Saegart's memorandums of September 1 to Mr. Lacy, and his covering letter regarding the results of the thorough geophysical work in the Sacaton area, and including their recommendations.

Saegart concludes that the area of indicated significant sulphide mineralization is limited to Zone A and is rather small in area (1800' by 3500'). Though small, this area still is large enough to contain an ore body. Mr. Courtright and I recommend six drill holes as a minimum test. The positions of three are shown on the attached map which is a copy of Attachment "A" from Saegart's report.

Proposed drill hole locations A, B, and C are within the area of highest I.P. response. These three are rather close-spaced, the reason being that one or two holes could be midleading in terms of average copper content.

Location D is intended to test Zone A along its apparent strike.

Location E is situated outside of the area of significant sulphides as described by Saegart. This hole is intended to determine whether the southerly drop-off in I.P. response is due to diminishing sulphide content or to some other geological condition such as deep leaching.

Location F on Zone D falls in the category of "just to be sure". In this regard, Mr. Saegart says that, "if a sulphide source exists, the sulphide content is too small to be of interest." This statement is entirely correct for most disseminated deposits, but there are exceptions. As an example, disseminated bornite alone can constitute ore even though theoretically the I.P. response would be low.

We have assumed an average depth of 500' for these six holes. Actually, this will vary depending on the strength of primary mineralization from hole to hole.

We estimate the drilling cost per foot at $9.50, including contract costs, sampling, assaying, supervising, etc. We are planning to purchase a used trailer from the Mission Contractor. This will be used for field core storage so that no persons but our samplers will see the core.

The cost of this program is summarized:

Drilling - (3000' at $9.50/ft)	$28,500
Trailer -	400
Contingencies -	1,100
Total	$ 30,000

If you agree with this program would you please get authorization for this amount. We would expect to begin drilling shortly thereafter.

It would seem that zone D termed the Casa Grande prospect, should be in a separate category. Consequently, the above total does not include money for any work that might be contemplated in that area.

There is an unexpended balance of approximately $9,000 in M.A.880. This authorization originally was set up principally to acquire options. One option payment of $7,500 is due December 1, 1961. By that time our drilling results may not be conclusive, in which case we would need to make the option payment.

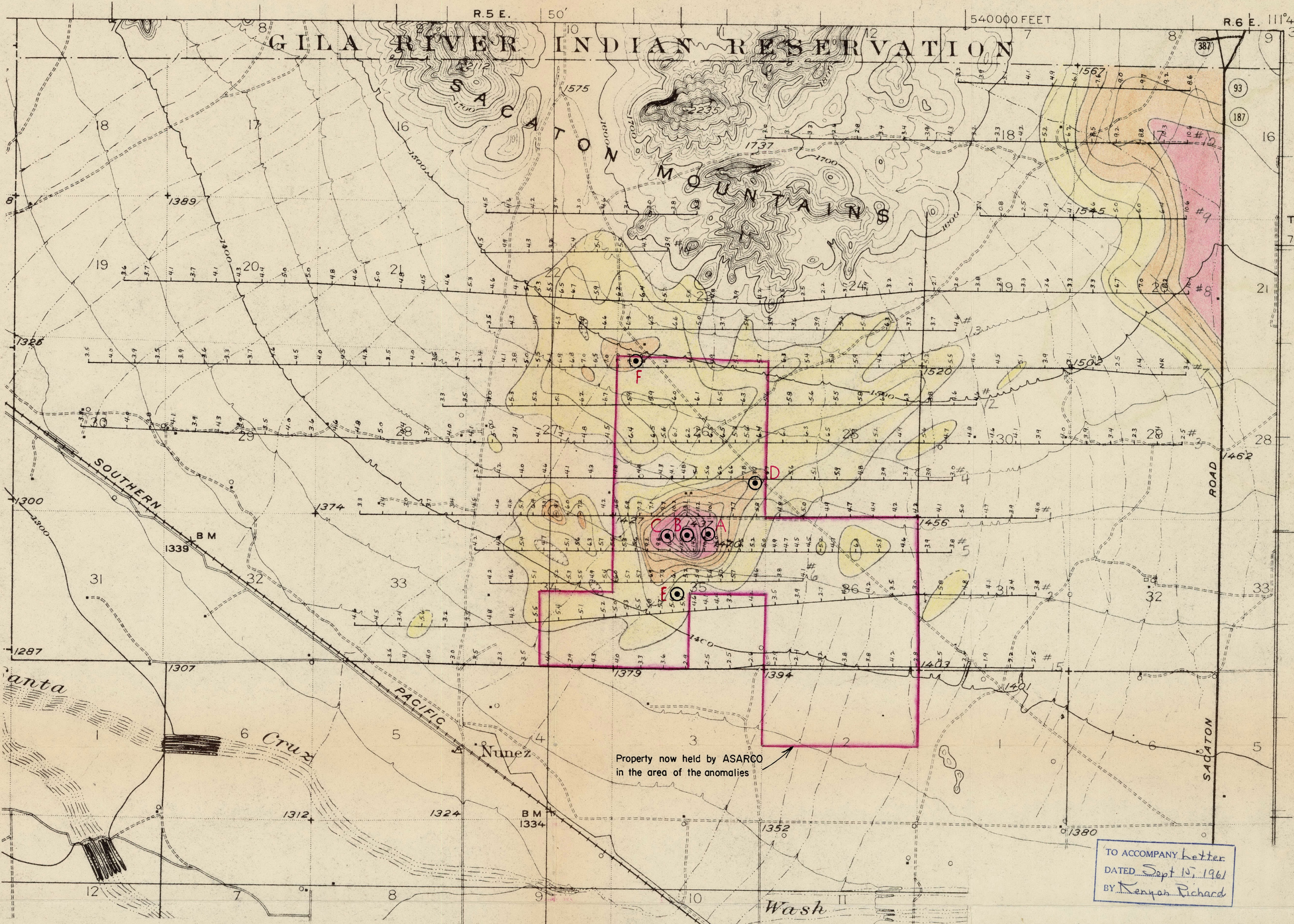
Yours very truly,

KENYON RICHARD

KR/z
Attach.

cc: DJPope, w/attach.
RJLacy, " "

Route file copy to:
TASnedden
ACHall
JHCourtright
KvdSteinen
WESaegart



EXPLANATION

I.P. RESPONSE

- below 5 m.v./v.
- 5 to 7 "
- 7 to 10 "
- above 10 "

I.P. response

#3 traverse number

traverse & stations

mineralized outcrop

CONTOURS of INDUCED POLARIZATION

SACATON PROSPECT

PINAL COUNTY ARIZONA

APPROX. SCALE: 1" = 1/2 mile

CONTOUR INTERVAL: 1 millivolt/volt

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 15, 1961

Mr. C.P.Pollock, Exploration Manager
American Smelting and Refining Company
120 Broadway
New York 5, New York

DRILLING RECOMMENDATIONS
Sacaton Prospect
Pinal County, Arizona

Dear sir:

Reference is made to Mr. Saegart's memorandums of September 1 to Mr. Lacy, and his covering letter regarding the results of the thorough geophysical work in the Sacaton area, and including their recommendations.

Saegart concludes that the area of indicated significant sulphide mineralization is limited to Zone A and is rather small in area (1800' by 3500'). Though small, this area still is large enough to contain an ore body. Mr. Courtright and I recommend six drill holes as a minimum test. The positions of three are shown on the attached map which is a copy of Attachment "A" from Saegart's report.

Proposed drill hole locations A, B, and C are within the area of highest I.P. response. These three are rather close-spaced, the reason being that one or two holes could be midleading in terms of average copper content.

Location D is intended to test Zone A along its apparent strike.

Location E is situated outside of the area of significant sulphides as described by Saegart. This hole is intended to determine whether the southerly drop-off in I.P. response is due to diminishing sulphide content or to some other geological condition such as deep leaching.

Location F on Zone D falls in the category of "just to be sure". In this regard, Mr. Saegart says that, "if a sulphide source exists, the sulphide content is too small to be of interest." This statement is entirely correct for most disseminated deposits, but there are exceptions. As an example, disseminated bornite alone can constitute ore even though theoretically the I.P. response would be low.

We have assumed an average depth of 500' for these six holes. Actually, this will vary depending on the strength of primary mineralization from hole to hole.

We estimate the drilling cost per foot at $9.50, including contract costs, sampling, assaying, supervising, etc. We are planning to purchase

11/6/83

Harold

Where is the map showing these A — F hole locations.

K.

a used trailer from the Mission Contractor. This will be used for field core storage so that no persons but our samplers will see the core.

The cost of this program is summarized:

Drilling - (3000' at $9.50/ft)	$28,500
Trailer -	400
Contingencies -	1,100
Total	$ 30,000

If you agree with this program would you please get authorization for this amount. We would expect to begin drilling shortly thereafter.

It would seem that zone D termed the Casa Grande prospect, should be in a separate category. Consequently, the above total does not include money for any work that might be contemplated in that area.

There is an unexpended balance of approximately $9,000 in M.A.880. This authorization originally was set up principally to acquire options. One option payment of $7,500 is due December 1, 1961. By that time our drilling results may not be conclusive, in which case we would need to make the option payment.

Yours very truly,

KENYON RICHARD

KR/z
Attach.

cc: DJPope, w/attach.
RJLacy, " "

Route file copy to:
TASnedden
ACHall
JHCourtright
KvdSteinen
WESaegart

ASARCO

Exploration Department
Southwestern United States Division

November 21, 1983

Mr. R. L. Brown, Vice President
Exploration Department
ASARCO Incorporated
Room 3422, 120 Broadway
New York, NY 10017

Sacaton Mine
History of Discovery

Dear Mr. Brown:

Last summer I wrote Vic Hollister proposing that a paper on Sacaton should be included in the Porphyry Copper Discovery volume, and that John Kinnison should write it. Hollister agreed (copies of both letters attached).

Kinnison said he would undertake the task and arrangements were made for access to the files here. However, on my return from vacation in September I found that he had not even started the paper. After checking with Hollister's office and determining that there was still time, Kenyon Richard took on the job. Enclosed herewith for approval are three (3) copies of his paper.

Yours very truly,

J. H. Courtright

J. H. Courtright

JHC/cg

Enclosures

cc: VFHollister (w/o encl)
KERichard (w/o encl)

KENYON RICHARD
Mining Geologist
11 EAST ORANGE GROVE ROAD—APT. 535
TUCSON, ARIZONA 85704

602 - 297-5733

November 17, 1983

Note to Asarco personnel and other editors of this manuscript:

I've used my own style which, to some extent, violates a few rules.

Certain acronyms and abbreviations are used in order that the fast reader can read faster. However, some extra punctuation, such as commas, dashes, and parentheses (and italics) are used to make the fast reader slow down and pay attention. It is hoped that these features will not be changed much just to produce conformance.

Otherwise, thanks are extended to those who may have occasion to study and critically improve this manuscript.

It should be noted that Courtright already has gone over this material carefully and removed (sensibly) quite a few of my favorite bits of inappropriate though interesting information.

Kenyon Richard

Sacaton Mine
History of Discovery

by

Kenyon Richard

The discovery of the Sacaton orebodies has been reported in industry trade journals (1974-1977) in a manner suggestive (a) that it was only a simple matter of 2 Asarco exploration geologists tripping over a small mineralized outcrop (300' diam.--30' high), essentially devoid of copper staining, in a large, alluvium-covered area,---and (b) that the subsequent actual ore discovery and drilling of a couple of orebodies was an unremarkable consequence of the recognition of the outcrop's significance.

These implications are partially correct. However, the Sacaton discovery was only *one episode* in a continuing and fairly systematic Asarco program. A limited commentary on the nature of Asarco's program *prior* to the Sacaton discovery will, therefore, be germane. Actually, 2 discoveries in addition to Sacaton are involved.

That specific por. Cu program consisted of "re-prospecting" large areas of the SW.-US., (among other regions). This re-prospecting effort had two aspects: (1) the mechanical procedures which comprised airplanes, autos and, mostly, boots, in search of outcrops of disseminated alteration/ mineralization; and (2) the geological techniques which narrowed the fields of mechanical search.

As to item (2) above, the following principal geological techniques are generalized:

(a) Large portions of the alt./min. outcrops over orebodies carry no Cu-stain. This is a standard condition in most productive por. Cu districts; however, *that* fact had been *overlooked* by the various generations of prospectors, prospector/engineers and even most geologists of the first half of the 20th Century. Also, the pioneering work of Blanchard (1968) and Locke (1926) carried the implication that the interpretation of leached outcrops was a guide to ore only in the known por. Cu districts.

(b) Literature Research: This included search for and study of very old as well as then-modern and -current scientific papers and maps. A *few* of the scientific papers (mostly USGS) of the first half of this century were particularly helpful in defining detailed geology within and close around the major known por. Cu districts. Articles in state and local geological publications (both regional and local subjects) and, surprisingly, articles in old trade journals too, were often helpful because the author would describe, say, clay-sericite and/or silicification all with Fe oxides---typical por. Cu-type alt./min.---but he would *not attach that* appellation because little if any Cu-stain was noted. These clues, sometimes only a few sentences in obscure, old publications, were enticing leads, indeed, for field checking.

(c) Asarco Files (1912-1950): Many clues similar to these described in the state and local publications noted under paragraph (b) above were found in files, both modern and ancient. An example: In 1912 AS&R (Asarco's original acronym) opened an "exploration" office in Tucson. The search for orebodies then consisted of individual mine and prospect examinations, those which "walked through the door" of the local mine manager, Richard (1978). Many of those old files were particularly useful 25-35 yrs. later.

(d) So-called "lineaments", which implies "lines" at the surface or, their real geological connotation, "structural planes" (particularly their intersections) were early hypothesized mostly, but not entirely, by academic geologists, as having controlled the positions of then-known por. Cu districts. Regardless of a paucity of demonstrable examples of *pre*-mineral structural control (only 4 districts, Bisbee, Miami, Silver Bell and Bagdad, Bryant and Metz (1966), Simmons and Fowells (1966), Richard and Courtright (1966), Anderson (1949), might have been classed as having then-known structurally controlled positions), the rather old hypothesis was revived during the mid- to late-'50s, particularly in the SW. where it became a favorite indoor sport of the exploration/academic geological fraternity. "Ruled" lines were drawn (by *al*most everyone) connecting everything with everything. These exercises were not regarded as practical and drawing lineament "lines" as representing structural planes connecting por. Cu systems was not part of Asarco's research efforts.

Asarco *did*, however, use the lineament idea in its por. Cu program in the distinctive sense that *broad* "trends" or "belts" marked either or both by roughly aligned successions (a) of small stocks of porphyries (not cupolas of single granitoid batholiths, necessarily, and *not* by connecting structural planes), and (b) of large or small zones of alt./min. (sometimes only leached pyrite in outcrops with indicated *very* small amounts of original Cu sulfides). This is noted farther along.

Partly to provide a record of areas covered by prospecting and partly to insure more-careful coverage, sketch/recon. geological maps were sometimes made. While doing that kind of mapping in the area SW. from Superior---a little more carefully than usual because he was trying to sort the volcaniclastic sequence in that area---John Kinnison discovered, in '60, a tiny sliver (about 10' x 200') of por. Cu alt./min. at the base of a hill of post-mineral basalt surrounded by Qal in all directions. That was the *only* surface expression of the Poston Butte por. Cu deposit. Asarco subsequently drilled 22 holes which, it was thought, defined a por. Cu system 1 mi. by 2.5 mi. in area. Although 3 holes cut "ore-grade" intercepts, altogether the results seemed too meager (as of then-projectable economics) to justify further work. (Asarco files; 1960-'63.)

The Poston Butte discovery is described herein (a) because it was a valid Asarco discovery of a por. Cu system, (later, discovered *again* by Conoco---Nason, et al. (1980)), (b) because the clue to its existence was indeed obscure, and (c) because it was a blaze on the trail to the Sacaton discovery.

Following (literally and "on trend") on Asarco's Poston Butte discovery, Art Blucher had just begun re-prospecting and sketch mapping in the wide-spaced ranges around Casa Grande. About the same time John Kinnison (Asarco files, 2/9/61) came up with a pencilled sketch approximately like Figure (1). The importance of this sketch is that it displays continuity of por. Cu systems within lengthy belts without known, long-trending, interconnecting structural planes. The projected triple intersection of belts a few miles west of Casa Grande was particularly intriguing, even though it was about 50 mi. from Ray and 40 mi. from Silver Bell, the nearest productive Cu mines. Obviously, that area of intersections should promptly be traversed.

It didn't take Kinnison and Blucher long. On Feb. 10, '61 after leaving the highway about 5 mi. W. of Casa Grande and circling around over the flat Qal terrain for an hour or so, they spotted the small hill, drove up to it and stepped out onto the outcrop of a por. Cu deposit. The hill (see Fig. 2) was unprepossessing inasmuch as it showed only a faint trace of Cu-stain in a couple of spots---not enough to have attracted any digging or sampling by prospectors. It consisted of granite and a thin dike of por., all altered to quartz-sericite-clay with weak but pervasive jarosite-goethite and a few specks of hematite-after-chalcocite, particularly in the dike. This was an outcrop which one would expect to have originally contained about 2% sulfides as pyrite/chalcocite/chalcopyrite assaying, say, .1-.2 Cu. However, what with nearest outcrops being the Sacaton Mts. 1.5 mi. N. which contain only a couple of very small, wide-spaced, Cu-stained spots, the hill was certainly an inviting exploration lead.

The Asarco Geophysical Dept. then appeared on the scene, and significant parts of an 11/61 report of their work and conclusions are excerpted:

"Geophysical surveys.....on the Sacaton Prospect include the usual recon. methods, I.P., resistivity and magnetics.....a total of 18 square miles was covered.....a new I.P. technique.....called "travelling depth profile".....to improve interpretations in the Sacaton area.....a seismic reflection survey.....to determine bed-rock depths.....Four anomalous zones were indicated by I.P...... travelling depth profiles.....Zone A [KR. note: See I.P. anomaly, Fig. 2].....indicated.....sulfides have rather *abrupt lateral* limits.....[KR. note: See Fig. (2)].....The geophysical target area was interpreted as the *boundary* of *significant sulfides.* [KR. note: Refer to the West Orebody outline on Fig. 2.]

Mostly because Asarco's N.Y. office was impressed with the geophysicists' view that the sulfide zone was small (laterally), only $30,000. was granted for 6 exploration holes. [KR. note: Along with this meager sum, a firm unwritten message was delivered by a high Asarco official that that was *all* we would get.]

The 1st 5 holes cut sulfides, but only a few short runs of ore-grade rock. Positioning the 6th hole (Fig. 2), obviously, was critical. Fortunately, during an informal meeting of several Asarco geologists, J. H. Courtright's insistence prevailed. If some of the other opinions (including the writer's) had been accepted, the 2 orebodies might not have been found. The 6th hole (potentially the last one) became the 1st hole within the West Orebody. (This, then, is a perfect example of the old exploration quip, "Always drill the last hole first.")

The Sacaton discovery illustrates 2 factors which are operative in almost every orebody discovery in new territory; (1) finding the mineral deposit (the simple conclusion of a long but systematic exploration trail), and (2) finding the orebody within the deposit (the early selection of the right set of practical geological facts from a large number of misleading geological impressions which often can be mistaken for facts). The real significance of either of these 2 factors is seldom evident until many holes have subsequently been drilled.

Except for some features of unusual pertinence, the general geology will not be described, herein. Instead the reader is referred to the fine article by Cummings (1982) for the geological details.

Reference is made to the longitudinal (ENE) sketch section Fig. 3, by Kinnison. This was compiled rather early in the drilling program and may be slightly distorted in some details, but it is adequate insofar as it displays some of the following important geological features, as follows:

(a) The bottom of the entire Sacaton hydroth. alt./min system is abruptly terminated by the near-flat, post-mineral Basement Fault at depths of 1800-2200'.

(b) A N-S. section would show the NNW. side of the Basement Flt. to be a steep (almost vert.), sharply curved up-turn. The SSW. side, as indicated particularly by the intercept in the Shaft (Fig. 2), dips 45° NNW.

(c) Thus, this "gravity sliding block", Cummings (1982), is shaped like a lopsided, flat-bottom boat. The approximate outline of this "boat" is the Basement Flt. where it defines the sub-outcrop of pre-mineral formations, as shown on Fig. 2.

(d) A number of post-conglomerate flts. having vert. separations of as much as 1500' have been mapped in the open pit on the

West Orebody or have been deciphered by vert. drillhole analyses. None of these flts. is known to have displaced the Basement Flt. It is to be noted that these faults *and* the Basement Flt. both cut the chalcocite blanket. The latter condition was of interest in regard to future exploration.

(e) Cummings (1982) states that the gravity sliding block moved N40-45E.

[KR note: If so, it may have moved about 6(?) mi. from the large, rather deeply buried "ore" body described by J. David Lowell in his lecture, Dec. 5, '82, AIME Arizona Conference and named the Casa Grande West. It is suggested that that ore zone at one time was at an appreciably higher elevation, relatively. The Sacaton gravity block slid down from the top of that zone.]

(f) As is evident on Fig. 2, the 2 Sacaton orebodies are small:

West Orebody: (Open pit---high w/o ratio---largely mined out)

33. mil. T. @ .76 Cu

East Orebody: (Cave mine planned)

13.4 mil. T. @ 1.45 Cu

In '63 Asarco explored extensively for the root of the Sacaton por. Cu system. Courtright spotted and drilled a number of wide-spaced holes in an area extending 2 to 7 mi. SW. of Sacaton. Several of these showed *deep, short* intercepts of "ore-grade" rock; and two of them closely straddled what later became Getty/Hanna's Casa Grande West. Only one of these holes showed cc. of "ore-grade." Most intercepts were of oxidized Cu.

Asarco then regarded that area as being the root of the Sacaton system. The relative high proportion, however, of oxidized Cu at depths of 1000 to 2000' (anomalous, certainly) discouraged further exploration in that immediate area under then-extant economic conditions.

As noted above, this represented a valid discovery, but in only half the full sense---that is, (1) the deposit was found, (2) but not the orebody.

Although connected with Asarco's exploration programs from '45 to '67, it has been necessary for the writer, in order to revive and correct memories as to dates, numbers and sequence of activities, to discuss Sacaton with Asarco geologists who are acquainted with it currently and historically. These discussions were beneficial and are appreciated. Special thanks is expressed for the valuable help of J. H. Courtright. Some data which have been supplied have been used either to copy or compile the 3 Figures, or are directly quoted, or specified (Asarco files: approx. 1949-1980) where feasible. Thanks are due Asarco for permission to publish this paper.

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	"Mining Magazine"	2/1975
	"World Mining"	12/1975
	"Engineering and Mining Journal"	6/1977

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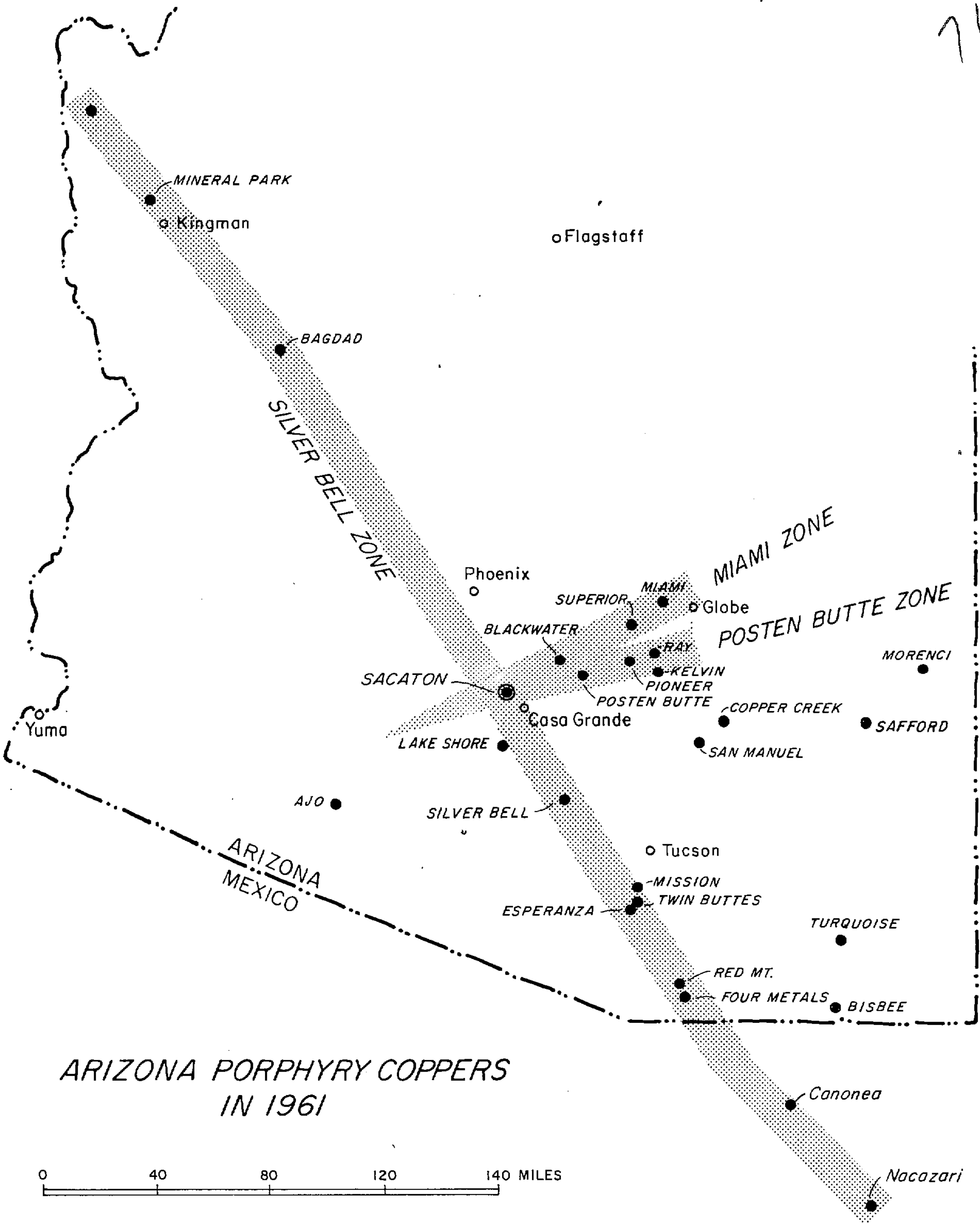

ARIZONA PORPHYRY COPPERS IN 1961

FIGURE I

Fig. 77

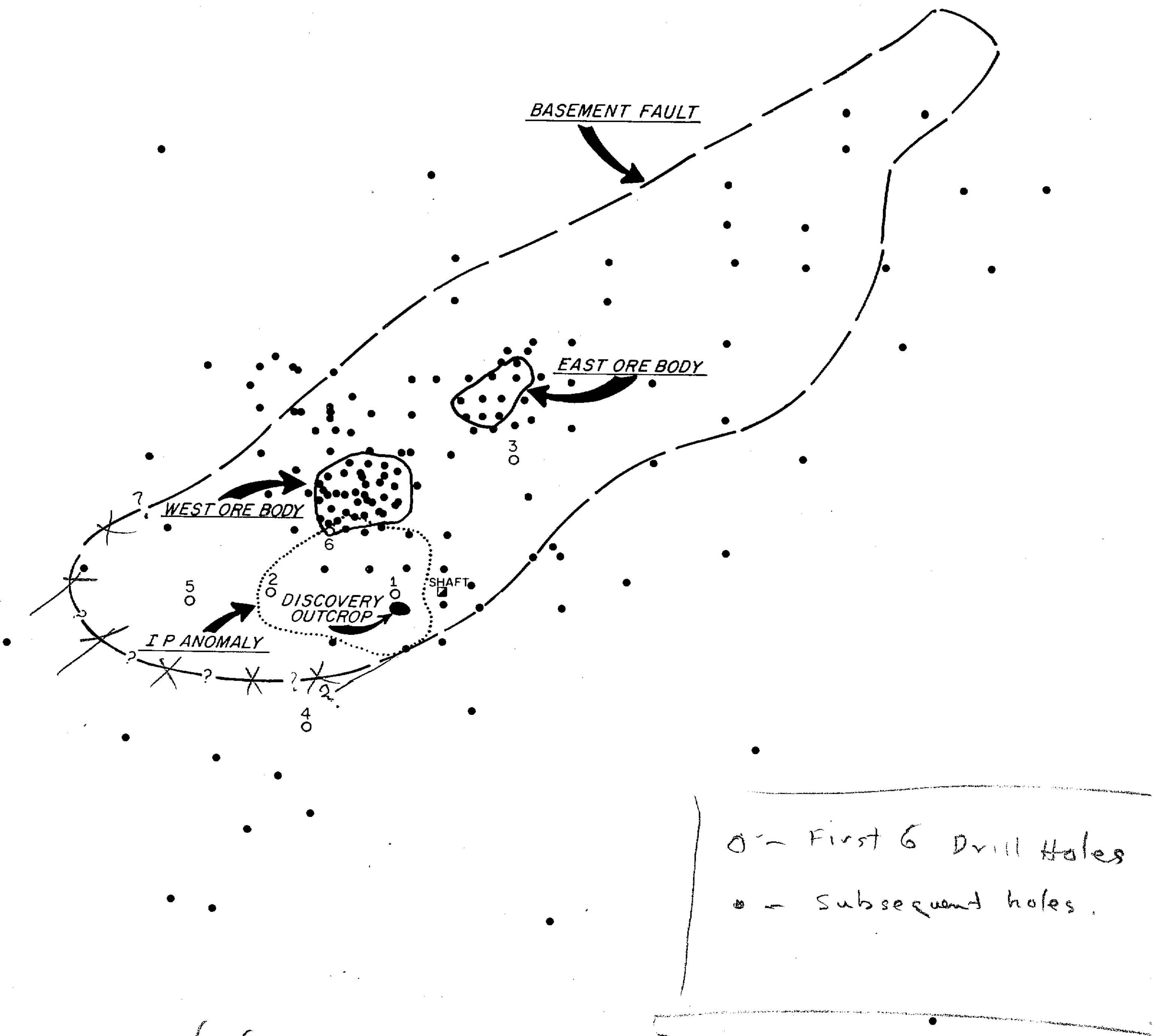

FIGURE 2

ASARCO SACATON PROJECT
Pinal County, Arizona

0 1000 2000 3000 4000 5000 FEET

JANUARY, 1973

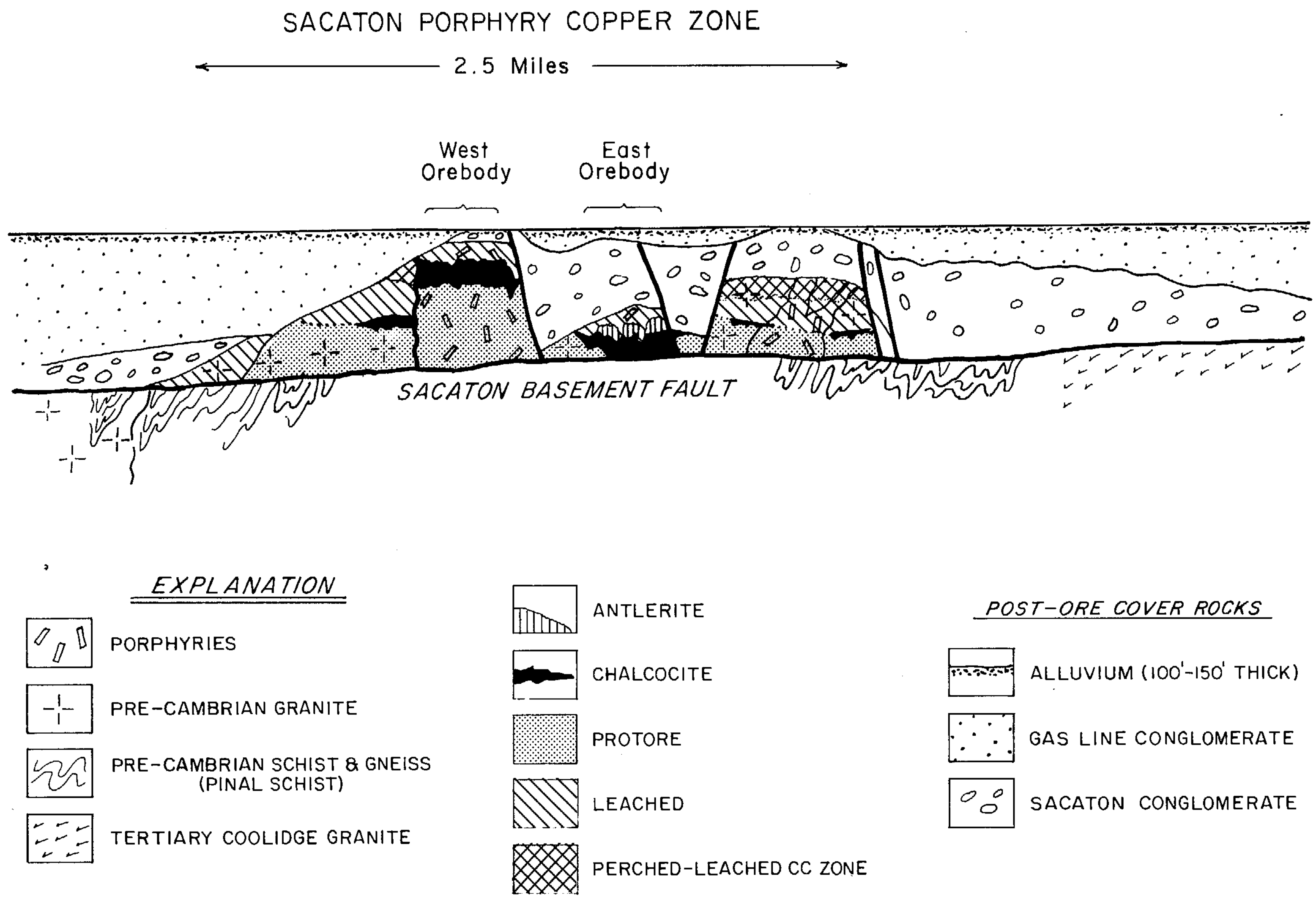

FIGURE 3 *SACATON DIAGRAMMATIC CROSS SECTION*

NOT TO SCALE

JANUARY, 1964