CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

3-10-21 Amole District
Pima County
Arizona

John E Kinnison

From Rich Lundin
Dec 1977

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Pima County, Arizona

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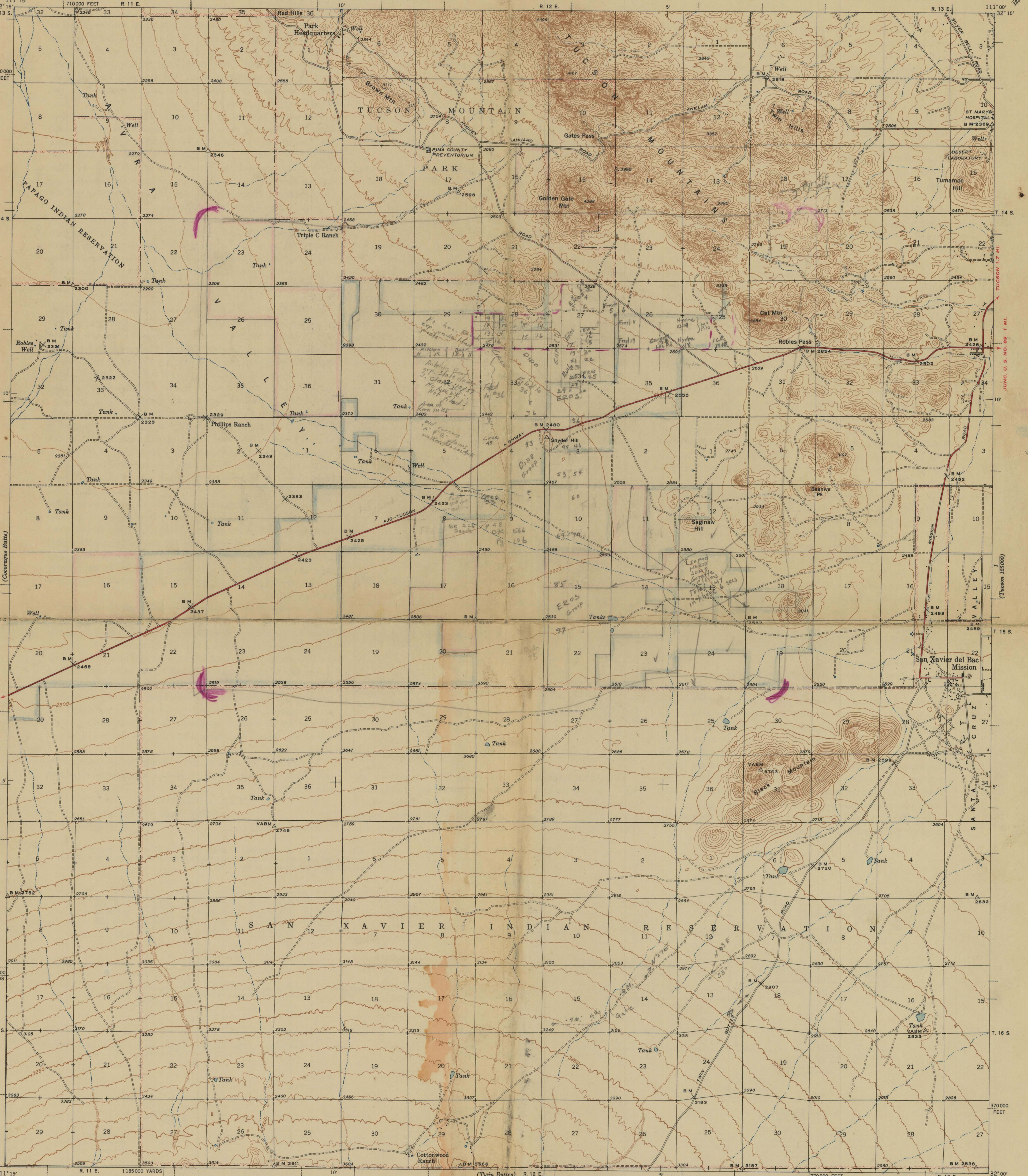
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WAR DEPARTMENT

ARIZONA
(PIMA COUNTY)
SAN XAVIER MISSION QUADRANGLE
15-MINUTE SERIES



Topography by E. S. Rickard and H. E. Skinner
Surveyed in 1940-1941

ROAD CLASSIFICATION 1947
Dependable hard-surface heavy-duty road
Secondary hard-surface all weather road
Dry weather roads
Loose-surface graded
Unsurfaced, graded
Dirt road
U. S. Route
State Route
More than two lanes indicated along road with tick at point of change

TRUE NORTH
MAGNETIC NORTH
14°
APPROXIMATE MEAN DECLINATION, 1941

Scale 1/62500
1 0 1 2 3 4 Miles
1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards
1000 0 3000 6000 9000 12000 15000 18000 Feet
1 .5 0 1 2 3 4 5 Kilometers

Contour interval 50 feet
Datum is mean sea level

Polyconic projection. 1927 North American datum
5000 yard grid based on U. S. zone system, F
10000 foot grid based on Arizona (Central) rectangular coordinate system

SAN XAVIER MISSION, ARIZ.
Edition of 1943
reprinted 1947
N3200—W11100/15

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THE TOPOGRAPHIC MAPS OF THE UNITED STATES

The United States Geological Survey is making a series of standard topographic maps to cover the United States. This work has been in progress since 1882, and the published maps cover more than 47 percent of the country, exclusive of outlying possessions.

The maps are published on sheets that measure about 16½ by 20 inches. Under the general plan adopted the country is divided into quadrangles bounded by parallels of latitude and meridians of longitude. These quadrangles are mapped on different scales, the scale selected for each map being that which is best adapted to general use in the development of the country, and consequently, though the standard maps are of nearly uniform size, the areas that they represent are of different sizes. On the lower margin of each map are printed graphic scales showing distances in feet, meters, miles, and kilometers. In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground. For example, the scale $\frac{1}{62,500}$ means that 1 unit on the map (such as 1 inch, 1 foot, or 1 meter) represents 62,500 of the same units on the earth's surface.

Although some areas are surveyed and some maps are compiled and published on special scales for special purposes, the standard topographic surveys and the resulting maps have for many years been of three types, differentiated as follows:

1. Surveys of areas in which there are problems of great public importance—relating, for example, to mineral development, irrigation, or reclamation of swamp areas—are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{31,680}$ (1 inch = one-half mile) or $\frac{1}{24,000}$ (1 inch = 2,000 feet), with a contour interval of 1 to 100 feet, according to the relief of the particular area mapped.

2. Surveys of areas in which there are problems of average public importance, such as most of the basin of the Mississippi and its tributaries, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile), with a contour interval of 10 to 100 feet.

3. Surveys of areas in which the problems are of minor public importance, such as much of the mountain or desert region of Arizona or New Mexico, and the high mountain area of the northwest, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{125,000}$ (1 inch = nearly 2 miles) or $\frac{1}{250,000}$ (1 inch = nearly 4 miles), with a contour interval of 20 to 250 feet.

The aerial camera is now being used in mapping. From the information recorded on the photographs, planimetric maps, which show only drainage and culture, have been made for some areas in the United States. By the use of stereoscopic plotting apparatus, aerial photographs are utilized also in the making of the regular topographic maps, which show relief as well as drainage and culture.

A topographic survey of Alaska has been in progress since 1898, and nearly 44 percent of its area has now been mapped. About 15 percent of the Territory has been covered by maps on a scale of $\frac{1}{500,000}$ (1 inch = nearly 8 miles). For most of the remainder of the area surveyed the maps published are on a scale of $\frac{1}{250,000}$ (1 inch = nearly 4 miles). For some areas of particular economic importance, covering about 4,300 square miles, the maps published are on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile) or larger. In addition to the area covered by topographic maps, about 11,300 square miles of southeastern Alaska has been covered by planimetric maps on scales of $\frac{1}{125,000}$ and $\frac{1}{250,000}$.

The Hawaiian Islands have been surveyed, and the resulting maps are published on a scale of $\frac{1}{62,500}$.

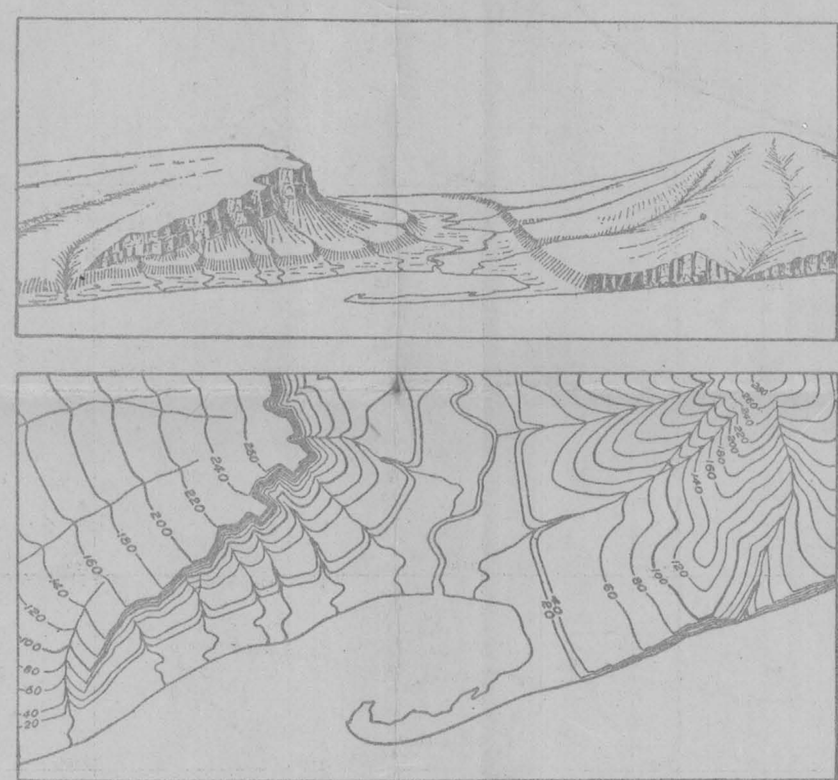
A survey of Puerto Rico is now in progress. The scale of the published maps is $\frac{1}{30,000}$.

The features shown on topographic maps may be arranged in three groups—(1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries. The symbols used to represent these features are shown and explained below. Variations appear on some earlier maps, and additional features are represented on some special maps.

All the water features are represented in blue, the smaller streams and canals by single blue lines and the larger streams by double lines. The larger streams, lakes, and the sea are accentuated by blue water lining or blue tint. Intermittent streams—those whose beds are dry for a large part of the year—are shown by lines of blue dots and dashes.

Relief is shown by contour lines in brown, which on a few maps are supplemented by shading showing the effect of light thrown from the northwest across the area represented, for the purpose of giving the appearance of relief and thus aiding in the interpretation of the contour lines. A contour line represents an imaginary line on the ground (a contour) every part of which is at the same altitude above sea level. Such a line could be drawn at any altitude, but in practice only the contours at certain regular intervals of altitude are shown. The datum or zero of altitude of the Geological Survey maps is mean sea level. The 20-foot contour would be the shore line if the sea should rise 20 feet above mean sea level. Contour lines show the shape of the hills, mountains, and valleys, as well as their altitude. Successive contour lines that are far apart on the map indicate a gentle slope, lines that are close together indicate a steep slope, and lines that run together indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley that lies between two hills. In the foreground is the sea, with a bay that is partly enclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends by a sea cliff. The hill at the left terminates abruptly at the valley in a steep scarp, from which it slopes gradually away and forms an inclined tableland that is traversed by a few shallow gullies. On the map each of these features is represented, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the topography of the area mapped: in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet. In order that the contours may be read more easily certain contour lines, every fourth or fifth, are made heavier than the others and are accompanied by figures showing altitude. The heights of many points—such as road intersections, summits, surfaces of lakes, and benchmarks—are also given on the map in figures, which show altitudes to the nearest foot only. More precise figures for the altitudes of benchmarks are given in the Geological Survey's bulletins on spirit leveling. The geodetic coordinates of triangulation and transit-traverse stations are also published in bulletins.

Lettering and the works of man are shown in black. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public roads suitable for motor travel the greater part of the year are shown by solid double lines; poor public roads and private roads by dashed double lines; trails by dashed single lines. Additional public road classification if available is shown by red overprint.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining quadrangles of which maps have been published. More than 4,100 quadrangles in the United States have been surveyed, and maps of them similar to the one on the other side of this sheet have been published.

Geologic maps of some of the areas shown on the topographic maps have been published in the form of folios. Each folio includes maps showing the topography, geology, underground structure, and mineral deposits of the area mapped, and several pages of descriptive text. The text explains the maps and describes the topographic and geologic features of the country and its mineral products. Two hundred twenty-five folios have been published.

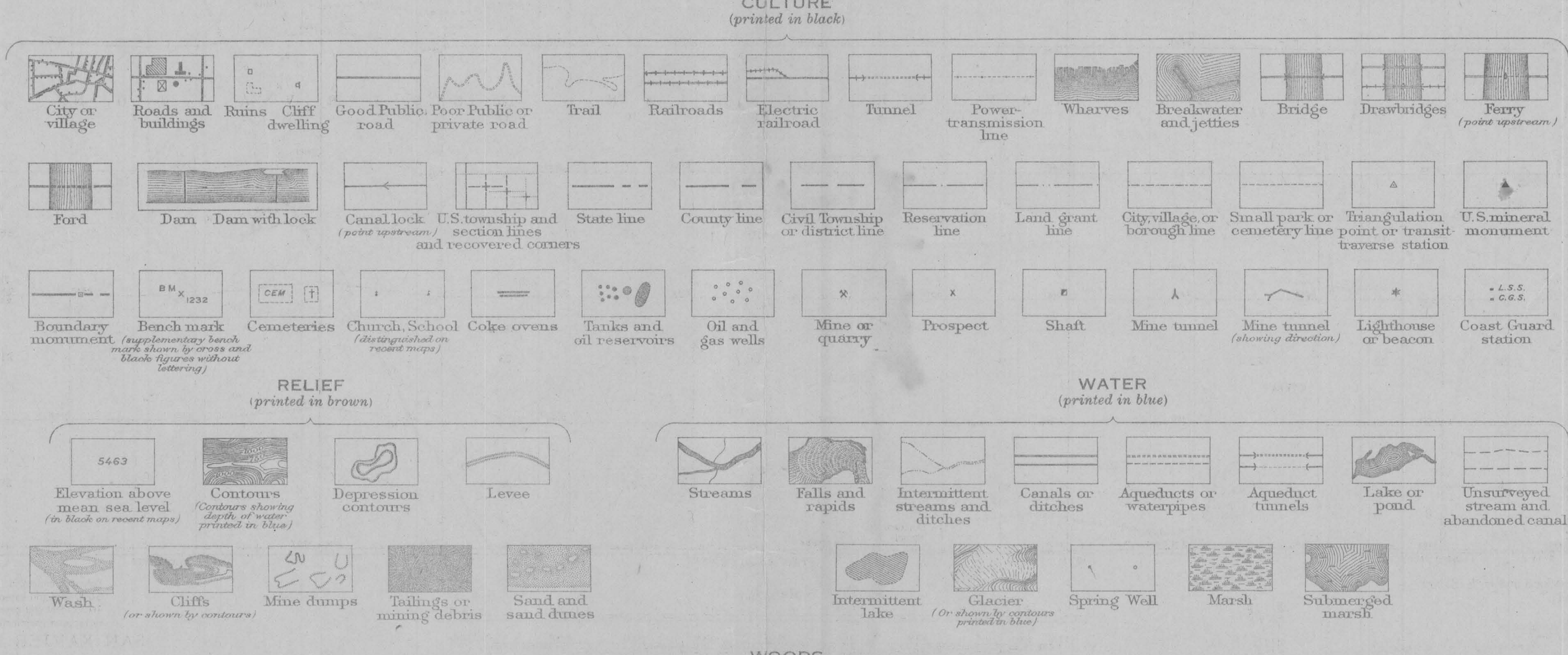
Index maps of each State and of Alaska and Hawaii showing the areas covered by topographic maps and geologic folios published by the United States Geological Survey may be obtained free. Copies of the standard topographic maps may be obtained for 10 cents each; some special maps are sold at different prices. A discount of 40 percent is allowed on an order amounting to $5 or more at the retail price. The discount is allowed on an order for maps alone, either of one kind or in any assortment, or for maps together with geologic folios. The geologic folios are sold for 25 cents or more each, the price depending on the size of the folio. A circular describing the folios will be sent on request.

Applications for maps or folios should be accompanied by cash, draft, or money order (not postage stamps) and should be addressed to

THE DIRECTOR,
United States Geological Survey,
November 1937. *Washington, D. C.*

STANDARD SYMBOLS

NOTE:—Effective on and after October 1, 1946, the price of standard topographic quadrangle maps will be 20 cents each, with a discount of 20 percent on orders amounting to $10 or more at the retail rate.



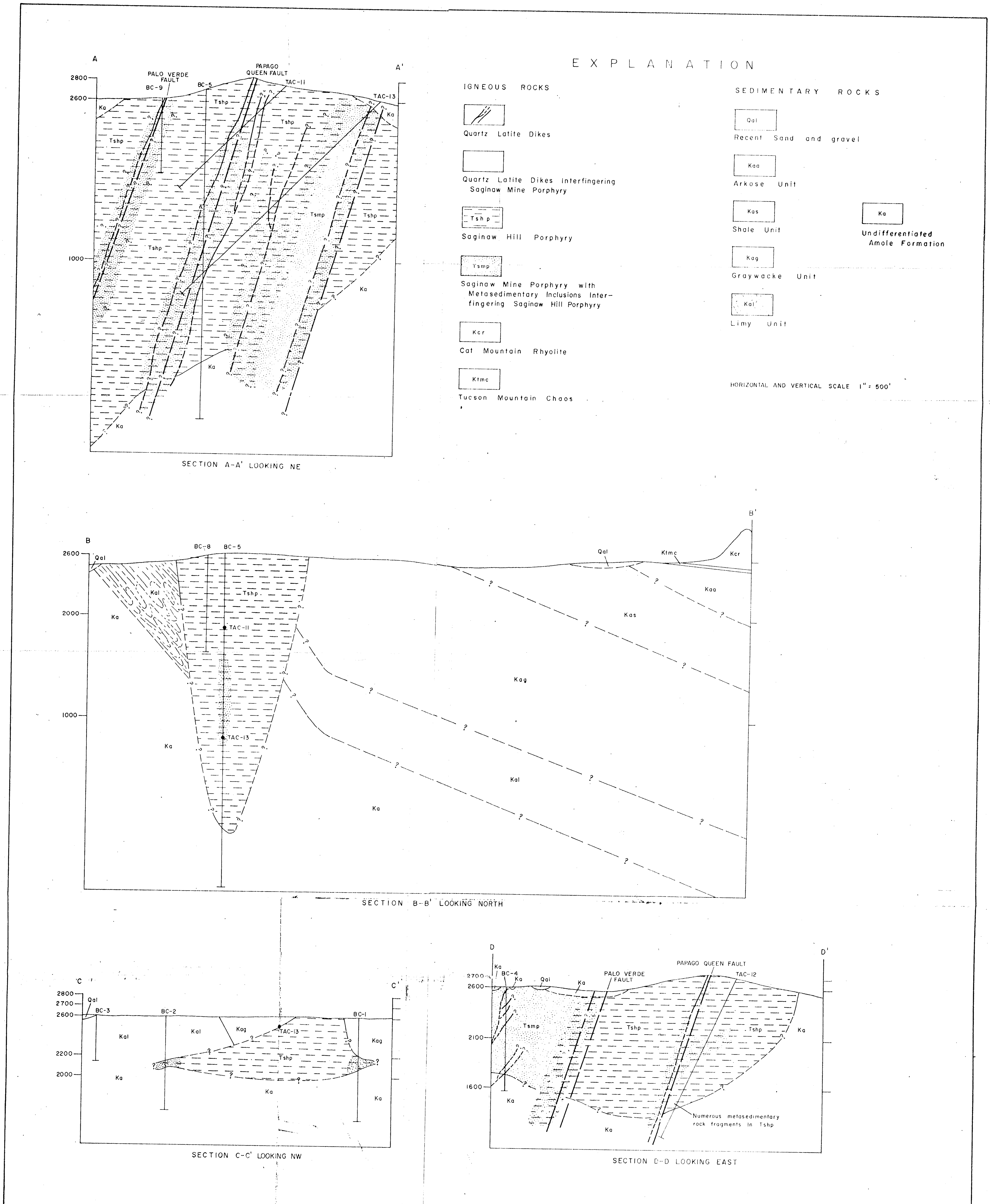


FIGURE II.

GEOLOGIC CROSS SECTIONS FOR FIGURE 3.

THOMAS RUSSELL FRANK, GEOLOGY THESIS, 1970

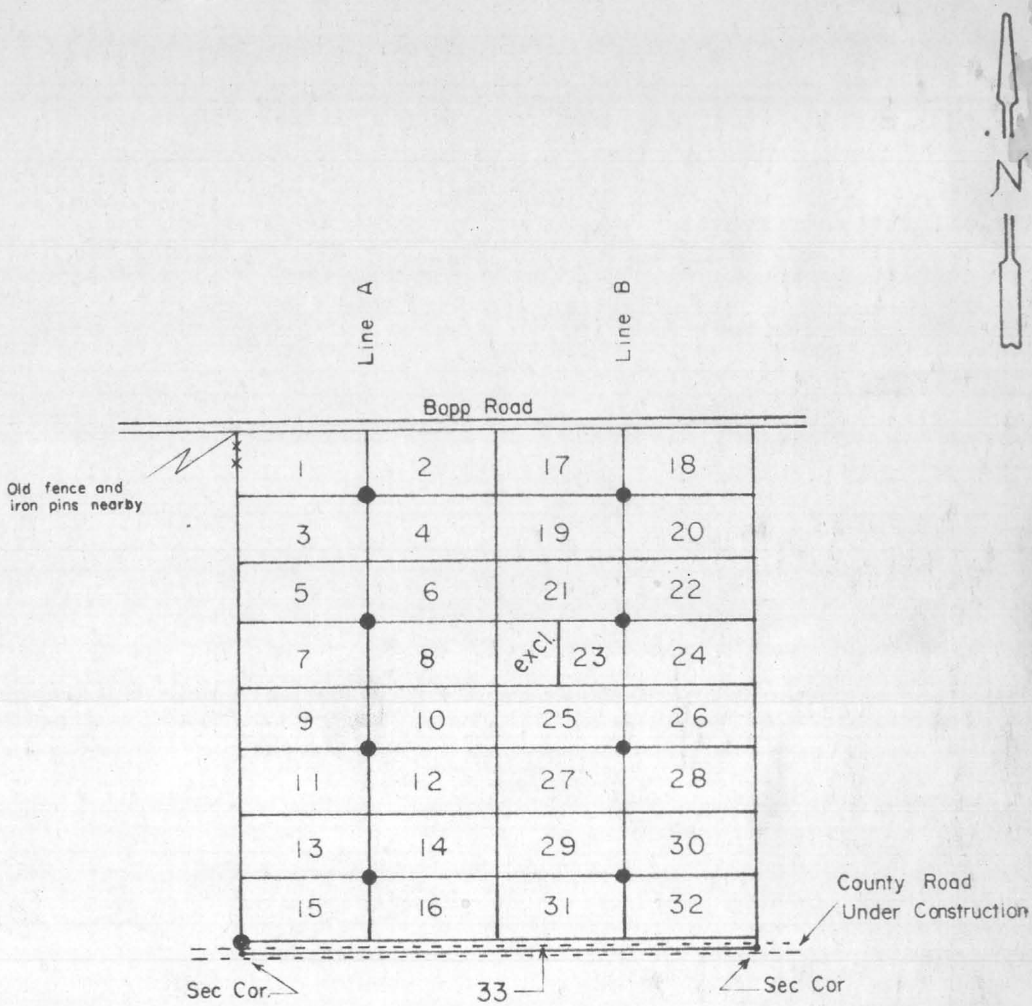
TOPOGRAPHIC BASE FROM U.S. GEOLOGICAL SURVEY
SAN XAVIER MISSION QUADRANGLE

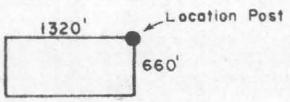
300 0 300 600 900 FEET
Contour interval 50 feet

GEOLOGY BY T. R. FRANK, 1970

FIGURE 3.--GEOLOGY OF THE SAGINAW HILL AREA, AMOLE DISTRICT, PIMA COUNTY, ARIZONA

THOMAS RUSSELL FRANK, GEOLOGY THESIS, 1970





Claim 23 660' X 660'
Claim 33 5288' X 117', Staked July 28

Sec. 32, State Land,
T 14 S, R 12 E, 2 miles
SW of Park Hill

Staked by auto traverse
June 24 and July 28, 1960 - J. E. K.

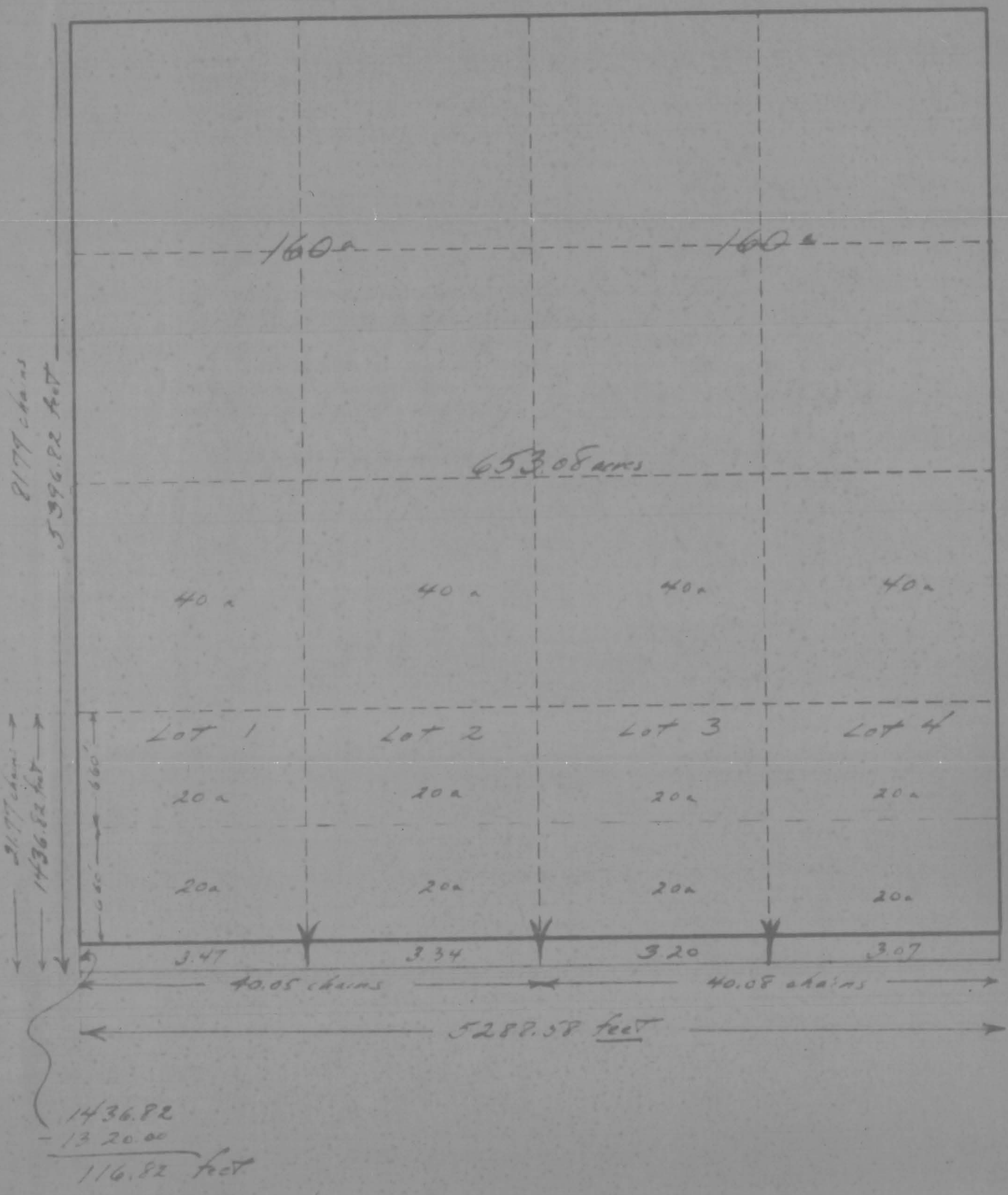
CLAIM MAP

AMENDED C. E. GROUP

Amole District, Pima County, Arizona

SCALE 1" = 2000'

SECTION 32, T. 14 S. R. 12 E.



AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
July 29, 1960

FILE MEMORANDUM

C. E. CLAIMS
Amole District

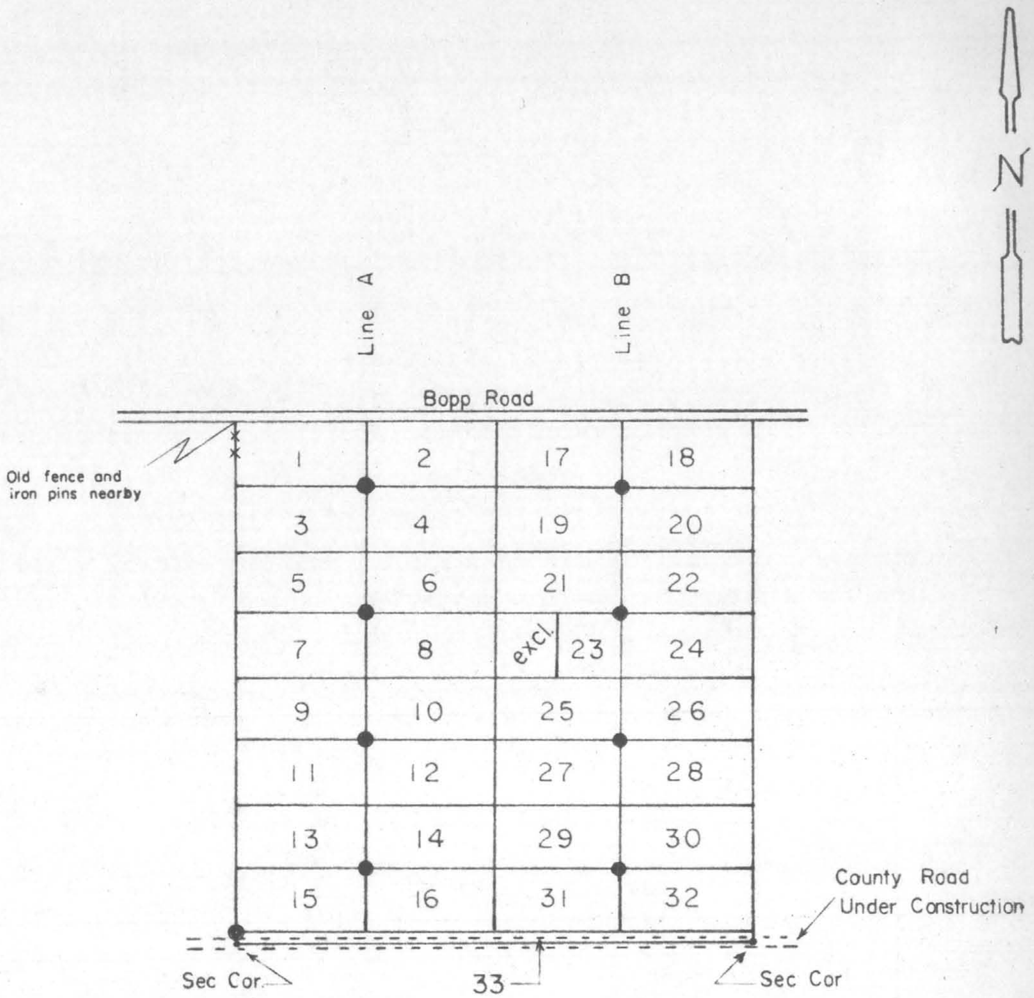
On July 28, 1960, CE claim notices 5 through 32 were replaced in the field by amended location notices. A new claim, CE 33, was staked same date.

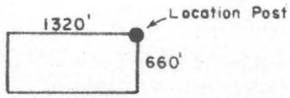
Attached claim map shows present claim layout and supersedes previous map. C. E. Williams signed the notices for ASARCO in his name, and placed them on the ground.

The portion of CE 23 excluded is under commercial lease, as advised by State Land Department, letter 7/22/60.

JOHN E. KINNISON

JEK/ds





Claim 23 660' X 660'
Claim 33 5288' X 117', Staked July 28

Sec. 32, State Land,
T14 S, R 12 E, 2 miles
SW of Park Hill

Staked by auto traverse
June 24 and July 28, 1960 - J. E. K.

CLAIM MAP

AMENDED C.E. GROUP

Amole District, Pima County, Arizona

SCALE 1" = 2000'

Kinnison

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 30, 1960

FILE MEMO

Amole District
Tucson Mountains

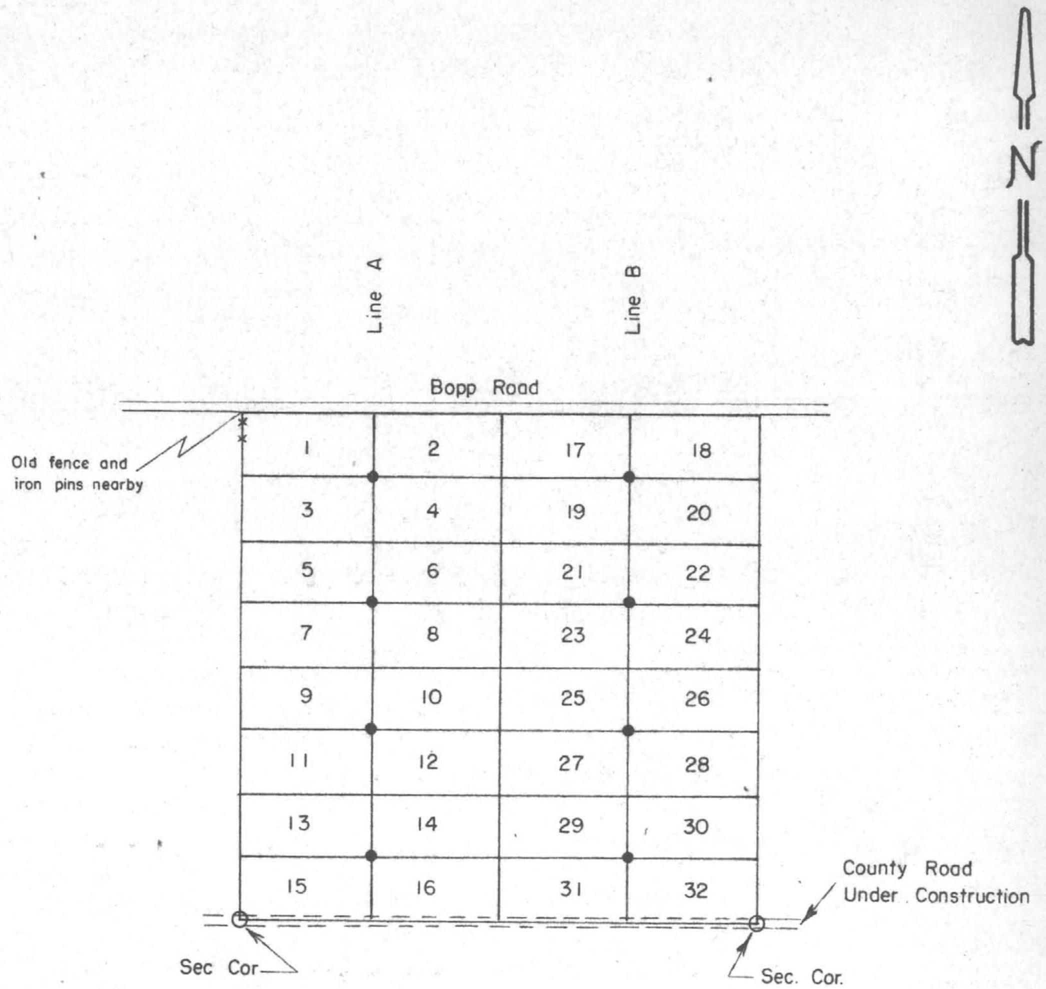
On June 24, 1960, I staked the C. E. group of 32 claims in State Sec. 32, T14S, R12E, 2 miles S. W. of Park Hill. The claims were staked under the name of C. E. Williams, a company employee. See attached claim map.

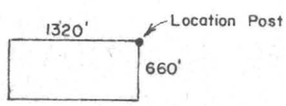
The survey was done by 4-wheel drive auto traverse, using a small auto compass and the speedometer. Referring to the attached map, the NE corner C.E. 1 was established by speedometer measurement along Bopp Road from the presumed N. W. corner Section 32 -- being an old fence and some nearby iron pins about 30' south of the road. The NE corner of C.E. 17 was established in the same manner. Lines A and B were run south and location posts (2" x 2" x 5') placed as shown each with 4 location notices in small plastic pill bottles. Lines A and B were checked against the south line of Sec. 32, and corners established as shown by U.S.G.S. survey markers. The error in length of line was short about 150-200', and deviation of bearing, checked against the section corners, was not measureable.

I estimate that any one post is not out of place much more than 150 feet.

John E. Kinnison

JEK/z





Sec. 32, State Land,
T 14 S, R 12 E, 2 miles
SW of Park Hill.

Staked by auto traverse June 24, 1960 - J.E.K.

CLAIM MAP - CE GROUP

Amole District, Pima County, Arizona

SCALE 1" = 2000'

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
April 25, 1960

<u>PERSONAL/CONFIDENTIAL</u>

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

AMOLE DISTRICT
Park Hill Area
North Boundary Area
<u>Pima County, Arizona</u>

Dear Sir:

The Mission-San Xavier alteration zone trends north-northwesterly and can be projected into the alluvium-covered area along the southwest flank of the Tucson Mountains. Here, in the Park Hill area about 9 miles north of our most northerly drill hole in the Reservation, Kern County Land Co. has drilled several holes which show interesting, though non-commercial, amounts of disseminated chalcopyrite in Cretaceous sediments. This mineralization is stronger than outcrops there have led us to expect.

This showing may or may not be related to the Mission-San Xavier zone. In any case it indicates the general environment is favorable for the occurrence of disseminated copper ore. Although we have no specific targets in the surrounding alluvium-covered areas, certain favorable structures can be projected into this area south and west of Park Hill; and in substantial areas the alluvium cover appears to be no more than 100' to 200' in depth. In these circumstances a search should be made for buried alteration zones from the vicinity of the north boundary of the Reservation to the Park Hill area. This whole area should be considered in two packages; (1) the Park Hill area proper, which lies south of the Tucson Mountain Park and north of the Ajo road (see attached map), and (2) the North Boundary area, which would include about 3 miles north and south of the Reservation boundary.

Exploration in the North Boundary area will be a relatively simple matter. IP surveys should be run in a reconnaissance fashion over an area of about 30 square miles within and north of the Reservation. According to data just received from Mr. Seegart, this would cost about $9,700.(survey on 1/2-mile spacing). We think this work can be accomplished without attracting attention and without the need for first locating a large number of claims. IP results would determine whether or not further efforts were needed.

The Park Hill area itself is a more complicated situation. An exploration program there should involve the following procedures:

an amount of new drilling equivalent to the 6667' of drilling Kern has already done. ASARCO would have a 50% interest in Kern's claims after completing this drilling. Or, ASARCO could gain a 60% interest by doing proportionately more drilling. Thereafter, the costs of drilling or other work, exclusive of salaries of technical personnel, would be divided according to the interest. The deal would be limited to a certain area. Wallace has suggested sections 27, 28, 29, and 32, which is a smaller area than we would plan to cover with claims. However, Kern would want some kind of participation in the whole of any ore body which was found to lie partly within the area specified in the deal and partly outside.

Kern has 80 claims which they would put into the deal. Within their group are a group of six and another group of 10 claims held by others. Wallace says these all are old claims on which assessment work and other legal requirements have not been fully maintained. However, he feels that a mining company could not successfully take this ground from these individuals. Kern has recently obtained options on these two groups. The only obligation for four years in $1600 annual assessment work; total purchase price $55,000 at end of four years. ASARCO would gain a half interest in these purchase obligations upon matching Kern's drill footage.

Kern is a company with extensive oil and ranch holdings and a strong cash position, so I understand. They would enter the deal as an investing partner and not as a carried interest. Presumably, though, if one party did not care to invest in a phase of the exploration (or development and operation), its interest would be proportionately diluted. ASARCO would manage both the exploration and any ensuing operation.

4. Induced polarization surveys should cover about 7 square miles, or a little more than the area to be claimed. This would cost $4,800.

5. Detailed geologic mapping should be done over about one square mile in the Park Hills proper, as well as a lim ited amount of reconnaissance mapping in the adjacent pediment areas. The Kern drill core should be logged. Salaries, $2,000; aerial photography, $500; splitting and assaying Kern drill core, $500 (Kern has sampled and assayed only the higher grade sections of the core).

6. Primarily to explore the area, and secondarily to meet the drilling footage required by Kern, we would plan first to drill about 20 wide-spaced shallow holes through the alluvium and into bedrock. These would cost $1700 per 200' hole, or $34,000, including both contract and indirect costs. Only part of these holes would be in the area of the Kern deal, and only part of the alluvium drilling could be credited as matching Kern's 6667' of bedrock coring. This latter point still needs negotiation. However, something like 5000' of bedrock coring, probably in deeper holes, would remain to match Kern's drilling. This would cost about $10 per foot, or $50,000.

Following is a summary of the above six items:

1.	Property status	$ 2,000
2.	Claim location	12,000
3.	Nunn negotiations	800
4.	IP surveys	4,800
5.	Geological mapping	3,000
6.	Shallow drilling	34,000
		56,600
	Matching Nunn's drilling	50,000
		$106,000

The cost to the Company for getting into this business for about the first year, then, would be approximately $56,600. The additional cost of matching the Nunn drilling would bring the total to $106,600. These costs are distinct from the cost of any work we might do in the North Boundary area.

It should be noted that any time the shallow drilling and the geophysical and other work is discouraging, ASARCO can drop out of the deal without having incurred any continuing obligations. The matter of matching Nunn's drilling footage, and thereby obtaining an interest in their claims and options, would be undertaken only if the preliminary work were encouraging.

Mr. Kinnison is preparing a map and report on the present state of our knowledge of the geology from the Pima District through the Reservation and into the Tucson Mts. As you know, we have been slowly accumulating information on the complex geological relationships in these areas for several years. This material will be in the mail within a few days, so I will not go into the geological details here. In the meantime I suggest you refer to the sketch map accompanying Mr. Kinnison's memorandum of December 17, 1959 which I transmitted to you January 4. This sketch shows the geological elements.

It might be noted that our earliest "lead" to the Mission ore body consisted of recognition that the hill surrounded by alluvium southeast of the Pima ore body contained evidence of disseminated copper, although nothing commercial was indicated in the hill itself. This meant that the Pima ore body might be part of a larger, buried mineralized zone, but at that time we had no specific target in the surrounding alluvium-covered area. This present Park Hill situation has certain similarities to that one. The analogy is pointed out merely to emphasize the generally tenuous nature of "leads" in this region; it is not intended to obscure the fact that exploration in the Park Hill area itself is in the "long shot" category.

Yours very truly,

KENYON RICHARD

KR/dm
Att: Claim Map
cc: DJPage - w/att.
File copy routed to:

TASnedden JRCourtright
ACHall JHKinnison

J E Kinnison
As-16.108

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
May 17, 1960

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

SOUTH AMOLE DISTRICT
Porphyry Copper Exploration

Dear Sir:

This will transmit Mr. Kinnison's geological report on the subject area. His carefully compiled map and text furnish the background for the generalizations about exploration possibilities contained in my April 25 letter to you.

The geologic map and interpretations thereof are based on original field work, mostly done by him and partly by other Company geologists. The resolution of Tertiary stratigraphy was aided in part by certain regional correlations worked out in the last few years by Mr. Courtright and me. There is considerable published information on the subject area, but without exception we have found these former publications to contain serious errors. The reasons for this appear to be a combination of incomplete field work, complex geologic relationships, and an environment of expansive alluvial cover and small isolated outcrops.

In any case we have found it necessary over the past 3 or 4 years to study and revise some of the published geological concepts of the region. In other words, we have had to concern ourselves with many problems which usually are left to the interest of the U. S. and State Geological Surveys. Kinnison's report and map represent the present state of our knowledge of the geology of the area, but inasmuch as studies are being continued intermittently some modifications may be necessary in the future.

By intention Kinnison's report is descriptive and academic in tone. It will primarily serve as a reference for you, the geophysicists and others. For example, in future letters we would expect to refer to a formation by name without necessarily at the same time having to define its significance in terms of structure, stratigraphic position or mineralization, our assumption being that the reader would refer to Kinnison's map or report.

In your letter of May 12 to me you mention Mr. Erwin's memorandum pointing out anomaly No. 1 in Block III of our Avra Valley aeromagnetic survey. At the time I wrote the April 25 letter to you I had not reviewed that survey. Subsequently, though, Mr. Kinnison had done so in connection with preparing his report, and he takes note of this in a section on geophysical considerations. I do not find a reply by any of us to the recommendations by Mr. Erwin and Mr. Lacy that property investigation and further geophysical work should be considered. However, I do know that at that time we considered the surface indication too weak to be of interest. As explained in my letter of April 25, our present interest derives from two principal new facts: (1) Kern's drill holes on Park Hill show a marked increase in disseminated chalcopyrite below 600', and (2) Kern's drill hole No. 3 situated nearly 2 miles southwest of Park Hill encountered porphyry with minor chalcopyrite.

I believe that after you and Mr. Lacy have had opportunity to study Kinnison's report, we all will then be in a better position to discuss the applications of geophysics. Your suggestion that Mr. Lacy should come to Tucson at an early date is a good idea.

Yours very truly,

Original Signed By
K. Richard

KENYON RICHARD

Attachment- Report with Map
KR/ds
cc: DJPage - w/att
RJLacy - w/att

File Copy routed to:
TASnedden
ACHall
JHCourtright
JEKinnison

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
May 18, 1960

MEMORANDUM FOR K. E. RICHARD

SOUTH AMOLE DISTRICT
Porphyry Copper Exploration

In his letter to Mr. Pollock of April 25, 1960, Mr. Richard discussed the property situation and outlined in general the plans for future procedure in the subject area. The following comments describe the principal geologic features which will influence exploration and interpretation of data gained therefrom.

SUMMARY

The Mission and Pima ore deposits, and the copper mineralization in the San Xavier Reservation occur within a broad belt of alteration which trends northwesterly toward the gravel covered pediment along the southwest flank of the Tucson Mountains. In this vicinity, the South Amole district, drilling at Park Hill by Kern County Land Co. (see attached map) disclosed significant disseminated copper mineralization in sediments adjacent to a monzonite intrusive. Their drilling also has shown that a shallow pediment extends farther west beneath gravel than previously supposed, and that weakly mineralized monzonite porphyry is there present. Disseminated copper occurs in a small monzonite plug at Saginaw Hill, 4 miles southeast of Park Hill.

These copper deposits in the South Amole district are not ore bodies, nevertheless they are significant in that they may be offshoots, or satellites, of a larger zone of disseminated mineralization concealed by alluvium on the adjacent pediment. Furthermore, our drilling on the Indian leasedid not discover a northern limit of the Mission-San Xavier alteration zone, so this important copper-bearing zone may questionably be projected into the wide alluvial covered pediment west and south of Saginaw Hill ("North Boundary area," Richard's letter to Pollock). For these reasons, parts of the South Amole district and San Xavier Reservation should be regarded as potentially ore-bearing.

I N D E X

MINERALIZATION

The disseminated Cu mineralization known in the Pima (Mission and San Xavier) and Amole Districts is of four related types. Wide halos of altered rock surround the ore zones.

1. Pervasive dissemination and local massive sulphide replacement in tactite; viz., the Mission ore zone and Pima mine. The tactites were formed from Paleozoic limestones.

2. Dissemination in fractured clastic sediments of the Amole and Pima groups; viz., the Mission ore zone and Pima mine, the sub-commercial deposit of the San Xavier lease, and parts of the Duval mine. These deposits have the characteristics of the so-called "porphyry coppers."

3. Dissemination in porphyries. This type is not dominant in the commercial deposits of this area. Mineralized porphyry occurs at Saginaw Hill, Mission, San Xavier lease, and Duval.

4. Bedded replacement of Amole group. This type of deposit occurs in Park Hill, discovered by Kern's drilling. The thin-bedded sediments are hardened by insipient silication, but bedding is preserved. Disseminated to massive chalcopyrite, pyrite and pyrrhotite selectively mineralize along bedding structure.

Alteration associated with (1) forms large areas of garnet, diopside and actinolite. Magnetite is present in the Pima mine. Alteration associated with (2) and (3) forms quartz, sericite, and clay, and is typical in a general way of the alteration found at Silver Bell and elsewhere. Much of the alteration of the "metaporphyry" at Mission is similar to feldspathization of the Ajo or Bagdad type.

PARK HILL DRILLING

Company interest in the South Amole district was stimulated when Wayne K. Wallace, chief geologist, Tucson office of Kern County Land Co., allowed me to see some of their drill cores and logs from Park Hill (letter, Richard to Pollock, 1/4/60). Subsequently, Richard and Courtright examined some of the core, and a report and drill logs by Wallace.

Kern drilled 6 holes in a joint effort with Ventures, Ltd., and a seventh hole after Ventures had dropped out. Two of these were shallow inclined holes to test specific targets, and another was a shallow vertical hole north of a major fault in the footwall block. The mineralization cut by these 3 holes is weak. The remaining four holes (Table 1), which bound an area roughly 400' x 500', are vertical and range from 1170' to 1550' in depth. All show appreciable mineralization.

The outcrop above the well mineralized ground is but weakly altered, and does not reflect the ore-grade horizon, which is below 600'. The rocks are thin bedded argillite (hornfels) and sericitized arkose. Beds dip about 45°, except in the first few hundred feet, where steeper dips are found to be truncated above a persistent 30° fault.

Kern has assayed only selected portions of core (Table 1) -- those zones in which there is visibly strong copper mineralization. The lower grade portions between these zones of high-grade received little attention from Kern geologists. Assays of the thin higher grade zones vary from about 1 to 5% Cu; 2-3% being the most common range. Certain lime-silicate argillite beds appear to be most favorable for the high-grade Cu concentrations. Pyrite and chalcopyrite replace these beds, yet preserve the bedding structure. The arkose appears to be most favorable for disseminated mineralization, but an undetermined amount of copper is also disseminated as tiny sulphide grains throughout the argillite. Silver is present in a ratio of about 1/2 oz Ag to each 1% Cu.

GEOPHYSICAL CONSIDERATIONS

The application of induced polarization, the method most directly responsive to disseminated sulphides, needs little comment. In the reconnaissance of parts of the San Xavier Reservation and southwest of Saginaw Hill, the first objective of IP surveys would be to discover whether or not the San Xavier altered zone has a northern limit, and to outline its location if it does continue. The weakly disseminated, sub-ore grade sulphide concentrations of the altered zone will be of significance if they can be detected. Since some beds of the Amole group contain very small quantities of syngenetic pyrite, a background response may have to be considered.

Magnetometer surveys would certainly pick up response from the magnetic post-ore basalts, and also from magnetic formations in the Pima group of pre-ore rocks. For examples, the Hycon aeromag. San Xavier survey for ASARCO pointed out the basalt cover with considerable success, and the Kern drilling southwest of Park Hill showed a magnetic high there to be caused by magnetic conglomerates of the Claflin Ranch or Silver Bell formation. Magnetite in the Pima mine ore zone (United Geophysical) and pyrrhotite zones at Park Hill (Kern Co.) have produced magnetic-high anomalies. The Park Hill magnetic high was also located by our Hycon survey; After a field check this area was recommended for further study by ASARCO geophysicists (Memo: Erwin to Lacy, 7/17/57; letter: Lacy to Richard 7/30/57). In contrast, a magnetic low has been found over some altered and sulphidized areas, such as San Manuel and Silver Bell. These examples are given to illustrate some of the features which would influence, and complicate, the interpretation of magnetic surveys in the Amole area.

Electromagnetic surveys need little comment here. The EM work at Mission and ensuing discussions have brought out the pertinent factors and problems. I might note, however, that southwest of Park Hill a strong EM high area (Kern Co. survey), elongated NW, may reflect a fault marking the edge of the shallow pediment; it might be that EM work could help outline the pediment, if this becomes necessary.

At Mission and San Xavier it proved possible to correlate bodies of heavy silicates (tactites) with gravity "highs" and to correlate some "structure-type" linear gravity features to contact (fault) structures. On a regional scale, high mountain blocks produce higher gravity response than deep valley blocks, and if the two are bounded by a large steep fault, the gradient between the high and low gravity intensity might so reflect.

The interpretation of response obtained over alluvium would be hampered because it is not possible to compensate for effects produced by the presently unknown bedrock topography in the South Amole area. Tactite bodies may or may not be concealed beneath alluvium on the San Xavier-Amole pediment; at least, there are no direct leads, or projections, which would so indicate. It is an open question, then, whether gravity surveys are warranted at this time.

ROCKS

The identifiable rock formations in the Pima-San Xavier-South Amole districts are numerous and varied, and it is essential to structural interpretations that they be recognized correctly. The stratigraphic column and igneous intrusives that have been resolved by Company geologists in recent years are shown on the attached map.

The geologic data that have in the past been published on the Pima District and Tucson Mountains are useful in varying degrees, but all those former works contain misleading and sometimes grossly incorrect interpretations. Two years ago I had written on the South Amole district in an unpublished thesis (University of Arizona). Parts of the geologic presentations now given are based on that work, and parts on mapping and drilling interpretations for the Company by J. H. Courtright, O. D. Evans, Byron Hardie, R. Cribbs, and myself. I consider that the information now set forth, even though brief, to be a significant advance over the geologic information which is available to other companies. Some additions and perhaps changes may incur in the future, as study of this area still continues, but I have no doubt that the salient facts as here described are correct. Where controversy exists I have attempted so to specify.

Pre-Ore Rocks

Mineral Hill granite. -- Pre-Cambrian. Coarse-grained interlocking quartz and pink or tan feldspar, with wisps of biotite-chlorite. Age open to some argument, as it hinges upon structural interpretation near Mineral Hill, and correlation by lithology to definite pre-Cambrian granite 3 miles to the southwest.

Cambrian Sediments. -- (1) Bolsa quartzite at base, about 600' thick; impure and gritty; thin, pebble-conglomerate at base. Overlain by (2) Cochise formation, 300' thick in north Tucson Mountains; not definitely known in Pima district, although a brown silty schistose quartzite, about 25-100' thick at Mineral Hill and Twin Buttes may be its equivalent. Overlain by (3) Abrigo limestone, about 350' thick; banded, gnarly limestone and siltstone.

Carboniferous and Devonian limestone. -- (1) Devonian Martin limestone, about 350' thick; thin- to medium-bedded limestone and dolomite; brown and gray, weathers to buff and pink tones; thin coral reef in upper half. Overlain by (2) Mississippian Escabrosa limestone, about 600' thick; thick-bedded pure, gray limestone; under slightest metamorphism forms massive, white, coarse-grained marble. Overlain by (3) Pennsylvanian Horquilla limestone, thickness plus or minus 1000', not accurately known; thin bed of red siltstone and chert-pebble conglomerate at base; lower portions limestone, some dolomite, few thin shale partings; upper portions more clastic with much sandstone and shale.

Permian limestone. -- (1) Earp formation -- in part equivalent to Bryant's Andrada formation -- overlies Horquilla limestone with gradational contact; Pennsylvanian-Permian boundary within lower part of unit; limestone, shale, sandstone, some red beds and gypsiferous units; thickness not established, probably between 300-800'. Overlain by (2) Scherrer formation; pure, fine-grained white quartzites, above and below a gray fine-grained dolomite with characteristic calcite nodules (1/8" to 1/2"); lower quartzite 300' (?), dolomite 150-300', upper quartzite 50-150'. Overlain by (3) Concha limestone, 800' plus thick; dark gray to black cherty limestone; generalized sequence is: 25' thin-bedded limestone at base, followed by 50' very cherty limestone, followed by 75' massive black limestone, followed by variable sequence of thin- to thick-bedded limestone and dolomite.

Amole group. -- Lower and Upper Cretaceous, upper parts may be earliest Tertiary. Thickness not accurately known, but probably exceeds 4000'. Limestone conglomerate up to 50' thick at base -- usually thinner. Amole group above this consists of a monotonous sequence of thin- to medium-bedded arkose and siltstone, shaly units, and occasionally a thin silty limestone bed. Tan to gray in weathered outcrop, with a few black shales and limestones. Unweathered silty sequences are dark to light gray, weakly calcareous, and contain traces of syngenetic pyrite and carbonaceous material. Near Saginaw Hill I have mapped four formations, but their correlations north and south of this area are uncertain. These are:

1. Braun formation, estimated thickness 1000' plus, overlies limestone conglomerate deposited on Permian Concha(?) limestone. Tan and gray (outcrop) siltstone and silty arkose, few thin limestones, generally thin-bedded or shaly.

2. Dead Cow formation, 2000' thick more or less. Interpreted to overlie Braun formation. Coarse-grained white or gray arkose, pebbly lenses common. Interbedded siltstones about 30% of section -- in outcrop these are generally covered. Lower Cretaceous fossils in middle. Unconformity near top, but lithology same above and below.

3. Mouse House formation, thickness uncertain, may be several hundred feet. Interpreted to overlie Dead Cow formation. Black and tan carbonaceous shales and shaly limestone. Contains Upper Cretaceous fossils (possibly Tertiary).

4. Echo Valley formation. Thickness unknown, may exceed 1000'. Similar to Mouse House formation, except that it contains fewer limestone beds. Also similar to Braun formation. May prove not to be feasible to separate this unit from underlying Mouse House formation.

Pima group. -- A new name, used for those rocks presumed to be of Lower Tertiary age, which lie between the Amole group and the Cat Mountain rhyolite. We presently divide this group into:

1. Silver Bell formation. Massive andesite-porphyry breccia. Courtright has found this unit to be very widespread -- from Silver Bell as far east as the Little Hatchet Mountains, New Mexico. The thickness varies from zero to 1000' more or less in the Amole-Pima area. Commonly it is strongly magnetic, but this is a variable feature. May be dominantly of flow-breccia or volcanic mud-flow origin, but water washed conglomerates are interbedded.

2. Claflin Ranch formation. -- Composed of conglomerate, arkose, and siltstone, possibly with a considerable amount of pyroclastic constituents. The conglomerates, except where metamorphosed, are moderately soft and pebbles and boulders weather out. The siltstone and arkose are similar to those of the Amole group. Andesitic debris is characteristic. Colors are gray to olive. Andesite pebbles may cause the formation to be locally magnetic. Red beds have been noted in what may be Claflin Ranch, west of the Tucson Mountains on the Papago Reservation; mapping in the Tucson Mountains at present includes the Recreation redbeds (formerly called Cretaceous) and some red conglomerates on "Piedmontite Hill" within this formation.

3. Tucson Mountain chaos. Known definitely only in Tucson Mountains, where it forms tabular layer below Cat Mountain rhyolite, and unconformably above the Amole group. Thickness varies from zero to 400'. Consists of unsorted rubble and huge "house-sized" blocks of all older rocks, formed by landslide action. May be younger than Silver Bell and Claflin formations, or partly equivalent.

4. Papago formation. Massive argillite which overlies the Paleozoic rocks in the Mission ore zone.

5. Kino formation. Conglomerate and argillite below "bottom thrust" in Mission Ore zone. May overlie Papago formation. Both Papago and Kino formations believed roughly equivalent to Claflin Ranch formation.

The relative ages of the above members of the Pima group are subject to further study. In general, the Claflin Ranch formation appears to vary tremendously in thickness and usually it lies beneath the Silver Bell formation. In particular localities it appears that Claflin-type beds overlie as well as underlie Silver Bell-type andesite. The similarity between certain features of the Tucson Mountain chaos and the Claflin Ranch suggests correlation, but inasmuch as the "chaos" contains fragments of Silver Bell and Claflin types, it may be in part or entirely younger.

Cat Mountain rhyolite. -- Lower Tertiary. A sequence of rhyolitic welded tuff-agglomerates. Thickness varies from zero to 800' plus.

Anklam formation. -- Lower Tertiary. Overlies Cat Mountain rhyolite with apparent conformity. Maximum thickness plus 500'. A new name to replace term "Safford tuff" as applied to these beds. Consists of tuffaceous lake beds of silt and arkose, poorly indurated.

Ivy May andesite. -- Replaces term "diopside andesite". Brown porphyritic andesite which intrudes Anklam formation as sills. May locally be a flow on Anklam beds.

Sierrita granite. -- This term has previously been defined in varying manners; some speculation still exists concerning the coarse-grained variety. Divisible into:

A. Twin Buttes phase. Gray medium-grained, even-textured quartz monzonite or granite, with thick euhedral books of biotite. Intrudes Paleozoic, Cretaceous, and Tertiary(?) rocks. Forms the principal mass of Sierrita granite outcrop.

B. Coarse-grained phase. Similar to A. but contains large orthoclase crystals. Texture more uneven. Biotite more altered. Contacts with Twin Buttes phase obscure. Forms footwall of "Basement fault" below Mission ore zone. Crops out west of Mineral Hill. This phase might originally have been pre-Cambrian granite, now partially melted or digested, but in any case it is indeed a part of the Sierrita granite mass.

Spherulitic rhyolite. -- Light colored siliceous rhyolites which intrude zone of Tucson Mountain chaos and cut lower part of Cat Mountain rhyolite.

Biotite rhyolite. -- Tan rhyolite, packed with foreign inclusions. Biotite laths numerous. Intrudes Ivy May andesite and Anklam formation. Dominantly pipe-like intrusive but also may form flow layer on San Xavier Reservation. Has characteristic textures -- both megascopic and microscopic -- which appear in all areas where it has been mapped.

Short's Ranch andesite. -- Light gray acid andesite porphyry. Intrusive near Saginaw Hill; may be flow elsewhere. Younger than Anklam formation.

Intrusive porphyries. -- Monzonite and quartz monzonite porphyry occur as small stocks and dikes. Includes "meta-porphyry" of Mission ore zone. These appear to be the youngest of the pre-ore intrusives.

Post-Ore Rocks

San Xavier formation. -- Middle Tertiary, possibly equivalent to Lower Miocene Minetta formation. Variable in thickness. Conglomerate and silty sandstone is overlain by flow of basalt porphyry with strikingly large feldspar phenocrysts, in turn overlain by conglomerate and silty sandstone. Lower conglomerate generally reddish in color. Upper conglomerate generally brown, with fragments of basalt porphyry. Rarely, large tabular blocks of shattered rock are interbedded with the conglomerates, and are probably landslide slabs.

Black Mountain basalt. -- Middle Tertiary. Black vesicular aphanitic basalt flows. Generally forms "tableland" topography.

"Older conglomerate". -- Well indurated conglomerate overlying Black Mountain basalt on the covered pediment of San Xavier Reservation.

Valley gravels. -- Generally unconsolidated gravels and sand of the present mountain-erosion cycle.

Intrusive andesite. -- Various andesitic and basaltic intrusives of small size. Some are post-Black Mountain basalt; some mapped in this category may be pre-ore.

EROSION SURFACES

Surfaces of erosion are important to structural analysis, inasmuch as they represent periods when older rocks were locally removed, and they frequently mark the end of an episode of structural disturbance. In this area, especially, some unconformities have been misinterpreted by other geologists to be fault structures. The several such surfaces which we have recognized here to be of particular importance are as follows:

1. Pre-Cambrian. The great unconformity between older pre-Cambrian and Paleozoic needs no comment.

2. Erosion between Permian and Cretaceous is seen here to have channeled only slightly into the Paleozoic rocks. The bedding of the two rock sequences is conformable. In some specific localities in southern Arizona this surface is one of considerable relief, erosion having cut into the pre-Cambrian. This condition, although not known or suspected, might exist in the San Xavier-Amole area.

3. At the end of the Cretaceous period, or in the earliest of Tertiary time, "Laramide" forces were initiated. The Paleozoic-Cretaceous sedimentary basin was destroyed, and epeiric seas were pushed out -- never to return. Sediments were intensely folded and locally, as at the Silver Bell mine area, may have been intruded by acid igneous bodies. These rocks were leveled to a surface of low relief called the "Tucson surface".

4. The Pima group was deposited on the Tucson surface. There may be intervals of erosion within the group, but these are not yet well known. Igneous intrusion may or may not have accompanied the close of this period.

5. In the Roskruge Mountains 20 miles west of the Tucson Mountains, the Pima group lies in large angular unconformity below the Cat Mountain rhyolite. Conglomerate and sandstone 10' thick mark the contact. At Silver Bell this unconformity is demonstrated by a thin conglomerate ~~of~~ at the contact. This surface of erosion is referred to as the "Papagueria surface". Where exposed in the Tucson Mountains it is not apparent as a major erosional surface.

6. After deposition of the Cat Mountain rhyolite and Anklam formations, and intrusion by igneous bodies, these rocks were altered, mineralized, faulted and tilted, and subsequently exposed to erosion. The surface produced was probably in part mountainous. This first post-ore erosion surface is named the "San Xavier surface". The San Xavier formation overlying it contains fragments of altered rock.

7. Erosion of parts of the San Xavier formation preceded the Black Mountain basalt. The beds below the basalt are in angular unconformity on a regional scale. Locally, sharp monoclinal folds cause steep unconformity.

8. The "older conglomerate" lies on an erosion surface of basalt; the extent of this erosion is not ~~k~~now known.

9. The present bedrock surface reflects the last phase of Basin-Range mountain structure, but now has been eroded to form the widespread pediments of the Pima-San Xavier-Amole region.

STRUCTURE

As may be seen on the attached geologic map, the structural pattern is complex throughout, but three major "structure blocks" are dominant.

1. The Mission ore zone and San Xavier alteration belt south of Black Mountain form the hanging wall plate of a post-ore low-angle fault, district-wide in its extent, which has moved mineralized rocks and Tertiary post-ore formations over Sierrita granite. This "Basement fault" has been referred to as a thrust fault; contrary to this conventional interpretation, our present belief is that it may have been formed by a free-sliding gravity block of huge dimensions. The position of the Basement fault north of the Reservation is unknown. Unless it is so great a feature as to involve the whole of the Tucson Mountains, it must emerge to the bedrock sub-outcrop somewhere in the "North Boundary" area. The internal structure of the upper plate is complex. Clues which will eventually point out the location of the faulted lower segment of the Mission ore zone are presently being sought.

2. The footwall block is composed of Sierrita granite in the Pima district. Near the Duval mine, ten miles south of Mission, the footwall block contains mineralized sediments and other rocks.

3. The Tucson Mountain block is probably formed, in part at least, by steep Range-front faults buried under alluvium some miles distant from bedrock outcrops. Certain pronounced fissures in alluvium near and northwest of Black Mountain may reflect steep bedrock structures which separate the Tucson Mountain block from the Reservation area.

John E. Kinnison
JOHN E. KINNISON

Attachments
JEK/ds

TABLE I

Park Hill Drill Hole Assays

No Assays: DDH's 1, 2, and 6
No Log : DDH 7 (1500' TD - penetrated some ore intercepts

DDH 3

Footage	Run	% Cu	Oz. Ag	
636.0 - 641.0	5	.13	.2	
641.0 - 646.0	5	.71	.4	
646.0 - 651.0	5	.92	.4	20'
651.0 - 652.0	1	.38	.2	.61% Cu
652.0 - 656.0	4	.75	.2	.3 oz Ag
656.0 - 659.0	4	3.96	1.0	
. . . . .				
704.5 - 709.5	5	.13	.2	6.5'
709.5 - 713.0	3.5	3.95	.7	2.41 Cu
713.0 - 716.0	3	.61	.4	.55 Ag
. . . . .				
722.0 - 727.0	5	.41	.3	7'
727.0 - 729.0	2	.47	.3	.42 Cu
. . . . .				.3 Ag
765.0 - 769.0	4	2.85	.3	
. . . . .				
871.0 - 876.0	5	.18		
876.0 - 881.0	5	.33		
881.0 - 886.0	5	.56		60'
886.0 - 891.0	5	.44		.27 Cu
891.0 - 896.0	5	.24		All
896.0 - 901.0	5	.18		Arkose
901.0 - 906.0	5	.21		
906.0 - 911.0	5	.18		
911.0 - 916.0	5	.18		
916.0 - 921.0	5	.15		
921.0 - 926.0	5	.23		
926.0 - 931.0	5	.31		
931.0 - 936.0	5	.33		
. . . . .				
1292.0- 1293.5	1.5	1.88	.4	
. . . . .				

1550 TD

0 - 445' Arkose, siltstone, some ls.

445 - 1550' Bx, dip 30°, at start. Diss Cu in Ark. below. Arg. and ark., some limy(?) beds. Spotty strong replacements and diss Cu to bottom.

TABLE I - Continued

DDH 4

Footage	Run	% Cu	Oz. Ag		
733.0 - 736.0	3	.09	.7		
736.0 - 739.0	3	1.97	1.3		
739.0 - 740.0	1	.45	.1		
. . . .	. . .	. . . . .	. . . . . .		
835.0 - 837.0	2	.11	.8		
837.0 - 838.0	1	2.06	1.2	5'	
838.0 - 839.0	1	.36	.5	3.81	Cu
839.0 - 842.0	3	5.54	2.2	1.66	Ag
842.0 - 844.0	2	.30	.4		
. . . .	. . .	. . . . .	. . . . . .		
1088.0- 1089.5	1.5	.45	.5		
1089.5- 1090.5	1.0	.31	.2	7'	
1090.5- 1092.5	2.0	.71	.3	.66	Cu
1092.5- 1095.0	2.5	.88	.4	.36	Ag
. . . .	. . .	. . . . .	. . . . . .		
1170 TD					

Ark and arg. Steep dips, flatten toward 220'. Bx, 30°, at 220' -- below beds dip 40-50°. Diss Cu logged from 220 down, increasing in strength. Bottom 50' weak.

DDH 5

Footage	Run	% Cu	Oz. Ag		
683.5 - 687.0	3.5	1.18	.6		
. . . .	. . .	. . . . .	. . . . . .		
688.0 - 692.0	4	1.15	.5		
. . . .	. . .	. . . . .	. . . . . .		
696.0 - 698.0	2	1.15	.5	6'	
698.0 - 700.0	2	3.95	1.6	2.61	Cu
700.0 - 702.0	2	2.73	.9	1.0	Ag
. . . .	. . .	. . . . .	. . . . . .		
710.5 - 712.0	1.5	4.45	1.4		
. . . .	. . .	. . . . .	. . . . . .		
763.5 - 770.5	2	1.16	.3	4.5'	
770.5 - 771.5	1	4.57	1.1	1.88	Cu
771.5 - 773.0	1.5	1.05	.3	.5	Ag
. . . .	. . .	. . . . .	. . . . . .		
839.0 - 843.0	4	3.02	.9		
. . . .	. . .	. . . . .	. . . . . .		
1178.5 TD					

0 - 300	Log diss Cu.
- 540	Mostly barren.
- 1150	Diss Cu and some strong replacement.
- 1178.5	Barren.

FILE MEMORANDUM

AVRA VALLEY HYCON-SURVEY
Aeromagnetic
Block III - Brown Mountain
Exerpts, Anomaly 1

Erwin to Lacy, Nov. 20, 1956

"Anomaly 1 - .... The correlation to the monzonite outcrop on Brown's map is notable. In plan, the sub-outcrop of the anomalous body is probably approximated by the area within the 1000 gamma contour. Theoretical calculations yield a depth of approximately 300-400' to the top of the anomalous body...."

Morrison to Lacy, April 29, 1957

"Anomaly 1, Block III - ....See maps T-13-16A* and T-13-17A*. This anomaly occurs in a silicified, spottedly mineralized sedimentary area...."

*These two maps, and also T-13-59A, T-13-60A, T-13-61A, T-13-62A, are not in the Tucson files.

Erwin to Lacy, July 17, 1957

"The position of anomaly 1 was located by Mr. Morrison approximately as shown on Hycon's map. Ground on the southern portion of the anomaly is heavily staked while the northern portion lies within the state-owned Tucson Mountain Park. A drill was located as nearly as could be determined slightly east of the center of the high, and Mr. Morrison and I observed that they were at a depth of 360 feet at the time we visited the area. Copper mineralization and alteration are evidenced in the surface exposures and prospect pits. Susceptibility measurements gave no insight into the probable cause of the anomaly but the correlation with the mineralization is noteworthy. It is interesting to observe that the western half of this feature lies in a gravel covered area. A check of ownership with respect to the magnetics seems warranted."

Lacy to Richard, July 30, 1957

"Some further ground geophysics is recommended over valley fill on the west part of anomaly 1 and on anomaly 4 if the property situation is favorable."

J. E. KINNISON

JEK/ds

GEOPHYSICAL DIVISION
Salt Lake City, Utah

June 14, 1960

Mr. J. E. Kinnison
American Smelting and Refining Company
813 Valley National Building
Tucson, Arizona

Dear John:

This will acknowledge receipt of your letter of June 6 and the package containing the samples.

I will distribute the results of the I.P. tests when they have been completed.

Thank you.

Very truly yours,

W. E. Saegart

W. E. SAEGART

WES:si
cc:K.E.RICHARD
R.J.LACY

Aa-16.1.0B
JEK

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
June 6, 1960

Mr. W. E. Saegart
American Smelting and Refining Company
600 Crandall Building
Salt Lake City, Utah

SOUTH AMOLE DISTRICT
I. P. Response
Black Cretaceous Shale

Dear Sir:

By another package I send six samples of Cretaceous rocks from the South Amole area. The Numbers 1-5 are all from the Mouse House and/or Echo Valley formations (see Amole report 5-18-60); they are black siltstone and shales, probably carbonaceous or graphitic, and contain tiny grains disseminated pyrite. The Number 6 sample is evidently an interbed of arkose, and since it also contains pyrite and is unaltered, I have included it. You will note occasional seams of calcite, and the weakly calcareous nature of much of the rock.

Please see attached sheet for location and description of samples.

Nearly identical rock has been extensively prospected by drilling in Section 32 east of the Mission ore zone. If an I. P. traverse is necessary in order to test the polarization response of these black shales -- in bulk -- the Section 32 area is exceptionally suitable in that there the rocks are extensive, and known to be entirely fresh (not mineralized).

Yours very truly,

JOHN E. KINNISON

JEK/ds
Attachment

POLARIZATION SAMPLES
Amole District, Arizona

1. From shaft started in alluvium, in Sec. 2, T15S,R12E, Distant 2900' S72° E from NW corner Sec. 2; more or less 1 1/4 miles N of Saginaw Hill. Black shaly siltstone. Tiny diss. metallic specks. Pyrite is not specifically identified.

2. Chips from water well, sludge pile approx. center SE 1/4 Sec. 28 by Park Hill -- shown on geol. map of Amole-San Xavier area. Black shaly siltstone identical with (1). Diss. pyrite in some fragments.

3. Chips from water well sludge, 100' N of Ajo Road in Sec. 35 T14S, R12E, near E line of Sec. 35, shown on geol. map. Black shaly siltstone identical to (1). Panned concentrate shows significant amount of pyrite.

4. Discarded core, Bear Creek DDH "1" in Sec. 28 by Park Hill -- see geol. map. Black shaly siltstone, identical to (1). Fine pyrite visible.

5. Discarded core, Bear Creek DDH "2" in Sec. 28. Same rock as in their hole "1".

6. Discarded core, Bear Creek DDH "1". Gray arkose with traces of diss. pyrite and thin veinlets. Rock is essentially unaltered and fresh.

Aa-16.1.0B
JEK

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
January 4, 1960

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

AMOLE DISTRICT
Southern Tucson Mountains
Pima County, Arizona

Dear Sir:

Enclosed is copy of memorandum and sketch map by Mr. Kinnison in which he describes some data which was recently shown to him regarding exploration activities in the southern Tucson Mountains. This material is of interest to us for several reasons, and I am sending it along to you, with copy to Mr. Lacy, because it has a bearing on Induced Polarization surveys which we have in mind.

Kern County Land Co. has obtained surprisingly good copper sulphide values in drill holes in a small, weak-looking alteration zone (marked (1) on Kinnison's map) which is covered by alluvium on the south and west. This suggests that the mineralized zone we have in our ground on the San Xavier Reservation may have some general continuity north-northwesterly beneath gravel cover into the area of Kinnison's map. (For your orientation the northwest corner of the property on the Reservation which we have retained, and which includes the mineralized outcrops you inspected with us on your recent visit here, is about 4 miles south of the Reservation north boundary line shown near the bottom of Kinnison's map.)

We had planned Induced Polarization surveys in this area along the Reservation north boundary sometime this winter, as we talked about briefly when you were here. This work would be done with the idea of trying to trace the possible north or northwestward continuation of the Reservation alteration zone. The information Kinnison has obtained improves the picture here and makes this area more interesting for IP surveys. There is no pressure to do the work right now, and I will report more fully on the matter of IP surveys before the surveys are to be made, but possibly Mr. Lacy can keep it in mind for such time as Mr. Saegart returns from South America.

We had not heretofore been aware that Bear Creek's claims extended so far south. This is unfortunate, but we will further investigate the question of the validity of the claims.

In an effort to get copies of the Kern County Land Co. drilling results, or at least to get a closer look at their data, I will approach Wallace with the idea that this Company might be interested in their property.

Yours very truly,

Original Signed By
K. Richard

KENYON RICHARD

Attachment
KR/ds
cc: RJLacy - w/att.

AMERICAN SMELTING AND REFINING COMPANY
Tucson   Arizona

December [illegible]

CONFIDENTIAL

MEMORANDUM FOR K. E. RICHARD

AMOLE DISTRICT

On 11/20/59 I talked with Wayne K. Wallace, who is in charge of field exploration in Arizona for Kern County Land Company, about their drilling in the Sedimentary Hills (called Park Hill by Kern) of the Tucson Mountains. He showed me sev eral maps and cross sections, assays, and drill cores. The accompanying sketch map is drawn from memory of these data.

Their drilling to date includes:

1. About 5 holes, in the belt of alteration (as mapped by Wallace) marked (1), which range from about 500 to 1500 feet deep. The ore occurs principally as banded chalcopyrite in limy siltstone beds. Certain limy beds, which are correlatable between drill holes, contain up to 5% Cu as disseminated and banded chalcopyrite in two- to six-foot thick beds. Some intervals average 0.4 to 1% Cu over distances up to 100 feet. Barren zones of argillite separate the mineralized beds. The bedding strikes NW and dips about 40° SW. It is evident that even if this zone is not a commercial deposit, it contains a significantly large quantity of copper. The drilling data has been compiled by Wallace into composite logs, and is well shown graphically on cross sections.

2. About a mile NW of Snyder Hill (2 on the map) a quartz monzonite porphyry was drilled, below 130 feet of gravel. Arkose, redbeds and conglomerate were also cored. The porphyry is not altered in the usual sense, although the feldspars are weakly kaolinized, and there may have been some recrystallization. Narrow blebs of chalcopyrite and veins of pyrite-chalcopyrite occur in the porphyry. No assays were made by Kern, but I estimate that this rock might contain .05 to .1% Cu. The arkose is weakly altered and shows limonite derived from pyrite. The conglomerate is composed of rounded andesite-pebbles and interbedded arkose, and may be the Silver Bell formation. It also contains traces of copper sulphide. Permian limestone is in fault contact (30° gouge, 20' no core) overlying Silver Bell(?) in one hole.

The target of this drilling was a magnetic high, caused by the Silver Bell(?) formation which is highly magnetic in the core. These claims have been abandoned by Kern.

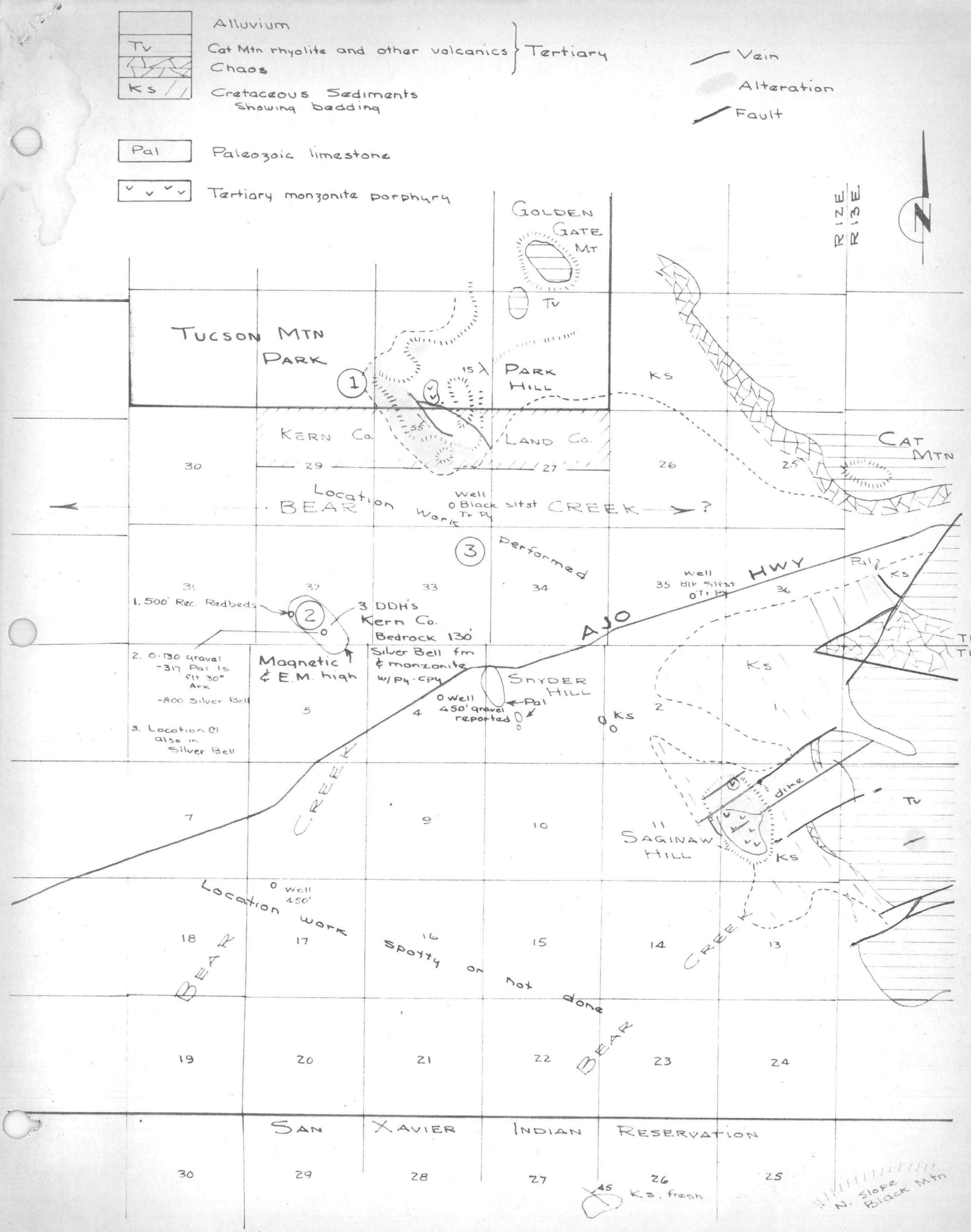
According to Wallace, Bear Creek Mining Co. has staked about 400 claims south, east, and west of Kern. During November they drilled two DDH's, just south of Kern claims (3 on the map) to 250 and 350 feet. A brief reconnaissance west of Saginaw Hill indicates that Bear Creek has staked a large area extending south to the San Xavier Indian Reservation, under the name of Richard Nielson, but that little if any location work has been done.

Wallace stated that Kern had proposed to Anaconda that drilling on their land be undertaken in a joint effort; this proposal was not accepted. He also intimated that a joint venture or a direct sale would be open to consideration with other companies.

Kern's exploration has established that considerable copper exists in the sediments of Park Hill, and that altered rocks and porphyry exist under a shallow pediment some distance SW of the nearest outcrops. Coupled with the known weak alteration and porphyry at Saginaw Hill, these data suggest this general area may now be regarded more favorably than in the past as a possible exploration lead. The data Kern has obtained would be useful in evaluating exploration possibilities in the area west of Black Mountain on the San Xavier Reservation, as well as a possible extension NW from that area into the Saginaw Hill vicinity.

John E. Kinnison
JOHN E. KINNISON

JEK/ds
cc: JHCourtright



Vicinity Saginaw Hill - S.W. Tucson Mtns.

December, 1959

Scale 1" = 1mi app.

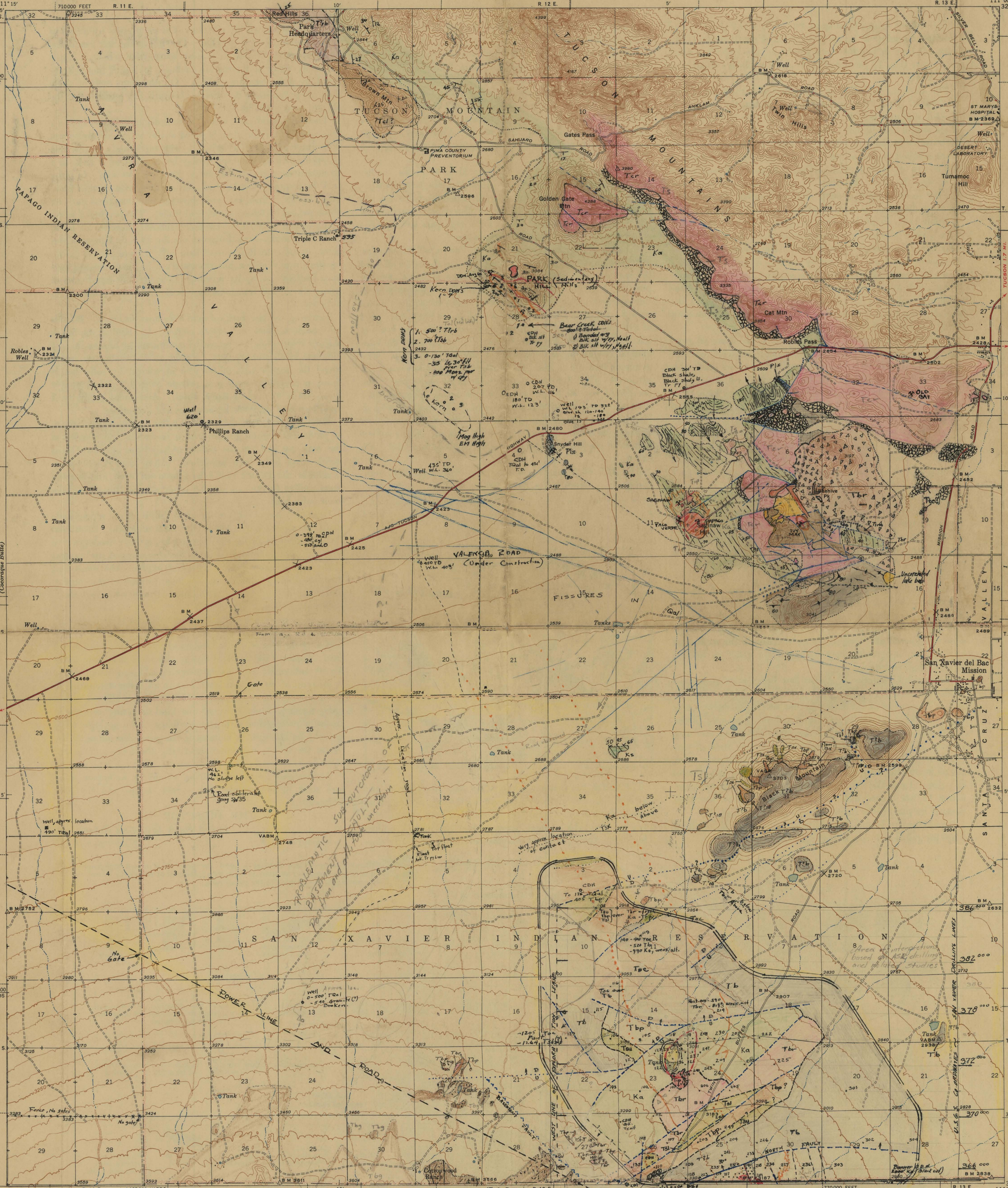
Dodo 21
2 Rec. 58

Dodo 23
19/4/60

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WAR DEPARTMENT

ARIZONA
(PIMA COUNTY)
SAN XAVIER MISSION QUADRANGLE
15-MINUTE SERIES



Topography by E. S. Rickard and H. E. Skinner
Surveyed in 1940-1941

ROAD CLASSIFICATION
1947
Dependable hard surface heavy-duty road
Secondary hard surface all weather road
Dry weather roads
Loose surface graded
Unsurfaced, graded
Dirt road
U. S. Route
State Route
More than two lanes indicated along road with tick at point of change

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1941

Scale $\frac{1}{62500}$

Contour interval 50 feet
Datum is mean sea level

Polyconic projection. 1927 North American datum
5000 yard grid based on U. S. zone system, F
10000 foot grid based on Arizona (Central) rectangular coordinate system

SAN XAVIER MISSION, ARIZ.
Edition of 1943
reprinted 1947
N3200—W11100/15

36

GEOLOGIC MAP
Revised: JEK Fall, 1959

THE TOPOGRAPHIC MAPS OF THE UNITED STATES

The United States Geological Survey is making a series of standard topographic maps to cover the United States. This work has been in progress since 1882, and the published maps cover more than 47 percent of the country, exclusive of outlying possessions.

The maps are published on sheets that measure about 16½ by 20 inches. Under the general plan adopted the country is divided into quadrangles bounded by parallels of latitude and meridians of longitude. These quadrangles are mapped on different scales, the scale selected for each map being that which is best adapted to general use in the development of the country, and consequently, though the standard maps are of nearly uniform size, the areas that they represent are of different sizes. On the lower margin of each map are printed graphic scales showing distances in feet, meters, miles, and kilometers. In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground. For example, the scale $\frac{1}{62,500}$ means that 1 unit on the map (such as 1 inch, 1 foot, or 1 meter) represents 62,500 of the same units on the earth's surface.

Although some areas are surveyed and some maps are compiled and published on special scales for special purposes, the standard topographic surveys and the resulting maps have for many years been of three types, differentiated as follows:

1. Surveys of areas in which there are problems of great public importance—relating, for example, to mineral development, irrigation, or reclamation of swamp areas—are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{31,680}$ (1 inch = one-half mile) or $\frac{1}{24,000}$ (1 inch = 2,000 feet), with a contour interval of 1 to 100 feet, according to the relief of the particular area mapped.

2. Surveys of areas in which there are problems of average public importance, such as most of the basin of the Mississippi and its tributaries, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile), with a contour interval of 10 to 100 feet.

3. Surveys of areas in which the problems are of minor public importance, such as much of the mountain or desert region of Arizona or New Mexico, and the high mountain area of the northwest, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{125,000}$ (1 inch = nearly 2 miles) or $\frac{1}{250,000}$ (1 inch = nearly 4 miles), with a contour interval of 20 to 250 feet.

The aerial camera is now being used in mapping. From the information recorded on the photographs, planimetric maps, which show only drainage and culture, have been made for some areas in the United States. By the use of stereoscopic plotting apparatus, aerial photographs are utilized also in the making of the regular topographic maps, which show relief as well as drainage and culture.

A topographic survey of Alaska has been in progress since 1898, and nearly 44 percent of its area has now been mapped. About 15 percent of the Territory has been covered by maps on a scale of $\frac{1}{500,000}$ (1 inch = nearly 8 miles). For most of the remainder of the area surveyed the maps published are on a scale of $\frac{1}{250,000}$ (1 inch = nearly 4 miles). For some areas of particular economic importance, covering about 4,300 square miles, the maps published are on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile) or larger. In addition to the area covered by topographic maps, about 11,300 square miles of southeastern Alaska has been covered by planimetric maps on scales of $\frac{1}{125,000}$ and $\frac{1}{250,000}$.

The Hawaiian Islands have been surveyed, and the resulting maps are published on a scale of $\frac{1}{62,500}$.

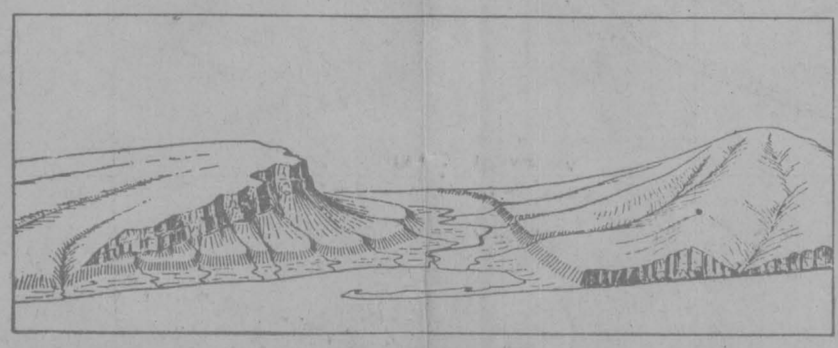
A survey of Puerto Rico is now in progress. The scale of the published maps is $\frac{1}{30,000}$.

The features shown on topographic maps may be arranged in three groups—(1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries. The symbols used to represent these features are shown and explained below. Variations appear on some earlier maps, and additional features are represented on some special maps.

All the water features are represented in blue, the smaller streams and canals by single blue lines and the larger streams by double lines. The larger streams, lakes, and the sea are accentuated by blue water lining or blue tint. Intermittent streams—those whose beds are dry for a large part of the year—are shown by lines of blue dots and dashes.

Relief is shown by contour lines in brown, which on a few maps are supplemented by shading showing the effect of light thrown from the northwest across the area represented, for the purpose of giving the appearance of relief and thus aiding in the interpretation of the contour lines. A contour line represents an imaginary line on the ground (a contour) every part of which is at the same altitude above sea level. Such a line could be drawn at any altitude, but in practice only the contours at certain regular intervals of altitude are shown. The datum or zero of altitude of the Geological Survey maps is mean sea level. The 20-foot contour would be the shore line if the sea should rise 20 feet above mean sea level. Contour lines show the shape of the hills, mountains, and valleys, as well as their altitude. Successive contour lines that are far apart on the map indicate a gentle slope, lines that are close together indicate a steep slope, and lines that run together indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley that lies between two hills. In the foreground is the sea, with a bay that is partly enclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends by a sea cliff. The hill at the left terminates abruptly at the valley in a steep scarp, from which it slopes gradually away and forms an inclined tableland that is traversed by a few shallow gullies. On the map each of these features is represented, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the topography of the area mapped: in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet. In order that the contours may be read more easily certain contour lines, every fourth or fifth, are made heavier than the others and are accompanied by figures showing altitude. The heights of many points—such as road intersections, summits, surfaces of lakes, and benchmarks—are also given on the map in figures, which show altitudes to the nearest foot only. More precise figures for the altitudes of benchmarks are given in the Geological Survey's bulletins on spirit leveling. The geodetic coordinates of triangulation and transit-traverse stations are also published in bulletins.

Lettering and the works of man are shown in black. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public roads suitable for motor travel the greater part of the year are shown by solid double lines; poor public roads and private roads by dashed double lines; trails by dashed single lines. Additional public road classification if available is shown by red overprint.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining quadrangles of which maps have been published. More than 4,100 quadrangles in the United States have been surveyed, and maps of them similar to the one on the other side of this sheet have been published.

Geologic maps of some of the areas shown on the topographic maps have been published in the form of folios. Each folio includes maps showing the topography, geology, underground structure, and mineral deposits of the area mapped, and several pages of descriptive text. The text explains the maps and describes the topographic and geologic features of the country and its mineral products. Two hundred twenty-five folios have been published.

Index maps of each State and of Alaska and Hawaii showing the areas covered by topographic maps and geologic folios published by the United States Geological Survey may be obtained free. Copies of the standard topographic maps may be obtained for 10 cents each; some special maps are sold at different prices. A discount of 40 percent is allowed on an order amounting to $5 or more at the retail price. The discount is allowed on an order for maps alone, either of one kind or in any assortment, or for maps together with geologic folios. The geologic folios are sold for 25 cents or more each, the price depending on the size of the folio. A circular describing the folios will be sent on request.

Applications for maps or folios should be accompanied by cash, draft, or money order (not postage stamps) and should be addressed to

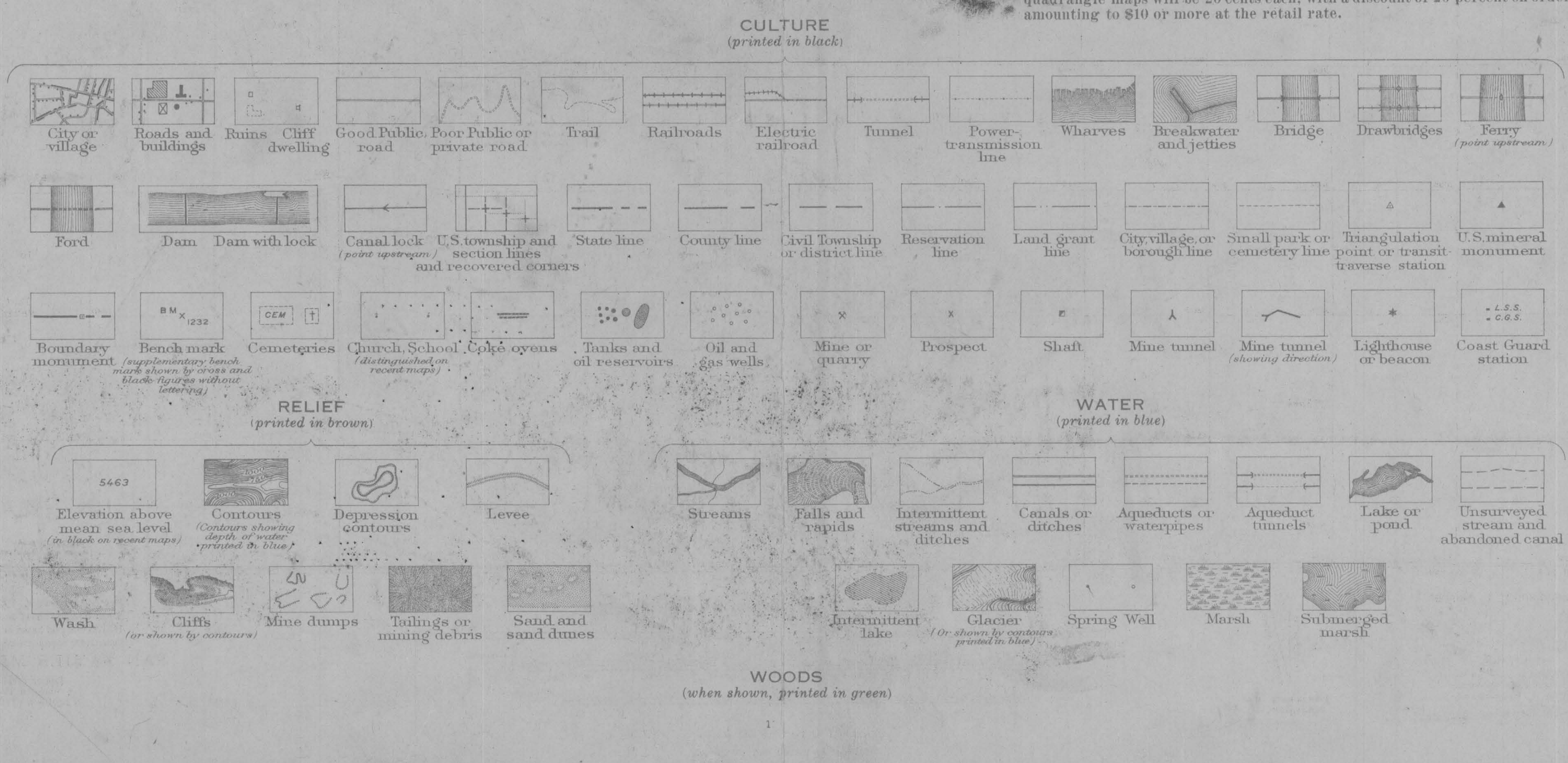
THE DIRECTOR,

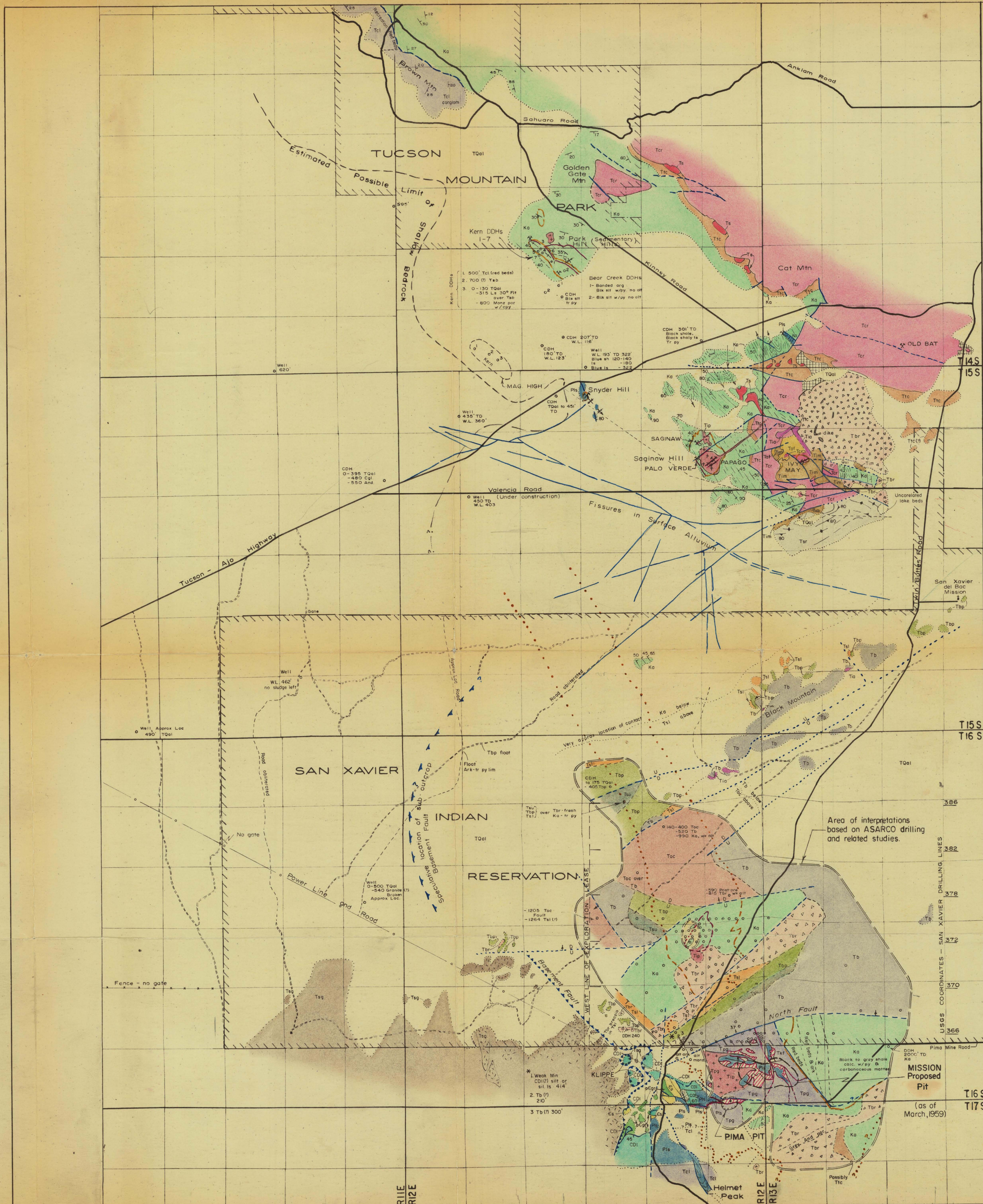
United States Geological Survey,

November 1937. *Washington, D. C.*

STANDARD SYMBOLS

Effective on and after October 1, 1946, the price of standard topographic quadrangle maps will be 20 cents each, with a discount of 20 percent on orders amounting to $10 or more at the retail rate.

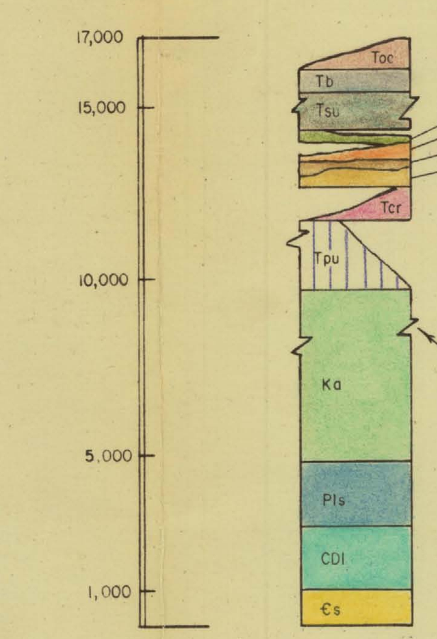




COLUMNAR SECTION

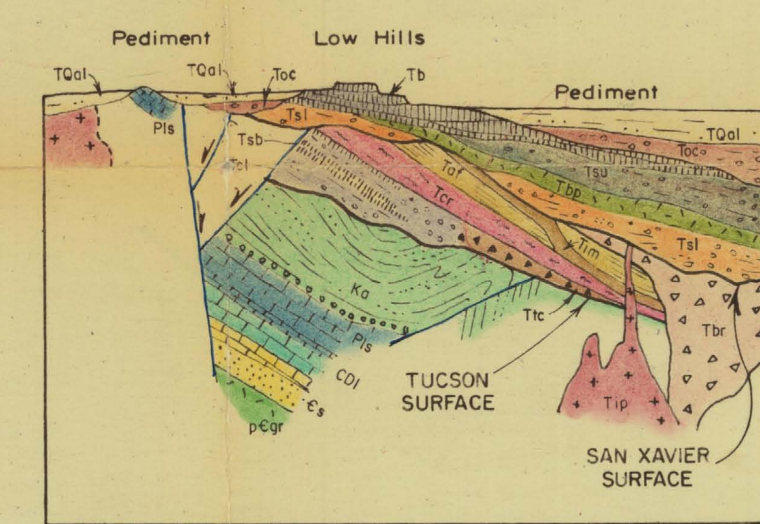
TO SCALE

1 inch = 1 mile



DIAGRAMATIC STRUCTURE STRATIGRAPHIC COLUMN

NOT TO SCALE



As reference for structural disturbance, note that these strata were approx. horizontal when deposited:
Ꞓs, CDl, Pls, Ka
Tcl, Tcr, Taf
Tbp (?)
Tb

OTHER SYMBOLS

- Maintained road
- Desert auto trail
- Drill hole (not all ASARCO holes shown, within ore zone proper)
- Outline of ASARCO drilling area; geology within, under alluvium, colored as though it were outcrop.
- Mine

LAYERED ROCKS
SEDIMENTARY AND EFFUSIVE

TERTIARY-QUATERNARY
- TQal — Valley gravels, surficial alluvium and talus

Major Erosion

LOWER MIOCENE (?) - UPPER (?) TERTIARY
- Toc — Older conglomerate. Overlies Tb

erosion

- Tb — Black Mountain basalt

erosion

- San Xavier formation:
  - Tsu — Upper conglomerate beds
  - Tbp — Basalt porphyry flows (locally dikes)
  - Tsl — Lower conglomerate beds

POST-ORE / PRE-ORE Major erosion — SAN XAVIER SURFACE

LOWER TERTIARY
- Tim — Ivy May andesite (sills)
- Taf — Anklam formation
- Tcr — Cat Mountain rhyolite

?

- Ttc — Tucson Mountain chaos
- Pima Group:
  - Tsb — Silver Bell formation
  - Tcl — Claflin Ranch fm. (mapped to include Recreation redbeds)
  - Tkf — Kino formation } Mission Ore Zone = Claflin ?
  - Tpg — Papago fm (below Kino ?) }
  - Tpu — Undifferentiated

Major erosion — TUCSON SURFACE

CRETACEOUS
- Ka — Amole group

PALEOZOIC
- Pls — Permian limestone. Includes Earp fm., Andrada fm., Scherrer fm., Concha ls
- CDl — Carboniferous and Devonian limestone. Includes Martin ls., Escabrosa ls, Horquilla ls
- Ꞓs — Cambrian Sediments. Includes Balsa qtzt., Cochise fm., Abrigo fm.

INTRUSIVE IGNEOUS ROCKS

- Tia — Andesite, intrusive as dikes and small bodies. Several ages included together, some of which may be pre-ore.

POST-ORE / PRE-ORE

LOWER TERTIARY
- May be post-Cat Mtn rhyolite:
  - Tsg — Sierrita granite
  - Sierrita granite Coarse-grained type
- Post-Cat Mtn rhyolite:
  - Tip — Porphyry intrusive qtz-monz, monz
  - Tbr — Biotite rhyolite
  - Ts — Spherulitic rhyolite
  - Tsr — Short's Ranch andesite

PRE-CAMBRIAN
- p€gr — Mineral Hill granite

STRUCTURE

- Fault
- Contact
- Low-angle fault. Thrust or gravity block
- Strike and dip of sediments
- Strike and dip of igneous flow layering
- Axis of Anticline
- Axis of Syncline
- Generalized bedding structure

NOTE: Structures dashed where obscure, dotted where covered. In the area of ASARCO drilling, structures shown solid where determined by substantial drilling data; dashed where only approx. known.

MINERALIZATION

- Vein, or mineralized fault
- Disseminated Cu bodies, >0.4 % Cu
- Limits of hypogene alteration. Dotted where uncertain.

American Smelting and Refining Company

GEOLOGY
of the Porphyry Copper Belt
SOUTH AMOLE - SAN XAVIER - MISSION
Pima County, Arizona

Scale 1:62500
(1 inch = 1 mile approx.)

0 1 2 3 Miles

Compiled April, 1960
J.E. Kinnison

1459

JEK

EROSION

Clay Al2O3 S.O2

EXPLANATION

SEDIMENTARY ROCKS

POST-MINERAL

- **Qal** — Alluvium and talus
- **Tal** — San Xavier conglomerate
  Angular to subrounded fragments, moderately consolidated. Beds tilt as much as 70. In places, contains mineralized rocks from nearby alteration zones.
- **Tsb** — Silver Bell formation
  Includes: andesite porphyry conglomerate, conglomerate of earlier rock types, volcanic rubble and chaos of large boulders. Overlain by Tcr.
- **Ks** — Cretaceous sediments
  Up to 10,000 feet arkose, quartzite, siltstone, conglomerate
- **Ps** — Paleozoic sediments
  About 4000 feet of Cambrian thru Permian limestones and quartzites.

IGNEOUS ROCKS - EXTRUSIVE

POST-MINERAL

- **TQb** — Basalt
  About 200' thick. Cap rock.
- **Tsa** — Shorts Ranch andesite
  At least 400 feet thick
- **Tcr** — Cat Mountain rhyolite
  At least 300 feet of layered pyroclastic with numerous foreign fragments. Overlies Tsb.

IGNEOUS ROCKS - INTRUSIVE

POST-MINERAL

- **Tha** — Hornblende andesite
  Dikes cutting Tal
- **Tbp** — Basalt porphyry
  Elongate masses, apparently intrusive
- **Tm** — Monzonite
  Small bodies associated with altered and mineralized rocks
- **Td** — Diabase
  Dike-like bodies
- **Tbr** — Biotite-rhyolite
  Contains abundant angular fragments of earlier rocks.
- **Tda** — Diopside-andesite
- **Tsg** — Sierrita granite
  Main mass of Sierrita Mts.
- **Pre-€** — Pre-Cambrian granite

AMERICAN SMELTING AND REFINING COMPANY

GEOLOGIC MAP of PIMA-SAN XAVIER RES.-AMOLE AREA

PIMA COUNTY, ARIZONA

BY O.D.E. & J.H.C.

MAY, 1956

SCALE 1:62500

0 1 2 3 4 MILES

MAP NO. 1297

Swallens office
Dick Shaw

Rep 450' Sec 17
Drilled 1937
Ralph -
W.L. 1953 Nov 403.

Sec 6 15-12
SE NE SE
435' D

SE SE - 6
435 D
W.L. 385 Nov 41 Report.
360 Meas. 54

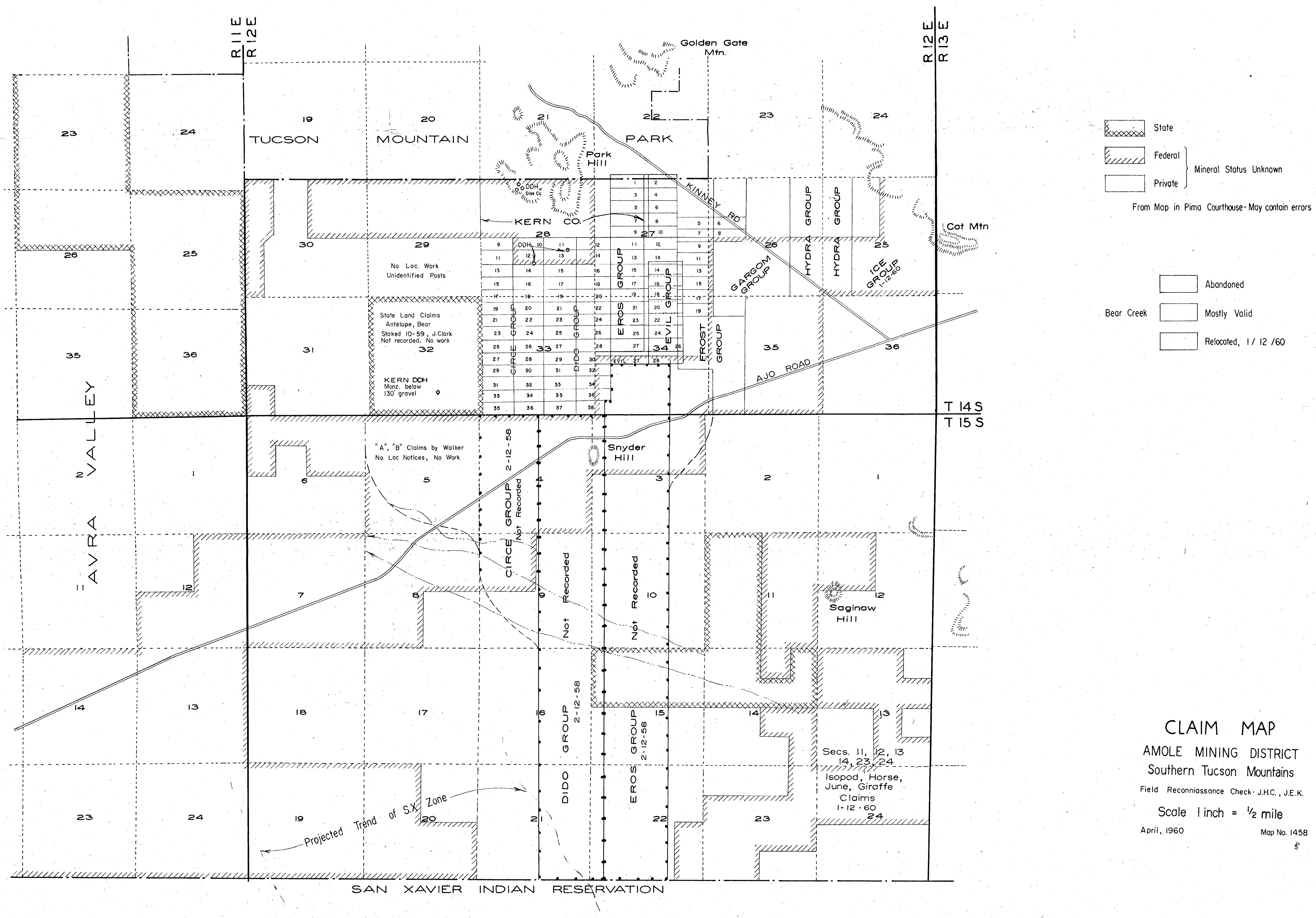
Sec 33 SE SW NE
Aug, 54
207 ' Reported
W.L. 116 1/2 54, Jan

NW NE SW
1951
Report 180
W.L. Meas. 1957, 122'

36
1957 - 301' D
~~Blue shale~~
Blue schist 58'-78
" sh 95
" 110 solid.
Blue ls. 130
Blue shale 150 hard
Blue ls. 180
" sh. 190
Blue ls. 301

36
SW SE NE 165
W.L 1940 96 1/2'
1929 Drilled
Brown l.s reported

Nash No 2
350 - 411 Met. porphyry. Some CS seen.
Traces li. lim. Some percent Py lim.
No 4 - May be Granite gn. boulders buried.
No 1 - to 173 ...
- 221 Black ...
...



CLAIM MAP

AMOLE MINING DISTRICT

Southern Tucson Mountains

Field Reconnaissance Check - J.H.C., J.E.K.

Scale 1 inch = ½ mile

April, 1960

Map No. 1458

PRONG FASTENER
BINDER

USE *Tatum* PRONG FASTENER
TO DUPLICATE REFER TO NUMBER
447-13
MADE IN U.S.A.

GENUINE PRESSBOARD

AMOLE DISTRICT