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

6 December 1973

Mr. W. E. Saegart
President
Quintana Minerals Corporation
1892 West Grant Road
Tucson, Arizona

Big Horn/Vulture Reconnaissance
Maricopa County, Arizona

Dear Sir:

This report and accompanying map are the result of a general reconnaissance of the southwest flank of the Vulture range, and most of the Big Horn mountains, in west-central Arizona. Field work consumed thirteen days in August and September of this year, and a verbal report was given in September on completion thereof. Information for your file record is presented primarily by the geologic reconnaissance map, and is supplemented briefly by the following.

BASIS FOR THE WORK

As indicated by maps which I presented during our initial conference, a Laramide granitic pluton, intrusive into pre-Cambrian terrain, extends southwesterly from a point 9 miles northeast of Wickenburg, across the Vulture range, and finally disappears beneath aluvium, for a total linear distance of 24 miles. Recurrent centers of mineralization are present along the axis of this linear feature, including the Sheep Mountain and Lane Mountain disseminated (but non-commercial) copper deposits.

I proposed that a reconnaissance be conducted to prospect the extension of this "lineament" southwest through the Big Horn range, where Laramide granite had been reported by a Kaiser geologist. Field work was started on the southwest flank of the Vulture mountains, where mapping by Kaiser Exploration had terminated, and extended into essentially unknown territory in the Big Horn range.

CONCLUSIONS

The lineament, as defined by Laramdie intrusives and minor mineralization, extends southwest across the Big Horn mountains. Copper mineralization, however, becomes progressively weaker from a more intense center a few miles west and south of Wickenburg. The southwestern part of this intrusive zone is essentially "dead" from a copper standpoint, and no leads are recognized which would support further work on the western alluvial covered flank of the Big Horn range.

Although this intrusive lineament could be further prospected by continued work along its projection southwesterly into and perhaps beyond the Eagle Tail mountains, you have indicated that such a program, in your opinion, ranks low in priority compared to other Quintana efforts, and that further reconnaissance is not justified at this time. Unless new information is obtained--of a nature which might place the southwest projection of this particular mineral/intrusive lineament in a different and more favorable light--I would concur in this decision.

DISCUSSION

Pre-Cambrian Geology:

Pre-Cambrian metamorphics consist of Yavapai schist, and of a complex of gneiss and generally fine-grained, but variable-textured granites. The schist lies to the south of the granite-gneiss complex, and the contact between the two units trends southwesterly across both the Vulture and Big Horn mountains. In the Big Horn range, a narrow belt of mafic schist, gneiss, and diorite within the "complex gneiss" unit appears to form a "marker" which parallels the main schist belt to the south.

Coarse-grained pre-Cambrian granite intrudes the gneiss complex, along a northeast trending axis parallel to but north of the schist belt. A large pre-Cambrian granite stock in the Vulture range lies northeast of the reconnaissance map herein presented, but occupies a similar position north of the schist belt, and is exposed on both sides of the cross cutting Laramide granite.

Laramide intrusives:

The large mass of medium-grained, biotite granite, megoscopically identical to the Laramide granites in the Florence-Sacaton region, extends from the area of King Soloman's wash in the Constellation district, northeast of Wickenburg, a distance of 24 miles to the alluvial flank of the southwest Vulture mountains. The contacts of this elongate pluton, which ranges from 1.5-2.5 miles in width, are parallel and remarkably straight. Although Tertiary low-angle gravity faults of significant magnitude displace the granite, dip-slip movement was parallel to the axis of the pluton, and therefore noticeable offsets in the strike of the granite are not present.

In the Big Horn range, Laramide granite reappears on a simple strike projection of the Vulture mass, but here the contacts are more irregular and the intrusive is generally much narrower.

The oldest section of Tertiary volcanics in the Big Horn range appears, with some modification, to correlate to the Vulture range volcanics. As in the Vulture range, the Big Horn volcanic section is also tilted steeply to the northeast. Presumably low-angle gravity faults like those which I have mapped in the Vulture range are also present in the Big Horn mountains, and the dip-slip movement on these faults is probably also parallel to the trend of the Laramide intrusive mass.

The post-granite rotation and faulting, although not affecting the strike outline of the intrusive, presents an outcrop exposure which more closely resembles a pre-rotation cross-section through the granite. With this in mind, the irregular configuration of Laramide granite in the Big Horn range may be interpreted as in part due to nearness of the southwest terminal end of this pluton, where the uniform dimension displayed in the Vulture range have given way to irregular intrusive fingers. The structural control of both the Laramide and pre-Cambrian granitic plutons is obscure. It is noteworthy that they both occupy the same general area, and are parallel to but somewhat north of the schist belt. An apparently separate pre-Cambrian granitic mass lies within the schist belt in the southeast Big Horn mountains.

Quartz monzonite porphyry, as a narrow dike, occurs near the Power Line in the western Vulture mountains, with associated quartz stringers and copper oxides. In the eastern part of the Big Horn range, similar porphyry dikes are found on both north and south Laramide granite contacts, and there are numerous dikes in the basin which drains westward from Little Horn Peak. Although the dikes in the Big Horn range may be texturally classed as typical of the porphyry-copper-type, they are devoid of mineralization.

Tertiary Volcanics:

The oldest volcanic sequence in the Big Horn range consists of Vitrophyre, both glassy and devitrified, and of andesite flows. The base of this sequence is composed of a thin but diagnostic red conglomerate and grit and a thin, yellow, waterlaid tuff. These volcanics are steeply dipping, as is a correlative sequence in the Vulture range.

The western frontal cliffs of the Big Horn range are made of a younger sequence of acid flows and tuffs, which dip moderately west. Flat or low-dipping vesicular basalt and tuff ring the periphyry of the Big Horn and Vulture ranges.

Mineralization:

Middle (?) Tertiary mineralization is represented by gold-quartz veins in Vulture-type volcanics at the U.S. mine and Tonopah-Belmont mines in the Big Horn mountains. The Vulture mine in the Vulture range, and some minor veins in the northwestern Big Horn mountains are probably of this age also. I know of only one Vulture-type gold-quartz vein (a minor unproductive vein) within Laramide granite, north of the Vulture mine and beyond the eastern limit of the attached map. The reasons for this are speculative, but perhaps the pre-Cambrian and Laramide granitic structural loci were unfavorable pathways for post-Laramide mineral solutions, which followed instead channels on the margin of the granitic zone.

Managan ese mineralization is widespread in the northern part of the Big Horn range, and may be as young and the vesicular basalts.

Copper mineralization may be shown, in the Vulture range, to be unquestionably pre-volcanic and largely post-Laramide granite. The mineralization at Wickenburg Peak (and similar but weaker occurences elsewhere near the southern margin of Laramide granite) may be pre-Cambrian, but conclusive proof is lacking. Minor quartz veins with copper oxides occur at numerous localities on the margins and within the Laramide pluton in the Vulture range, and are clearly Laramide. Small seams of copper oxides occur at many points within the Laramide granite, and are sufficiently numerous to constitute a very low grade disseminated oxide mass in two areas just west of Wickenburg. Although these seams do not have an obvious hydrothermal "plumbing system", I have interpreted them as of hydrothermal origin, originating from the oxidation of tiny seams of copper sulphide without pyrite.

The copper "showings" above described are most numerous within a few miles south and west of Wickenburg, and occur with decreasing intensity southwest along the southern margin of the Laramide granite in the Vulture range. This reconnaissance failed to show a lead under alluvial cover on the southwestern margin of the Vulture range, and no mineralized outcrops were found in the alluvial plain beyond the general edge of outcrop. The wide expanse of alluvium precludes a positive statement, but I feel it is unlikely that a major copper deposit is concealed in that area.

In the Big Horn range, copper "shows" are extremely scarce, and generally limited to small oxide seams in or near Laramide granite, on the eastern slope. As described in the foregoing, Laramide granite and porphyry continue across the range, where they disappear beneath alluvium in the basin reintrant which drains west from Little Horn Peak. Copper occurances in this area are quite rare and certainly no leads exist to guide further exploration. Because of the presence of monzonite porphyry, this basin and surrounding areas were covered quite thoroughly.

Respectfully submitted,

Registered Geologist
CERTIFICATE EXPIRES
John E. Kinnison
DEC. 31, 1973
ARIZONA, U.S.A.

John E. Kinnison

JEK/lr

Mining Geologist
Registered: Arizona
California

JOHN E. KINNISON
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85704

Home
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May 30, 1974

J. David Lowell
5211 N. Oracle Road
Tucson, Arizona 85704

Dear Dave:

Drill hole SW-1 penetrated pre-Cambrian granite, unmineralized with the possible exception of rather weak epidote development. The rock is soft and contains much clay alteration--probably due to weathering.

Drill hole SW-2 also penetrated pre-Cambrian granite, very coarse grained and completely fresh.

Hole SW-2 was disappointing, but sufficient room still exists for a covered porphyry copper deposit. The next hole should be located about one mile NE of W-2 on section 20, placing it thus closer to the broad zone of weak mineralization and geochemical anomaly in sections 15 and 21.

Epidote in SW-1 is clearly not related to our target area, but could suggest an altered zone to the south.

Very truly yours,

John E. Kinnison

Registered Geologist
Certificate Expires
John E. Kinnison
Dec. 31, 1974
Arizona, U. S. A.

Attachments: summary drill logs

Sacaton West CAP
Drill Logs

SW-1

0-230 ft.	Alluv. and gravels.
230-340	pre-Ꞓ granite cuttings; fresh.
360-420	Granitic cuttings; some clay; very fine.
420-560	Vy fine granitic cuttings--"sandy" with some clay.

Note: The fine cuttings suggest over-grinding of soft rock, and possible contamination from alluvial section.

Spot Cores: Kaolinized pre-Cambrian granite--alteration probably due to weathering. Weak epidote development.

SW-2

0-130 ft.	Alluvium.
130-450	pre-Ꞓ granite cuttings. 190-220 ft; Gougy. 390-400 ft; Small amount of rusty limonite, probably from oxidation of mafics.

Spot Cores:

224-290 ft.	Coarse pre-Ꞓ gr, fresh. Slight hematite on hair-line fractures.
450-452	Very coarse-grained pre-Ꞓ granite, fresh. Vertical joints.

John E. Kinnison

Registered Geologist
Certificate Expires
John E.
Kinnison
Dec. 31, 1974
Arizona, U. S. A.

Ellsworth Silver No 0111
Cochise Co Ariz

Tuesday Ap 2 1974

Bill Saegart called re Ellsworth prop 9 miles East of Douglas - Wants 1 day exam to determine bulk potential of this Pb-Ag depos.
Geol by John Faik

Owner Earl Ellsworth
364-2220
Douglas

~~cost~~ Best time for call is @ 7 AM or 6 pm

Saw John Faik @ AGS tonite and advised of exam next week.

Ap 3 — picked up reports at Quintana
Saegart advised would be interested in as little as 2 Mill ton Reserve.
but depends on profit potential

Mining Geologist
Registered: Arizona
California

JOHN E. KINNISON
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85704

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(602)327-1888

April 21, 1974

Memorandum for:
W. E. Saegart,
President
Quintana Minerals Corporation
1892 West Grant Road
Tucson, Arizona 85705

Subject: Ellsworth Silver Prospect, Cochise County, Arizona

I examined the subject property on Monday, April 15, concentrating my effort on the so-called "Panther zone" which is shown by John Faick's maps to be the most extensive area of mineralization, and to have the highest Ag:Pb ratio. This area encompasses generally the group of small hills known as Pennywise, Cindy, and Terry Cat.

I conclude that sufficient tonnage cannot be found to be of interest to Quintana.

The mineralization that has been superficially prospected by small open cuts and "pot-holes" consists of short and narrow zones, generally steeply dipping in conformity with sedimentary bedding. The assays listed by Mr. Faick all have come from these thin beds, and are honestly represented to be "selected" samples. My observations suggest that these samples represent only the best hand-sorted ore. My own samples (assays attached) show that unsegregated dumps and the surface material between the diggings contain very little silver. Because lead and silver occur together, there is likewise little potential for development of a lead ore body.

Over the weekend before my examination, Mr. Faick advised me that a deal was brewing with a small Colorado outfit; it seemed possible, however, that it would fall through. I am now told that a short term option has been granted.

John E. Kinnison

Registered Geologist
CERTIFICATE EXPIRES
John E. Kinnison
DEC. 31, 1974
ARIZONA, U.S.A.

Encl.

Samples   Ellsworth Silver

4104- 40 ft diameter area; top of Pennywise Hill

4105 - Slope, east side Pennywise Hill -- including small prospecting holes.

4106 - Cindy Hill, Gosson about 30'x5'. Dumps and surface

4107 - Hillslope float 100' diam. area. 300' E of 4106

4108 - Dump. East side Pennywise Hill - large open cut.

4109 - Dump. Trench at turn off to Pennywise Hill

4110 - Surface south of 4109

4111 - Chip across top of Terry Cat Hill near End lines Panther 1 & 4

4112 - Hand sorted ore piled near turnoff to Pennywise Hill (about 1-2 tons). Carefully sampled.

4113 - Grab from dump at Terry Cat Hill.

John E Kinnison

Registered Geologist
CERTIFICATE EXPIRES
John E.
Kinnison
DEC. 31, 1974
ARIZONA, U. S. A.

1435 SOUTH 10th AVENUE
P.O. BOX 1889

Jacobs Assay Office

Registered Assayers

PHONE 622-0813

85702 Tucson, Arizona, April 18th, 1974

Sample Submitted by Mr. John E Kennison

Sample Marked	GOLD Ozs. per ton ore	GOLD Value per ton ore * $	SILVER Ozs. per ton ore	COPPER Per cent Wet Assay	LEAD Per cent Wet Assay	Per Cent Wet Assay	Per Cent Wet Assay	Per Cent Wet Assay
#4104			0.10					
5			0.15					
6			0.20					
7			0.10					
8			0.05					
9			0.40					
4110			0.10					
11			0.15					
12			2.25					
13			0.55					

REGISTERED ASSAYER
CERTIFICATE EXPIRES
1041
BENJAMIN P. JACOBS
Dec. 31, 1974
ARIZONA U.S.A.

* Gold Figured $ 100.00 per oz. Troy

Charges $ 30.00

Very respectfully,
Ben P. Jacobs

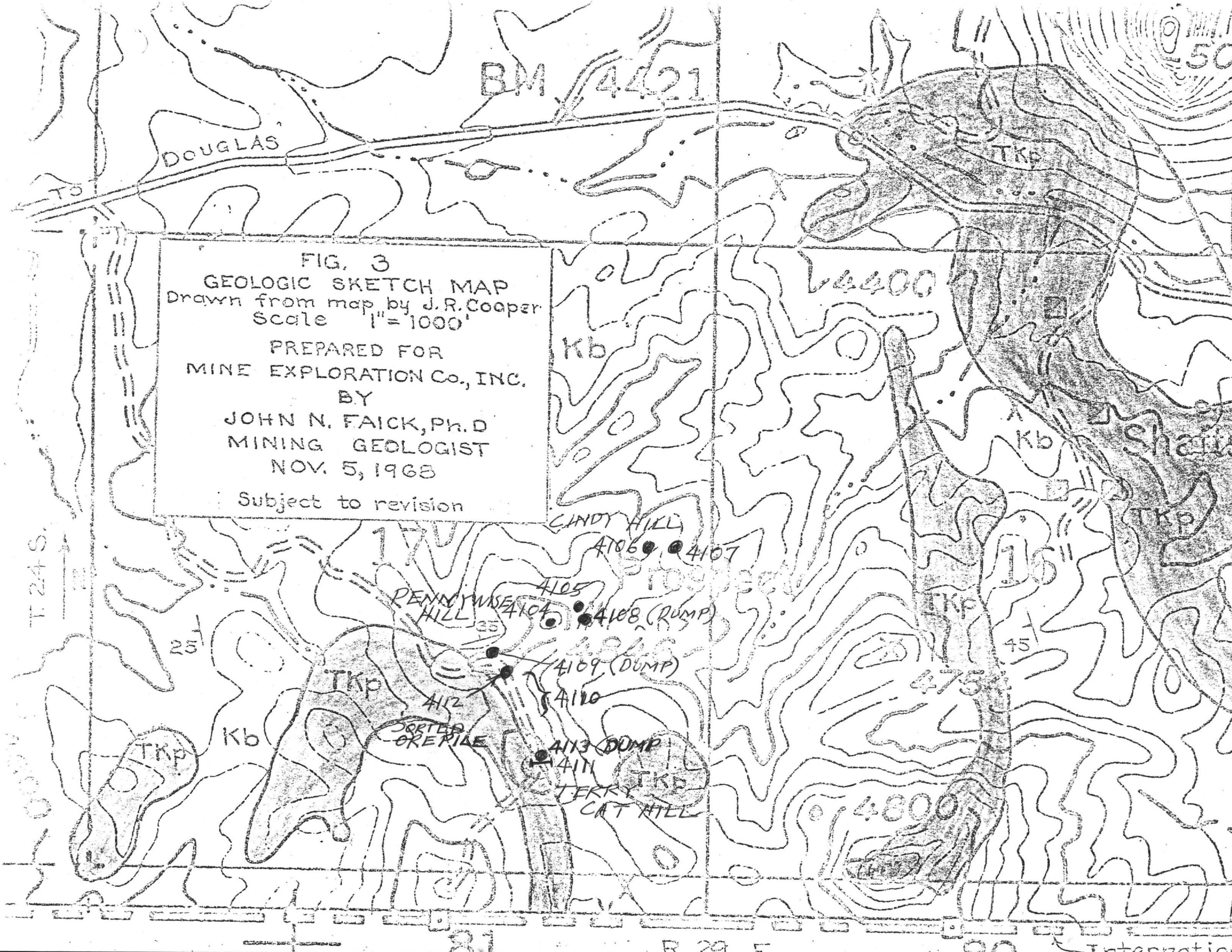

FIG. 3
GEOLOGIC SKETCH MAP
Drawn from map by J. R. Cooper
Scale 1" = 1000'
PREPARED FOR
MINE EXPLORATION Co., INC.
BY
JOHN N. FAICK, Ph. D
MINING GEOLOGIST
NOV. 5, 1968
Subject to revision

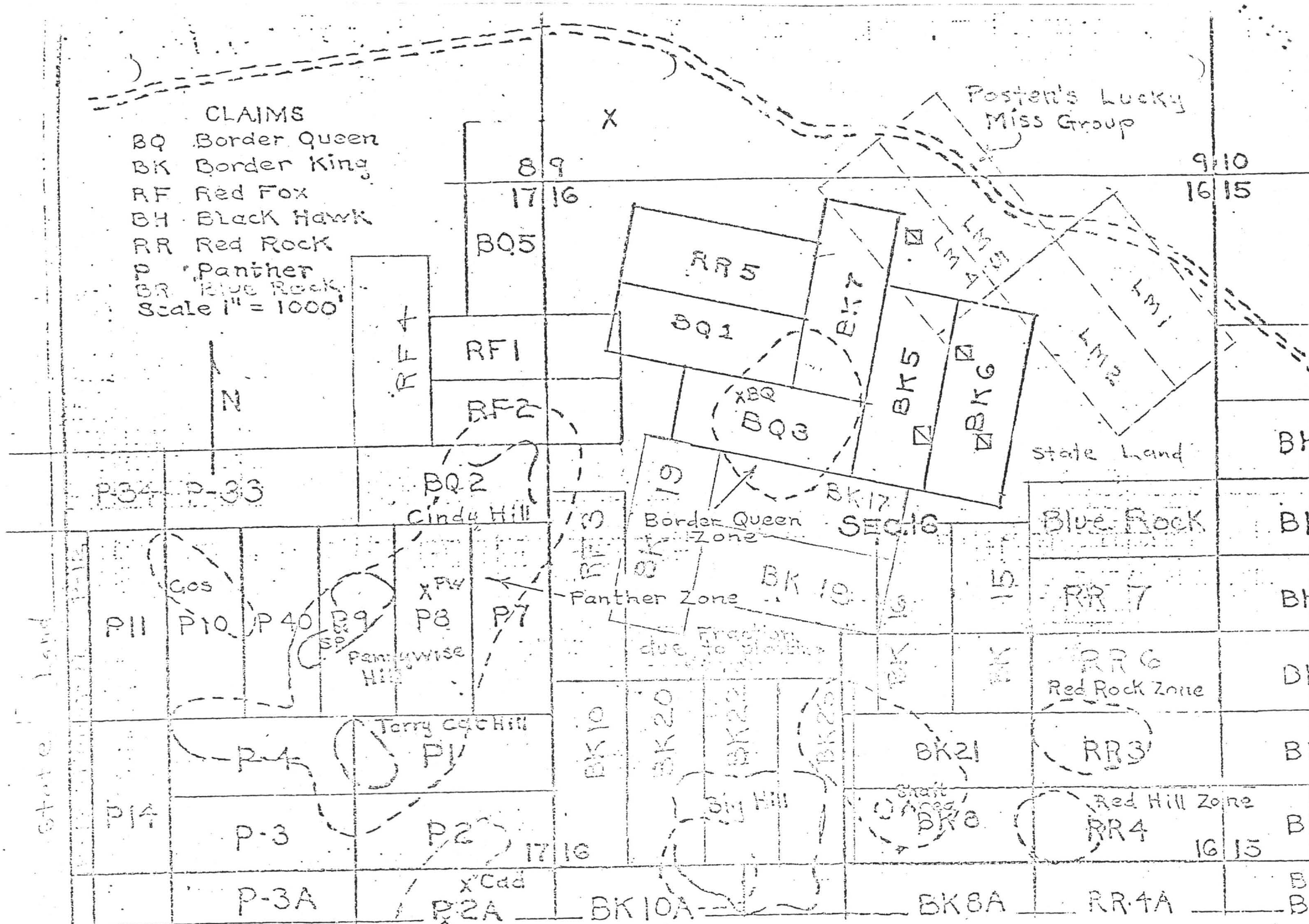

FIG. 2

CLAIM MAP OF SOME OF ELLSWORTH CLAIMS
Subject to revision

BY
JOHN N. FAICK, Ph.D
MINING GEOLOGIST
NOV. 5, 1968

Mining Geologist
Registered: Arizona
California

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85704

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February 6, 1974

Mr. W. L. Kurtz
Manager, Southwestern Exploration Division
American Smelting and Refining Company
1150 N. 7th Avenue
Tucson, Arizona

Subject: Ajo District and Growler Pass, porphyry copper exploration, Pima County, Arizona

Dear Sir:

I have completed a reconnaissance of the geology of the subject area, and have reviewed drill hole information and other data. The following is my report on the geology and the exploration possibilities of the district, including a review of the "basement fault."

INTRODUCTION

On November 16, 1973, a meeting was held between you and me, in company with Mssrs. Sell and Graybeal, to discuss the scope of a preliminary study of exploration potential in the Ajo district.

The general objective was simply to improve upon geologic knowledge of the district, to advance beyond my earlier work--done in 1961--and to provide a "starting point" from which to begin more specific work if such then seemed desirable. The area of examination was to include both the Ajo district proper, and Growler Pass to the south where Laramide granite was known.

Specific points which would be studied were:

1. The postulated "Basement fault:" could its existance be more convincingly confirmed, or should the theory be discarded?

2. Clues to the direction of movement, if the Basement fault was conceptually upheld.

3. The intrusive granitic centers at Growler Pass and in the Ajo district would be examined for possible minor mineralization which might, at this time, be viewed with more interest than during my earlier work.

4. Brief consideration would be given the exotic copper oxides in post-mineral rocks south of the Ajo deposit.

We envisioned the work consisting of a brief field review of all pertinent areas, largely for observation rather than for detailed mapping. All previous drill hole results as reported to Quintana by J. D. Lowell would be evaluated and, If possible, fit into an intelligible district interpretation.

Field work consumed 12 days. A preliminary verbal report was given to James Sell, Fred Graybeal, and Harold Courtright on January 9 of this year and was summarized to you on January 15.

The following is a summary of all my salient findings; I am pleased that the exploration possibilities are favorable. Time will be scheduled at our mutual convenience for verbal presentation of certain details not here given, and for a field tour.

The attached maps were prepared by the Asarco drafting department.

CONCLUSIONS AND RECOMMENDATIONS

In my report to Kenyon Richard of August, 1961, I postulated that there existed in the Ajo district a large, low-angle gravity fault similar to that in the Mission (Pima) district, and that this fault had displaced the Ajo (New Cornelia) ore zone in the upper plate from its former position, or "root," in the footwall. This proposal was based on limited field work, combined with a reinterpretation of structural features mapped by Gilluly (Prof. Paper 206) in the 1930's. This reinterpretation was based primarily on the spatial relationships between the Chico Shuni fault and the outcrop areas of tilted Locomotive fanglomerate (post-ore). These relationships are unchanged and still form a valid basis for a working hypothesis.

That hypothesis is now greatly strenghthened by three new lines of evidence.

1. The composition of part of the Locomotive fanglomerate, which lacks a nearby source for the constituent fragments.

2. Drilling by Quintana and others which shows that basement gneiss lies directly beneath steeply tilted fanglomerate.

3. Subsidiary higher-angle faults, interpreted from field evidence and drill hole data just south of the Ajo Pit.

I now consider that the existance of a district-wide basement fault is substantially proven, and that it undoubtedly passes beneath the Ajo ore zone. As will be suggested later, however, there is considerable question whether or not the fault has cut across and displaced high-grade primary ore such as that which is mined from the New Cornelia pit.

Comparison to other gravity faults suggests that the Ajo "root" area should be to the southwest (a direction at a right angle to tilting); it is in this direction, in the vicinity of Growler Pass some 12 miles distant, that correlative rock units are found. An intrusive granitic center with associated minor copper mineralization is there present, and it seems highly probable that the Ajo "root" is concealed by volcanic or alluvial cover on the margin of the Laramide pluton.

One exploration drill hole was sunk by Phelps Dodge in Growler Pass, 2 miles west of Bates well, and there may be other holes which I have not located. It does not appear, however, that this was an extensive program. Although porphyry was not seen, the granitic intrusive is flanked by minor (but widespread) mineralization on the west, and a program to search for possible major copper deposits which might be concealed on the periphery of the granite is a worthwhile endeavor in itself. Since this area is likely to constitute the Ajo district "root," the justification for an earnest exploration effort is thereby substantially increased.

I would recommend that Asarco give full attention to exploration possibilities in and surrounding Growler Pass, if the problems raised by the land status (Organ Pipe Monument) are not insurmountable.

Other possibilities, which may warrant eventual consideration, are:

1. The exotic copper occurances south of Ajo near the Copper Giant group may be syngenetic--both detrital and chemical in origin. Certainly no connection should be made to water drainage from the Ajo deposit (as I had concluded in my 1961 report.) The source of this copper is to the east, and might be searched for in both the upper plate and in the footwall.

2. There may be potential for deep deposits southwest of the New Cornelia pit, between Arkansas mountain and Cardigan Camp, as a direct extension of the Ajo ore zone. There may be individually held claims in this area, but exploration here would certainly cause a boundary situation with Phelps Dodge.

3. Consideration could be given to prospecting northeast of the Little Ajo Mountain fault, along a projection ENE from the Ajo deposit, for recurrent centers of mineralization.

These latter possibilities are poorly defined at this time, and would require more study to evaluate their worth, and to provide specific recommendations for action.

I regard the exploration potential at Growler Pass quite favorably, and recommend the following steps:

1. The region which lies generally between Bates well on the south and Daniels arroya on the north, and between the limestone ridges east of Growler Pass and the west flank of the Growler Range must be mapped carefully. Special attention should be directed towards locating any small but possibly significant outcrops surrounded by cover volcanics or alluvium, which may have been missed by my rapid reconnaissance. Color aerial photographs with good resolution at 1" to 2000 feet should be obtained by private contract, unless available U-2 enlargements prove satisfactory.

2. Laramide plutons are usually susceptible to rough delineation by magnetics. The region under consideration should be flown by aeromag on N-S lines, spaced one-half mile apart. Elevation should be sufficient to minimize volcanic interferance.

3. I. P. coverage over a 4-mile width surrounding the estimated periphyry of the Laramide granite should be considered.

4. Following geologic mapping and aeromagnetic surveys, widely spaced, blind scout drilling--with or without I. P. coverage--should be carefully considered.

GEOLOGY: GENERAL STATEMENT

The Ajo quadrangle is described in detail by Gilluly, and the geologic map (Att. A) north of latitude 32-15, is essentially his--modified in some critical areas by my mapping and rock correlation. For the purpose of this report, I will assume that all previous reports, including Gillully's, is available to the reader, and that he is familiar with geographic place names. There are, of course, details of interest resulting from my recent observations in the field, but only those features related to the immediate exploration problems will be here discussed. Miscellaneous information not of immediate importance will be given verbally during or preceeding our planned field trip.

SUMMARY OF ROCK UNITS

PRE-ORE

Older Pre-Cambrian Basement:

The Cardigan gneiss and Chico Shuni granite (quartz monzonite) are assigned to the pre-Cambrian on indirect evidence.

The Cardigan gneiss is typically a mafic injection gneiss, with lenses of biotite or chlorite schist, diorite, and aplite. It is intruded by the Chico Shuni granite--a distinctive coarse-grained rock with pink orthoclase phenocrysts, similar in texture to other pre-Cambrian granites such as the Oracle. Southwest of Chico Shuni well a long xenolith, or pendant, of metamorphosed rhyolite ignimbrite and quartzite is engulfed by the Chico Shuni granite. Gilluly's correlation of this pendant with the Paleozoic led him to assign the Chico Shuni granite to the Mesozoic. Such a correlation is improbable, and assignment of this metamorphosed pendant should be either to the pre-Cambrian schists, or to the Mesozoic.

The Chico Shuni granite plays an important role in structural interpretations, later presented, and it would be desirable to know its age with some confidence. An assignment to the pre-Cambrian is tentatively made on the basis of texture, general metamorphism reported by Gilluly from microscopic study, and correlation to granite in Growler Pass which appears to lie beneath Bolsa quartzite.

The Chico Shuni granite, if not definitively pre-Cambrian, certainly pre-dates the intrusive activity of the Laramide era, and should it prove eventually to be Mesozoic, it none the less is "basement" in so far as Laramide activity and mineralization is concerned.

The granite near and southwest of Tule well, although mapped with the Chico Shuni, is medium-grained and texturally different from the Chico Shuni. I did not see the contact with typical Chico Shuni, but the Tule well area granite is probably a separate intrusive--as noted by Gilluly. It is intruded by the Tule Well andesite, whose age is also an unknown.

Paleozoic and Mesozoic:

Bolsa quartzite, and limestone and quartzite of probable Pennsylvanian/Permian age, are present near Growler Pass, and fragments of Paleozoic limestone are present in parts of the Tertiary Locomotive fanglomerate.

Mesozoic volcanics and sediments crop out over a large area west of Bates well, and in a small canyon west of Scarface mountain in Growler Pass. Where I have seen these rocks, they are argillites, arkose, rhyolite porphyry or tuffaceous arkose, and ignimbrite (?).

Correlation with the Oxframe argillite and Papago (Rudolfo) formation seems probable.

The Concentrator volcanics, which are largely similar to the Silver Bell formation, is well described by Gillully. Rhyolite near the Ajo pit is probably correlative to the Cat Mountain rhyolite.

The only presently known outcrop of Concentrator volcanics is the large mass south of Ajo; this formation may be present southwest of Bates well, however, for I have seen only the northern fringe of that area of Mesozoic rocks.

Laramide Intrusives:

On the geologic map (Att. A), I have subdivided the Laramide into three principal groups, in a manner somewhat different from Gilluly. Although all of the Laramide rocks are probably related in time, and all of the granitic plutons are megascopically similar, they occupy different geographic settings, and are therefore treated separately.

The Cornelia quartz monzonite is here restricted to the mass west of Gibson Arroya. This unit was named and described by Gilluly, and has been studied on a "sample grid" basis by Wadsworth. It is a granitic textured pluton typical of the Laramide, with a western quartz diorite border facies. Wadsworth has described several zoned facies within the mass, but his map, based soley on the study of sample points, is of questionable value. I have mapped an area of aplite in the northeast end of the pluton which intrudes and engulfs the medium-grained granitic mass, and this aplite may be correlative to Wadsworth's "core" of "porphyritic micro-quartz monzonite." Also shown, based on distant views and colored areal photographs, is an area of "light colored" Cornelia--possibly representing a zonal change of some type.

East of Gibson Arroya, granites similar to--but more altered than--the Cornelia are mapped as a separate unit, because structural interpretation suggests that these units were not of the same intrusive center originally, and are now close together due to large scale low-angle faulting.

The quartz monzonite porphyry of the Ajo pit intrudes (by inference) the granite, and in the pit itself appears to intrude quartz diorite. I have not found exposures of the granite-porphyry contact, but the two units are "side by side" with no evidence of gradation between the two. Gilluly had considered the porphyry as simply a facies of the granitic rocks, but this seems unlikely. Wadsworth has attempted to correlate the porphyry in the Ajo pit with his "core" of micro-quartz monzonite in the Cornelia quartz monzonite west of the Gibson fault since both contain "corroded" quartz phenocrysts. The phenomena of "corrosion" and so-called resorption embayment is a feature ubiquitous to many porphyries and other fine-grained intrusives, and is not sufficiently diagnostic for purposes of correlation without supplemental evidence.

Granite in Growler Pass is demonstratively intrusive into Paleozoic strata, and is assigned to the Laramide with little hesitation on the basis of textural characteristics. According to Mr. Stathis, who recently traversed this intrusive, it is not zoned.

The age of the Cornelia quartz monzonite, west of Gibson arroya, is assigned on the basis of textural characteristics so common to the Laramide, and its intrusive relationship to the Chico Shuni granite which is older--probably pre-Cambrian but possibly Mesozoic. The granite and porphyry east of Gibson arroya intrude the Concentrator volcanics, and are texturally comparable to Laramide intrusives. Radiometric dates from the Ajo ore deposit are Laramide, and these lend credence to the postulated Laramide Igneous activity.

SUMMARY OF ROCK UNITS

POST-ORE

General Statement:

With the exception of the Tule andesite, described below, all formations in this catagory are demonstrably post-ore. They are structurally divisible into an older series which has been steeply tilted--the Locomotive fanglomerate and Ajo volcanics, and a younger gently dipping series of conglomerate, acid andesites, and basalt flows.

Tule Andesite:

Although this unit now appears to have little or no bearing on exploration in the district, I have spent a modest amount of field time observing it because, in my 1961 reconnaissance, I correlated it with the pre-ore Concentrator volcanics. Gilluly's correlation was to the Sneed andesite, or conceivably the Ajo volcanics.

From recent observations, I conclude that it is not directly correlative with any of the known extrusive formations, but rather is a large intrusive plug--possibly a vent. Near Tule well the andesite, on its southwest edge, splays into a series of west-trending dikes which dip 60° north. On its northwest edge, south of Salt well, it also is a series of dikes. At Tule well the dikes intrude a medium-grained granite, here mapped (with reservation) with the Chico Shuni. The dikes near Salt well intrude typical Chico Shuni granite.

The marginal dikes and central massive andesite are altered, porphyritic andesites of a drab greenish brown color, which, being nonresistant to erosion, occupy a dissected pediment. The feldspars are chalky, and the mafics chloritized; the rocks might be described as pervasively propylitized.

The age is unknown. South of Salt well a hill of Ajo volcanics and Locomotive fanglomerate--probably a detached erosional klippe above the "basement fault"--are surrounded by Tule andesite which intrudes Chico Shuni granite, but which does not cut the Locomotive/Ajo. This suggests that the Tule andesite pre-dates the Ajo basement fault, but outcrops are too poor to be firmly convincing. I am inclined to think that it is a vent for flows equivalent to the Ajo Volcanics, but in fact the Tule andesite could be as old as pre-Cambrian.

So far as can be surmised, the unit has no significance to current exploration proposals.

Locomotive fanglomerate:

This formation, together with the overlying Ajo volcanics, filled a deep post-ore basin of uncertain origin, but which was probably genetically related to structural evolution of the district. It was subsequently tilted and, according to my interpretation, cut by a low-angle fault of major proportions. The stratigraphy of the Locomotive offers not only one of the arguments for the existance of this fault--herin termed the "Ajo basement fault"--but also part of the evidence which points the way toward resolution of direction of movement along this fault.

My reconnaissance has led to division of Gilluly's Locomotive into three principal members: "lower," "west," and "east." Further work might disclose additional mappable units.

The lower unit is clearly in depositional contact against Concentrator volcanics and porphyry in the area south and southwest of the Ajo pit. Deposition was against a steep slope, and the beds pinch out to the west. Fragments are angular, and the unit consists of unsorted mudflows, monolithologic breccias, and large exotic "landslide" blocks. Fragments consist of Concentrator volcanics, Laramide granite, quartzite, and minor porphyry. Some of the fragments are altered and mineralized, and are clearly derived from the Ajo deposit. Paleozoic limestone fragments, although a very minor constituent, are visually conspicuous because of their diagnostic appearance in a setting of otherwise drab igneous rocks. Although limestone occurs also in the two other members, it is clearly more abundant in the lower member. The western part of the lower member contains fragments of Chico Shuni granite, the limits of which are diagrammatically shown on the geologic map.

The west member is very distinctive as a mappable unit. It consists of layered mudflows and subordinate sheet flood gravel--composed almost solely of Chico Shuni granite. The color is red brown due to the color of the Chico Shuni and to hematite cement. Boulders of Chico Shuni granite reach 6 ft. in diameter, and in general the fragments increase in size to the west. One large landslide block of Chico Shuni is mapped on the west edge of outcrop, just east of the Chico Shuni fault. The contact of this member with Cardigan gneiss, in the area west of Cardigan camp, is nowhere clearly exposed, but I interpret it as a complex zone of high angle faults. Although there may have been a component of sedimentary transport either "up" or "down" the dip of the tilted strata, it appears that a dominent component was from the west. Although the west member is in contact with a wide expanse of Cardigan gneiss, both to the west and north, it is noteworthy that gneiss is virtually absent from the unit.

The east member is well layered, and locally well stratified. Both mudflows and sheet flood gravel are present, and in the southeast exposures there are fine-grained, thin-bedded sandy siltstones. The constituent fragments are Laramide granite, quartzite, and Concentrator volcanics. Cardigan gneiss is present in minor quantities. An occasional fragment of Paleozoic limestone is present. The color is gray to brownish, and is never as red-brown as the west member. Monolithologic breccias (as at Bluestone holes "A" and "B") are present in the lower part of the east member, and one porphyry exotic "slab" was reported by Lowell, at Quintana hole G-4.

The most accessible areas of the west member are along and west of the road leading south to the San Antonio silica quarry in the Chico Shuni hills, whereas the east member is well exposed on the Darby well road, east and south of Locomotive rock (Locomotive rock, a prominent landmark, is composed of the east member.) The area centrally between these accesible exposures offers the clue to the relationship between the east and west members, and was widely traversed to determine this relationship. At several points unequivocal exposures show that mudflows of the east and west members are interbedded. The two members must interfinger, and although this relationship was not precisely mapped, it is shown diagrammatically on the geologic map.

The sheet flood gravel of the east member was probably deposited with minimal initial dip, and the thin-bedded silty sandstones near the Copper Giant group were probably in the axis of the basin. Indeed, the suggestion is that the mudflows and sheet flood gravels of the east member were deposited within the basin axis, and also spread to the western edge of the flat portion of the basin, where they interfingered with the somewhat thicker mudflows of the west member. The implication is that the east member had a source to the east, with perhaps some component of transport either "up" or "down" the dip of the now tilted beds.

The thickness of the Locomotive fanglomerate is subject only to estimate. There exists no measured section, and the apparent thickness which approaches 10-12,000 feet is probably due in part to repetition by unrecognized faults. Some component of initial dip may complicate estimates. Certainly, however, it is a thick unit, and must be at least 6,000 feet.

<u>Ajo Volcanics:</u>

These generally nondescript andesite flows and tuffs conformably overlie the Locomotive fanglomerate. The volcanic interval was initiated during Locomotive deposition, as shown by the two narrow lenses of volcanics near Locomotive rock. I have spent insufficient time studying this formation to offer stratigraphic comments--and I am uncertain whether practical subdivisions are to be had. Gilluly estimated the Ajo volcanics to be between 3,500 and 5,000 feet thick, although fault duplication may be incorporated within this apparent thickness.

Younger Volcanics and Conglomerate:

The Daniels conglomerate, best exposed in Daniels arroya on the south slope of the Chico Shuni Hills is, in the Little Ajo mountains, the local base of the younger series of strata. The conglomerate is moderately indurated, and in Daniels arroya contains fragments of Chico Shuni granite derived from outcrops adjacent to the north, and onto which the formation laps. It here consists of nearly flat strata which much resembles Gila conglomerate, although it is doubtless older. It also contains fragments of gneiss, and of various andesites--some of which may be representative of the Sneed andesite.

On Childs mountain, west of Sneed Ranch, a similar conglomerate overlies several hundred feet of acid andesite with a distinctive platy layering, which Gilluly named the Sneed andesite. Near Salt well a white, bedded tuff with biotite crystals underlies the andesite. The base is not exposed, but it probably rests on Locomotive fanglomerate north of Ajo.

To the south, in the Growler Pass area and on Scarface mountain, Acid andesites probably correlative to the Sneed overlie a conglomerate which is surely correlative with the Daniels. This conglomerate, which consists mainly of Laramide granite fragments, dips north with about 10° of initial (?) dip and laps onto Laramide granite bedrock. A lower unit of acid flows underlies the Daniels (?) conglomerate on the bluffs at the south end of the Growler Range, but I have seen these principally through binoculors, and have no details.

It seems that the Daniels conglomerate, therefore, is essentially contemporaneous with the extrusion of acid flows, including the Sneed at the type locality.

On Childs mountain and at Black Mountain, the Childs latite underlies the upper basalt flows which cap several nearby ranges. The Childs latite is a porphyritic andesite--based on megascopic terminology--and is correlative to similar rocks known from widely scattered localities as basalt porphyry (Asarco files), or "Turkey Track andesite" (Cooper and others.) It appears to overlie Daniels conglomerate at Childs mountain, and no fragments of this distinctive porphyry have been found within the Daniels.

The uppermost volcanic flows are Gilluly's Batamote andesite. These are typical dark basalts, usually vesicular, and produce mesa-like ranges with rubbly talus slopes.

The upper series of volcanics, including the Daniels conglomerate, is flat lying in general, although the Sneed at Sneed Ranch dips up to 35°. They are clearly cut by some high-angle faults, as at Black Mountain, but are younger than the tilting and faulting which affects the Locomotive fanglomerate. They are distinctly a cover-sequence for those events which are of most importance to exploration.

NEW CORNELIA (AJO) ORE ZONE

The Ajo ore deposit consists of high-grade primary ore, mostly in porphyry, and to a lesser extent in residual areas of diorite. Early production graded in excess of 1% Cu, with 0.5% Cu cutoff; for the past 30 years the grade of ore has consistently ranged from .8-.9% Cu with a cutoff as low as .35% Cu. A thin chalcocite zone dips steeply south in conformance with the tilted, pre-Locomotive erosion surface. The primary ore in porphyry was capped by a layer of copper oxides, formed largely in place beneath modern topography with little or no migration of copper. The Concentrator volcanics in the ore zone, although pyritizied to some extent, generally are very low-grade.

The original shape of the Ajo deposit, referenced to the surface at the time of formation, is not only difficult to understand, but is equally difficult to describe. The difficulty is of two derivations: first, the deposit is now steeply tilted, and secondly, the original top and bottom are evidently narrow, restricted fracture systems whose location is not adequately mapped--perhaps scarcely recognized as such.

The only published cross sections are by Gilluly, interpreted from drill data available in 1934. Deep drill holes were few at that time, and any interpretation of the area beneath the early pit is subject to considerable chance for error. Although his interpretations at depth seem, on casual inspection, to be largely guesswork, I have made independent interpretations on trial sections, and I am convinced that his cross sections have been thoughtfully prepared, in so far as limitations of drill data will permit. For your convenience I have reproduced his sections in a separate packet. For purposes at hand, I have prepared attachment B to illustrate the shape of the porphyry and its relationship to ore. In its present position, the porphyry in the central pit dips gently southwest, and strikes northwest. On the southwest, however, it narrows and plunges steeply southwest. As portrayed on the cross section of attachment B, the southwest hanging wall is actually a series of small "fingers;" the footwall is more or less smooth. The strikes of hanging wall and footwall, although both NW, converge slightly to the southeast; some of the most continuous high-grade ore is within this constriction. As illustrated by attachment C, mineralogic zones appear to have a northwest elongation, parallel to the porphyry.

Even casual inspection of the porphyry as shown by attachment B suggests that an original vertical axis through the deposit now plunges gently northeast, at right-angles to the steep southwest limb of the porphyry which was originally horizontal or very slightly north-dipping. This limb was thus a flat dike or "sill" with a breached top and regular base. The suboutcrop of this "sill-like" porphyry, rather than being an apex, was simply its erosional exposure on the side of a steep pre-Locomotive ridge. The more gently dipping porphyry in the central pit was then a thick dike dipping 35 or 40° northeast. Counter-clockwise rotation (discussed later) which affected only the area around the mine, when compensated, would produce an original north-northwest strike for this porphyry dike.

A perplexing aspect of the Ajo deposit is its apparent lack of a decently developed "top" or "bottom" on either side of the high-grade primary core. Granted that the Concentrator volcanics--rhyolite near the mine--might be a poor host, a major zone of fractures with some alteration and evidence of mineralization should be seen at a distance from the porphyry, since the surface now is virtually an original cross section of the deposit. This, however, is not obviously the case. To the north, northwest, and northeast the limits of alteration are almost coincident with the pit limits. To the east, the former "bottom" of the ore zone is strongly altered and pyritized (with some evidence of copper), where exposed at the pit limits. Although dumps and plant site cover most of the area east of this exposed mineralization, old maps show no extended area of prospecting in this direction. To the west, mineralization fades abruptly west of Arkansas mountain--the former "top" of the porphyry.

The following suggestion is not given with great conviction, but seems at least possible. Assuming that the original "plumbing system" for the deposit was controlled by steep E to ENE fissures (a commonplace habit in Arizona), the present course of such fissures, allowing for tilting and rotation, should now still be southwesterly. A narrow zone of minor prospect pits in Concentrator volcanics does, in fact, extend about S-70-W through Arkansas peak and onto the south slope of Pinnacle peak. Perhaps this constricted zone is all there is of the former upward extension of the Ajo ore deposit--which formed only in the porphyry for reasons unexplained.

The outline above given would permit ore to continue, theoretically along the downward projection of the steeply dipping southwest "limb" of porphyry so far as the porphyry itself extended. It is therefore possible that such a downward extension of ore (actually a strike projection with reference to the original position of the ore deposit) might be truncated by the basement fault. It also follows that deep drilling between Arkansas Peak and Cardigan Camp, positioned over lean-looking outcrops or Locomotive fanglomerate, is not totally fruitless.

The actual "root" of the deposit, under the above theory, would now plunge east beneath the plant site, and would surely be truncated and displaced by the basement fault, although ore is not known from that area. Indeed, nothing is known of exploration to the east, and Phelps Dodge would not be likely to announce ore beneath the dumps and plant until development was eminent.

THE BASEMENT FAULT

Introduction:

Gilluly's interpretation of the district geology was predicated on rotational motion adjacent to high-angle faults now exposed within a few miles of the Ajo deposit. Briefly, he envisioned the following history.

1. The depositional lower contact of the Locomotive fanglomerate south of the pit was believed to extend westerly past Cardigan Camp, over an erosion surface there carved on gneiss, to a point north of North Ajo peak, where it was cut off by the Chico Shuni fault. The Gibson fault--since it seemed to have little effect on the trace of this surface--was thought to be pre-Locomotive and thus to have no part in post-Locomotive structural history.

2. The footwall block of the Little Ajo mountain fault was rotated southerly, and produced the steep dips now seen in the Locomotive fanglomerate.

3. The Locomotive fanglomerate not only wedged out westerly, but also (by implication) wedged out on the south--near the Chico Shuni fault--by an abrupt mountainous front which in its present position lies down dip.

4. The Chico Shuni fault (mapped to extend just east of north along the west side of North Ajo peak) was a hinge fault which died out a little to the north of North Ajo peak, but had a throw measured in thousands of feet further south.

5. The detached remnants of Locomotive fanglomerate and Ajo volcanics, on a spur extending west from North Ajo peak, were deposited against an originally steep northerly dipping mountain slope cut on Cardigan gneiss--the southern limits of the basin in that area.

Discussion of Gilluly's Interpretation:

The rotational motion and hinge action outlined above, by themselves, are hardly a compelling theory, though one may argue that surely they are at least possible.

Gilluly's interpretation has, however, <u>one</u> distinct advantage: the Ajo ore deposit, which is located adjacent to the Cornelia quartz monzonite, is thereby allowed to have approximitely the same spatial position when initially formed: the Gibson fault--post-ore but pre-Locomotive, displaced the ore deposit downward from its original position as a cupola above the main mass of quartz monzonite. Since Gilluly's work, the Ajo deposit has become a classic example of an ore deposit associated with an apically truncated stock.

The alternative theory here presented requires that the Ajo ore deposit was displaced for miles on a low-angle gravity fault, yet by chance came to rest adjacent to the Cornelia stock. Since the odds against this are obviously high, the merits of a genetic association of the Ajo ore deposit with the Cornelia stock will be briefly examined.

Arguments for genetic correlation are:

1. The granitic stock (Cornelia quartz monzonite) west of the Gibson fault is megascopically similar to the granite east of the Gibson fault, and was thus correlated by Gilluly. The east mass is intruded by porphyry and mineralized.

2. The main granitic mass west of the Gibson fault has a western diorite border facies. The granite east of the Gibson fault is bounded, also on the west, by a similar diorite.

3. Thus two similar intrusives are more or less "side by side" across the Gibson fault. The Ajo deposit adjoins the east mass.

Of these three arguments, only the last--the "spatial association"--really carries weight, since most Laramide granitic plutons in Arizona have similar compositional and textural features, and some have dioritic margins.

However, the argument of spatial association really boils down to a passive assumption: "What else do you expect?" Faced with a viable alternative, this argument must be abandoned, and the alternative evaluated on its own merits.

Although it is improbable (a matter of statistics) that <u>one</u> Laramide granite and an ore deposit would be displaced for a great distance along a gravity fault, yet stop adjacent to a <u>second</u> Laramide granite stock, this is unquestionably possible. On the other hand, when I question Gilluly's interpretation of movement on the Chico Shuni fault, and problems raised by the whole question of tilting in relationship to the Little Ajo mountain fault, I do so because the <u>mechanism</u> seems insufficient.

<u>Discussion of the Ajo Basement Fault:</u>

The primary clue to existance of the basement fault consists of two erosional remnants of Locomotive fanglomerate and Ajo volcanics, resting on Cardigan gneiss on a small spur which extends westerly from North Ajo peak (Att. A). The Locomotive fanglomerate and Ajo volcanics dip about 60° southwest, yet the contact of these strata with the underlying Cardigan gneiss can be traced around the rim of the outcrop at about the same elevation. The contact beneath the westernmost exposure completely encircles the base of the tilted strata, which dip in places almost vertically. It seems doubtful that this is a depositional contact; furthermore, the gneiss is somewhat sheared and laced with chlorite for a short distance beneath the contact, and I found one exposure of gouge and breccia in a small gully on the north side. I interpret these exposures to represent a low-angle fault--the Ajo basement fault--along which the Locomotive/Ajo have been brought in contact with a footwall of Cardigan gneiss.

The composition of the west member of the Locomotive fanglomerate furnishes evidence which requires that the Ajo basement fault exists. The alternative to the basement fault must hypothesize that a steep mountain slope formed the original southern limit of the Locomotive in the vicinity of North Ajo peak; west of the Chico Shuni fault the Locomotive rests on this surface as detached remnants, whereas to the east the surface was rotated down and has been reached by the present level of erosion only along the Locomotive-Cardigan contact between North Ajo peak and Cardigan Camp. The composition of the Locomotive should reflect the composition of this postulated mountain slope, as well as the basement west of Cardigan Camp.

In actual fact, the Locomotive composition is foreign to the postulated depositional slopes. Between Cardigan Camp and North Ajo peak the Locomotive west member is composed almost entirely of Chico Shuni granite, yet it is in contact with Cardigan gneiss in this interval. The detached erosional remnants west of the Chico Shuni fault are also the west member, but are in contact (along Gilluly's mountain slope) with gneiss. A brief inspection of the geologic map reveals that, in the area from whence the fragments in the west member might have been derived, the only bedrock would have been Cardigan gneiss--which is virtually absent from that member.

The answer, of course, is that these contacts are not depositional, but rather that the Locomotive fanglomerate has been moved along the Ajo basement fault to its present position over a terrain solidly dominated by Cardigan gneiss. Its original location was in a basin carved on Chico Shuni granite, which supplied the constituent fragments to the west member.

The detached remnants of Locomotive west of the Chico Shuni fault are klippen. The basement fault has been dropped down on the east, and the wide expanse of tilted Locomotive/Ajo strata has not been dissected by the present level of erosion. No hinge motion on the Chico Shuni fault is required. The total displacement on the Chico Shuni fault is unknown, though it could be greater than the 800-1000 feet calculated from assumptions based on the 400-500 foot horizontal throw measured on the base of the Ajo volcanics. There are many possible structural relationships which might exist between North Ajo peak and Quintana hole G-5, four miles to the southeast, which failed to reach the basement fault at its total depth of 2613 feet.

Cardigan gneiss in the footwall of the basement fault has been penetrated by a number of drill holes south of Darby well, near Black mountain (Atts. A and D). Quintana G-1 and G-7 suggest that the fault dips northerly. Quintana G-2 is interpreted to be in a slightly down-faulted area relative to G-1. Quintana G-3 and the nearby Homestake holes all penetrated Cardigan gneiss in a structurally high fault block, beneath shallow Locomotive fanglomerate. According to Loghry, Phelps Dodge "5," one mile north of Locomotive Rock, may have penetrated gneiss, as there is a large quantity of muscovite in the cuttings.

Rotation along two faults south of the Ajo pit support the general hypothesis of the basement fault, and suggest northerly direction of movement. Drilling south of the pit intersected bedrock at more shallow depths than would be predicted from the steep dips of the Locomotive-bedrock contact. In this same area the strike of the fanglomerate is more westerly than the general average of N 50° W. Part of the strike is doubtless due to initial dip in the beds near the bedrock contact, thus reflecting the steep pre-Locomotive surface. However, I suggest that much of the strike deviation is caused by rotation on two principal faults, shown on Att. A to extend easterly from an exposed fault block of Concentrator volcanic one-half mile east of Cardigan Camp. These faults are shown in cross-section on Att. D.

The block of Concentrator volcanics at Cardigan Camp is a landslide block within the Locomotive fanglomerate. The larger block to the east, however, is bounded on the north by a visible fault. American Metals 1 and Knox 3 penetrated this fault above Concentrator volcanics, whereas A-3 is positioned so that it drilled through the fault and then penetrated the Locomotive-volcanic contact. To the east, the Bluestone holes seem to require that the fault splits into two strands, as shown. Further east still, PD-4 apparently penetrated the "American Metals" block, whereas PD-1 and A-2 to the north penetrated the "Bluestone" block. Cross-section would show that the displacements are greatest between the bedrock outcrop and A-2/PD-1, and between A-2 and PD-4; and intermediate along the cross section shown (Att. D) through Bluestone 1 and A-6. The least displacement occurs near the fault outcrop to the west. Thus, in addition to down dip displacement, these faults produced counterclockwise rotation, which may account for about 20° of strike deviation in this area. South of the southern fault strand, the fanglomerate maintains a uniform northwest strike.

I interpret these faults to be associated normal faults in the upper plate, which probably merge into the basement fault. I have mapped similar faults in the Vulture range, where movement and rotation could be pinpointed by stratigraphic relationships. Since movement on these subsidiary faults compliments movement on the main fault, movement on the Ajo basement fault would have had a northerly component.

Faults which displace the Basement Fault:

The Chico Shuni fault has been discussed in the foregoing. I have modified the trace of this fault, as shown on Att. A, from Gilluly's map, by utilizing oblique viewing techniques on color U-2 photographs. The major trace of the fault can be easily followed north across the Cornelia quartz monzonite, but does not displace the Daniels conglomerate on its southerly extension. The strand mapped by Gilluly just west of North Ajo peak dies out, or terminates, a short distance to the north as he had indicated.

Since the Cardigan gneiss is apparently continuous from the klippen west of North Ajo peak to its contact with the Cornelia quartz monzonite, it follows that the mountains west of Gibson arroya are also in the footwall of the basement fault.

The Gibson fault has dropped the basement fault down on its east side, so that the upper plate is in contact with the footwall on the west side. The Gibson and Chico Shuni faults are essentially en echelon, and are bridged by a westerly trending zone of faults with diverse strikes between Cardigan Camp and North Ajo peak.

The Little Ajo mountain fault apparently truncates the Gibson fault, and is probably a major range front fault. The Black mountain fault is post-basalt, but its relationship to the Little Ajo mountain fault is not known.

Location of the "Root":

The direction of movement on the basement fault may be inferred by comparison to others which have been studied. The gravity faults in the Pima district (Mission) and the Vulture range, as well as the San Manuel fault, offer comparative examples. The fault blocks in each of these areas moved down dip; rotation of post-ore strata took place about an axis at a right angle to the dip, so that motion is down dip towards the direction of dip in the tilted strata. If this rule is applied to the Ajo district, the Ajo "root" must be to the southwest.

The west member of the Locomotive fanglomerate requires a basin comprised primarily of Chico Shuni granite. Such a source exists largely southwest or south of Chico Shuni well. Although the area between Daniels arroya and the west edge of Growler Pass is covered by alluvium and post-ore formations, the Chico Shuni granite may extend as a large mass to the base of the Bolsa quartzite in Growler Pass.

Mesozoic rocks exposed in and north of Growler Pass provide a general correlation with the Concentrator volcanics at Ajo, and Laramide granites are present in both areas. Limestone, found as fragments in the lower member of the Locomotive, is also aresent at Growler Pass.

In short, all rocks which should provide a "match" between the Ajo district and its proposed "root" area do so; the theoretical direction of motion deduced from the tilted Locomotive strata is compatable.

The Laramide granite in Growler Pass, although not a direct lead, is an intrusive center of interest. Scattered copper oxides in the Paleozoic (?) conglomerate west of Bates well, and weak alteration and limonite derived from pyrite in the Mesozoic outcrop west of Scarface mountain attest to mineralization on the west flank of this intrusive.

The origin of the deep mid-Tertiary sedimentary and volcanic basins, and the mechanism of subsequent gravity faults, is poorly understood at this time. The two occur together so frequently in Arizona, however, that a relationship may be inferred. Possible mechanisms, evolved from my interpretation of similar features in the Vulture range, suggest that a general uplift of these basins was ruptured by faults which began as steeply dipping structures, but which flattened with depth. Rotation took place on the regionally concave fault surface, and continued uplift maintained the fault movement. The trailing edge of the tilted blocks should eventually produce a dip-slope basin which would, in theory, be filled by non-rotated conglomerate. The Daniels conglomerate, between Daniels arroya and Scarface mountain, may occupy such a basin.

Very truly yours,

John E. Kinnison