POSTON BUTTE PROJECT (f)

# GEOLOGY OF THE FLORENCE DEPOSIT, FLORENCE, ARIZONA

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# INTRODUCTION

Florence, the Pinal County seat, is roughly halfway between Tucson and Phoenix in Southern Arizona, along the Gila River as seen in figure 1. It is a long established farming community, where the County Court House and the State Prison are located, never suspected of being economically mineralized until quite recently.

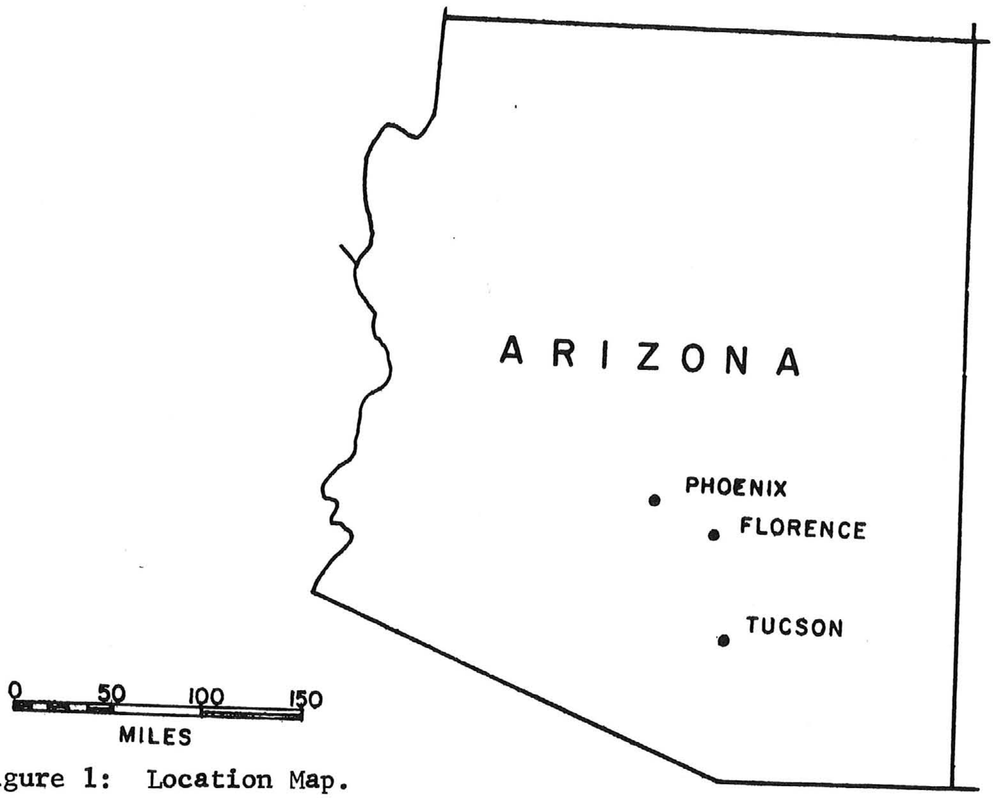



Figure 1: Location Map.

## RESULTS TO DATE:

Since CONOCO's initial discovery in February, 1969, 114,057 feet of core and rotary drilling have been done in the area up to the present time; of this, 64,949 feet were drilled in 1971. 43,653 feet have been drilled in and adjacent to the ore body on 1000' centers with some 500' centers.

21,296 feet were drilled in location of the ore body, perimeter drilling, validation, and assessment drilling. Detailed logging of drill cores is the only way to understand the size, shape, and direction of the ore body. Careful logging of the rotary drill cuttings has shown us the thickness of overburden, mineralization and the alteration zones. The ore body is outlined in figure 2.

During the early phase drilling, IP, gravitometer, and mercury vapor surveys were done to aid in location of and possibly outline the ore body. This year an IP survey was extended to evaluate the area around the Florence ore body and locate targets for exploration drilling. Similarly an MV survey was run covering much of the same area. About 99% of the areas surveyed are covered by overburden and conglomerate. Subsequent drilling on some of the MV and/or IP highs showed only a few areas which warrant further drilling because of the alteration or mineralization in the rock. The Florence ore body is entirely buried under at least 320 feet of alluvium, Gila, and Whitetail conglomerate so a great deal of drilling is needed during the next two years to even begin to truly understand this ore body, and arrive at an accurate estimation of tonnage and grade.

## PLANS:

Our drilling program for 1972 will involve drilling approximately 83 holes for a total drilling depth of 96,900 feet. Of this, 76,900 feet are planned within the ore body and on its perimeter to get a more reliable calculation on the reserves. 20,000 feet are planned as validation, assessment, and exploration drilling. Isopach maps of ore thickness and ore grade are being used to prepare a priority of holes to be drilled. Eleven holes will be deepened; this is calculated in the predicted depth.

Our logging is done on a form for computer use, and a close correlation is kept between each geologist on the Florence project to make sure of uniformity.

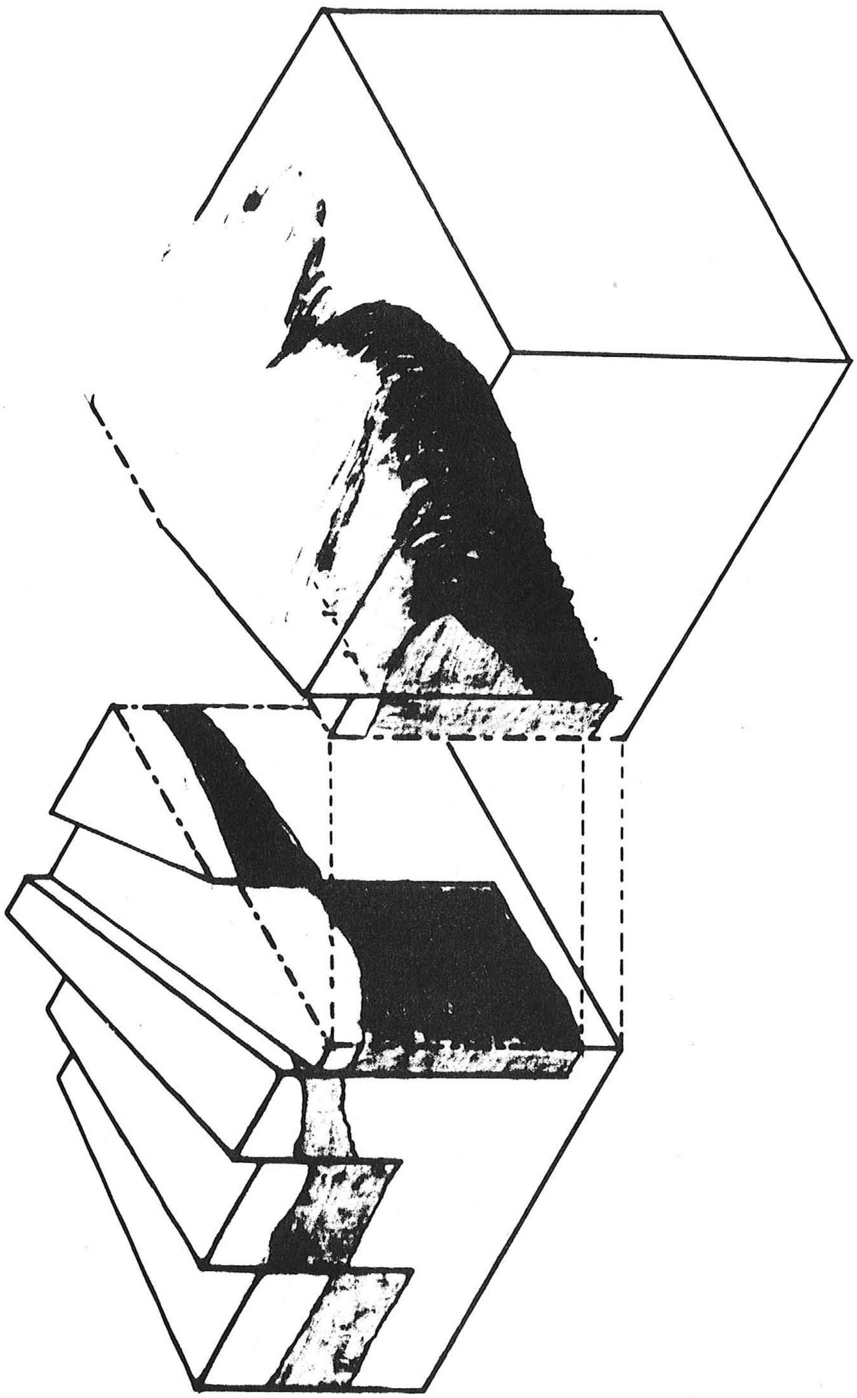


Figure 2: **BLOCK DIAGRAM OF FLORENCE DEPOSIT**

All the previous drill cores have been relogged onto this form. The computer interpretation on the geologic data is expected to be of tremendous help, both in a better understanding of the Florence ore body and for information that will aid future porphyry copper exploration. In 1972 we hope to develop a better understanding of the alteration sequence from fluid inclusion studies, and emission spectrographic analysis for a number of elements from each alteration zone.

HISTORY:

Approximately 1800 years ago, the Ho Ho Kam Indians moved into the Florence area, settled and began farming right through the area of our ore deposit. Their settlement lasted about 1250 years until 1450 A. D. when they left the Gila Valley, and completely disappeared. One of the speculations on what happened to the tribe is that they joined another tribe, and became the present Pima-Papago Indian tribe. If this is the case, they became a more nomadic, less civilized group.

Toward the end of the 17th Century, a missionary group led by Father Kino came through the area and visited the Ho Ho Kam ruins at what later became Casa Grande National Monument. In 1853, the United States purchased from Mexico what they named the New Mexico Territory and included what ten years later became the Territory of Arizona. About 1866, the town of Florence came into existence, making it the fifth oldest settlement in Arizona. It began as a farming community, which was occasionally attacked by the Apache Indians, and frequently harassed by them until close to the turn of the century. The United States Cavalry had troops stationed in the area following the Civil War adding some protection for the early settlers. Florence enjoyed a surge of growth in 1908 when the State Prison was placed there. Subsequently, it appears to have changed, but slightly.

Much of the Florence mineralized area is held by CONOCO at the original exploration suggestion of Bill Kern and has truly proved out to be an ore body.

Bill was led to Florence in the early 1960's following the Ray? Lineament, and was encouraged by the outcrop on Poston Butte. At that time ASARCO held the property. ASARCO drilled several holes around the edge of the ore body, none of which were in the better portion. Subsequently, they dropped their leases and permits. In 1969, Bill came with CONOCO and quickly picked up all the available State leases. Drilling began under the direction of Ray Barkley and quickly indicated that Cecil England's and Earnest McFarland's properties were essential. At this point ASARCO decided they wanted all the Florence property they could get back again. A nail-biting negotiation began with former Governor, Senator, Judge McFarland with CONOCO finally getting the lease option on his property. ASARCO picked up a lease option on the property to the west of McFarland and CONOCO got all the rest.

## GENERAL GEOLOGY

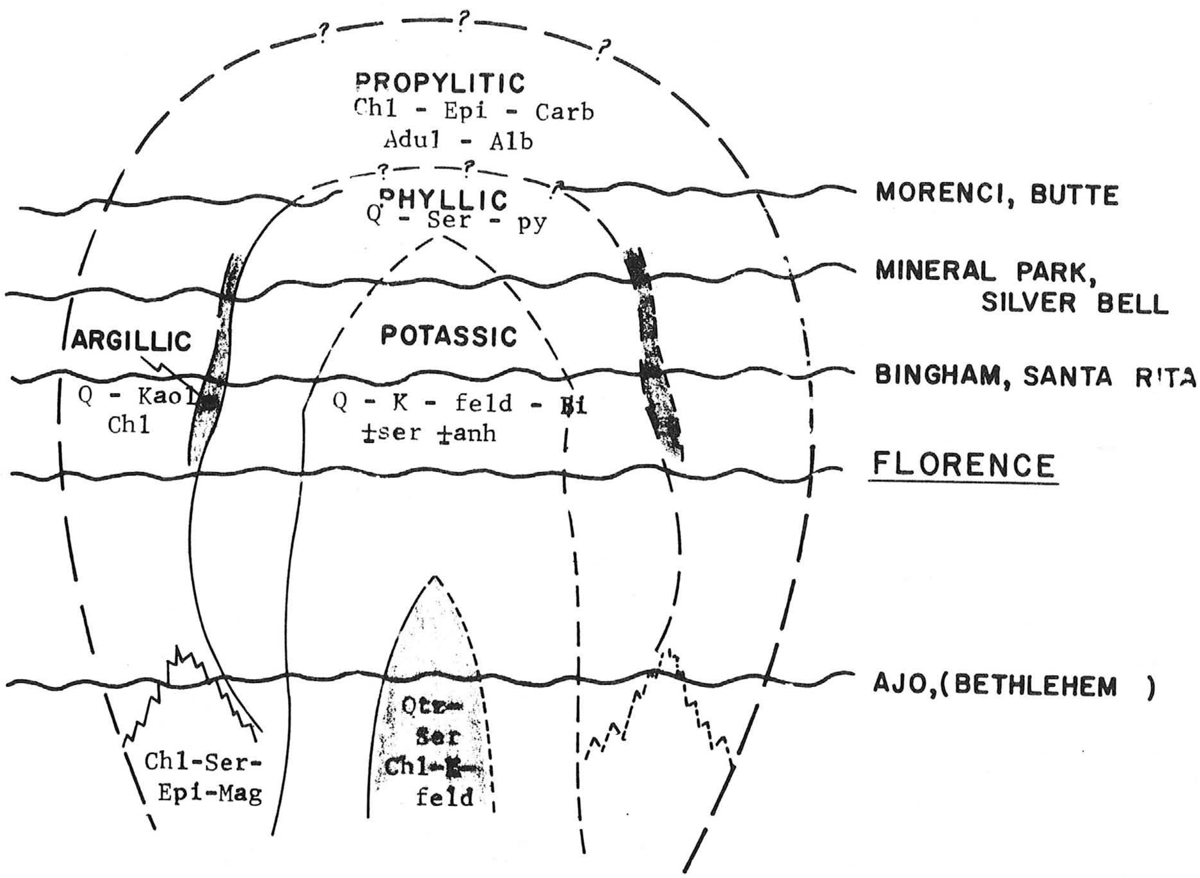
Drilling to date has shown that the Florence ore body nicely fits a porphyry copper deposit as described by Lowell and Guilbert (pp. 374-375):

> "A porphyry deposit is here defined as a copper and/or molybdenum sulfide deposit consisting of disseminated and stockwork veinlet sulfide mineralization emplaced in various host rocks that have been altered by hydrothermal solutions into roughly concentric zonal patterns. The deposit is generally large, on the scale of several thousands of feet, although smaller occurrences are recognized. The relatively homogeneous and commonly roughly equidimensional deposit is associated with a complex, passively emplaced stock of intermediate composition including porphyry units. It contains significant amounts of pyrite, chalcopyrite, molybdenite, quartz, and sericite associated with other alteration, gangue, and ore minerals and metals including minor lead, zinc, gold, and silver. Mineralization and alteration suggest a late magmatic-mesothermal temperature range. The deposit is generally associated with breccia pipes, usually with a large crackle brecciation zone, and is surrounded by peripheral mineralization.
>
> The grade of primary mineralization in typical porphyry copper deposits ranges up to 0.8% Cu and 0.20% Mo, ..." Figure 3 shows the alteration zoning.

Figure 3

**ALTERATION ZONING IN PORPHYRY ORE DEPOSITS**

Derived from Lowell & Guilbert (p. 405)




Abbreviations:

Adul. --- Adularia
Alb. ---- Albite
Bi. ----- Biotite
Carb. --- Carbonate
Chl. ---- Chlorite
Epi. ---- Epidote
Kaol. --- Kaolinite
K-feld. - Potassium feldspar
Mag. ---- Magnetite
py. ----- Pyrite
Qtz. or Q Quartz
Ser. ---- Sericite

The Florence deposit's beginning dates back to emplacement of a Precambrian granitic batholith. This major granitic batholith, the Oracle Granite, dated in other areas as 1.3 billion years old, is probably the basement quartz monzonite porphyry of the Florence Deposit. It possibly intruded lower Precambrian Pinal (?) Schist which has been located about three miles off to the northwest. Mafic dykes and sills intruded the porphyry, probably in late Precambrian.

During late Precambrian and early Paleozoic, most of Arizona was subjected to regional stress which brought about a number of lineaments. Two and possibly three of these lineaments crossed in the Florence area creating a crustal weakness for the Laramide intrusive and hypogene activity that formed the ore body as shown in figure 4.

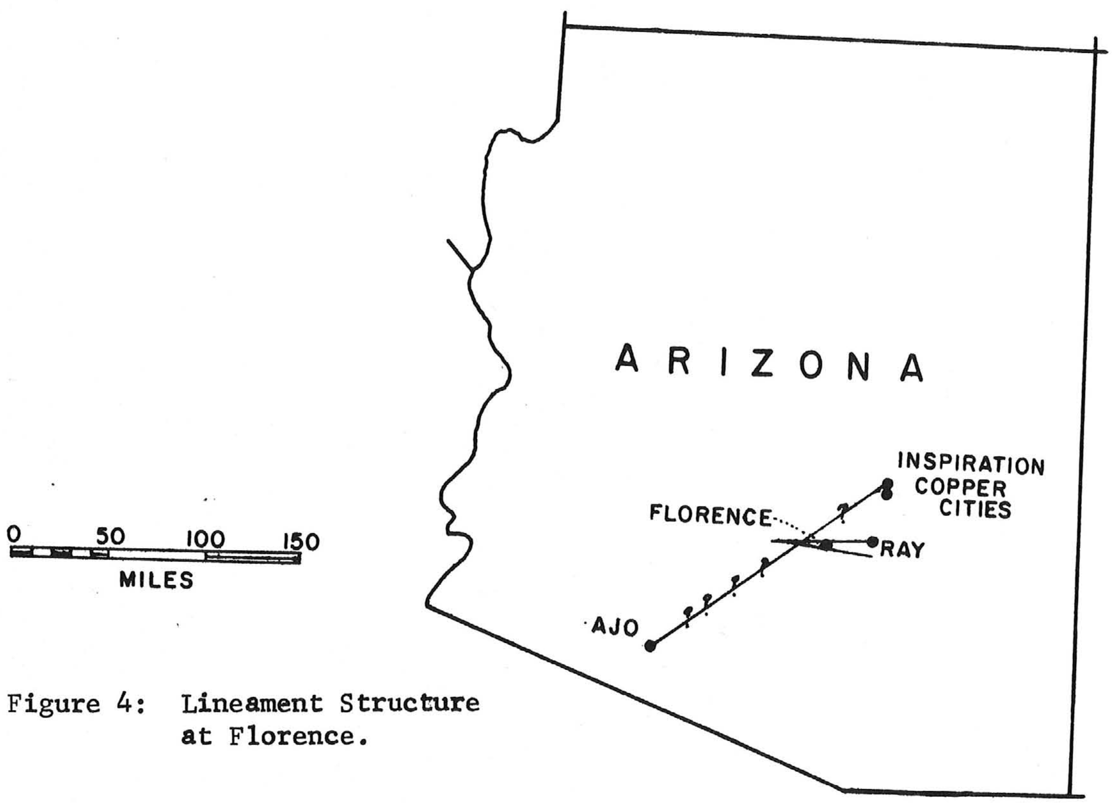



Figure 4: Lineament Structure at Florence.

The Ray Lineament trending N70 E goes through the Ray Deposit, Florence Deposit, Blackwater Deposit, and the Sacaton Deposit. The Florence Deposit appears to trend east-northeast. There is a N70 E vein-dyke system two miles northeast of Florence on the Aztec Property. The Apollo 9 infrared photo over Florence recorded a N70 E structural feature just north of Poston Butte apparent for over thirty miles. Another vein-dyke system on the Aztec Property trends east-west. This east-west lineament? is supported by high altitude (60,000') photos showing this trend is at least twenty miles wide. An east-west vein-dyke system is on the Red Hills Prospect nine miles to the east. A north 45 E possible lineament is also exposed by a vein-fracture system on the Aztec Property. This lineament? if extended, goes through the Superior, the Globe-Miami districts to the northeast, and the Ajo Deposit to the southwest. The Magma mine in Superior reports both east and northeast trending faults of an "old system", (Hammer and Peterson, p. 1294). The northeast system appears to be similar in Globe-Miami which "... suggests that the faults in the two areas are part of the same system," (Hammer and Peterson, p. 1292). At the Copper Cities Mine, "... the Lost Gulch Quartz Monzonite - the host rock for the Copper Cities Mine - is intruded along a northeastward zone ..." (Simmons and Fowells, p. 152). At Ajo, "The Able fault is a very strong premineral fault that cuts across the northwest corner of the pit. The fault strikes N40 E ...", (Dixon, p. 126).

If deposition took place during Paleozoic, it was completely eroded away by early Tertiary times throughout the area. During Late Paleozoic, the Pre-cambrian-early Paleozoic stress fields were reactivated, creating a zone of weakness for the Laramide Orogeny. At Florence, during Laramide time, a grano-diorite porphyry complex and associated sills and dykes were intruded into the quartz monzonite porphyry. The drilling to present indicates that associated breccia pipes may have developed. Toward the end of and following the intrusion, hypogene alteration and mineralization occurred. Hypogene mineralization generally preferred the quartz monzonite porphyry as the host rock but alteration was not limited to this rock type.

Drilling has shown the horizontal concentric alteration zones beginning with potassic in the center, going to sericitic then propylitic on the outside, similar to most other porphyry deposits, (Lowell and Guilbert), with no hypogene alteration zones vertically above the potassic zone. Argillic alteration is supergene, similar to the Santa Rita District, (Rose and Baltosser), found only in the oxide zone. The alteration zones and the mineralized area are elongate to the east-northeast, dipping to the southwest. Loss of vertical hypogene alteration zones is due either to erosion or to low angle faulting. A number and variety of post mineral dykes occur throughout the area. Oxidation began during Laramide. Only minor supergene enrichment, as a thin chalcocite blanket developed. This is because of low pyrite, low sulphur in the oxidizing ore zone, caused by: rapid erosion of the upper half of the sericitic alteration shell; or faulting away of that shell; or copper mineralization limited to only the potassic alteration zone.

The oxide-sulfide interface is quite complex, even by removing the most recent faulting. On the east side it deepens to the southwest. A ridge or hill is formed in the south, and on the west a steep trough developes, rising rapidly on the far west side. Considering that this interface was near horizontal at the time of oxidation, a complex tectonic sequence followed the oxidation. At this point, we have no way of knowing the original direction of the emplaced ore body; was it as the concentric spherical picture of Lowell and Guilbert's report (p. 405) or could it have formed as a horizontal or flat tilted parabaloidal shape? Could tilting have occurred as indicated in the Apollo 9 photo which shows Florence the nose of an anticline or syncline? Whatever the original shape and direction, faulting subsequent to the ore body's emplacement appears to have principally shaped the oxide-sulfide interface as it now appears. In places, drilling has gone from the oxide zone, into a block of a true sulfide zone, not intermixed, then back into the oxide zone. At depth, drilling in the sulfide zone, then oxide zone has been enountered, going back into the sulfide zone. Low angle faulting associated with high angle graben-horst faulting is seen in a number of porphyry deposits in Arizona. A generalized picture of what may have happened in Florence is shown in figures 5a and 5b. During oxidation and faulting in Florence, one block probably fluctuated bringing about an intermixed oxide-sulfide zone. The oxidation occurred principally before the uplifting, which brought about the most recent graben-horst faulting, and rapid erosion. The most recent structural trends are to the north and north-northwest indicated by present drilling and an earlier gravitometer survey as shown on figure 6. From the 60,000' photos, a N25 W lineament or major structural feature south of the Gila River may also cross through the ore body. It appears much narrower (one mile) and more prevalent, indicating more recent movement. The Apollo 9 infrared photo over Florence recorded this N25 W structural feature north of the River, an estimated two miles west of Poston Butte. The bottom bed deposited during this period of recent faulting is probably the post Laramide, Tertiary, Whitetail or Yellow Peak conglomerate described by Blucher, (p. 72) which fills the downdropped blocks and is capped by a flat-lying reddish-brown sandstone (Phil Sterling). Lying unconformably on this is the Gila or Rock Peak conglomerate (Sell, p. 73) if our interpretation is correct. Recent alluvium covers the conglomerate in the Florence area.

The ore body now lies entirely beneath the water table which will cause some mine operation problems of an opposite nature from most desert mines continually searching for water.

## ROCK TYPES OF THE DEPOSIT

Mineralized rock types associated with the Florence deposit are intrusive and hypabyssal in origin. Approximately 90% of the mineralization is contained in quartz monzonite porphyry and granodiorite porphyry. Other igneous rocks include diabase, diorite, basalt, andesite, dacite, latite, rhyodacite, and

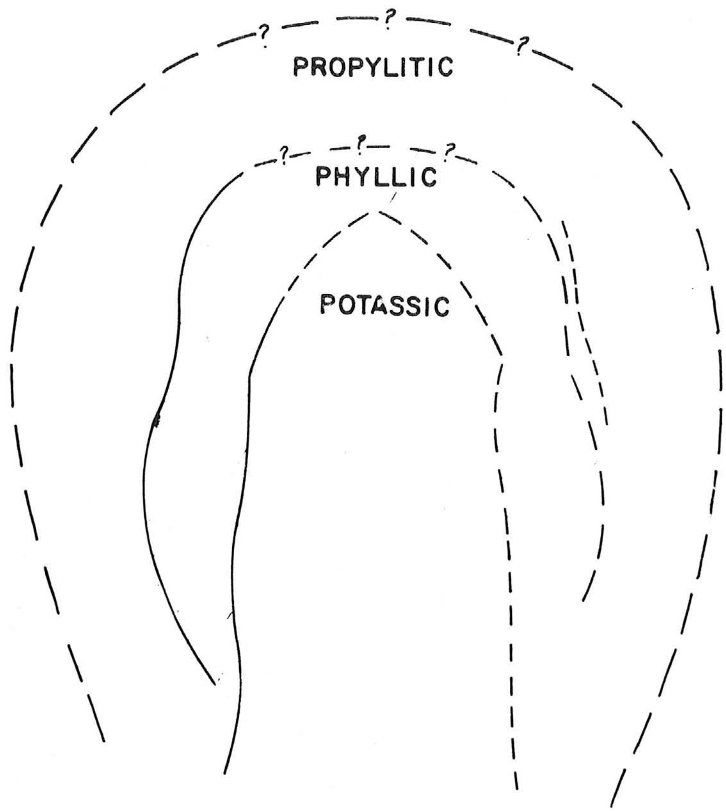
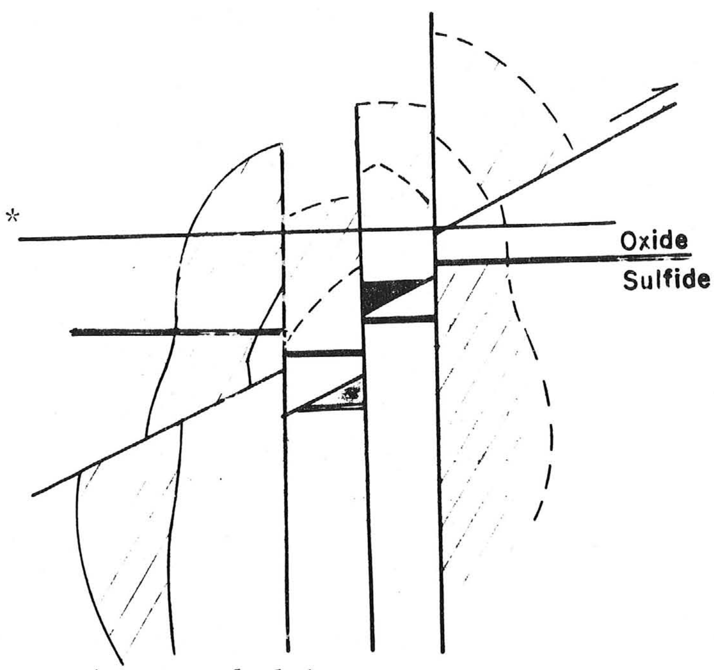



Figure §a




* Bedrock surface before most recent faulting.

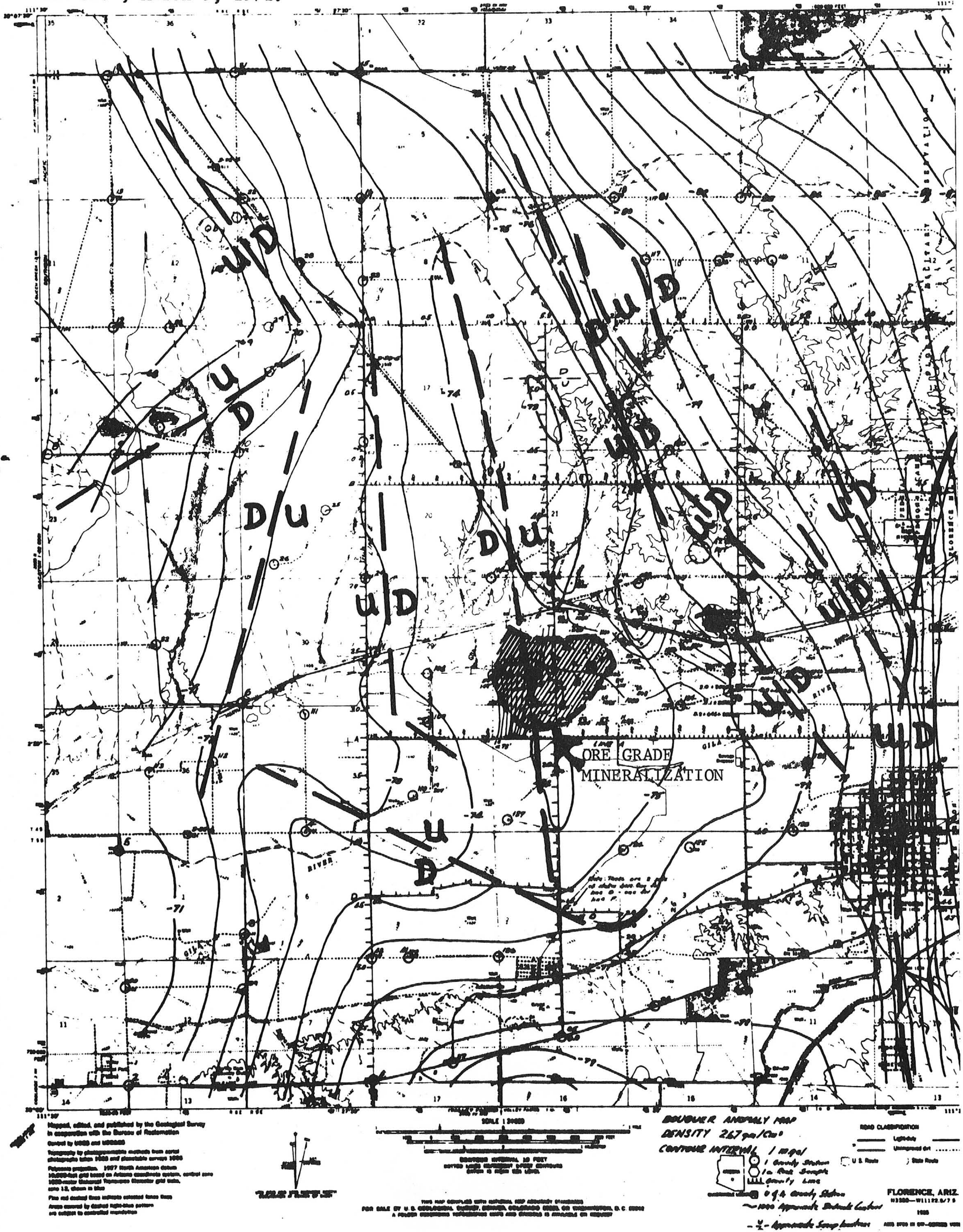
Figure 5b. Post-Mineral Horst-Graben and Related Faulting.

BOUGUER ANOMALY MAP by: Robert West
From: "Gravity Survey of the Florence Area, Pinal County, Arizona--for Continental Oil Co.", March 9, 1971.

Structural Interpretation by Dick Knapp
December 14, 1971

Figure 6





aplite. The ages of these intrusive rock types are imprecisely known, but based on comparison to other deposits and knowledge of Arizona geology, three ages of igneous activity are postulated - Precambrian, Laramide, and Tertiary-Quaternary. Subsequent to crystallization of these intrusive rock types a final period of erosion, faulting, and deposition occurred which resulted in burial of the deposit by Tertiary-Quaternary conglomerate and alluvium. A geologic map at the 500' level of the deposit is presented in figure 7 and a cross section is shown in figure 8.

Precambrian rock types include an intrusive quartz monzonite porphyry mass and dikes of diabase and diorite. The quartz monzonite porphyry is volumetrically the largest mineralized rock type and is correlated with the Oracle quartz monzonite porphyry batholith. Aplite dikes occur within the intrusive mass with gradational to sharp contacts. These contacts indicate a close genetic association with the late stages of quartz monzonite porphyry formation.

The quartz monzonite porphyry intersected in the Florence core consists of coarse grained, subhedral, twinned K-feldspar phenocrysts (25-35%) embedded in an hypidiomorphic to xenomorphic, medium grained matrix of quartz (15-30%), plagioclase (20-35%), and biotite (5-8%). Locally graphic and myrmekitic intergrowths are developed although these could be a result of hydrothermal alteration. K-feldspar phenocrysts in this rock are generally dusty textured, pink colored, slightly perthitic, and locally may show some microcline twinning. These K-feldspar phenocrysts may range up to two inches in size and include plagioclase and biotite crystals. Plagioclase matrix crystals are commonly zoned and generally range in composition from andesine ($An_{38}$) to oligoclase ($An_{26}$). Accessory minerals include apatite, rutile, sphene, zircon, and magnetite.

The quartz monzonite porphyry is the major host for copper mineralization.

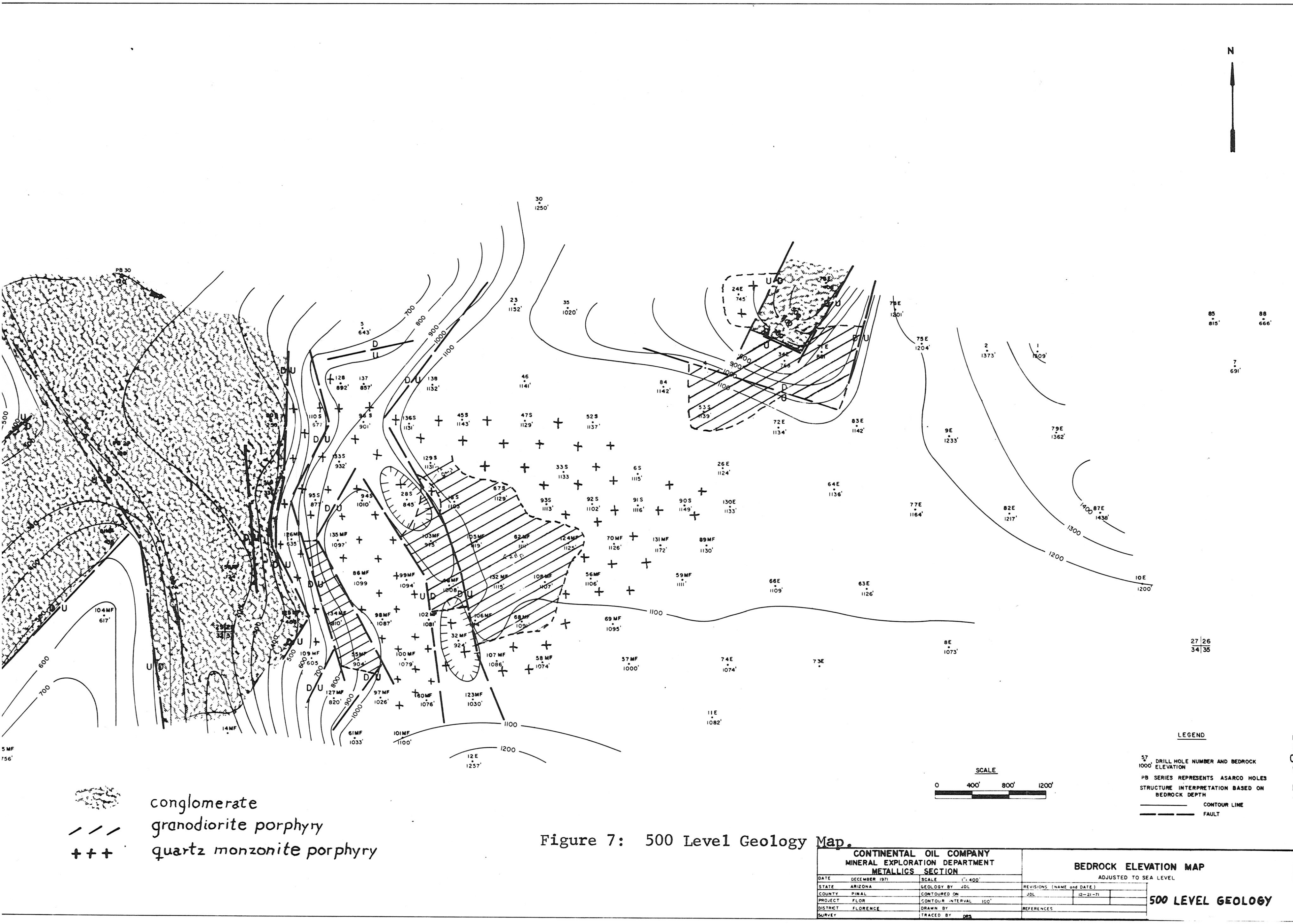



Figure 7: 500 Level Geology Map.

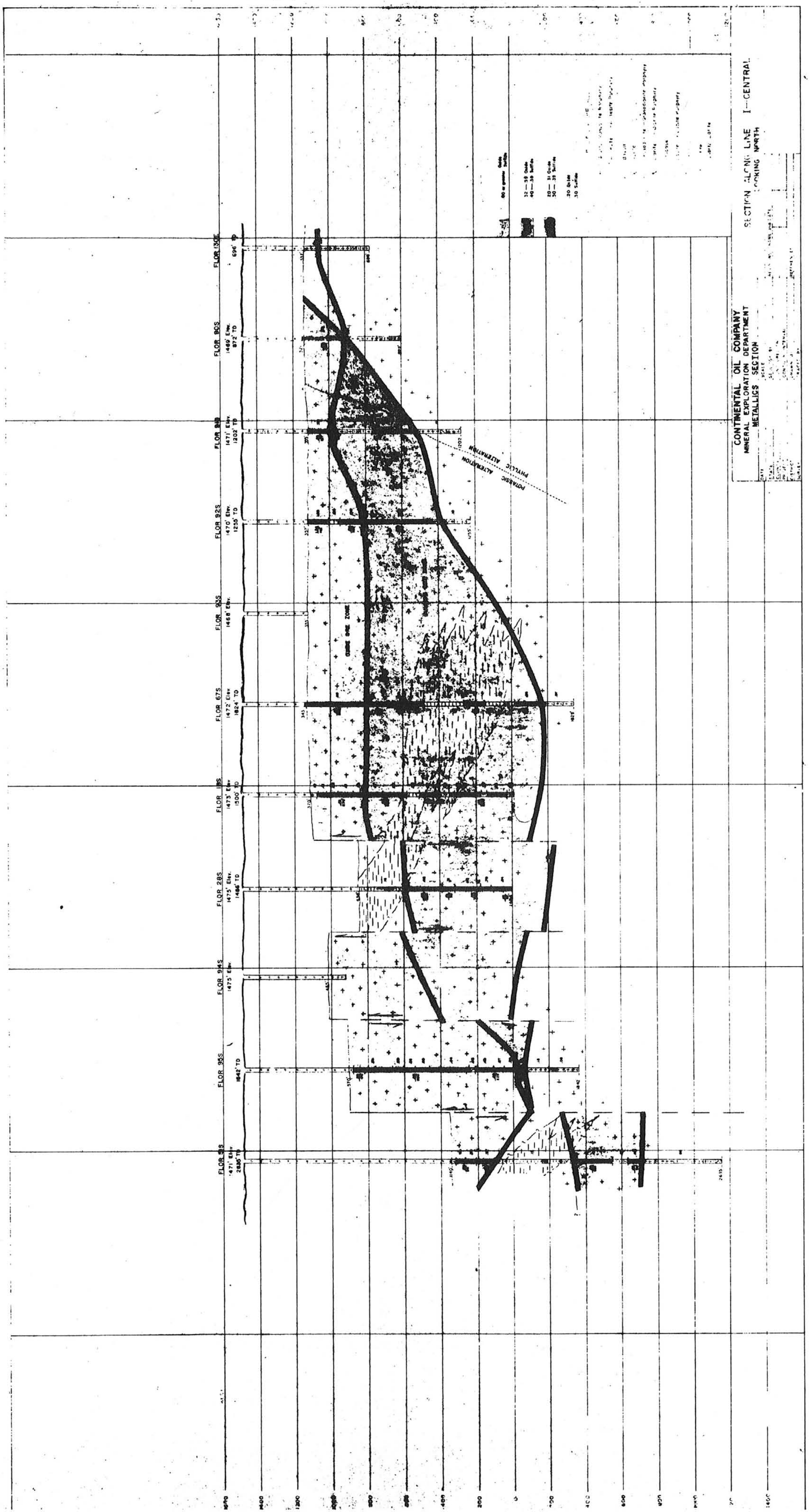

CONTINENTAL OIL COMPANY
MINERAL EXPLORATION DEPARTMENT
METALLICS SECTION
SECTION ALONG LINE I-CENTRAL
LOOKING NORTH
PHYLLIC ALTERATION
POTASSIC ALTERATION

Figure 8

Fracturing, brecciation, and development of permeable zones related to emplacement of Laramide granodiorite porphyry controlled the distribution of mineralization. Chalcopyrite as the major primary copper sulfide occurs in veinlets and disseminations with biotite in the quartz monzonite porphyry. Adjacent to contacts with granodiorite porphyry the quartz monzonite porphyry is generally more intensely mineralized with chalcopyrite.

Diabase and diorite apparently occurring as dikes or sills are probably in part of Precambrian age. The exact age of these more mafic rocks relative to quartz monzonite porphyry is unknown. Inclusions of some varieties of these mafic rocks are found in quartz monzonite porphyry but in other cases, some contacts indicate a younger age for the mafic rocks. The diabases and diorites are fine grained, dark, and dense, ranging in core intercepts from a few inches to tens of feet. Petrographically these rocks consist of plagioclase laths embedded in a mafic matrix. Although these basic rock types are volumetrically low in abundance, the diabases and diorites are highly mineralized. Locally the altered varieties of these rocks contain 10-15% chalcopyrite.

Laramide igneous activity is represented by granodiorite porphyries. The granodiorites associated with the Florence deposit are subdivided into three petrographic varieties. The exact relationship between the two major varieties is uncertain although there is a genetic relationship. In some cases inclusions of the lighter, more coarse grained granodiorite type 1 are present in the darker, finer grained granodiorite 2, but in other cases the contacts are gradational. This would suggest that granodiorite type 1 is a slightly earlier phase of the Laramide intrusive system than type 2 granodiorite. The relationship of granodiorite porphyry 3 to the other varieties is unknown.

Granodiorite porphyry 1 is a light gray, medium to fine grained rock with quartz, plagioclase, and biotite phenocrysts set in a xenomorphic matrix of quartz and K-feldspar. Modal ranges are quartz (15-20%), plagioclase (40-50%), K-feldspar (15-20%), and biotite (5%). Myrmekitic and graphic textures are locally developed. Plagioclase phenocrysts tend to be compositionally zoned and range from $An_{30}$ to $An_{40}$. Accessory amounts of rutile, apatite, zircon, and magnetite are also present.

Granodiorite porphyry 2 is a medium gray, more mafic and finer grained rock than granodiorite porphyry 1. Quartz, biotite, and plagioclase phenocrysts are set in a very fine grained xenomorphic matrix of quartz, K-feldspar, biotite, and plagioclase. Modal composition is quartz (20%), plagioclase (50%), K-feldspar (15-20%), and biotite (5-10%). Plagioclase phenocrysts are oscillatory zoned with an average composition in the andesine range. Accessory minerals include zircon, apatite, and magnetite.

Based on current drill hole data, the thickest portion of the granodiorite porphyry mass is present in the vicinity of holes 48-MF and 103-MF ( 1100' thick). Fingers of granodiorite porphyry extend to east-northeast and to the northwest of this thickest section. Another fairly thick portion of granodiorite porphyry extends to the northeast of the ore body and is associated with mineralization in holes 34-E and 71-E.

Both granodiorite types are generally weakly mineralized in comparison with quartz monzonite porphyry. This relative lack of mineralization may be a function of composition or structure. In general, the granodiorite porphyries are less intensely fractured than quartz monzonite porphyry. Mineralization when developed in the granodiorite porphyry is mostly veinlet controlled. In terms of geometry of granodiorite porphyry in relation to ore and the nature of contact mineralization the granodiorite porphyry must have played a fundamental role in the development of porphyry copper type mineralization. Following the intrusion and partial crystallization of granodiorite porphyry, fractures developed in the largely consolidated crystal-magma system. Probably at this late stage of crystallization, saturation occurred with a resulting migration of water to zones of weakness. This migration of water and dissolved constituents was responsible for the deposition of copper sulfides and hydrothermal alteration.

The third variety of granodiorite porphyry is greenish gray, very fine grained, and contains only plagioclase and quartz phenocrysts. Granodiorite porphyry 3 appears to be restricted to dikes or small intrusive masses. A modal composition for this mineralized variety is quartz (15-20%), K-feldspar (15-20%), biotite (5-10%), and plagioclase (40-55%).

Laramide igneous activity may also have been responsible for the development of mixed or intrusive breccia zones. These breccia zones commonly consist of mixtures of quartz monzonite porphyry, granodiorite, diorite, diabase, and other rock types set in a fine grained, finely comminuted matrix. These zones may also be intensely mineralized and resemble breccia pipes.

Following the intrusion of granodiorite types, dikes and sills of Tertiary hypabyssal intrusive rock are intersected in core. These rocks include latites, dacites, andesites, basalts, quartz latites, and diorites. These rock types are devoid of primary porphyry copper type mineralization. However, during subsequent oxidation of sulfide copper mineralization, latites, andesites, and basalts locally acted as precipitating hosts to the copper bearing solutions. Thus, these rocks locally form rich zones of exotic oxide copper mineralization.

During Tertiary-Quaternary time faulting and burial of the deposit occurred. The thickness of this overburden is variable ranging from 320' to 1225' in the area of the ore body. The depth to the pre-overburden surface along the eastern half of the ore body varies from 320' to 350' but along the western portion the depth of burial is greatest as a result of faulting. This overburden consists of partially consolidated conglomerate and alluvium.

## STRUCTURE

Structural interpretations within the Florence deposit have been made entirely on the basis of drill hole information. As the deposit is covered by a minimum of 320' of conglomerate and alluvial cover, structural interpretations have been based on depth to basement rock, structures encountered in core drilling and alteration changes.

Two sets of post-mineralization faulting based on strike trend associated with mid-Tertiary (?) Basin and Range orogenesis have been recognized at Florence as indicated by figure 9. The major set is a series of north-south to north 25° west striking normal faults. The west edge of the deposit is bounded by at least three normal step faults downdropping the west side approximately 700 feet as shown in figure 8. A graben in the center of the deposit 1000' long and 400' wide has been downdropped a maximum of 266'.

Possible lateral movement has occurred along the west side of the graben. Large thicknesses of granodiorite porphyry have been encountered within the graben and can be correlated to the east. The upthrown area west of the graben contains small amounts of granodiorite porphyry as dikes or sills. Closer spaced drilling is needed within the upthrown block near the west edge of the graben and to the northwest and southwest portions of the deposit to determine direction and distance of lateral movement.

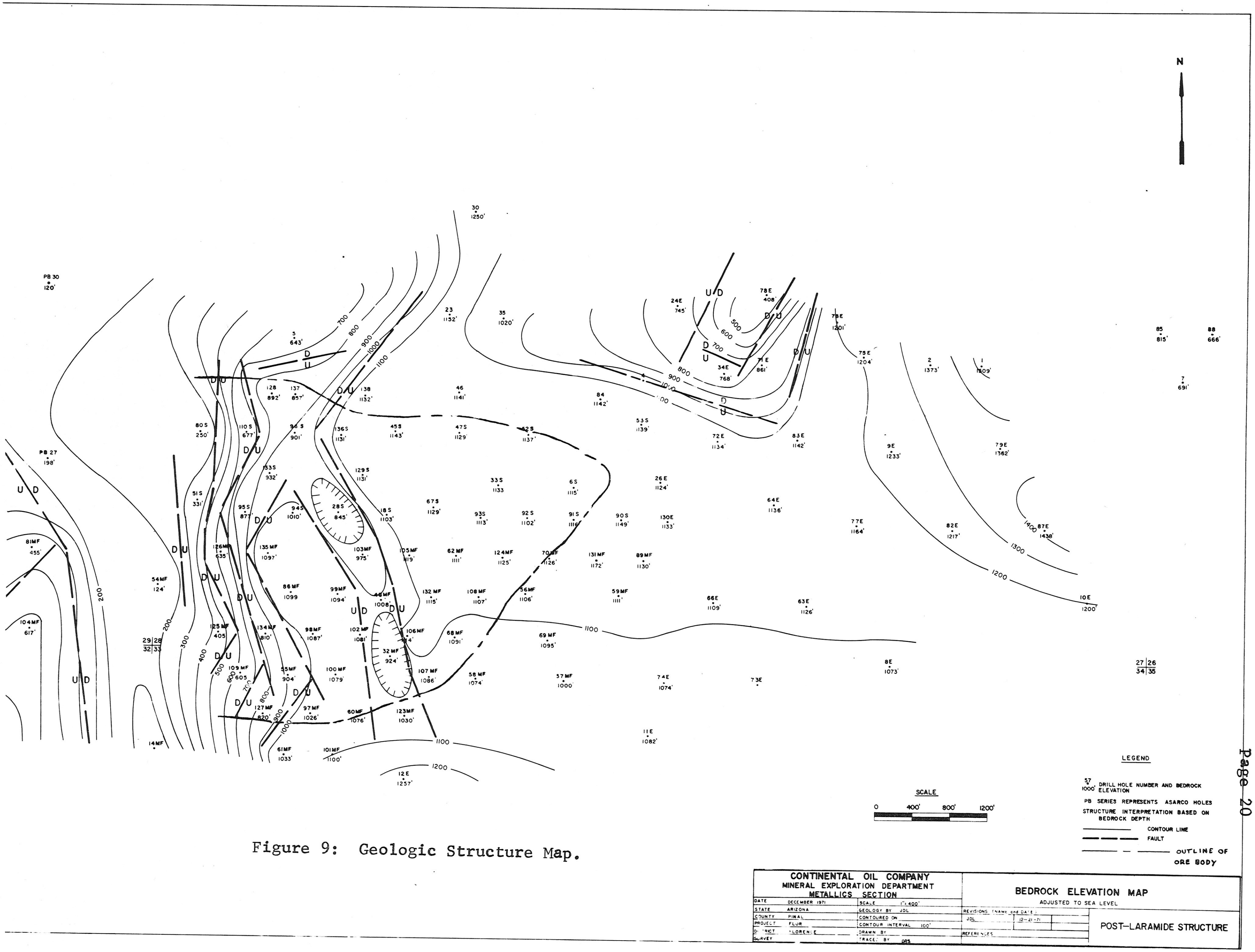


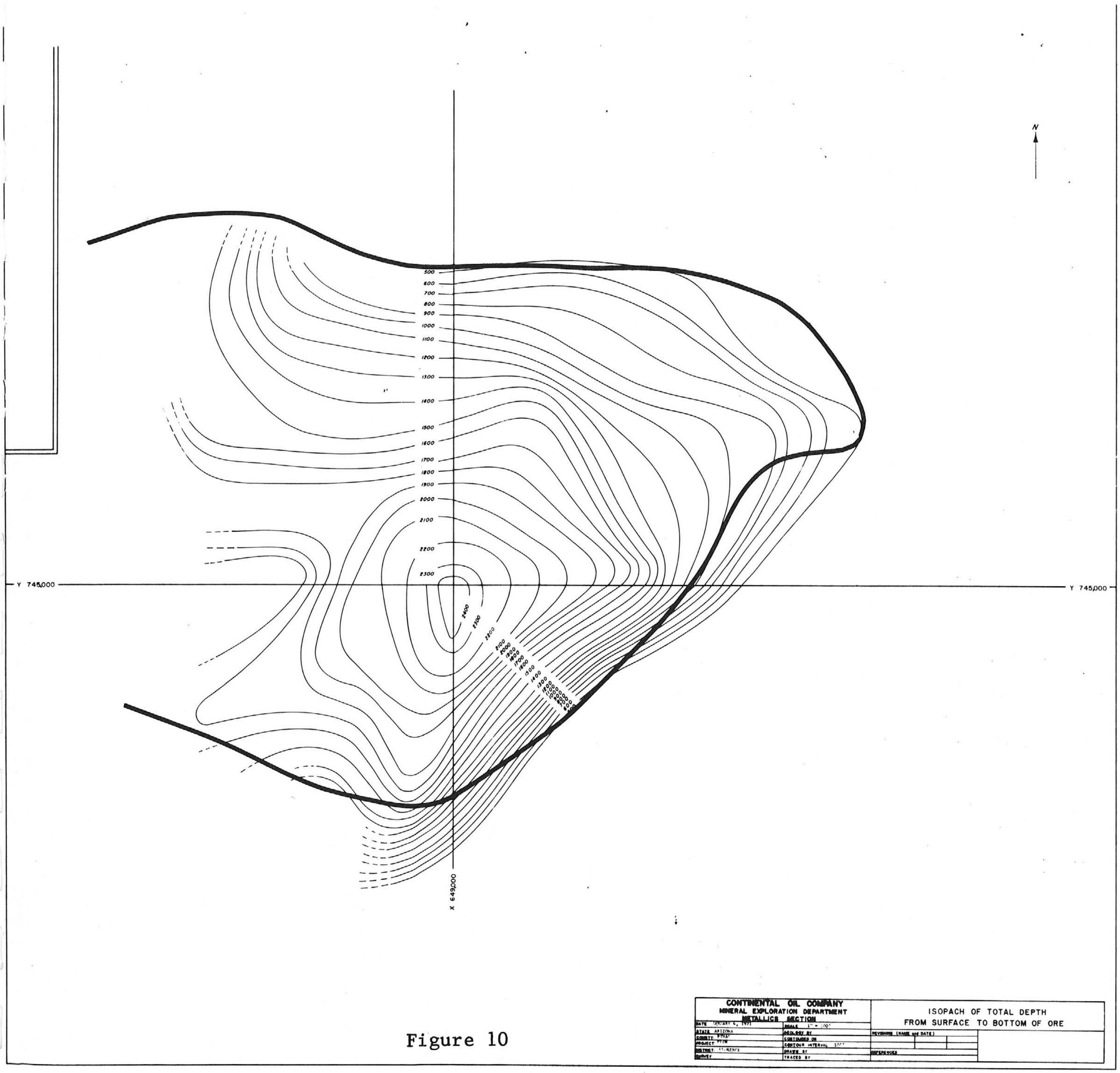

Figure 9: Geologic Structure Map.

The second set of post-mineralization faults are those striking north $30^\circ$-$35^\circ$ east. Northeast faulting within the deposit is known to occur in the northwest portion truncating the N25°W striking graben. A northeast striking fault is suspected to terminate the ore zone on the south side. Drilling in the area has shown intense brecciation in the oxidized zone. The encountered brecciation in conjuction with a change from potassic alteration to propylitic alteration over a horizontal distance of 800 feet southward shows that there is a good possibility of a fault with no apparent change in elevation of bedrock.

The problem of low angle faulting within the Florence deposit is a subject of wide speculation and difficult to determine at this point in our drilling program. Low angle faults have been mapped on other porphyry districts in Arizona and have been shown to be part of the tensional system which produced north-south striking horst and graben structures common to the districts. The displacemnnt on these faults has been normal to the strike of the north-south striking grabens.

Using this information and figure 10 one can see in the northeast portion of the deposit the bottom of the ore zone is dipping approximately $40^\circ$ to the southwest normal to the strike of the graben in the center of the deposit. A breccia zone 10' to 55' wide intruded by a post-mineral basalt was intersected in three drill holes in this area. A three point solution produced a strike of north $40^\circ$ west and dip of $35^\circ \pm 5^\circ$ to the southwest normal to the graben and step-faulting within the deposit.

Alteration changes from potassic to sericitic with depth have also been noted in this portion of the ore body. Below the low angle fault sericite and pyrite increase while potassium-feldspar decreases.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METALLICS SECTION
DATE JANUARY 6, 1971
SCALE 1" = 200'
STATE ARIZONA
GEOLOGY BY
COUNTY PINAL
CONTOURED BY
PROJECT
CONTOUR INTERVAL 100'
DISTRICT FLORENCE
DRAWN BY
SURVEY
TRACED BY
ISOPACH OF TOTAL DEPTH
FROM SURFACE TO BOTTOM OF ORE
REVISIONS (NAME and DATE)
REFERENCES

Figure 10

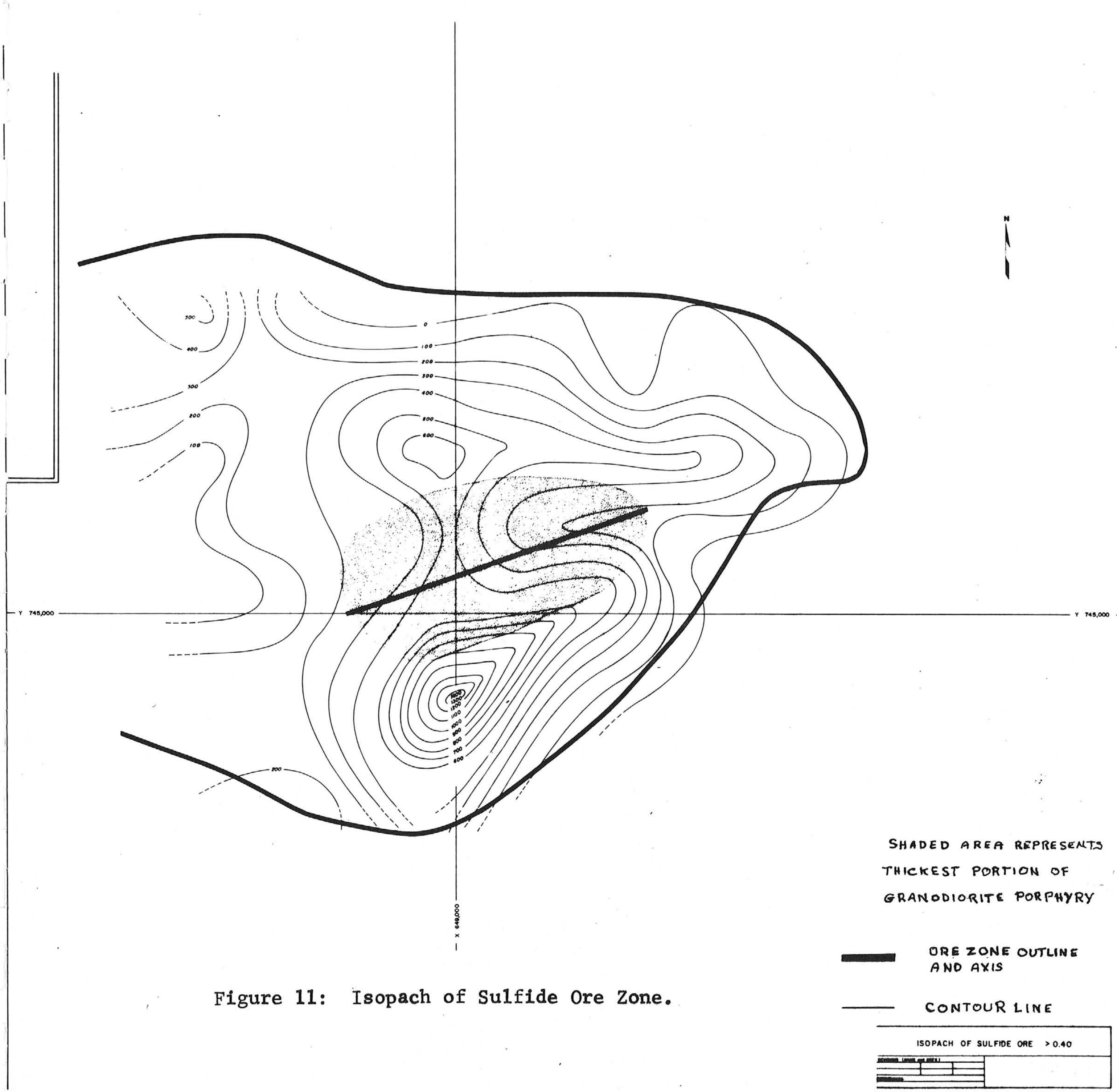



Figure 11: Isopach of Sulfide Ore Zone.

These three bits of evidence show low angle faulting may have taken place within the Florence deposit and may be a major control over the depth of ore grade material in the northeast portion of the deposit. Displacement along the fault may have moved the hanging-wall to the northeast.

The greatest structural feature and most important for localization of ore within the Florence deposit is the intrusion of Laramide granodiorite porphyry along the N70 E striking Ray Lineament. Figure 11, with the shaded area representing the greatest thickness of Laramide granodiorite porphyry shows the elongation of the granodiorite to the east-northeast with the thickest sulfide mineralization peripheral to the granodiorite. North of the granodiorite sulfide mineralization reaches a thickness of 600 feet. To the south it reaches a maximum of 1400 feet.

Control over formation of sulfide mineralization peripheral to the granodiorite is thought to be a combination of fracturing produced by forceful intrusion of the granodiorite porphyry. Zones of intrusive (?) breccia have been encountered in drilling along contact with quartz monzonite porphyry.

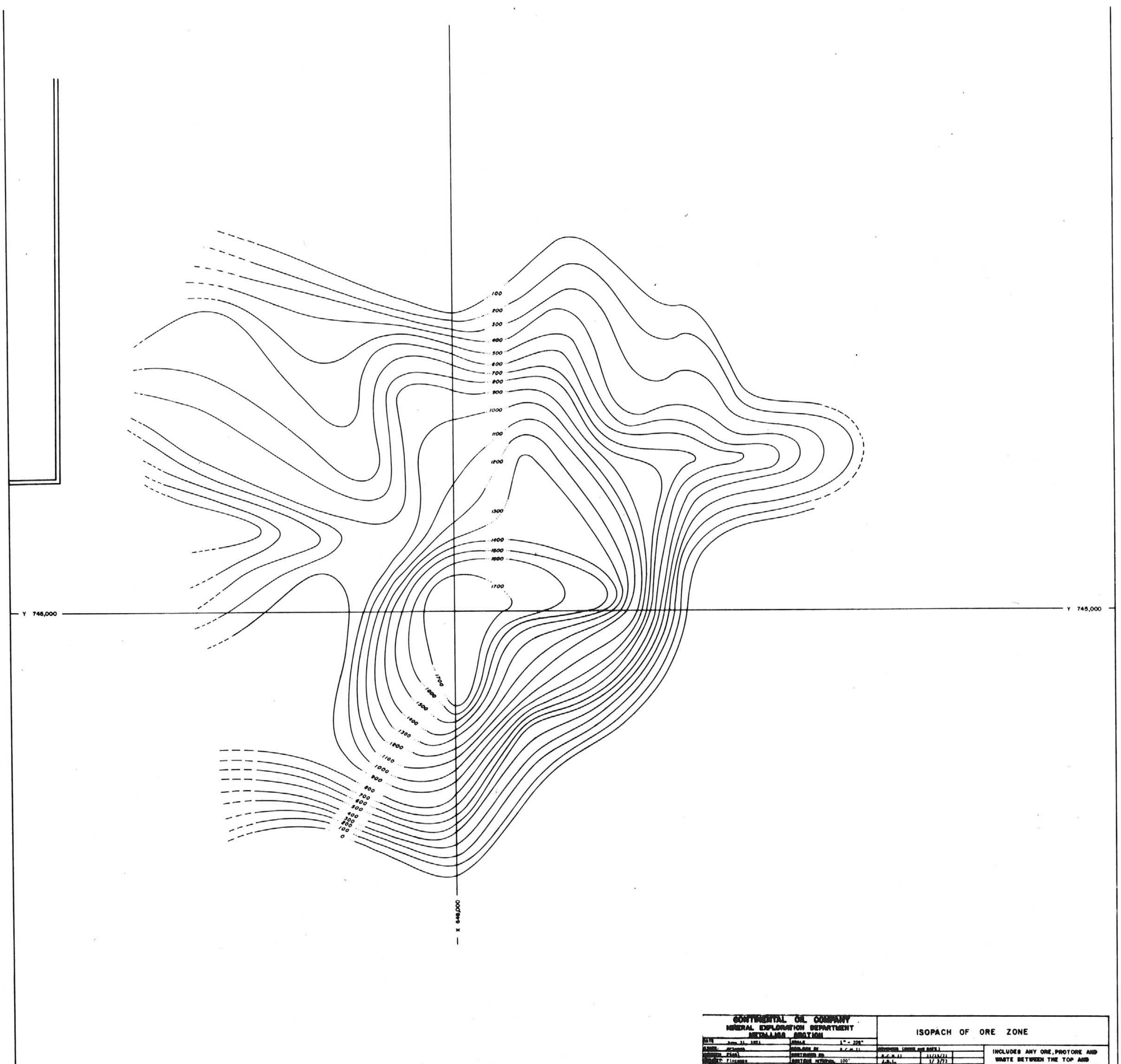
A hypothetical structural sequence for the Florence deposit is postulated as follows: During Laramide orogeny (Late Cretaceous to Early Cenozoic) granodiorite porphyry intruded the Precambrian Oracle quartz monzonite porphyry along the pre-existing Ray Lineament. Mineralization and alteration followed. During Oligocene uplift and erosion occurred with the possibility of tilting to the northeast exposing the ore body. Evidence for tilting has not been specifically found around Florence but regional geology has shown tilting has occurred thirty miles to the northeast. Oxidation subsequently occurred during exposure of the ore body. During Mid-Tertiary, perhaps Miocene-Pliocene, Basin and Range faulting occurred downdropping the west side of the ore body. Deposition of Whitetail conglomerate occurred during, and continued after, Basin and Range orogenesis in Miocene time. Intrusion of volcanic dikes occurred from Mid-Tertiary to as late as Pleistocene(?). No definite age can be correlated as yet. Deposition of Gila (?) conglomerate occurred during Pliocene to Pleistocene times.

## MINERALIZATION

The Florence deposit contains substantial tonnages of both oxide and sulfide ore types. In general these ore types are distinct from a geological and metallurgical view. Zones of mixed oxide and sulfide are noted only in a few holes. Total tonnage of both ore types amounts to Cu. Ore is thickest in the vicinity of holes 32-MF and 108-MF and in general shows northeast to east-west trends as is shown on figure 12.

Mineralogy of the oxide zone consists predominantly of chrysocolla, tenorite, and medmontite. Additional minerals found in the oxide ore zone include cuprite, azurite, malachite, shattuckite, and native copper. Chrysocolla and tenorite generally occur along fracture planes as fillings and coatings although some chrysocolla does replace plagioclase (as shown by the slides). Medmontite, a montmorillonite type clay containing copper, is a more common replacement of plagioclase sites in the argillized rock. The thickness of the oxide zone is variable ranging from 0'-785'. From available drill hole data the ore averages 250'-300' thick. The thickest portion of the oxide zone lies in the vicinity of holes 86-MF--110-S and 124-MF as shown in figure 13.

The development of the oxide ore zone is related directly to supergene processes. The oxidation of the sulfide ore body and the accompanying argillization are a consequence of supergene alteration.



100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Y 748,000
X 648,000
0
CONTINENTAL OIL COMPANY
MINERAL EXPLORATION DEPARTMENT
ISOPACH OF ORE ZONE
1" = 200'
100'
INCLUDES ANY ORE, PROTORE AND WASTE BETWEEN THE TOP AND BOTTOM INTERCEPTS OF ORE ZONE


figure 12

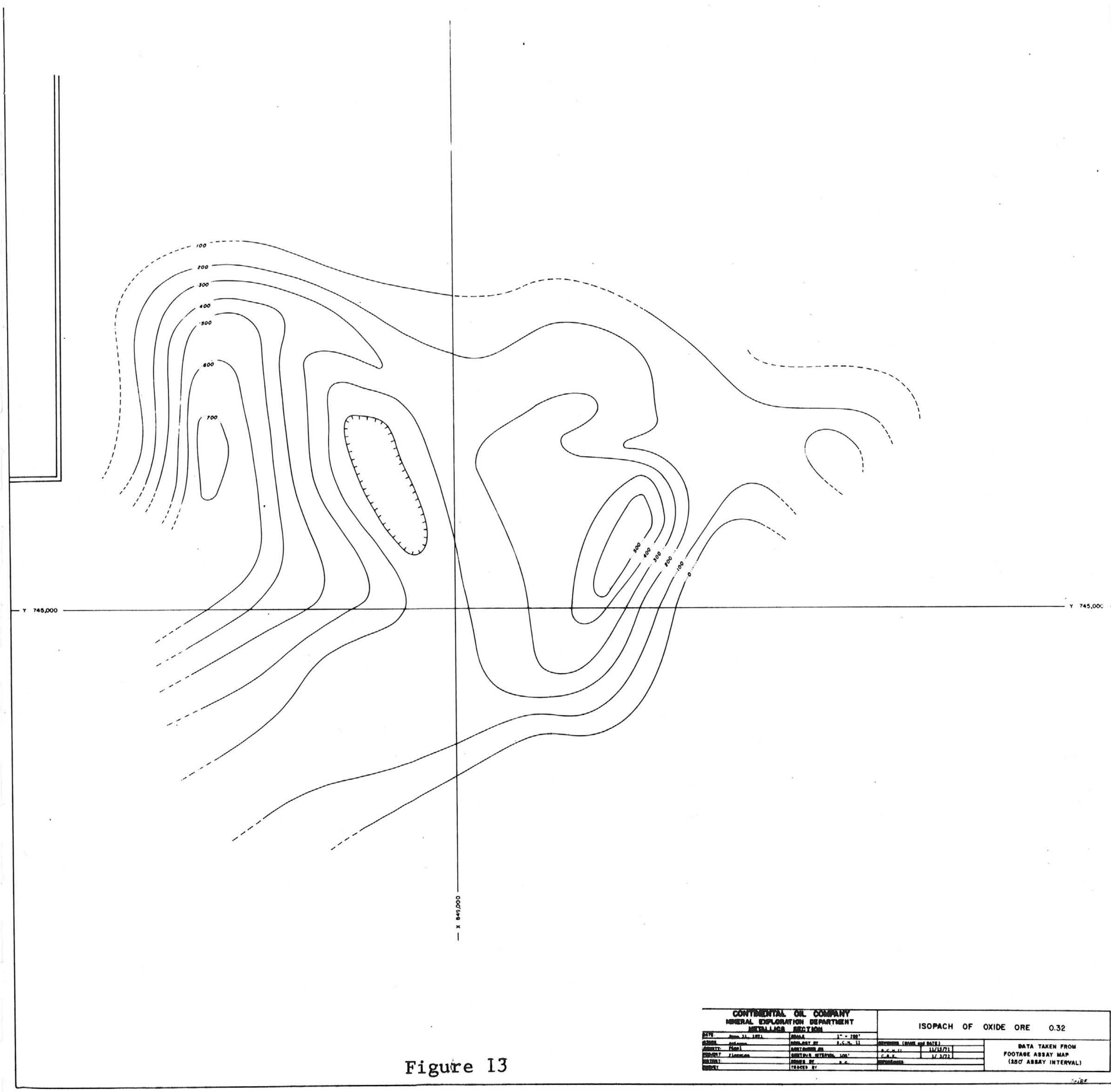

100
200
300
400
500
600
700
Y 745,000
X 849,000
CONTINENTAL OIL COMPANY
MINERAL EXPLORATION DEPARTMENT
METALLICS SECTION
ISOPACH OF OXIDE ORE 0.32
CONTOUR INTERVAL 100'
TRACED BY
DATA TAKEN FROM
FOOTAGE ASSAY MAP
(150' ASSAY INTERVAL)

Figure 13

Rock composition controls somewhat the nature and intensity of oxide mineralization. The major portion of the oxide ore is contained in quartz monzonite porphyry and granodiorite porphyry but oxide copper development is most intense in more basic rocks such as andesite and basalt. The mineralogy of this oxide ore in the basic rocks consists of chrysocolla, tenorite, cuprite, and native copper generally averaging in grade between 0.60-1.00% copper. This oxide mineralization exists along fractures in post-sulfide, Tertiary intrusive dikes and sills. Apparently the more basic composition of the rock types resulted in the precipitation of exotic oxide copper minerals.

Metallurgically, three types of oxide ore are recognized at Florence, (Hazen Research Inc., 1971). They are:

1) Chrysocolla type
2) High Iron type
3) Mixed type.

The chrysocolla type is characterized by visible copper oxide minerals, chiefly chrysocolla and lesser amounts of tenorite. Iron oxides as goethite and/or hematite may be present in sparse to moderate amounts but never intense. Included in the chrysocolla type are copper stained clay minerals or other layer silicates along fractures and copper stained altered feldspar phenocrysts.

The high iron type contains moderate to abundant iron oxides with little or no visible copper oxide mineralization. Iron oxide mineralogy consists of goethite or hematite-commonly as a mixture. Minor jarosite may be present. The basis for recognizing this zone is that copper may enter the goethite structure and effect leaching behavior.

The mixed ore type is a mixture of both the chrysocolla and high iron types.

The mixed zone is recognized in two ways - as alternating intervals of chrysocolla type and high iron type not large enough to be mixed separately and as significant amounts of copper oxide minerals, chiefly tenorite and chrysocolla with intense iron oxide staining.

Leached capping is also a significant feature of the oxide zone. In general the nature of boxworks and the limonite coloration have proved to be reliable indications of mineralization at depth. In the potassic zone of the ore body boxworks are commonly observed to be only partially leached with the limonite color dominated by hematite indicating a high chalcopyrite to pyrite ratio. In the sericitic zone, the limonite coloration is dominated by goethite indicating the pyritic mineralization at depth.

Secondary sulfide enrichment is commonly thin in the Florence deposit. Oxide mineralization may be admixed in the enrichment zone in roughly equal amounts with sulfide minerals. Total copper and oxide copper assays are important in this transition zone to determine the exact copper extraction methods to be used. The mineralogy of this zone consists of chalcocite, covellite, chalcopyrite, and bornite. Chalcocite is the major component of this zone and generally occurs as coatings on pyrite grains. The thickness of the chalcocite zone is variable ranging from 0-600' and is thickest along the potassic-sericitic alteration boundary. The chalcocite zone does not appear to be related to post-sulfide structures. The relative thinness of the chalcocite zone may be a result of a number of factors such as 1) low total sulfide content, especially in the potassic zone; 2) lack of porosity and structure; or 3) subsequent destruction of chalcocite zones by faulting and/or erosion.

The hypogene sulfide zone is represented by pyrite, chalcopyrite, and molybdenite. Minor amounts of galena and bornite are also noted. The total sulfide content ranges from 2-3% in the potassic zone up to 5-10% in the sericitic zone. Primary sulfide ore is restricted to the hydrothermally developed potassic alteration zone and generally shows a high chalcopyrite to pyrite ratio.

Sulfide mineralization is related to structure and alteration. The mineralization is predominantly veinlet controlled. Higher grade mineralization is commonly associated with mixed zones which may be produced in part by structural brecciation. The proximity of sulfide mineralization adjacent to the granodiorite porphyry and the relatively low grade center that this intrusive outlines indicates that granodiorite porphyry is also a major control.

Sulfide ore is thickest in the vicinity of holes 32-MF and 108-MF. From the isopach of sulfide ore presented in figure 11, northeast and east-west trends are apparent. These trends may be a reflection of Precambrian structural patterns that were reactivated during the Laramide mineralization event.

Molybdenum, silver, and gold may also be recovered from the sulfide ore. The average for these metals in the ore is, 0.0101% Mo, 0.099 oz/ton Ag, and 0.0016 oz/ton Au. Mo shows a general correlation with Cu content. Zonation of Ag and Mo shows a general northeast to east-west trend paralleling the potassic sericitic alteration boundary along the eastern section of the ore body.

## ALTERATION

Porphyry copper mineralization at the Florence deposit is associated with supergene and hypogene alteration zones. The supergene alteration is related to the amount of oxide mineralization and extensive argillization. Hypogene alteration is distributed in concentric halos which consist of potassic, sericitic, and propylitic alteration types. The exact dimensions of the alteration zones are not known, but in plan view at the 500' level as shown in figure 14, the potassic zone is 3500' long in the north-south direction and >3000' long in the east-west dimension. Outward from this alteration zone, the sericitic alteration type varies from 500' wide at the southern region to 2500' long along the eastern edge. The propylitic zone apparently extends much farther outward and its dimensions are probably in the tens of thousands of feet. Alteration intensity at Florence is primarily veinlet or fracture controlled. Based upon the rough correlation between hypogene alteration boundaries and granodiorite distribution, especially along the eastern edge of the deposit, the granodiorite porphyry may have acted as the center of symmetry for the altering fluids.

Supergene alteration developed in response to oxidation of the sulfide ore deposit. This oxidation resulted in the development of clay minerals and iron oxides in addition to copper oxide minerals. The mineralogy of this argillic zone includes Kaolinite, montmorillonite types, halloysite, allophane, illite, quartz, chlorite?, vermiculite?, and hematite-goethite. Argillization primarily affects the plagioclase grains and to a lesser extent the mafic minerals. This argillization is commonly most intense along fractures.

The intensity of hypogene alteration and the resulting mineral assemblage depends on a number of factors such as temperature, pressure, composition of the altering fluids, time, and composition of the wall rocks. At Florence, the more mafic rocks such as diorite and diabase respond differently to the hypogene alteration processes than more felsic rocks such as granodiorite porphyry and quartz monzonite porphyry. Commonly the mafic rocks are more intensely biotized, chloritized, and epidotized than the felsic intrusives.

Alteration in the potassic zone is distinguished by the hydrothermal assemblage K-feldspar-biotite-sericite. This assemblage is distributed adjacent to

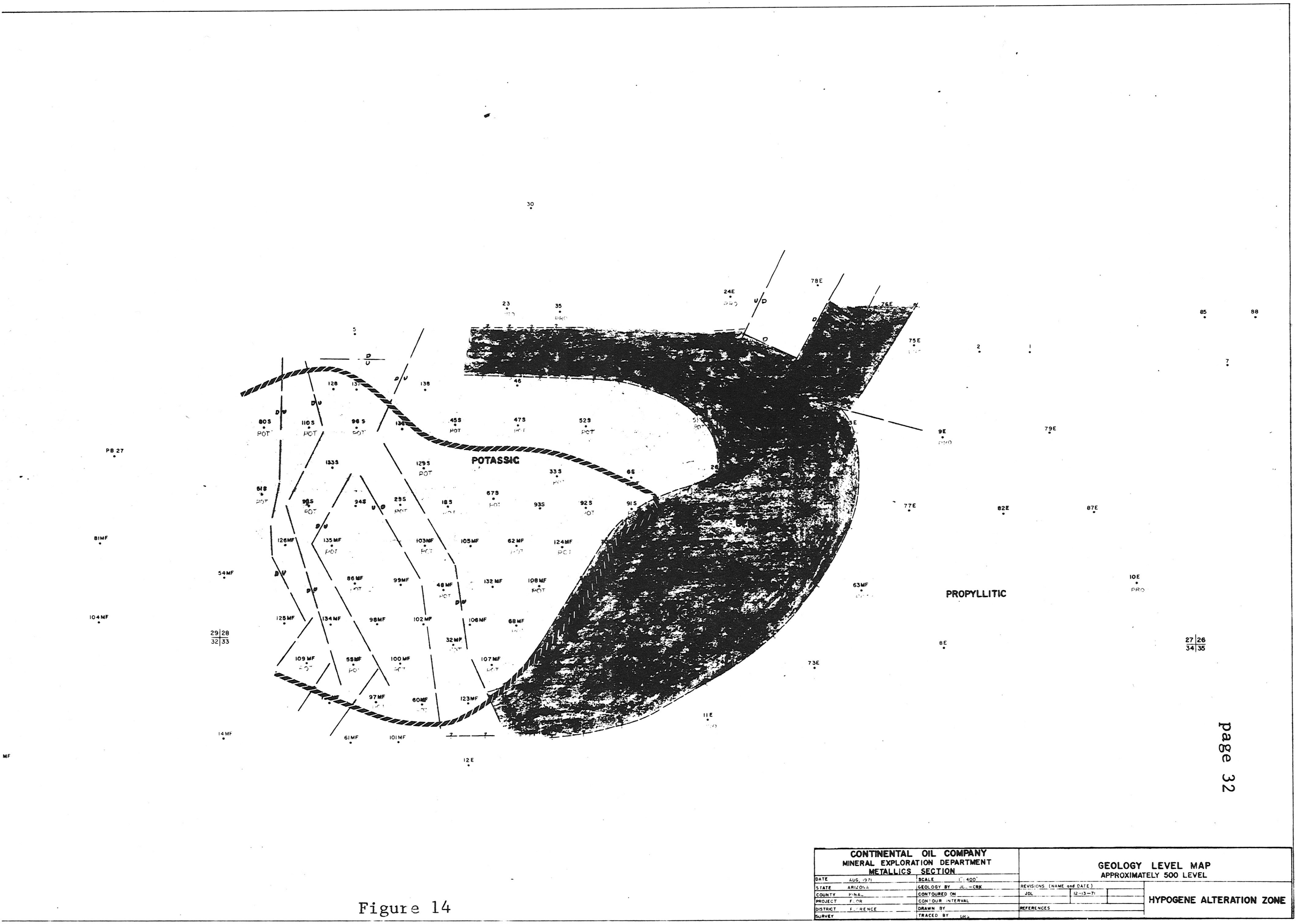

POTASSIC
PROPYLLITIC
CONTINENTAL OIL COMPANY
MINERAL EXPLORATION DEPARTMENT
METALLICS SECTION
DATE AUG. 1971
STATE ARIZONA
COUNTY PINAL
DISTRICT FLORENCE
SURVEY
SCALE 1"=400'
GEOLOGY BY JL - CRK
CONTOURED ON
CONTOUR INTERVAL
DRAWN BY
TRACED BY
REVISIONS (NAME and DATE)
REFERENCES
GEOLOGY LEVEL MAP
APPROXIMATELY 500 LEVEL
HYPOGENE ALTERATION ZONE

Figure 14

veinlets and also locally in a pervasive manner. Additional components of this assemblage are quartz, chlorite, calcite, gypsum?, anhydrite, sphene, rutile, and locally epidote. Magnetite is also a component of this assemblage and may occur as separate veinlets or in association with mafic grains. Sulfides associated with this alteration include pyrite, chalcopyrite, and molybdenite. In this zone, the total sulfide content is 2-4% with chalcopyrite exceeding pyrite.

Sericitic zone mineralogy is simple in nature. The bulk of the assemblage is comprised of quartz, sericite, and pyrite with some local quantities of rutile. Sericitic zone alteration is predominantly restricted to veinlets generally composed of quartz and pyrite. Total sulfide in this zone exceeds the sulfide quantities in the potassic assemblage and amounts to 5-10% sulfide content which consists mostly of pyrite.

The propylitic alteration zone represents the outer fringe alteration of the Florence deposit. Mineralogically this alteration consists of the assemblage epidote, sericite, carbonate, chlorite, quartz, rutile, magnetite, pyrite, adularia, and zeolites. In general, this alteration is weaker in degree of development than potassic or sericitic alteration and is lowest in total sulfides, averaging 1% pyrite.

Within the ore grade potassic zone of the deposit, a retrograde propylitic alteration apparently developed. This alteration is restricted to veinlets and consists of quartz, carbonate, and chlorite. This assemblage probably represents a later superimposed stage of alteration after potassic alteration.

## GEOPHYSICAL AND GEOCHEMICAL EXPLORATION

The Florence copper deposit has been outlined with a fair degree of success with a few geochemical methods. The methods Continental Oil has used primarily are gravity survey, induced polarization, and mercury vapor detection. The gravity survey was useful in determining general bedrock depths and displacemnnts. The induced polarization was used to outline our deposit and other areas of interest. The geochemical method - mercury vapor detection-was also used to delineate the Florence deposit and to look for other promising areas.

GRAVITY SURVEY:

A gravity survey was conducted in the area by Robert West during August and September of 1970. The purpose was to delineate the subsurface scarp or scarps which downdrop the western edge of our deposit. Data was taken in the area of the ore body and outside of it. The data to the north has been used in exploratory drilling and has shown that gravity data can be a very effective tool.

The principle of the system is that variations in the density of rocks near the surface of the earth create small differences in the pull of gravity. These differences can be measured and interpreted providing several corrections are used in transforming the raw data into usable data. By mathematically "removing" the regional gravity effect, even better local anomalies may be observed and interpreted. The basis for interpretation of bedrock depths in this area is a bedrock which is more dense than the overlying, loosely consolidated sediments. Thus, the deeper the sediments, the less the pull of gravity compared with that of an equal amount of bedrock.

Using these principles, the gravity data was interpreted as shown on figure 6. The structural interpretation shown agrees very well with drill hole data to date. The most outstanding feature of this interpretation is a large horst which trends roughly NNW, truncated to the south, and thinning

GRAVITY SURVEY, con't:

to the north. This is the horst upon which the ore body sits. West of this horst is a graben which trends roughly north-south, and which is responsible for the groundwater flow to the north. East of the major horst is one, or more likely, a series of downthrown step faults.

As the exploratory drilling done in the area agrees with these interpretations, the gravity data has proved to be very useful in this area in interpreting bedrock displacements, and sometimes depths.
(West, 1970).

INDUCED POLARIZATION SURVEYS:

Two induced polarization surveys have been run in the area. The first survey, which was essentially a test of the effectiveness of I. P. over the ore body, was conducted in October and September of 1970 by Mining Geophysical Surveys. The second survey, which was a much more extensive reconnaissance survey, covering the ore body and much of the surrounding lands, was conducted during the spring of 1971 by McPhar Geophysics Incorporated. The results of this survey were used in exploratory drilling during 1971. The drilling results were discouraging, although preliminary.

Induced polarization is a method of locating scattered primary sulfide mineralization through electronically charging the ground by applying a current and then observing the electrical behavior or response. The principle is that an individual sulfide grain which exhibits metallic-like conductivity, will react much as a leaky condenser when current runs over its surface - ie., it will develop a small voltage potential. This behavior of the sulfides can be detected by observing the decay voltage after the current is shut off ( the current will "flow back" after the current is shut off) or by comparing the impedence (resistivity) of the rock with change in A.C. current frequency. A complication to this method is that some non-metallic, non-sulfide minerals react in the same manner as do the sulfides - notably some of the clays such as bentonite and montmorillonite, plus some other minerals such as pyrolusite and magnetite. (Brandt, 1966).

The preliminary survey by Mining Geophysical Surveys indicated a moderate I.P. and resistivity response over the ore body area, indicating that I.P. would be useful in the area. Subsequently, the reconnaissance survey by McPhar Geophysics was conducted to attempt to better outline the ore body and to indicate areas of further interest. The results of this survey are shown on figure 15. As can be seen, the deposit is reflected as a probable anomaly which is shown as an ENE extension of a major trending definite and probable metal factor anomaly. The NNW major trending anomaly has another ENE extension to the north which looks similar to the one in which the deposit is located. North of that there is another isolated "definite metal factor anomaly", and to the east are a couple of "probable metal factor anomalies." (Hauck, 1971).

During the latter part of 1971, most of these anomalies, and a good number of drill holes proposed by McPhar were rotaried to bedrock as an extension of our validation and assessment program. Holes were located so as to drill into either I.P. or MV anomalies and where possible, both. The results are discouraging overall. Ten holes were drilled, and out of these holes, only five seemed to show any hope of being in the vicinity of any mineralization. Those were holes 12-P and 13-P which were drilled mainly on an MV high; 15-P which was drilled on a possible I.P. anomaly; 19-P which was drilled into the definite I.P. anomaly just west of the deposit; and 30-P which was drilled in the west end of the

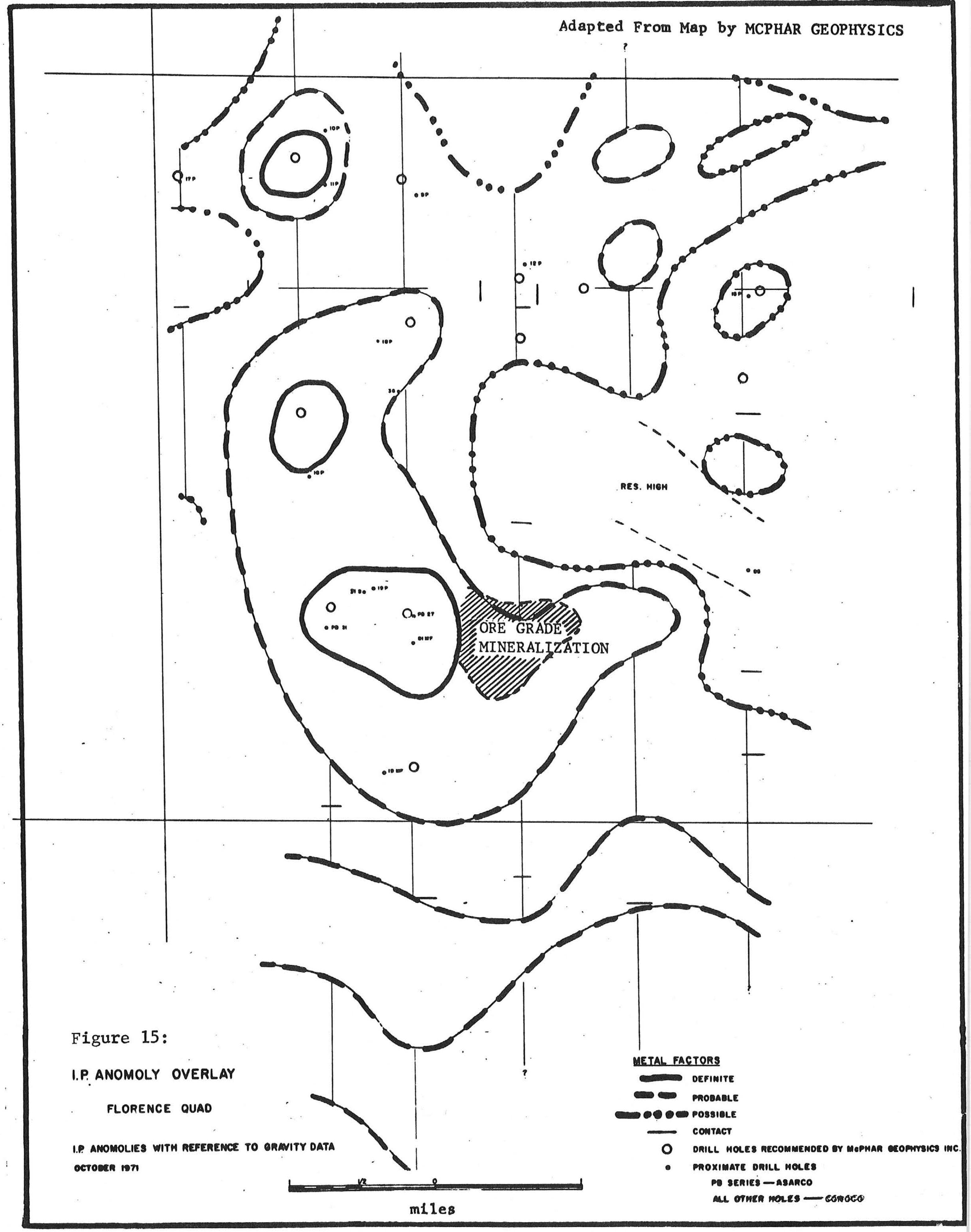



Figure 15:

I.P. ANOMOLY OVERLAY

FLORENCE QUAD

I.P. ANOMOLIES WITH REFERENCE TO GRAVITY DATA

OCTOBER 1971

definite I.P. anomaly west of the deposit. These holes (with the exception of 15-P) all showed a propylitically altered quartz monzonite porphyry, with slight to moderately high geochemical Cu, and sometimes anomalous Ag, Pb, Zn, and Hg values. Hole 17-P also had anomalous Ag.

However, there were several discouraging aspects of the I.P. data. None of the holes intersected any true verification of the I.P. anomalies (although some may lie at a greater depth - not on the bedrock surface). In addition, the axis of the NNW trending definite - probable anomaly has been shown to lie on or in the general vicinity of the large graben which trends north-south; and which drops the western part of the deposit. This suggests that resistivity lows, and possibly I.P. highs, are associated with the sediment filled graben (which has a high clay and groundwater content.)

In summary, the I.P. work has shown some very well defined anomalies which, so far, we haven't been able to entirely substantiate on the basis of having any mineralization. Future drilling will probably be done on these highs to fully evaluate this I.P. work.

MERCURY VAPOR DETECTION:

The Radiation Lab Group in Ponca City, under the leadership of Preston Gant, has been developing mercury vapor detection equipment and techniques right along with the copper deposit, and has compiled an enormous quantity of data from on and around the area. The detection methods and equipment are some of the best, if not the best, now used. These methods have also shown that mercury vapor detection can be a relatively fast and cheap exploration method. The Florence staff has used this data in exploratory drilling - mostly to the north of the deposit - with moderate success.

MERCURY VAPOR DETECTION, con't.

Anomalous mercury concentrations are known to be associated with porphyry copper type deposits, as well as disseminated gold, silver, zinc, and mercury deposits. Mercury, in the native state, is liquid, and maintains a high enough vapor pressure to release small but significant amounts of mercury vapor (measured in "nanograms" = $10^{-9}$ grams). This vapor will migrate upwards from a buried deposit, and if sensitive enough equipment is used, can be detected on the surface - in the soil, the soil gas, or in the air above a deposit. (Gant, et.al., 1971).

The basic principle is to trap and measure this gas. The Ponca City group does this in a couple of ways, but the principle is all the same - by passing a large volume of air over a gold plated nichrome wire, the available mercury is amalgamated on the gold. By passing a current through the wire, the mercury is "burned" off and passed through a spectrophotometer which measures the amount of mercury there is in the air. In this manner, a very small amount of mercury may be effectively measured. (Gant, et. al., 1971).

A map of the MV results is shown on figure 16. The red-colored circles are those readings which are 1.5 times background. As can be seen, there is a general area of highs around the deposit, delineating the deposit fairly well. Also to be noted are the areas of general highs around holes 12-P, 13-P and 18-P. (sections 16 & 17)

Almost all of the anomalies outside of the ore body have been drilled in conjunction with I.P. anomalies. Overall, the results are discouraging, although there are indications that MV highs were located over areas where bedrock was indeed anomalous in mercury content. Rotary hole 18-P was a big hope, since it is in the vicinity of both an MV high, and an I.P. anomaly which is similar to the one that the deposit is located on. Bedrock in 18-P was very deep (1586')


INDIVIDUAL BUBBLE DATA

O BUBBLE STATION • DRILL HOLE
● > 1.5 x BACKGROUND
⊕ 1.3 — 1.5 x BACKGROUND
⊘ 1.0 — 1.3 x BACKGROUND

ANOMALY OUTLINES

—·· — MV ANOMALY OCT. 3 — 17
—·—·— MV ANOMALY NOV. 3 — 9

SCALE

0 2000' 4000' 6000'

Figure 16:

MERCURY VAPOR DATA

FLORENCE PROJECT AREA

INDIVIDUAL BUBBLE DATA BY CLEO SCOTT & ASSOCIATES AS OF JUNE 3, 1971

ANOMALY OUTLINES TAKEN FROM CONOCO RESEARCH REPORT NO. 1202-1-1-71: A MINERAL EXPLORATION SYSTEM — MEASUREMENT OF MERCURY VAPOR IN AIR AND SOIL GAS", BY GANT, MOTES, AND AYLOR, JANUARY, 1971

R8E R9E

MERCURY VAPOR DETECTION, con't.

with no indications of mineralization. Holes 12-P and 13-P, however, are more promising. Both were shallow (210' and 180', respectively) with weak alteration and fairly heavy limonite and hematite staining at the bedrock-conglomerate contact. Hole 12-P was subsequently cored for 50 feet, and the geochemical assays were anomalous - mercury running an average of 225 ppb., with 325 ppb. high, and anomalous values of silver, copper, and zinc. Another hole, 16-P, was drilled on both an MV and an I.P. anomaly. Here the alteration was poor, but the spot core ran 217 ppb. Hg, which again, is an anomalous mercury value.

Therefore, while no direct indications of sulfide mineralization were drilled into, on MV anomalies to the north of the deposit, there is evidence from a couple of the holes that MV highs are associated with anomalous mercury concentrations in bedrock. This is important to establish, as it may be in some cases that MV highs could be attributed to other sources which could confuse the results. Possible sources of mercury other than bedrock might be from surface contamination, such as smelter fumes, fungicides, etc. or from some sort of subsurface source such as recent volcanic deposits, or perhaps from mercury which has migrated laterally from its source. The possibility that mercury may originate from other such sources should be kept in mind when using MV data.

The detection of mercury vapor, then, promises to be a good geochemical tool, to be used with the other available exploration methods. Since the use of mercury vapor detection is probably as yet in a developmental stage, and since exploration at Florence has not yet drilled out all of the MV anomalies, a complete evaluation cannot be made at this time.

## HYDROLOGY

The Florence deposit is situated beneath the present flood plain of the

Gila River, within the groundwater underflow. Therefore, dewatering the mine area will be a problem in developing the Florence deposit.

SURFACE WATER:

The Gila River is a major river in south-central Arizona, draining some 18,305 square miles upstream from the Ashhurst-Hayden Dam. The dam, however, which is located 16 miles upstream from Florence, effectively eliminates any floodwater threat from this part of the river. A tributary to the Gila, the San Pedro River, with a drainage area of about 4,471 square miles, enters the Gila River downstream from the dam, however, and does pose a threat from floodwaters. Peak recorded discharge in the San Pedro has been 98,000 c.f.s. at Charleston and 90,000 c.f.s. at Reddington. (Halpenny, 1971).

Our consultant in hydrology, Leonard Halpenny of the Water Development Corporation, calculated that any threats to the mining operation could be effectively eliminated by the use of a dike around part of our pit. The dike would be 14 feet high at the narrowest point between our pit and the river, tapering down 4000' to the east and 4000' to the west to two or three feet in height.

SUBSURFACE WATER:

Subsurface water will be the prime concern at Florence. To date, most of the available information on groundwater hydrology is based on a quantitative pumping test conducted by the Water Development Corporation, some U.S.G.S. data (Hardt and Cattany, 1965), and some qualitative information gained from rotary and core drilling in the area.

Groundwater depth at the Florence Project is at about 190 feet - a depth that has been declining over a long period of time due to pumping rates which are greater than replenishment rates. Groundwater is recharged primarily by the underflow of the Gila River. Groundwater is thought to be contained primarily by the recent alluvium, the Gila and Whitetail conglomerates, and the upper fractured and weathered portion of bedrock.

Groundwater flows generally to the west, at a gradient of about 40 feet/mile, until reaching the deposit. In the vicinity of the Florence Project, groundwater veers north, where the gradient apparently drops to 20 feet/mile. (Halpenny, letter and map of November 19, 1971). The northward flow of groundwater is in response to a lowered water table in the Queen Creek - Magma area to the northwest due to heavy pumping. Groundwater probably travels north through a relatively deep north-south trending graben which downdrops the western side of the deposit. The significance of this northward gradient, as explained by Halpenny, is that the effect of dewatering on the surrounding agricultural areas to the south will be less than ordinarily expected. (Halpenny, letter of November 19, 1971).

Preliminary pumping tests in three rotary holes by Elenburg Drilling Company, while not useful for quantitative determination of permeability and porosity of the conglomerate, provided some idea of relative water producing capabilities at various depths and locations in the deposit. In general, very little water was pumped above 250'. Also, it seemed that more water was produced with depth, as long as in the conglomerate.

From rotary drilling, it is also thought that in many areas, bedrock is overlain by a relatively loose sand which is probably a good "water sand". Water wells in the vicinity are frequently partially in bedrock, probably producing some of their water from the upper fractured and weathered bedrock

SUBSURFACE WATER, con't.

surface. With this information, plus the drilling tests of Elenburg, it is thought that most groundwater is carried in the conglomerate, with some in the overlying recent alluvium, and some in the fractured, weathered top of bedrock. The deeper bedrock - particularly the sulfide zone - in all probability acts as a barrier, or as a "hydrologic bedrock", where little water can be stored or transmitted.

A pumping test was conducted in January of 1971 by Water Development Corporation to determine quantitative physical constants of the aquifers above bedrock. One well was pumped while two were observed. The coefficient of transmissibility was determined to be 525,000 gallons per day per foot, while short term coefficients of storage were determined to be 7 and 10 percent. The long term coefficient of storage as determined by the U.S.G.S. (Hardt and Cattany, 1965, p. 77) is 17 per cent, which is confirmed by the calculated short term coefficients.

Using these physical constants, and some assumptions based on these, Halpenny has worked out dewatering programs for the Florence Project. A more thorough knowledge of the hydrologic constants will be needed for a more precise idea of dewatering procedures. Pumping tests to determine these are planned in 1972.

## COMPUTER LOGGING

It was determined, once the Florence deposit was established as a possible ore body, that the use of a computer as an aid in sorting out the many variables which are encountered in the evaluation of such a deposit would be very desireable. Accordingly, the Florence staff, in conjunction with Joe Paden, Engineer of the Mineral Department in Denver, and Dale Cooper of Ponca City's Computer Department, has adopted a system of logging which puts the raw geologic data - including assays - in a standardized, easily codeable system. Of course, the reliability of the data which is coded, and the reliability of the way it is coded is very basic to how reliable the computed results themselves are. The results that can be obtained from a good set of raw data, coupled with several good computer programs are staggering and promise to help the project immensely once they are in effect.

The logging system now in use is a method of recording several parameters plus comments which will be of value to the geologists. The comments will not be programmed, but will be punched for reproduction. The parameters are of two general groups: identifier information and geologic information. Two data cards are punched for each 2½ foot interval - one card with the programable parameters, and one card with comments. The 2½ foot intervals were chosen in this instance to retain a detailed geologic picture with respect to structure, contact relationships, and alteration.

Of the two general kinds of parameters used, the basic ones are the identifying parameters. Identifying parameters now used are:

Project Identification
Drill Hole Number
Coordinates or Location Code
Elevation
Inclination of Hole

The geologic information parameters are a bit more complex. The parameters now used are:

Core Run and Recovery
Rock Type
Structure: Fracture Intensity
Fracture Attitude
Fault Attitude
Alteration Minerals: K-feldspar, biotite, quartz, sericite, chlorite, epidote, carbonate, gypsum, anhydrite, magnetite, hypogene hematite, plus several variables.
Oxide Zone Mineralization: Limonite, hematite, readily leachable copper oxide, or copper oxide in clays and feldspar sites.

Metallurgical Zone: Divides rock into zones which will probably be treated differently metallurgically - a single column is used to classify the five different metallurgical types.
Sulfide Zone Mineralization: Pyrite, chalcopyrite, bornite, molybdenite, covellite, plus several variables.
Assays: Total Cu, CuOx, Mo, Ag, Au, Pb, and Zn.

Each variable is assigned a particular column and the information used is coded as shown on figure 17. Rock type names are coded with an abbreviated 3 to 4 letter symbol. Fracture intensity is coded by numbers according to the quantity of fractures per foot (0 - 5 fractures/foot = 1), while dip is recorded according to the predominant dip angle (40 - 50 = 5). Alteration intensities are recorded with a scale ranging from 1 to 3; 1 = sparse, 2 = moderate, and 3 = abundant.

The remaining columns on our computer sheet are used for remarks. Important information which is not otherwise coded is recorded here. The illustration should be self-explanatory. This information is stored only - it cannot be used by the computer other than to print it out.

POSSIBLE USES OF COMPUTER:

The possible uses of this data by the computer are truly exciting, and while a real study of these are beyond the scope of this paper, a few possibilities are presented.

Statistical evaluation is the name of the computer game, and one of the exciting processes in a developmental stage, as we are now in, is a correlation analysis to determine mineralization trends and variability. By correlating

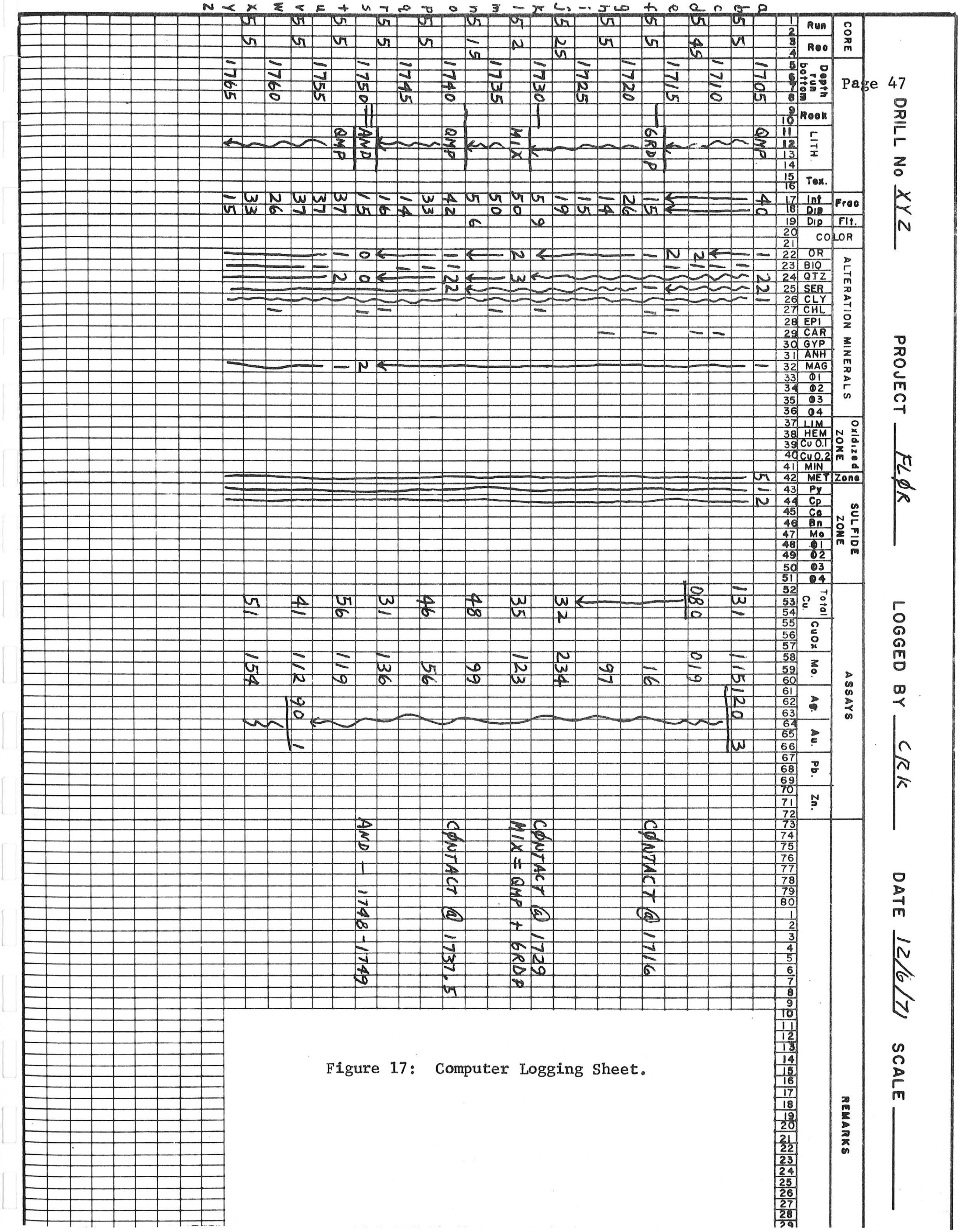



Figure 17: Computer Logging Sheet.

drill hole assays, and calculating the means and the variations for a certain population of the drill hole assays - e.g. for each drill hole - the computer will calculate mean assays with the variance (range) within certain limits. If the limits picked were 95%, then 95% of the time, the assays will fall within that variance. Thus, the predictability of the mineralization will be known for each area - areas that have a large variance and thus a low predictability will warrant more drill holes. Conversely, drill holes are saved where the predictability is good, and a great deal of time and money can be saved. Uses of this same principle should be entirely feasible on other variables for predicting certain values, with confidence limits. The computer can also plot these values on a map and contour them.

Variations of this idea, and the use of the computer for interpolation and extrapolation of all kinds of values, plus many other computational abilities, plus the ability to quickly plot values for easy interpretation make a computer assisted program very useful indeed. Other possible uses that could be of value at this time include:

- Exploration Evaluation
  - Correlation Analysis
  - Sequential Drilling Analysis
  - Preliminary Geologic Reserve Estimation
  - Compositing Drill Hole Assays
  - Level Maps and Cross Sections with Geology and Composites
- Pit Design, Tonnage and Grade
  - Calculate Mineable Ore Reserves
  - Pit Design - Including optimum bench height, elevation, etc.
- Financial Analysis
  - Grade Cutoff and Production Rate to Maximize Profit
  - Scheduling Pit Production
  - Equipment Selection and Process Optimization

These programs and more are now available for lease or purchase from various proprietary software firms, or perhaps could be converted from previous programs used in oil exploration, development, and production.

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Pozdon, Butto

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# The BHP Florence Project

*DRILLING But No Blasting*

*Richard Sichling*

**Eighth Annual International**

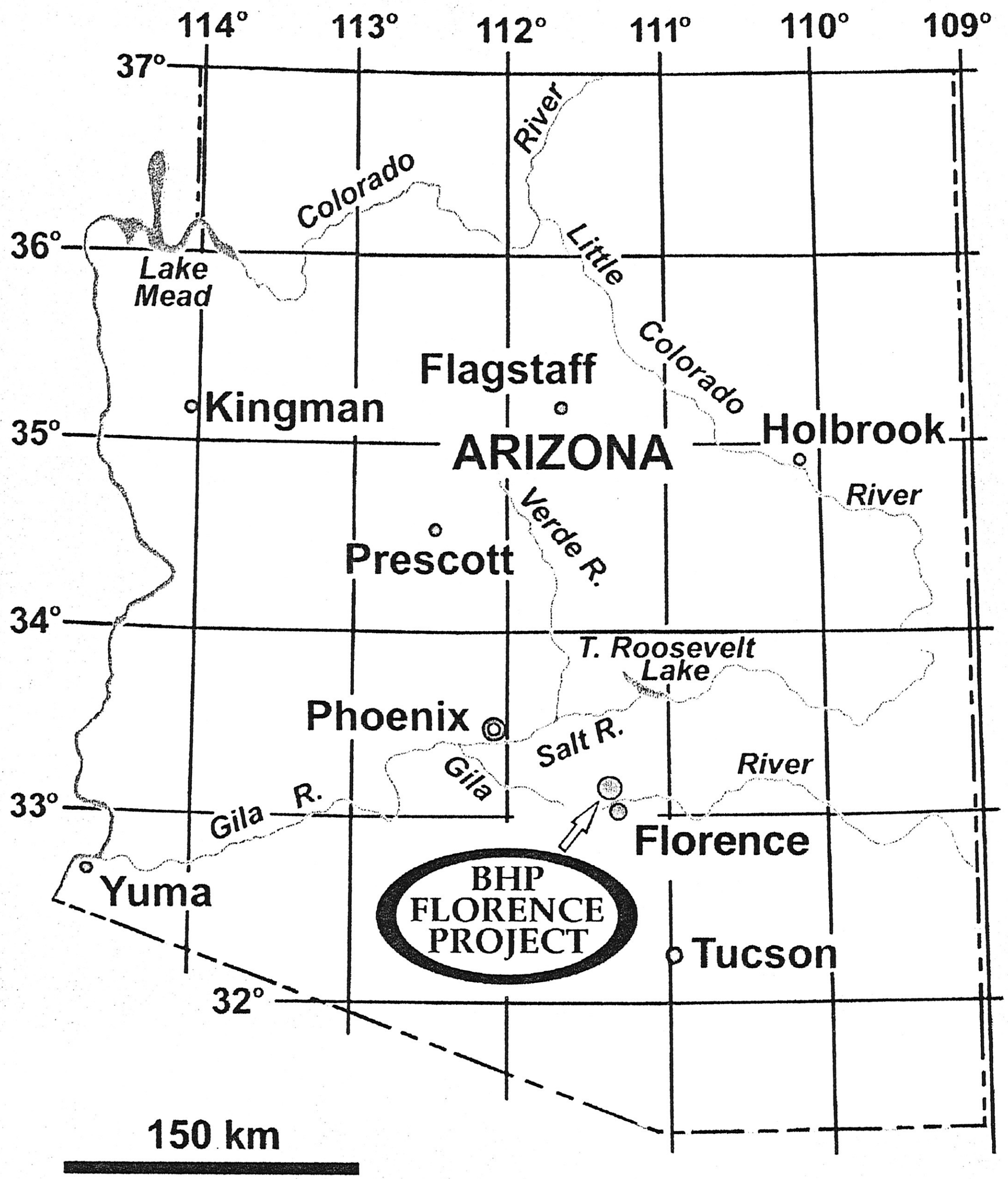
**Mine Safety and Health Conference**

***Casa Grande, Arizona***

***October 6-8 1998***

# Introduction

- Florence Deposit- Location, History
- In-situ Leaching- General Process
- In-situ Leach process at Florence
- Safety
- Conclusion

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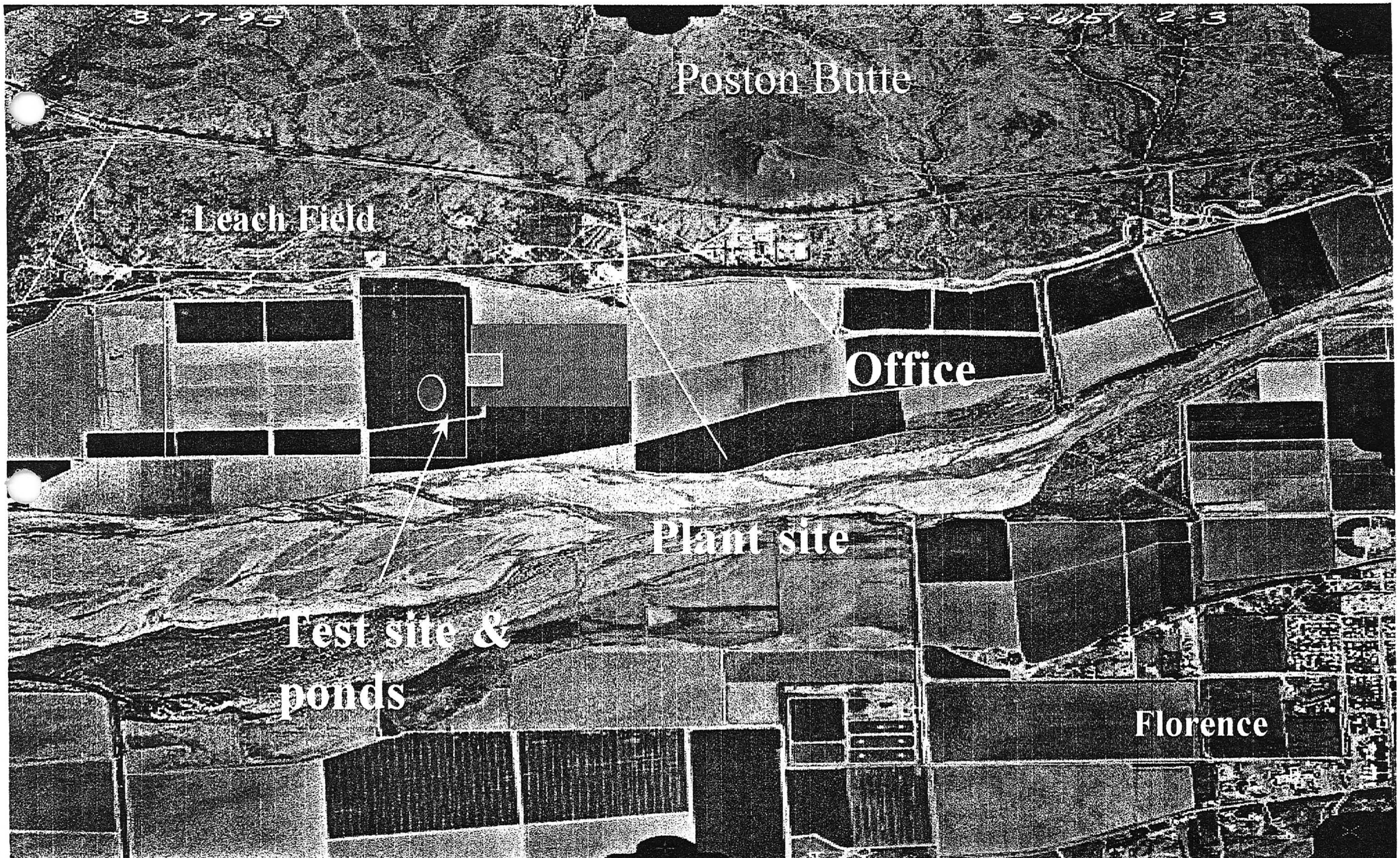
# Aerial View of Mine Site
# Florence, Arizona

BHP



# History of Florence Project

- Pilot Plant and Underground Development Mine operated by CONOCO-1972-1974
- Magma purchases the 10,400 acre site 1992
- Decision to permit the site as an in-situ leach mine 1995
- Permit activities started Feb 1995
- Jan 1996 BHP purchases Magma
- 1997 all Permits and agreements in place
- Leach test and reclamation of leach area under way

# In-Situ Mining

BHP

- In-Situ Mining - Selective recovery of a desired material without displacing the bulk rock mass
- In-Situ leaching process of copper is achieved with a weak diluted sulfuric acid solution pumped into a ore body. Once the copper is dissolved, the solution is pumped out and the copper recovered through a closed loop system.

# Advantages of In-Situ Mining

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- Minimal permanent land surface disturbance
- Less long-term surface pollution potential
- Low safety hazard
- Lower energy requirements
- Shorter lead time prior to production
- Can be developed in area of high infrastructure

# Disadvantages of In-Situ Mining

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- Lower metal recovery
- Lower accessory element recovery
- Long extraction times
- Potential environmental permitting problems

# STATUS TO DATE

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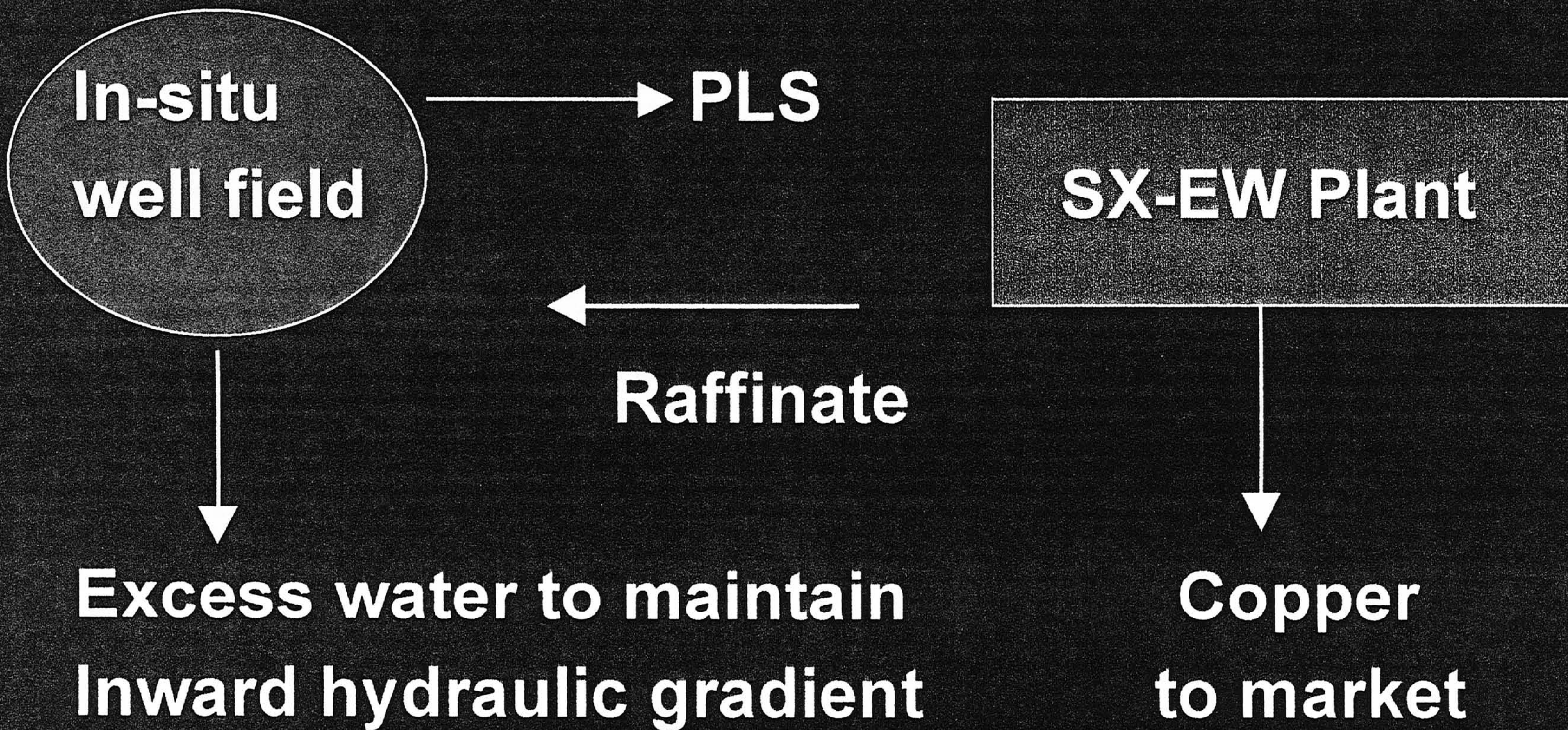
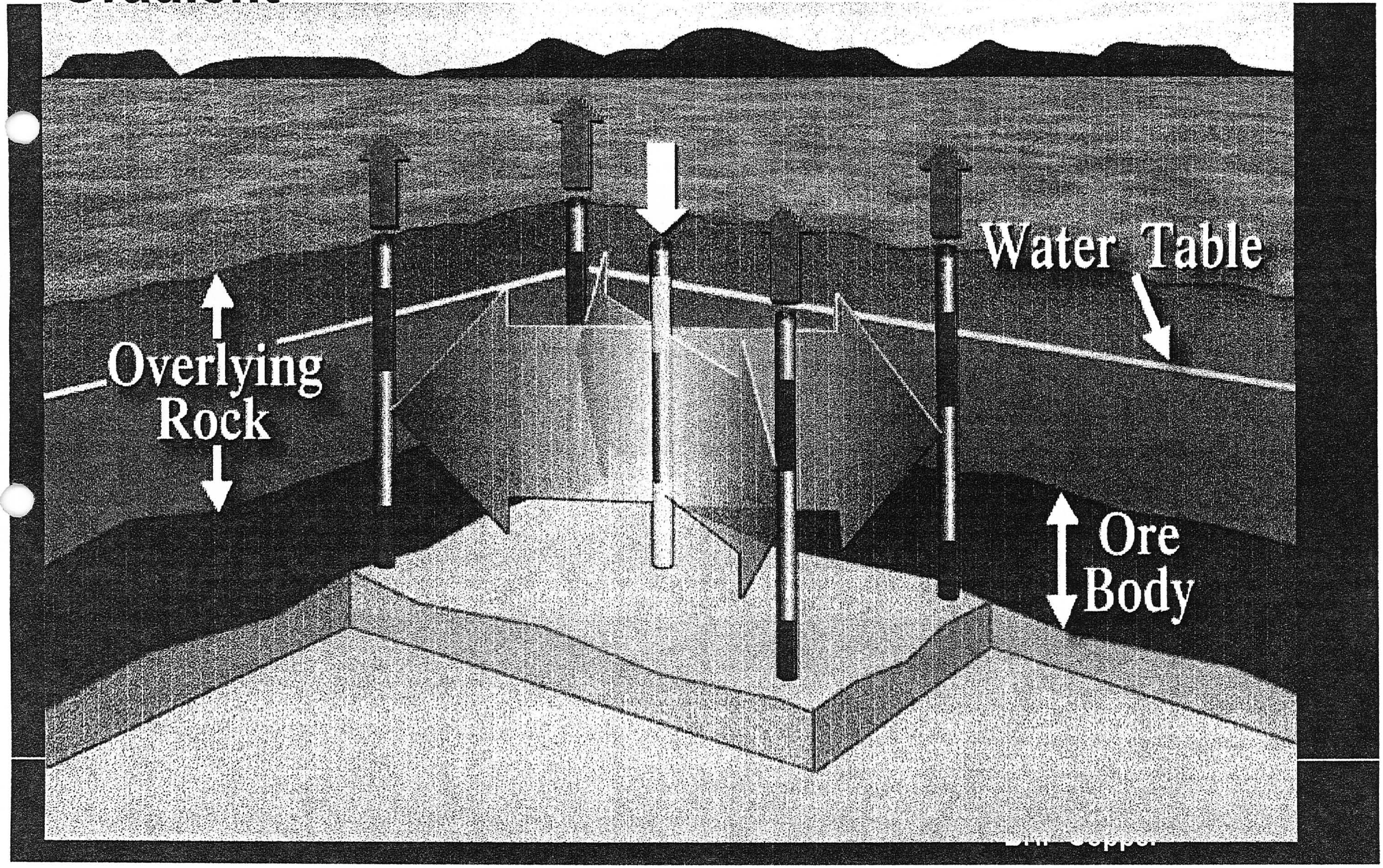
- State/Fed Environmental Permits in Place
- Mineral Resource Program Completed
  - Mineral Resource Grade Model Constructed
- Hydrologic Tests Completed
- Archaeological Agreements in Place
- Facilities/Impoundment's Designed to BADCT Specifications
- Strong Community Support of Mine
- 90-Day Compliance Test Successful
- Reclamation, Mine Plan in Progress

# In-Situ process flow sheet

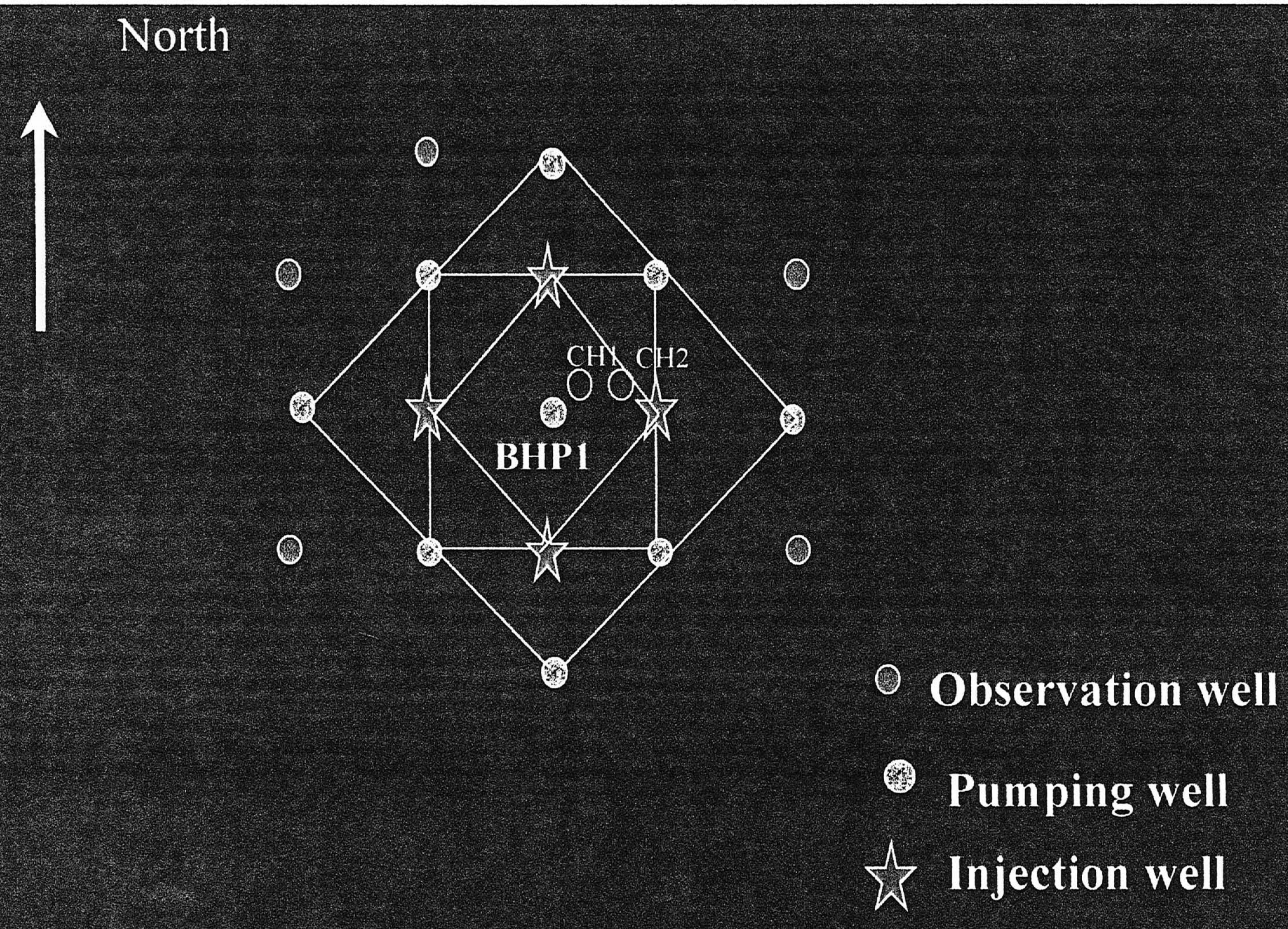


# In-Situ Leaching Operates on Principle of Inward Hydraulic Gradient

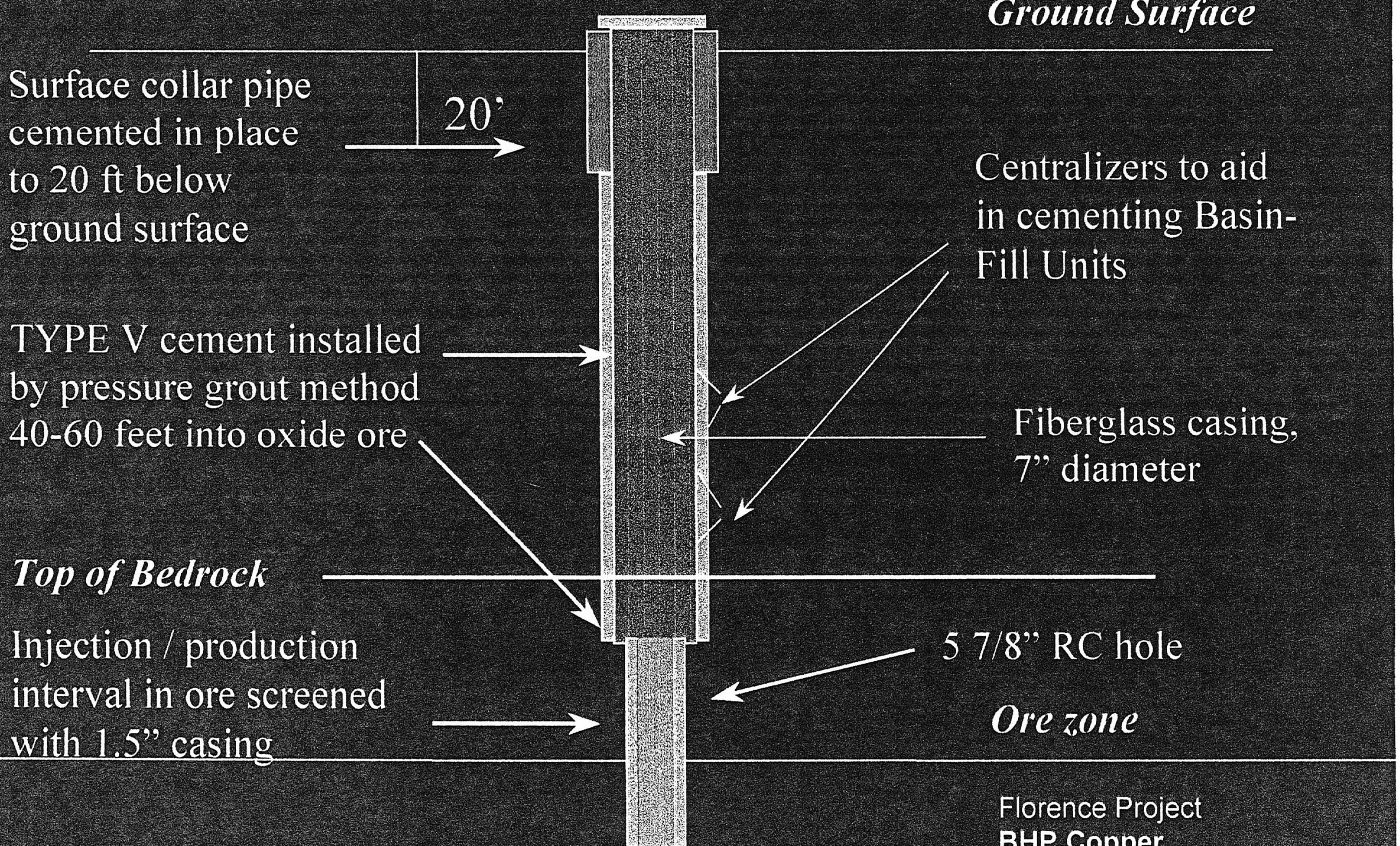
BHP



# WELL PATTERN - FIELD TEST



# TYPICAL WELL DESIGN

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# Pumping WELL

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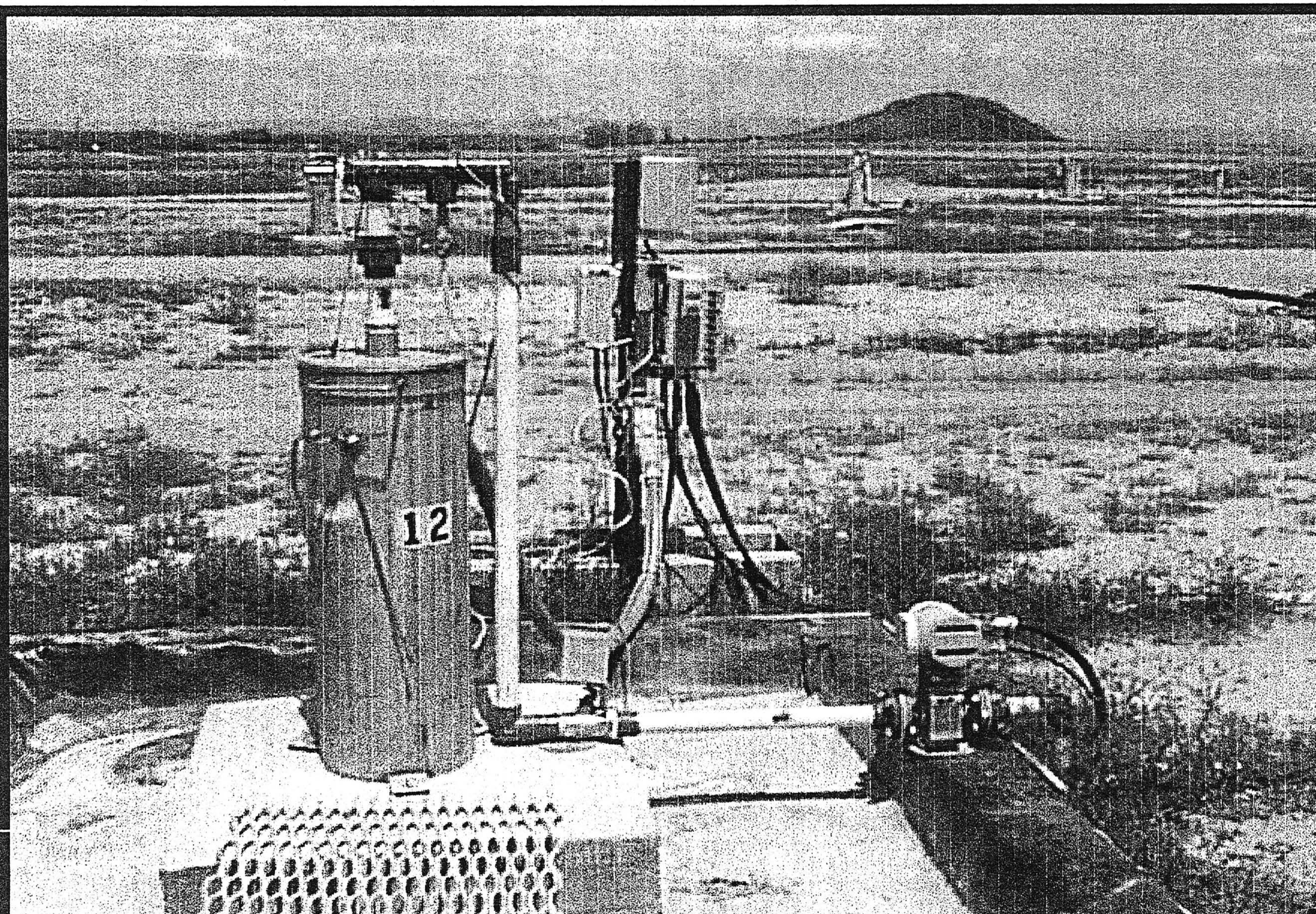
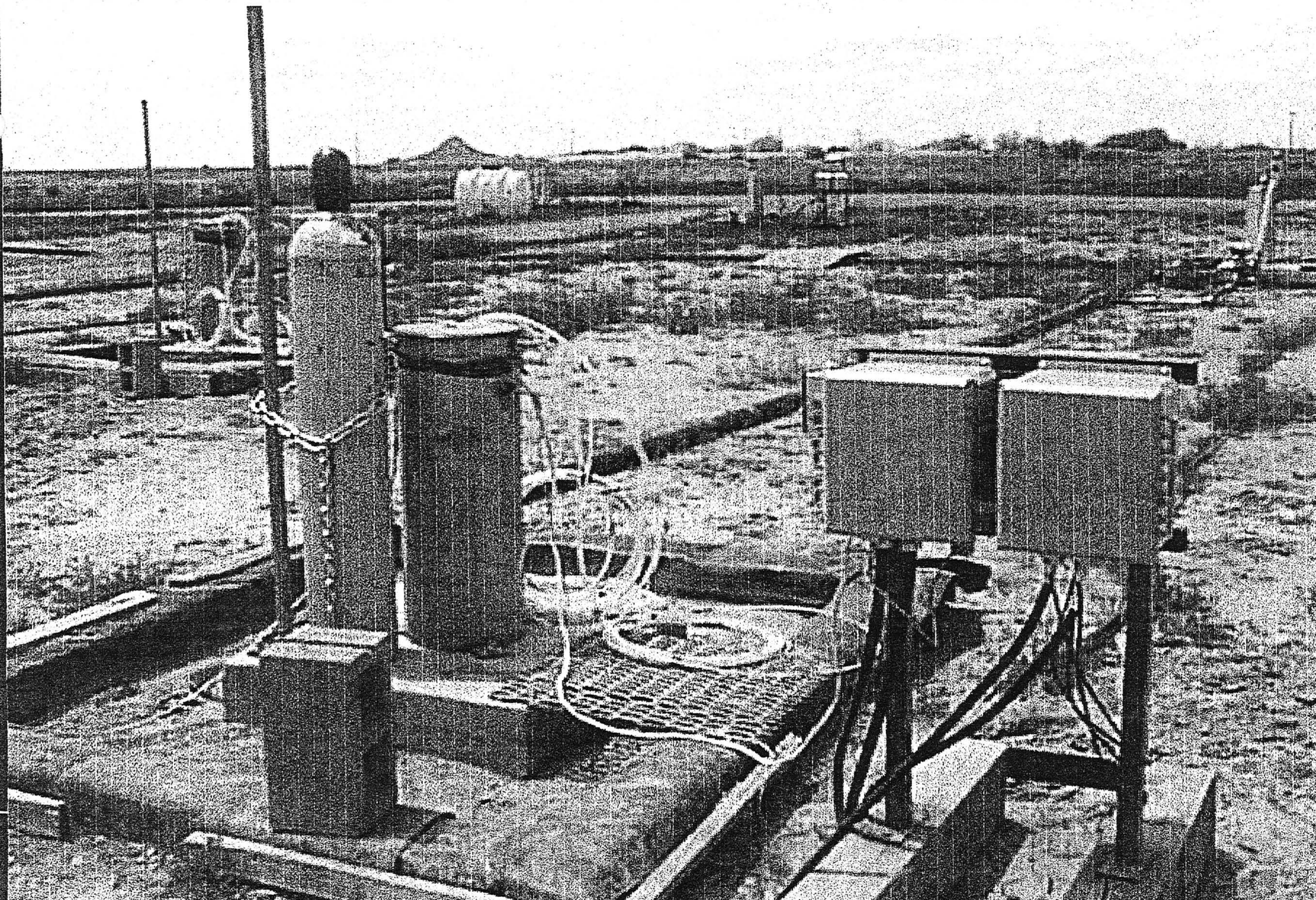


# GEOCHEMISTRY WELL

BHP



# MANUAL & COMPUTER CONTROLS

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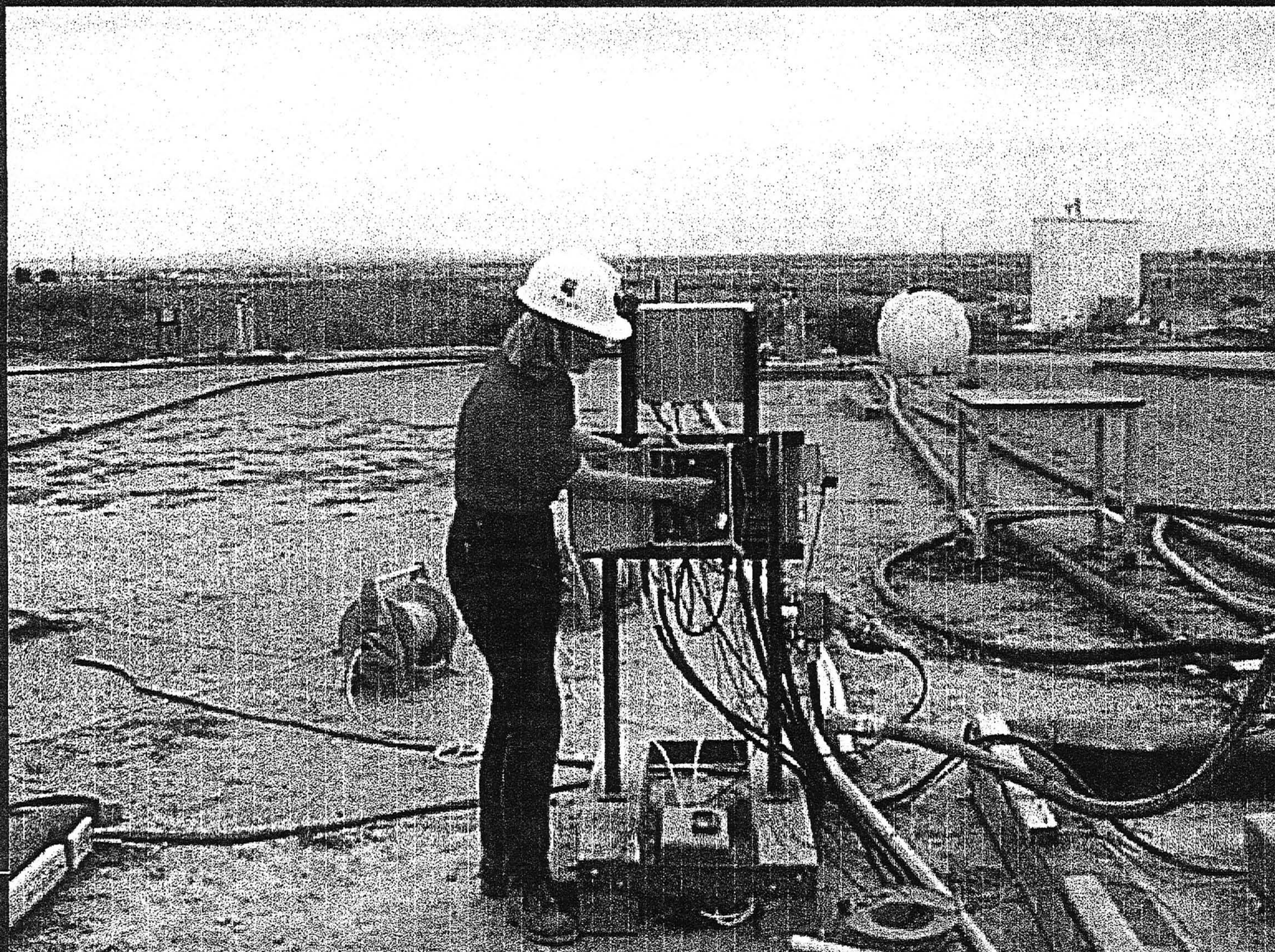

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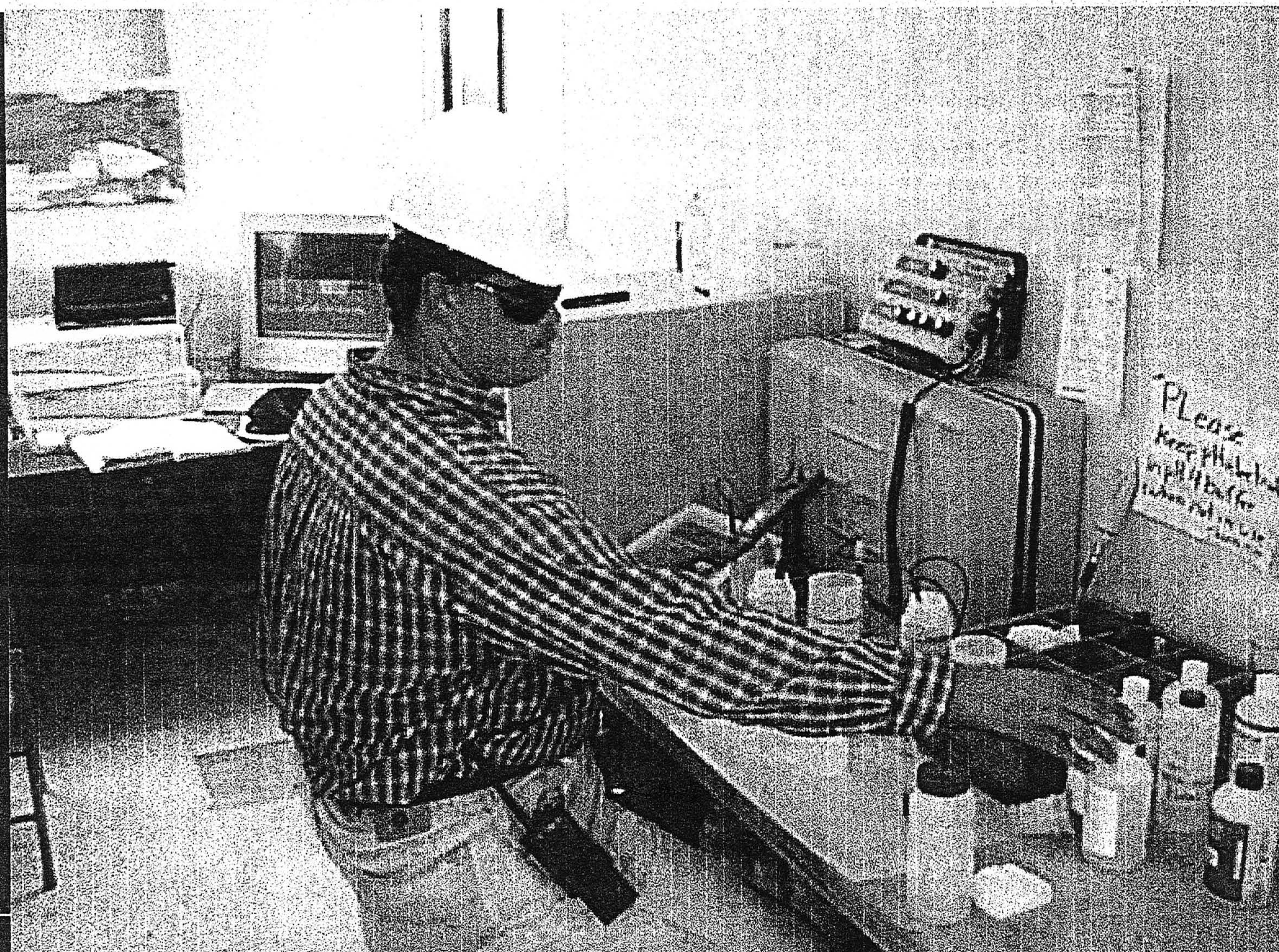
# Monitoring pH & EC at Control Room

BHP

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# EVAPORATION POND & PLANT

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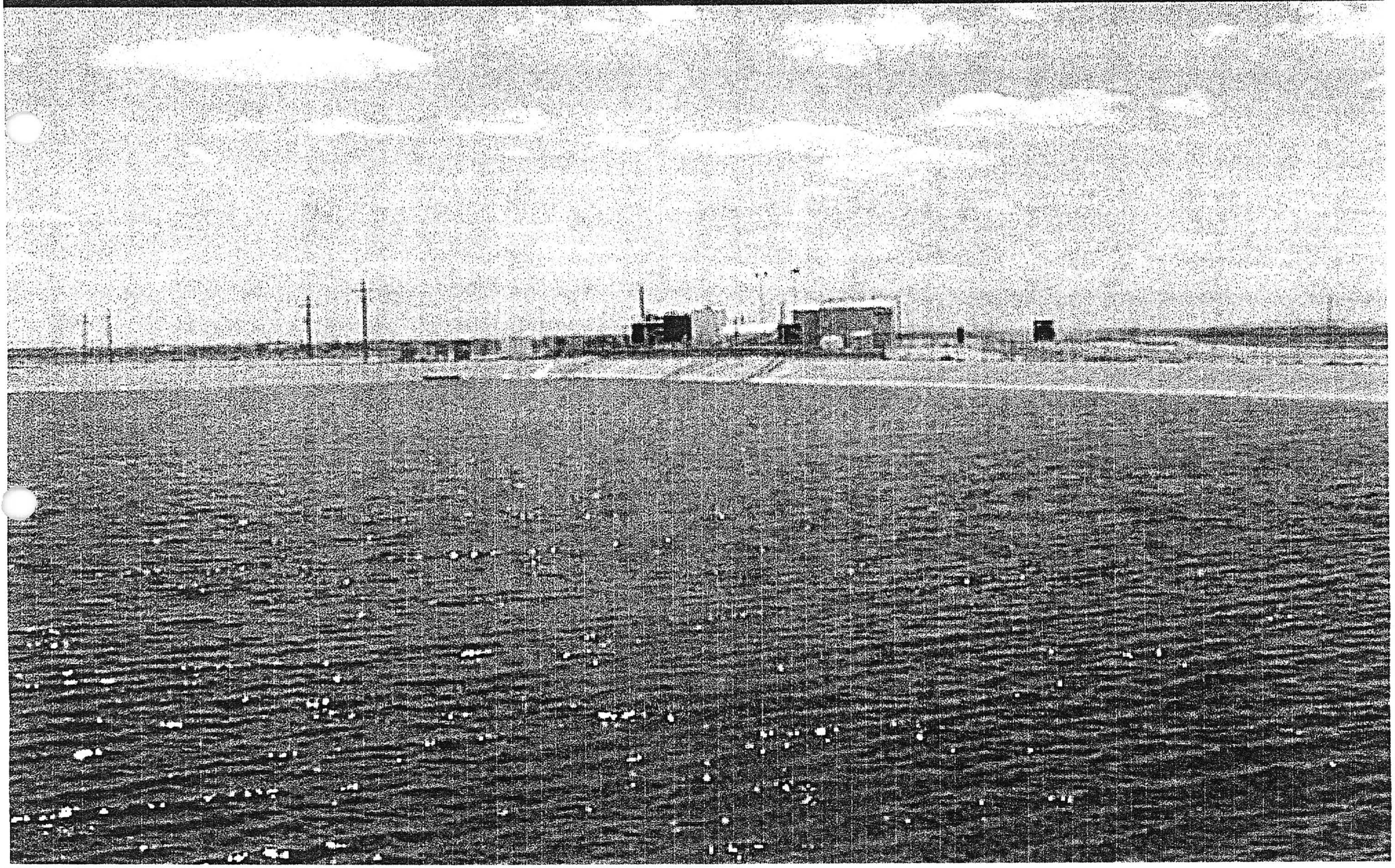

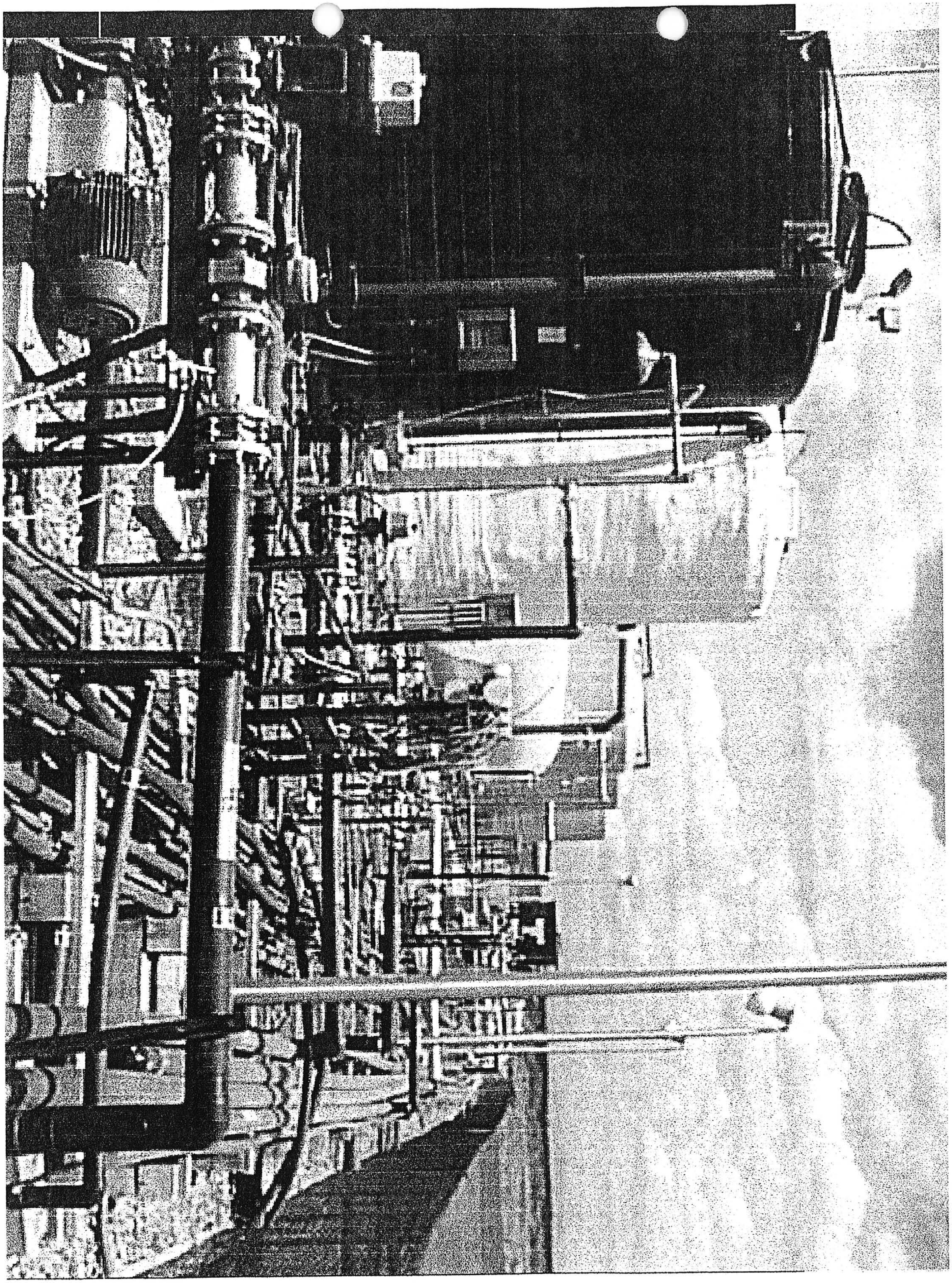

# In Conclusion

BHP

- In-Situ mining is the selective recovery of a desired material without displacing the bulk rock mass
- Is done in a closed loop system
- Is environmentally friendly
- Is a very safe way of mining