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

Yuma Cty, Harquahala Dist, Socorro Mine

in Canada, the nickel copper
mines, but thus far in vain,
matte being refined in the

l imported and entered for
ted States in 1901 was 117,-
at $1,847,166, as compared
of nickel matte, etc., valued
The amount of nickel pro-
re imported into the United
pounds, worth between five
. There was a decided in-
n of nickel from New Cale-
he price of nickel oxide has
ver per pound than the metal,
has been sold at $2.20 a
dustry is increasing rapidly,
so, a decided increase in the
n the United States. The ex-
and matte from the United
769,655 pounds, as compared
in 1900.
alt oxide imported into the
was 71,969 pounds, valued at
with 54,073 pounds, valued at
he United States refines the
ckel matte produced at the
ly the United States exported
5,869,655 pounds in 1901, or
as exported in 1900.
ickel in Canada in 1901 was

---

a lecture on liquid air de-
é Internationale des Elec-
cted in London *Engineering*,
ed a large number of inter-
d at extremely low tempera-
fic heat of air, which at or-
constant at 0.21, increases
peratures are combined with
00° C. and 10 atmospheres
eat becomes .2585, and at 75
nd the same temperature it is
calculations as to the power
d-air machines it is unsafe to
t of air as a constant. Ozone
epared by electric discharges
ow temperature, and liquefies
being -118°C. At the tempera-
quid ozone is perfectly stable,
t it deteriorates on the least
rful explosive now known, M.
mixture of liquid ozone and
eing endothermic bodies—that
rated by their decomposition.
petroleums, separated out by
at low temperatures are, M.
ectly fluid at -190° C., can be
e construction of low temper-
The latent heat of liquid air
be 65 calories, the determin-
e simplest manner by placing
ning liquid air on a recording
he rate of evaporation. Im-
ent lamp in the liquid and
, the rate of evaporation was
urrent being measured it was
nount of energy expended in
evaporated in a given time.
r referred to his method of
n from coal gas by a system
n at low temperatures. This
ery economical where large
re required.

D COAL IN LOCOMO-
recently made on the Rio
& Pacific Railroad in Mexico,
Beaumont and coal from
e shown that from 3.4 to 3.5
ere equivalent to 1 short ton
ices the cost of the equivalent
d on the road is only from 45
of coal.

GOLD DEPOSITS OF ARIZONA.

By Joseph Hyde Pratt.

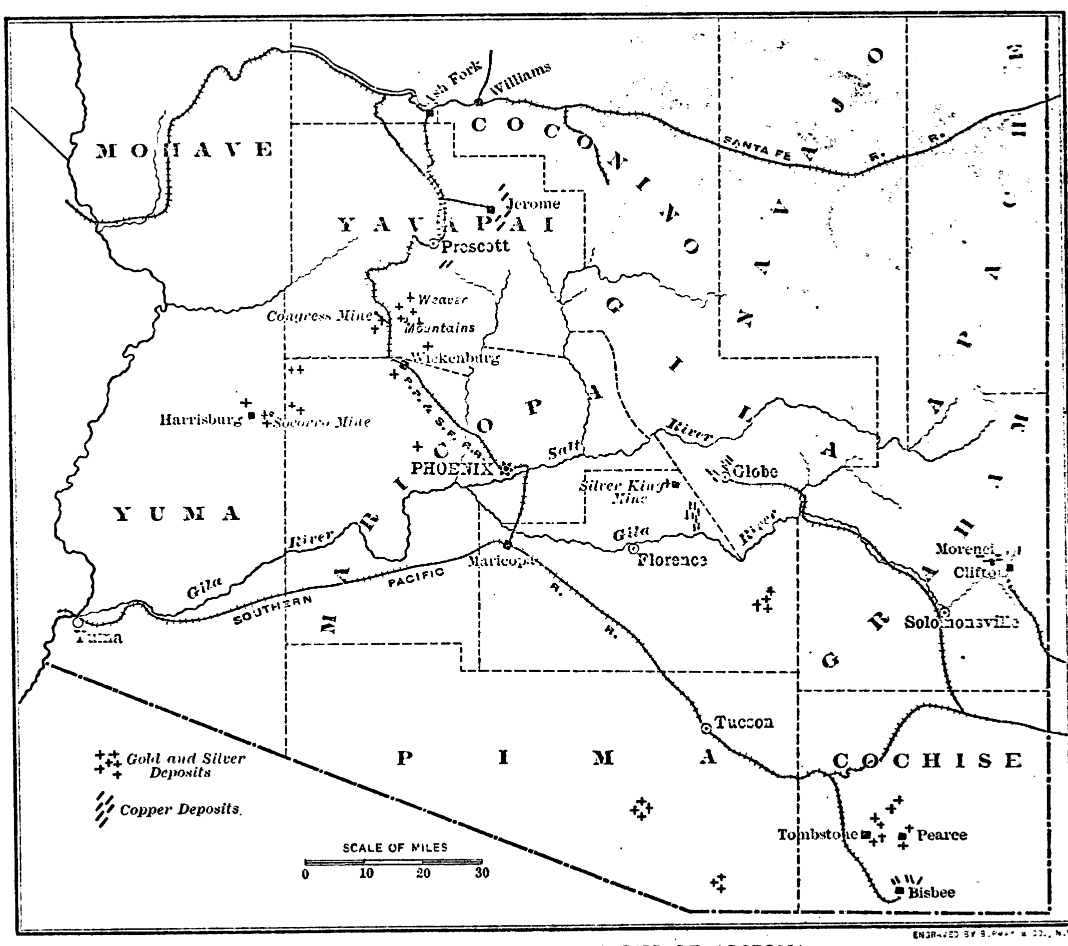
In The Engineering and Mining Journal of January 4, 1902, under the heading of "Gold and Silver in 1900," the following statement is made: "The attempt to reopen some of the old mines of Arizona while successful in some cases, has been a failure in others, and the territory remains about where it was a year ago so far as gold production is concerned."

This statement is true so far as the actual production of gold and silver bullion is concerned; but it is far from being the case when the actual condition of the gold mining industry in Arizona is considered. There has been in the past year a very decided and encouraging advance in the development of gold mining properties, and at the end of 1902 the results will be apparent in the increased production of gold from this Territory. There has been, and is still, a great deal of wildcat speculation in the gold mining properties of the Territory, and in a number of cases supposed gold mining properties have been bought and companies incorporated to handle them where the property was known to have little or no value. These methods are, however, now considerably over-balanced by the development of gold properties on a sound and substantial basis.

Extending across the Territory from the southeast toward the northwest is an extensive formation of carboniferous limestone with which a great series of ore deposits are directly or indirectly associated. The principal rocks underlying this limestone formation are granites and gneisses. Other sedimentary rocks, that are found associated with the limestone, are sandstone (which has in many places been entirely metamorphosed into quartzite) and conglomerate. Cutting these sedimentary rocks are large masses of porphyritic rock, quartz porphyry, trachyte, and dikes of diorite.

It is in this mineral belt that the large deposits of copper have been found. The principal gold mines are found in four distinct districts: One is in the southeastern part of the Territory in Cochise County in the vicinity of Tombstone. The principal mine of this district is perhaps the old Pearce near the town of the same name, and now known as the Commonwealth Mine. Another district is in the vicinity of Tucson, where the mines occur thirty miles north and south of that city. Still another is known as the Weaver Mountain Mining District, and it might be well to include in this the mines that are found extending almost continuously in a slightly southwest direction from the Weaver Mountains to the Vulture Mountains. In this district would be included the celebrated Congress Mine, the recently opened Octave, and the Vulture. Forty miles to the west of this district is the Harqua Halla Mountain District which includes the parallel range known as the Harcuvar Mountains. In this district are located the noted Harqua Halla Mines which give prominence to this section, now the scene of active mining and prospecting.

There are a number of other places throughout the Territory where gold has been found, but there is little systematic mining now being done for gold or silver in them with the exception perhaps of the Silver King Mine which is located in the northeastern part of Pinal County and which has been one of the noted producers of the Territory. In many of the copper producing districts more or less gold is found.

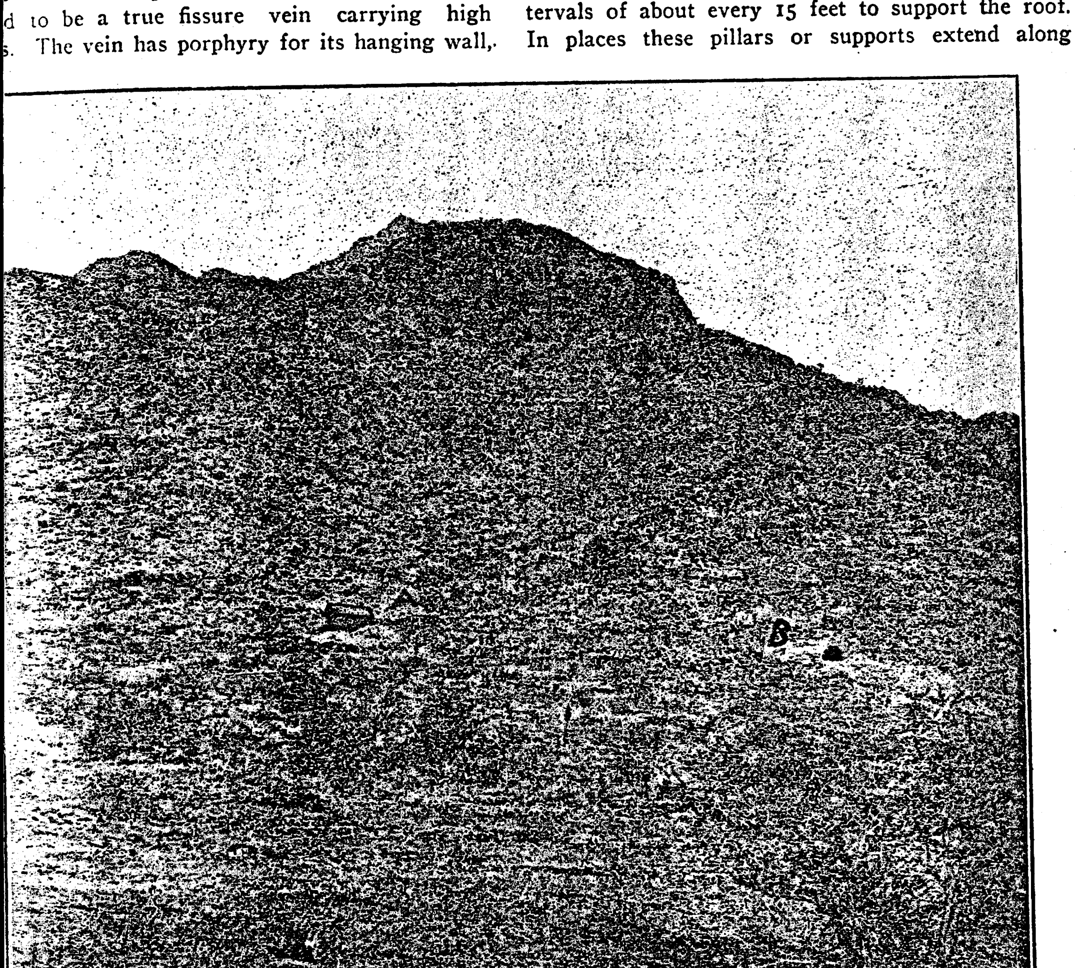


MAP OF GOLD PRODUCING REGIONS OF ARIZONA.

In all the districts referred to there is a great deal of activity and strong companies are obtaining control of mines and claims with the intention of developing them and, if possible, making producers of them. The Weaver Mountain and Harqua Halla Mountain districts, which were recently visited by the writer, were showing up some good properties and both gave promise of developing into regular producers of gold.

The accompanying figure gives a general idea of the location of the gold deposits in these districts.

One noticeable feature of the veins in the Weaver Mountain and Harqua Halla Mountain districts was their regularity and their constant dip at a sharp angle. Many of them are true fissure veins in granite or porphyry. An interesting mine visited is the Socorro, which is owned by the Socorro Gold Company, of Hartford, Conn. This mine is located in Yuma County on the southwestern slopes of the Harqua Halla Mountains about 40 miles in a straight line southwest of Wyckenburg which is on the Santa Fe, Prescott and Phoenix Railroad, and about 3½ miles a little south of east of Harrisburg. The property consists of eight full claims, the general location of which are indicated on the accompanying figure.



A. Shaft. B. Mill Site.
SOCORRO GOLD COMPANY'S PROPERTY, YUMA COUNTY, ARIZONA.

geology of this immediate vicinity is somewhat x. The main country rock or mass of the ains is a granite which is overlain with the ntary rocks, limestone and quartzite, whose are dipping at sharp angles. A mass of por- was observed on the Henry Clay and Los s claims, but its exact extent could not be de- ed. The quartzite was observed between this yry and the limestone. While the most of the etween the porphyry and the limestone is a ite, there was one band or dike that was very tly a quartz porphyry.

mineral vein has only been encountered on enry Clay claim and it was discovered by ac- The alluvial deposits were being treated for gold contents and as these were removed a vein was exposed. On investigating this it d to be a true fissure vein carrying high s. The vein has porphyry for its hanging wall, as far as could be judged, porphyry is also the wall; but nothing solid was encountered so it could not be accurately determined what the wall was. The vein is very uniform in its which is 24° 30' toward the north, and it has this dip to the 250-foot level, which is as far as ould be examined. It has a general N.E.-S.W. ke. As far as could be determined there is no cropping of the vein on the surface, the only e where it has been exposed being at the scene he placer working.

he vein is practically perfect in its development, the whole distance along its dip of 250 feet, and he length of 160 feet along its strike at the var- s places at which it has been cut and exposed by s of shafts and stopes, it has held its uniform of 24° 30'. Its width varies from 18 to 36 inches would average 28 inches. Wherever the vein een exposed, it has on both sides a clay (kao- d material) selvage, which varies from ½ inch inches in thickness. This is a true fissure vein, although it could not be examined to a depth of feet, yet its uniformity in this distance and its eral geological location all point to the con- sion that it will reach to a great depth.

he development work that has been done on this perty has all been on the Henry Clay claim with exception of course of the work that was re- quired in the locating of the other claims. All of this work was done a number of years ago, ore that was taken out having been hauled by wagon to a stamp mill located at Harrisburg. The main work consists of an inclined shaft that has been sunk on the vein, following its dip for about 250 feet. At the present time the shaft can only be examined to the 244-foot level as water is encountered at this depth; but, judging from the appearance of the bottom of the shaft and from information that could be obtained, the shaft does not extend more than 6 or 8 feet farther. The vein is just as strong at this 244-foot level as at any other point along this distance. To the 150-foot level the ore has been more or less thoroughly taken out by means of drifts and stopes for a distance of 30 to 40 feet on each side of the shaft. Pillars of ore have been left at intervals of about every 15 feet to support the roof. In places these pillars or supports extend along the strike of the vein so that there is no opening from one stope to another. Here and there, where the sulphides apparently predominated, large blocks of ore have been left. The present company has widened the old shaft and thoroughly timbered it to the 150-foot level, making a shaft with an inside clear measurement of 5 by 8 feet and sufficiently wide for a double track.

Nearly 80 feet directly east of the mouth of this shaft is another inclined shaft which has been sunk following the dip of the vein. It can be examined for a depth of 53 feet, but beyond this it has been filled up with waste material taken from the stopes and its exact depth is unknown. At the 38-foot level a stope can be entered which extends for 20 feet on the vein towards the southwest. The other stopes were so filled up with waste material that they could not be entered. The vein here has been worked in a manner similar to that in the other shaft, by drifting and stoping from each side of the shaft. How far that has been continued to the northeast of the shaft is not known as no stopes or drifts could be entered in that direction. The vein wherever observed in this shaft and stope was as regular as that observed in the other.

There is a favorable location for the erection of a stamp mill on a spur of the mountain and a little to the east of south of the shaft as shown in Fig. 1. The mill can be built upon a solid rock foundatio and will have plenty of room for the disposal of tai ings. Below the mill site there is a flat lev stretch on the edge of the gulch which is conve iently located for the erection of the cyanide pla for the treatment of the concentrates. A 20-stam mill is now in course of erection and as soon as th is completed the cyanide plant will be built. A su ficient supply of water for the stamp mill, cyani plant and camp is obtained from a well in the va ley about 1½ miles east of Harrisburg and 16,0 feet from the mine. This valley or ravine is t drainage for a large section of this mountaino country and there is a strong flow of undergrou water which is reached by wells from 28 to 30 fe in depth. The water is conveyed from the well two large tanks of 50,000 gallons capacity ea which are located on a slope of the mountain abo the mill.

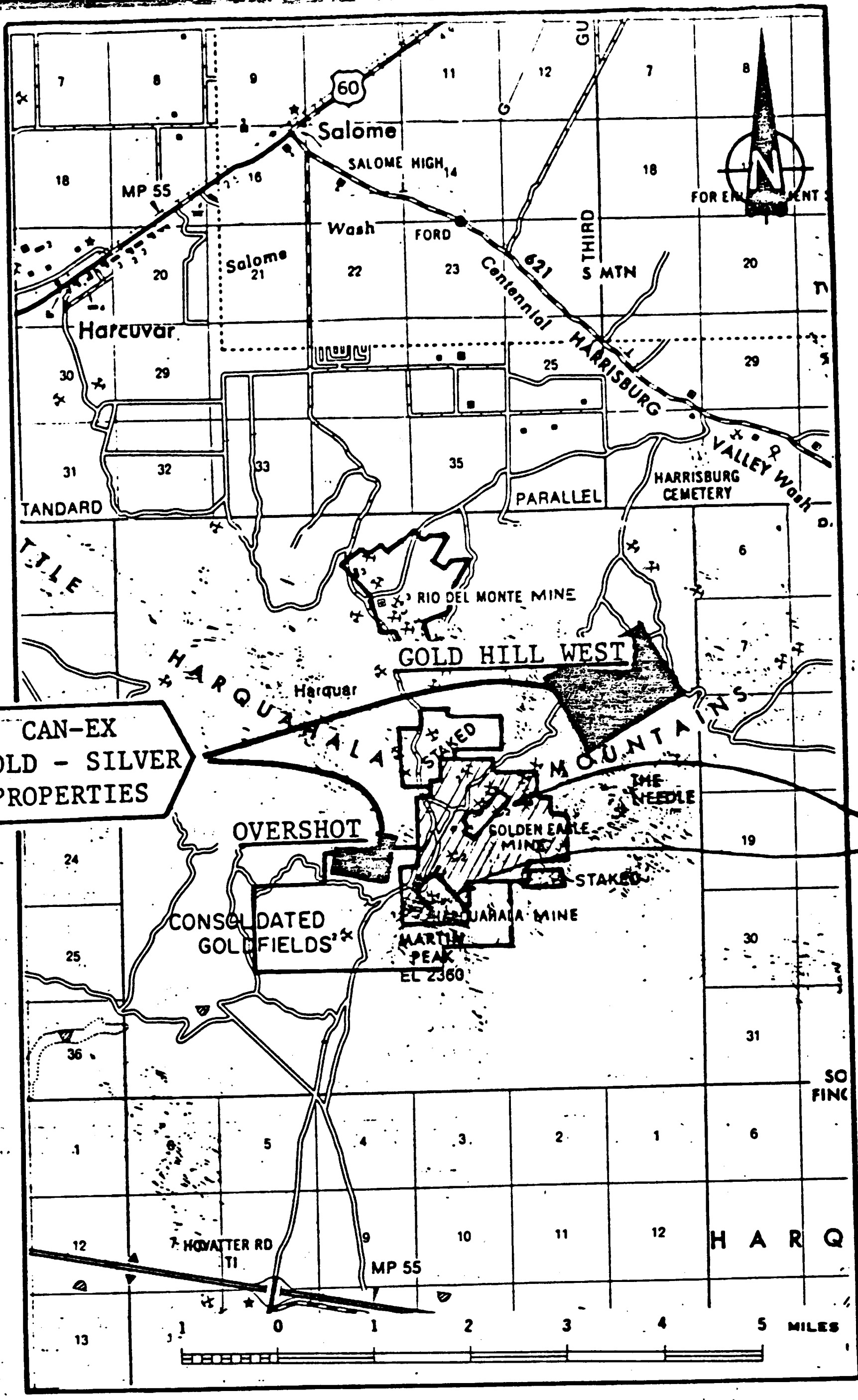
Assays that were made from the ore from t vein show it to be one that will probably carry the average at least $20.00 per ton. Many of t bunches of sulphides that were assayed show values from $100 to $150 per ton.

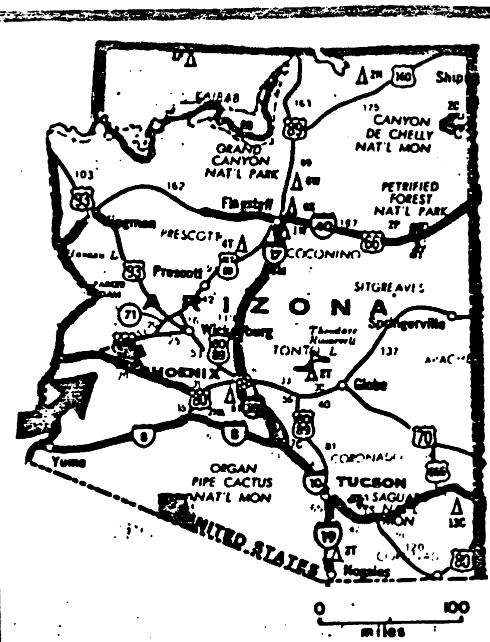
Since the Socorro Gold Company began active o eration in this section there has been a great deal prospecting carried on and a number of other pr erties opened up, so that although the district from 40 to 60 miles from the railroad, there is general air of progress and activity in the vicini

FLUORSPAR.

Fluorspar, or fluorite, is generally found in ve in limestones, sandstones, mica slate, clay slate, a gneiss. Although widely distributed, this mine has been found in commercial quantities in but f localities in the United States. Until 1898 the o source of fluorspar in the United States was mines in Hardin and Polk counties, Southern I nois. The same general geological formation tends over to Western Kentucky, and in 1898 posits of fluorspar were discovered around Sal Livingston County, and Marion, Crittenden Cou Ky. A small amount of fluorspar is also obtai from Caldwell County, Ky. In a number of ca by-products are obtained, as galena, which is sa by the Rosiclaire Lead and Fluorspar Company, largest operators of the mines in Illinois, and zinc carbonate, obtained by the Chicago Min Company from their mines in the vicinity of Mar Crittenden County, Ky. The Kentucky Fluors Company, the Fluorspar Company, and the W ern Fluorspar Company have opened mines in C tenden County, Ky., and are now producers of mineral. The Eagle Fluorspar Company is ducing from deposits in both Crittenden and ingston counties, Ky. Fluorspar deposits have cently been discovered in Smith, Wilson, and Tr dale counties, Tenn.; and the Tennessee Fluor & Mining Company has been incorporated to w deposits near Bellwood, Smith County. In the cinity of Dome, Yuma County, Ariz., fluorspar curs abundantly. If the demand for the use fluorspar for smelting purposes increases, there be a market for these Arizona deposits. Form the chief use of fluorspar was in the preparatio hydrofluoric acid, but only a small amount is used for this purpose.

The use of fluorspar in the manufacture of op cent glass is increasing. By far the greatest us fluorspar is as a flux for iron, in which use many vantages are claimed for it and it is rapidly super ing limestone. Fluorspar can be used to advan probably, in copper smelting and in reducing other metals. The total production of fluorspa 1901 was 19,586 short tons, valued at $113,80 compared with 18,450 tons, valued at $94,500 in The average price per ton reported for the duct of 1901 was $5, the same as in The amount of the ground fluorspar sold in was 3,700 tons, valued at $34,100, as compared 3,000 tons, valued at $17,000 in 1900—an increa 700 tons in amount, but of $17,100 in value, th crease being due to the low price of ground f





Total Recorded and
Estimated Production
200,000 oz. GOLD
100,000 oz. SILVER

CAN-EX RESOURCES LTD.

WEST-CENTRAL ARIZONA GOLD PROJECT

OVERSHOT and GOLD HILL WEST Properties

CAN-EX RESOURCES LTD.

ARIZONA GOLD-SILVER PROJECT - READY FOR DRILL TESTING

Initial surface sampling, VLF-EM surveying and geological mapping have been completed on the Overshot property, of Can-Ex Resources Ltd, located 80 miles west-northwest of Phoenix, Arizona. Interest in the property was generated by a small outcrop with alteration and structural features similar to the Harquahala Mine, which is adjacent to the Overshot property. The Harquahala Mine has produced an estimated 200,000 oz. of gold plus 180,000 oz. of silver.

Assay values from surface sampling ranged up to 0.26 oz.gold per ton and 1.9 oz. silver per ton. These were contained in an area anomalous in lead, zinc, copper and arsenic, which situation also exists at the Harquahala Mine. VLF-EM surveying and geological mapping show this area to be at a strong structural intersection with a stockwork of quartz veins.

Some shallow percussion drill holes have been put down to test the extent and direction of the geochemical anomaly with encouraging results.

On the Gold Hill West property, located a couple of miles northeast of the Harquahala Mine, on the same geologic trend, two veins have been mapped and sampled. In underground workings a narrow high grade quartz vein contained in a wider sheared zone yielded assays as 1.76 oz.gold per ton. A stoped area below these samples has not yet been sampled. On a ridge above the underground workings, and within a limestome formation, a fracture system has been traced for 300 feet. It parallels the underground vein and is intermittently mineralized with jasperoid and gold-silver minerals. Two samples averaged 0.15 oz.gold per ton and 2.5 oz.silver per ton. A third area 300 ft. north of these two veins has been explored by a small adit. A sample of selected dump material assayed 0.24 oz.gold per ton. It is intended to drill the area of the two veins to test for high grade ore at depth and for low grade ore in the limestone and between the two veins.

PERRY PROPERTIES

James R. Perry

Member, American Institute
of Certified Planners
M.S., Urban Planning

The Financial Center, Suite 1300
3443 N. Central Avenue
Phoenix, Arizona 85012
(602) 274-7653

MEMORANDUM

TO: Gold Mining Companies
Acquisition/ Exploration Officers

FROM: James R. Perry, M.S., AICP
President and Designated Broker
Perry Properties, Inc.

DATE: February 4, 1988

The former General Partner in the Rio del Monte claims group in southwestern Arizona recently died.

The mineral rights including the real estate in fee are now for sale exclusively through Perry Properties, Inc.

A brief description and map is attached herewith.

We highly recommend that you look closely at this gold mining opportunity!

If you would like to see the geology report and/or the property, or have questions or comments, please respond.

Thank you for your business.

Precious Metals Exploration Venture
Super Prospect for Speculative Investment
GOLD PROPERTY!
Rio del Monte Mines

Description:

1. Twenty patented claims and approximately 392 acres, in fee, covering the outcrops of a number of gold-silver bearing quartz veins discovered around 1890.
2. "The quartz veins containing the gold mineralization are entirely within the patented claim group."
3. "The property has produced gold and silver-bearing ores and concentrates."
4. The mines are near the Harquahala and Gold Eagle mines, "which produced over $50,000,000 in gold at today's prices."
5. Once owned by U.S.Senator Ridgeway (prior to 1900).
6. "The Rio del Monte is one of the few remaining unexplored gold-silver deposits in southern Arizona... In my opinion the Rio del Monte is a gold-silver deposit which merits further exploration." "The proven past production, fee simple ownership of both the surface and mineral estate, and the proximity of both rail and truck transportation make the Rio del Monte patented claims a good speculative gold-silver prospect." (all above from: Ted H. Edye, Registered Geologist, Arizona "A Geological Investigation of the Rio del Monte patented claim group near Salome Yuma County Arizona" (1982).

Location:

1. A block of 20 patented lode claims whose boundaries are defined by Mineral Survey 1738 (available from BLM).
2. The claims cover portions of Sections 3,4,9, and 10, T4N R13W. Depicted on Hope Quadrangle (USGS).
3. The property is in La Paz County, near the north end of the Little Harquahala Mountains, south of the town of Salome.
4. The property is reached from Salome on U.S. 60 and the Santa Fe Railroad over 4.5 miles of County - maintained gravel road. It may also be reached from the south over about 10 miles of county - maintained gravel road from the Hovatter Road exit on Interstate 10.

Price:

$785,000

For More Information Contact:

James R. Perry,
Exclusive Listing Agent
Perry Properties, Inc.
3443 N. Central Ave., Ste. 1300
Phoenix, AZ 85012
(602) 274-7653

Above information is subject to errors and ommissions and has been provided by the owner or consulting geologists, and no guarantee is made or implied. A geologic investigation has been made and is available to principals. Courtesy to brokers.

PRELIMINARY REPORT ON THE STRUCTURE AND STRATIGRAPHY OF THE SOUTHERN LITTLE HARQUAHALA MOUNTAINS, YUMA COUNTY, ARIZONA

Stephen M. Richard
Department of Geosciences
University of Arizona
Tucson, Arizona 85721

ABSTRACT

Precambrian through Tertiary rocks in the southern Little Harquahala Mountains record a complex history of Mesozoic and Tertiary deformation. Precambrian quartz monzonite is overlain by: 1) about 1000 m of Paleozoic strata correlated with the Bolsa, Abrigo, Martin, Redwall, Supai, Coconino and Kaibab Formations; 2) up to 1000 m of Mesozoic dacitic to rhyolitic volcanic and volcaniclastic rock; 3) at least 750 m of Mesozoic lithofeldspathic sandstone, conglomerate and siltstone. Probable high-angle faulting prior to deposition of the Mesozoic sandstone is indicated by rapid facies changes, massive conglomerate and basal onlap onto older units to the southeast. Subsequently, the strata were folded into a large southeast-vergent fold limb. This fold was refolded about steep axes trending N-NE. In Late Cretaceous time the deformed rocks were thrust over Mesozoic clastic, volcaniclastic and volcanic rocks along the Hercules thrust. Mesozoic strata below the Hercules thrust are lithologically and stratigraphically different from Mesozoic strata above the fault. Mesozoic structures are strongly overprinted by Tertiary(?) NW-dipping, moderate to low-angle, normal-separation faults and associated northerly trending faults. The youngest structures are north- to northwest-trending, near-vertical oblique- or strike-slip faults with an associated northeast-dipping normal fault. One of the near-vertical faults cuts poorly indurated east-dipping Tertiary(?) gravel.

INTRODUCTION

The Little Harquahala Mountains are located within the Basin and Range province in west central Arizona. Access to the area is excellent, either by the Hovatter Road, which connects Salome with I-10 through the western edge of the study area, or by the Buckeye-Salome Road through the northeast edge of the area (Fig. 1).

The Little Harquahala Mountains occupy an area of overlapping Mesozoic and mid-Tertiary tectonism. The purpose of this project is to determine the structural geometry of Paleozoic rocks in the Little Harquahala Mountains in an attempt to define the kinematics of Mesozoic and Tertiary deformation in the area. To this end, a geologic map of the southern part of the range was made. The base map used was a 1:12,000 enlargement of part of the Hope, Arizona 15' series U.S.G.S. quadrangle (1961). This paper contains descriptions and preliminary interpretations of the rocks and structures of the Little Harquahala Mountains. A more complete discussion will be presented in a forthcoming circular to be published by the Arizona Bureau of Mines and Mineral Technology.

GENERAL GEOLOGY

Precambrian quartz monzonite in the central part of the range is overlain by a highly faulted northeast-trending, steeply dipping cratonic Palezoic section. Depositionally above the Paleozoic rocks are Mesozoic volcanic and volcaniclastic rocks and Mesozoic lithofeldspathic sandstones. On the south, the sedimentary rocks overlie an assemblage of altered crystalline rocks of uncertain age along the complex steep to low-angle Sore Fingers fault zone (Fig. 2). On the north, the Precambrian quartz monzonite structurally overlies Mesozoic clastic, volcaniclastic and volcanic rocks informally known as the Harquar section. The lower plate Mesozoic rocks are lithologically and stratigraphically different from Mesozoic rocks in the upper plate. The Harquar section is intruded in the northern part of the range by the Granite Wash Granodiorite, dated at 65 m.y. (Damon, 1968) and 69 m.y. (Eberly and Stanley, 1978). Along the western edge of the range, southwest-dipping volcanic rocks of probably Miocene age overlie the Harquar section. The range is structurally bounded on the northeast by an inferred northwest-trending oblique-slip fault in the vicinity of Centennial Wash. A complete summary of the regional geology of west central Arizona is presented by Reynolds (1980, and this volume).

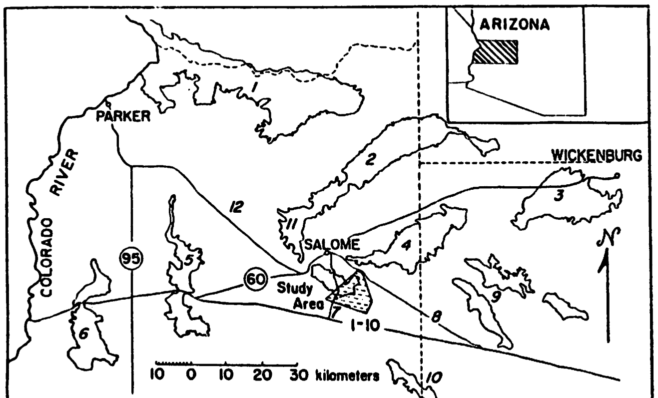


Figure 1. Location map showing study area and points referred to in text, numbered as follows: (1) Buckskin Mtns.; (2) Harcuvar Mtns.; (3) Vulture Mtns.; (4) Harquahala Mtns.; (5) Plomosa Mtns.; (6) Dome Rock Mtns.; (7) Hovatter Road; (8) Buckeye-Salome Rd.; (9) Big Horn Mtns.; (10) Eagle Tail Mtns.; (11) Granite Wash Mtns.; (12) Ranegras Plain.

STRATIGRAPHY

The Little Harquahala Mountains contain rock units ranging in age from Precambrian to Tertiary. The pre-Cenozoic stratigraphic column includes approximately 1000 m of Paleozoic rocks, a highly variable thickness of Mesozoic volcanic and volcaniclastic rocks up to 900 m thick and Mesozoic lithofeldspathic sandstones with a maximum exposed thickness of 750 m. For lithologic descriptions of the Paleozoic and Mesozoic section in the central part of the area, see the accompanying stratigraphic column (Fig. 4). In addition, a variety of igneous and metamorphic rocks of uncertain age are exposed in the Sore Fingers area, and Precambrian quartz monzonite and amphibolite gneiss underlie the Paleozoic section. The rock units are divided into five major groups reflecting the geologic development of the area. These are: 1) Precambrian basement consisting of intrusive and metamorphic rocks; 2) Paleozoic cratonic sediments; 3) Mesozoic continental deposits; 4) the Sore Fingers Complex; and 5) Cenozoic deposits which are only briefly described. Thicknesses of rock units were determined using measurements from the geologic map.

Precambrian Rocks

Granitic rocks occupying the northeast boundary of the map area are depositionally overlain by the Bolsa Quartzite and thus are known to be of Precambrian age. North of Martin Peak, gneissic rocks intruded by this granite crop out over a small area and are also considered Precambrian.

Quartz monzonite underlying the Bolsa Quartzite is ubiquitously altered in the vicinity of the unconformity to an assemblage of light green argillized or epidotized feldspar set in a red stained argillic groundmass with abundant quartz eyes. Sericite and epidote are common. In less intensely altered zones, further from the unconformity, the quartz monzonite consists of a medium-grained quartz, plagioclase and minor biotite groundmass with 1-3 cm potassium feldspar phenocrysts. Some of the alteration at the contact may be due to pre-Bolsa weathering, but the presence of similar alteration within the Bolsa requires post-Paleozoic chemical changes as well. The contact between the Bolsa and quartz monzonite commonly is faulted.

Amphibolite gneisses consisting of medium-grained hornblende and plagioclase crystals occur at the northwest edge of the map area above the Hercules thrust (Fig. 2). Near-vertical, northeast-trending foliation in these gneisses is characteristic of early proterozoic gneisses in west central Arizona (Reynolds, 1980). This foliation is disrupted and folded within 10-15 m of the Hercules thrust.

Paleozoic Rocks

A cratonic Paleozoic section overlies the Precambrian basement in the Little Harquahala Mountains. The stratigraphy of these rocks resembles the southeast Arizona Paleozoic section in its lower part and the Grand Canyon section in its upper part. Miller (1970) described a similar section in the southern Plomosa Mountains and noted its resemblance to the section in the Little Harquahala Mountains. He recognized the Bolsa, Abrigo, Martin, Escabrosa, Supai, Coconino and Kaibab Formations. Varga (1977) reported an essentially identical section in the western Harquahala Mountains, except the Abrigo and Martin Formations are apparently absent due to a bedding plane fault. Varga (1977) favored correlation of the carbonate unit below the Supai with the Redwall Limestone instead of the Escabrosa Limestone. In the absence of definitive evidence for either correlation, I have chosen to continue Varga's usage. Except for this change, Miller's (1970) correlations are used in this report.

The Kaibab Formation in the Little Harquahala Mountains is unique in western Arizona. Miller (1970) and Varga (1977) described strata resembling units 1 and 2 of this report, but units 3, 4 and 5 are absent in all other sections described in west central Arizona. Quartz-chert sandstone and conglomerate at the top of unit 5 are probably Mesozoic but are too thin and poorly exposed to map separately.

Mesozoic Rocks

Two distinct Mesozoic sequences are present in the Little Harquahala Mountains--the Harquar section and the southern Little Harquahala section. Formal nomenclature for these rocks is lacking. A Mesozoic age is inferred from stratigraphic position above Paleozoic rocks and involvement in late Cretaceous deformation (see Tectonic Interpretations).

The Harquar section includes volcanic and sedimentary rocks lying below the Hercules thrust. These were not studied in detail. Within the area mapped, porphyritic andesite flows overlie lithic sandstone, siltstone and conglomerate. The section is distinguished from the southern Little Harquahala section by the more intermediate composition of the volcanic rocks, the greater abundance of conglomerate and the predominance of volcanic clasts in the conglomerate.

The southern Little Harquahala section is described in the stratigraphic column (Fig. 4). Conglomerates and rapid facies changes at the base of the lithofeldspathic sandstone unit indicate a period of deformation and erosion prior to deposition of the sandstone. The contact between the sandstone and underlying volcaniclasts is conformable along a northeast-trending zone southeast of the Needle. In this area the volcaniclastic rocks fine upward into a shale horizon overlain by the sandstones. To the south, a rapid facies change occurs, possibly involving telescoping of facies on hidden faults, and the base of the section becomes conglomeratic. The volcanic and volcaniclastic units apparently pinch out, and in the Limestone Hills (Fig. 2), a massive limestone conglomerate overlies Paleozoic rocks at the base of the sandstones. The contact there is sheared and is interpreted to be a minor fault. Thinning of the volcanic unit, coarsening of the basal sandstone section and overlap onto Paleozoic rocks are indicative of uplift in the southern part of the area during or after deposition of the volcanics and before deposition of the Mesozoic sandstones.

Sore Fingers Crystalline Complex

The Sore Fingers crystalline complex is an informal name assigned to an assemblage of intrusive and metamorphic rocks in the southern part of the map area. The complex is named after two low hills in the southernmost Little Harquahala Mountains called the Sore Fingers on the Hope 15' quadrangle. The complex is bounded by faults on the northwest, southwest and northeast and covered by alluvium on the southeast. The age of the complex is uncertain but is probably Precambrian and Mesozoic.

The most abundant lithology in the Sore Fingers complex is a quartz monzonite porphyry. Equant to slightly elongate light flesh-pink potassium feldspar phenocrysts up to 8 cm long occur in a groundmass of 1-5 mm quartz, plagioclase and altered biotite. This rock has yielded a minimum age of 140 m.y. (K-Ar, biotite, Rehrig and Reynolds, 1980). Slight alteration is concentrated along joints throughout the intrusion but is locally intense and extensive, converting large areas of quartz monzonite to a dense black siliceous alteration product in which 1-3 mm quartz eyes and 3-5 mm white feldspar "spots" are all that is left of the original texture. Silicification

Compare to gneiss devel. in other core complexes

Figure 2

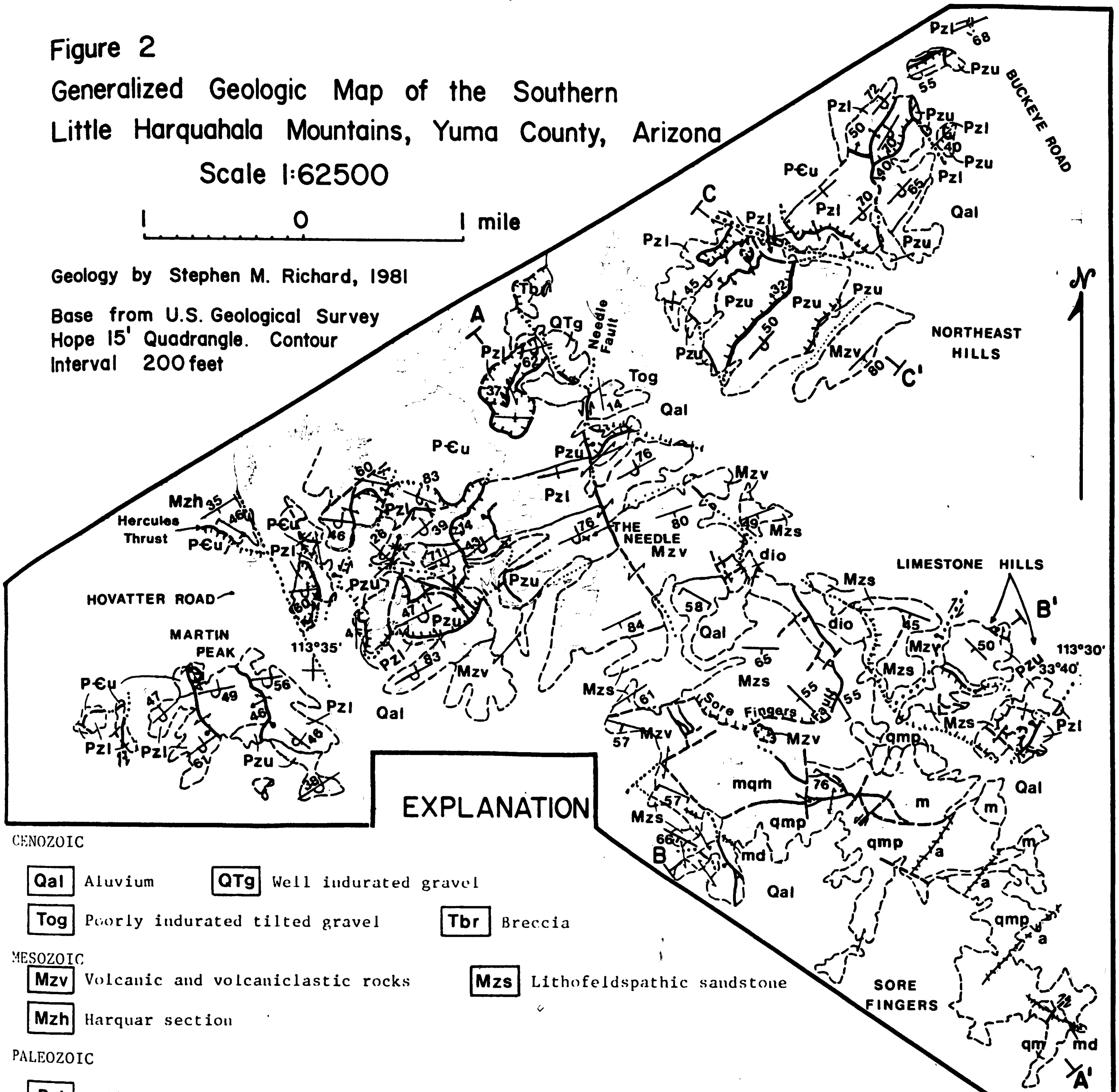
Generalized Geologic Map of the Southern Little Harquahala Mountains, Yuma County, Arizona

Scale 1:62500

1 0 1 mile

Geology by Stephen M. Richard, 1981

Base from U.S. Geological Survey Hope 15' Quadrangle. Contour Interval 200 feet



EXPLANATION

CENOZOIC

- **Qal** Aluvium
- **QTg** Well indurated gravel
- **Tog** Poorly indurated tilted gravel
- **Tbr** Breccia

MESOZOIC

- **Mzv** Volcanic and volcaniclastic rocks
- **Mzs** Lithofeldspathic sandstone
- **Mzh** Harquar section

PALEOZOIC

- **Pzl** Bolsa through Supai formations, undivided
- **Pzu** Coconino and Kaibab formations

PRECAMBRIAN

- **P€u** Quartz monzonite

PRECAMBRIAN OR MESOZOIC SORE FINGERS COMPLEX

- **qmp** Quartz monzonite porphyry
- **mqm** Metamorphosed and altered quartz monzonite
- **dio** Diorite
- **m** Metamorphic rocks
- **qm** Slightly prophyritic quartz monzonite

DIKES **md** Microdiorite **a** Aplite

Contacts- definite, approximate, inferred or concealed

Faults- with dip, ball on downthrown side, arrows show relative motion, barbs on upper plate. 20

Attitudes of bedding- inclined, vertical, overturned 30 60

Cleavage- inclined 20

Folds- Axial trace of anticline, syncline, overturned syncline

1982

and biotitization seem to be the major effects of the alteration. The porphyritic quartz monzonite is intruded by a diorite or quartz diorite in the northeast part of the complex and by a number of small bodies of equigranular quartz monzonite, only one of which is shown on the geologic map (Fig. 2). In the northern part of the complex, the porphyritic quartz monzonite is in both gradational and fault contact with slightly metamorphosed and altered porphyritic granite. This unit is characterized by red staining, zones with weak crystalloblastic foliation, slightly rounded pink-red feldspar phenocrysts and abundant quartz veins. Foliation attitudes are not consistent over the area; the fabric seems to be a very local phenomenon.

The porphyritic quartz monzonite is intruded into an extremely heterogeneous assemblage of meta-igneous and meta-sedimentary rocks. Contacts, where not faulted, are gradational, with interleaving of various lithologies, and locally appear migmatitic. Porphyritic quartz monzonite, variably altered or foliated with gradational contacts, is a widespread component of the metamorphic terrane. These relations suggest that the quartz monzonite may be derived, at least in part, from partial melting of the metamorphic rocks. The metamorphic rocks are generally quartzo-feldspathic with minor biotite, altered to chlorite and muscovite. Strong alteration obscures contact relationships everywhere. Pods and lenses of black microdiorite are common. Foliation is locally strong but generally is weakly developed and irregular.

TERTIARY ROCKS

Tertiary rock units include a breccia and two overlying gravels. The breccia occurs in a northwest-trending zone north of the Needle which is believed to be a northeast-dipping low-angle fault zone. It is underlain by Paleozoic rocks east of the Needle fault (Fig. 2) and by Precambrian quartz monzonite to the west. The breccia is composed of crushed Paleozoic clasts ranging from brecciated blocks several meters long to angular pebbles. The rock is strongly cemented by calcite or silica. East of the Needle fault, a poorly indurated gravel overlies the breccia, dipping 15° to the east. Near the fault, the gravel contains boulders of Supai Formation up to 1 m in diameter along with clasts of other Paleozoic lithologies and Precambrian quartz monzonite; it becomes finer grained up-section away from the fault. West of the Needle fault, the breccia and Precambrian quartz monzonite are overlain by an untilted well-indurated gravel composed of Paleozoic clasts up to about 40 cm in diameter.

STRUCTURE

Six deformation events are recognized in the southern Little Harquahala Mountains. From oldest to youngest they are: 1) probably high-angle faulting before deposition of the Mesozoic lithofeldspathic sandstone; 2) large-scale south- to southeast-vergent folding; 3) refolding of earlier folds about steep north-northeast plunging axes; 4) thrust faulting; 5) northeast-trending, moderate- to low-angle normal faulting with associated high- and low-angle faults; 6) north- to northwest-trending strike- or oblique-slip faulting with an associated northwest-trending low-angle normal fault. These structures will be described in chronologic order.

Onlap of Mesozoic clastic rocks across a thin Mesozoic volcanic sequence and across a major northeast-trending fault in the Limestone Hills (Fig. 2) suggests that the fault was related to uplift of Paleozoic rocks, which were a source for clasts in the basal part of the clastic sequence. At the very least, major movement on the largest northeast-trending fault in the Limestone Hills predates shearing along the base of the clastic unit.

The early large-scale fold is apparent in the general decrease in dip of strata from vertical and overturned beds in the northeast- to moderately south-dipping beds in the south. The axis of this fold is subhorizontal and trends east-northeast. Southeast vergence is indicated by northwest-dipping overturned beds and by extrapolation from the western Harquahala Mountains.

The second folding event is evident in the change from northeast to southeast strike on Martin Peak and south of the Needle (Fig. 2). Antiformal synclines and synformal anticlines in the highly faulted area east of Martin Peak are also believed to be related to this event. Axes are moderately northeast-plunging to vertical but are difficult to determine because of the earlier folding event.

The Hercules thrust places Precambrian quartz monzonite on Mesozoic volcanic and clastic rocks of the Harquar section north of the Paleozoic outcrop belt. The fault dips gently to the southwest. Foliation in gneissic rocks above the fault is folded, and a northwest-trending southwest-dipping cleavage is strongly developed in clastic rocks below the fault.

Cleavage with a similar orientation and character is present in Mesozoic sandstone south of the Needle, in rocks along the northwest-trending steep faults bounding the Sore Fingers complex, along the fault bounding the klippe of volcanic rock lying on the Sore Fingers Complex and along a fault within the Sore Fingers Complex. As cleavage is not folded and is not axial planar to folds, its development evidently postdated the folding.

Northeast-striking, northwest-dipping, low-angle normal-separation faults cut Paleozoic and Mesozoic rocks (Figs. 2,3). Dips of the faults vary from 0 to 40°. Major faults of this type placed a large klippe of Paleozoic rocks on Precambrian quartz monzonite north of the Needle, extended the Paleozoic section in the area between the Needle and Martin Peak and in the Northeast Hills and juxtaposed Mesozoic and crystalline rocks along the Sore Fingers fault. Northwest- to north-striking, east-dipping steep to low-angle faults are associated with the normal-separation faults. They are characterized by strongly brecciated fault zones. Northwest-dipping normal-separation faults in general cannot be correlated across these structures, indicating that they may act as tear faults.

The youngest structures in the area are a set of northwest- to north-trending high-angle strike- or oblique-slip faults. The Hovatter Road fault and the Needle fault show left separation downthrown on the northeast, and the Northeast Hills fault shows right separation down on the southwest (Fig. 2). The northeast-dipping breccia zone north of the Needle is believed to represent a detachment on which the Northeast Hills moved northeast off the central axis of the range. Although the breccia zone apparently is

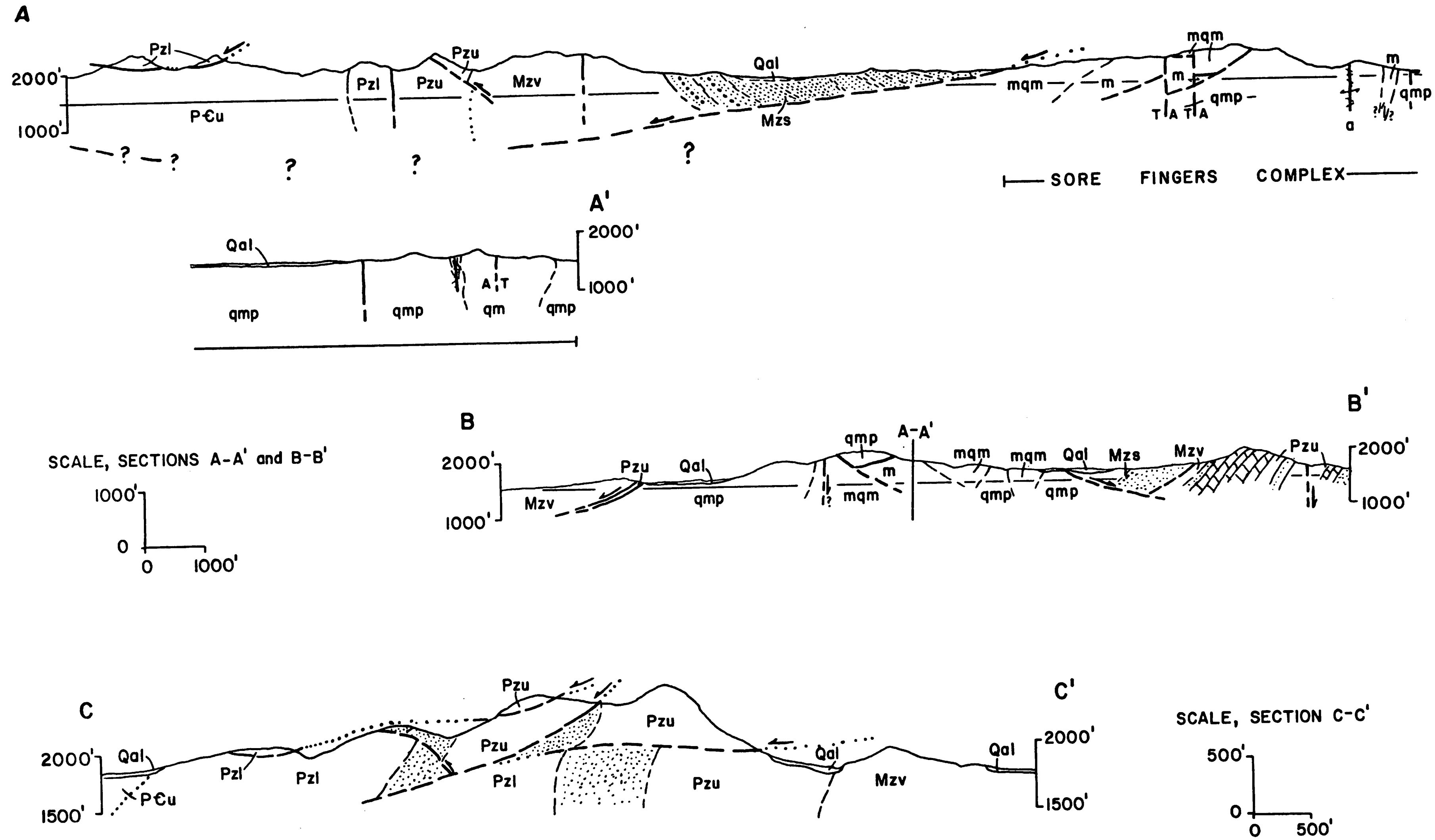
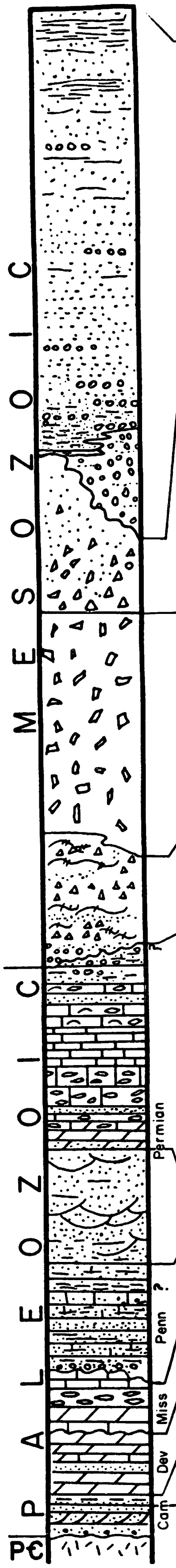


Figure 3: Geologic Cross Sections
Southern Little Harquahala Mountains

For explanation see Fig. 2.

A|T Strike slip fault, movement A - away from viewer
T - toward viewer

Upper Paleozoic Coconino Sandstone



LITHOFELDSPATHIC SANDSTONE: Brown weathering, grey fresh sandstone, dark grey siltstone and silty shale, and pebble to cobble conglomerate; clasts in conglomerate mostly Paleozoic lithologies; sequence fines upward from coarse sand and conglomerate at base to mostly siltstone at top; lenticular sand bodies; cross bedding present, not common; complex relations at base--conformable and unconformable contacts present.

SEDIMENTS DERIVED FROM QUARTZ PORPHYRY: light grey or grey green epiclastic conglomerate and sandstone; massive, similar in appearance to quartz porphyry, distinguished by clastic textures, rare quartzite clasts, less prominent phenocrysts and rare magnetite lamina; sequence fines upward.

QUARTZ PORPHYRY: massive light grey green or grey intrusive and extrusive quartz porphyry; altered plagioclase, biotite or hornblende and quartz phenocrysts in very fine grained groundmass; locally intrusive into Lower Volcanic Unit, but stratiform shape of body and cover of lithologically similar epiclastic sediments suggests extrusive origin.

LOWER VOLCANIC UNIT: maroon and purple silicic flows; aphanitic groundmass with minor quartz and feldspar phenocrysts, flow banding present; agglomerates; laminated and massive tuff; red volcanic lithic sandstones interbedded in southwest; local red conglomerate at base--clasts include volcanic rocks, porphyritic granite and Paleozoic lithologies.

KAIBAB LIMESTONE:
Unit 5: basal tan silty sandstone, cherty light pink grey limestone, with quartz-chert sandstone, conglomerate and mudstone of probable Mesozoic age at top.
Unit 4: thick bedded light grey limestone; cherty and fossiliferous; gastropods, Chaetetes corals and brachiopods; abundant chert at top.
Unit 3: even, medium bedded dark grey limestone; poorly preserved fusilinids and large gastropods present.
Unit 2: massive cherty medium grey limestone; crinoid grainstone; large Productid brachiopods abundant in upper part.
Unit 1: basal sandy dolomite grades up into cherty fossiliferous dolomitic limestone, with large crinoid columnals, echnoid spines and brachiopods; capped by tan silty sandstone; probable Toroweap Formation equivalent.

COCONINO SANDSTONE: white vitreous medium grained well sorted quartzite; mostly very thin bedded, plane laminated; med. to large scale troughy cross beds present.

SUPAI FORMATION: interbedded white vitreous quartzite, calcareous sandstone, maroon mudstone, limestone or dolomite; thick bedded; lenticular beds; medium scale troughy cross bedded sandstone beds present; prominent dark brown varnished outcrops.

REDWALL LIMESTONE: lower thick bedded light grey limestone and dark grey dolomite form prominent bands; upper massive cherty light grey limestone, variably dolomitized; variably preserved crinoid grainstone at top; local thin karst breccia at base; karsted zone at top.

MARTIN FORMATION: brown, grey and tan dolomite and dolomitic limestone; chocolate brown sandy beds at base; one or two coarse, very poorly sorted sandstone beds in section; carbonate beds laminated, massive and mottled.

ABRIGO FORMATION: dark grey, maroon and grey green sandy shale, contact gradational at base; bioturbation in some thin siltstone beds.

BOLSA QUARTZITE: maroon grey feldspathic sandstone; grit and pebble conglomerate at base; medium to fine grained sandstone with siltstone partings up section; planar tabular cross beds common.

PRECAMBRIAN QUARTZ MONZONITE.

FIGURE 4. STRATIGRAPHIC COLUMN

cut by the Needle fault, it lies on quartz monzonite west of the fault and on Paleozoic limestone east of the fault, requiring movement on the Needle fault before the breccia developed. The two faults thus have overlapping periods of activity.

TECTONIC INTERPRETATIONS AND DISCUSSION

The geologic history of the Little Harquahala Mountains begins in the Proterozoic(?) with the deposition of volcanic and sedimentary rocks which were metamorphosed and then intruded by one or more generations of porphyritic granitic rock. During Paleozoic time a cratonic section was deposited. The Coconino sandstone is the only formation that shows evidence of continental deposition. Karst horizons above the Martin Formation and the Redwall Limestone indicate periods of subaerial erosion, but there is no evidence of major Paleozoic orogenic activity.

The presence of chert pebbles and igneous intrusive rock clasts in the basal Mesozoic section implies a period of uplift and locally extensive erosion following deposition of the Kaibab Limestone. Preservation of several hundred feet of Kaibab strata not reported in adjacent areas indicates that the Little Harquahala Mountains were not eroded as deeply as those areas. Mesozoic volcanic rocks, thought to represent the Jurassic arc in this area, thin to the southeast through non-deposition, erosion, tectonic thinning or some combination of these. They are present in the southern Plomosa Mountains (Miller, 1970) but are not exposed and are probably absent in the western Harquahala Mountains. Again, the Little Harquahala Mountains were the site of thicker accumulation than nearby areas. These relations are interpreted to be the result of early Mesozoic high-angle faulting as a result of which the Little Harquahala Mountains occupied a down-dropped block. Activity on these faults during or just after Jurassic(?) volcanic activity suggests that these structures may be related to the Mojave-Sonora megashear, which was also active during or just after Jurassic arc magmatism (Kluth, pers. comm., 1981). Mesozoic(?) lithofeldspathic sandstone was deposited across these older structures, ending the major Phanerozoic period of deposition in the region.

Subsequent history of the study area involves several deformational events but no significant deposition. Large-scale south-vergent folds are believed to be correlative with similar structures observed in the western Harquahala Mountains (Varga, 1977; Reynolds, Keith and Coney, 1980). Similar fold structures are known in the Big Maria (Krummenacher et al., 1981); Little Maria (Emerson, 1981); Old Woman (Howard, 1981); and Clark Mountains (Burchfiel and Davis, 1971) of California. Folds in the Harquahala Mountain area may represent the eastern termination of a belt of middle Mesozoic compressional structures characterized by large-scale basement involved folding.

Folds with steep north-northeast plunging axes have not been reported in adjacent areas. They are similar to drag structures expected along strike-slip faults, but the absence of complementary folds on the opposite side of appropriately oriented structures is not consistent with this hypothesis. These folds remain an enigma.

The Hercules thrust is pre-Late Cretaceous in age. Correlation of fabrics from the Harquahala Mountains and the Granite Wash Mountains suggests that low-angle faults which place Precambrian on Paleozoic rocks are truncated by the Granite Wash Granodiorite (S. Reynolds, pers. comm., 1981), which has yielded K-Ar biotite ages of 65 and 69 m.y. (Damon, 1968; Eberly and Stanley, 1978). Biotite from sheared granite directly above the Hercules thrust in the northern Little Harquahala Mountains yielded a K-Ar age of 66 m.y. (Rehrig and Reynolds, 1980). The amount and direction of tectonic transport are not known. The presence of older structures mentioned above may have provided enough relief on the basement surface that great vertical throw was not required to place Precambrian on Mesozoic rocks in the Late Cretaceous. However, the difference in Mesozoic clastic rocks above and below the fault requires significant lateral transport.

Northwest-dipping normal-separation faults cutting the Paleozoic section are subject to various interpretations. Apparent north to northwest transport is more consistent with northerly transport directions indicated for Late Cretaceous thrust faults in the western Harquahala Mountains (Reynolds, Keith and Coney, 1980) than with regional northeast extension indicated by extensive southwest-dipping mid-Tertiary strata in the area (Rehrig, Shafiqullah and Damon, 1980; Scarborough and Wilt, 1979). Interpretation as thrust faults requires post-thrust northwest tilting of the faults. The northeast-trending arch, which now forms the Harquahala Mountains (Reynolds, this volume), provides a possible means to achieve this tilting. However, independent evidence for extension of this arch into the Little Harquahala Mountains presently is lacking. I have chosen to interpret these faults as mid-Tertiary normal faults because of their complex, discontinuous geometry, association with highly brecciated tear-like faults and absence of undeformed crosscutting dikes.

The relationship between the Hercules thrust and the Sore Fingers fault is a key problem. The attitude of the Sore Fingers fault, its brecciated character and the probable younger on older juxtaposition suggest that it is correlative with the northwest-dipping normal-separation faults. Rock assemblages which are lithologically similar to the Sore Fingers Complex or which are similarly altered are unknown in the Little Harquahala, Harquahala and Granite Wash Mountains. A major hidden contact between the Sore Fingers Complex and the Harquar section below the Hercules thrust is necessary. Considering the altered condition and probable depth of intrusion of the coarse crystalline rocks of the Sore Fingers Complex and the unmetamorphosed character of the Harquar section, a buried unconformity or fault is the most probable candidate. Further mapping in the area is required to resolve this problem.

North- to northwest-trending oblique- or strike-slip faults are Tertiary(?) in age. The Needle fault cuts east-dipping Tertiary(?) gravel north of the Needle. This assignment requires that the brecciated zone associated with the Needle fault is Tertiary(?) as well.

In summary, structures in the Little Harquahala Mountains are interpreted to indicate Mesozoic high-angle faulting, southeast-vergent folding, folding about steep north-northeast plunging axes and Late Cretaceous thrust faulting. These structures are overprinted and obscured by chaotic Tertiary structures including early northeast-trending northwest-dipping normal-separation faults and later north- to northwest-trending strike- or oblique-slip faults.

ACKNOWLEDGEMENTS

I would like to thank Peter Coney, Bill Dickinson and Steve Reynolds, who introduced me to the geology of west central Arizona, for their encouragement, assistance, and hours of discussion. Conversations with Lucy Harding, Stan Keith and Rick Leveque have been a continuing source of inspiration. Field assistance, moral support and a stream of ideas were provided by Dawn Harvey, Kerry Inman, Bill Jefferson and Nancy Riggs. Financial support was provided by GSA Grant #270880, NSF Grant #8018500, awarded to Peter Coney and Lucy Harding, and a research assistantship from the Arizona Bureau of Geology and Mineral Technology. This paper was reviewed by S. Calvo, W. R. Dickinson, K. F. Inman, W. S. Jefferson, T. Lawton and N. Riggs.

REFERENCES

Burchfiel, B. C. and Davis, G. A., 1971, Clark Mountain thrust complex in the Cordillera of Southeastern California, in Elders, W. A. (ed.), Geological Excursions in Southern California: Univ. Calif., Riverside, Campus Museum Contrib., no. 1, p. 1-28.

Damon, P. E., 1968, Correlation and chronology of ore deposits and volcanic rocks, in Annual Progress Report COO-689-100, Contract AT(11-1)-689 to U.S. Atomic Energy Commission: University of Arizona, Geochronology Labs, Tucson, 75 p.

Eberly, L. D. and Stanley, T. D., Jr., 1978, Cenozoic stratigraphy and geologic history of southwestern Arizona: Geol. Soc. America Bull., v. 89, p. 921-940.

Emerson, W. S., 1981, Mesozoic and Cenozoic deformation and igneous activity in the Little Maria Mountains, Riverside County, California (abs.), in Tectonic Framework of the Mojave and Sonoran Deserts, California and Arizona: U.S. Geol. Survey, Open-file Rpt. 81-503.

Howard, K. A., 1981, Mesozoic framework of the southeastern Mojave Desert region, California: Geol. Soc. America, Abstr. with Program, v. 13, p. 62.

Krummenacher, D. et al., 1981, Middle Mesozoic compressional tectonics and Tertiary extensional overprint in the Big Maria, Little Maria, Riverside, and Arica Mountains and Palen Pass areas of Riverside County, California: Geol. Soc. America, Abstr. with Programs, v. 13, p. 492.

Miller, F. K., 1970, Geologic map of the quartzite quadrangle, Yuma County, Arizona: U.S. Geol. Survey Geologic Quad. Map GQ-841, 1:62,500.

Rehrig, W. A. and Reynolds, S. J., 1980, Geologic and geochronologic reconnaissance of a northwest-trending zone of metamorphic core complexes in southern and western Arizona: Geol. Soc. America, Mem. 153, p. 131-157.

Rehrig, W. A., Shafiqullah, M. and Damon, P. E., 1980, Geochronology, geology and listric normal faulting of the Vulture Mountains, Maricopa County, Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 89-110.

Reynolds, S. J., 1980, Geologic framework of west-central Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 1-16.

Reynolds, S. J., Keith, S. B. and Coney, P. J., 1980, Stacked overthrusts of Precambrian crystalline basement and inverted Paleozoic sections emplaced over Mesozoic strata, west central Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 45-52.

Scarborough, R. and Wilt, J. C., 1979, A study of uranium favorability of Cenozoic sedimentary rocks, Basin and Range province, Arizona, Part I, General geology and chronology of pre-late Miocene Cenozoic sedimentary rocks: Ariz. Bur. Geol. Min. Tech., Open-file Rpt. 79-1 or U.S.G.S. Open-file Rpt. OFR-79-1429, 101 p.

Varga, R. J., 1977, Geology of the Socorro Peak Area, western Harquahala Mountains: Ariz. Bur. Geol. Min. Tech., Circ. 20, 20 p.

Tucson, Arizona
November 26, 1975

To: Mr. J.B. Imswiler
IMC

From: A.J. Perry
Perry, Knox, Kaufman, Inc.

Subject: Arizona (IMC) Porphyry Copper Project - Monthly Report - November, 1975

A.J. Perry reconnoitered the Bonanza-Golden Eagle area, Yuma Co., in detail and determined that no possibilities exist for substantial deposits in the granite of the semi-pediment area extending north from the Bonanza or in the Paleozoic(?) quartzite-shale and limestone sequence of the surrounding hills. A report is in preparation.

Data pertaining to drilling accomplished by BCMC in the area near Superior's Anomaly 21, located west of Duval's Mineral Park, was obtained thru an information trade. Using that data Mining Geophysical Surveys (Gordon Wieduwilt) has made an independent interpretation of the 21 area and concludes that the anomaly(?) is "essentially a deep alluvial basin which extends northwesterly -- the Basin is in excess of 3000' deep". (copies of the GP report and BCMC data are attached). We now have eliminated our positive target and as depths are in excess of those anticipated, our 40 WAL series claims located Sept. 20 and 21 and covering all of Sec. 28 and N2/NW34 - T23N - R18W will be abandoned. A small area, thought by Wieduwilt to be anomalous and located just west of two well altered low hills (W/2-Sec.26 E/2-27) will be considered.

The Superior Oil Company has outlined a mineral reserve of +55 million tons of mixed oxide-sulfide ores assaying 0.68% Cu, 0.79% Zn and 0.22 oz Ag in four areas on the Strong and Harris Properties located at Johnson Camp in Cochise County. They seek a partner to finance the next phases of work. We briefly reviewed the Superior data and engaged Mr. Norman Weiss to report on the metallurgical outlook. Mr. Weiss finds that ore treatment tests are at an early stage but the outlook for a breakthru is not promising. We recommended that no interest be taken in this opportunity.

Comments by Mr. Joe Kantor, geologist for Superior, with respect to other opportunities possibly available in the Johnson area have led to our acquiring data pertaining to the J.P. Project Area (an area controlled by J. Sullivan of Scottsdale) located south of Cyprus' Burro Pit now under exploitation. Ralph W. Parson's reports supplied by Sullivan are now under study.

A.J. Perry devoted 7 days during November to the Project - N.I. Colburn 3½.

In drill hole LHS-84-1, the interval from 280 feet to 290 feet ran 0.007 oz Au/ton. No other detectable Au or Ag values were reported in the remainder of the hole.

In drill hole LHS-84-2 the interval from 235 feet to 240 feet ran 0.005 oz Au/ton in the quartzite just above the granite contact. No other detectable Au values were reported. Scattered traces of Ag were reported up to a maximum of 0.34 oz Ag/ton.

The following intercepts were reported from drill hole LHS-84-3:

190 - 195 feet	(5 feet)	0.007 oz Au/ton	Granite ✓
190 - 195 feet	(5 feet)	0.88 oz Ag/ton	Granite ✓
245 - 250 feet	(5 feet)	0.004 oz Au/ton	Granite ✓
245 - 250 feet	(5 feet)	1.00 oz Ag/ton	Granite ✓

problems here w/assay log, conflicts

Several thin, widely scattered intervals ran on the order of 0.004 to 0.005 oz Au/ton. The remaining Ag values were on the order of 0.3 oz Ag/ton or less.

The following intercepts were reported from drill hole LHS-84-4:

100 - 105 feet	(5 feet)	0.007 oz Au/ton	Granite
175 - 190 feet	(15 feet)	0.02 oz Au/ton	Granite
(includes	5 feet)	0.041 oz Au/ton	Granite
290 - 295 feet	(5 feet)	0.006 oz Au/ton	Granite
315 - 335 feet	(20 feet)	0.020 oz Au/ton	Granite

Several thin scattered intervals ran on the order of 0.005 oz Au/ton or less. No Ag values greater than 0.50 oz/ton was received (Figure-14).

No assays were submitted from drill hole LHS-84-5.

From drill hole LHS-85-1 the entire granite section was assayed. No anomalous values above 0.05 ppm Au or 0.20 ppm Ag were detected.

No samples from drill hole LHS-85-2, which encountered only basalt flows and bedded tuffs, were submitted.

Drill hole LHS-84-4 was collared in altered granite from which outcrop samples containing up to 8 ppm Au were collected. The proposed target for this hole was the granite-metamorphic contact. From 0 to 345 feet the hole passed through altered, brecciated, hemati- tic granite. A mylonitic zone intercepted from 345 feet to 350 feet marks the thrust which separates the altered granite from a weakly altered Jurassic dacite porphyry which intrudes the Jurassic sediments. The hole was terminated at a depth of 395 feet within the dacite body (Figure-7).

Drill hole LHS-84-5 was located approximately 1000 feet south of 84-4. The proposed target was the same altered granite inter- cepted in 84-4. After passing through 20 feet of unconsolidated alluvium the hole entered a moderately indurated quarternary vol- caniclastic conglomerate composed of 50% basaltic and 50% dacitic material. This hole was terminated at a depth of 45 feet due to a major drill rig breakdown.

DRILLING PROGRAM - 1985

Drilling began on March 6th, and was completed on March 12th, 1985. Eight holes were drilled for a total footage of 2060 feet.

Drill hole LHS-85-1 was proposed to test the major northwest trending fault along the western end of the property. After passing through 20 feet of alluvium, the hole passed through interbedded basalt flows and tuffaceous sediments to a depth of 265 feet. Intensely brecciated and altered granite was encoun- tered to a depth of 430 feet. After passing through a 15 foot thrust fault zone the hole entered Jurassic sediments which com- prise the footwall rocks in this part of the property. The hole was bottomed at a depth of 485 feet (Figure-8).

Drill hole LHS-85-2, which is located about 1300 feet east of LHS-85-1, was planned to test a north-south trending fault zone. After drilling through 35 feet of alluvium, the hole entered a section of interbedded basalt flows and tuffaceous sediments. The hole did not pass out of this section by 345 feet and was terminated at that depth (Figure-8).

What mineralization·

Drill hole LHS-85-3 through LHS-85-8 were drilled to test the extent of the mineralization encountered in hole number LHS-85-4. Drill hole LHS-85-3 passed through 30 feet of alluvium and basalt flows to a depth of 75 feet. It then abruptly entered Jurassic sediment redbeds, apparently as a result of local horsting and was terminated in the sediments at a depth of 305 feet (Figure - 9).

Drill hole LHS-85-4 encountered altered brecciated granite below 35 feet of alluvium. The hole continued in the granite to a depth of 165 feet, below which Jurassic sedimentary footwall rocks were encountered. The hole was terminated at a depth of 205 feet (Figure-10).

Drill hole LHS-85-5 passed through 70 feet of alluvium before entering altered granite breccia. At 105 feet the hole passed out of granite into metamorphic footwall rocks and was terminated at a depth of 145 feet (Figure-11).

Drill hole LHS-85-6 encountered altered granite from the collar to a depth of 75 feet. At 75 feet the hole entered metamorphic footwall rocks and was terminated at a depth of 125 feet (Figure-12).

Drill hole LHS-85-7 entered altered granite at 10 feet which continued to a depth of 300 feet, at which point the hole entered footwall Jurassic sediments. Traces of copper oxides were noted immediately above the footwall contact. The hole was terminated at a depth of 325 feet (Figure-13).

Drill hole LHS-85-8 was located 150 feet north of LHS-85-3. After passing through 15 feet of alluvium, the hole passed through altered granite to a depth of 100 feet, below which Jurassic footwall rocks were encountered. This hole was terminated at a depth of 125 feet (Figure-9).

RESULTS OF DRILLING PROGRAMS

Cuttings from both of 1984 and 1985 drilling were analyzed by a 1 assay ton fire assay with an A.A. finish. Values for samples submitted on 1984 were reported in oz Au/ton. Those for 1985 were reported in P.P.M..

Drill hole LHN-84-2 passed through 260 feet of unaltered interbedded Tertiary volcaniclastic sandstones and rhyodacite tuffs before entering altered, brecciatd, hematitic, Socorro Granite.

The altered granite persisted to the bottom of the hole at 505 feet.

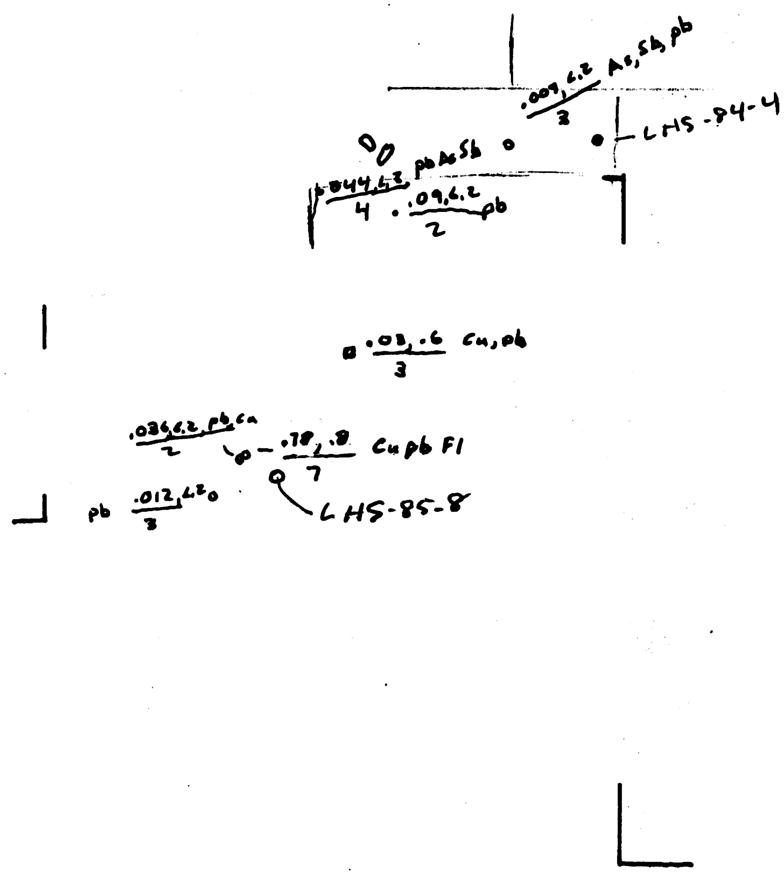
Drill hole LHN-84-3 was bottomed at a depth of 385 feet in the detached Tertiary section after passing through a sequence of unaltered interbedded conglomerates, tuffs and basalt flows. None of the intended targets were intercepted.

Drill hole LHN-84-4, was proposed to test the fault zone separating the Paleozoic sediments from the Socorro Granite. After passing through 55 feet of alluvium, the hole encountered tan sandstone of the Supai Formation to a depth of 110 feet. From 110 feet to 395 feet, the hole passed through a tan quartzite unit which became increasingly calcareous towards its base. From 395 feet to the bottom of the hole at 435 feet, the hole encountered reddish brown calcareous siltstone without intercepting any of the intended targets.

Drill hole LHN-84-5 encountered 305 feet of unconsolidated alluvium and was terminated at that depth without intercepting any of the intended target zones.

<u>1985 Drilling Program</u>

Drilling began on March 12, 1985 and was terminated on March 25th after drilling four holes for a total of 2,420 feet. A proposed fifth hole in the northeast corner of the property was not drilled due to a possible property conflict with another claim owner.

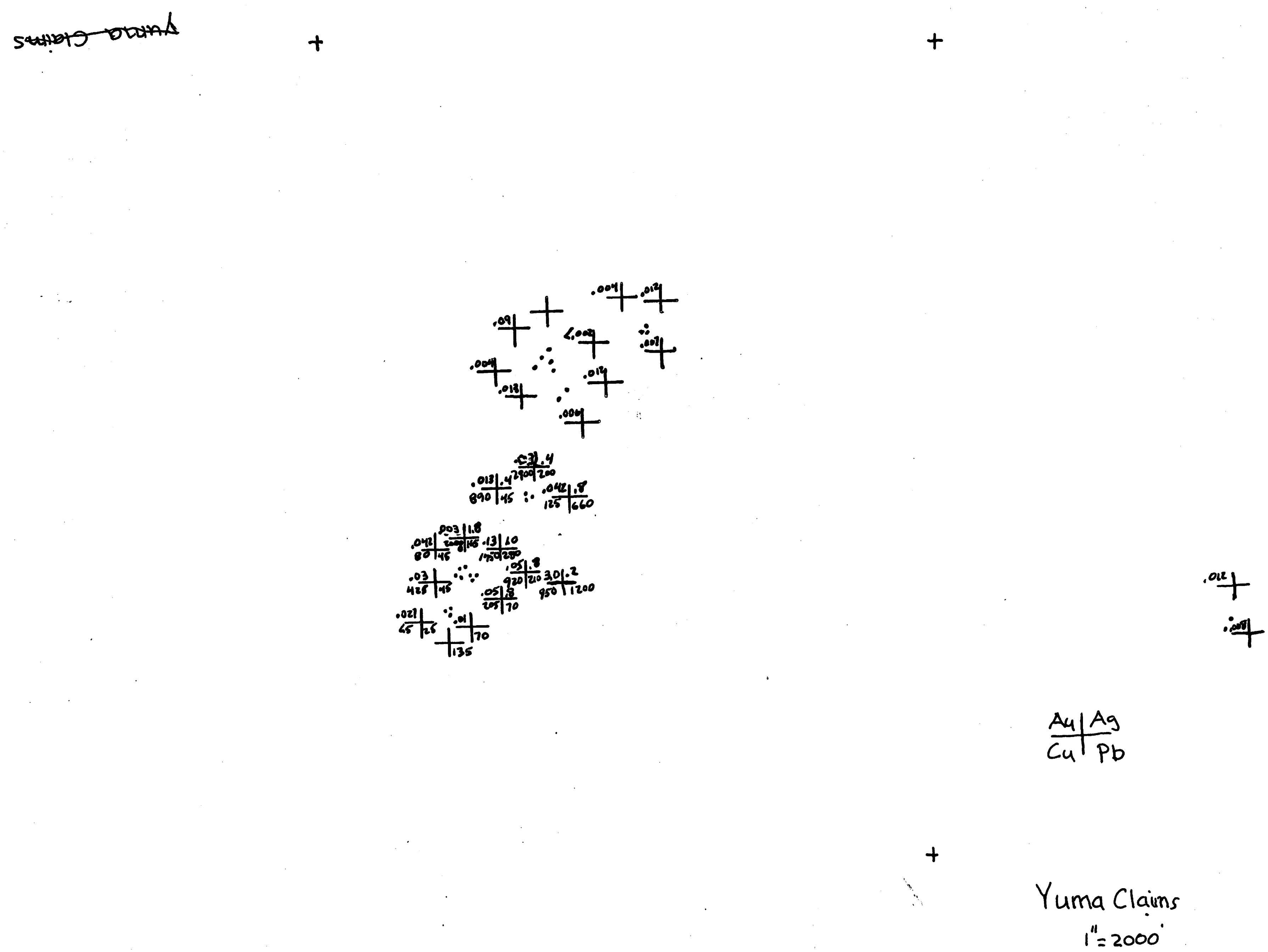


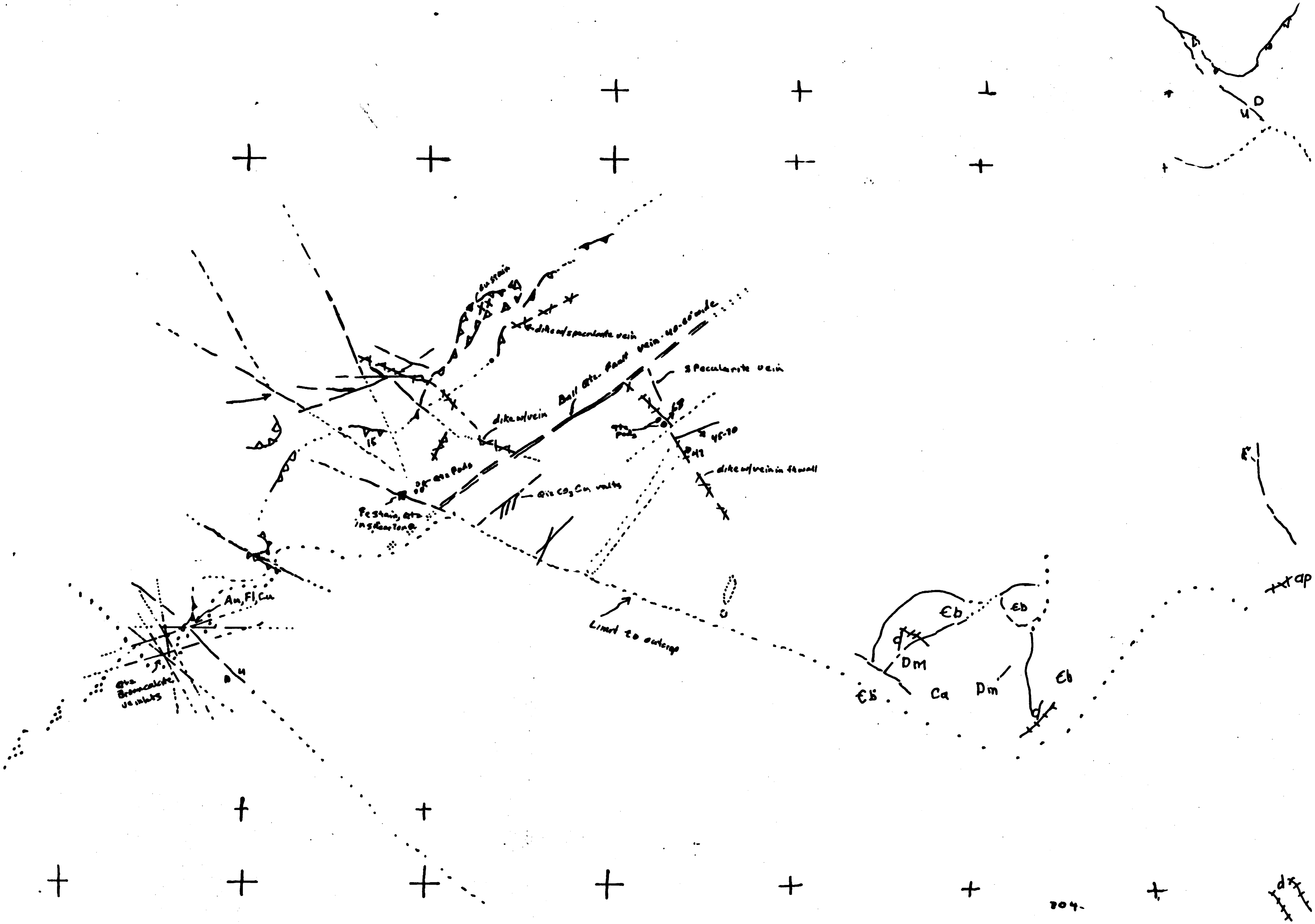
Au, Ag / #Samples Anomalous elements

1" = 200'

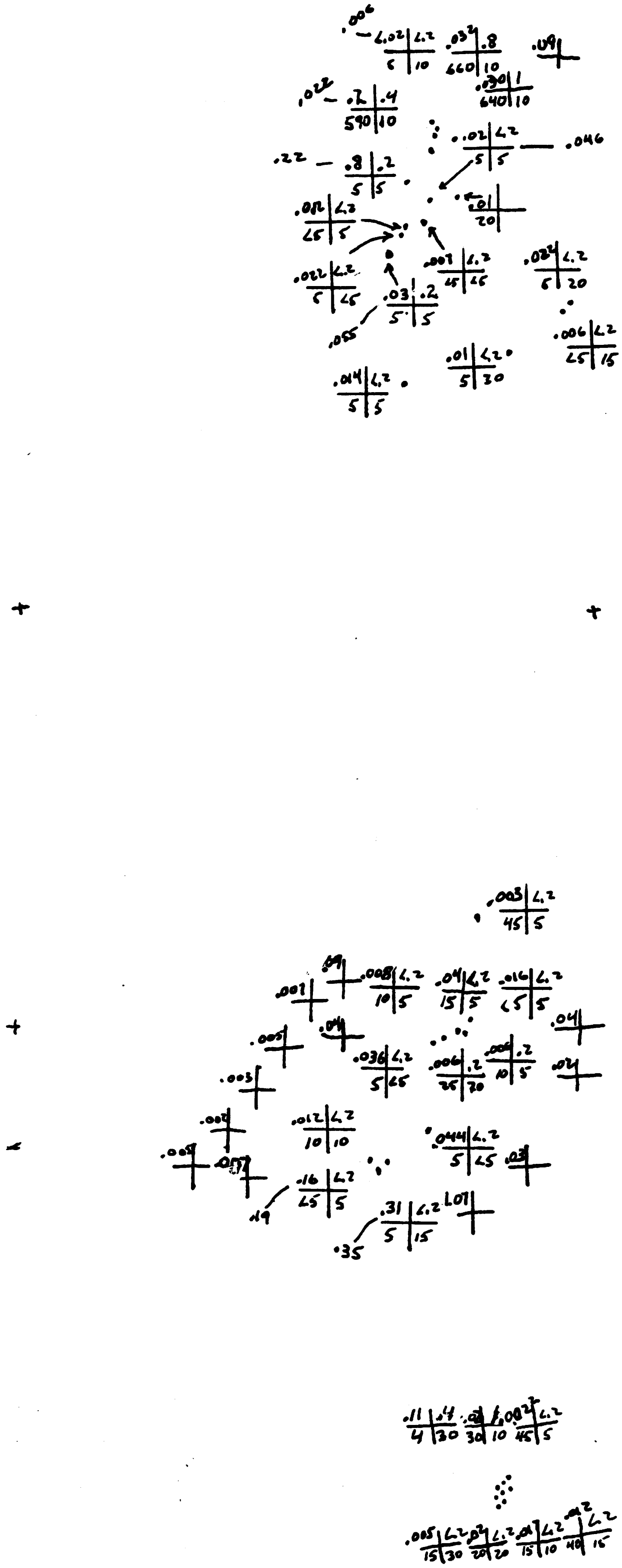
Au Ag / #Samples

Yuma Claims


Au | Ag
Cu | Pb
Yuma Claims
1" = 2000'

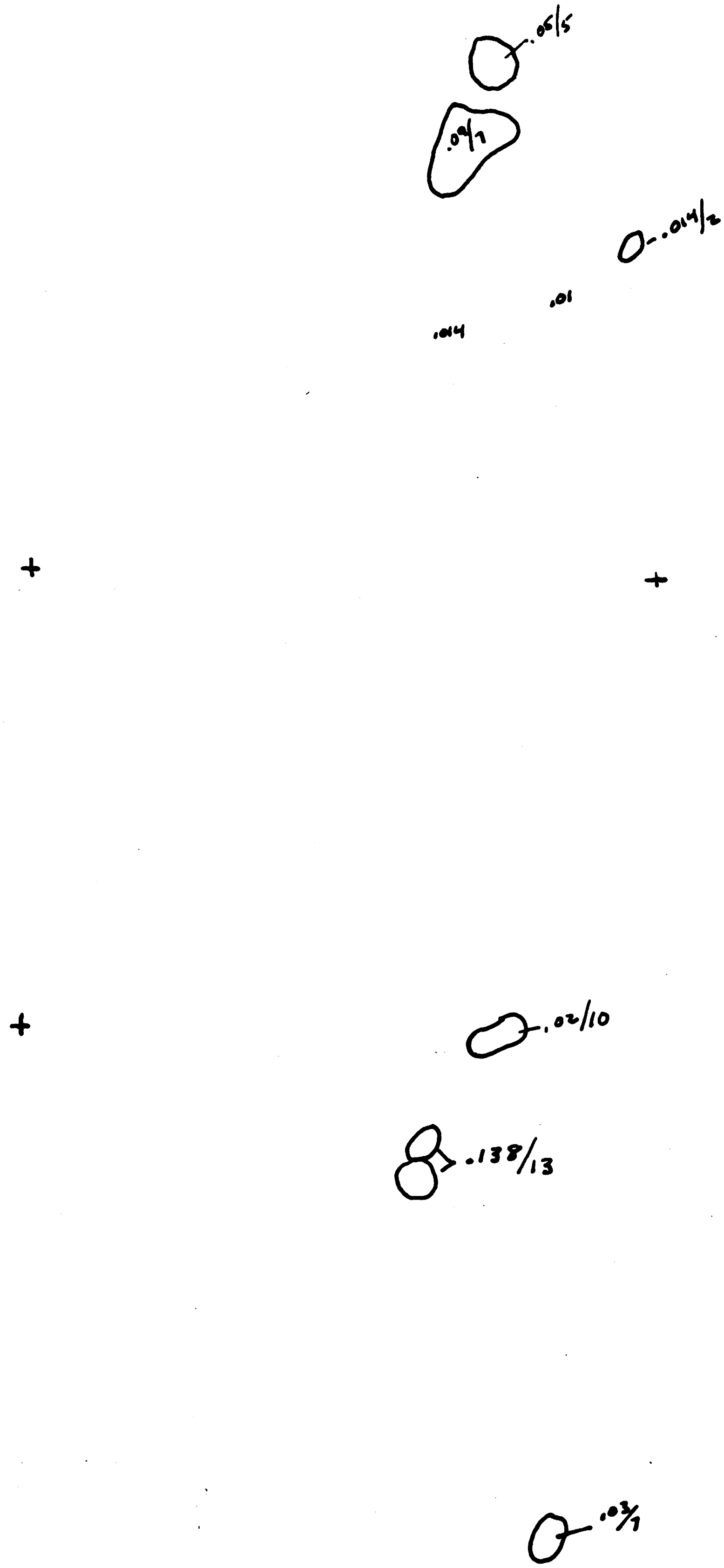


1" = 1000'
Yuma claims

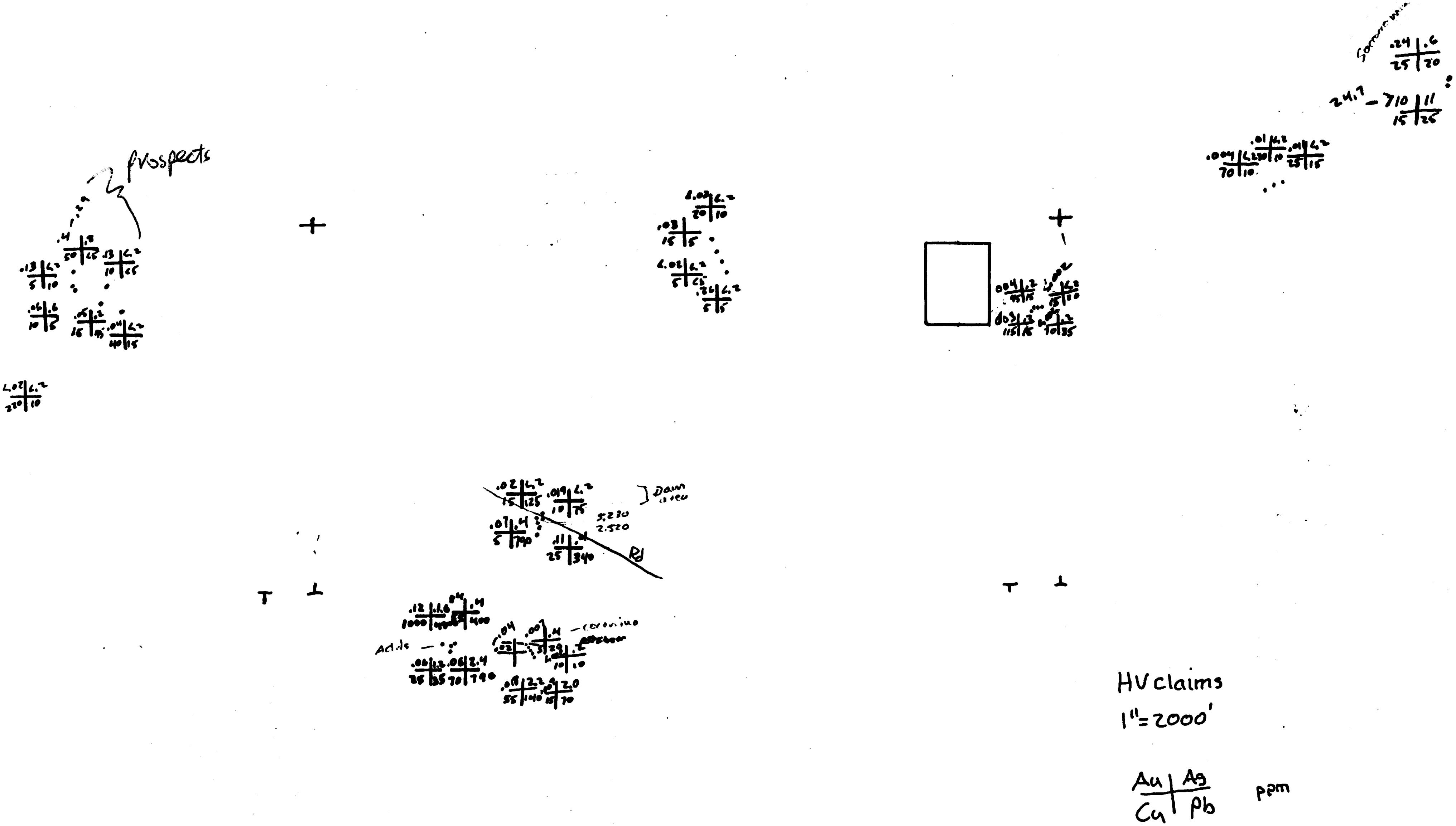


Au | Ag
Cu | Pb

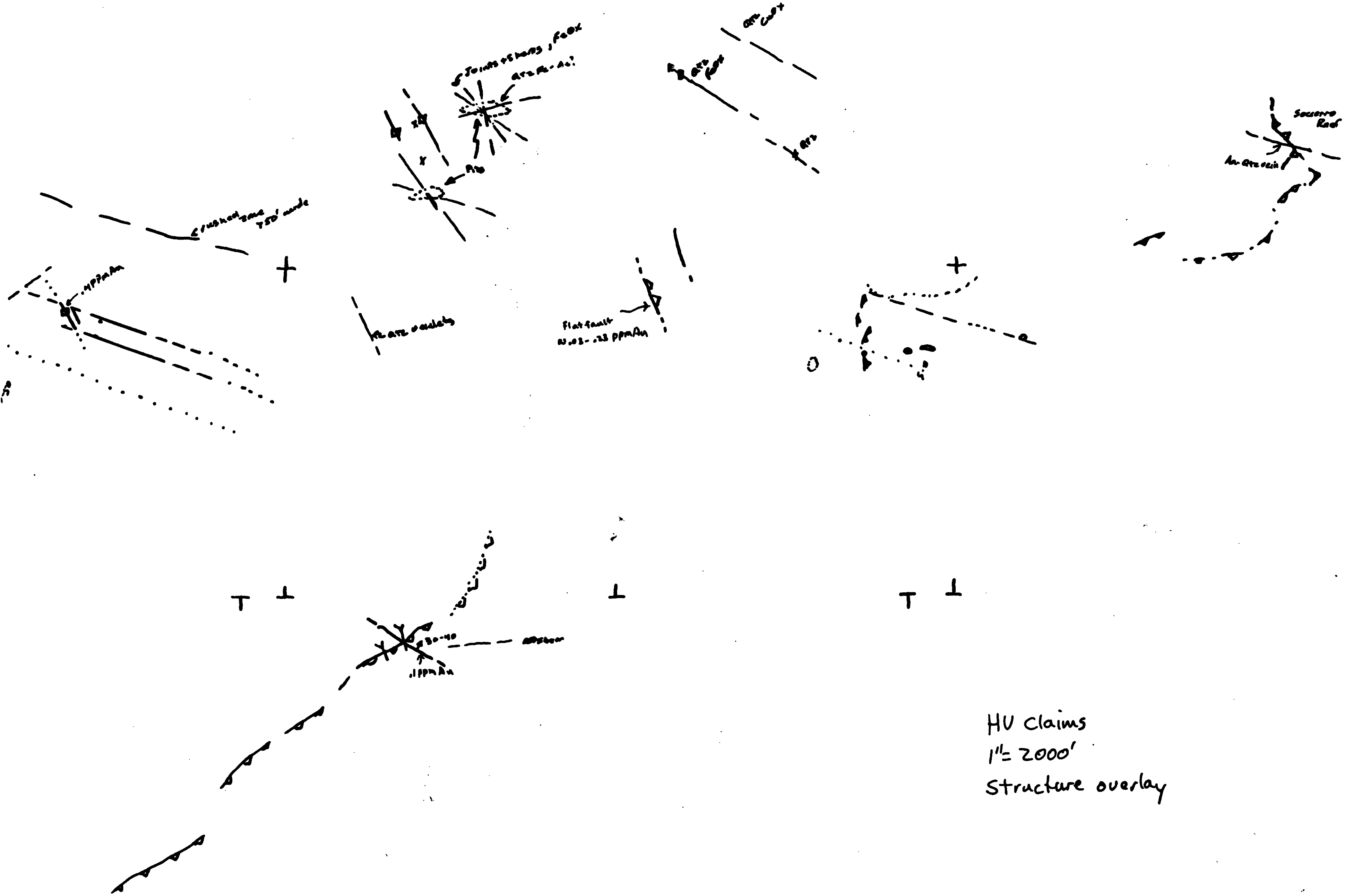
HV Claims
INset



HU Claims
Inset
Au/#samples

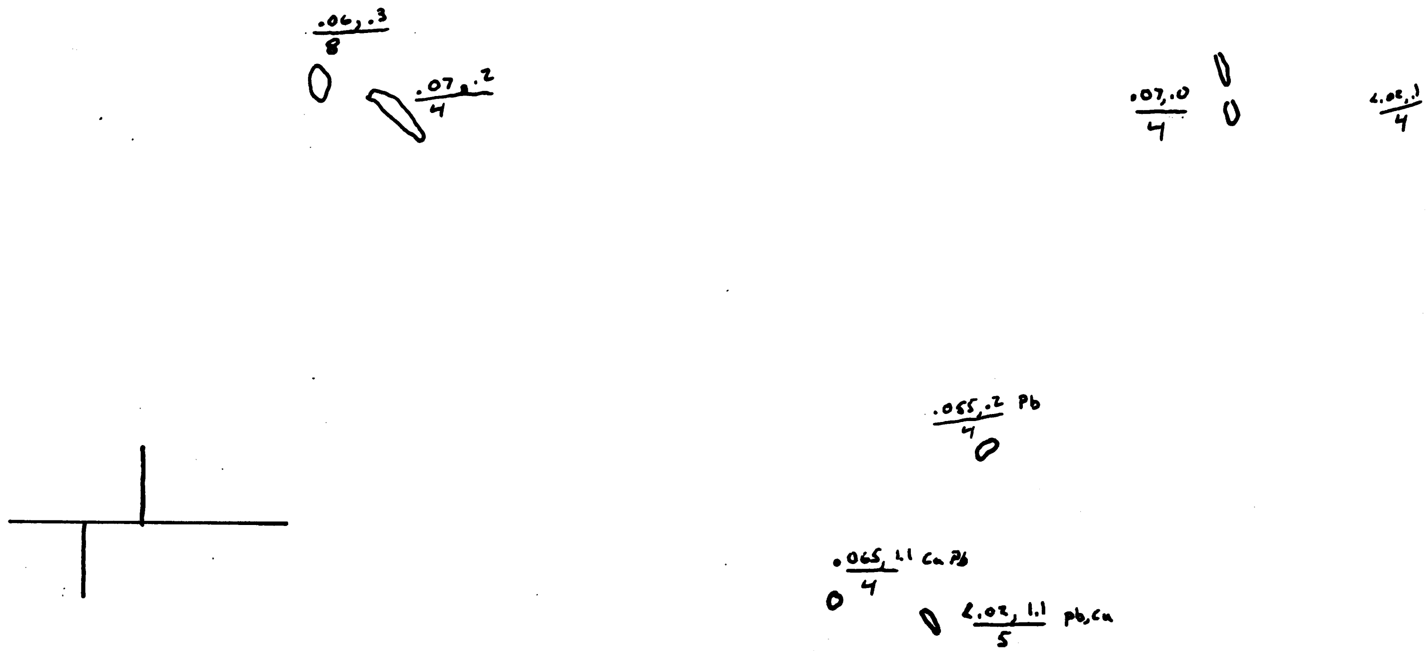


Prospects
Adits
Rd
HV claims
1" = 2000'
Au | Ag
Cu | Pb
ppm



HV Claims
1"= 2000'
Structure overlay

HV Claims
Geology Inset



.06,.3 / 8
.07,.2 / 4
.07,.0 / 4
<.02,.1 / 4
.055,.2 Pb / 4
.065, 1.1 Cu Pb / 4
<.02, 1.1 Pb,Cu / 5

Tucson, Arizona
November 3, 1975

To: Mr. J.B. Imswiler
IMC

From: A.J. Perry
Perry, Knox, Kaufman, Inc.

Subject: IMC-ARIZONA PROJECT MONTHLY REPORT - October, 1975

Summary

N.I. Colburn completed the report of her initial reconnaissance of the Harquahala-Harcuvar Mountains region, Yuma and Maricopa Counties on October 17. Subsequently several of the areas were reviewed with A.J. Perry -- specifically: Cunningham Pass, Golden Eagle-Bonanza Mines area and Alaska-Rio Del Monte (see Figure 1). Several other areas were briefly visited. Only the Golden Eagle-Bonanza area appeared to have any possible exploration potential.

Some office work was devoted to the continued Detrital Valley aeromag followup. Bear Creek appears ready to accept trade of data in PKK's possession detailing some work done in N.M. for information re: drilling in our anomalous area west of Duvals' Mineral Park. We have an appointment this week with C.L. Elliot, geophysist, to review the Superior detailed data.

One day was devoted to a field examination of the claims of L. Burkhart, situated on the west side of Tortolita Mountains, NW of Tucson in Pima and Pinal Counties. Although there are numerous small copper oxide and sulfide occurrences in Pre-Cambrian rocks in at least three areas on the claims, it is doubtful that any attention should be devoted to the area by IMC.

Mr. Imswiler appears to be proceeding well in final detailed negotiations with BCMC re: Cuprite Area.

A.J. Perry devoted 6 days to IMC-AZ during the report period, N.I. Colburn 12.

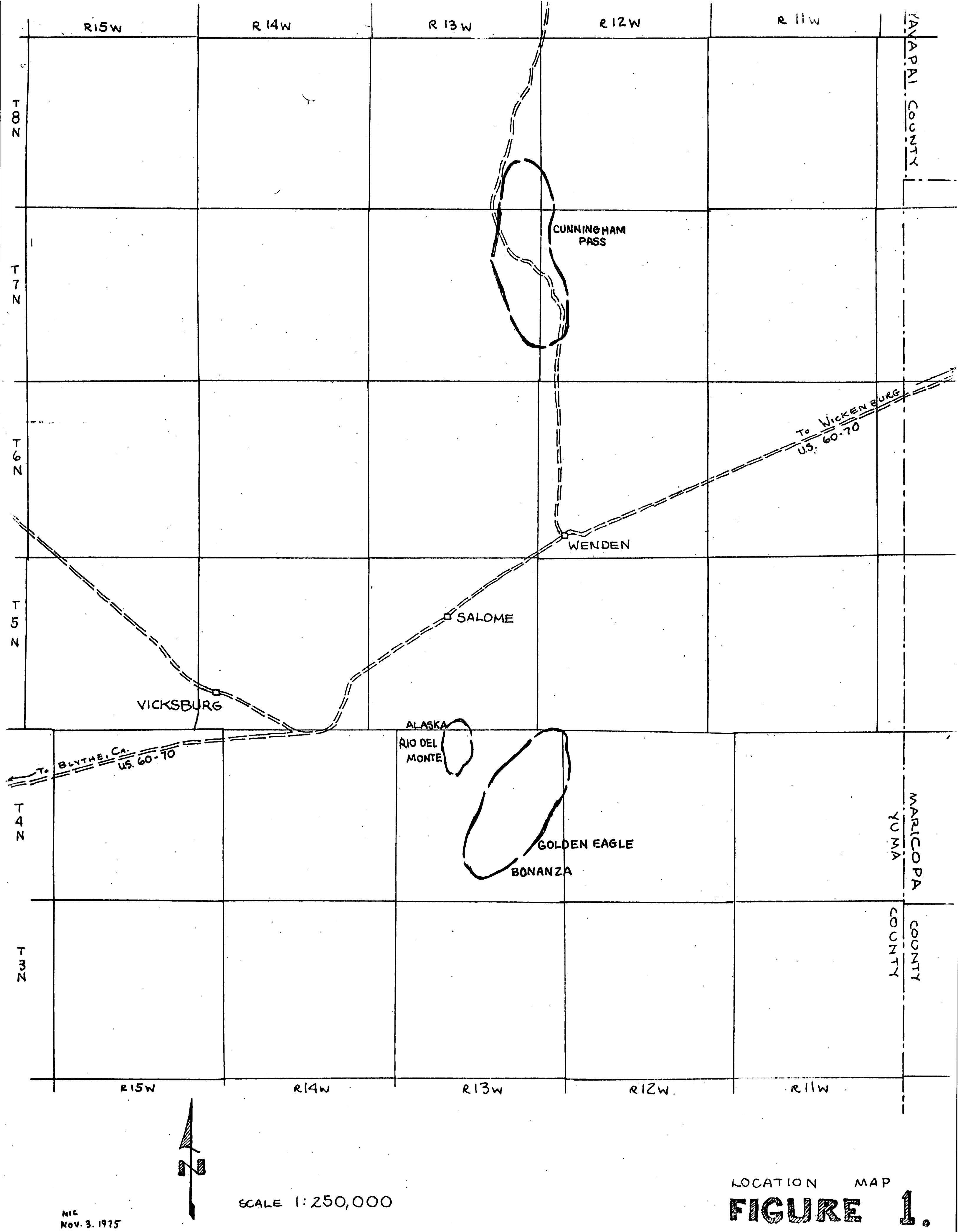
Detail

In the Golden Eagle-Bonanza (Harquahala) Mines area there has been past production from a lower Cambrian (?) sedimentary sequence of limestone, quartzite-shale which is in fault contact with an underlying-sometimes cupiferous-Laramide(?) granite. Remaining potential may exist; 1) along the edge of a rather substantial sized granite area of lower elevation, beneath sediments similar to those at Golden Eagle and Bonanza or, 2) within the granite itself, possibly in areas having suffered structural disruption such as that open cut area situated NW of Golden Eagle (see Figure 2). Initial inquiry indicates CFI drilled in the area in 1969-70. We are contacting claims owners, attempting to obtain information for review.

Proposed Activity, November

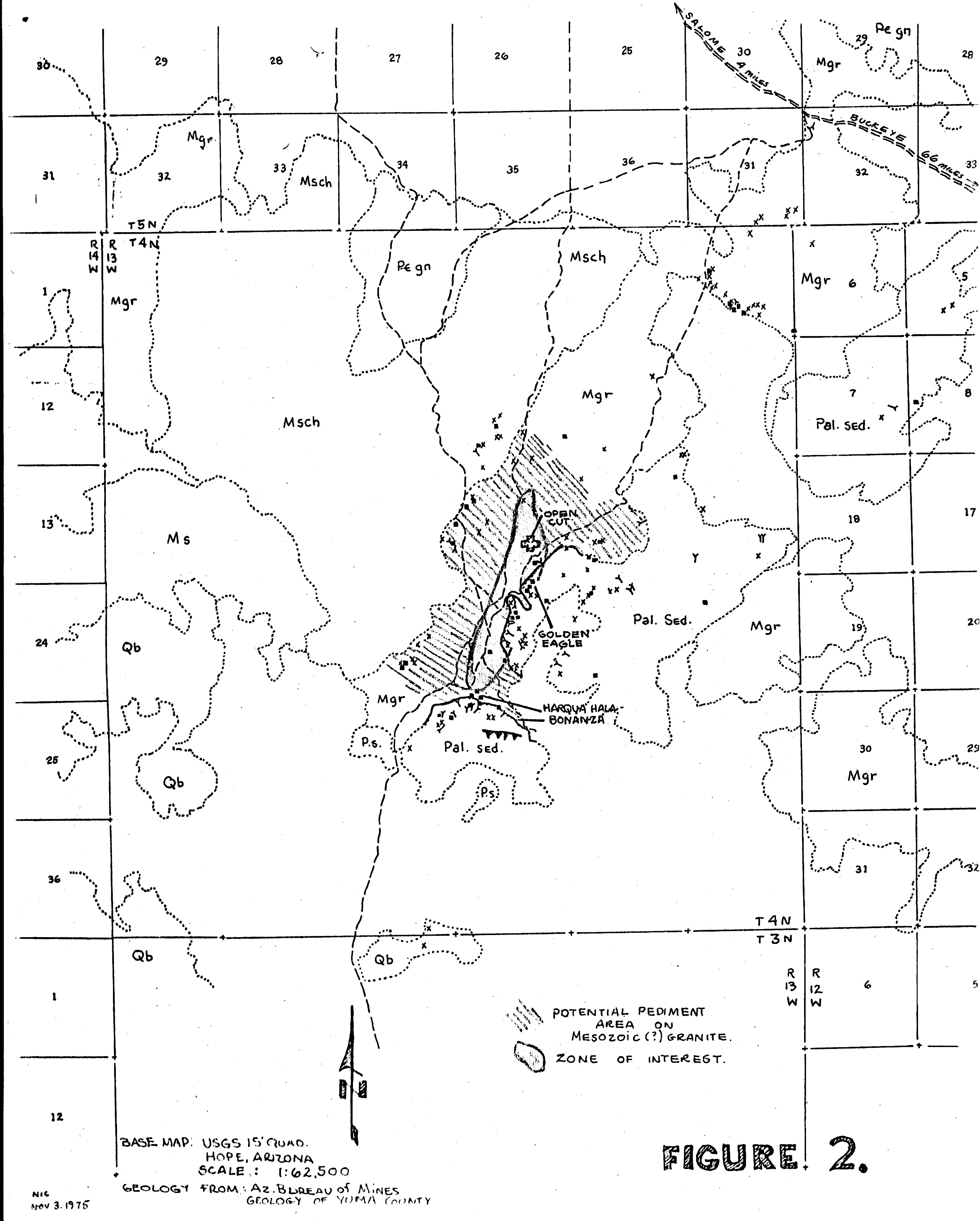
It is anticipated that; 1) the possibilities of our anomaly west of Mineral Park, in Detrital Valley, will be geophysically analyzed and a decision made as to the advisability of undertaking exploration. 2) We expect to screen all remaining Detrital Valley geophysically anomalous areas. 3) Some final determination will be made of the potential at Bonanza-Golden Eagle. 4) Additional recon will be conducted of areas in Yuma Co., time permitting.

A.J. Perry



LOCATION MAP

FIGURE 1.



SALOME 4 MILES
BUCKEYE 66 MILES
T5N
T4N
R 14 W
R 13 W
Mgr
Msch
Pε gn
Ms
Qb
Pal. Sed.
P.s.
OPEN CUT
GOLDEN EAGLE
HARQUA HALA
BONANZA
T4N
T3N
R 13 W
R 12 W
POTENTIAL PEDIMENT AREA ON MESOZOIC (?) GRANITE.
ZONE OF INTEREST.
BASE MAP: USGS 15' QUAD.
HOPE, ARIZONA
SCALE: 1:62,500
GEOLOGY FROM: AZ. BUREAU of MINES
GEOLOGY OF YUMA COUNTY
NIC
NOV 3. 1975

FIGURE 2.

And - Hum Vol.

PRELIMINARY REPORT ON THE STRUCTURE AND STRATIGRAPHY OF THE SOUTHERN LITTLE HARQUAHALA MOUNTAINS, YUMA COUNTY, ARIZONA

Stephen M. Richard
Department of Geosciences
University of Arizona
Tucson, Arizona 85721

ABSTRACT

Precambrian through Tertiary rocks in the southern Little Harquahala Mountains record a complex history of Mesozoic and Tertiary deformation. Precambrian quartz monzonite is overlain by: 1) about 1000 m of Paleozoic strata correlated with the Bolsa, Abrigo, Martin, Redwall, Supai, Coconino and Kaibab Formations; 2) up to 1000 m of Mesozoic dacitic to rhyolitic volcanic and volcaniclastic rock; 3) at least 750 m of Mesozoic lithofeldspathic sandstone, conglomerate and siltstone. Probable high-angle faulting prior to deposition of the Mesozoic sandstone is indicated by rapid facies changes, massive conglomerate and basal onlap onto older units to the southeast. Subsequently, the strata were folded into a large southeast-vergent fold limb. This fold was refolded about steep axes trending N-NE. In Late Cretaceous time the deformed rocks were thrust over Mesozoic clastic, volcaniclastic and volcanic rocks along the Hercules thrust. Mesozoic strata below the Hercules thrust are lithologically and stratigraphically different from Mesozoic strata above the fault. Mesozoic structures are strongly overprinted by Tertiary(?) NW-dipping, moderate to low-angle, normal-separation faults and associated northerly trending faults. The youngest structures are north- to northwest-trending, near-vertical oblique- or strike-slip faults with an associated northeast-dipping normal fault. One of the near-vertical faults cuts poorly indurated east-dipping Tertiary(?) gravel.

INTRODUCTION

The Little Harquahala Mountains are located within the Basin and Range province in west central Arizona. Access to the area is excellent, either by the Hovatter Road, which connects Salome with I-10 through the western edge of the study area, or by the Buckeye-Salome Road through the northeast edge of the area (Fig. 1).

The Little Harquahala Mountains occupy an area of overlapping Mesozoic and mid-Tertiary tectonism. The purpose of this project is to determine the structural geometry of Paleozoic rocks in the Little Harquahala Mountains in an attempt to define the kinematics of Mesozoic and Tertiary deformation in the area. To this end, a geologic map of the southern part of the range was made. The base map used was a 1:12,000 enlargement of part of the Hope, Arizona 15' series U.S.G.S. quadrangle (1961). This paper contains descriptions and preliminary interpretations of the rocks and structures of the Little Harquahala Mountains. A more complete discussion will be presented in a forthcoming circular to be published by the Arizona Bureau of Mines and Mineral Technology.

GENERAL GEOLOGY

Precambrian quartz monzonite in the central part of the range is overlain by a highly faulted northeast-trending, steeply dipping cratonic Palezoic

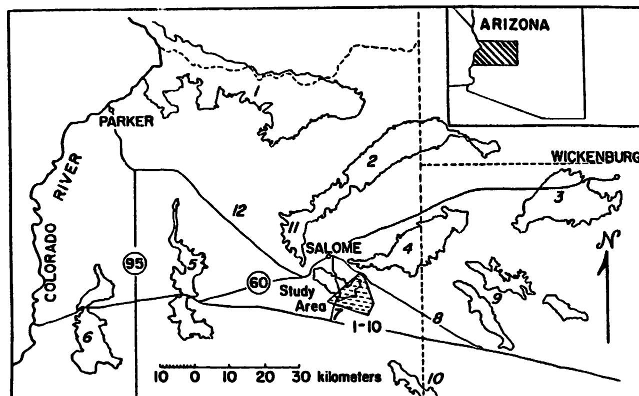


Figure 1. Location map showing study area and points referred to in text, numbered as follows: (1) Buckskin Mtns.; (2) Harcuvar Mtns.; (3) Vulture Mtns.; (4) Harquahala Mtns.; (5) Plomosa Mtns.; (6) Dome Rock Mtns.; (7) Hovatter Road; (8) Buckeye-Salome Rd.; (9) Big Horn Mtns.; (10) Eagle Tail Mtns.; (11) Granite Wash Mtns.; (12) Ranegras Plain.

section. Depositionally above the Paleozoic rocks are Mesozoic volcanic and volcaniclastic rocks and Mesozoic lithofeldspathic sandstones. On the south, the sedimentary rocks overlie an assemblage of altered crystalline rocks of uncertain age along the complex steep to low-angle Sore Fingers fault zone (Fig. 2). On the north, the Precambrian quartz monzonite structurally overlies Mesozoic clastic, volcaniclastic and volcanic rocks informally known as the Harquar section. The lower plate Mesozoic rocks are lithologically and stratigraphically different from Mesozoic rocks in the upper plate. The Harquar section is intruded in the northern part of the range by the Granite Wash Granodiorite, dated at 65 m.y. (Damon, 1968) and 69 m.y. (Eberly and Stanley, 1978). Along the western edge of the range, southwest-dipping volcanic rocks of probably Miocene age overlie the Harquar section. The range is structurally bounded on the northeast by an inferred northwest-trending oblique-slip fault in the vicinity of Centennial Wash. A complete summary of the regional geology of west central Arizona is presented by Reynolds (1980, and this volume).

STRATIGRAPHY

The Little Harquahala Mountains contain rock units ranging in age from Precambrian to Tertiary. The pre-Cenozoic stratigraphic column includes approximately 1000 m of Paleozoic rocks, a highly variable thickness of Mesozoic volcanic and volcaniclastic rocks up to 900 m thick and Mesozoic lithofeldspathic sandstones with a maximum exposed thickness of 750 m. For lithologic descriptions of the Paleozoic and Mesozoic section in the central part of the area, see the accompanying stratigraphic column (Fig. 4). In addition, a variety of igneous and metamorphic rocks of uncertain age are exposed in the Sore Fingers area, and Precambrian quartz monzonite and amphibolite gneiss underlie the Paleozoic section. The rock units are divided into five major groups reflecting the geologic development of the area. These are: 1) Precambrian basement consisting of intrusive and metamorphic rocks; 2) Paleozoic cratonic sediments; 3) Mesozoic continental deposits; 4) the Sore Fingers Complex; and 5) Cenozoic deposits which are only briefly described. Thicknesses of rock units were determined using measurements from the geologic map.

Precambrian Rocks

Granitic rocks occupying the northeast boundary of the map area are depositionally overlain by the Bolsa Quartzite and thus are known to be of Precambrian age. North of Martin Peak, gneissic rocks intruded by this granite crop out over a small area and are also considered Precambrian.

Quartz monzonite underlying the Bolsa Quartzite is ubiquitously altered in the vicinity of the unconformity to an assemblage of light green argillized or epidotized feldspar set in a red stained argillic groundmass with abundant quartz eyes. Sericite and epidote are common. In less intensely altered zones, further from the unconformity, the quartz monzonite consists of a medium-grained quartz, plagioclase and minor biotite groundmass with 1-3 cm potassium feldspar phenocrysts. Some of the alteration at the contact may be due to pre-Bolsa weathering, but the presence of similar alteration within the Bolsa requires post-Paleozoic chemical changes as well. The contact between the Bolsa and quartz monzonite commonly is faulted.

Amphibolite gneisses consisting of medium-grained hornblende and plagioclase crystals occur at the northwest edge of the map area above the Hercules thrust (Fig. 2). Near-vertical, northeast-trending foliation in these gneisses is characteristic of early proterozoic gneisses in west central Arizona (Reynolds, 1980). This foliation is disrupted and folded within 10-15 m of the Hercules thrust.

Paleozoic Rocks

A cratonic Paleozoic section overlies the Precambrian basement in the Little Harquahala Mountains. The stratigraphy of these rocks resembles the southeast Arizona Paleozoic section in its lower part and the Grand Canyon section in its upper part. Miller (1970) described a similar section in the southern Plomosa Mountains and noted its resemblance to the section in the Little Harquahala Mountains. He recognized the Bolsa, Abrigo, Martin, Escabrosa, Supai, Coconino and Kaibab Formations. Varga (1977) reported an essentially identical section in the western Harquahala Mountains, except the Abrigo and Martin Formations are apparently absent due to a bedding plane fault. Varga (1977) favored correlation of the carbonate unit below the Supai with the Redwall Limestone instead of the Escabrosa Limestone. In the absence of definitive evidence for either correlation, I have chosen to continue Varga's usage. Except for this change, Miller's (1970) correlations are used in this report.

The Kaibab Formation in the Little Harquahala Mountains is unique in western Arizona. Miller (1970) and Varga (1977) described strata resembling units 1 and 2 of this report, but units 3, 4 and 5 are absent in all other sections described in west central Arizona. Quartz-chert sandstone and conglomerate at the top of unit 5 are probably Mesozoic but are too thin and poorly exposed to map separately.

Mesozoic Rocks

Two distinct Mesozoic sequences are present in the Little Harquahala Mountains--the Harquar section and the southern Little Harquahala section. Formal nomenclature for these rocks is lacking. A Mesozoic age is inferred from stratigraphic position above Paleozoic rocks and involvement in late Cretaceous deformation (see Tectonic Interpretations).

The Harquar section includes volcanic and sedimentary rocks lying below the Hercules thrust. These were not studied in detail. Within the area mapped, porphyritic andesite flows overlie lithic sandstone, siltstone and conglomerate. The section is distinguished from the southern Little Harquahala section by the more intermediate composition of the volcanic rocks, the greater abundance of conglomerate and the predominance of volcanic clasts in the conglomerate.

The southern Little Harquahala section is described in the stratigraphic column (Fig. 4). Conglomerates and rapid facies changes at the base of the lithofeldspathic sandstone unit indicate a period of deformation and erosion prior to deposition of the sandstone. The contact between the sandstone and underlying volcaniclasts is conformable along a northeast-trending zone southeast of the Needle. In this area the volcaniclastic rocks fine upward into a shale horizon overlain by the sandstones. To the south, a rapid facies change occurs, possibly involving telescoping of facies on hidden faults, and the base of the section becomes conglomeratic. The volcanic and volcaniclastic units apparently pinch out, and in the Limestone Hills (Fig. 2), a massive limestone conglomerate overlies Paleozoic rocks at the base of the sandstones. The contact there is sheared and is interpreted to be a minor fault. Thinning of the volcanic unit, coarsening of the basal sandstone section and overlap onto Paleozoic rocks are indicative of uplift in the southern part of the area during or after deposition of the volcanics and before deposition of the Mesozoic sandstones.

Sore Fingers Crystalline Complex

The Sore Fingers crystalline complex is an informal name assigned to an assemblage of intrusive and metamorphic rocks in the southern part of the map area. The complex is named after two low hills in the southernmost Little Harquahala Mountains called the Sore Fingers on the Hope 15' quadrangle. The complex is bounded by faults on the northwest, southwest and northeast and covered by alluvium on the southeast. The age of the complex is uncertain but is probably Precambrian and Mesozoic.

The most abundant lithology in the Sore Fingers complex is a quartz monzonite porphyry. Equant to slightly elongate light flesh-pink potassium feldspar phenocrysts up to 8 cm long occur in a groundmass of 1-5 mm quartz, plagioclase and altered biotite. This rock has yielded a minimum age of 140 m.y. (K-Ar, biotite, Rehrig and Reynolds, 1980). Slight alteration is concentrated along joints throughout the intrusion but is locally intense and extensive, converting large areas of quartz monzonite to a dense black siliceous alteration product in which 1-3 mm quartz eyes and 3-5 mm white feldspar "spots" are all that is left of the original texture. Silicification

Figure 2

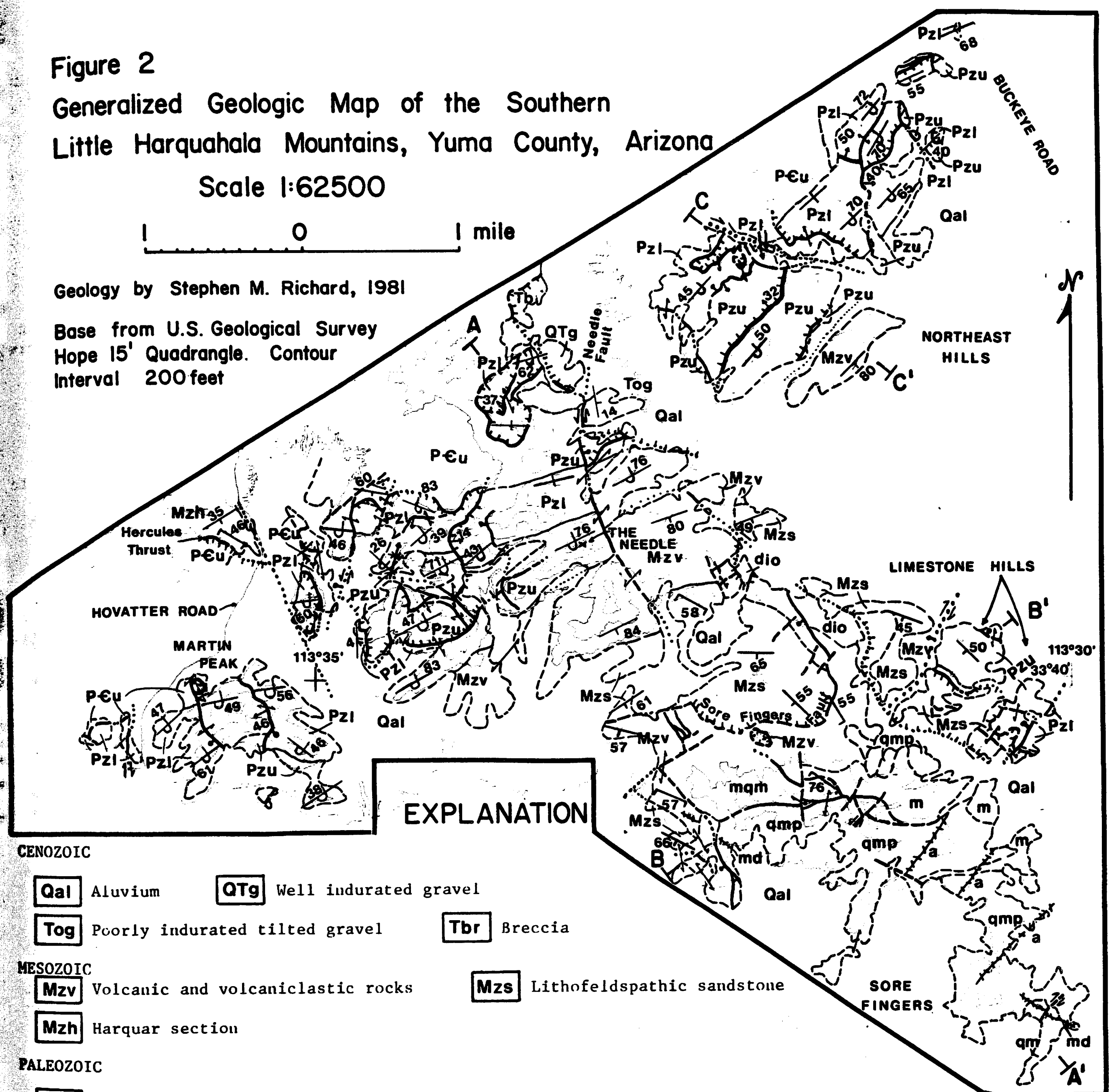
Generalized Geologic Map of the Southern Little Harquahala Mountains, Yuma County, Arizona

Scale 1:62500

1 0 1 mile

Geology by Stephen M. Richard, 1981

Base from U.S. Geological Survey Hope 15' Quadrangle. Contour Interval 200 feet



EXPLANATION

CENOZOIC

- **Qal** Aluvium
- **QTg** Well indurated gravel
- **Tog** Poorly indurated tilted gravel
- **Tbr** Breccia

MESOZOIC

- **Mzv** Volcanic and volcaniclastic rocks
- **Mzs** Lithofeldspathic sandstone
- **Mzh** Harquar section

PALEOZOIC

- **Pzl** Bolsa through Supai formations, undivided
- **Pzu** Coconino and Kaibab formations

PRECAMBRIAN

- **P€u** Quartz monzonite

PRECAMBRIAN OR MESOZOIC SORE FINGERS COMPLEX

- **qmp** Quartz monzonite porphyry
- **mqm** Metamorphosed and altered quartz monzonite
- **dio** Diorite
- **m** Metamorphic rocks
- **qm** Slightly prophyritic quartz monzonite

DIKES

- **md** Microdiorite
- **a** Aplite

Contacts- definite, approximate, inferred or concealed

Faults- with dip, ball on downthrown side, arrows show relative motion, barbs on upper plate.
20

Attitudes of bedding- inclined, vertical, overturned
30 60

Cleavage- inclined
20

Folds- Axial trace of anticline, syncline, overturned syncline and biotitization seem to be the major effects of the alteration. The porphyritic quartz monzonite is intruded by a diorite or quartz diorite in the northeast part of the complex and by a number of small bodies of equigranular quartz monzonite, only one of which is shown on the geologic map (Fig. 2). In the northern part of the complex, the porphyritic quartz monzonite is in both gradational and fault contact with slightly metamorphosed and altered porphyritic granite. This unit is characterized by red staining, zones with weak crystalloblastic foliation, slightly rounded pink-red feldspar phenocrysts and abundant quartz veins. Foliation attitudes are not consistent over the area; the fabric seems to be a very local phenomenon.

The porphyritic quartz monzonite is intruded into an extremely heterogeneous assemblage of meta-igneous and meta-sedimentary rocks. Contacts, where not faulted, are gradational, with interleaving of various lithologies, and locally appear migmatitic. Porphyritic quartz monzonite, variably altered or foliated with gradational contacts, is a widespread component of the metamorphic terrane. These relations suggest that the quartz monzonite may be derived, at least in part, from partial melting of the metamorphic rocks. The metamorphic rocks are generally quartzo-feldspathic with minor biotite, altered to chlorite and muscovite. Strong alteration obscures contact relationships everywhere. Pods and lenses of black microdiorite are common. Foliation is locally strong but generally is weakly developed and irregular.

TERTIARY ROCKS

Tertiary rock units include a breccia and two overlying gravels. The breccia occurs in a northwest-trending zone north of the Needle which is believed to be a northeast-dipping low-angle fault zone. It is underlain by Paleozoic rocks east of the Needle fault (Fig. 2) and by Precambrian quartz monzonite to the west. The breccia is composed of crushed Paleozoic clasts ranging from brecciated blocks several meters long to angular pebbles. The rock is strongly cemented by calcite or silica. East of the Needle fault, a poorly indurated gravel overlies the breccia, dipping 15° to the east. Near the fault, the gravel contains boulders of Supai Formation up to 1 m in diameter along with clasts of other Paleozoic lithologies and Precambrian quartz monzonite; it becomes finer grained up-section away from the fault. West of the Needle fault, the breccia and Precambrian quartz monzonite are overlain by an untilted well-indurated gravel composed of Paleozoic clasts up to about 40 cm in diameter.

STRUCTURE

Six deformation events are recognized in the southern Little Harquahala Mountains. From oldest to youngest they are: 1) probably high-angle faulting before deposition of the Mesozoic lithofeldspathic sandstone; 2) large-scale south- to southeast-vergent folding; 3) refolding of earlier folds about steep north-northeast plunging axes; 4) thrust faulting; 5) northeast-trending, moderate- to low-angle normal faulting with associated high- and low-angle faults; 6) north- to northwest-trending strike- or oblique-slip faulting with an associated northwest-trending low-angle normal fault. These structures will be described in chronologic order.

Onlap of Mesozoic clastic rocks across a thin Mesozoic volcanic sequence and across a major northeast-trending fault in the Limestone Hills (Fig. 2) suggests that the fault was related to uplift of Paleozoic rocks, which were a source for clasts in the basal part of the clastic sequence. At the very least, major movement on the largest northeast-trending fault in the Limestone Hills predates shearing along the base of the clastic unit.

The early large-scale fold is apparent in the general decrease in dip of strata from vertical and overturned beds in the northeast- to moderately south-dipping beds in the south. The axis of this fold is subhorizontal and trends east-northeast. Southeast vergence is indicated by northwest-dipping overturned beds and by extrapolation from the western Harquahala Mountains.

The second folding event is evident in the change from northeast to southeast strike on Martin Peak and south of the Needle (Fig. 2). Antiformal synclines and synformal anticlines in the highly faulted area east of Martin Peak are also believed to be related to this event. Axes are moderately northeast-plunging to vertical but are difficult to determine because of the earlier folding event.

The Hercules thrust places Precambrian quartz monzonite on Mesozoic volcanic and clastic rocks of the Harquar section north of the Paleozoic outcrop belt. The fault dips gently to the southwest. Foliation in gneissic rocks above the fault is folded, and a northwest-trending southwest-dipping cleavage is strongly developed in clastic rocks below the fault.

Cleavage with a similar orientation and character is present in Mesozoic sandstone south of the Needle, in rocks along the northwest-trending steep faults bounding the Sore Fingers complex, along the fault bounding the klippe of volcanic rock lying on the Sore Fingers Complex and along a fault within the Sore Fingers Complex. As cleavage is not folded and is not axial planar to folds, its development evidently postdated the folding.

Northeast-striking, northwest-dipping, low-angle normal-separation faults cut Paleozoic and Mesozoic rocks (Figs. 2,3). Dips of the faults vary from 0 to 40°. Major faults of this type placed a large klippe of Paleozoic rocks on Precambrian quartz monzonite north of the Needle, extended the Paleozoic section in the area between the Needle and Martin Peak and in the Northeast Hills and juxtaposed Mesozoic and crystalline rocks along the Sore Fingers fault. Northwest- to north-striking, east-dipping steep to low-angle faults are associated with the normal-separation faults. They are characterized by strongly brecciated fault zones. Northwest-dipping normal-separation faults in general cannot be correlated across these structures, indicating that they may act as tear faults.

The youngest structures in the area are a set of northwest- to north-trending high-angle strike- or oblique-slip faults. The Hovatter Road fault and the Needle fault show left separation downthrown on the northeast, and the Northeast Hills fault shows right separation down on the southwest (Fig. 2). The northeast-dipping breccia zone north of the Needle is believed to represent a detachment on which the Northeast Hills moved northeast off the central axis of the range. Although the breccia zone apparently is

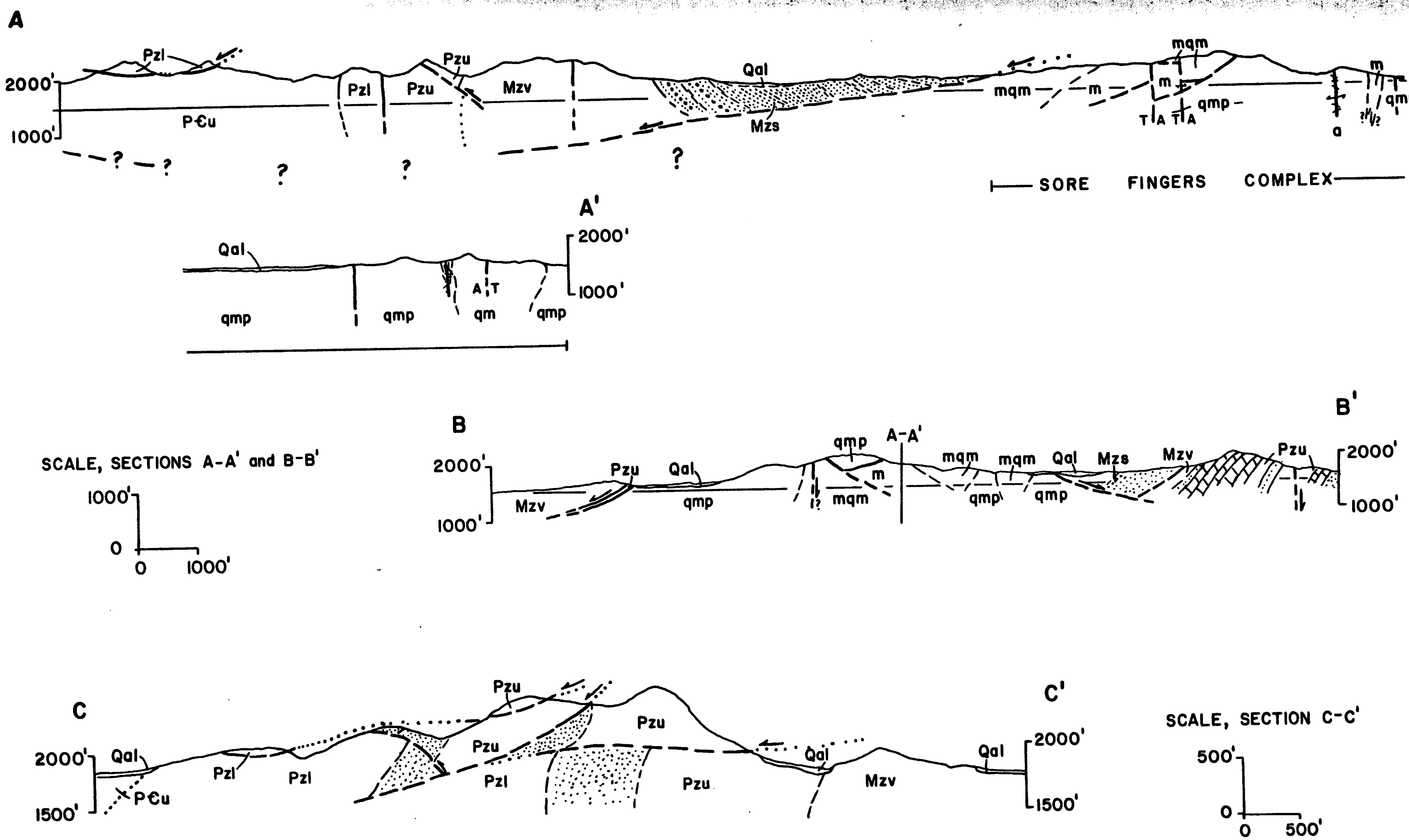


Figure 3: Geologic Cross Sections
Southern Little Harquahala Mountains

For explanation see Fig. 2.

A|T Strike slip fault, movement A - away from viewer
T - toward viewer

Upper Paleozoic Coconino Sandstone

LITHOFELDSPATHIC SANDSTONE: Brown weathering, grey fresh sandstone, dark grey siltstone and silty shale, and pebble to cobble conglomerate; clasts in conglomerate mostly Paleozoic lithologies; sequence fines upward from coarse sand and conglomerate at base to mostly siltstone at top; lenticular sand bodies; cross bedding present, not common; complex relations at base--conformable and unconformable contacts present.

SEDIMENTS DERIVED FROM QUARTZ PORPHYRY: light grey or grey green epiclastic conglomerate and sandstone; massive, similar in appearance to quartz porphyry, distinguished by clastic textures, rare quartzite clasts, less prominent phenocrysts and rare magnetite lamina; sequence fines upward.

QUARTZ PORPHYRY: massive light grey green or grey intrusive and extrusive quartz porphyry; altered plagioclase, biotite or hornblende and quartz phenocrysts in very fine grained groundmass; locally intrusive into Lower Volcanic Unit, but stratiform shape of body and cover of lithologically similar epiclastic sediments suggests extrusive origin.

LOWER VOLCANIC UNIT: maroon and purple silicic flows; aphanitic groundmass with minor quartz and feldspar phenocrysts, flow banding present; agglomerates; laminated and massive tuff; red volcanic lithic sandstones interbedded in southwest; local red conglomerate at base--clasts include volcanic rocks, porphyritic granite and Paleozoic lithologies.

KAIBAB LIMESTONE:

Unit 5: basal tan silty sandstone, cherty light pink grey limestone, with quartz-chert sandstone, conglomerate and mudstone of probable Mesozoic age at top.

Unit 4: thick bedded light grey limestone; cherty and fossiliferous; gastropods, Chaetetes corals and brachiopods; abundant chert at top.

Unit 3: even, medium bedded dark grey limestone; poorly preserved fusilinids and large gastropods present.

Unit 2: massive cherty medium grey limestone; crinoid grainstone; large Productid brachiopods abundant in upper part.

Unit 1: basal sandy dolomite grades up into cherty fossiliferous dolomitic limestone, with large crinoid columnals, echnoid spines and brachiopods; capped by tan silty sandstone; probable Toroweap Formation equivalent.

COCONINO SANDSTONE: white vitreous medium grained well sorted quartzite; mostly very thin bedded, plane laminated; med. to large scale troughy cross beds present.

SUPAI FORMATION: interbedded white vitreous quartzite, calcareous sandstone, maroon mudstone, limestone or dolomite; thick bedded; lenticular beds; medium scale troughy cross bedded sandstone beds present; prominent dark brown varnished outcrops.

REDWALL LIMESTONE: lower thick bedded light grey limestone and dark grey dolomite form prominent bands; upper massive cherty light grey limestone, variably dolomitized; variably preserved crinoid grainstone at top; local thin karst breccia at base; karsted zone at top.

MARTIN FORMATION: brown, grey and tan dolomite and dolomitic limestone; chocolate brown sandy beds at base; one or two coarse, very poorly sorted sandstone beds in section; carbonate beds laminated, massive and mottled.

ABRIGO FORMATION: dark grey, maroon and grey green sandy shale, contact gradational at base; bioturbation in some thin siltstone beds.

BOLSA QUARTZITE: maroon grey feldspathic sandstone; grit and pebble conglomerate at base; medium to fine grained sandstone with siltstone partings up section; planar tabular cross beds common.

PRECAMBRIAN QUARTZ MONZONITE.

FIGURE 4. STRATIGRAPHIC COLUMN

cut by the Needle fault, it lies on quartz monzonite west of the fault and on Paleozoic limestone east of the fault, requiring movement on the Needle fault before the breccia developed. The two faults thus have overlapping periods of activity.

TECTONIC INTERPRETATIONS AND DISCUSSION

The geologic history of the Little Harquahala Mountains begins in the Proterozoic(?) with the deposition of volcanic and sedimentary rocks which were metamorphosed and then intruded by one or more generations of porphyritic granitic rock. During Paleozoic time a cratonic section was deposited. The Coconino sandstone is the only formation that shows evidence of continental deposition. Karst horizons above the Martin Formation and the Redwall Limestone indicate periods of subaerial erosion, but there is no evidence of major Paleozoic orogenic activity.

The presence of chert pebbles and igneous intrusive rock clasts in the basal Mesozoic section implies a period of uplift and locally extensive erosion following deposition of the Kaibab Limestone. Preservation of several hundred feet of Kaibab strata not reported in adjacent areas indicates that the Little Harquahala Mountains were not eroded as deeply as those areas. Mesozoic volcanic rocks, thought to represent the Jurassic arc in this area, thin to the southeast through non-deposition, erosion, tectonic thinning or some combination of these. They are present in the southern Plomosa Mountains (Miller, 1970) but are not exposed and are probably absent in the western Harquahala Mountains. Again, the Little Harquahala Mountains were the site of thicker accumulation than nearby areas. These relations are interpreted to be the result of early Mesozoic high-angle faulting as a result of which the Little Harquahala Mountains occupied a down-dropped block. Activity on these faults during or just after Jurassic(?) volcanic activity suggests that these structures may be related to the Mojave-Sonora megashear, which was also active during or just after Jurassic arc magmatism (Kluth, pers. comm., 1981). Mesozoic(?) lithofeldspathic sandstone was deposited across these older structures, ending the major Phanerozoic period of deposition in the region.

Subsequent history of the study area involves several deformational events but no significant deposition. Large-scale south-vergent folds are believed to be correlative with similar structures observed in the western Harquahala Mountains (Varga, 1977; Reynolds, Keith and Coney, 1980). Similar fold structures are known in the Big Maria (Krummenacher et al., 1981); Little Maria (Emerson, 1981); Old Woman (Howard, 1981); and Clark Mountains (Burchfiel and Davis, 1971) of California. Folds in the Harquahala Mountain area may represent the eastern termination of a belt of middle Mesozoic compressional structures characterized by large-scale basement involved folding.

Folds with steep north-northeast plunging axes have not been reported in adjacent areas. They are similar to drag structures expected along strike-slip faults, but the absence of complementary folds on the opposite side of appropriately oriented structures is not consistent with this hypothesis. These folds remain an enigma.

The Hercules thrust is pre-Late Cretaceous in age. Correlation of fabrics from the Harquahala Mountains and the Granite Wash Mountains suggests that low-angle faults which place Precambrian on Paleozoic rocks are truncated by the Granite Wash Granodiorite (S. Reynolds, pers. comm., 1981), which has yielded K-Ar biotite ages of 65 and 69 m.y. (Damon, 1968; Eberly and Stanley, 1978). Biotite from sheared granite directly above the Hercules thrust in the northern Little Harquahala Mountains yielded a K-Ar age of 66 m.y. (Rehrig and Reynolds, 1980). The amount and direction of tectonic transport are not known. The presence of older structures mentioned above may have provided enough relief on the basement surface that great vertical throw was not required to place Precambrian on Mesozoic rocks in the Late Cretaceous. However, the difference in Mesozoic clastic rocks above and below the fault requires significant lateral transport.

Northwest-dipping normal-separation faults cutting the Paleozoic section are subject to various interpretations. Apparent north to northwest transport is more consistent with northerly transport directions indicated for Late Cretaceous thrust faults in the western Harquahala Mountains (Reynolds, Keith and Coney, 1980) than with regional northeast extension indicated by extensive southwest-dipping mid-Tertiary strata in the area (Rehrig, Shafiqullah and Damon, 1980; Scarborough and Wilt, 1979). Interpretation as thrust faults requires post-thrust northwest tilting of the faults. The northeast-trending arch, which now forms the Harquahala Mountains (Reynolds, this volume), provides a possible means to achieve this tilting. However, independent evidence for extension of this arch into the Little Harquahala Mountains presently is lacking. I have chosen to interpret these faults as mid-Tertiary normal faults because of their complex, discontinuous geometry, association with highly brecciated tear-like faults and absence of undeformed crosscutting dikes.

The relationship between the Hercules thrust and the Sore Fingers fault is a key problem. The attitude of the Sore Fingers fault, its brecciated character and the probable younger on older juxtaposition suggest that it is correlative with the northwest-dipping normal-separation faults. Rock assemblages which are lithologically similar to the Sore Fingers Complex or which are similarly altered are unknown in the Little Harquahala, Harquahala and Granite Wash Mountains. A major hidden contact between the Sore Fingers Complex and the Harquar section below the Hercules thrust is necessary. Considering the altered condition and probable depth of intrusion of the coarse crystalline rocks of the Sore Fingers Complex and the unmetamorphosed character of the Harquar section, a buried unconformity or fault is the most probable candidate. Further mapping in the area is required to resolve this problem.

North- to northwest-trending oblique- or strike-slip faults are Tertiary(?) in age. The Needle fault cuts east-dipping Tertiary(?) gravel north of the Needle. This assignment requires that the brecciated zone associated with the Needle fault is Tertiary(?) as well.

In summary, structures in the Little Harquahala Mountains are interpreted to indicate Mesozoic high-angle faulting, southeast-vergent folding, folding about steep north-northeast plunging axes and Late Cretaceous thrust faulting. These structures are overprinted and obscured by chaotic Tertiary structures including early northeast-trending northwest-dipping normal-separation faults and later north- to northwest-trending strike- or oblique-slip faults.

ACKNOWLEDGEMENTS

I would like to thank Peter Coney, Bill Dickinson and Steve Reynolds, who introduced me to the geology of west central Arizona, for their encouragement, assistance, and hours of discussion. Conversations with Lucy Harding, Stan Keith and Rick Leveque have been a continuing source of inspiration. Field assistance, moral support and a stream of ideas were provided by Dawn Harvey, Kerry Inman, Bill Jefferson and Nancy Riggs. Financial support was provided by GSA Grant #270880, NSF Grant #8018500, awarded to Peter Coney and Lucy Harding, and a research assistantship from the Arizona Bureau of Geology and Mineral Technology. This paper was reviewed by S. Calvo, W. R. Dickinson, K. F. Inman, W. S. Jefferson, T. Lawton and N. Riggs.

REFERENCES

Burchfiel, B. C. and Davis, G. A., 1971, Clark Mountain thrust complex in the Cordillera of Southeastern California, in Elders, W. A. (ed.), Geological Excursions in Southern California: Univ. Calif., Riverside, Campus Museum Contrib., no. 1, p. 1-28.

Damon, P. E., 1968, Correlation and chronology of ore deposits and volcanic rocks, in Annual Progress Report COO-689-100, Contract AT(11-1)-689 to U.S. Atomic Energy Commission: University of Arizona, Geochronology Labs, Tucson, 75 p.

Eberly, L. D. and Stanley, T. D., Jr., 1978, Cenozoic stratigraphy and geologic history of southwestern Arizona: Geol. Soc. America Bull., v. 89, p. 921-940.

Emerson, W. S., 1981, Mesozoic and Cenozoic deformation and igneous activity in the Little Maria Mountains, Riverside County, California (abs.), in Tectonic Framework of the Mojave and Sonoran Deserts, California and Arizona: U.S. Geol. Survey, Open-file Rpt. 81-503.

Howard, K. A., 1981, Mesozoic framework of the southeastern Mojave Desert region, California: Geol. Soc. America, Abstr. with Program, v. 13, p. 62.

Krummenacher, D. et al., 1981, Middle Mesozoic compressional tectonics and Tertiary extensional overprint in the Big Maria, Little Maria, Riverside, and Arica Mountains and Palen Pass areas of Riverside County, California: Geol. Soc. America, Abstr. with Programs, v. 13, p. 492.

Miller, F. K., 1970, Geologic map of the quartzite quadrangle, Yuma County, Arizona: U.S. Geol. Survey Geologic Quad. Map GQ-841, 1:62,500.

Rehrig, W. A. and Reynolds, S. J., 1980, Geologic and geochronologic reconnaissance of a northwest-trending zone of metamorphic core complexes in southern and western Arizona: Geol. Soc. America, Mem. 153, p. 131-157.

Rehrig, W. A., Shafiqullah, M. and Damon, P. E., 1980, Geochronology, geology and listric normal faulting of the Vulture Mountains, Maricopa County, Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 89-110.

Reynolds, S. J., 1980, Geologic framework of west-central Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 1-16.

Reynolds, S. J., Keith, S. B. and Coney, P. J., 1980, Stacked overthrusts of Precambrian crystalline basement and inverted Paleozoic sections emplaced over Mesozoic strata, west central Arizona: Ariz. Geol. Soc. Digest, v. 12, p. 45-52.

Scarborough, R. and Wilt, J. C., 1979, A study of uranium favorability of Cenozoic sedimentary rocks, Basin and Range province, Arizona, Part I, General geology and chronology of pre-late Miocene Cenozoic sedimentary rocks: Ariz. Bur. Geol. Min. Tech., Open-file Rpt. 79-1 or U.S.G.S. Open-file Rpt. OFR-79-1429, 101 p.

Varga, R. J., 1977, Geology of the Socorro Peak Area, western Harquahala Mountains: Ariz. Bur. Geol. Min. Tech., Circ. 20, 20 p.

Corporate Structure

Public Offering: By 20Apr83 prospectus registered 10Jun83 with B.C.Sup't. of Brokers, Can-Ex Resources Ltd. are offering 600,000 common shares at $1 each to net 90¢ for a total of $540,000.

Incorporated: B.C., 20Sep82.

Head Office: Box 12542, 2580-1066 W.Hastings St., Vancouver.

Reg.Office: 1400-1030 W.Georgia St., Vancouver

Registrar & Tsf. Ag: Guaranty Trust Company

Authorized Capital: 10,000,000.

Shares Issued:

For $150,150 at 15¢	1,001,000
For property	750,000
Offered by 20Apr83 prospectus	600,000
	2,351,000

Escrow & Pooled Shares: 750,000 escrowed; 1,001,000 pooled for release 25% on V.S.E. listing day and 25% each 3 months thereafter.

Directors: Garry Anselmo, president, Richmond B.C.; David Chowen, secretary, Richmond, B.C.; Robert Morgan, Vancouver, B.C.; Peter Frohloff, Delta, B.C.

Principal Shareholder: Garry Anselmo with 700,000 shares.

ONE B.C. SILVER PROPERTY AND FOUR ARIZONA GOLD PROJECTS FUNDED BY PROSPECTUS

The issuer is the sole owner of the American Boy Property which comprises 14 contiguous mineral claims located in the Omenica Mining Division, B.C. Can-Ex acquired this property by agreement dated 30Sep82 from Tri-Con Mining Ltd. at a cost of $21,415, an undivided one-half of 750,000 escrowed shares, and a royalty of 5% of the net smelter returns. Can-Ex is required to perform annual assessment work.

A report P.E. Fox, P.Eng., dated 6Oct82 stated the prospect comprises eight silver-bearing veins explored and developed at various times since 1911. The veins range from 10 centimeters to 1.5 meters thick within which ore-grade material is developed in narrow shoots up to 30 meters wide. Mr. Fox recommends an exploration program consisting of grid preparation, geological mapping, geochemical soil survey, EM-16 survey, backhoe trenching, diamond drilling and assaying at a cost of $160,000. The two diamond drill holes comprising 320 meters of drilling are proposed to test the high grade shoot in the #4 vein.

By an agreement with Tri-Con Mining Ltd., dated 30Sep82, Can-Ex acquired all of the outstanding shares of Can-Ex Resources (U.S.) Inc. which company holds options to purchase the Pump, Gold Crown, Overshot and Gold Hill West prospects situated in Arizona, U.S.A. The cost to the issuer of these four properties was $129,603, an undivided one half interest in 750,000 escrowed shares and a royalty equal to 5% of the net smelter returns.

The Pump prospect consists of 18 contiguous mining claims located in the Big Horn District, Maricopa county. During 1981, Tri-Con Mining Ltd. carried out an extensive exploration program which yielded a successful test on 2,500 tons of material. From these pilot operations gold to value of $21,748 was recovered. Numerous assays obtained by various operators and consulting geologists range from 0.003 oz./ton to 1.305 oz./ton gold. Mr. Fox in his report dated [illegible]Oct82, recommends a two stage work program consisting of geological mapping, EM-16 surveys, sampling, and diamond drilling at a cost of $95,000.

The Gold Crown prospect consists of 10 contiguous mining claims located in the Big Horn District, Maricopa county. Mr. Fox in his report dated 14Oct82 recommends a program of geological mapping, EM-16 surveys and a limited percussion or rotary drill program at a cost of $31,500.

The option agreement for both the Pump and Gold Crown prospect is for a term of 15 years from 19May81, monthly payments of $372 and a royalty of 7.5% of the proceeds from the sale of all ores, minerals or other materials recovered from the property.

The Overshot prospect consists of 8 contiguous mining claims located in the Ellsworth Mining Division, Yuma county. The prospect comprises numerous pits and small shafts, now largely caved or slumped. Assays of the mineralized zone range from 0.003 oz./ton to 0.030 oz./ton gold. A recent heap-leach operation indicated a grade of 0.030 oz./ton gold for the material mined. Mr Fox in his report dated 19Oct82 recommends a limited program of geological mapping and geophysical work with follow-up trenching at a cost of $16,000.

The Gold Hill West prospect consists of 30 mining claims located in the Ellsworth Mining District, Yuma county. During 1981 Tri-Con Mining Ltd. carried out an exploration program consisting of sampling, mapping, trenching and diamond drilling at a cost of $5,746. Gold occurs in several shear zones 0.5 to 1.2 meters thick and up to 35 meters long. Assays of this vein material range from 0.01 oz./ton to 0.33 oz./ton gold. Mr. Fox in his his report dated 18Oct82 recommends a program consisting of geological mapping, sampling and drilling at a cost of $107,500.

The option agreement for both the Overshot and Gold Hill West prospects is for a term of 15 years from 22Sep82 and 20May81 respectively, monthly payments of $1,240 and a royalty of 7.5% of the proceeds from the sale of all ores, minerals or other materials recovered from the property.

Ellsworth District, Table 4 Cont.

MINING DISTRICT AND MINES	LOCATION T.	R.	Sec.	MINERAL PRODUCTS	GEOLOGY	TYPE OF OPERATION AND PRODUCTION	REFERENCES
*17. Yuma Mine (Ironwood & Arizona Dev. Co., Yuma Copper Co., Spry, Liberator Mines Co., Snyder, Minerals Corp. of America, So. Calif. Chemical Co.)	6N	14W	SE¼ 19 NE¼ 30 Protracted	Cu, Ag, Au, Fe	Mostly oxidized copper mineralization in contact metamorphosed limestone beds in metamorphosed Mesozoic sediments intruded by Laramide granite and cut by acidic and basic dikes. Strong iron gossans from primary magnetite and pyrite, with quartz stringers, calcite, and contact metamorphic minerals. Wall rocks fractured and strongly chloritized and epidotized.	Shaft, tunnel, and open cut workings. Prospected and mined intermittently but mainly from 1942 through 1963, producing some 8600 tons of ore averaging about 2.3% Cu, 0.3 oz. Ag/T, and 0.03 oz. Au/T.	Copper Handbook, 1909 Bancroft, 1911, p. 95-97 ABM file data
Totally withdrawn IX. Fortuna District (Central and Southern Gila Mountains) Figure 2	9S-11S	19W-20W	---	Au, Ag, Cu-, Mica-, Fe-, Mn-, W-, (Be, Ta, Nb; Th, Rare Earths)	1. Free gold, often with minor copper mineralization and pyrite, with a gangue of quartz, calcite, iron oxides, and manganese oxides, in irregular, lensing veins in fault and fracture zones in Mesozoic schist. Some traces of tungsten. 2. Muscovite mica and samarskite in irregular pegmatites in small intrusive of Laramide granite (T 10S, R 20W, N cen. sec. 22, protracted). 3. Placer gold, mainly from old tailings.	One major shaft mine and several small prospects worked sporadically from the early 1890's to about 1951. Estimated and recorded production would be some 213,500 tons of ore, almost all from the Fortuna mine, containing about 134,429 ounces of gold, 10,650 ounces of silver and 98 pounds of copper. Sporadic placer operations, mainly on old tailings of the Fortuna mine, yielded about 60 ounces of gold with some minor silver. There has been no commercial production of mica or other rarer minerals from the pegmatites.	Blake, 1897, 1898 Wilson, 1933, p. 181-202; 1934 (rev. 1967), p. 151-156 ABM file data
1. Fortuna mine (La Fortuna Gold Mg. & Mllg. Co., Fortuna Mines Corp., Elan Mg. Co., McDaniels & Harrison, Enderton, Holmes & Nichelson, Wish Mg. & Mllg. Co., Maitland, Burton)	10S	20W	N Cen 21 Protracted	Au, Ag, Fe, Cu-	Free gold with silver in rounded grains and as thin irregular veinlets with limonite or pyrite, with traces of copper, in fractured quartz in a branching chimney-like ore body along a fissure zone in Mesozoic schist. Wall rocks are carbonatized and silicified. Many branching and intersecting faults.	Shaft mining operations, mainly from 1896 through 1904, and sporadically up into 1941. Total estimated and recorded production would be some 213,000 tons of ore averaging about 0.63 oz. Au/T, 0.05 oz. Ag/T and a few pounds of copper.	Blake, 1897, 1898 Wilson, 1933, p. 189-199; 1934 (rev. 1967), p. 152-155 ABM file data
[illegible]	[illegible]			[illegible]	[illegible] RllW, SW¼ sec. 11; Lucky Strike prospect - T2S, RllW, N cen. sec. 12; and Camp Creek prospect - T2S, RllW, W cen. sec. 1. 2. Irregular bunches of galena, partly oxidized to anglesite and cerussite, with fluorite and quartz, and minor wulfenite and lead oxide, in fractures in a fault zone cutting Precambrian schist with chert bands.	[illegible]	Wilson, 1933, p. [illegible]
XI. Harquahala District (Harquahala and Little Harquahala Mountains) Figure 9	4N-5N	10W-13W	---	Au, Ag, Pb, Cu, W, Fe, Mn, Zn, Ti, Gypsum, Marble, Quartzite	1. Pockety and irregular deposits containing gold with variable amounts of silver, copper, lead, and zinc, associated with iron oxides and gypsum where oxidized and auriferous pyrite in depth, in brecciated, lenticular, quartz-jasper veins along faults and shear zones cutting tilted, folded, and faulted Paleozoic and possibly Mesozoic and Precambrian metamorphosed formations. Intrusions of Laramide granitic bodies and aplitic and more basic dikes. Strong deformation. 2. Spotty, and mostly minor, tungsten mineralization associated with discontinuous quartz lenses and veins in altered granite and metamorphosed rocks. 3. Gold placer deposits, mainly in gulches in the Little Harquahala Mountains near the Bonanza (Harquahala) mine. 4. Seams and irregular replacement bodies of manganese oxides, often associated with iron oxides, along fracture zones in metamorphosed Paleozoic or Mesozoic limestone.	Numerous large to small mines and prospects worked from shafts, tunnels, adits, and open cuts. Operations date back to 1880's and continued intermittently to recent times. Total estimated and recorded production of precious and base metals would be some 160,000 tons of ore containing about 130,582 ounces of gold, 89,500 ounces of silver, 45 tons of copper, 61 tons of lead and minor zinc. About 615 ounces of placer gold with some silver was produced, mostly prior to 1900. Some 1100 short ton units of tungsten oxide has been reported shipped from the district as well as a few lots of sorted 20% manganese ore. For many years marble and quartzite, mainly for crushed stone, has been quarried. The titaniferous magnetite sand has not been exploited. Some gypsum produced for agricultural use.	Bancroft, 1911, p. 104-115 Wilson, 1934(rev. 1967), p. 128-133; 1961, p. 32 Farnham & Stewart, 1958, p. 83-84 Dale, 1959, p. 3-11 Harrer, 1964, p. 137 Townsend, 1962, p. 18 Funnell & Wolfe, 1964, p. 191 ABM Bull. 180, 1969, p. 376 Varga, 1976 ABM file data

Harquahala District, Table 4 Cont.

MINING DISTRICT AND MINES	LOCATION T	R.	Sec.	MINERAL PRODUCTS	GEOLOGY	TYPE OF OPERATION AND PRODUCTION	REFERENCES
1. Blue Eagle, Bunker Hill, and Four Winds mine group. (Bunker, Stehle, Campbell)	5N	12W	SW¼ 18, NE¼ 19, W Cen 20	Au, Ag, W, Fe, Cu-	1. Pockety and irregular deposits of siliceous gold-silver ore in brecciated quartz lenses and veins, usually associated with iron oxides, in fissure zones cutting Precambrian metamorphic schist, gneiss and quartzite. Minor associated copper. 2. Stringers, blebs, and narrow discontinuous seams of scheelite along cleavage or fissure zones, with quartz, in Precambrian metamorphics.	Shaft, adit, and open cut operations, worked intermittently from the early 1900s through 1956. Production of precious metals, mainly as high silica-gold flux ore, would be some 430 tons averaging about 0.4 oz. Au/T and 0.6 oz. Ag/T. Some 1100 short ton units of 60% WO_3 produced in the 1950s.	Dale, 1959, p. 6-7 ABM file data
2. Bonanza (Harquahala) and Golden Eagle mine group (Hubbard & Bowers, Bonanza Mg. Co., Harqua Hala Gold Mg. Co., Yuma Warrior Mg. Co., Harquahala Operating Co., Bonanza & Golden Eagle Mg. Co., Jones, Oberstine)	4N	13W Protracted	SW¼ 22, NW¼ 27, NE¼ 22	Au, Ag, Pb, Cu, Zn-	Rich, pockety shoots of gold with minor silver in a gangue of iron oxides, shattered quartz, calcite, and gypsum in oxidized zone, above about 300-foot depth, in shear zones and shattered quartzite in strongly folded and faulted Paleozoic sedimentary beds intruded by Laramide quartz monzonite. In depth, gold values mainly in auriferous pyrite with some copper and lead sulfide mineralization, in fracture veins in underlying crushed and fractured quartz monzonite. Veins often flat dipping with larger and richer deposits in the shattered quartzite.	Shaft, tunnel, and open cut operations. Extensive stoping in oxidized zone. Discovered in 1888 and worked intermittently on large scale to 1918. Subsequently on small scale, largely by reworking dumps and tailings, to 1964. Total estimated and recorded production would be some 150,000 tons of ore averaging about 0.85 oz. Au/T, 0.53 oz. Ag/T and minor lead and copper.	Bancroft, 1911, p. 105-109 Wilson, 1934 (rev. 1967), p. 128-131 ABM file data
3. Gold Dyke mine group (Campbell)	4N	13W Protracted	NE¼ 7	W, Au, Ag, Fe, Mn	Small, sporadic pockets of scheelite with iron and manganese oxides in discontinuous quartz veins in extensively fractured Laramide granitic intrusive. Diabase dikes. Some gold mineralization prospected in the veins in early 1900's.	Shallow open cuts, trenches, and shafts. Worked in early 1900's for Au and some ore shipped. In 1951 some 100 short ton units of 60% WO_3 produced.	Dale, 1959, p. 7 ABM file data
4. Gold Leaf, Rattlesnake, and Rosebud mine group (Hudgens, Worcester)	5N	12W	NW¼ 13 13	Au, Ag, Fe, Cu-	Spotty, high-grade gold values with minor copper oxides in lensing quartz, brecciated wall rock, and iron oxides in a shear zone cutting Precambrian granitic gneiss.	Shaft and tunnel workings. Prospected in late 1800's but worked mainly from 1930 through 1941, producing some 400 tons of ore averaging about 0.6 oz. Au/T, 0.2 oz. Ag/T and minor copper.	ABM file data
[illegible] (Hercules Gold Mg. Co., Shanley, McDonald, Rogers & Farrington, Cline & Hurtz, Sharp)	5N	12W	S Cen 18	Au, Ag, Cu, Fe	Gold and silver mineralization, with local copper, in brecciated, discontinuous, banded, quartz-jasper fissure veins cemented by limonite from oxidation of auriferous pyrite and chalcopyrite. Wall rock is a Precambrian quartz diorite gneiss intruded by quartz diorite dikes and overlain by Precambrian calcareous schist.	Incline shaft, adits, and open cut operations. Worked prior to 1900 and sporadically from 1934 through 1950, producing a total of some 2670 tons of ore and siliceous gold flux averaging about 0.25 oz. Au/T, 0.27 oz. Ag/T, and 1½ tons of copper.	Bancroft, 1911, p. 109-110 Wilson, 1934 (rev. 1967), p. 132 ABM file data
6. Hidden Treasure mine (Magic group; Myers & Lazure, Johnson, Nohlecheck & Hummel, Powell, Kast & Johnson, Howell, Seely & Johnson, Warren, Wilkinson & Walsh, Tulsa Minerals Corp.)	5N	11W	N Cen & NW¼ 29	Au, Ag, Cu-, Pb-, Zn-, Mn-, Fe-	Free gold particles with silver in irregular cellular masses of limonite and calcite, local chrysocolla, oxidized lead and zinc minerals and manganese oxides in seams and tabular replacements along a fault or shear zone in Paleozoic or Mesozoic quartzite and silicified limestone. Wall rock intensely silicified with some sericitization.	Shaft, tunnel, and open cut workings. Located in 1932 and mined somewhat sporadically through 1967, producing some 1775 tons of ore averaging about 0.95 oz. Au/T, 3.9 oz. Ag/T and minor Cu, Pb, and Zn. In 1953-1954, several small lots of 20% Mn shipped to Wendon stockpile.	Wilson, 1934 (rev. 1967), p. 133 Farnham & Stewart, 1958, p. 83 ABM file data
7. Mars & Mescal mine group (Old Noel; Nuevo Mundo Mountain Mines, Jerome Wenden Copper Co.)	5N	11W	NW¼ 19	Cu, Au, Ag, Fe	Irregular lenses of oxidized copper mineralization with silver and gold, in brecciated diorite, cherty limestone and heavy batches of iron oxides, along a fissure zone bordering a diorite dike in a complex Precambrian granite-schist alternating with altered distorted Paleozoic or Mesozoic limestone. Series of northwest-striking diorite dikes along fissure zone.	Tunnel operations, mainly in 1916 through 1918, producing some 110 tons of ore averaging about 11% Cu, 0.15 oz. Au/T and 0.3 oz. Ag/T.	ABM file data
8. Rio del Monte mine (Rio del Monte Mg. Co., McCauley & Orberg, Rio del Monte Mines Inc.)	4N	13W Protracted	SE¼ 4	Au, Ag, Cu, Pb, Zn, Fe	Lenticular shoots of quartz and limonite containing oxidized copper minerals and gold, and lenses and pods of partly oxidized lead and zinc mineralization in vuggy quartz, in irregular veins cutting Precambrian granitic-gneiss capped by some volcanic flows.	Shaft operations. Known as early as 1899 but worked mainly, intermittently, from 1913 through 1949, producing some 350 tons of ore averaging about 0.23 oz. Au/T, 0.7 oz. Ag/T, 0.3% Cu and 0.2% Pb. Zn not recovered.	ABM file data

northwest (southeast-directed subduction) if the chemical trends reflect the approximate geometry of a paleosubduction zone. This zone is on the opposite side of the arc from the position generally assumed, indicating that the Jurassic plutonic rocks were not generated in response to classical Andean-type convergent plate margins. The magmatic arc probably formed in an intraocean enviroment and subsequently was rafted northward and accreted to this part of the northern Pacific rim during the late Mesozoic. Middle and Upper Jurassic clastic sediments underlying Cook Inlet to the southeast, and derived from the magmatic arc, are classified as backarc deposits rather than an arc-trench gap sequence.

GEOCHRONOLOGY AND TECTONIC EVOLUTION OF THE PRIEST RIVER CRYSTALLINE/METAMORPHIC COMPLEX OF NORTHEASTERN WASHINGTON AND NORTHERN IDAHO

REHRIG, William A., Geologic Studies Grp, Phillips Petr. Co., 8055 Tufts Ave Pkwy, Dnv, CO 80237; REYNOLDS, Stephen J., Ariz. Bur. Geol. & Mineral Tech., Tucson, AZ 85719; ARMSTRONG, Richard Lee, Dept. of Geologic Sciences, Univ. of Vancouver, B.C., Canada V6T 2B4

The Priest River complex straddling the Idaho-Washington border shares many similarities with the Kettle and Okanogan metamorphic core complexes farther west. Continued regional work indicates that an intricate sequence of plutonic, metamorphic and deformational events ranging in age from Precambrian to early Tertiary has affected the Priest River terrain. Decifering the absolute chronology of this history is made difficult because of a widespread Eocene thermal event which correlates with mylonization and cataclasis along the Newport detachment fault. Recent study revealing progressively more brittle mylonitic textures, slickensiding, and incipient chloritic breccia (near Rathdrum) along the complex's eastern margin with the Purcell Trench and Coeur d'Alene Lake suggest the presence of a detachment fault analogous to the Newport structure.

Lineation in gently east-dipping mylonitic rocks along the east edge of the Priest River complex trends N70-80°E. This deformational fabric apparently has been superimposed upon an earlier (Cretaceous?) metamorphic fabric with N50-60°E lineation. Isotopic and structural evidence suggests that both low-angle foliations have resulted from the transposition of high-angle, NE-trending, metamorphic fabrics in pre-Belt gneisses. This ancestral structural grain remains adjacent to the Newport fault on the west and southwest.

Results of new Rb-Sr and U-Pb dating on gneissic and intrusive rocks critical to unraveling the sequence of metamorphic, intrusive and mylonitic events will be discussed.

NAMING FOSSIL SOILS IN PALEOENVIRONMENTAL RECONSTRUCTIONS

RETALLACK, Greg J., Department of Geology, University of Oregon, Eugene, OR 97403

Fossil soils (paleosols) have been extensively used for stratigraphic correlation, and have usually been called "soils," and (perhaps more appropriately) "geosols" or "pedoderms." In each of these cases the named object was a traceable ancient land surface, with its catenae of different kinds of soils varying laterally according to regional differences in climate, organisms, parent material, topography and time of formation.

A different system of naming is required for the paleoenvironmental interpretation of different kinds of fossil soils, either laterally within an ancient land surface or on successive ancient land surfaces within a stratigraphic section. I propose extending the standard soil mapping units of the U.S. Department of Agriculture to the naming of fossil soils. These units are named after localities, for example the Avalon Series paleosols. Specific paleosols are named from the texture of their A horizon, *e.g.* the Avalon silt loam paleosol, or named from other features. These names are non-interpretative mapping units independent of genetic classifications of modern soils.

Named and described fossil soils are then open to interpretation. The effects of diagenesis after burial of the soil must be carefully considered. The remaining non-diagenetic features of fossil soils may provide evidence for past climate, topographic position, depth to water table and its chemistry, vegetation, fauna and rates of sedimentation, subsidence and uplift.

Such a system of naming has proved useful for the paleoenvironmental interpretation of Triassic paleosols from near Sydney, Australia, and of Late Eocene and Oligocene paleosols from Badlands National Park, South Dakota. These paleosols will be discussed as examples.

SUPERIMPOSED MESOZOIC AND CENOZOIC TECTONICS, WEST-CENTRAL ARIZONA

REYNOLDS, Stephen J., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719

Mountain ranges around Salome, Arizona contain evidence for a complex superposition of Mesozoic and Cenozoic tectonism. The main tectonic events are listed below in apparent chronologic order from oldest to youngest: 1) Deposition of middle Mesozoic volcanic and volcaniclastic rocks; 2) Deposition of thick sequences of Mesozoic clastic rocks; 3) Formation of major northeast-trending, southeast-vergent folds that overturn much of the Paleozoic and Mesozoic section in the Little Harquahala and western Harquahala Mountains; 4) Possible emplacement of thrust sheets in the Granite Wash Mountains; 5) Late Cretaceous plutonism, locally accompanied by high-grade metamorphism and northeast-vergent ductile deformation in the Harcuvar and Harquahala Mountains; 6) Major north-vergent thrusting that emplaced Precambrian crystalline basement over Paleozoic and Mesozoic rocks in the Little Harquahala and Harquahala Mountains; 7) Intrusion of Eocene (?) muscovite granites discordantly across fabrics related to events 5 and 6, accompanied by cooling of metamorphic and plutonic rocks in the western Harcuvar and Granite Wash Mountains; 8) Intense mylonitization that produced a gently dipping foliation and conspicuous, east-northeast trending lineation; 9) Intrusion of post-mylonitization microdiorite dikes at 25 m.y.B.P.; 10) East-northeast-directed detachment faulting (from ? to 15 m.y.B.P.) accompanied by antithetic rotation of upper-plate rocks, by uplift and cooling of lower-plate mylonitic rocks, and possibly by formation of large east-northeast-trending anticlines and synclines that define the present physiography of the region; and 11) Formation of Basin and Range(?) high-angle faults.

LATE CRETACEOUS-EARLY TERTIARY PERALUMINOUS GRANITOIDS OF ARIZONA - CALIFORNIA AND THEIR RELATED MINERAL DEPOSITS

REYNOLDS, Stephen J., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719; KEITH, Stanley B., 2748 E. 9th St., Tucson, AZ 85713; DEWITT, Ed, M.S. 905, U.S. Geological Survey, Denver, CO 80225

Peraluminous granitoids of Late Cretaceous to early Tertiary age in Arizona and southeastern California 1) contain primary muscovite and garnet; 2) have well-developed pegmatitic, alaskitic, and aplitic phases; 3) are highly silicic with SiO_2 >65%; and 4) postdate typical Laramide, metaluminous plutons. They are markedly depleted in the lithophile elements K, Rb, U, Th, and Li when compared to peraluminous, muscovite-bearing granitoids of Eurasia that commonly contain significant U, Sn, W, Mo, Be, Li, and F mineralization. Most peraluminous granitoids of Arizona and California are not associated with significant mineral deposits. Commercial W mineralization occurs in the wall rocks adjacent to several plutons, and Mo, Be, and Li minerals occur locally, but are not presently commercial. The Arizona-California granitoids, like their world-wide counterparts, have relatively high Sr^{87}/Sr^{86} initial ratios (>.710), indicating that they contain a significant crustal component. The regional variations in lithophile content of the granitoids may reflect differences in composition of the underlying crust. If so, deep crustal materials beneath Arizona and southeastern California were greatly depleted in most lithophile elements before the peraluminous granitoids were produced. As we have suggested previously, the Arizona-California lower crust may have been depleted by an episode of anatexis that produced the voluminous 1.45 b.y.-old granites. Alternatively, the chemical differences between the Arizona-California and Eurasian granitoids may be partly a reflection of their different tectonic settings. Specifically, the Arizona-California granitoids were produced during an episode of low-angle subduction, whereas the Eurasian granitoids resulted from continental collision.

STRUCTURE AND STRATIGRAPHY OF THE LITTLE HARQUAHALA MOUNTAINS, YUMA COUNTY, ARIZONA

RICHARD, Stephen, M. Laboratory of Geotectonics, Department of Geosciences, University of Arizona, Tucson, Arizona, 85721

A continuous Paleozoic to Mesozoic depositional sequence is exposed in the southern Little Harquahala Mountains. The Paleozoic section is approximately 1000 m thick and is correlative with the lower Paleozoic Bolsa, Abrigo and Martin Formations of southeast Arizona, and the upper Paleozoic Redwall, Supai, Coconino and Kaibab Formations of the Colorado Plateau. This Paleozoic section is depositionally overlain by a lithologically varied Mesozoic (?) section composed of up to 1000 m of rhyodacitic volcanic and volcaniclastic rocks, capped by a minimum of 1100 m of arkose. Dips within the section increase northward (down-section) from 50°S to vertical and overturned. The large-and small-scale structures indicate the presence of a major SSE-vergent fold. Regional relationships suggest that the fold is cut off at its base by sub-horizontal faults. North-dipping faults cut the Paleozoic rocks and have northerly tectonic transport, locally placing Paleozoic rocks over Precambrian granite. At the southern end of their exposure, Mesozoic rocks overlie a complex assemblage of intrusive and metamorphic rocks along a low-angle fault. No tectonites or lineated rocks are present in the lower plate. East-dipping faults associated with intense brecciation cut all other low-angle faults in the Paleozoic rocks. The youngest faults are north-to northwest-trending, oblique-slip faults which locally involve Tertiary (?) gravel. Clockwise oroclinal bending of the sedimentary rocks accompanied this faulting. Structures in the Little Harquahala Mountains are apparently the result of superimposed Mesozoic to Recent compressional, extensional and wrench tectonics.

A MODEL FOR GAHNITE AND MAGNETITE FORMATION DURING METAMORPHISM OF SULFIDE-RICH ROCKS

RIRIE, G. Todd, Union Oil Research, P.O. Box 76, Brea, CA 92621

Studies of four Precambrian Pb-Zn-Cu sulfide deposits from central Colorado reveal that each contain the minerals gahnite ($ZnAl_2SiO_4$) and magnetite. These deposits have been regionally metamorphosed to the amphibolite facies with the ore minerals displaying recognizable metamorphic textures. This suggests that the sulfides formed early (premetamorphic) within the host pelitic schists, probably originating as disseminated sulfides within black shales. Many previous investigators have evaluated these deposits as hydrothermal and magmatic in origin.

Regional metamorphism to the amphibolite facies produced reactions, northwest (southeast-directed subduction) if the chemical trends reflect the approximate geometry of a paleosubduction zone. This zone is on the opposite side of the arc from the position generally assumed, indicating that the Jurassic plutonic rocks were not generated in response to classical Andean-type convergent plate margins. The magmatic arc probably formed in an intraocean enviroment and subsequently was rafted northward and accreted to this part of the northern Pacific rim during the late Mesozoic. Middle and Upper Jurassic clastic sediments underlying Cook Inlet to the southeast, and derived from the magmatic arc, are classified as backarc deposits rather than an arc-trench gap sequence.

GEOCHRONOLOGY AND TECTONIC EVOLUTION OF THE PRIEST RIVER CRYSTALLINE/METAMORPHIC COMPLEX OF NORTHEASTERN WASHINGTON AND NORTHERN IDAHO

REHRIG, William A., Geologic Studies Grp, Phillips Petr. Co., 8055 Tufts Ave Pkwy, Dnv, CO 80237; REYNOLDS, Stephen J., Ariz. Bur. Geol. & Mineral Tech., Tucson, AZ 85719; ARMSTRONG, Richard Lee, Dept. of Geologic Sciences, Univ. of Vancouver, B.C., Canada V6T 2B4

The Priest River complex straddling the Idaho-Washington border shares many similarities with the Kettle and Okanogan metamorphic core complexes farther west. Continued regional work indicates that an intricate sequence of plutonic, metamorphic and deformational events ranging in age from Precambrian to early Tertiary has affected the Priest River terrain. Decifering the absolute chronology of this history is made difficult because of a widespread Eocene thermal event which correlates with mylonization and cataclasis along the Newport detachment fault. Recent study revealing progressively more brittle mylonitic textures, slickensiding, and incipient chloritic breccia (near Rathdrum) along the complex's eastern margin with the Purcell Trench and Coeur d'Alene Lake suggest the presence of a detachment fault analogous to the Newport structure.

Lineation in gently east-dipping mylonitic rocks along the east edge of the Priest River complex trends N70-80°E. This deformational fabric apparently has been superimposed upon an earlier (Cretaceous?) metamorphic fabric with N50-60°E lineation. Isotopic and structural evidence suggests that both low-angle foliations have resulted from the transposition of high-angle, NE-trending, metamorphic fabrics in pre-Belt gneisses. This ancestral structural grain remains adjacent to the Newport fault on the west and southwest.

Results of new Rb-Sr and U-Pb dating on gneissic and intrusive rocks critical to unraveling the sequence of metamorphic, intrusive and mylonitic events will be discussed.

NAMING FOSSIL SOILS IN PALEOENVIRONMENTAL RECONSTRUCTIONS

RETALLACK, Greg J., Department of Geology, University of Oregon, Eugene, OR 97403

Fossil soils (paleosols) have been extensively used for stratigraphic correlation, and have usually been called "soils," and (perhaps more appropriately) "geosols" or "pedoderms." In each of these cases the named object was a traceable ancient land surface, with its catenae of different kinds of soils varying laterally according to regional differences in climate, organisms, parent material, topography and time of formation.

A different system of naming is required for the paleoenvironmental interpretation of different kinds of fossil soils, either laterally within an ancient land surface or on successive ancient land surfaces within a stratigraphic section. I propose extending the standard soil mapping units of the U.S. Department of Agriculture to the naming of fossil soils. These units are named after localities, for example the Avalon Series paleosols. Specific paleosols are named from the texture of their A horizon, *e.g.* the Avalon silt loam paleosol, or named from other features. These names are non-interpretative mapping units independent of genetic classifications of modern soils.

Named and described fossil soils are then open to interpretation. The effects of diagenesis after burial of the soil must be carefully considered. The remaining non-diagenetic features of fossil soils may provide evidence for past climate, topographic position, depth to water table and its chemistry, vegetation, fauna and rates of sedimentation, subsidence and uplift.

Such a system of naming has proved useful for the paleoenvironmental interpretation of Triassic paleosols from near Sydney, Australia, and of Late Eocene and Oligocene paleosols from Badlands National Park, South Dakota. These paleosols will be discussed as examples.

SUPERIMPOSED MESOZOIC AND CENOZOIC TECTONICS, WEST-CENTRAL ARIZONA

REYNOLDS, Stephen J., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719

Mountain ranges around Salome, Arizona contain evidence for a complex superposition of Mesozoic and Cenozoic tectonism. The main tectonic events are listed below in apparent chronologic order from oldest to youngest: 1) Deposition of middle Mesozoic volcanic and volcaniclastic rocks; 2) Deposition of thick sequences of Mesozoic clastic rocks; 3) Formation of major northeast-trending, southeast-vergent folds that overturn much of the Paleozoic and Mesozoic section in the Little Harquahala and western Harquahala Mountains; 4) Possible emplacement of thrust sheets in the Granite Wash Mountains; 5) Late Cretaceous plutonism, locally accompanied by high-grade metamorphism and northeast-vergent ductile deformation in the Harcuvar and Harquahala Mountains; 6) Major north-vergent thrusting that emplaced Precambrian crystalline basement over Paleozoic and Mesozoic rocks in the Little Harquahala and Harquahala Mountains; 7) Intrusion of Eocene (?) muscovite granites discordantly across fabrics related to events 5 and 6, accompanied by cooling of metamorphic and plutonic rocks in the western Harcuvar and Granite Wash Mountains; 8) Intense mylonitization that produced a gently dipping foliation and conspicuous, east-northeast trending lineation; 9) Intrusion of post-mylonitization microdiorite dikes at 25 m.y.B.P.; 10) East-northeast-directed detachment faulting (from ? to 15 m.y.B.P.) accompanied by antithetic rotation of upper-plate rocks, by uplift and cooling of lower-plate mylonitic rocks, and possibly by formation of large east-northeast-trending anticlines and synclines that define the present physiography of the region; and 11) Formation of Basin and Range(?) high-angle faults.

LATE CRETACEOUS-EARLY TERTIARY PERALUMINOUS GRANITOIDS OF ARIZONA - CALIFORNIA AND THEIR RELATED MINERAL DEPOSITS

REYNOLDS, Stephen J., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719; KEITH, Stanley B., 2748 E. 9th St., Tucson, AZ 85713; DEWITT, Ed, M.S. 905, U.S. Geological Survey, Denver, CO 80225

Peraluminous granitoids of Late Cretaceous to early Tertiary age in Arizona and southeastern California 1) contain primary muscovite and garnet; 2) have well-developed pegmatitic, alaskitic, and aplitic phases; 3) are highly silicic with SiO_2 >65%; and 4) postdate typical Laramide, metaluminous plutons. They are markedly depleted in the lithophile elements K, Rb, U, Th, and Li when compared to peraluminous, muscovite-bearing granitoids of Eurasia that commonly contain significant U, Sn, W, Mo, Be, Li, and F mineralization. Most peraluminous granitoids of Arizona and California are not associated with significant mineral deposits. Commercial W mineralization occurs in the wall rocks adjacent to several plutons, and Mo, Be, and Li minerals occur locally, but are not presently commercial. The Arizona-California granitoids, like their world-wide counterparts, have relatively high Sr^{87}/Sr^{86} initial ratios (>.710), indicating that they contain a significant crustal component. The regional variations in lithophile content of the granitoids may reflect differences in composition of the underlying crust. If so, deep crustal materials beneath Arizona and southeastern California were greatly depleted in most lithophile elements before the peraluminous granitoids were produced. As we have suggested previously, the Arizona-California lower crust may have been depleted by an episode of anatexis that produced the voluminous 1.45 b.y.-old granites. Alternatively, the chemical differences between the Arizona-California and Eurasian granitoids may be partly a reflection of their different tectonic settings. Specifically, the Arizona-California granitoids were produced during an episode of low-angle subduction, whereas the Eurasian granitoids resulted from continental collision.

STRUCTURE AND STRATIGRAPHY OF THE LITTLE HARQUAHALA MOUNTAINS, YUMA COUNTY, ARIZONA

RICHARD, Stephen, M. Laboratory of Geotectonics, Department of Geosciences, University of Arizona, Tucson, Arizona, 85721

A continuous Paleozoic to Mesozoic depositional sequence is exposed in the southern Little Harquahala Mountains. The Paleozoic section is approximately 1000 m thick and is correlative with the lower Paleozoic Bolsa, Abrigo and Martin Formations of southeast Arizona, and the upper Paleozoic Redwall, Supai, Coconino and Kaibab Formations of the Colorado Plateau. This Paleozoic section is depositionally overlain by a lithologically varied Mesozoic (?) section composed of up to 1000 m of rhyodacitic volcanic and volcaniclastic rocks, capped by a minimum of 1100 m of arkose. Dips within the section increase northward (down-section) from 50°S to vertical and overturned. The large-and small-scale structures indicate the presence of a major SSE-vergent fold. Regional relationships suggest that the fold is cut off at its base by sub-horizontal faults. North-dipping faults cut the Paleozoic rocks and have northerly tectonic transport, locally placing Paleozoic rocks over Precambrian granite. At the southern end of their exposure, Mesozoic rocks overlie a complex assemblage of intrusive and metamorphic rocks along a low-angle fault. No tectonites or lineated rocks are present in the lower plate. East-dipping faults associated with intense brecciation cut all other low-angle faults in the Paleozoic rocks. The youngest faults are north-to northwest-trending, oblique-slip faults which locally involve Tertiary (?) gravel. Clockwise oroclinal bending of the sedimentary rocks accompanied this faulting. Structures in the Little Harquahala Mountains are apparently the result of superimposed Mesozoic to Recent compressional, extensional and wrench tectonics.

A MODEL FOR GAHNITE AND MAGNETITE FORMATION DURING METAMORPHISM OF SULFIDE-RICH ROCKS

RIRIE, G. Todd, Union Oil Research, P.O. Box 76, Brea, CA 92621

Studies of four Precambrian Pb-Zn-Cu sulfide deposits from central Colorado reveal that each contain the minerals gahnite ($ZnAl_2SiO_4$) and magnetite. These deposits have been regionally metamorphosed to the amphibolite facies with the ore minerals displaying recognizable metamorphic textures. This suggests that the sulfides formed early (premetamorphic) within the host pelitic schists, probably originating as disseminated sulfides within black shales. Many previous investigators have evaluated these deposits as hydrothermal and magmatic in origin.

Regional metamorphism to the amphibolite facies produced reactions,

NICOR MINERAL VENTURES

One of the NICOR basic energy companies

Suite 12 2341 South Friebus Avenue Tucson, Arizona 85713 602-881-8871

August 9, 1985

Mr. Milton Schultz
P. O. Box 25219
Phoenix, AZ 85002

Dear Mr. Schultz:

NICOR Mineral Ventures is a wholly owned subsidiary of NICOR, Inc., which is listed on the New York Stock Exchange. NICOR Mineral Ventures is involved with the exploration and development of metal and industrial mineral properties.

A few weeks ago while working in the Harquahala Mountains area I happened upon your claim area, particularly the Alaska mine. The area impressed me as having some potential for gold mineralization. At the Alaska mine I also noticed a number of drill holes.

Do you have any information on the results of the drilling or any other data which might help us evaluate your claims? Such information will help us determine if your claims would justify further exploration and possibly a lease proposal. Please don't hesitate to call me. Looking forward to your reply.

Sincerely yours,

Gary A. Parkison

GAP/gsl

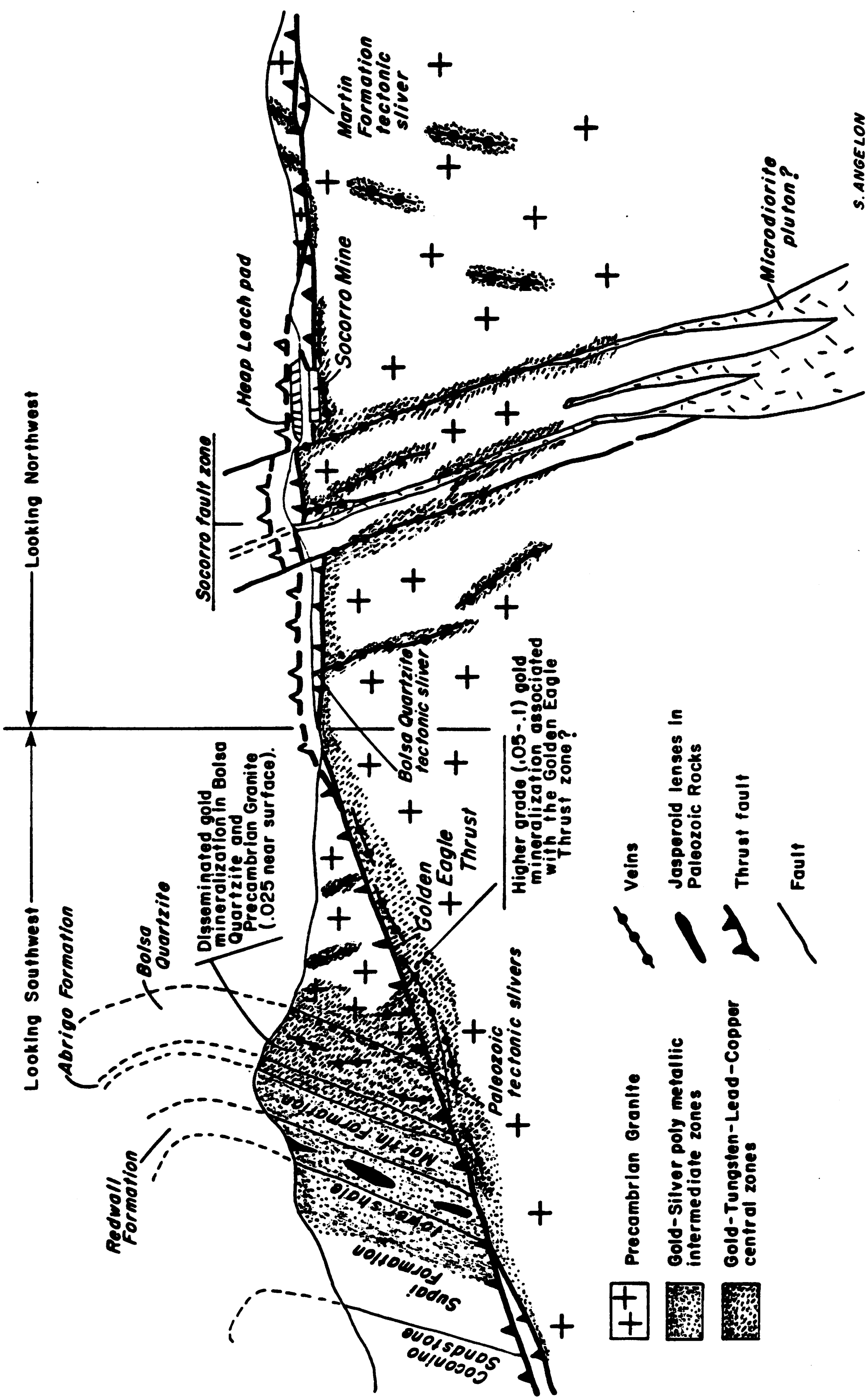
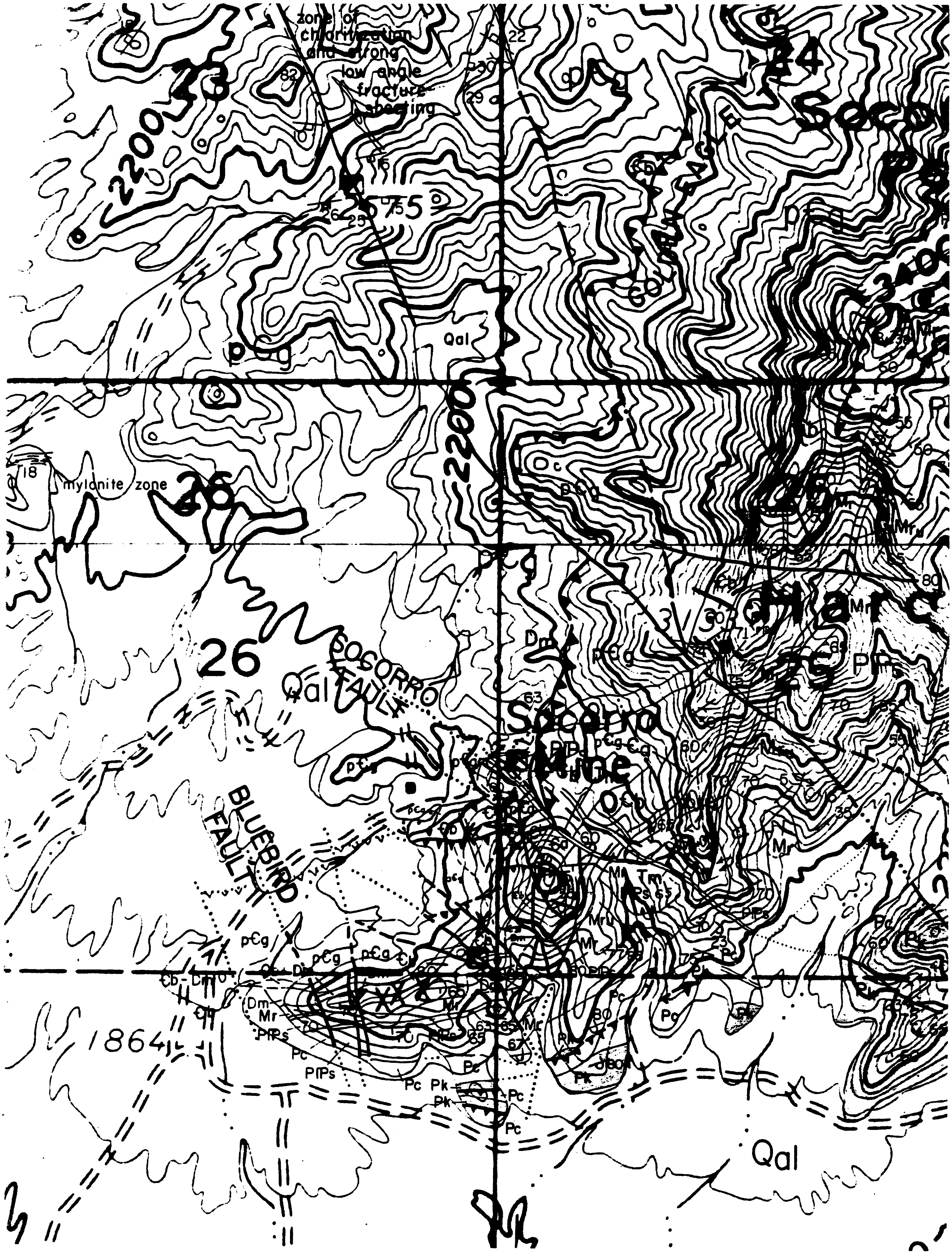


Figure 25. Cross section illustrating exploration model for inferred disseminated gold deposit beneath the Socorro Reef gold anomaly.



zone of chloritization and strong low angle fracture spacing
2200
13
24
pЄg
Qal
mylonite zone
26
SOCORRO FAULT
BLUEBIRD FAULT
Socorro Mine
Dm
Ocb
Mr
PPs
Pc
Pk
1864
Qal

In the southern PRC, the Spokane dome mylonitic zone is 4 km thick, and fades structurally upward and downward into amphibolite-grade metamorphic rocks without a concordant detachment fault or chloritic breccia. Kinematics of the mylonites determined from ubiquitous S and C surfaces and asymmetric porphyroclasts indicate that movement was top-to-the-east on the eastern and western limbs of the dome. Muscovite, sillimanite, and locally andalusite were stable during the later stages of mylonitization. Locally within Spokane dome, thin (0.5 m), top-to-the-west, non-penetrative ductile shears cut the earlier top-to-the-east mylonites and probably correlate with the Newport fault.

Thick, mid-crustal ductile shearing and shallower detachment faulting represent contrasting structural styles in the PRC. Mylonitization may represent Mesozoic intracontinental shearing caused by the accretion of microplates to the west. The Newport fault fits a model of Eocene crustal stretching which accompanied the uplift of the PRC.

MESOZOIC THRUST SHEETS OF THE HARQUAHALA AND LITTLE HARQUAHALA MOUNTAINS, WESTERN ARIZONA

No 65059

RICHARD, Stephen M., Univ. of Calif., Santa Barbara, CA 93117, REYNOLDS, Stephen J., and SPENCER, Jon E., Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719

A basal parautochthon and three overlying, stacked thrust sheets in the western Harquahala (WHM) and Little Harquahala (LHM) Mountains, western Arizona, consist of (in ascending order): (1) quartz-phyric rhyodacite to rhyolite volcanic and hypabyssal rocks overlain by approximately 2 km of feldspathic-lithic, feldspathic, and volcaniclastic sandstone, conglomerate, and siltstone, correlated with the McCoy Mountains Formation (MMF). Volcaniclastic sandstone and andesitic to dacitic volcanic rocks intercalated in the middle part of this section indicate that volcanism continued during deposition of the MMF in this area. (2) heterogeneous igneous and metamorphic rocks overlying the MMF thin from a minimum of 250 m thick in the NE to zero in the SW. (3) Precambrian granitic rocks nonconformably overlain by a complete, cratonic Paleozoic section (1000m) overlain by Jurassic(?) dacite to rhyodacite volcanic rocks (900m) and lithic feldspathic sandstone (750m). Two phases of folding in these rocks predate thrusting: large, NE-trending, subhorizontal folds, overturned to the SE are refolded about steeply-plunging, north-trending axes. Metamorphic grade in the Paleozoic rocks increases from unmetamorphosed in the SW LHM to lower greenschist in the WHM. (4) Precambrian schists and granitic rocks make up the highest thrust sheet.

Schistosity is only weakly developed along faults in the LHM, while thin mylonite zones with N-S-trending stretching lineation are present in the WHM. S-C fabrics within mylonite zones indicate transport of upper plates to the south. These thrusts represent the northeastern edge of the Cordilleran fold-thrust belt in western Arizona, but are unusual because they are directed away from rather than toward the interior of the North American continent.

STRUCTURAL CONFIGURATION OF THE SANTA CLARA AVENUE OIL FIELD, VENTURA BASIN, CALIFORNIA

No 60055

Richards, Matthew E., Dept. of Geology, Oregon State University, Corvallis, Oregon 97331

The nonmarine Sespe Formation of Oligocene age has produced 7 million barrels of oil which is trapped by a Miocene mafic igneous intrusion, which cuts across bedding. Throughout most of the oil field, the Miocene and older beds dip about 15° to 25° northwest. The intrusion is probably related to the outpouring of Conejo Volcanics throughout much of the southern Ventura basin. The Pacific Farms #1 well penetrated 4000 feet of igneous rocks below 5100 feet, whereas wells less than 500 feet to the northwest penetrated Sespe Formation over this interval. The western wall of the intrusive body is located by 10 wells which pass repeatedly through the Sespe - intrusive contact. Structure contours on the intrusive contact with the Sespe on the northwest show that the contact varies from N45°E 85°±20°SE in the southern portion of the field, to N90°E 85°S in the northern end of the field. The southeast wall of the intrusion is not cut by wells, but its location is controlled by a well about 4000 feet southeast of the northwest wall. If the intrusive contact is rotated to its position when it was intruded prior to tilting of the middle and late Miocene Modelo Formation, the Sespe overhangs the igneous body along a contact with paleo-dip of 80°NW. Two wells penetrate large inclusions of Sespe within the intrusion. The cause of lateral closure in the field is not yet known but may be related to early Miocene normal faulting of the Sespe Formation.

STRATIGRAPHY AND GEOLOGIC HISTORY OF THE PAJARITO MOUNTAINS, SANTA CRUZ COUNTY, ARIZONA

No 66905

RIGGS, Nancy, Department of Geosciences, University of Arizona, Tucson, AZ 85721

Detailed geologic mapping in the Pajarito Mountains west of Nogales indicates that rhyolitic crystal tuff exposed in most of the range is Jurassic in age. The stratigraphic section comprises 3000 m of crystal tuff, unconformably overlain by up to 1000 m of Glance-equivalent coarse conglomerate and 200 m of Bisbee Formation sandstone, siltstone, algal limestone, and conglomerate. This package is in fault contact with mid-Tertiary andesitic to rhyolitic flow, tuff, and volcaniclastic sedimentary rocks. Although previous workers have assigned a Cretaceous age to the basal crystal tuff, a pre-earliest Cretaceous age is indicated by the stratigraphic position of the tuff below Glance-equivalent conglomerate. In addition, the presence of locally interstratified cross-bedded arkosic sandstone within the crystal tuff suggests correlation with the early Jurassic Ali Molina Formation.

The geologic history of the Pajarito Mountains begins with Jurassic volcanism between 200-150 m.y. ago, represented by the rhyolitic crystal tuff. High-angle block faulting and erosion of the arc are reflected in the late Jurassic-early Cretaceous coarse conglomerate. Early Cretaceous Bisbee subsidence and sedimentation are represented by probable lake sediments. Thrust faulting and northeast-trending mineralized shears may record crustal shortening associated with the Laramide orogeny. Following mid-Tertiary volcanism, northwest- and northeast-trending high-angle faults juxtaposed Tertiary and Mesozoic strata. Finally, uplift along a north-northeast-trending high-angle fault exposed a section of older Mesozoic rocks on the east and younger Cenozoic rocks on the west.

WHOLE-ROCK STRONTIUM ISOTOPIC AGES OF MESOZOIC PLUTONS IN THE WEST WALKER RIVER AREA, EAST-CENTRAL CALIFORNIA

No 65102

ROBINSON, Allen C., Branch of Isotope Geology MS937, U. S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

Strontium isotopic data for 270 whole-rock samples from 12 Mesozoic granitoids within a 30-km radius of the confluence of the West Walker and Little Walker Rivers, east-central California, yield 2 Late Jurassic ages of 161.3 ± 4.5 m.y. and 155.0 ± 3.0 m.y. and 10 Late Cretaceous ages ranging from 96.9 ± 0.9 m.y. to 82.4 ± 1.1 m.y. Initial $^{87}Sr/^{86}Sr$ values range from 0.70412 to 0.70637. These units include three of four plutons described in detail and three of four others mentioned briefly that are termed older felsic and mafic plutons in GSA Special Paper 176 (Schweickert, 1976). Since the theme of the Special Paper is the assignment of a probable Early Jurassic age to the older plutons in support of a conceptual tectonic model, it is worth emphasizing that none of the whole-rock Sr ages of the units termed older plutons are older than Late Jurassic and two are Late Cretaceous.

An argument for the Early Jurassic age of the shallowly emplaced China Garden pluton is the conjecture that it erupted a nearby dacitic tuff thought to be part of a volcano-sedimentary sequence lithologically and structurally similar to fossiliferous Upper Triassic to upper Lower Jurassic strata 25 km north. The Sr data do indicate contemporaneity of the pluton with the dacitic tuff and also with an underlying rhyolite intruded by the pluton. A Late Cretaceous 10-point whole-rock isochron of 90.4 ± 1.5 m.y. for the rhyolite is the youngest age yet determined for Mesozoic volcanic rocks in the Sierra Nevada.

Much of the shallow-level Late Jurassic Desert Creek pluton has undergone albitization, resulting in Rb loss. A suite of progressively altered granite samples from one locality in the pluton gives a rotated six-point whole-rock isochron of 87.4 ± 1.9 m.y., matching the age of the adjacent Late Cretaceous porphyritic granite of Taylor Valley.

LATE HOLOCENE RECURRENT FAULTING ON THE GLEN IVY NORTH STRAND OF THE ELSINORE FAULT, SOUTHERN CALIFORNIA

No 65536

ROCKWELL, T.K., Geology Dept., San Diego State Univ., San Diego, CA 92182; LAMAR, D.L., 1318 Second st. Suite 27, Santa Monica, CA 90401; McELWAIN, R.S. and MILLMAN, D.E., Geology Dept., San Diego State Univ., San Diego, CA 92182

Sediments exposed in test trenches across the Glen Ivy North strand of the Elsinore fault zone consist of stratified clayey silt, silt, sand, and gravel with several interbedded 0.1 to 2cm thick peat horizons, three of which have been dated. Lateral slip is demonstrated by stratigraphic mismatch across individual fault strands, offset sand and gravel channels, the anastomosing nature of the individual strands, and the local and regional fault geometry, geology, and geomorphology. At least four individual fault strands show vertical separations of up to 50cm and provide evidence for the following late Holocene seismic events: one or two earthquakes since 1660 A.D. $\pm^{300}_{100}$, one or two between 1275 A.D. $^{+100}_{-65}$ and 1660 A.D. $^{+300}_{-100}$, one between 1260 A.D. ±40 and 1275 A.D. $\pm^{100}_{65}$, and at least three prior to 1260 A.D. ±40. These data yield a recurrence interval for groundbreaking earthquakes of about 200 - 300 years, which combined with previous estimates of the long term horizontal slip rate of 1 to 7 mm/yr, suggest typical earthquake magnitudes of 6 to 7.

PLEISTOCENE VERTEBRATES FROM DOWNTOWN SAN FRANCISCO, CALIFORNIA

No 60750

RODDA, Peter U. and BAGHAI, Nina L., Department of Geology, California Academy of Sciences, San Francisco, CA 94118

Well-preserved, disarticulated cranial and post-cranial elements of *Mammuthus columbi* (Columbian Mammoth) and *Bison latifrons* (Giant Bison) were recovered from gravelly, sandy clay of the Colma Formation at the south base of Telegraph Hill in San Francisco, California. The fossils were recovered from the middle of a 12-foot-thick sequence of interbedded sand and clay exposed in an excavation at the intersection of Pacific and Columbus Streets. The animals apparently were buired in a boggy environment at the south base of a steep hillside underlain by Franciscan shale.

GEOLOGIC MAP OF THE LITTLE HARQUAHALA MOUNTAINS, WEST-CENTRAL ARIZONA

Jon E. Spencer, Stephen M. Richard, and Stephen J. Reynolds

Arizona Bureau of Geology and Mineral Technology

Open-File Report 85-9

1985

(3 sheets, scale 1:24,000)

GEOLOGIC MAP OF THE LITTLE HARQUAHALA MOUNTAINS, WEST-CENTRAL ARIZONA

INTRODUCTION

The Little Harquahala Mountains of west-central Arizona contain major Mesozoic thrust faults that juxtapose a complex assemblage of Mesozoic sedimentary and volcanic rocks, Paleozoic cratonic strata, and Jurassic and Precambrian crystalline rocks. The structurally lowest rocks, referred to as the Harquar plate, consist of a Jurassic volcanic and volcaniclastic sequence depositionally overlain by primarily sedimentary rocks of the Jurassic and/or Cretaceous McCoy Mountains Formation. The Hercules thrust separates these rocks from the structurally overlying Hercules plate, which is composed of a variety of crystalline rocks of Precambrian(?) and Jurassic(?) age. The structurally higher Centennial thrust places Precambrian, Paleozoic, and Mesozoic sedimentary rocks of the Centennial plate over the Hercules plate. Crystalline rocks in the southern part of the range, referred to as the Sore Fingers assemblage, are structurally below the Centennial plate, but their structural relationship to the Hercules and Harquar plates is uncertain. Lithologic similarity of the Sore Fingers assemblage to rocks of the Hercules plate suggests that the two packages of rocks are related and probably continuous at depth beneath the Centennial plate.

Pre-late Cretaceous rocks of the area locally contain well-developed cleavage and large- and small-scale folds. Large-scale folds are best displayed in the Centennial plate, where the Paleozoic section is commonly steeply dipping or overturned because it occupies the core of a large northeast-trending fold that is overturned to the southeast. Spaced cleavage is present in most parts of the range, but is most intensely developed in Mesozoic rocks of the Harquar plate and along the major thrusts. The sense of transport on the Hercules thrust is not well constrained in the Little Harquahala Mountains, but is probably south to southwest based on asymmetric petrofabrics along a continuation of the thrust in the Granite Wash Mountains to the north.

Post-thrusting rocks include the Upper Cretaceous Granite Wash Granodiorite, which intrudes the Hercules thrust, and a variety of of middle Tertiary volcanic rocks that dip gently off the southwest flank of the range.

Previous studies of the geology and mineral resources of the range are mostly restricted to descriptions of mines (Keith, 1978) and reconnaissance geological mapping (Rehrig and Reynolds, 1980). The Hercules thrust was first recognized in reconnaissance studies by Reynolds and others (1980), Keith and others (1981), and Reynolds (1982). The Golden Eagle thrust, a fault discussed by Reynolds and others (1980) and Keith and others (1981), is interpreted by Richard (1982, 1983, this report) as a discontinuous Tertiary(?) fault of minor displacement that places steeply dipping Paleozoic rocks over Precambrian monzogranite of the Centennial plate. The Centennial thrust, a generally intracrystalline structure, was not recognized in earlier reconnaissance studies. The rocks and structures of most of the Centennial plate and Sore Fingers Assemblage are described in detail by Richard (1982, 1983), and the information presented here on this area is taken entirely from Richard (1983) with very little modification. The remainder of the range was mapped by the authors in 1982 and 1983.

Plutonic rock nomenclature used in this report is in accordance with that adopted by the IUGS (Streckeisen, 1976). Stratigraphic thicknesses, where given, are estimated from the outcrop width in areas of only minor structural complication.

DESCRIPTION OF MAP UNITS

POST-THRUSTING UNITS

Qs SURFICIAL DEPOSITS (QUATERNARY)--Variably consolidated sand, gravel, and conglomerate deposits, and talus, generally poorly sorted and poorly bedded.

Tvmi MAFIC TO INTERMEDIATE VOLCANICS (MIDDLE TERTIARY)--Vesicular to non-vesicular, dark gray to black flows and flow breccias. One to two mm olivine(?), pyroxene(?) and plagioclase phenocrysts are locally recognizable. Red, highly vesicular scoria and flow breccias are locally present. Quartz, hornblende(?), and biotite(?) phenocrysts are present in less mafic units such as those forming the hills south of Martin Peak. This unit is resistant to weathering and typically forms steep slopes or cliffs.

Tvi INTERMEDIATE-COMPOSITION TUFF BRECCIA (MIDDLE TERTIARY)--Orange-weathering, pumiceous, tuff breccia with 1-5 cm diameter, light gray to light brown, volcanic clasts containing 1-5 mm hornblende and 1-2 mm biotite phenocrysts. Present only in unsurveyed SW1/4 sec. 31, T. 4 N., R. 13 W.

Tvr RHYOLITE (MIDDLE TERTIARY)--Light-tan to dark-brown weathering, generally homogeneous, welded, rhyolite tuff with phenocrysts of quartz, sanidine, biotite, and hornblende. Includes associated dikes that are similar in composition and color, and commonly have a spheriolitic groundmass.

Tc CONGLOMERATE (MIDDLE TERTIARY)--Fining-upward sequence of conglomerate containing clasts up to 1 m diameter of Paleozoic and Precambrian rocks of the Centennial plate. Top of sequence consists of pebble conglomerate, sandstone, and mudstone.

Tbr BRECCIA (MIDDLE TERTIARY)--Composed mostly of angular clasts of

Paleozoic carbonates. Clasts range in size from several cm to several m. Breccia is generally polymictic, but locally contains monolithologic zones, and is well cemented by calcite or silica. The breccia is in low-angle fault contact with Precambrian granite and Paleozoic sedimentary rocks. The low-angle fault is interpreted as a normal fault, and the breccia is interpreted as the product of faulting and related tectonism. The breccia is assigned a middle Tertiary age based on these interpretations and on the interpretation that the fault was active in mid-Tertiary time, as is typical for normal faults of the region. Isolated outcrops of breccia in the southeastern part of the study area (secs. 20 and 28, T. 4 N., R. 12 W.) are largely derived from Coconino Sandstone and Mesozoic clastic rocks and could be associated with a concealed low-angle fault.

Kg GRANITE WASH GRANODIORITE (UPPER CRETACEOUS)--Light-gray, medium-grained, equigranular, biotite granodiorite that generally contains 5 to 10 percent mafics, of which less than 3 to 5 percent is hornblende. Also contains accessory sphene and opaque oxides.

Kgd BORDER PHASE OF GRANITE WASH GRANODIORITE (UPPER CRETACEOUS) --Dioritic, quartz dioritic, or granodioritic rocks with highly variable texture and mineralogic composition. Common varieties include the following: (1) medium-grained, equigranular to slightly porphyritic quartz diorite and granodiorite with more mafic minerals than main-phase granodiorite; commonly contains several percent hornblende phenocrysts that are 1 to 2 cm in length; (2) medium-grained, equigranular diorite to quartz diorite with 50 to 60 percent hornblende and biotite, locally slightly porphyritic with up to 5 percent phenocrysts of hornblende and plagioclase; (3) fine- to medium-grained, porphyritic quartz diorite to diorite with 5 to 10 percent hornblende phenocrysts as long as 1 cm; (4) coarse-grained diorite with abundant crystals of hornblende as long as 2 cm, and varying amounts of medium-grained plagioclase; and (5) hornblendite containing less than 10 percent plagioclase.

ROCKS OF THE HARQUAR PLATE

Rocks of the Harquar plate consist of a sequence of Mesozoic sedimentary and volcanic rocks that rest depositionally on volcanic rocks of probable Jurassic age. The sedimentary and volcanic rocks overlying the basal volcanics are correlated with the McCoy Mountains Formation of Harding (1982) and Harding and Coney (1985), and are divided into two informal members on the basis of sandstone and conglomerate clast composition: the lower, quartz-rich Ranegras member and the upper, volcanic-lithic to feldspathic Harquar member. These informal members may be only locally applicable, but we tentatively correlate the Ranegras member with basal sandstone members one and two and the mudstone member of Harding and Coney (1985), and the Harquar member with the conglomerate, sandstone, and siltstone members of Harding and Coney (1985).

Kgr GRANITE OF THE HARQUAR PLATE (JURASSIC, CRETACEOUS, OR PRECAMBRIAN)--Gray to orange-brown weathering, medium-grained, moderately porphyritic granite. The nature of the contact between this granite and the surrounding Hovatter volcanics is obscured by alteration. If the contact between the granite and volcanics is a fault, the granite could be Precambrian. Located in one area approximately one and one-half km (1 mi.) east of Harquar Peak.

McCoy Mountains Formation of the Harquar plate

Harquar member (informal name) of the McCoy Mountains Formation

Khs SEDIMENTARY ROCKS OF THE HARQUAR MEMBER, UNDIVIDED (JURASSIC AND/OR CRETACEOUS)--Sandstone and conglomerate similar to that in the lower and upper sandstone units and conglomerate unit of the Harquar member (described below). Light grey, feldspathic and lithic sandstones with magnetite-rich laminations are characteristic features of this member.

Khu UPPER SANDSTONE UNIT OF THE HARQUAR MEMBER (JURASSIC AND/OR CRETACEOUS)--Interbedded sandstone, conglomeratic sandstone, and sparse conglomerate, with local maroon siltstone partings. Sandstone is light to medium gray, fine- to coarse-grained, feldspathic-lithic to lithofeldspathic. Mudcracks occur locally on maroon siltstone partings. Mudstone rip-ups and soft-sediment-deformation features are locally present. Conglomerate clasts of quartzite, sparse volcanic rocks, and carbonate are up to 30 cm in diameter but typically are less than 10 cm diameter. Contact with underlying conglomerate unit is marked by the upward appearance of siltstone partings.

Khc CONGLOMERATE UNIT OF THE HARQUAR MEMBER (JURASSIC AND/OR CRETACEOUS)--Very poorly sorted, light to medium gray, massive conglomerate to poorly bedded conglomeratic sandstone. Clasts are typically 2-20 cm in diameter but range up to 2 m. Clast lithologies include a variety of volcanic rock types with lesser amounts of variably laminated pink quartzite (Coconino sandstone?), and Paleozoic carbonates. Conglomerate is generally sand-matrix dominated, matrix supported, and variably tuffaceous. Interbedded volcanic flows are locally present. Basal contact is gradational with interbedded volcanic and conglomeratic rocks, and is placed at top of highest major volcanic flow.

Khv

HOVATTER VOLCANIC UNIT OF THE HARQUAR MEMBER (JURASSIC AND/OR CRETACEOUS)--Gray-green intermediate-composition volcanic flows, tuffs, volcaniclastic sediments, and feldspathic and volcanic-lithic sandstones, with minor interbedded quartz-rich sandstone of possible eolian origin at lower stratigraphic levels. Volcanic rocks consist primarily of greenish andesite(?) with local plagioclase phenocrysts, and locally occurring gray-lavender, biotite-hornblende flow-banded rhyodacite(?), light-gray biotite rhyolite(?), and gray dacite(?) with quartz and plagioclase phenocrysts. Interbedded volcaniclastic sedimentary rocks are common, but are difficult to distinguish from flows in areas of intense deformation or contact metamorphism near the Granite Wash Granodiorite. Basal contact is marked by spaced cleavage and is probably faulted. Stratigraphic position of this unit above lower sandstone and conglomerate unit (map unit JKhl) is based on structural position and interpretation that fault movement on the basal contact has been minor. Also included in this unit are hypabyssal andesite(?) and rhyodacite(?) intrusives within other units of the Harquar member. The Hovatter volcanic unit is divided into silicic (s) and intermediate (i) map subunits in the area 2-2.5 km (1.5 mi.) east of Harquar Peak.

JKhl

LOWER SANDSTONE UNIT OF THE HARQUAR MEMBER (JURASSIC AND/OR CRETACEOUS)--Massive to poorly-bedded, light- to medium-gray to locally greenish-gray conglomerate and sandstone. Sandstone is medium- to coarse-grained. Clasts are dominantly subrounded quartzite cobbles with less-abundant subrounded clasts of Paleozoic(?) carbonates and sparse, subangular clasts of medium- to dark-gray volcanic rock. Also contains very sparse volcanic flows. Lower contact is faulted except in SW1/4 SE1/4 sec. 7, T. 4 N., R. 13 W. where rocks similar to the lower sandstone unit of the Harquar member depositionally overlie rocks correlative with the upper unit of the Ranegras member.

Ranegras member (informal name) of the McCoy Mountains Formation

Kr

ROCKS OF THE RANEGRAS MEMBER, UNDIVIDED (JURASSIC AND/OR CRETACEOUS)--Sandstone, siltstone, and conglomerate, undivided, of the Ranegras member. Quartz-rich sandstones, including orthoquartzites, are characteristic of this member, and magnetite-rich laminations are almost entirely absent.

JKru

UPPER SANDSTONE UNIT OF THE RANEGRAS MEMBER (JURASSIC AND/OR CRETACEOUS)--Gray-, brown-, or orange-weathering, medium- to thin-bedded sandstone with less abundant siltstone and conglomerate beds. Sandstone is quartzose to feldspathic, but is locally greenish and volcanic-lithic. Sequence commonly includes tan-brown to greenish calcareous sandstone and siltstone, thin beds of silty limestone, and calcareous concretions. Thin brown carbonate lenses and calcareous oncolites (?) are also locally present. Conglomerates occur as lenses less than 2 meters thick, are matrix-supported to clast-supported, and contain well-rounded clasts of quartzite in a sandy matrix. The basal contact of the upper sandstone unit is placed at top of massive conglomerate beds of underlying conglomerate unit.

JKrc CONGLOMERATE UNIT OF THE RANEGRAS MEMBER (JURASSIC AND/OR CRETACEOUS)--Clast-supported, quartzite-cobble conglomerate. Most clasts are subrounded to rounded, but some are subangular. Clasts are mostly 1-10 cm diameter, but range up to 30 cm diameter. Sandstone matrix is quartzo-feldspathic. Base of unit placed at base of lowest major conglomerate bed.

JKrl LOWER SANDSTONE UNIT OF THE RANEGRAS MEMBER (JURASSIC AND/OR CRETACEOUS)--Sandstone with conglomerate, conglomeratic sandstone, siltstone, and calcareous sandstone and siltstone. Sandstone varies from orthoquartzitic to quartzofeldspathic, and is more quartz rich toward base. Metamorphosed orthoquartzites are white and highly resistant to weathering. Less quartz-rich sandstones weather tan-brown or gray and are locally calcareous. Locally interbedded calcareous clastic rocks and silty limestones are brown to dark-gray weathering. Conglomerate clasts are generally subrounded to rounded and are composed almost entirely of quartzite, but locally include cobbles of intermediate-composition volcanic rock, light-colored rhyolite(?), and red chert. Conglomerate beds are most abundant near base of unit. Maroon siltstones associated with conglomerate beds are a distinctive lithology in this unit.

Basal volcanic and volcaniclastic rocks of the Harquar plate

Jbvs SEDIMENTS DERIVED FROM THE BLACK ROCK VOLCANICS (JURASSIC?)--Light-colored to greenish, poorly sorted conglomerate, conglomeratic sandstone, and sandstone composed of disaggregated quartz porphyry of the underlying Black Rock Volcanics. Conglomerate-filled channels are locally associated with light-gray calcareous lenses.

Jbv BLACK ROCK VOLCANICS (JURASSIC)--Silicic to intermediate-composition ash-flow tuffs, flows, and hypabyssal intrusions, and volcaniclastic sedimentary rocks. Sequence includes the following: (1) light-colored porphyry with 5 to 15 percent plagioclase phenocrysts and 5 to 10 percent quartz eyes 1 to 4 mm in diameter; commonly contains several percent hexagonal biotite books and possible hornblende; probably includes both hypabyssal bodies and welded ash-flow tuff; (2) greenish to dark-gray, aphanitic andesite with approximately 10 percent altered hornblende and mafic clots that are 0.5 to 2mm in diameter; (3) dark-gray volcaniclastic sandstone with plagioclase and quartz grains as large as 4 mm in diameter; (4) tan-, pink-, or cream-colored, rhyodacite(?) tuff and flow-banded rhyodacite(?); and (5) volcanic breccia.

ROCKS OF THE HERCULES PLATE

Ja ALASKITE (JURASSIC?)--Dikes and irregular bodies of medium- to fine-grained alaskite, locally with aplitic texture; some areas contain unmapped pods of diorite or gabbro and pendants of mafic metamorphic rocks with a steep, northeast-trending gneissic foliation.

Jg PORPHYRITIC QUARTZ MONZODIORITE(?) (JURASSIC?)--Dark-gray granitic rock with about 10-15%, 5-30 mm, K-feldspar phenocrysts in intergrown groundmass of 1-15 mm albitic plagioclase, 1-2 mm quartz, and highly intergrown 1-2 mm anhedral biotite, hornblende(?), and magnetite(?). Albitization of plagioclase and apparently also of K-feldspar prevents accurate classification of this granitoid. Classification here as quartz monzodiorite(?) is based on hand-lens examination of stained and unstained slabs. Grades southward into a medium-grained, equigranular to slightly porphyritic, biotite monzogranite(?). A sample of this unit yielded a $^{87}Sr/^{86}Sr$ value of 0.70766 ± 0.00004 with a Rb/Sr value of 0.4166 (P. Damon and M. Shaffiqullah, written communication, 1984), indicating that the unit is not of the same age as Precambrian granitic rocks elsewhere in Arizona, and is probably of Mesozoic age.

p€u GNEISSIC METAMORPHIC ROCKS AND ALASKITE, UNDIVIDED (JURASSIC OR PRECAMBRIAN)--Includes thinly-banded, fine-grained granitic gneiss and gneissic granite, altered and sheared mafic dike(?) rocks, a variety of fine-grained, moderately leucocratic granitic rocks, and alaskite. These rocks are suspected of being part of the Hercules Plate, but this correlation is tentative.

ROCKS OF THE CENTENNIAL PLATE

Precambrian granitic rocks of the Centennial plate are overlain by a sequence of Paleozoic and Mesozoic sedimentary and volcanic rocks. Stratigraphic thicknesses of Paleozoic and Mesozoic units are based on average map thickness, and probably only approximate depositional thicknesses due to tectonic disruption.

McCoy Mountains Formation of the Centennial plate

The McCoy Mountains Formation of the Centennial plate consists of a broadly fining-upward sequence of sandstone, siltstone, and silty shale with local conglomerate lenses. As discussed by Richard (1983), it resembles a sequence of Mesozoic sedimentary rocks in the Apache Wash area of the nearby Plomosa Mountains (Miller, 1970; Harding, 1982). These rocks in the southern Plomosa Mountains are thought to be correlative with the McCoy Mountains Formation (Harding and Coney, 1985), but it is uncertain whether they correlate with the upper or lower of the two broadly fining-upward sequences (Ranegras and Harquar members in the Little Harquahala Mountains) that make up the McCoy Mountains Formation (Harding, 1982; Harding and Coney, 1985).

Ks

VOLCANIC, INTRUSIVE, AND SEDIMENTARY ROCKS OF THE CENTENNIAL PLATE, UNDIVIDED (JURASSIC AND/OR CRETACEOUS)--Strongly foliated and cleaved, light-colored, quartz-feldspar schists interpreted to have been derived from Mesozoic volcanic, alaskitic, and volcaniclastic rocks. Association with Paleozoic dolomite and less cleaved, quartz-feldspar sandstones is interpreted as suggesting an affinity to rocks of the Centennial plate. Exposed in thrust window near Buckeye-Salome Road in eastern part of map area.

mu

UPPER SANDSTONE AND SILTSTONE UNIT (JURASSIC AND/OR CRETACEOUS)--Medium- to dark-brown weathering, fine- to coarse-grained, poorly sorted, thin- to thick-bedded, lithofeldspathic sandstone and light-brown- or gray-weathering siltstone and silty shale. Sand grains are mainly monocrystalline and polycrystalline quartz, feldspar, rock fragments, and chert. Beds are normally massive or vaguely plane laminated with only sparse low-angle cross beds. Local conglomerate lenses contain clasts up to 15 cm diameter of primarily vitreous tan quartzite, with less abundant limestone and volcanic rock fragments and rare intrusive rock fragments. In general the unit fines upward, with coarse-grained sandstone and conglomerate predominant near the base, and siltstone and shale progressively more abundant higher in the section. Unit is in gradational contact with underlying lower unit. Distinguished from lower unit by presence of significant feldspar in sandstones and by contrast with distinctive drab gray-green color of lower unit. Thickness is a minimum of 700m.

Kml

LOWER SANDSTONE UNIT (JURASSIC AND/OR CRETACEOUS)--Gray-green to olive-drab, medium- to thin-bedded, very-poorly sorted, angular, fine-grained sandstone to gritstone. Grains are mostly volcanic rock fragments and feldspar with minor quartz. Conglomerate beds are sparse in northwestern outcrops, but are more abundant and dominate the section to the southeast. Clast compositions vary greatly and were apparently controlled by local topography. Clasts include quartzite, volcanic rocks, and upper Paleozoic sedimentary rocks. This unit is absent in northwestern areas where the upper unit rests directly on underlying volcaniclastic sediments. To the east and south the lower unit appears and becomes progressively thicker and more conglomeratic. The contact with the underlying volcaniclastic sandstone is gradational.

Needle formation (informal name) of the Centennial plate

The Needle formation (informal name) overlies a basal, non-volcanogenic, Mesozoic sedimentary unit, and is composed of a sequence of volcanic flows, tuffs, and derivative volcaniclastic sedimentary rocks. Richard (1983) named the basal Mesozoic sedimentary unit the Needle formation, but we revise his usage and apply the name Needle formation to only the overlying volcanogenic rocks.

It is presently unknown if the volcanic rocks in the Needle formation are correlative with the Hovatter volcanic unit of the Harquar member of the McCoy Mountains Formation in the Harquar plate, or are correlative with the Black Rock volcanics of the Harquar plate. Correlation with the Hovatter volcanic unit would indicate that the McCoy Mountains Formation of the Centennial plate is correlative with the upper sedimentary units of the Harquar Member of the McCoy Mountains Formation.

Jnvs VOLCANICLASTIC SEDIMENTARY UNIT (JURASSIC?)--Light- to medium-gray-green, volcanic sandstone and conglomerate. Massive conglomerate or breccia near base grades upward into sandstone. A thin, evaporite and shale zone forms the top of the unit in the area southeast of the Needle. Conglomerate clasts consist primarily of angular volcanic rocks with minor subrounded to rounded vitreous quartzite and rare Paleozoic limestone. Sandstone grains are primarily volcanic rock fragments and sericitized feldspar. Cross-bedding is apparent in some magnetite-rich beds. Base is marked by upward appearance of sedimentary textures. Maximum thickness is 335 meters.

Jnvu UPPER VOLCANIC UNIT (JURASSIC?)--Gray-green, massive, homogeneous volcanic porphyry with a fine-grained groundmass; contains phenocrysts of quartz, albitized plagioclase, potassium feldspar, and biotite(?). Original texture and mineralogy are obscured by pervasive propylitization. Basal contact is locally intrusive but at map scale is parallel to other depositional contacts, suggesting an extrusive origin. Unit is interpreted as a silicic dome with an autobrecciated carapace forming base of overlying volcaniclastic sedimentary unit. Altered and deformed quartz-feldspar porphyry sills in Paleozoic rocks are probably related to this porphyry. Maximum thickness is 335 meters.

Jnvuu UPPER VOLCANIC UNIT AND VOLCANICLASTIC SEDIMENTARY UNIT, UNDIVIDED (JURASSIC?)--Equivalent to units Jnvs and Jnvu, undivided.

Jnvl LOWER VOLCANIC UNIT (JURASSIC?)--Silicic flows, ash-flow tuffs, agglomerates, massive and laminated tuff, and red volcanic-lithic sandstone and conglomerate. Volcanic rocks are purple-gray, maroon, gray, and gray-green. They are generally flow-banded and contain quartz and plagioclase phenocrysts, with the percentage of phenocrysts being lower than in the upper volcanic unit. Conglomeratic red beds at base of unit contain clasts of limestone, volcanic rocks, quartzite, and rare medium-grained, porphyritic granitoid rocks. Basal contact is probably conformable. Unit is very poorly exposed and is not more than about 210 meters thick.

Basal Mesozoic sedimentary unit of the Centennial plate

Mzs BASAL MESOZOIC SEDIMENTARY UNIT (JURASSIC?)--Basal, red, tan, and dark gray-green siltstone and fine-grained sandstone with a few white limestone beds, overlain by light-gray, fine- to coarse-grained sandstone and pebble to cobble conglomerate with maroon siltstone partings. Sandstone grains include, in order of decreasing abundance: monocrystalline quartz, chert, polycrystalline quartz, limestone, potassium feldspar, magnetite, muscovite, and schist. Conglomerate clasts include tan vitreous quartzite (Coconino?), red-brown and white coarse-grained quartzite (Bolsa?), white-weathering chert, and sparse tan-weathering siltstone and limestone. Unit is between 50 and 70 meters thick. The lower contact is probably an unconformity, as suggested by the abrupt change in lithology and inferred depositional environment at the basal contact. Best exposed in valley just southeast of the Needle (unsurveyed NE1/4 SE1/4 NW1/4 sec. 24, T. 4 N., R. 13 W.).

The tectonic significance of the basal, nonvolcanogenic, Mesozoic sedimentary unit is uncertain because we cannot assess how much time, if any, is missing at the contact between the sandstone and overlying volcanic rocks. If the sandstone is substantially older than the volcanics, it could represent mild tectonism and sedimentation well before the onset of regional mid-Mesozoic magmatism. In this case, the sandstone would probably correlate with the Triassic Moencopi Formation or related units. If, on the other hand, there is little or no time missing at the sandstone-volcanic contact, then the sandstone could represent basin formation and initial sedimentation reflecting the onset of mid-Mesozoic magmatism and associated tectonism.

Paleozoic and Precambrian rocks of the Centennial plate

c BRECCIA-CONGLOMERATE (PALEOZOIC?)--Massive breccia or conglomerate occurring as intraformational masses in gradational contact with Kaibab limestone. Consists of buff to red, fine-grained sandstone to boulder conglomerate. Most of the unit is a massive cobble to boulder conglomerate with angular clasts up to 3 m diameter. Conglomerate is monolithologic near enclosing Kaibab limestone, and grades into shattered but untransported rock. Interpreted as a cavern-filling deposit formed after Kaibab deposition and before deposition of overlying Mesozoic clastic rocks.

u SEDIMENTARY ROCKS, UNDIVIDED (PALEOZOIC)--Sedimentary rocks of probable or known Paleozoic age but too deformed or altered to be assigned to a specific formation.

k KAIBAB LIMESTONE (PERMIAN)--Composed of 5 units. In ascending order, these are: (1) dolomitic sandstone grading upward into cherty dolomitic limestone which is overlain by fossiliferous gray limestone and dolomitic limestone. This unit is capped by fine-grained tan sandstone with laminated carbonates. (2) Cherty, gray, bioclastic limestone, (3) uniform, medium-bedded, light- to dark-gray limestone, (4) medium- to thick-bedded, light-gray limestone with abundant fossils and chert, (5) a lower tan sandstone with a few conglomerate lenses overlain by cherty and fossiliferous limestone similar in character to unit four. Total thickness is approximately 250 m in the least deformed section. The Kaibab Limestone conformably overlies the Coconino Sandstone.

Pku UPPER MEMBER (INFORMAL) OF KAIBAB LIMESTONE (PERMIAN)--Includes units 3, 4, and 5 described above.

Pkl LOWER MEMBER (INFORMAL) OF KAIBAB LIMESTONE (PERMIAN)--Includes units 1 and 2 described above.

Pc COCONINO SANDSTONE (PERMIAN)--Uniformly white to pinkish-brown, fine-grained vitreous quartzite. Non-resistant due to pervasive internal fracturing. Sandstone is uniformly thin to very-thin bedded and mostly plane-bedded, although medium-scale trough cross beds are locally present. Thickness is 190m. Basal contact is conformable and is placed at top of highest brown- or tan-weathering impure sandstone bed of the Supai formation.

Ps SUPAI FORMATION (PENNSYLVANIAN)--Interbedded shale, sandstone, and limestone. Basal 15 to 20 meters is composed of non-resistant maroon siltstone with interbedded quartzose sandstone and chert-pebble conglomerate. The rest of the Supai formation is composed of a variety of lenticular lithosomes, including gray limestone, tan dolomite or dolomitic limestone, silty brown to tan dolomite, white vitreous quartzite, maroon siltstone, thin-bedded tan siltstone, shaley siltstone, and calcareous siltstone. Beds are typically 1-2 m thick. Total thickness is 150-200 m.

Basal contact is marked by limestone conglomerates formed on a karst surface on top of Redwall Limestone. Correlation with the Supai Group is based on the lithologies and associations of rock types. However, since individual formations of the Supai Group have not been recognized in the Little Harquahala Mountains, the Supai Group has been reduced in rank to a formation (Richard, 1983).

Mr

REDWALL LIMESTONE (MISSISSIPPIAN)--Consists of three units. In ascending order, these are: (1) Interbedded, massive, white limestone and massive, tan dolomite overlying a basal bed of sandy varicolored limestone; (2) variably dolomitized cherty limestone; and (3) medium-bedded light-gray limestone. Thin, karst-related conglomerates locally occur along the disconformable basal contact. Total thickness is about 100m.

Dm

MARTIN FORMATION (DEVONIAN)--Medium gray, tan, and brown, medium-grained to porcelaneous dolomite and dolomitic limestone. Dolomite is well bedded and medium to thick bedded. Beds are internally laminated, mottled, or massive. Disconformably overlies Abrigo Formation. Thickness is about 100 m.

Ꞓba

BOLSA QUARTZITE AND ABRIGO FORMATION, UNDIVIDED (CAMBRIAN)--Bolsa quartzite as described below, plus conformably and gradationally overlying Abrigo Formation which consists of interbedded thin- to very-thin-bedded, dark-brown to red-brown sandstone, black, maroon, and greenish-gray shale and siltstone, and local medium-bedded tan carbonate beds. Thickness varies from 0 to 27 meters due primarily to tectonic thickness modifications, but the least deformed sections are about 15 meters thick.

Ꞓb

BOLSA QUARTZITE (CAMBRIAN)--Maroon, red-brown, and gray-purple feldspathic quartz grit, sandstone, and siltstone. The lower part of the formation consists of medium-bedded feldspathic grit with abundant planar-tabular cross beds in sets up to 20 cm thick. A thin zone of cobble conglomerate locally overlies the basal nonconformity. Grain size decreases up-section, beds become thinner, and cross beds are less common. The upper part consists of thin- to medium-thin-bedded, brown sandstone with white laminations and gray or light green-gray, silty or shaley partings. Thickness ranges from 50 to 100 meters, probably in part due to original thickness changes.

pꞒg

GRANITOIDS OF THE CENTENNIAL PLATE (PRECAMBRIAN OR MESOZOIC)--Medium-grained biotite monzogranite; groundmass of 2-4 mm, blocky, euhedral plagioclase, with interstitial quartz and biotite, as well as subhedral quartz in rounded grains up to one cm diameter. K-feldspar forms blocky phenocrysts up to 5 cm long. Very similar to porphyritic monzogranite of Sore Fingers assemblage (unit Jp€mg). Intruded by aplitic leucogranite and pegmatite dikes. Contact with granite of Centennial plate is abrupt, but is obscured by alteration and deformation.

p€a ALASKITE OF THE CENTENNIAL PLATE (PRECAMBRIAN)--Medium-grained, equigranular, white to orangish-weathering alaskite. Poorly resistant to weathering. Locally foliated near thrust faults.

€g GRANITE OF THE CENTENNIAL PLATE (PRECAMBRIAN)--Orange- to brown-weathering, non-resistant, medium-grained, porphyritic granite with 1-3 cm long K-feldspar phenocrysts. Minor biotite is typically altered to aggregates of muscovite and magnetite. Masses of hematite, chlorite, opaque minerals, and sericite are interpreted as altered mafic minerals. Alteration characterized by light-green, argillitized or epidotized feldspar set in a reddish, argillic groundmass with abundant relict quartz has affected rocks near the depositional contact with overlying Cambrian Bolsa Quartzite. Modal mineral composition of one sample indicates granite plots in the monzogranite subfield of the granite field (Richard 1983). In northeastern outcrops near Centennial Wash, unit grades into medium-grained, equigranular to porphyritic, muscovite-biotite granite, which is continuous across Centennial Wash into the western Harquahala Mountains.

ROCKS OF THE SORE FINGERS ASSEMBLAGE

Intrusive and metamorphic rocks in the southeastern Little Harquahala Mountains are referred to as the Sore Fingers assemblage (Richard, 1983). This assemblage is separated from bedrock in the rest of the Little Harquahala Mountains by faults. A K-Ar biotite age of 140 m.y. suggests a Jurassic age for the assemblage (Rehrig and Reynolds, 1980), but a Precambrian age is also possible. These rocks are similar to crystalline rocks of the Hercules plate, and it is possible that they are correlative and structurally continuous beneath the Centennial plate.

p€di DIORITIC INTRUSIVE (JURASSIC OR PRECAMBRIAN)--Fine- to medium-grained plagioclase, chloritized biotite or hornblende, and quartz, with abundant secondary epidote. Mafic content and grain size are variable, but rock is characteristically equigranular. Intrudes metamonzogranite (map unit Jp€mmg) and contains inclusions of metamonzogranite near contact.

Jp€gr GRANITE (JURASSIC OR PRECAMBRIAN)--Equigranular to slightly porphyritic biotite granite (syenogranite). Grain size is variable, and a fine-grained contact phase is locally present. Contacts with monzogranite are gradational, but local inclusions of monzogranite indicate that granite is slightly younger. Petrologic similarities and the gradational nature of the contact suggest that both are related to the same intrusive event. This rock is commonly foliated, but the orientation of foliation is highly variable.

Jp€mmg METAMORPHOSED MONZOGRANITE (JURASSIC OR PRECAMBRIAN)--Monzogranite (Map Unit Jp€mg) is weakly metamorphosed along its northern boundary. Rock unit is distinguished from map unit Jp€mg by the smaller size and rounded character of K-feldspar phenocrysts, and by its more indurated character and common reddish stain. Rock is locally foliated.

Jp€mg MONZOGRANITE (JURASSIC OR PRECAMBRIAN)--Coarsely-porphyritic biotite granite (monzogranite), with pink K-feldspar phenocrysts up to 8 cm long. Texture varies from coarsely porphyritic to locally almost equigranular.

p€mu METAMORPHIC ROCKS AND LEUCOGRANITE, UNDIVIDED (JURASSIC? AND/OR PRECAMBRIAN?)--Igneous, metaigneous, and metasedimentary rocks, including quartz-muscovite schist, plagioclase-biotite gneiss, and sparse lenses of biotite schist. Variably foliated porphyritic monzogranite and medium- to fine-grained leucogranite are the dominant rock types in some areas. The foliated monzogranite and leucogranite are probably related to the monzogranite. The metamorphic rocks are the oldest in the Sore Fingers assemblage.

ROCKS OF UNCERTAIN STRATIGRAPHIC OR STRUCTURAL AFFINITY

MzCzbr BRECCIA (CENOZOIC OR MESOZOIC)--Volcanic and granite-clast breccia. Unit consists of two subunits, each containing dominantly or entirely clasts of one rock type. Contact between two is gradational. Granitic clasts resemble nearby underlying granite. Volcanic clasts are non-vesicular, medium-to dark-gray, dark-brown to dark-gray weathering, aphanitic, with plagioclase phenocrysts 3-4 mm diameter. Exposed only at one locality just north of the C.A.P. canal (unsurveyed sec. 18, T. 3 N., R. 13 W.).

Mzvu VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED (MESOZOIC)--Gray, green, and maroon volcanic breccia, probably of rhyodacitic, dacitic, and andesitic composition. Exposed as a small klippe overlying granite at one locality is southernmost Little Harquahala Mountains (unsurveyed sec. 20, T. 3 N., R. 13 W.). Rock unit is dissimilar to the nearby Black Rock volcanics, but could correlate with the lower volcanic unit of the Centennial plate.

Mzp€gr GRANITE (MESOZOIC OR PRECAMBRIAN)--Equigranular to moderately porphyritic, light greenish-gray granite with 0.5-2.0 cm K-feldspar phenocrysts, 3-6%, 1-3 mm biotite crystals, and accessory sphene and apatite. Exposed only in the southernmost Little Harquahala Mountains.

MzpЄu METAMORPHIC AND INTRUSIVE ROCKS, UNDIVIDED (MESOZOIC AND/OR PRECAMBRIAN)--Moderately high-grade, metasedimentary and metaigneous rocks exposed as pendants within Granite Wash Granodiorite in sec. 33 in the northwest part of the range. Includes banded quartzofeldspathic gneiss, calc-silicate lithologies, and metasedimentary rocks with textural and compositional banding resembling relict bedding. Rock unit commonly contains a steep, metamorphic foliation.

MAP SYMBOLS

××× MAFIC DIKE--Typically fine-grained, equigranular, hornblende-plagioclase rock. Dike rock is locally porphyritic, may contain biotite, and is variably altered. Weathers dark gray and is poorly resistant to weathering. Dikes are typically oriented NW-SE and are largely if not entirely middle-Tertiary in age.

SILICIC TO INTERMEDIATE DIKE--Includes (1) slightly porphyritic, fine-grained andesite(?) with variably chloritized hornblende and biotite, (2) very-fine grained, locally porphyritic, medium-gray rhyolite(?) (3) light-gray to pinkish-gray, porphyritic rhyodacite(?), generally highly altered with quartz (up to 5 mm diameter), plagioclase (up to 5 mm diameter), subhedral to anhedral feldspar up to 2 cm long, and biotite up to 2 mm diameter, (4) non-resistant, medium-dark-gray, fine-grained, locally slightly porphyritic dacite(?) containing feldspar, quartz, chloritized hornblende or biotite, and limonite after pyrite cubes, (5) red or brown amorphous silica dikes. Most of these dikes are probably of mid-Tertiary age.

QUARTZ VEIN--Typically milky-white bull-quartz with local copper and iron sulfide and oxide mineralization.

50 STRIKE AND DIP OF BEDDING--Upright

45 STRIKE AND DIP OF BEDDING--Overturned

25 STRIKE AND DIP OF BEDDING--Approximate

35 STRIKE AND DIP OF BEDDING--Stratigraphic top direction indicated by bar and ball

STRIKE OF BEDDING--Vertical

HORIZONTAL BEDDING

STRIKE AND DIP OF CONTORTED BEDDING

STRIKE AND DIP OF SPACED CLEAVAGE--Arrow shows trend and plunge of associated lineation

STRIKE OF SPACED CLEAVAGE--Vertical

HORIZONTAL SPACED CLEAVAGE

STRIKE AND DIP OF BEDDING AND PARALLEL SPACED CLEAVAGE

STRIKE AND DIP OF SCHISTOSITY, COMPOSITIONAL BANDING, OR METAMORPHIC SHAPE FABRIC--Arrow shows trend and plunge of associated lineation

STRIKE AND DIP OF MYLONITIC FOLIATION

STRIKE AND DIP OF JOINT

STRIKE OF VERTICAL JOINT

STRIKE AND DIP OF CLOSELY SPACED JOINTS

STRIKE AND DIP OF FLOW FOLIATION

FLOW BRECCIA

CONGLOMERATE

MARKER UNIT OR MAPPABLE CONTACT WITHIN MAP UNIT

TREND AND PLUNGE OF SMALL FOLD AXES

TREND AND PLUNGE OF SYNCLINE

TREND AND PLUNGE OF ANTICLINE

THRUST FAULT--Showing dip. Dashed where approximately located, dotted where concealed. Teeth on upper plate.

LOW-ANGLE NORMAL FAULT--Dashed where approximately located, dotted where concealed. Hatchures on upper plate.

LOW-ANGLE FAULT WITH NORMAL SEPARATION--Dashed where approximately located, dotted where concealed. Teeth and hatchures on upper plate.

HIGH-ANGLE NORMAL FAULT--Dashed where approximately located, dotted where concealed. Bar and ball on upper plate.

---- HIGH-ANGLE FAULT--Dashed where approximately located, dotted where concealed.

REFERENCES CITED

Harding, L. E., 1982, Tectonic significance of the McCoy Mountains Formation, southeastern California and southwestern Arizona [Ph.D. dissertation]: Tucson, University of Arizona, 197 p.

Harding, L. E., and Coney, P. J., 1985, The geology of the McCoy Mountains Formation, southeastern California and southwestern Arizona: Geological Society of America Bulletin, v. 96, p. 755-769.

Keith, Stanley B., Reynolds, S. J., Rehrig, W. A., and Richard, S. M., 1981, Low-angle tectonic phenomenon between Tucson and Salome, Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 81-2, 114 p.

Keith, Stanton, B., 1978, Index of mining properties in Yuma County, Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 192, 185 p.

Miller, F. K., 1970, Geologic Map of the Quartzsite quadrangle, Yuma County, Arizona: U.S. Geological Survey Geologic Quadrangle Map GQ-841, 1:62,500.

Rehrig, W. A., and Reynolds, S. J., 1980, Geologic and geochronologic reconnaissance of a northwest-trending zone of metamorphic core complexes in southern and western Arizona, in Crittenden M.D., Jr., Coney, P. J., and Davis, G. A., eds., Cordilleran metamorphic core complexes: Geological Society of America Memoir 153, p. 131-158.

Reynolds, S. J., 1982, Multiple deformation in the Harcuvar and Harquahala Mountains, west-central Arizona, in Frost, E. G., and Martin, D. L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, Cordilleran Publishers, p. 137-142.

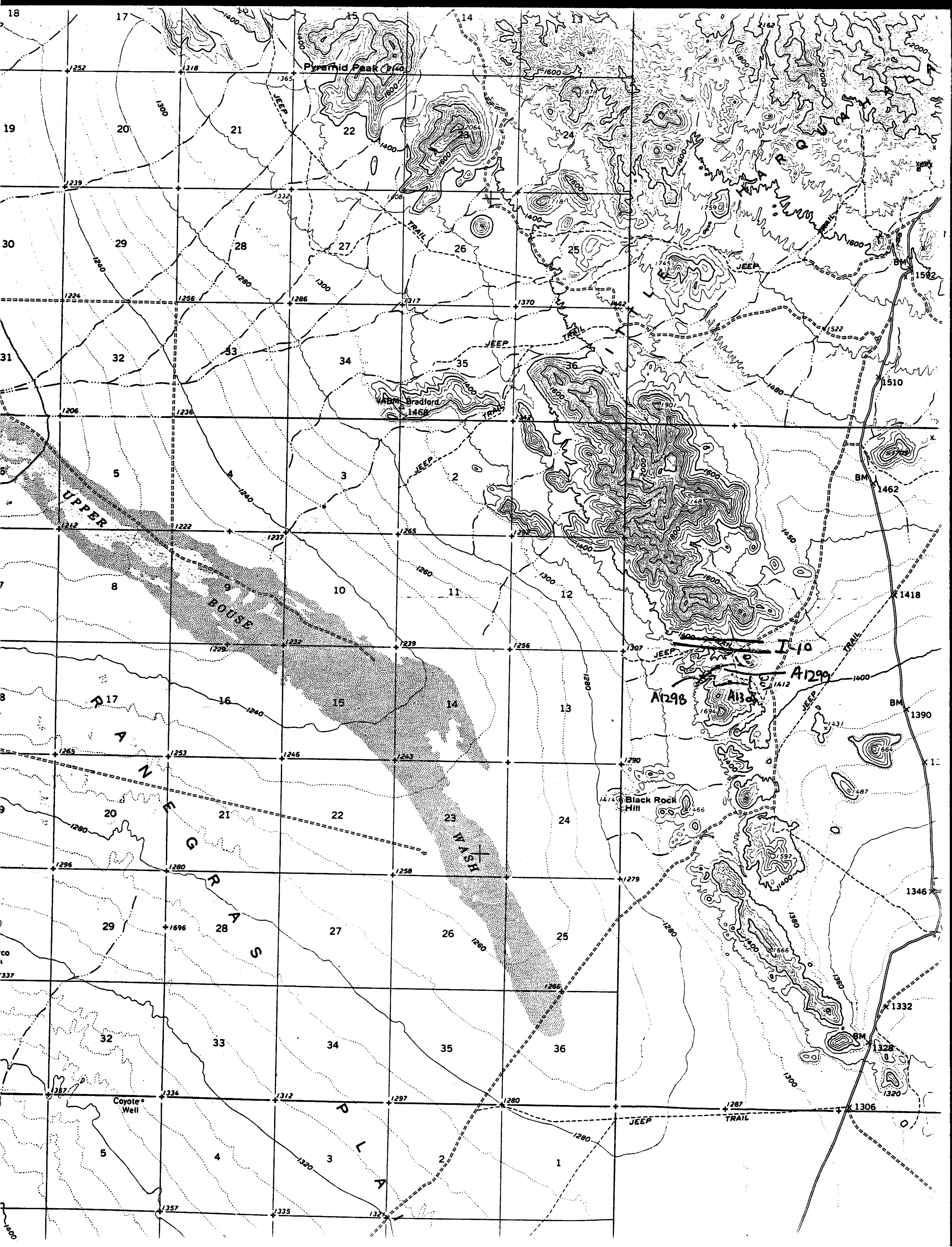
Reynolds, S. J., Keith, S. B., and Coney, P. J., 1980, Stacked overthrusts of Precambrian crystalline basement and inverted Paleozoic sections emplaced over Mesozoic strata, west-central Arizona, in Jenney, J. P., and Stone, Claudia, eds., Studies in western Arizona: Arizona Geological Society Digest, v. 12, p. 45-51.

Richard, S. M., 1982, Preliminary report on the structure and stratigraphy of the southern Little Harquahala Mountains, Yuma County, Arizona, in Frost, E. G., and Martin, D. L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado

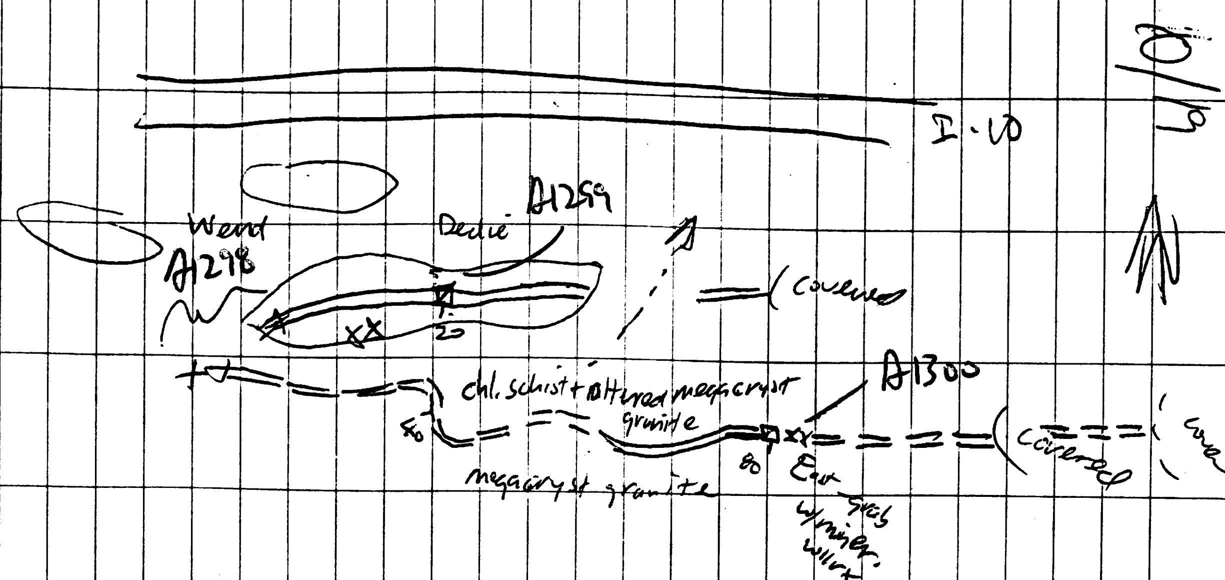
River region, California, Arizona, and Nevada: San Diego, Cordilleran Publishers, p. 235-244.

Richard, S. M., 1983, Structure and stratigraphy of the southern Little Harquahala Mountains, Yuma County, Arizona [M.S. thesis]: Tucson, University of Arizona, 154 p.

Streckeisen, A., 1976, To each plutonic rock its proper name: Earth-Science Reviews, v. 12, p. 1-33.



Pyramid Peak
JEEP
TRAIL
VABM Bradford 1468
UPPER BOUSE WASH
RANEGRAS PLAIN
Black Rock Hill
Coyote Well
BM 1592
BM 1462
BM 1390
BM 1328
1306
1332
1346
1418
1510
I-10
A1299
A1298
A130



300'

Vein is white, glassy qtz, massive to locally vuggy, w/ FeOx, spec. hem, local earthy FeOx and brecc., local CuOx.

REGIONAL METAMORPHISM IN THE PRIEST RIVER COMPLEX, N.E. WASHINGTON, N. IDAHO, AND S. BRITISH COLUMBIA. **№ 96236**

RHODES, B.P., Dept. of Geol. Sciences, Cal. State University, Fullerton, CA 92631, and HYNDMAN, D.W., Dept. of Geology, University of Montana, Missoula, MT 59812

Amphibolite-grade metasedimentary and metaplutonic rocks within the southern Kootenay Arc define the Priest River Complex (PRC). The PRC is surrounded by unmetamorhosed and low-grade sedimentary rocks, mainly of the lower Belt Supergroup. Metamorphism on the western flank of the complex is gradational amid granitic rocks of the Loon Lake batholith. Along this gradational zone, semipelitic rocks of the Proterozoic Prichard Formation increase in metamorphic grade into the PRC. In it's central part, the PRC is overlain by unmetamorphosed Prichard rocks of the upper plate of the Newport detachment fault. On its eastern flank, the PRC ends at the Purcell trench. The trench locally contains eastward dipping, low-angle(?) faults that juxtapose low-grade lower Belt rocks that were affected by burial metamorphism only, against the regionally metamorphosed, sillimanite-grade rocks of the PRC. A northeastern finger of the PRC is sandwiched between the eastern limb of the Newport fault and the Purcell trench. Within this finger, displacement along both the Newport fault and Purcell trench apparently fades into zones of gradational metamorphism. Rocks within the interior of the PRC contain a comparatively uniform degree of metamorphism within the sillimanite-zone.

The peak of regional metamorphism within the PRC postdates the Prichard Formation, and may be Jurassic or Early Cretaceous. This metamorphism is also superimposed on possible pre-Belt basement in the interior of the complex. In the Southern PRC, a second, much less pronounced, mid-amphibolite facies metamorphism accompanied eastward verging mylonitization and affected the late Cretaceous Mount Spokane Granite, but mostly predated the 60-70 my old Mount Rathdrum Granite. Final cooling of the PRC occurred during and was probably caused by Eocene extension, uplift, and unroofing.

STABILIZATION OF LANDSLIDES USING CANTILEVERED OR TIED-BACK RETAINING WALLS - TWO CASE HISTORIES **№ 99878**

RICE, RAYMOND H., Dames & Moore, 500 Sansome Street, San Francisco California 94111

Two case histories are presented illustrating the use of cantilevered or tied-back, pier-supported retaining walls to stabilize landslides on residential property in the San Francisco Bay area.

Case 1: Warren Drive Slide, San Francisco - Several residential lots on the slopes of Mount Sutro were significantly damaged by landsliding in the 1960's and were restored by a buttress fill. Excavation for residential units at the base of the slope in 1979 triggered additional movements. The properties were stabilized by the construction of a heavily reinforced and tied-back concrete retaining wall supported on drilled piers; a drainage gallery was also installed. A unique aspect of this project was that the lots at the toe of the slide area were considered developable upon completion of the stabilization system.

Case 2: Ganz Property, Belvedere - A major landslide in January 1980 severely damaged the lower portion of a steeply sloping property on Belvedere Island, above San Francisco Bay, and threatened to undermine a residential structure. The slide area was stabilized by a wall system consisting of the following: an upper wall composed of hand dug piers with tied-back as well as cantilevered soldier beams, an intermediate cantilevered wall founded on drilled, cast-in-place piers; and a rip rap sea wall to protect the toe of slope. The project was complicated by the extremely steep slope which was almost inaccessible to conventional equipment.

MESOZOIC AND TERTIARY STRUCTURE OF THE HARQUAHALA MOUNTAINS, WEST-CENTRAL ARIZONA **№ 102194**

RICHARD, Stephen M, Dept. of Geological Sciences, Univ. of Calif., Santa Barbara, Ca. 93106

The Harquahala Mountains provide a well-exposed section through >5 km of pre-Tertiary crust due to unroofing by the Bullard Detachment fault (BDF). The Harquahala Thrust (HT) crops out around the circumfrence of the central part of the range superposing heterogeneous Precambrian gneisses and plutonic rocks on Precambrian granitoids overlain by Paleozoic and Mesozoic strata. A consistent north-south stretching lineation and assymetric petrofabrics indicate upper plate transport to the south. Pegmatites emmanating from the garnet-two mica granite of Brown's Canyon (>44.5 Ma, Rehrig, 1982) cut the HT. Cratonic Paleozoic strata in the lower plate are depositionally overlain by northeastward-thickening early Mesozoic (pre-volcanic) feldspathic sandstone, siltstone, and conglomerate that record uplift of the Mogollon highland. Underlying Paleozoic rocks were folded into a large-scale SE-facing, overturned fold, and cut by flat faults with northward separation prior to HT movement. Metamorphic grade in Paleozoic and Mesozoic rocks below the HT increases to lower amphibolite facies in the NE. In the Arrastre Gulch area, Phanerozoic strata are upside down over >10 square km. Retrograde shear zones with variable transport directions complicate the structural geometry in this area.

The BDF can be traced for 15 km SW from the NE end of the range. Unmetamorphosed Mesozoic clastic rocks in megabreccia just above the fault in the Arrastre Gulch area could have been derived from a lower plate source (Red Hills) as near as 15 km to the SW providing a much lower minimum estimate for transport in this area than in the Harcuvar Mountains to the NW (50 km, Reynolds and Spencer, 1985). Mid-Tertiary dikes in the central part of the range strike NW (040-045) and dip mostly 90 to 65 NE (as low as 40 NE). These are cut by the BDF but cut all other low-angle faults. If dikes of this swarm were originally vertical, up to ~35 of SW tilting of the range occurred in connection with denudation by the BDF.

"PERCHED" GROUNDWATER CONDITIONS IN ORANGE COUNTY **№ 99806**

ROBBINS, Gary A., Woodward-Clyde Consultants
203 North Golden Circle Drive, Santa Ana, CA 92705
LINKLETTER, George O., Woodward-Clyde Consultants
203 North Golden Circle Drive, Santa Ana, CA 92705

"Perched" groundwater conditions on the Coastal Plain and adjoining mesas of Orange County are poorly understood. Limited information is available on the relation of shallow water and geology, directions of flow, locations of recharge and discharge, and the extent of hydraulic connection with deeper aquifers. Based on a number of investigations conducted to evaluate shallow groundwater conditions, the following observations can be made.

The shallow groundwater may often not be perched and may be in hydraulic continuity with deeper water-bearing zones. In places the shallow zone may exhibit semiconfined or confined characteristics, as reflected by the rise in water levels during drilling and well emplacement, and by low storage coefficient values obtained from well tests. In some areas, significant vertical downward gradients have been observed. These conditions may serve to complicate delineation of lateral flow directions. Locally, shallow groundwater flow appears to be significantly influenced by topography and land use. Lateral flow directions in the shallow zone are often significantly different from the deeper water bearing zones. Tidal response is also frequently observed in the near coastal area. Differences in tidal responses between shallow zones may served to direct flow in significantly different directions, diurnally. Hydrologic units in the shallow zone generally possess low hydraulic conductivity and poor quality water.

SEDIMENTOLOGICAL EVIDENCE FOR THE PALEOCEANOGRAPHY AND TECTONIC SETTING OF MID-LATE JURASSIC COAST RANGE OPHIOLITES, CALIFORNIA **№ 102649**

ROBERTSON, Alastair, H.F., Geology Dept., Edinburgh Univ., U.K., currently at USGS, 345 Middlefield Road, Menlo Park, CA 94025

Sedimentary rocks within and above the extrusives of the dismembered Mid-Late Jurassic Coast Range ophiolites (CRO) shed light on paleoceanographical and tectonic processes.

Inter-lava sediments (S. California, e.g. Point Sal; Quinto Creek) record open ocean accumulation mostly above the CCD. Extrusives are in places overlain by metalliferous silicate, oxide and minor sulphide facies (e.g. Lone Tree Creek; Quinto Creek; Del Puerto) attributed to hydrothermal processes at spreading centers and/or seamounts. These are overlain by volcaniclastic and radiolarian sediments up to several hundred m thick, that accumulated in a relatively fertile ocean in the vicinity of volcanic arc edifices (e.g. Questa Ridge; Stanley Mtn.; Healdsburg). Local derivation in a marginal basin is more probable than continentward from a Cascade-type volcanic arc. In N. California (e.g. Harbin Springs; Geysers area; Mt. St. Helena), up to several hundred m of ophiolite-derived coarse clastic units are attributed to pervasive strike-slip and accretion. Accretion is also recorded by dismembering of the ophiolites and development of ophiolitic colored melange (Paskenta area).

In the light of fossil (radiolarian) and geochemical ("immobile" trace element) data, the CRO is seen as a major marginal basin complex formed above a continentward-dipping subduction zone. Most marginal basin crust was subducted but volcanic edifice, arc and fore-arc units were preferentially preserved. After formation at more southerly paleolatitudes, the marginal basin was compressed, dismembered and finally incorporated into the continental margin by strike-slip and accretionary processes. Subsequently, more open ocean crust reached the trench and Franciscan terranes began to accrete from Tithonian time onwards.

IDENTIFICATION AND MITIGATION OF SLOPE INSTABILITY ON DEVELOPED PROPERTIES IN SOUTHERN CALIFORNIA **№ 99881**

ROBERTSON, Hugh S., Robertson Geotechnical, Inc., 2500 Townsgate Rd., Westlake, CA 91361; HOLLINGSWORTH, Robert A., Kovacs-Byer and Associates, Inc., 11430 Ventura Blvd., Studio City, CA 91604

The repair of hillside properties damaged by slope instability presents a challenging problem for the geotechnical professional. Early recognition of instability is essential to the successful mitigation of the hazard. Thorough observation of structural distress, experience, and an understanding of construction are needed to differentiate typical distress from subtle distress associated with the initiation of slope instability. Other soil related processes cause distress similar in

GSA Cordill.

1710-609 GRANVILLE ST.
P.O. Box 10363 Stock Exchange Tower
Vancouver, B.C.
V7Y 1G5
683-7265
(Area Code 604)

PUBLISHED DAILY
SUBSCRIPTION RATE
$300.00 PER YEAR

NO.110(1988)
JUNE 8, 1988

George Cross News Letter

"Reliable Reporting"

NO.110(1988)
JUNE 8, 1988

WESTERN CANADIAN INVESTMENTS

HUNTINGTON RESOURCES INC. (HUN-V)

SPECTACULAR 235 FOOT INTERSECTION ON BRETT CLAIMS

INTERSECTION IN FEET	AVERAGE OF GOLD ASSAY IN OZ/TON	NO. OF CUTS FROM REJECT
130-135	.13	3
135-140	2.85	2
140-145	5.66	4
145-150	11.07	2
150-155	3.65	3
155-160	1.84	2
160-165	2.47	2
165-170	1.35	2
170-175	1.56	2
175-180	1.44	2
180-185	3.55	3
185-190	1.27	2
190-195	9.02	3
195-200	7.52	3
200-205	5.83	2
205-210	2.06	2
210-215	5.08	3
215-220	2.67	2
220-225	4.25	3
225-230	2.37	2
230-235	2.53	3
235-240	3.02	1
240-245	1.01	1
245-250	.58	1
250-255	.347	1
255-260	.395	1
260-265	.986	1
265-270	.474	1
270-275	.480	1
275-280	.496	1
280-285	.123	1
285-290	.152	1
290-295	.436	1
295-300	.191	1
300-305	.863	1
305-310	1.81	1
310-315	.189	1
315-320	1.08	1
320-325	.817	1
325-330	.384	1
330-335	.614	1
335-340	.385	1
340-345	.497	1
345-350	.266	1
350-355	.249	1
355-360	.703	1
360-365	.609	1

Stirling D. McIlveen, president of Huntington Resources Ltd., reported a 235 foot intersection averaging 2.03 oz.gold/t in reverse circulation hole RC-88-11 on the Brett claims 26 km west of Vernon, B.C. Lacana Mining Corp. will have earned its 51% interest when the $500,000 program for 1988 has been completed.

Phase 1 of the 1988 program consists of 2,000 feet of reverse circulation drilling in the the central section of the Main Shear zone where numerous intersections were encountered in 1987. (SEE MAP OVERLEAF PAGE 1, which includes some drilling results from 1987). RC-88-11 was targeted to test the continuity of high grade gold mineralization intersected in holes No.87-29, 30 & 47 on section 8+05N. It was collared on the east side of the Main Shear zone and was drilled through and beyond these three core intersections. The mineralization is largely in the footwall of the Main Shear zone and includes an upper higher grade section of 145 feet averaging 2.95 oz.gold/t with much visible gold and a section beneath with 90 feet averaging 0.548 oz.gold/t. (AREA MAP OVERLEAF PAGE 2. See GCNL No.40 p.2 26Feb88 for previous article).

BRICAN RESOURCES LIMITED (BRI-V;BRIIF-Nasdaq)

VERNON CLAIMS TO BE FURTHER EXPLORED

Brican Resources has secured financing for work in 1988 of the 100% Gold Star property adjacent to the Brett claims of Huntington Resources (SEE ABOVE.)

The mineralization is of two types: gold values associated with quartz veining in steep shear zones cutting tertiary volcanic rock, and gold mineralization disseminated in porous horizons of flat-lying volcanic tuff adjacent to the shear zones. This latter type of mineralization offers potential for larger tonnages.

On property, three shear zones have been delineated by geophysical surveys. Detailed geochemical soil surveys have discovered anomalous gold zones on each shear zone where it cuts the porous tuff horizon.

CAN-EX RESOURCES LTD. (CXZ-V)

SOCORRO REEF STRUCTURE 3.5 MILES ALONG STRIKE BY 200 FEET WIDE TO BE DRILLED TO FOLLOW UP TO ORE GRADE GOLD VALUES ON SURFACE

Drilling is scheduled to start by June 30,1988 on the Socorro Reef gold project on which Can-Ex Resources recently secured an option to purchase a 100% interest.

The Socorro Reef is located 10 miles NE of the formerly producing Harquahala Mine, and 75 miles WNW of Phoenix, Arizona. The Harquahala mine is estimated to have produced some 200,000 oz. gold in the early 1900's from a similar geological environment. There are a number of other old workings on the Can-Ex property which have estimates of modest gold production. The geology and records of former production attracted major companies in the early 1980's. While the general region of the property has developed several new mines in the last few years the immediate area of the Henry Bell mine within the Socorro Reef property has been quiet.

The current drilling will be the first stage of testing of a limestone formation stratigraphically above a gold geochemical anomaly 3,000 feet long by up to 1,000 feet wide contained within a quartzite formation trending southwesterly from the Henry Bell mine. Previous drilling by a major company indicated a substantial tonnage of subeconomic gold mineralization in the quartzite. This anomalous area is within a gold mineralized limestone, quartzite formation, mapped over a 3.5 mile northeast - southwest strike length having mineralized widths of 200 feet. Near the middle of the strike length of the structure is the Henry Bell workings. In the immediate area of the Henry Bell mine, channel surface sampling in the limestone returned values shown in the table.

GOLD	SILVER	WIDTH FT.	
0.88	0.3	20	
0.20	0.5	40	
0.22	1.5	20	
0.49	4.6	30	
0.13	0.7	20	
0.19	1.6	60	these 6 samples are over a 200 ft.
0.07	1.0	10	strike length, within a 200 ft. width
0.10	0.3	20	Same area
0.07	0.7	30	Same area
0.17	0.6	10	From an old adit at Henry Bell.
0.82	24.0	10	From old pit 300 ft. n of Henry Bell
0.56	0.6	GRAB	
0.93	6.4	GRAB	800 ft. north of Henry Bell
0.10	1.32	GRAB	800 ft. north of Henry Bell

To minimize assaying difficulties often encountered in this type of gold property the company will use larger than normal samples, with careful mixing, screening and assaying procedures.

-CONTINUED ON PAGE TWO-

[redacted]

Texasgulf memo

Date March 8, 1985

To Chuck Lane Location Reno

From Blair Salisbury Location Golden

Subject Gravity Survey Little Harquahala South

Four gravity lines were surveyed. These included two eastern S 30° W lines designated by you on a map transmitted to me and two alternate lines per our discussion yesterday.

Line A is the easternmost, and starts on a limestone hill outcrop slightly east of your described origin.

Line B starts 800 feet northeast of a previous drill hole and prospect pit (chrysocolla) which you had given as a possible origin.

Line C starts at B 22 + 00 S and runs 1600 feet N 75° W.

Line D starts at B 26 + 00 S and runs 3000 feet due west.

<u>Interpretation</u>

Line C crosses the thrust plate contact into altered mesozoic (Tertiary ??) clastics (volcaniclastics ?) no gravity low occurs - the mesozoic rocks here are not less dense than the granite.

Lines A + B show distinct boundaries to shallow granitic basement:

~28 + 00 on B vertical?

~12 + 00 on A >>30% slope to south

You should be okay within ~250 feet (probably much better) north of a line connecting these locations, and out of luck south.

Line D is clearly south of this break (deepening alluvium) in its westward extension. I strongly suspect that the low values indicate the basalt of the hills around this area to be floored by low density alluvium &/or volcaniclastics, and do not lie on granite basement.

The gravity data appear to be climbing back up as the high basalt hills south of the main graded highway are approached, suggestive of basement horsting there. However, the edge is probably too far to be of interest (too much scree cover), at least here. Carl Windels and I can debate whether terrain, regional gradients, etc., come into play here, and this may influence just how terribly deep we think the basement is south of the 2800 B - 1200 A lineament fault or basin edge.

Conclusion

Conducting a few days of gravity here was a good idea. It clearly limits our area of interest, which is a shame from an economic viewpoint of prospective area.

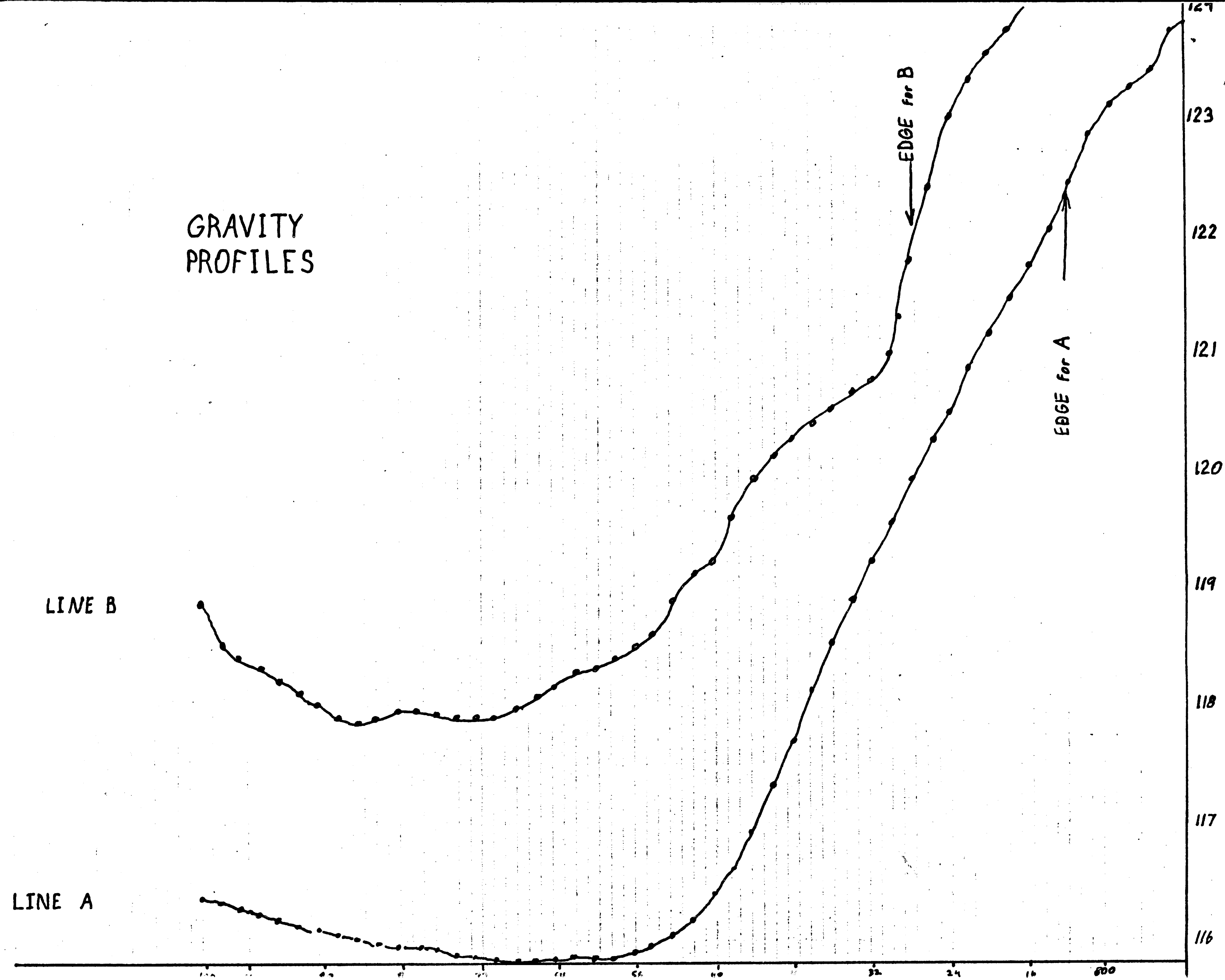
I have no idea when I can finish processing the data, but will try to get them to you in map form as soon as practical.

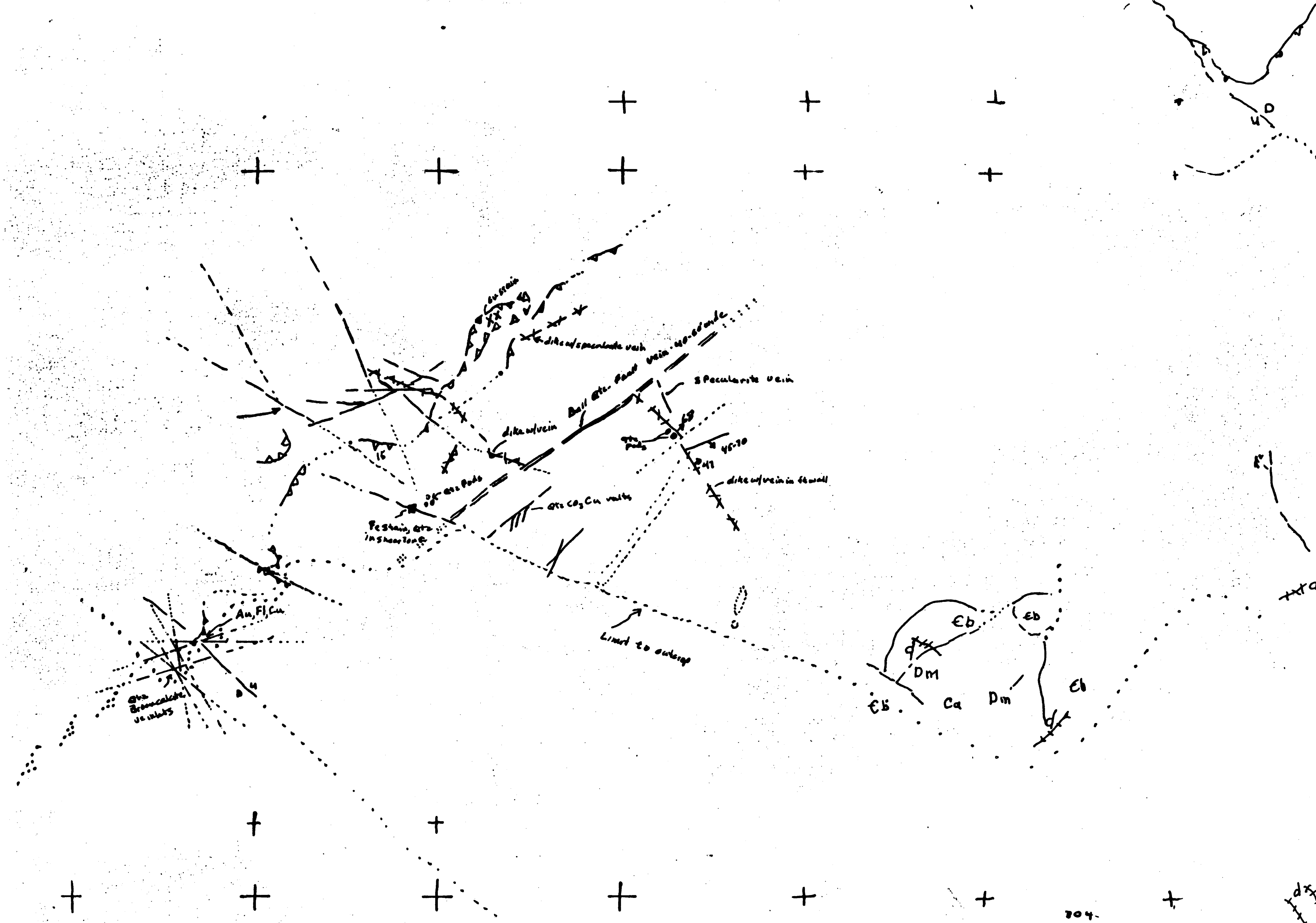
We will have a chance to discuss these conclusions before your drilling, though.

Blair Salisbury (dc)

BS/dc

GRAVITY PROFILES





204.

1" = 1000'
Yuma Claims

Sample Log

Page 1

County YUMA State AZ T. 4 N R. 12+13 W

Location	Remarks
127251	QTZ CARBONATE VNS BLEEDING UP INTO P, DK BRN CC, YEL-BRN LIM ON FRINGE, WHT QTZ CENTER
252	just above contact w/ purple Mzs & qzite + sil. Ls - loc. bxiated w/ minor feox-qz vnlts
253	P CARBONATES + QTZITES, MnO2, V/SL HEM CHERTY LENSES IN LS
254	GRAB OF PURPLISH MZ (MESOZOIC) JUST BELOW P, SMALL CC VNS (WHITE)
255	N76E 42NW QTZ-SID VNS, BRN/YELL-BRN LIM
256	LT GREEN, VERY SILICEOUS ALMOST PORCELAIN TEXT, DK MIN (DISSEM), CRISS-CROSSED BY QTZ/CC VNLTS, BETWEEN Mz + Pems
257	3'x6' PATCH Pems, QTZ/SER, HEM, LIM, BLEACHED ZONE
258	Pems, SILICIC, CHLOR, GREEN, NEAR BOTTOM OF PLATE
259	GRAB OF SILICIC/PORCELAIN LT GREEN TO TAN
266	Pems AT STRUCTURE INTERSECT, SOME SER, BRN TO YEL/OR BOXWORKS, HEM ON FRCS
261	prospect on N10W 20SW sil zone - Mzs w/ feox on frx & lgt green silic. rx w/ qz-carb vnlts
262	Pems N20-50W FRCS, QTZ SMEARED
263	lgt green clay-sericite alt. granite - v. str. broken w/ hem. STAIN AND dissem spots
264	5' SILICEOUS LAYER WITH JAR. TAN, SL HEM, CC + TINY QTZ VNLTS, N60W 45 SW
PSPCT 265	SILICIFIED, BXIATED MATERIAL, HEM ON FRCS, RED BRN BOXWORKS
266	SILICIFIED BXA, ANGULAR TO SUBROUNDED FRAGS, HEM, LIM AFT PY, BUF/BRN CC IN FRCS, N30W 12" WIDE
267	10'x30' SILICEOUS PATCH, CC CEMENT, Pems FRAGS, CuOx, BOXWORKS, HEM, QTZ IS FRAGMENTED
268	at thrust contact Ls w/ granite - Ls gray, mass. w/ calc-sil vnlts - gr sheared, chl cng wk
269	3' OFFSET IN THRUST, Mz + Pems, CC CEMENT
270	N70E rubbly struct w/ orange ochre feox STAIN - in granite adj white qz-carb vnlt
271	12" SILICEOUS ZONE IN Pems, SL HEM, SERICITE, FAULT JUNCTION, LOW + HI ∠
272	N60W fault zone of granite rubble w/ minor CuOx & orange ochre feox
273	SILICEOUS MICRO BXA, TAN TO LT BRN WITHIN Pems, N50E - N35E, 15-20NW
274	granite near thrust, ?1 - some qz vnlts & orange ochre feox - small N60W shear
275	N43W VERT, N62W 81NE, N22W 78NE QTZ VNS IN Pems, HEM LIM AFT PY, BRN CC
PSPT 276	N53W 74 SW, HEM QTZ FRAC IN Pems, CuOx, SILICIFIED BXA, STOCKPILE GRAB
DUMP 277	GRAB OF 276

Sample Log

County ______ State ______ T. ______ R. ______

Location	Remarks
127 278	N45E MICRO DIORITE DIKE, QTZ/HEM VNS, LARGE LENSES SPEC HEM, CuOx, YEL/BRN FEOx ON FRCS, CHLORITIZED Pemg
279	GENL GRAB OF QTZ/cc VNS IN Pemg, LIM
280	SILICEOUS ZONE AT Pemg - Mz - P̄, FAULT INT, CuOx, LIM, HEM, LT BRN cc VNS
281	10" SILICEOUS MICRO BxA? BETWEEN REDBEDS & PORPH ANDESITE (PINKISH)
282	QTZ VN in ≃ ∥ FAULTS, N52W 67NE, 1" WIDE WHT & BLK SILICEOUS BANDS
283	strongly sheared granite - greenish ser, dissem lim aft. py · few vnlts hematite
284	Pemg LOW ∠ SHEAR, QTZ, w/TOUR, HEM
285	Pemg, BUFF w/MORE THAN USUAL QTZ/cc VNS, DK BRN cc
286	SILICIFIED MICRO-BxA BETWEEN Pemg & Mz, REDDISH/OR COLOR
287	qz-siderite vnlt N85W in granite
288	SILICIFIED MICRO-BxA WITHIN Pemg, RUST COLOR
289	Pemg, HEM AT SURFACE, SILICIFIED, BLEACHED, QTZ/SER, CuOx
PSPCT 290	Pemg, QTZ/SER, HEM, CuOx, LIM → PY, CHRYS VNLTS
291	base granite thrust onto Mz · 5' pit · granite str broken w/ CuOx, feox, green arg-ser
292	N80W, TINY ∥ QTZ/cc VNS, LIM, SILICEOUS RX AT Pemg/Mz CONTACT
293	granite above thrust cont w/ Mz. orange ochre feox STAINED, vnlt material
294	N10E HEM/MnO_2 ZONE Pemg
295	N10W SILICIFIED ZONE Pemg, 1' QTZ/cc VN, HEM, BRN cc
296	CALCAREOUS UNIT AT SHEAR, P̄? QTZ/CC VNLTS, HEM, JTI BELOW
297	siderite-quartz vnlts N20W w/ chloritized diorite?)
298	dk green, fine grd, locally porph fsp, rock - w/ v. fine dissem limonite - aft py?
PSPT 299	N82E 72NW FAULT IN Pemg & N22W 3' BASALT DIKE, QTZ, HEM, LIM → PY, cc ON FRCS, SER
300	N10W BDING? ALONG THRUST N60E, SILIC, HEM, CALCAREOUS
301	N30-40W fract w/ limonite aft py, qz vnlts, sid-qz vnlt in str. crushed granite
PSPT 302	N40E FRCS IN LT MINE RX, HEM, LIM, SILICIC, CuOx

Sample Log

Page ——

County YUMA State AZ T. 4N R. 12 + 13 W

Location	Remarks
127301	qz-sid vnlts in granite
302	PSPCT, N40E FRACS IN LT XLINE ROCK, HEM, LIM, SILICIFICATION CuOx
303	small jasperoidal spot ~ contact rhyolitic? volc? on Arkosic sed - qz-sid vnlts
304	N70W qz vnlts in siliceous volc w/ hem after biot, qz vnlts
305	GREEN, APHANITIC GROUND MASS W/ SAN + QTZ PHENOS, DISSEM SPEC HEM W/ CHRYS SPECKS, 3'x4' PAT
306	base volc plate - incr. frx, qz-sid vnlts, minor feox - grab vnlts & feox on N70W frx-vn
307	SILICIFIED BXA, QTZ/SER, CC, HEM, N40W FRACS
308	REDDISH, SILICIC ZONE IN VOLC, WELDED TUFF?
309	N70W QTZ/CC VNS, SL HEM
310	12" FEOX BAND BETWEEN Pcmg + Jv, OX MIN IN QTZ, TOUR? SHEAR ZONE IS 3' THICK
311	Pcmg THRUST OVER METAS, N15E 18 SW, LIM AFT PY
312	QTZ/CC VN NEAR MICRO DIORITE DIKES + SM PLUGS, BRN/YEL CC, CHL, N70W, SPEC HEM, FEOX
313	N-S 65E QTZ VN, BRN CC, 6" THICK VNS FOR 30', SM CuOx SPOTS, CHRYS IN CC VNS
314	N0-20E siderite vnlts ·½-2" bxa cemented · in meta rock below granite
315	siliceous feldsp gneiss w/ sericite & bull qz vnlts, feox on frx
316	N15W 2' QTZ/CC VN, LT BRN CC IN GNEISS
317	PSPCT, Pcmg, FAULT INTERSECT, N30E + VERT, N60E 76NW, VARIOUS LOW ∠ FRACS, ALL FRCS CONTAIN QTZ-SER, HEM, SPEC HEM
318	carbonate-qz vn, orange ochre, in granite
319	qz-siderite vnlts in granite
320	PSPCT ON N3E 45NW QTZ/CHL VN, HEM, CuOx
321	Pcmg OVERLYING METAMORPHICS, 2" SHEAR, HIGHLY FRAC ABOVE + BELOW, QTZ/HEM VNS, DISSEM LIM→PY IN META
322	META, ZONE OF STRONGLY FRAC, QTZ VNING, LIM → PY
323	qz-sid vnlts in meta - qtzitic gneiss - just below thrust
324	PSPCT, N65E + N10W FAULTS, (HI ∠) IN META, QTZ, CHRYS, HEM, MnO_2, DISSEM SPEC HEM
325	LOW ∠ SHEAR IN META? LIM → PY ON FRCS, FEOX
326	HEMATITIC SHEAR IN META, N10W
327	FRACS W/ QTZ-CC VNS, LT BRN CC, FLAT VNS

Sample Log

_____ County __________ State __________ T. ______ R. ______

Location	Remarks
127 328	QTZ/CC VNS N65-85E IN METR, SER ALT OUTWARD FROM VNS, SCATTERED LARGE LIM → PY
329	reddish brown feox STAINED, well broken, arg-ser meta · str sio · qz vnlts
330	6' CHIP GRAB ACROSS HEM FACE IN META, WIDE GNEISSIC BANDING, DISSEM LIM → PY, BRN CC VNS HEM COLOR N80E CC VNS
331	greenish feldspathic gneiss - well broken - sio. feox, minor dissem lim
332	SELECT CHIP OF LIM → PY, CHLOR- GNEISS, FEOx, JAR
333	well developed biot gneiss · well broken w/ red brn feox
334	N60W 40SW SHEAR, QTZ, CC, LIM → PY, HEM, 12" CHIP ACROSS
335	HEM ALONG BANDING IN GNEISS
336	CHIP GRAB ACROSS FEOx, CHLOR SCHIST
337	APLITE DIKE ? N20E IN GNEISS, HEM, LIM → PY ON FRACS
338	qz vns w/ ep · brown feox in chloritized gneiss & dior. rx - brown to ochre feox
339	N42W FAULT, BRN QTZ/CC VNS, YEL/BRN CC, COARSE CLEAR CC ON FRCS, FEOx
340	15' CHIP GRAB, BETWEEN NxNW FAULTS, SER, LIM → PY, SL HEM
341	HEM FAULT, RUBBLE ZONE, N55W 25SW, CC CEMENT
342	across contact dior & quartzofeldsp. gneiss - broken, qz vnlts minor feox
343	prospect N75W fault in gneiss w/ MOD brown, to red feox
344	low portion metaplate N20W qz · sio vn in chloritized, broken, sheared gneiss
345	qzofsp gneiss w/ loc bands chlorite - weak sio vnlts & feox on frx
346	N50W white qz vn - slightly broken w/ sio w/ orange ochre to red feox
347	PSPCT, N50W 60SW SILICEOUS HEM FRACS
348	qtzitic rock in gneiss · STRONGLY hematitic · cut by few qz vnlts
349	N35E QTZ/CC VN IN PCMS, YELLOW → BRN FEOx
350	SHAFT, N35E QTZ VN, HEM, CuOx, LIM → PY
351	N35E qz vn · grab from N SIDE in shallow pit
352	LARGE PIT, CHIP GRAB OF WALLS, SILICEOUS-HEM BANDS, HIGHLY ALTERED PCMS
353	SHAFT, N60E LOW ∠ QTZ/CC VNS, HEM BANDS ‖ TO SHEAR
354	white bull qz · N10W, silic. zone N10E qz bxa on N35E

Sample Log

Page ____

____ County ____________ State ____________ T. ________ R. ________

Location	Remarks
355	N40W 20-40 SW STRUCTURES, SIO_2, LT BRN CC, HEM, WO_x
356	N35E qz vn. loc boxworks, wk orange ochre Feox
357	silicified hematitic granite w/ qz vnlts
358	PSPCTS N10E-10W /55E, MINERALIZED FRACS, HEM, QTZ, WO_x, MnO_2, Pcmg
359	N25W, N5E & N20E qz vns in granite
360	PSPCT Pcmg, CHRYS VNLTS, QTZ, DISSEM LIM → PY, HEM, WO_x, MnO_2, BOXWORKS, FRESH PY

Geochemical Analysis Report

GSI

TO: Mr. J.O. Guthrie
Newmont Exploration Ltd.
200 W. Desert Sky Rd.
Tucson, AZ 85704

Lot Identity: NEC-60310A 9R8
Digest: 5.0 gram

Report Date: 03/13/86

Arizona General Little Harquahala
Rock Chips

Sample ID	#	Ag ppm	As ppm	Au ppm	Cu ppm	Hg ppm	Mo ppm	Pb ppm	Sb ppm	Tl ppm	Zn ppm
NT 127251	1	.0658	25.59	.0072	772.6	<.496	6.248	47.32	5.199	<.992	285.6
NT 127252	2	.1519	17.50	.0075	96.64	<.489	3.340	71.81	9.439	3.502	116.1
NT 127253	3	.0892	7.119	.0240	29.03	<.492	2.941	134.9	<.984	<.984	489.7
NT 127254	4	<.047	17.33	.0049	30.93	.7761	2.511	10.78	<.954	<.954	25.24
NT 127255	5	.2028	13.92	.0140	306.1	<.480	10.80	312.5	6.440	3.334	205.2
NT 127256	6	<.047	4.656	.0045	30.71	.7555	3.000	59.19	<.954	<.954	6.169
NT 127257	7	.2721	19.80	.1464	76.83	<.490	6.803	132.8	1.937	<.952	243.1
NT 127258	8	<.047	2.674	.0054	5.255	.7789	1.404	7.206	1.092	<.950	53.05
NT 127259	9	.0603	3.215	.0039	22.88	.5372	1.426	17.96	1.844	1.664	7.054
NT 127260	10	.4481	8.447	.0228	104.7	<.491	7.156	433.3	<.982	<.982	27.50
NT 127261	11	.1993	26.25	.0156	512.2	.5574	5.505	140.9	4.962	<.980	85.93
NT 127262	12	.2464	4.638	.0063	147.6	<.989	1.317	28.08	.9938	2.350	15.85
NT 127263	13	.1440	6.241	.0052	418.9	<.483	1.889	319.2	.9906	<.967	53.22
NT 127264	14	<.048	16.47	.0050	95.31	.7142	2.420	42.42	2.445	<.965	25.05
NT 127265	15	2.241	20.28	.1583	34.08	<.482	110.5	254.4	3.506	1.995	13.35
NT 127266	16	8.431	47.86	.5977	21.80	<.484	174.0	309.3	2.953	<.968	15.39
NT 127267	17	.5655	11.44	.2333	593.5	.6914	10.72	414.8	1.043	<.970	149.0
NT 127268	18	.0954	11.11	.0173	38.55	<.480	4.151	197.8	1.018	3.782	33.38
NT 127269	19	.0533	5.749	.0190	79.64	<.486	1.845	81.61	<.972	3.386	45.38
NT 127270	20	<.049	6.611	.0069	3.330	<.494	1.965	14.15	<.988	<.988	24.95
NT 127271	21	.0834	4.793	.0130	27.14	<.724	1.661	54.31	1.353	2.205	49.99
NT 127272	22	.2332	18.84	.0047	854.7	<.483	2.588	30.21	1.107	2.431	17.90
NT 127273	23	.1551	30.10	.1045	77.89	.7959	1.476	28.29	<.976	2.166	77.48
NT 127274	24	.1396	12.86	.0039	13.59	1.558	2.518	32.54	<.946	2.412	32.93
NT 127275	25	<.047	13.26	.0041	18.20	1.147	2.605	22.15	<.956	<.956	72.65
NT 127276	26	3.949	18.75	3.789	135.0	.9794	57.96	447.5	6.970	1.300	112.6
NT 127277	27	.2978	7.252	.2109	131.0	<.489	5.135	81.68	1.241	2.772	140.8
NT 127278	28	3.896	100.1	.3007	5980	9.817	5.528	2981	29.33	<.978	6335
NT 127279	29	.1242	10.10	.0091	66.40	<.835	4.525	135.3	<.980	<.980	351.1
NT 127280	30	2.808	112.7	.0445	5030	1.323	9.978	79.83	924.	<.984	639.6
NT 127281	31	.0954	19.39	.0055	168.0	<.480	3.380	15.18	20.82	<.961	123.8
NT 127282	32	<.049	16.47	.0030	36.72	<.491	2.096	44.63	7.208	<.982	164.8
NT 127283	33	.1698	13.32	.0475	16.05	<.487	4.143	106.8	2.518	<.974	63.61
NT 127284	34	.7248	46.16	.0999	269.6	.9428	44.21	450.3	13.70	<.978	51.00
NT 127285	35	.0920	7.145	.0050	18.96	<.488	1.299	17.40	<.976	3.114	43.62
NT 127286	36	<.049	36.41	.0057	21.87	.8399	6.399	96.05	1.152	<.990	40.42
NT 127287	37	.1364	28.98	.0054	37.83	.8787	2.165	50.64	<.980	<.980	126.1
NT 127288	38	.2910	26.97	.0018	84.87	1.447	8.306	17.06	1.559	1.669	46.46
NT 127289	39	.3767	11.97	.0433	65.61	<.482	18.75	873.7	<.965	<.965	187.5
NT 127290	40	31.92	27.00	2.956	5989	<1.61	29.40	931.8	16.01	<.974	3404
NT 127291	41	.2783	16.99	.0051	57.56	.9050	1.906	34.68	<.968	<.968	103.3
NT 127292	42	.2947	20.84	.0105	837.5	<.491	5.977	43.63	<.982	<.982	105.5
NT 127293	43	.2701	16.81	.0063	43.44	.9484	1.932	33.76	<.965	<.965	103.0

Lot ID: NEC-60310A

Sample ID	#	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
NT 127294	44	.3828	7.025	.0107	36.45	<.540	4.318	51.95	1.294	<.965	90.63
NT 127295	45	.3841	24.60	.0322	235.4	1.029	3.860	216.4	8.993	<.982	937.9
NT 127296	46	4.301	35.32	.0080	1492.	.9555	4.029	148.9	2.894	<.950	2307.
NT 127297	47	13.45	21.10	.0101	939.8	<.480	2.756	47.54	10.32	1.945	548.3
NT 127298	48	.1707	6.181	<.001	89.96	.9413	1.452	6.618	<.980	<.980	133.2
NT 127299	49	1.395	28.51	.0110	117.8	.6802	7.297	311.9	2.052	<.974	236.1
NT 127300	50	.2280	30.31	.0051	130.6	<.483	6.953	67.49	3.013	1.829	90.73
NT 127301	51	2.206	16.50	.0182	316.2	.8486	4.037	605.9	3.875	<.968	434.2
NT 127302	52	16.36	16.24	.0107	797.6	<.494	2.932	606.1	10.05	<.988	89.70

Red: Indicates data above high standard and may not be quantitatively accurate.

==

This report has been reviewed and approved by:

_______________ Date: 3/14/86

William B. Henderson, Lab Director/Chemist

RECEIVED

Geochemical Analysis Report

TO: Mr. J.O. Guthrie
Newmont Exploration Ltd.
200 W. Desert Sky Rd.
Tucson, AZ 85704

Lot Identity: NEC-60319B
Digest: 5.0 gram

Report Date: 03/19/86

Arizona General Rock Chips — Little Harquahala

Sample ID	#	Ag ppm	As ppm	Au ppm	Cu ppm	Hg ppm	Mo ppm	Pb ppm	Sb ppm	Tl ppm	Zn ppm
NT 127303	1	<.048	12.00	.0101	2.631	<.480	2.298	18.41	2.262	<.961	3.762
NT 127304	2	<.047	35.26	.0034	3.805	1.611	3.094	11.18	3.196	1.158	3.168
NT 127305	3	.3845	2.581	.0061	1253.	<.482	.8303	18.68	<.965	<.965	171.1
NT 127306	4	<.048	15.28	.0061	54.27	<.489	2.797	40.00	2.699	<.978	26.49
NT 127307	5	.1701	6.934	.0064	91.90	<.493	2.579	14.15	2.229	<.986	139.0
NT 127308	6	<.049	8.665	.0152	9.618	<.491	2.637	17.54	3.012	<.982	8.440
NT 127309	7	.1120	18.78	.0114	18.80	<.493	2.655	90.06	1.119	<.986	227.1
NT 127310	8	.2126	7.944	.1165	38.27	.5399	13.48	77.92	1.803	<.978	31.99
NT 127311	9	.0764	3.634	.0058	11.48	<.487	1.828	16.51	<.974	<.974	20.54
NT 127312	10	.0899	17.43	.0095	8.440	1.265	3.102	33.72	<.968	1.373	433.4
NT 127313	11	5.284	30.10	.0216	1068.	<.493	4.859	279.6	38.88	<.986	536.6
NT 127314	12	.2431	36.38	.0065	180.0	<.492	4.348	157.2	2.127	<.984	2210.
NT 127315	13	.1314	34.11	.0066	18.29	<.499	4.543	28.68	1.071	<.998	129.8
NT 127316	14	.1991	117.2	.0070	47.02	<.476	8.770	22.65	3.942	1.353	321.2
NT 127317	15	.1638	5.922	.0084	26.40	<.480	1.919	17.98	<.961	<.961	39.29
NT 127318	16	.2582	31.15	.0075	130.4	<.483	5.123	130.6	1.206	<.967	1024.
NT 127319	17	.0920	8.373	.0067	20.98	<.488	2.194	35.41	1.286	<.976	200.4
NT 127320	18	105.8	103.4	.9718	6334	<1.23	14.84	2988	90.80	<.956	269.5
NT 127321	19	.9071	32.88	.0093	88.42	<.486	2.901	86.20	2.160	2.225	43.79
NT 127322	20	.3831	4.059	.0037	34.43	.5563	2.288	20.24	1.346	<.956	6.681
NT 127323	21	.3742	28.22	.0043	53.73	<.483	6.926	44.94	2.006	<.967	800.0
NT 127324	22	40.01	45.40	.1148	5880	2.238	4.157	1044.	25.15	<.980	368.9
NT 127325	23	.6835	5.833	.0106	186.8	.6948	6.914	39.53	1.547	<.968	44.75
NT 127326	24	.8606	13.90	.0042	48.09	<.483	2.762	52.97	1.326	<.967	449.1
NT 127327	25	.2650	12.39	.0141	353.4	<.481	3.337	48.63	1.859	<.963	87.35
NT 127328	26	.1986	8.564	.0039	9.456	<.477	2.860	14.61	<.954	<.954	88.29
NT 127329	27	.1499	63.97	.0037	137.3	<.477	36.83	57.93	<.954	<.954	178.6
NT 127330	28	<.048	18.89	.0028	28.46	<.489	2.904	21.37	<.978	<.978	59.28
NT 127331	29	<.047	4.162	.0032	14.55	<.478	1.950	8.905	<.957	<.957	17.63
NT 127332	30	<.048	6.992	.0048	33.55	<.481	4.195	8.055	<.963	<.963	91.03
NT 127333	31	.2740	17.86	.0073	30.41	.5718	2.623	5.861	1.298	<.959	83.18
NT 127334	32	7.085	21.61	.0179	582.9	<.486	18.89	294.9	2.841	<.972	213.6
NT 127335	33	.2428	11.01	.0072	30.53	.5883	2.303	11.17	<.941	<.941	52.57
NT 127336	34	.1346	6.208	.0066	87.69	.5379	1.456	8.273	1.699	<1.02	81.26
NT 127337	35	.2877	4.933	.0063	39.46	<.512	2.670	17.16	<1.02	1.068	47.21
NT 127338	36	.2129	8.503	.0048	20.33	.9233	4.189	5.139	1.095	<.950	55.48
NT 127339	37	.3115	7.936	.0083	29.48	.5448	2.483	12.65	1.302	2.048	39.86
NT 127340	38	1.103	9.315	.0062	83.27	1.107	1.097	64.94	1.106	<1.00	68.95
NT 127341	39	.3022	9.199	.0067	59.05	.7951	2.948	77.48	1.100	<1.00	147.9
NT 127342	40	.1014	9.157	.0074	62.47	<.514	1.390	8.474	1.070	<1.02	57.75
NT 127343	41	.0717	29.83	.0026	24.05	<.505	3.730	13.03	1.338	<1.01	104.9
NT 127344	42	.0681	10.85	.0036	59.95	1.233	12.15	26.58	1.151	<1.01	65.79
NT 127345	43	<.053	14.59	.0056	32.34	1.530	1.980	17.68	<1.06	<1.06	87.49

GSI, 2741 Toledo St.,Suite 211, Torrance, CA 90503 Phone: 213/320-3680

Sample ID	#	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
NT 127346	44	<.052	23.70	.0094	11.74	<.523	6.829	8.484	<1.04	<1.04	87.12
NT 127347	45	.2293	11.33	.0481	25.13	<.517	68.25	203.5	2.022	<1.03	124.4
NT 127348	46	.9335	4.466	.0278	32.33	.6564	5.824	150.3	<1.03	<1.03	45.60
NT 127349	47	<.052	11.46	.0032	5.556	1.424	5.162	10.70	<1.05	<1.05	117.6
NT 127350	48	3.048	71.99	.1652	2344.	1.990	49.81	670.0	4.931	<1.00	156.0
NT 127351	49	2.658	11.45	.0904	139.0	1.505	8.205	331.9	1.803	<1.05	32.04
NT 127352	50	8.176	51.03	.2221	859.4	<2.01	43.79	1471.	10.83	<.936	1002.
NT 127353	51	.7649	14.45	.1233	77.83	1.050	7.402	241.1	1.902	<1.00	98.26
NT 127354	52	.1493	3.632	.0147	20.62	.6788	3.681	75.81	<1.01	<1.01	116.5
NT 127355	53	12.87	40.40	2.506	5585	<.711	37.35	601.5	4.196	<1.06	178.4
NT 127356	54	.6178	8.658	.0211	75.22	<.537	4.090	123.5	<1.07	<1.07	191.6
NT 127357	55	.2952	11.38	.0300	103.3	1.478	5.550	60.41	2.054	1.381	124.4
NT 127358	56	3.385	180.7	.3281	5234	5.175	22.22	2242	3.483	<1.01	5301
NT 127359	57	.1714	5.623	.0114	217.3	.7582	2.630	47.62	<1.00	<1.00	178.0
NT 127360	58	7.984	37.68	21.35	1107.	<.495	77.83	452.3	5.271	<.990	264.1

Red: Indicates data above high standard and may not be quantitatively accurate.

==

This report has been reviewed and approved by:

______________________ Date: 3/20/86

William B. Henderson, Lab Director/Chemist

To ______________________

Date ______________ Time ______________

WHILE YOU WERE OUT

M ______________________

of ______________________

Phone ______________________

Area Code Number Extension

TELEPHONED		PLEASE CALL	
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		URGENT	
RETURNED YOUR CALL			

Message Bill Carter
327-9323
work out for idea
in Salve
wk of
Feb. 24th

Operator

To GAP

Date ______ Time ______

WHILE YOU WERE OUT

M Del Schultz

of 602-256-8447

Phone ______

Area Code | Number | Extension

TELEPHONED		PLEASE CALL	
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		URGENT	
RETURNED YOUR CALL			

Message You can talk 1/2 minute on this beeper

-re Alaska Mine

-should give him a call when in Phoenix, will come and talk

Operator

Tim Atkinson

(602) 488-3702 Yuma Cty AZ

{Harquahala -- - St Joe } drill +
{Bonanza -Anselco } underground
-Sun Oil } 1,000,000
@ .1 oz/t

Terms –

have spent $1,500,000

this property and others

-75% of property -exploration

5% NSR	net

Red Rover – can

Looked at by WSD & GFB, summer 1981, no further interest by NICOR. Visit area 8/24/82

PERRY PROPERTIES, INC.
The Financial Center, Suite 1300
3443 N. Central Avenue
Phoenix, Arizona 85012
(602) 274-7653

February 4, 1988

Mr. Hugo Dummett
District Geologist
Westmont Mining, Inc.
2341 S. Friebus, Ste. 12
Tucson, Az. 85713

Dear Hugo:

Enclosed please find the GSA Resources, Inc. geologic investigation report on the Rio del Monte, along with my sales memorandum.

I look forward to meeting you and Mr. Sam Robinson at the Schefler Cafe in Salome on Tuesday, February 9, 1988 at 2:00 p.m., and driving from there to see the property.

Sincerely,

James R. Perry

James R. Perry

cc:
N. Douglas Grimwood
James Jack

JRP/ts

UPS Next Day Air Pak

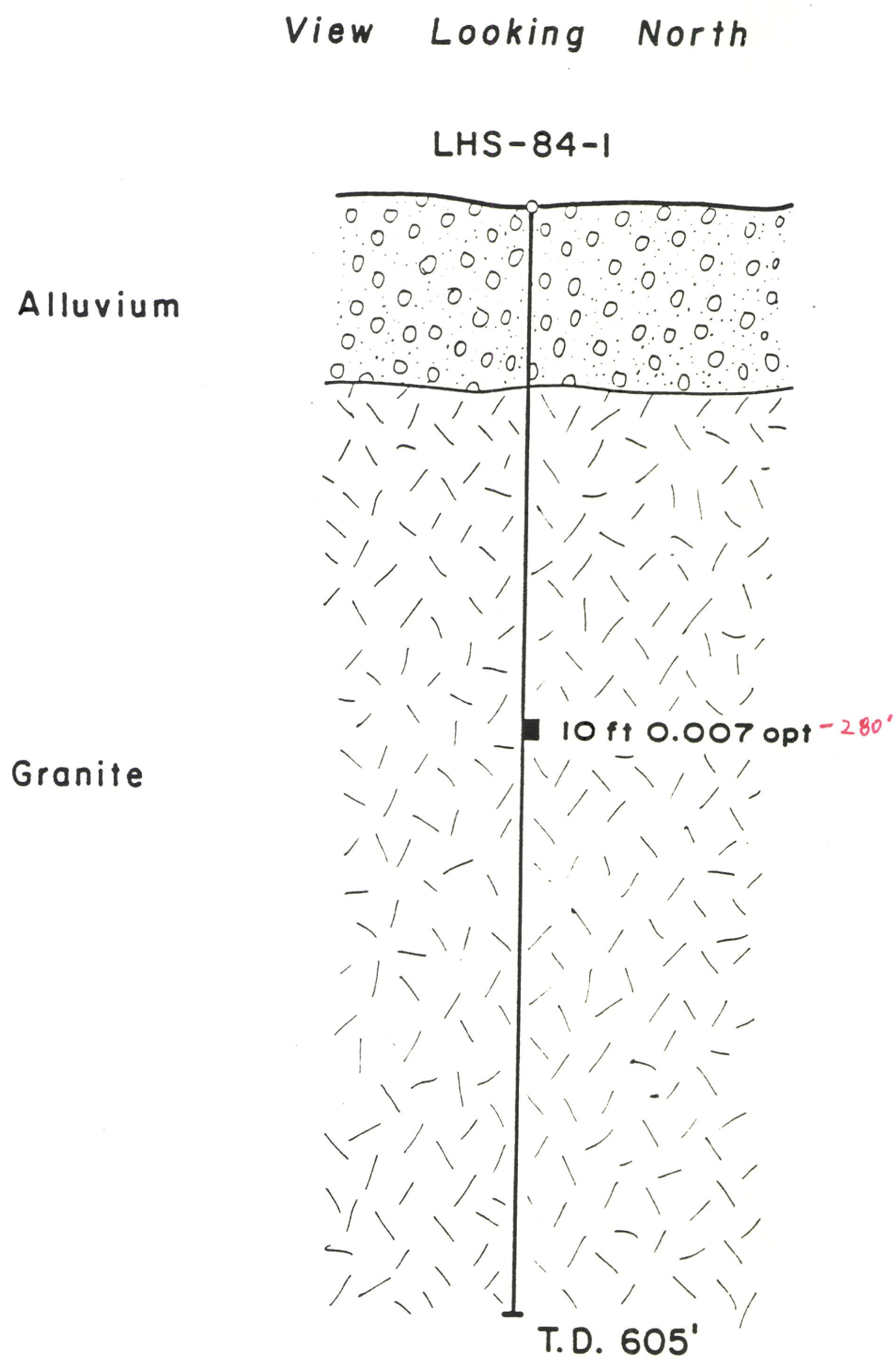
REALTOR

M.S., AICP
Broker

James R. Perry
President

Perry Properties, Inc.
Commercial Real Estate Brokerage

Financial Center, Suite 1300
3443 N. Central Avenue
Phoenix, Arizona 85012
(602) 274-7653



Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

DRILL HOLE LHS-84-1

FIG.4

Scale: 1 inch equals 100 feet	Data by: C. LANE
Drafted by: Asplund · Oct.15, 1985	

Texasgulf, Inc.
Project: Little Harquahala South
Drill Hole: LH-S- 84-2 / LHS 84-2
Grid Location:
Collar Elevation:

____ core from ____ to ____
____ core from ____ to ____
____ core from ____ to ____ p.1

Drill Log Forms
Drillers: Drilling Services Company
Logged By: C. Laze
Start: 9/25/84
Finish:
Survey:

Depth	Bearing	Dip
Collar		90°

Scale	Structure Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Assays					
				Alluvium									
10													
20													

LHS-84-2 P. 2

depth	rec	rock type	structure	description	alteration	mineralization	assays			
				Alluvium						
90										
100										
110										
120										
130										
140										
150										
160										
170										
180										

LHS-84-2 P.3

depth	rec	rock type	structure	description	alteration	mineralization	Au	Ag
							Au	Ag
				Basalt. Black on fresh surface weathered surfaces red brown.				
	11366						<.003	.09
190				Sandstone. Tan to red brown. Qtzose. Cly matrix. Frags of fresh basalt.				
	11367						<.003	.07
	11368						<.003	.03
200	11369						<.003	.05
	11370			Qtzite, 205-210 Lt grngrey, Underlying material grey to red grey. Coarse grained Highly fractured.	Appears to be recrystallized	Red + specular hematite as ragged disseminations	<.003	.09
210	11371						<.003	.05
	11372						<.003	.08
220	11373						<.003	.34
	11374						<.003	.11
230	11375						<.003	.09
	11376						.005	.11
240	11377		▲▲▲	Thrust Fault?			<.003	.15
	11378			Granite, Red brown + Lt green gray. Appears brecciated.	Lt green grey sericitized fldsps.	Red + specular hematite as ragged disseminations + in veins. Traces of black MnO2 on fracture surfaces	<.003	.09
250	11379						<.003	.06
	380						<.003	.22
260	11381						<.003	.07
	11382						<.003	.06
270	[illegible]						<.003	.08
	11384				Chlorite occuring along thin hairline shears		<.003	.04
280								

ALL VALUES IN OZS./TON

LHS 84-2 p.4

rec	rock type	structure	description	alteration	mineralization	ALL VALUES IN OZS./TON Au	Ag
1134			Granite as above			~~.18~~ <.003	~~<.003~~ .18
	T.	D.				probably	

300

310

320

330

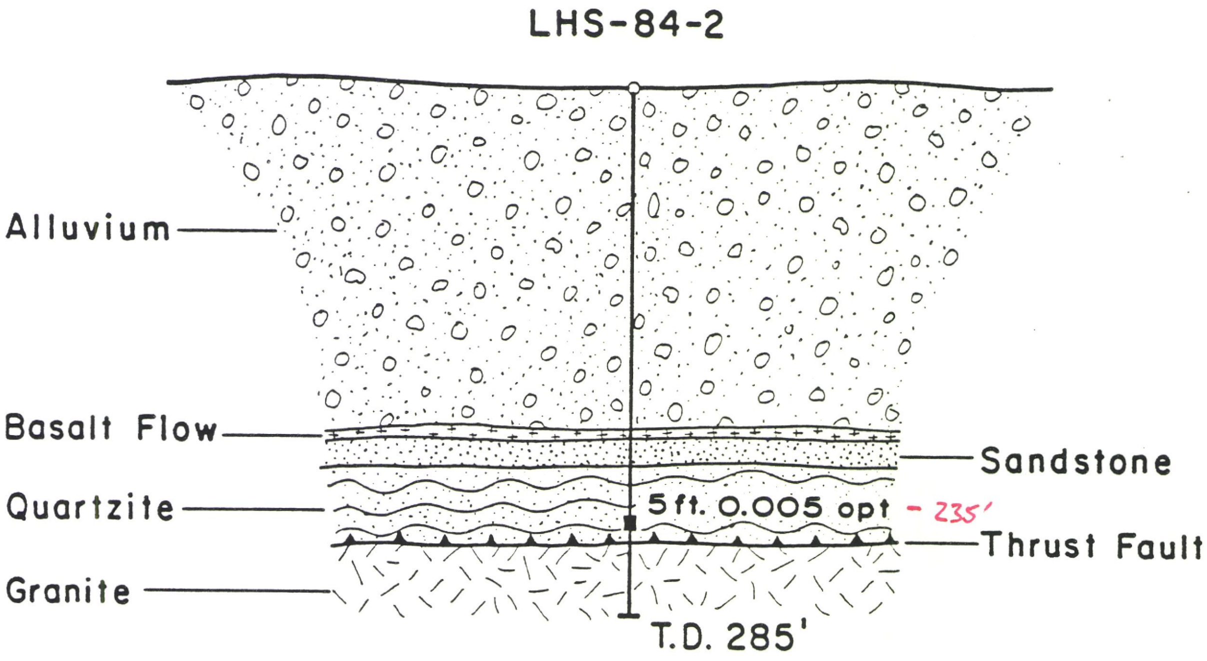
340

350

360

370

View Looking West



Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

DRILL HOLE LHS-84-2

FIG.5

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct. 15, 1985	

Texasgulf, Inc.
Project: Little [illegible]
Drill Hole: [illegible] LHS 84-3
Grid Location:
Collar Elevation:

Drill Log Forms
Drillers: Drilling Services Company
Logged By: [illegible]
Start: 9/25/80
Finish:
Survey:

Depth	Bearing	Dip
Collar		90°

___ core from ___ to ___
___ core from ___ to ___
___ core from ___ to ___

P. 1

Scale	Structure	Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample	Interval	Assays					
					Alluvium										

LHS 84-3 p.2

depth (ft)	rec	rock type	structure	description	alteration	mineralization	Au	Ag
80–130				Alluvium				
130–140				Granite. Red brown Brecciated	Upper 5' altered to white & [illegible] white [illegible]. Appears Silicified	white mica. Abundant specular hematite along numerous microfractures		
140–145	11386						<.003	.08
145–150	11387						<.003	.06
150–155	11388						<.003	.06
155–160	[illegible]						<.003	.06
160–165	[illegible]						<.003	.06
165–170	[illegible]						<.003	.20
170–175	[illegible]						<.003	.28
175–180	[illegible]						<.003	.09

assays: ALL VALUES IN OZS./TON

	rec	rock type	structure	description	alteration	mineralization	assays ALL VALUES IN OZS./ton Au	Ag	
	11394			Granite as above			Missing	Missing	
190	11395						.003	.13	.004 3 Au
	11396				185-~~200~~ 20% Lt grn gry sericite		.007	.88	.43 Ag
200	11397						.003	.28	
	11398						<.003	.05	
210	11399						<.003	.12	
	11400					Trace of pyrite w/n calcite veinlets	<.003	.11	
220	11401						<.003	.51	.21 / .27
	11402						<.003	.27	
230	11403						<.003	.23	
	11404						Missing ~~.003~~	Missing	
240	11405				235-~~245~~ abundant yellow-green + yellow hard clay.	Abundant red brown hematite in fractures + bxc matrix. Reacts w/HCl	.003	.09	
	11406						.003	.21	
250	11407			Granite, Mixture of Lt grn gry + red brown to maroon	Lt grn gry sericite. Some chlorite. Partially Silicified	Hematite in Fractures	.004	.07	
	11408						.011	1.00	
260	11409						.003	.26	
	11410						<.003	.15	
270	11411						.003	.13	
	11412						<.003	.14	.013
280	11413						<.003	.09	.705

ALL VALUES IN OZS./TON

depth	rec	rock type	structure	description	alteration	mineralization	Au	Ag
	11414			280- Bright red + Lt grn grey granite	Sericite	Brilliant red hematite colors bra matrix & occurs as veinlets	<.003	.09
	11415						.003	.74
290	11416			Granite. Dark red brown + Lt grn grey.	Lt grn grey sericite. Trace chlorite	Brown to red brown hematite in veinlets + as disseminations. MnOx coats fracture surfaces	<.003	.19
	11417						<.003	.07
300	11418						Missing	Missing
	11419						Missing	Missing
310	11420						<.003	.02
	11421						.003	.22
320	11422						<.003	.12
	11423						<.003	.15
330	11424						<.003	.12
	11425						<.003	.12
340	11426						<.003	.14
	11427			Dk brown intensely brecciated granite.	Abundant chlorite. Trace sericite. Fairly fresh Flsrs	Weak HCl reaction. Some dark hematite in fractures. Scattered calcite filled fractures.	<.003	.03
350	11428						<.003	.14
	11429						<.003	.07
360	11430			Red brown brecciated granite	Dark green chlorite. Some Lt grn grey sericite	Trace calcite in fractures. Red hematite + specular hematite in fractures + as disseminations	<.003	.08
	11431						<.003	.42
370	11432						<.003	.09
	11433						<.003	.08
380								

depth	rec	rock type	structure	description	alteration	mineralization	Au	Ag
	11434			Granite as above			<.003	.04
390	11435						.003	.09
	11436						.004	.10
400	11437						<.003	.10
	11438						<.003	.09
	11439				very Fresh unaltered Flsps w/ trace lt-grn gry sericite & chlorite		<.003	.08
410	11440						<.003	.07
420	11441				w/5 weak alteration cloudy to lt green gray sericitized Flsps	Bright red brown hematite. strong HCl reaction.	<.003	.07
	11442						<.003	.08
430	11443						<.003	.10
	11444						<.003	.13
440	11445						.003	.12
	11446						<.003	.05
450	11447						<.003	.03
	11448			Bright red brown Granite	Traces of lt grn gry Sericite	Abundant bright red hematite.	<.003	.05
460	11449						<.003	.06
	11450						.003	.04
470	11451						<.003	.03
	11452						<.003	.01
480	11453						<.003	.05

ALL VALUES IN OZS./TON

LHS 84-3 P. 6

rec	rock type	structure	description	alteration	mineralization	Au	Ag
11454			Same as above			<.003	.04
11455						<.003	.04
11456						<.003	0.10
11457						<.003	.04
11458						<.003	.05
11459						.004	.07
11460				Fragments of lt grn gray clay. (sericite?)	Gradually increasing amt of red hematite	.003	.12
11461						.005	.16
11462						.006	.21
11463						.005	.16
11464						.003	.08
11465					Fe pseudos after pyrite	.004	.17
11466				545-555 [illegible] as above. Clay flks, Lt green gray sericite	545-555 Blood red hematite comprises ~30% of material some [illegible] pseudos after pyrite	.003	.25
11467			Bright red brecciated granite			<.003	.09
11468						<.003	.10
11469			Granite as above, Red brown & lt green gray	Lt green gray sericite. Trace chlorite.	Red brown + specular hematite in fractures + as disseminations	.003	.04
11470						Missing	
11471						.003	.47
11472						.003	.30
11473						.005	.08

ALL VALUES IN OZS./TON

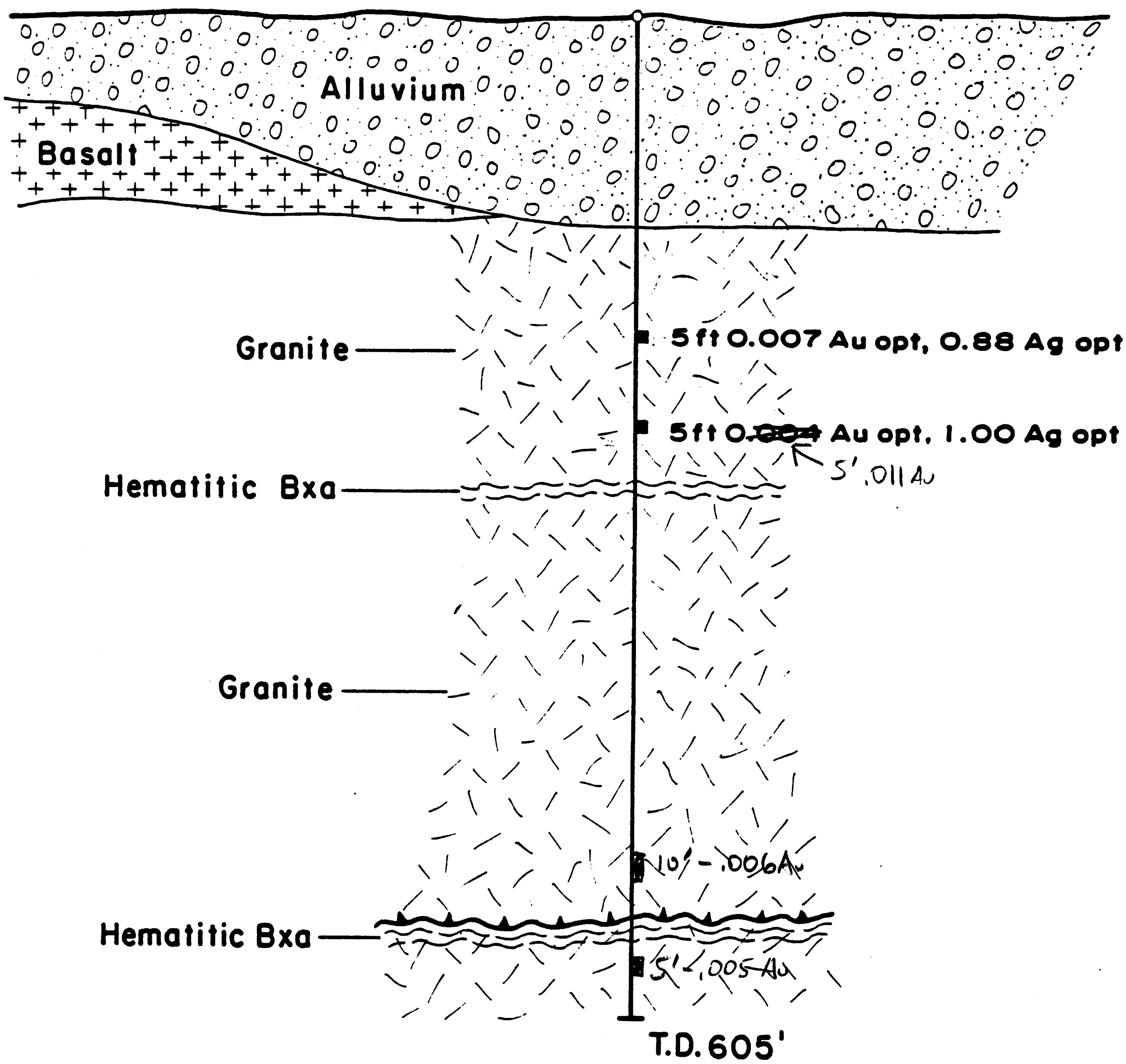
LHS-84-3 P.7

depth	rec	rock type	structure	description	alteration	mineralization	Au	Ag
	11474			580· Granite becomes dk. red gray + lt green gray	Trace Chlorite. Abundant Sericite	Trace red brown hematite.	.005	.04
590	11475						.003	.04
	11476						.003	.03
600	11477					abundant red brown hematite	.003	.01
605	11478						.003	.01

assays: ALL VALUES IN OZS./TON

View Looking West

LHS-84-3



Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

DRILL HOLE LHS-84-3

FIG. 6

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct. 15, 1985	

Texasgulf, Inc.

Project: Little Harquahala South

Drill Hole: LHS 84-4

Grid Location:

Collar Elevation:

____ core from ____ to ____

____ core from ____ to ____

____ core from ____ to ____ 0.1

Drill Log Forms

Drillers: Drilling Services

Logged By: Clarke

Start: 3/27/84

Finish:

Survey:

Depth	Bearing	Dip
Collar		90°

Scale	Structure	Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag
					Granite. Brecciated. Mixture brown, lt grngry	brown hematite in fractures & matrix of bx. lt grn gry sericite. Reacts w/ HCl.		11479	.003	.04
								11480	.003	.02
								11481	.004	.01
								11482	.003	.07
20						Check →		11483	.04	<.003
								11484	.004	.5
30								11485	<.003	.06
								11486	<.003	.02
								11487	<.003	.09
					45 - Unit becomes red-brown.	45. Brighter red hematite more abundant. lt grn gry sericite appears confined to matrix of bx		11488	<.003	.11
								11489	<.003	.04
					55 Unit becomes lt grngry + yellow brown	55-60 Abundant Lt grn gry sericite + yellow brown limonite weak HCl reaction.		11490	.003	.52
					60. lt brown	60 - Decrease in sericite. Limonite increases to color rock lt brown		11491	<.003	.02
					65 - Dk red brown	65 - Increase in red brown hematite		11492	<.003	.05
70								11493	.003	.28
80								11494	<.003	.13

ALL VALUES IN OZS./TON

3.3

depth	rec	rock type	structure	description	alteration	mineralization	Au	Ag
							assays	
							ALL VALUES IN OZS./TON	
	11495			Reddish brown granite as above	Chlorite, sericite.	Hematite, limonite. Weak reaction for HCl. Minor trace hem pseudos after pyrite.	<.003	.1
	11496						<.003	.06
90	11497						<.003	.06
	11498						<.003	.17
100	11499						.007	.04
	11500						.005	.02
110	11501						.003	.01
	11502			115-130 Granite lt grn grey due to abundant sericite	115-125 Abundant lt grn gry sericite	redbrown hematite	.003	.03
120	11503						.005	.12
	11504						<.003	.09
130	11505			130- red brown granite bx	minor trace sericite	Abundant red brown hematite. Trace yellow brown limonite, Hematite in veinlets in bx matrix. red + black.	.003	.03
	11506						.005	.03
140	11507						.003	.01
	11508					145-160 white bull qtz veins	.003	.01
150	11509						.005	.01
	11510						.004	.20
160	11511			160-165 unit becomes very lt grn gry	160-165 abundant lt grn gry sericite	160-165 mixture lt grn gry sericite + white bull qtz minor red brown hematite trace black hematite	.003	.07
	11512			165- red brown granite as above brecciated	Trace sericite	Red brown hematite trace limonite, trace black hematite	.003	.01
170	11513						<.003	.01
177	11514						.041	.06

LHS 84-4 P.3

depth	rec	rock type	structure	description	alteration	mineralization	assays: All VALUES IN OZS/TO[N]	
180	11515				185-195 Large pieces of green sericite		.01	.03
190	11516						.009	.04
	11517						.004	.01
200	11518						.003	.01
	11519						<.003	.01
	11520					205 - Traces white bull qtz.	.003	.01
210	11521				215- Large pieces of lt grn sericite	215- Red brown +specular hematite	.004	.01
220	11522						.003	.01
	11523						.003	.04
230	11524						<.003	.05
	11525						<.003	.03
240	11526			235- Color changes to more reddish brown	Trace sericite	235- increase in amt of red hematite Trace specular hematite	.003	.10
	11527			245-250- overall color lt grn gray	245-250 abundant white bull qtz & lt grn gry sericite	245-250- white bull qtz Trace redbrown hematite, limonite & specular hematite after pyrite.	.005	.05
250	11528			250- red brown granite as above			.003	.13
	11529						.004	.12
260	11530			260- Dark red Granite	260-265 ≈ 20% Lt grn gry sericite	260- Abundant red and red-black hematite. Some specular hematite after Pyrite	<.003	.05
	11531				265- Trace amts of Lt grn gry sericite		.003	.02
270	11532						<.003	.05
	11533			275-280 Lt grn gry color	Rock mostly brecciated sericite.		.003	.11
280	11534						<.003	.08

IHS-P4-4 D 4

depth	rec	rock type	structure	description	alteration	mineralization	Au (OPT)	Ag (OPT)
280	11535						<.003	.04
	11536						<.003	.10
290	11537			290-300 Dark red Granite	Some green sericite	290-300- Bright red hematite in matrix Specular hematite fills fractures, some pseudos after pyrite, some dark calcite (siderite)	.006	.09
	11538						<.003	.07
300	11539			300-310 Green + yellow-brown granite	≈0% sericite	abundant limonite gives color to rock	<.003	.07
	11540						.003	.13
310	11541			310-325 Unit becomes deep red in color	≈10% sericite in grn gr	310-325 abundant dark red hematite + limonite strong reaction for HCl	.003	.16
	11542						.021	.12
320	11543						.023	.10
	11544			325-335 yellowbrown + lt grn gry granite			.013	.09
330	11545						.025	.13
	11546			335-345 Green chloritic granite	Abundant chlorite + sericite	yellowbrown limonite + specular hematite	<.003	.04
340	11547						.010	.04
	11548			345-350 lt tan mylonite? + granite	Mixture of chlorite + sericite	strong HCl reaction. Limonite + specular hematite	<.003	.05
350	11549			Brown dioritic intrusive?			<.003	.01
	11550						<.003	~~.03~~ .04
360	11551						<.003	.06
	11552						<.003	.03
370	11553						<.003	.03
	11554						<.003	.02

depth	rec	rock type	structure	description	alteration	mineralization	OPT assays Au	Ag		
	11555	v v v					<.003	.01		
	11556	v v					<.003	.04		
390	11557	v v					<.003	.01		
		T.	D.							

View Looking West

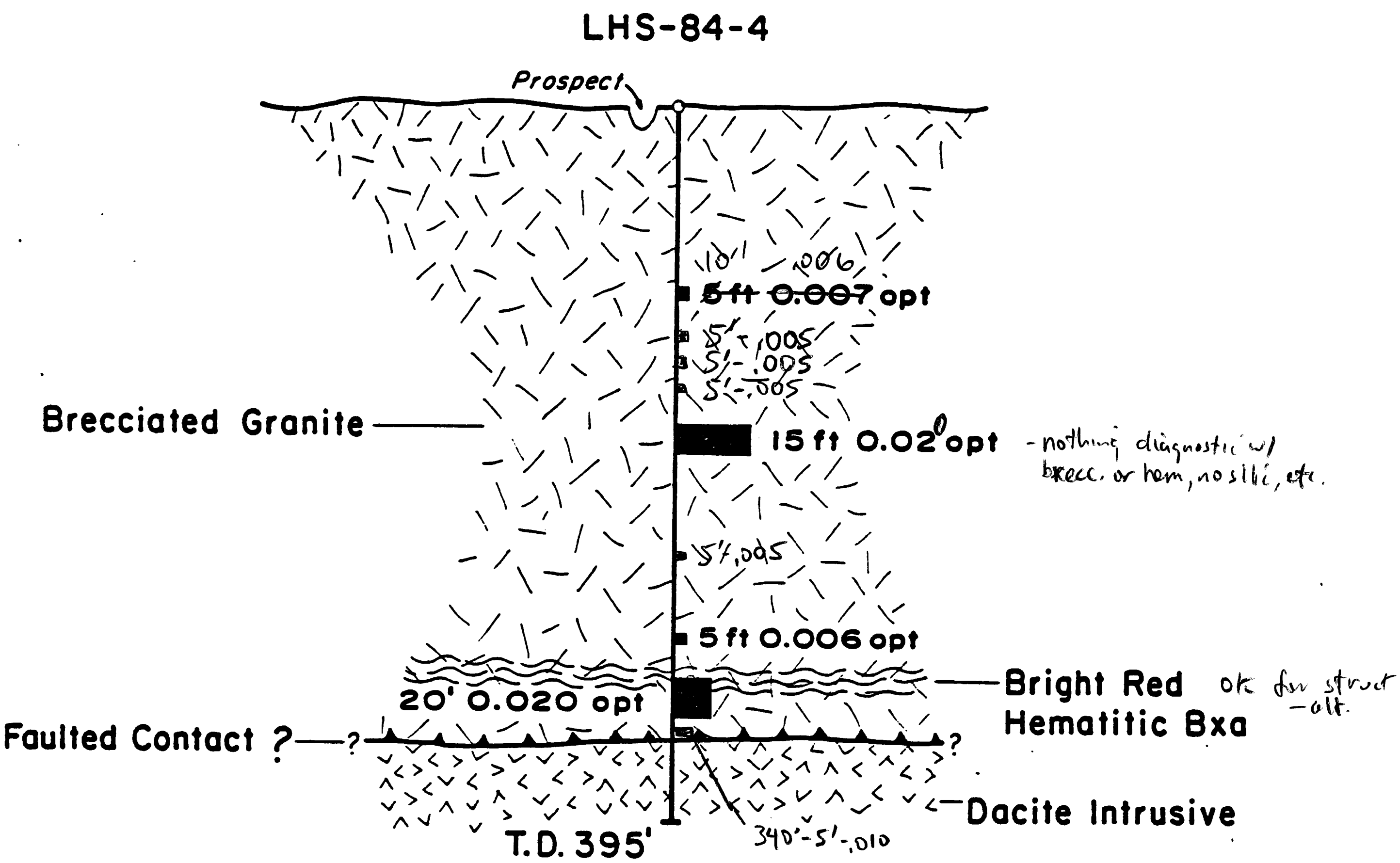


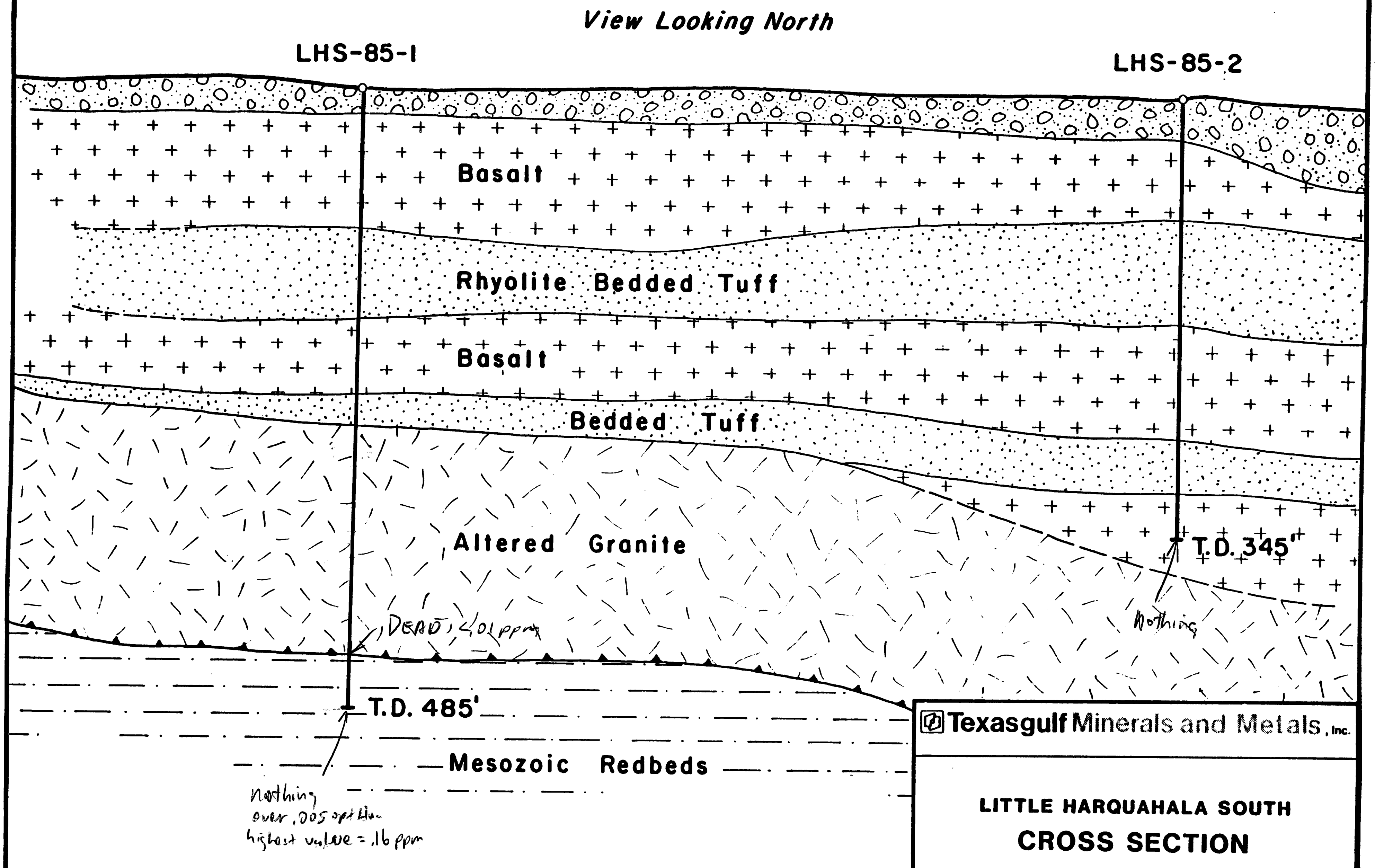
FIG. 7

Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

DRILL HOLE LHS-84-4

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct. 15, 1985	



Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

CROSS SECTION

LHS-85-1 AND LHS-85-2

Scale: 1 inch equals 100 feet		Data by: C. LANE,
Drafted by: Asplund	Oct.10, 1985	

FIG.8

Texasgulf, Inc.

Project: Little Harquahala South

Drill Hole: LHS 84 5

Grid Location:

Col'ar Elevation:

____ core from ____ to ____

____ core from ____ to ____

____ core from ____ to ____

Drill Log Forms

Drillers: Drilling Services Company

Logged By: [illegible]

Start: 9/29/84

Finish:

Survey:

Depth	Bearing	Dip
Collar		90°

Scale	Structure	Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Assays					
					alluvium			11558						
								11559						
								11560						
								1156[illegible]						
					[illegible] brown [illegible]			11562						
								11563						
								1156[illegible]						
								11565						
								11566						
	T.													

Texasgulf, Inc.
Project: Little Harquahala South
Drill Hole: LHS 85-4
Grid Location:
Collar Elevation:

Drill Log Forms
Drillers: Drilling Services Co.
Logged By: C. Lanzi
Start: 3/10/85
Finish:

____ core from ____ to ____
____ core from ____ to ____
____ core from ____ to ____

Survey:

Depth	Bearing	Dip
Collar		90°

Scale	Structure Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag			
								ALL VALUES IN PPM				
0–35				Alluvium								
35	Sericitized - Carbonated			Coarsely xln granite, Red brown white + lt gray-grey, Brecciated	Sericitized Flsps. CaCO3, Hem/Py pseudos. Abn white qtz		11686	.01	.2			
40							11687	.07	.2			
							11688	.01	<.2			
50							11689	.02	<.2			
							11690	.02	<.2			
60					60-65 Lt tan unit in granite due to high CO3 content.		11691	.04	<.2			
							11692	.02	<.2			
70							11693	.06	<.2			
80							11694	.16	<.2			

20 .01 ppm

.005

.02 .02 .05 .16 .04 .10 .53 .09

LHS 85-4

Scale	Structure	Alteration	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag
				Granite as above, [illegible] gray [illegible] brown. [illegible]	[illegible] Abundant CO_3. Numerous hem/Py [illegible]		[illegible]	.04	<.2
				~90' .0054			[illegible]	.16	<.2
							[illegible]97	.03	<.2
					90 to 95 – Color changes slightly to [illegible] brown due to more limonite. More hem/Py [illegible]. Traces of specular hematite.		[illegible]	<.01	<.2
							11[illegible]	<.01	<.2
							[illegible]00	.05	<.2
							[illegible]01	.03	<.2
							[illegible]02	<.01	<.2
							[illegible]03	<.02	.2
							1204	<.02	<.2
							1205	.05	<.2
							1206	<.01	<.2
					140-145 Slight change in color to red brown due to slight [illegible] in red hematite. 145 – silicified Micro bra[illegible] Lt Brown. Some sericite [illegible] Qtz stockwork.		1207	.01	.3
							1208	.06	.3
							[illegible]09	.01	.5
							[illegible]10	<.01	<.2
							1211	<.01	<.2
				Thrust					
				[illegible] sequence. [illegible]	165 – Thrust Fault. 165 – 175 Silicified? [illegible] [illegible] siltstn. [illegible] brown, red brown + olive. Traces hem[illegible], limonite [illegible]		[illegible]12	<.01	<.2
							[illegible]13	<.01	.4
				175'	Brecciated red brown + maroon siltstn + [illegible]		[illegible]14	<.01	<.2

Weak silicification [illegible]

ALL VALUES IN PPM

Scale	Structure	Alteration	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag
				LHS·85·7					
				Mz Maroon SS & Stn as above	Fresh muscovite		11715	<.01	<.2
							11716	.05	<.2
							11717	<.01	<.2
700							11718	.02	<.2
							11719	<.01	<.2
				705 T.D					
710									

ALL VALUES IN PPM

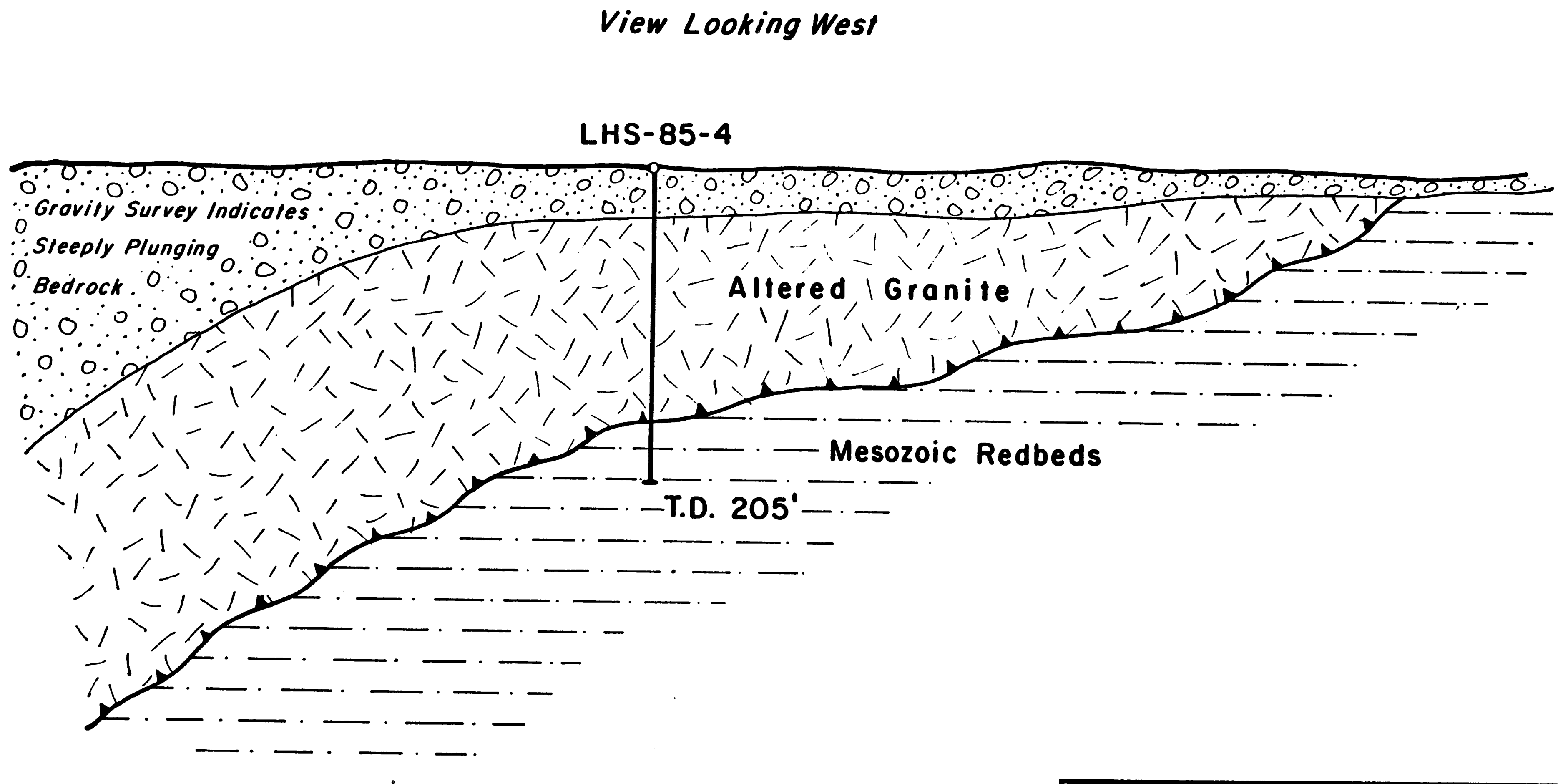


FIG. 10

Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

CROSS SECTION

LHS-85-4

Scale: 1 inch equals 100 feet		Data by: C. LANE,
Drafted by: Asplund	Oct.10, 1985	

Texasgulf, Inc.

Project: Little Harquahala South

Drill Hole: LHS 85-5

Grid Location:

Collar Elevation:

____ core from ____ to ____

____ core from ____ to ____

____ core from ____ to ____

Drill Log Forms

Drillers: Drilling Services Co.

Logged By: C. Land

Start: 3/10/85

Finish:

Survey:

Depth	Bearing	Dip
Collar		90

Scale	Structure	Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample	Interval	Au	Ag			
										ALL VALUES IN PPM				
					Alluvium									
2														
30														
40														
50														
60														
70					altered granite, red brown & lt grn grey, brecciated	limonite, hematite/py pseudos. Carbonated, sericitized flds + hematite		1120		<.01	.2			
80								1121		.02	.7			

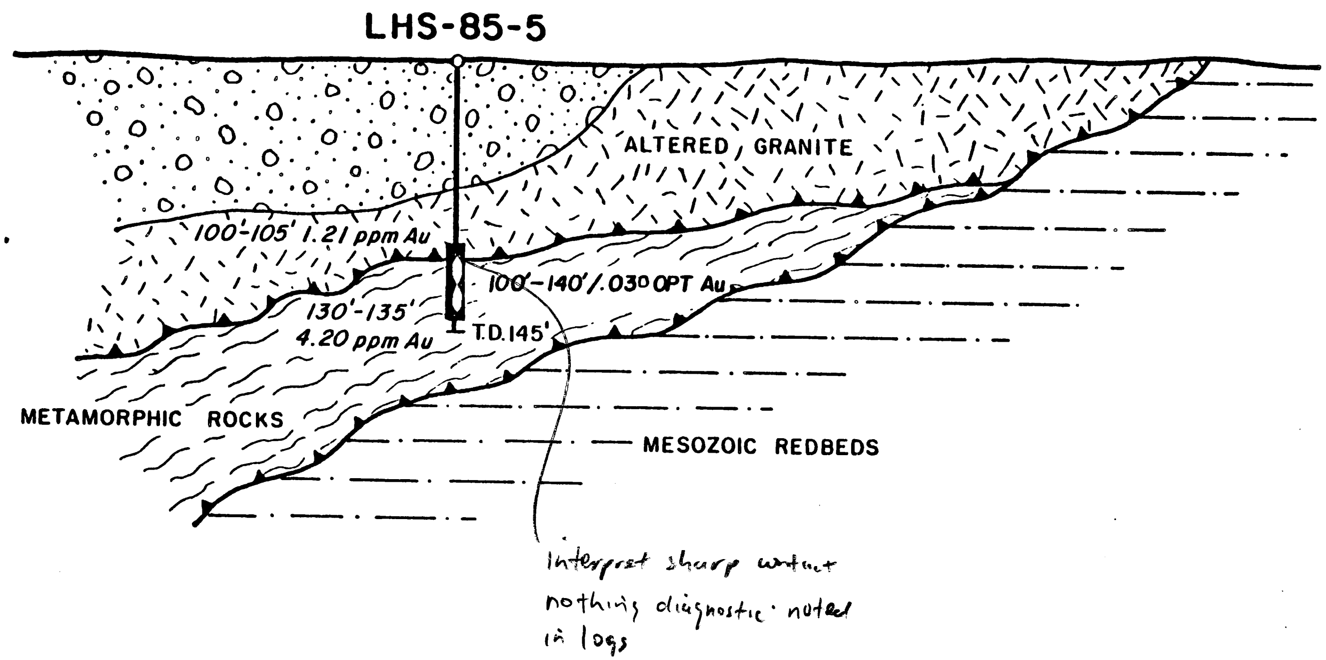
LHS 85 #5

Str.	Alters.	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au ppm	Ag ppm
							11722	.01	.5
							11723	.06	.3
							11724	.01	.4
							11725	.07	.3
				Knife edge contact?	100-105' Gray to dark green chlorite; Minor hem/Py pseudo's		11726	1.21	1.5
				Red hematitic + dark green chloritic metavolcanic rocks			11727	.12	.4
					100-140' .019		11728	.76	1.5
					1.03 ppm = .030 opt Au .015		11729	.54	6.1
							11730	.48	4.7
					25' .059 opt Au ...		11731	.06	2.3
					40' .031		11732	4.20	3.4
							11733	.35	3.3
							11734	.04	1.0

Assays — ALL VALUES IN PPM

T.D. 145

View Looking Southwest



Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

CROSS SECTION
LHS-85-5

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct.10, 1985	

FIG. 11

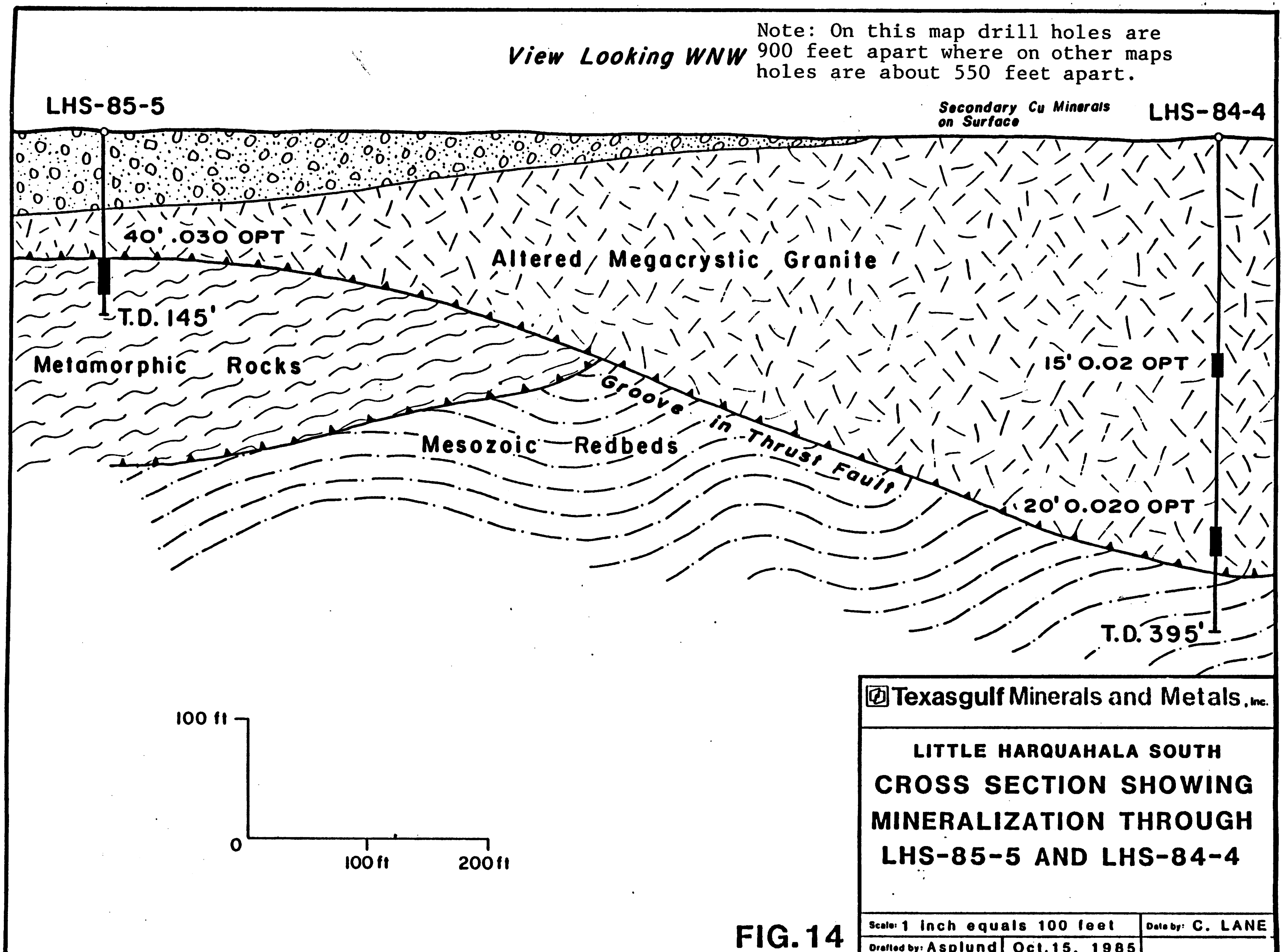

View Looking WNW
Note: On this map drill holes are 900 feet apart where on other maps holes are about 550 feet apart.
LHS-85-5
Secondary Cu Minerals on Surface
LHS-84-4
40' .030 OPT
Altered Megacrystic Granite
T.D. 145'
Metamorphic Rocks
15' 0.02 OPT
Groove in Thrust Fault
Mesozoic Redbeds
20' 0.020 OPT
T.D. 395'
100 ft
0
100 ft
200 ft
Texasgulf Minerals and Metals, Inc.
LITTLE HARQUAHALA SOUTH
CROSS SECTION SHOWING MINERALIZATION THROUGH LHS-85-5 AND LHS-84-4
Scale: 1 inch equals 100 feet
Data by: C. LANE
Drafted by: Asplund
Oct. 15, 1985

FIG. 14

Texasgulf, Inc.
Project: Little Harquahala South
Drill Hole: LHS-85 6
Grid Location:
Collar Elevation:

Drill Log Forms
Drillers: Drilling Services Co.
Logged By: C. Lane
Start: 3/11/85
Finish:
Survey:

Depth	Bearing	Dip
Collar		90°

_____ core from _____ to _____
_____ core from _____ to _____
_____ core from _____ to _____

Scale	Structure / Alteration	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag
	Sericite, Carbonatized Hematitic		Yellowbrown, brown + ltgrngry brecciated granite.	Brown carbonate veinlets, white qtz. Ltgrngry sericite on flsrs + matrix				
						11735	<.01	.3
20						11736	<.01	.2
						11737	<.01	.5
				25-30: 50% ltgrngry sericite + chlorite		11738	<.01	.3
30						11739	<.01	.2
				35-40 - 20% red hematite coating fractures imparts red color to sample		11740	<.01	<.2
40						11741	<.01	<.2
						11742	.01	<.2
				50'-3-4' wide basalt dike. Enclosing granite colored pink due to hematite staining esp along fractures,		11743	<.01	<.2
						11744	<.01	<.2
			60 -	Very intense fracturing of granite. Trace Hem/py pseudos. Some silicification. Rare secondary qtz veining		11745	.01	<.2
						11746	<.01	.2
70						11747	.01	.3
			Metamorphic Plate	Redbrown + dkgreen hematitic silicified metamorphic rock. Some ltgrngry sericite		11748	<.01	.6
80						11749	<.01	1.2

ALL VALUES IN PPM

LHS-85-6

Scale	Structure	Alteration	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Assays (ALL VALUES IN PPM) Au	Ag
				[illegible] - Bright red hematitic stain on dk green silicified metamorphic rock	Weakly carbonatized. Some silicification, Trace limonite, hematite + sericite		11749	<.01	1.2
							11750	.04	.6
							11751	.02	.4
100							11752	<.01	.3
							11753	<.01	.3
110							11754	<.01	.2
							11755	<.01	.3
120							11756	.08	.3
							11757	X	.3
			T.D.						

View Looking West

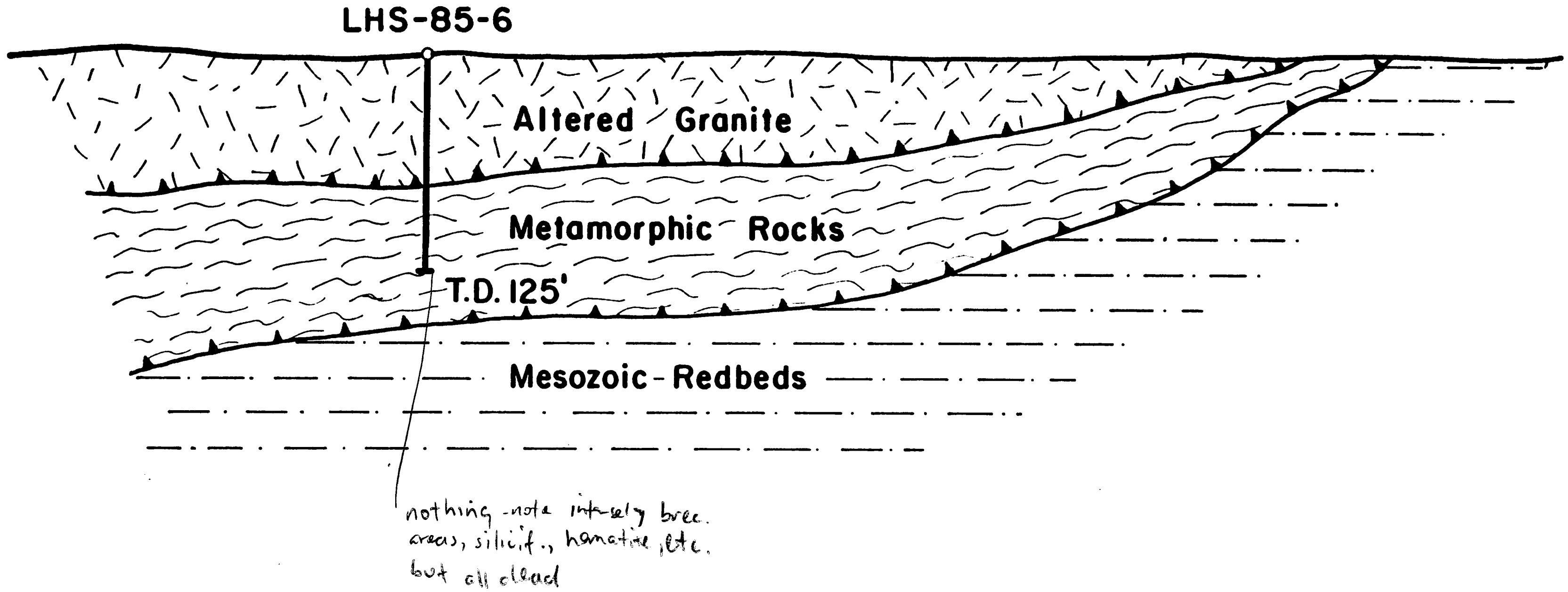


FIG. 12

Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

CROSS SECTION

LHS-85-6

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct. 10, 1985	

~~Texas~~gulf, Inc.

Project: Little Hurquahala South

Drill Hole: LHS 85 7

Grid Location:

Collar Elevation:

Drill Log Forms

Drillers: Drilling Services Co.

Logged By: C. Lode

Start: 3/11/85

Finish:

Survey:

Depth	Bearing	Dip
Collar		

____ core from ____ to ____

____ core from ____ to ____

____ core from ____ to ____

Scale	Structure	Alteration	Rock Type		Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Assays Au	Ag				
					Alluvium				ALL VALUES IN PPM					
					Granite. Dk yellowbrown, white + Lt green-gray. Brecciated	Brecciated. Carbonate alteration Sericitized matrix of broken min Fisrs. Rare hem/py pseudos		11758	.01	.2				
								11759	<.01	<.2				
								11760	<.01	<.2				
								11761	<.01	.3				
								11762	.01	<.2				
								11763	<.01	<.2				
40								11764	.07	<.2				
								11765	.02	<.2				
		Carbonate						11766	.01	<.2				
						55-60 Abundant Lt gray-gray sericite		11767	.01	<.2				
								11768	<.01	<.2				
		Sericitic						11769	<.01	<.2				
70						70- Traces hem/py pseudos		11770	<.01	<.2				
80								11771	<.01	<.2				

LHS-95-7

Struc.	Alteration	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag					
							ALL VALUES IN PPM						
			granite – unchanged from above			1772	<.01	.2					
			85-95 Color change to yellow brown	85-95 increase in limonite and CO_3 content. Increase in brecciation and hem/py pseudos.		1773	<.01	.2					
				95- Intensely brecciated. Overall color due to increased hematite esp in matrix. 1-2% corroded hem/py pseudos		[illegible]	<.01	<.2					
			95- color change to red brown			[illegible]	<.01	<.2					
						[illegible]	<.01	<.2					
			105 – color change to yellow brown	Increase in limonite content		[illegible]	<.01	<.2					
						[illegible]	<.01	.3					
						[illegible]	<.01	.3					
			color change to more lt grn grey	numerous Hem/py pseudos		[illegible]	<.01	.2					
						[illegible]	.01	<.2					
						[illegible]	<.01	<.2					
			135-155 Color change to dark red with green. Some dk green chloritic matrix. More prevalent altered zone along base	Brecciated Meta rock. Some hem/py pseudos		[illegible]	.01	<.2					
	Chloritic					[illegible]	.01	<.2					
						[illegible]	<.01	<.2					
			155-165 Brecciated black basalt			[illegible]	<.01	<.2					
						[illegible]	<.01	<.2					
						[illegible]	<.01	<.2					
			altered brecciated red brown & lt grn grey granite			[illegible]	<.01	.2					
						[illegible]	<.01	.3					
						[illegible]	<.01	.4					

LHS-857

St.	Struc.	Alterat.	Rock Type	Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag
				granite as above			11792	<.01	.5
				190-195 Brightred hematitic zone. Intraplate thrust?			11793	.06	.4
				195- yellowbrown white & green gray			11794	.05	.4
					Increasing chlorite content imparting dull green color to granite. Abundant hematite - some may be corroded hem/py pseudos. Some CO3		11795	.04	.5
							11796	.02	.4
							11797	.01	.3
							11798	<.01	<.2
							11799	.01	<.2
							11800	.01	<.2
							11801	<.01	<.2
					235-240.5' Interval color change to darker colored green. Mighty brecciated. Increase in hematite along fractures. More chlorite		11802	<.01	<.2
							11803	<.01	<.2
							11804	<.01	<.2
							11805	.02	<.2
							11806	<.01	<.2
							11807	<.01	<.2
							11808	.03	<.2
							11809	.05	.9
					270-275 Interval of slightly higher hematite imparting darker color to green		11810	.04	.7
							11811	.09	.6

ALL VALUES IN PPM

Sc.	Struc. / Alterat.	Rock Type		LHS. 85.7 Rock Descriptions	Description of Mineralization, Alteration, Structures	Recovery	Sample Interval	Au	Ag				
								ALL VALUES IN PPM					
	Sericitized with weak silicification			Granite - as above			11812	.12	<3				
					285-295 - Increase in red hematite weakly silicified. V. minor trace CuOx, Lt gray, sericitized clay gouge along shears		11813	.02	3.4				
							11814	.08	3.3				
							11815	.03	2.2				
				Mz - argillized ss + sltstn of redbed sequence	300-315 sltstn yellow brown due to limonite staining. some carbonate. Sheared		11816	<.01	.3				
							11817	.09	<.2				
							11818	<.01	<.2				
					315 - unaltered Mayoon redbed ([illegible]?)		11819	<.01	.3				
							11820	<.01	<.2				

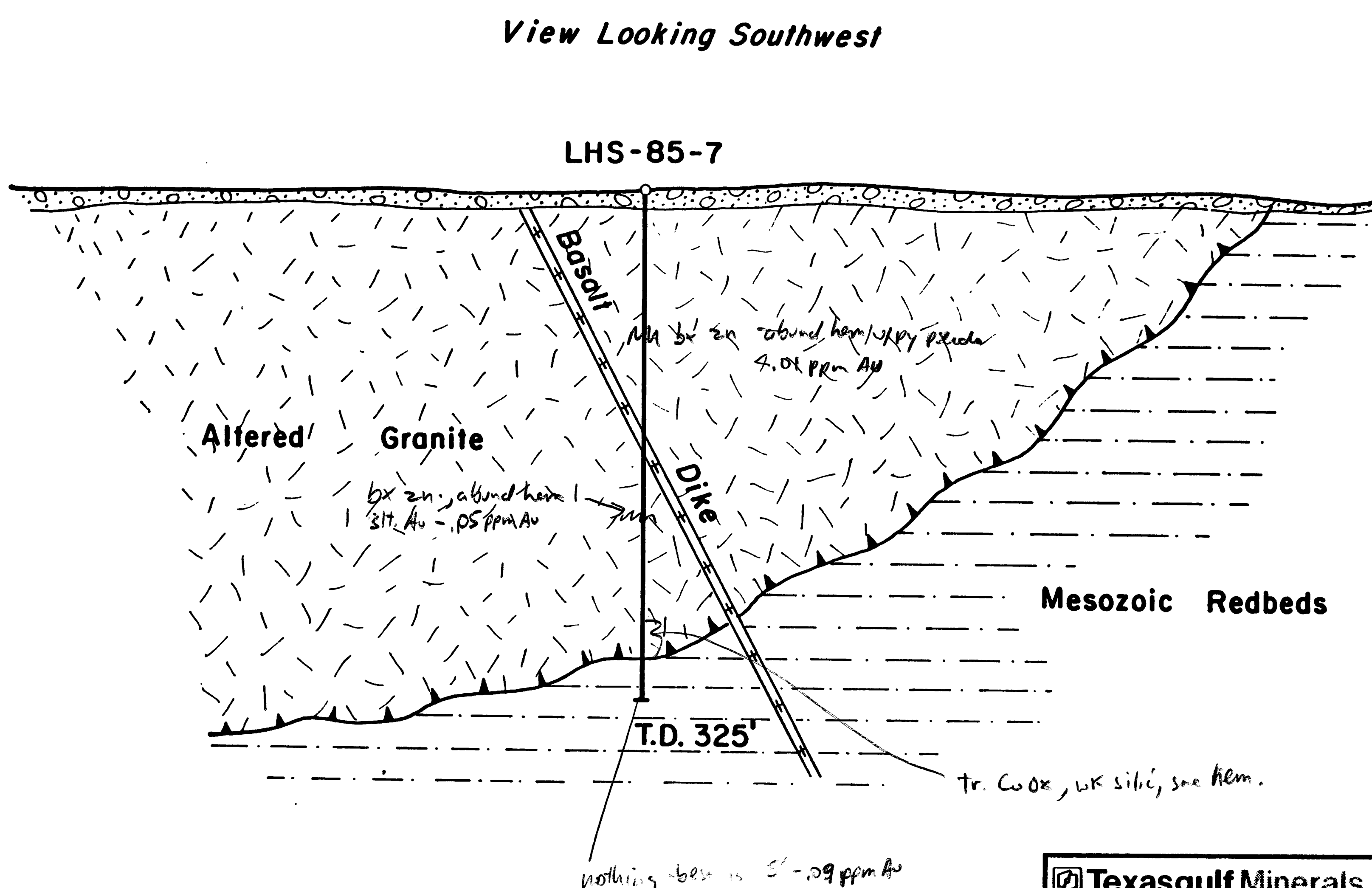


FIG. 13

Texasgulf Minerals and Metals, Inc.

LITTLE HARQUAHALA SOUTH

CROSS SECTION

LHS-85-7

Scale: 1 inch equals 100 feet		Data by: C. LANE
Drafted by: Asplund	Oct.10, 1985	