THE RAY OREBODY

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STOP 1

Stop One is located on Section A-A' near A' on the 2490 level. To the north is Ray's central silicate mining area. The stop with regard to the hypogene zoning is located on the east edge of the ore shell.

The diabase to the east is pyrite halo, sulfides are 3 volume percent, the chalcopyrite to pyrite ratio is 1:10. Biotite alteration is moderate with relict db texture still present. Supergene alteration is dominated by jarocite and clay alteration.

Looking west along A-A':

The area immediately below is our South Silicate mining area.

The road running along the Pearl Handle Pit edge is the old dike road, (2000 elevation). Paralleling this road is the basin bounding Diabase Fault.

The Diabase Fault bisects the hypogene system and establishes a boundary between the silicate and sulfide ore being mined.

Looking into the Pearl Handle Pit keep in mind the mining operation has developed a window through the upper plate of the Emperor Fault. This window exposes the Apache Group rocks, including the diabase, which have been down dropped on the west side along the Diabase Fault.

The mining area just north of the Pearl Handle is primarily stripping in the leached cap. The color change from red brown to black green in the middle of the bench is the Apache Group, rock contained in a horst block bounded by the Diabase and North End Faults.

STOP 1 (cont'd)

In the distance you can see the West Pit, which is located in the enriched pyrite halo. The bulk of the secondary sulfide ore produced at Ray has come from this area, through the underground block cave operations prior to 1955, and open pit operations since. Development of the chalcocite blanket was influenced by the east dipping West End Fault, (the slope failure along the west end is easily recognizable), the south dipping North End and the north dipping Sun Fault. The apparent extension of the pyrite halo is due, in part, to rotation of west ore shell on the Diabase Fault.

STOP 2

The second stop is in the Cairo area of the Pearl Handle Pit. The 1700 mining level is currently providing the bulk of our sulfide ore. Along the southern end of the level is an exposure of the Diabase Fault with upper plate Pinal Schist (west side) against diabase. Moving to the north along the bench, change in rock types demonstrates the effect rock type can have on the minerals formed.

STOP 3

The third stop is on the 1660 level in the Pearl Handle Pit. Exposures of the Emperor Fault overlying diabase and Apache Group rocks demonstrate some of the difficulty in recognizing structures from drilling. Granite Mountain Porphyry, which was the mineralizer at Ray, can also be viewed at this stop.

THE RAY OREBODY

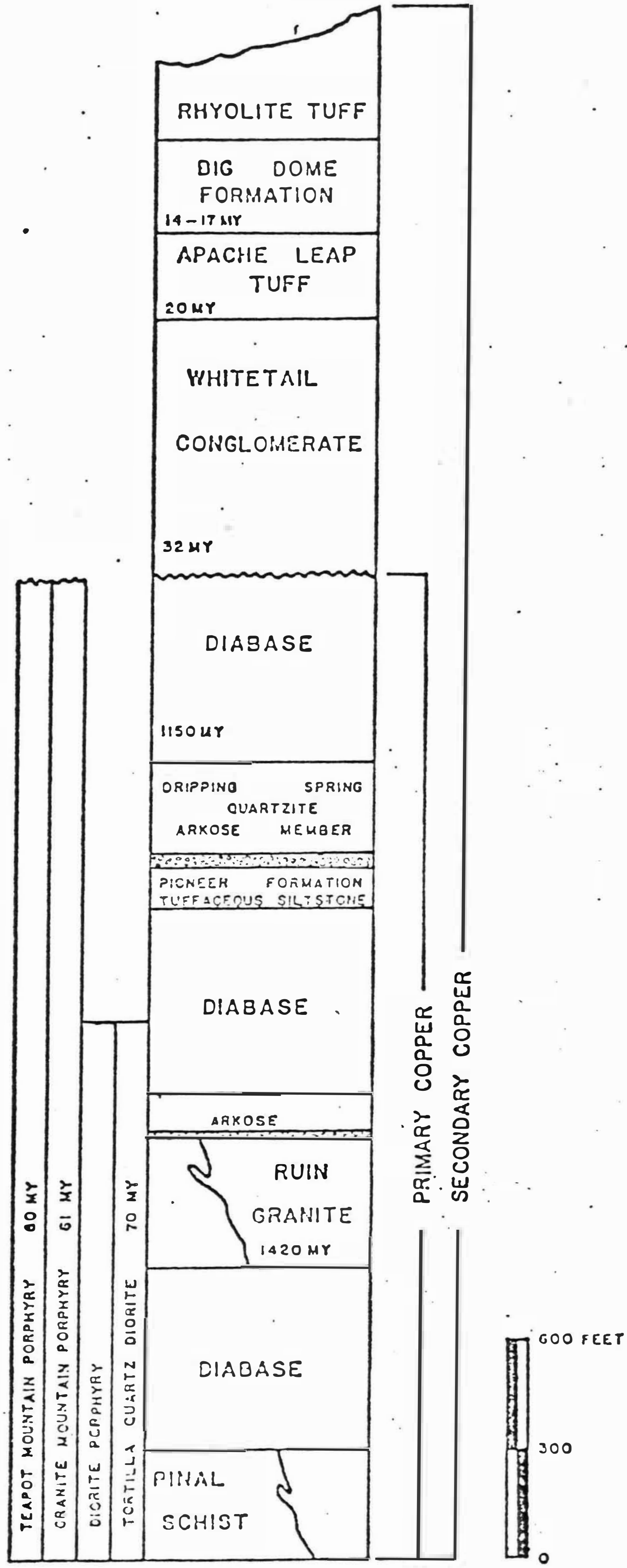
INTRODUCTION

The Ray Mine is owned and operated by Kennecott Minerals Company and is located in eastern Pinal County, Arizona, seventy miles southeast of Phoenix. The deposit has been a major copper source since 1911, producing an estimated 3 million tons of copper. The bulk of the production has been derived from sulfide ores. Mining was accomplished by underground methods until 1955 when full conversion to open pit methods was achieved.

Currently we are mining approximately 26,000 tons of sulfide ore and 14,000 tons of silicate ore on a seven-day-per-week basis. The sulfide ore is crushed to minus 10 inches at the mine and shipped by rail some 18 miles to the concentrator and smelter at Hayden. The silicate ore is processed entirely at the mine using a percolation/agitation leaching system with the final product being electrowon cathode copper.

LITHOLOGIES

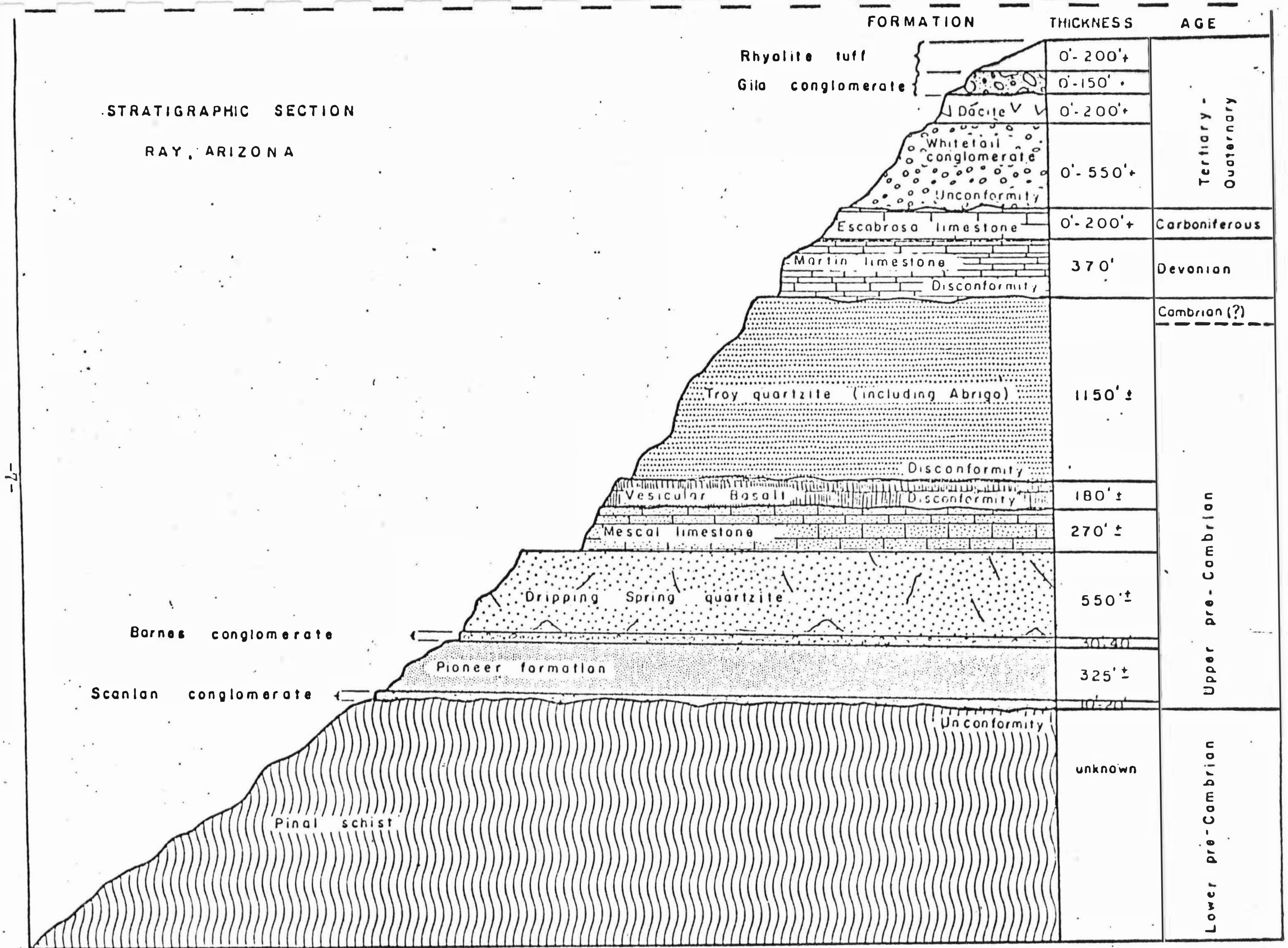
The diagram on page 5 shows the lithologic units which are important in the Ray deposit. The oldest rock is the Pinal Schist which is composed of quartz-sericite and quartz-chlorite-epidote metasediments, as well as some metavolcanic units. A metarhyolite unit in the schist has been dated at 1660 m.y. (Livingston and Damon, 1968).


RHYOLITE TUFF
BIG DOME FORMATION
14 – 17 MY
APACHE LEAP TUFF
20 MY
WHITETAIL CONGLOMERATE
32 MY
DIABASE
1150 MY
DRIPPING SPRING QUARTZITE ARKOSE MEMBER
PIONEER FORMATION TUFFACEOUS SILTSTONE
DIABASE
ARKOSE
RUIN GRANITE
1420 MY
DIABASE
PINAL SCHIST
TEAPOT MOUNTAIN PORPHYRY 60 MY
GRANITE MOUNTAIN PORPHYRY 61 MY
DIORITE PORPHYRY
TORTILLA QUARTZ DIORITE 70 MY
PRIMARY COPPER
SECONDARY COPPER
600 FEET
300
0

The Ruin or Oracle Granite, which is compositionally a quartz monzonite, intrudes the schist and has been dated in the Winkelman area at 1420 m.y. (Livingston and Damon, 1968). Following a long period of erosion, the younger Precambrian quartzose sediments of the Apache Group were deposited.

The Pioneer Formation is approximately 230 feet thick and consists of interbedded arkose and tuffaceous siltstones with a basal conglomerate (Scanlan Conglomerate member). Above the Pioneer Formation, there is typically 40 feet of basal Dripping Spring (Barnes Conglomerate). Above this we have approximately 250 feet of the lower arkose-quartzite member of the Dripping Spring. Although the upper Dripping Spring, the Mescal Limestone and the Troy Quartzite are present east of the mine, they are not important from the standpoint of copper mineralization. The entire stratigraphic section for the Ray area is shown on page 7.

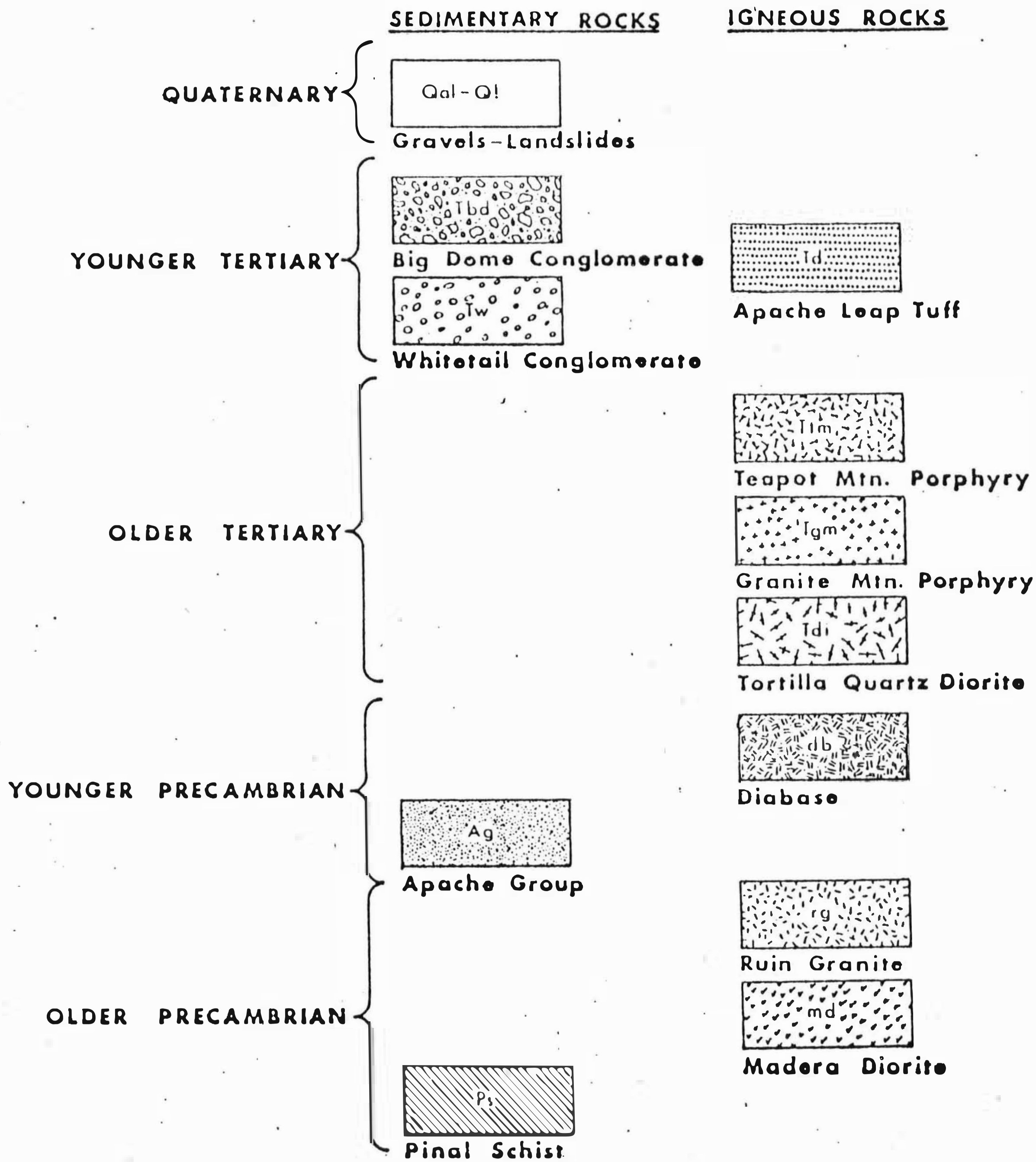
Extensive diabase intrusions, mostly as sills, occurred 1150 m.y. ago (Livingston and Damon, 1968). The preore mineralogy of the diabase is variable; however, the bulk of it appears to have been a hornblende-pyroxene labradorite diabase with minor quartz, biotite, orthoclase, magnetite and apatite. At Ray, this diabase is an important host rock. In the mine area there are two sills which average about 500 feet in thickness. The sills prefer certain stratigraphic horizons which are:

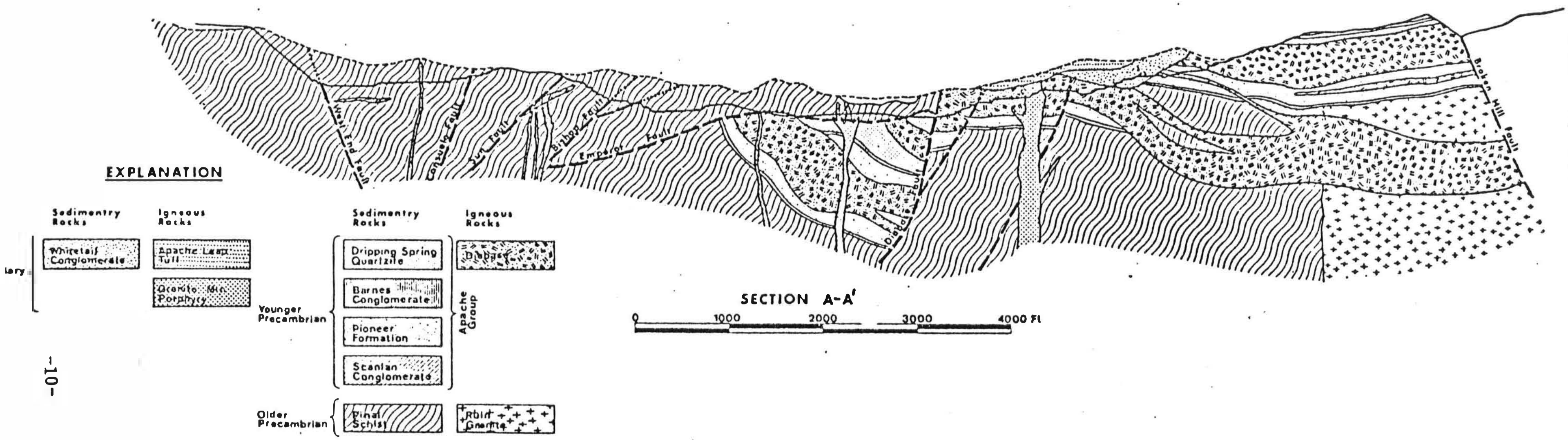


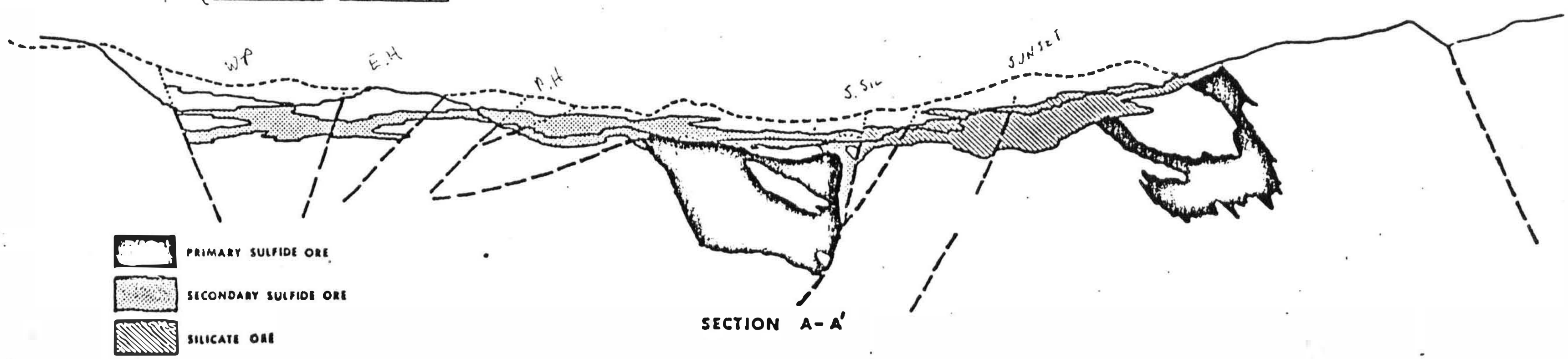
STRATIGRAPHIC SECTION
RAY, ARIZONA
FORMATION
THICKNESS
AGE
Rhyolite tuff
Gila conglomerate
Dacite
Whitetail conglomerate
Unconformity
Escabrosa limestone
Martin limestone
Disconformity
Troy quartzite (including Abrigo)
Disconformity
Vesicular Basalt
Disconformity
Mescal limestone
Dripping Spring quartzite
Barnes conglomerate
Pioneer formation
Scanlan conglomerate
Unconformity
Pinal schist
0'-200'+
0'-150'+
0'-200'+
0'-550'+
0'-200'+
370'
1150'±
180'±
270'±
550'±
30-40'
325'±
10-20'
unknown
Tertiary - Quaternary
Carboniferous
Devonian
Cambrian (?)
Upper pre-Cambrian
Lower pre-Cambrian


BROKEN HILL FAULT
LIVINGSTON FAULT
SCHOOL FAULT
DIABASE FAULT
EMPEROR FAULT
BISHOP FAULT
CONSUELO FAULT
NORTH END FAULT
SUN FAULT
WEST END FAULT
TEAPOT FAULT
Qal
Ag
Td
Tbd
Tw
Tgm
Ps
rg
Tlm
db
md
0
1/2
1 mile

EXPLANTION


SEDIMENTARY ROCKS
IGNEOUS ROCKS
QUATERNARY
Qal - Ql
Gravels - Landslides
YOUNGER TERTIARY
Tbd
Big Dome Conglomerate
Tw
Whitetail Conglomerate
Td
Apache Leap Tuff
OLDER TERTIARY
Ttm
Teapot Mtn. Porphyry
Tgm
Granite Mtn. Porphyry
Tdi
Tortilla Quartz Diorite
YOUNGER PRECAMBRIAN
db
Diabase
Ag
Apache Group
OLDER PRECAMBRIAN
rg
Ruin Granite
md
Madera Diorite
Ps
Pinal Schist


West End Fault
Conwell Fault
Sun Fault
Bishop Fault
Emperor Fault
Diablo Fault
Broken Hill Fault
EXPLANATION
Sedimentry Rocks
Igneous Rocks
lary
Whitetail Conglomerate
Apache Leap Tuff
Granite Mtn. Porphyry
Younger Precambrian
Dripping Spring Quartzite
Barnes Conglomerate
Pioneer Formation
Scanlan Conglomerate
Apache Group
Diabase
Older Precambrian
Pinal Schist
Ruin Granite
SECTION A-A'
0
1000
2000
3000
4000 Ft


W.P
E.H
P.H
S. Sil
SUNSET
PRIMARY SULFIDE ORE
SECONDARY SULFIDE ORE
SILICATE ORE
SECTION A-A'

(1) the Pinal Schist-Ruin Granite about 300 feet below the Apache Group, (2) the middle of the Pioneer Formation, and (3) between the lower arkose and upper siltstone members of the Dripping Spring Quartzite. Going north through the mine, the sill in the Pioneer migrates downward into the schist and granite. Likewise, the upper sill in the Dripping Spring Quartzite migrates downward into the Pioneer Formation. Economic hypogene copper mineralization is not found in Precambrian rocks above the upper diabase sill in the Dripping Spring Quartzite.

The Tortilla Quartz Diorite (Sonora Diorite) dated at approximately 70 m.y. (Banks and others, 1973) is largely restricted to the south and west sides of the deposit. Depending upon its location within the sulfide system, the quartz diorite can contain ore grade (at least 0.4% copper) hypogene copper mineralization.

The Granite Mountain Porphyry has been dated at 60 m.y. (see Banks and others, 1972-1973, Livingston and others, 1968, and McDowell, 1971) and has been long considered to be the causative intrusive at Ray. The rock is in reality a porphyritic granodiorite composed of oligoclase, quartz, biotite-magnetite, and orthoclase phenocrysts with an orthoclase matrix (Cornwall and others, 1971). At the present surface, the main mass of Granite Mountain Porphyry is west of Ray in the Granite Mountain area where it is at least two miles in diameter and appears to have intruded near a northwest trending Pinal Schist/Ruin Granite contact.

In the mine, there are several small masses of Granite Mountain Porphyry which are aligned in a N70°E direction along a zone of weakness referred to as the "Porphyry break" (Metz and Rose, 1966). Diamond drilling indicates that some of these masses may coalesce at depth to form a stock central to the hypogene ore mineralization.

The Teapot Mountain Porphyry is slightly younger than the Granite Mountain Porphyry and intrudes as stocks and dikes along a northeast trend north of Ray. The Teapot is characterized by large euhedral orthoclase and quartz phenocrysts. The Calumet Breccia Pipe may be associated with one of the Teapot Mountain stocks. The upper portion of the pipe contains secondary copper mineralization and supergene effects have largely masked relationships between mineralization and fragmentation. Recent drilling shows two periods of hypogene mineralization. The first period is associated with the main stage of mineralization at Ray and is characterized by pyrite-chalcopyrite-quartz veins which are terminated at fragment boundaries. The second period fills the breccia interstices, cuts the fragments and is characteristically galena-sphalerite-dolomite and/or rhodochrosite.

In summary, the major Laramide intrusive masses in the Ray district are all mineralized, all intrude along a northeast trend and they vary compositionally (south to north) from quartz diorite, to granodiorite, to quartz monzonite.

The tertiary began with the deposition of the Whitetail Conglomerate 32-plus million years ago (Cornwall and others, 1971). The Whitetail at Ray is divided into two facies. One is reddish brown and is composed primarily of schist fragments. The other is light brown and contains abundant Paleozoic Limestone and Apache Group/diabase fragments, with minor schist. Both Whitetail facies exhibit poor sorting and bedding.

The Apache Leap Tuff (Superior Dacite) sheet was deposited 20 million years ago (Creasey and Kistler, 1962). The Apache Leap Tuff is about 230 feet thick and is a rhyodacite (Cornwall and others, 1971), with a light pink to white basal unit overlain by a red to black welded vitrophyre which grades upward into a light reddish brown tuff. Supergene solutions have rendered the vitrophyre unit unrecognizable over the deposit.

The Big Dome Formation was named for the exposure south of the mine (Krieger and others, 1974). A biotite tuff within the Big Dome has been dated discordantly at 14 and 17 m.y. (Cornwall and others, 1971). In the deposit area, the Big Dome can be subdivided into a schist-porphyry facies and a coarser grained, gray mixed limestone-Apache Group facies.

The youngest rock unit at Ray is a water lain rhyolite tuff. This light pink to brown tuff appears to interfinger with the Big Dome in places and may resemble it in age. Approximately three miles west of Ray, in the Copper Butte area, age-equivalent rhyolite tuffs and flows exceed in volume the Big Dome-equivalent gravels.

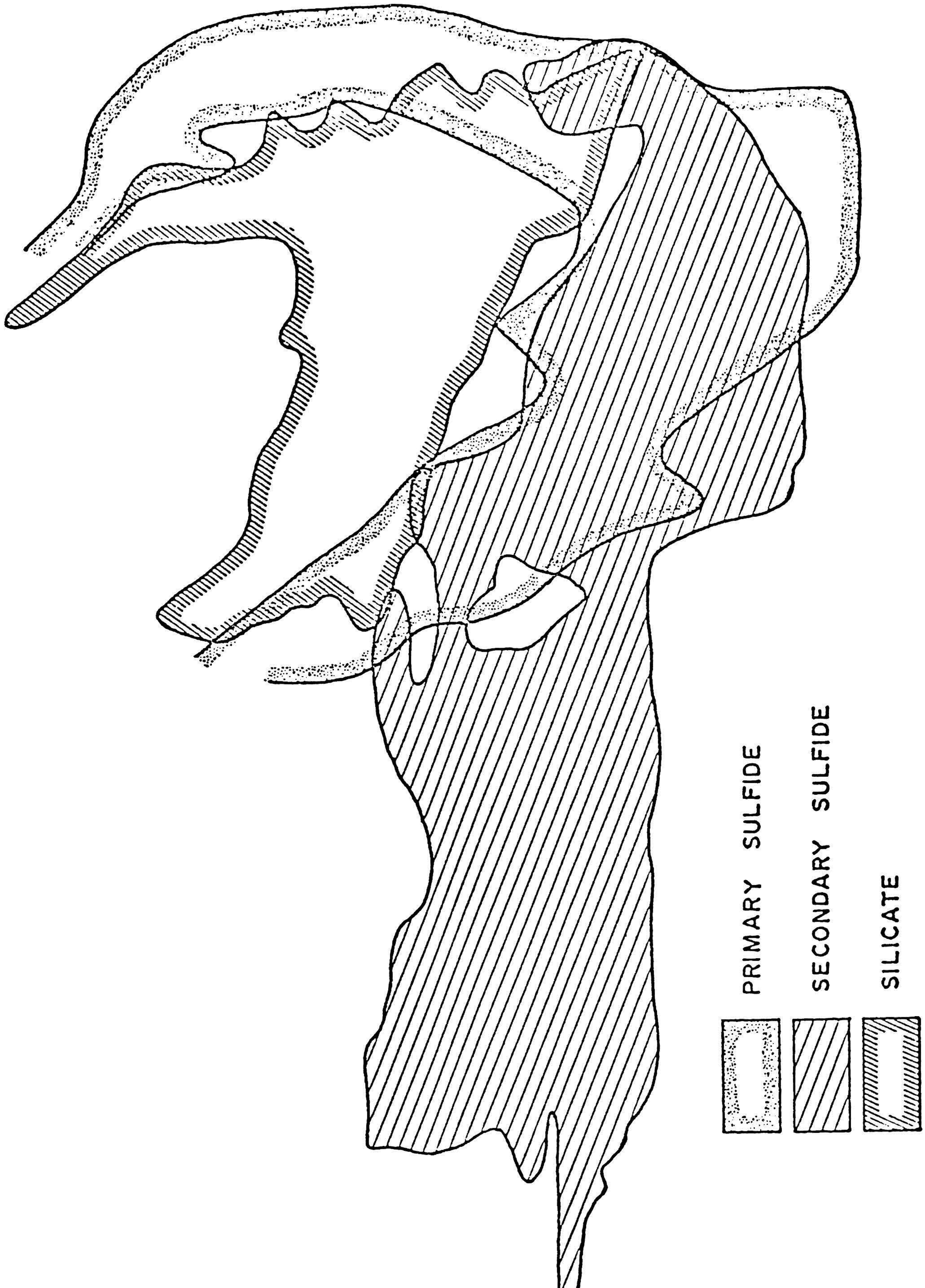
Secondary copper mineralization can be found in any of the lithologies shown on page 5 with the exception of the Ruin Granite.

The geologic map on page 8 gives a general feeling for the distribution of the major rock units. The western part of the mine is predominately Pinal Schist, while the eastern portion is mixed diabase and undifferentiated Apache Group. Note the masses of Granite Mountain Porphyry and the onlap of the postmineral volcanics and sediments.

ORE TYPE DISTRIBUTION

Page 15 illustrates the distribution of the various ore types at Ray. Of interest is the location of the secondary chalcocite zone to the west of and above the hypogene ore zone. Most of the chalcocite occurs in the Pinal Schist which is the dominant rock type in the western portion of the mine. The location of the chalcocite orebody is affected by structure. The hypogene orebody is horseshoe shaped with the open end being the result of the combined effects of postmineral faulting, intrusion and erosion. Note that the Diabase Fault bisects the hypogene ore zone.

The silicate orebody was developed in the low total sulfide-high


PRIMARY SULFIDE
SECONDARY SULFIDE
SILICATE

chalcopyrite core zone and is essentially restricted to the area east of the Diabase Fault. The combination of low available sulfur and the composition of the diabase were probably responsible for the formation of copper silicates in this area.

Several small zones of native-oxide copper mineralization occur in the orebody and are largely fault controlled. The largest area of this type of mineralization occurs in the north central portion of the mine where the North End, Emperor, Diabase, Livingston and School Faults converge.

ZONING

The deposit exhibits a typical hypogene sulfide zoning pattern with an outer high sulfide-low copper pyrite halo, an ore zone of moderate sulfide content characterized by approximately equal amounts of chalcopyrite and pyrite, and an inner low sulfide-high copper zone which is chalcopyrite in the diabase and, in places, pyritic in the quartzose rocks.

The bulk of the ore grade (at least 0.40% copper) mineralization occurs in the semi-reactive, mafic, Precambrian diabase host rock. Molybdenite mineralization favored the quartzose lithologies.

In the Precambrian rocks and the Granite Mountain Porphyry, the hypogene alteration zones from the inside out are (a) biotite-K-feldspar, (2) quartz-sericite and (3) epidote-chlorite. In the diabase, biotite-clay

ZONING (cont'd)

alteration predominates in both the core and ore zones. Chlorite and epidote increase outward into the pyrite halo. There is no extensive development of hypogene sericite or K-feldspar in the diabase. In all rock types, the frequency of quartz veins decreases outward from the center of the deposit.

STRUCTURE

The Ray Mine area has a complex tectonic history. High angle normal and reverse faults have been active at various intervals over a long period of time. Some structures that developed prior to the formation of the orebody have been intermittently active up to recent times. The area has alternately been under compression in Laramide time, then a release of compression and perhaps active rifting. Further compression in mid-Tertiary time, release, and then a late Tertiary compression with final release during development of basin and range structures.

The most obvious fault systems at the Ray Mine are the Diabase and Emperor Faults. Several other significant faults are documented in the mine area, including the Bishop, North End, Sun, West End, Consuelo, School and Livingston Faults. In the silicate orebody there is at least one additional unnamed fault with several hundred feet of displacement.

The Diabase Fault is a moderately to steeply westerly dipping normal fault, characterized by several tens of feet of gougy, broken and brecciated rock and up to a few feet of strong gouge. In the Pearl Handle Pit, the hanging wall of the Diabase Fault contains the downthrown diabase/Apache Group sequence, which is overlain by schist in the upper plate of the Emperor Fault.

In the northern corner of the Pearl Handle Pit the normal displacement of the Diabase Fault is about 800 feet, west side down. Southeastward in the mine the displacement increases to more than 2,000 feet. The Diabase Fault terminates the Emperor Fault to the east. East of the Diabase Fault, the Emperor Fault was uplifted and eroded away.

The Diabase Fault bisects the hypogene ore shell, dropping the ore to the west (See sections, page 10). The fault also tends to form a boundary separating the secondary copper mineralization; chalcocite to the west and copper silicates to the east. The chalcocite, and to some degree the copper silicates, tend to penetrate the primary sulfide zone to greater depths along this fault. Native copper and some cuprite mineralization also tend to be localized along the Diabase Fault.

There have probably been several episodes of movement along the Diabase Fault during and following Tertiary time. Drag folding in some areas indicates both reverse and normal movement; the most recent being normal. Slickensides on native copper sheets within the fault zone indicate fairly recent movement. Fault zones to the north of the mine, which may be an extension of one strand of the Diabase

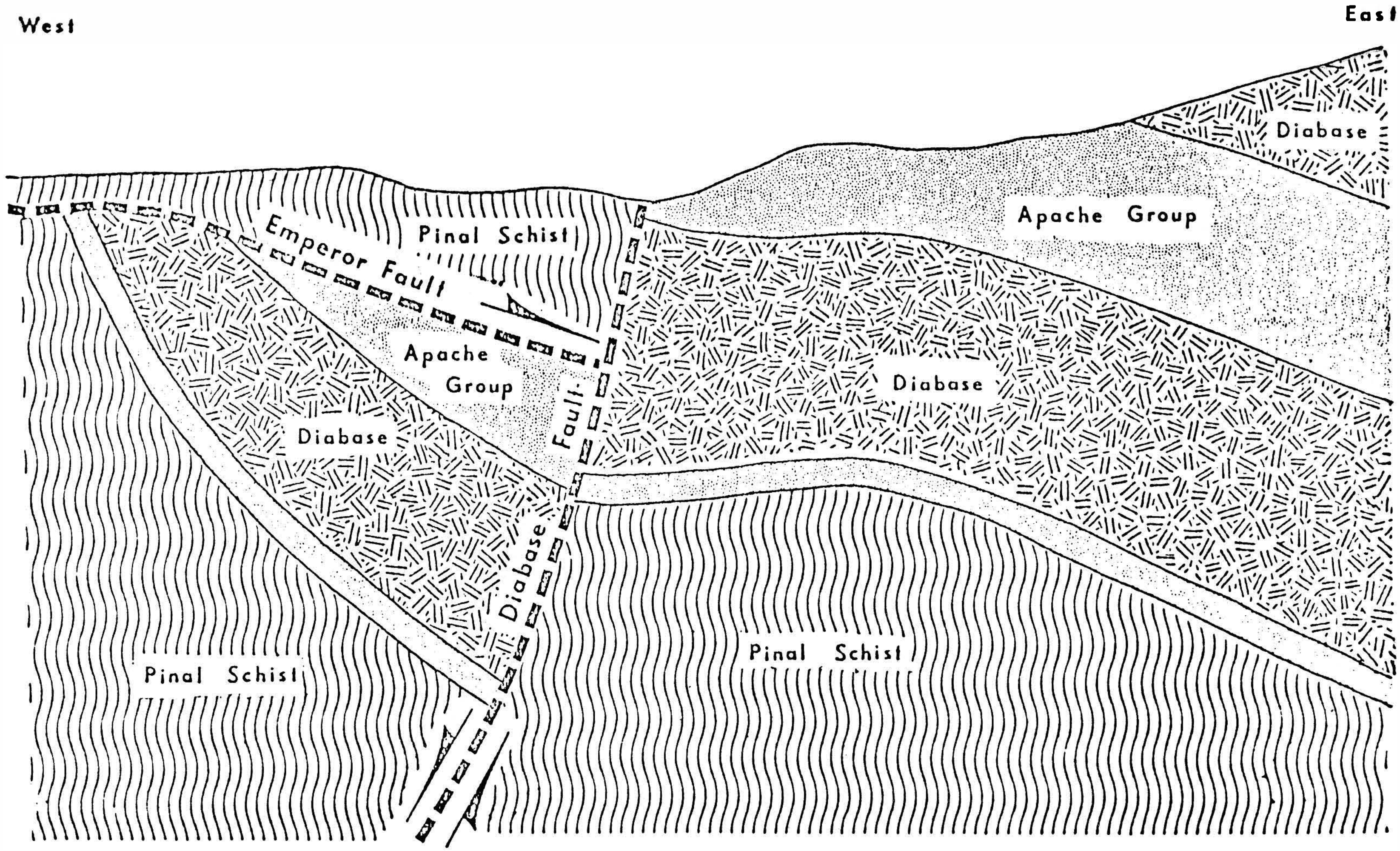
Fault, displace pleistocene terrace gravels.

The Emperor Fault is commonly characterized by several feet of dense, dark gouge and up to tens of feet of gougy, broken and brecciated rock. On the whole, the fault dips about 10 to 30 degrees southeasterly in the Pearl Handle Pit and northerly in the West Pit. The upper plate, consisting mainly of schist with some porphyry and minor diabase, overlies schist, some porphyry and the diabase/ Apache Group sequence in the mine area.

It is now believed the Emperor Fault is a gravity slide rather than a thrust fault. For a number of years it was an open question whether the small masses of Granite Mountain Porphyry in the mine area were offset by the low angle Emperor Fault. Drilling indicated the porphyry intruded up through the lower plate as dikes and small apophyses, mushrooming out above the fault. In some cases, the mushrooming suggested the liklihood of Granite Mountain Porphyry offset along the Emperor Fault. A few years ago mining exposed an area where porphyry occurred in both the upper and lower plates. The fault was observed to cut across the porphyry; however, due to the close spatial relationship between the porphyry masses in the lower plate and those in the upper plate, the post porphyry movement is believed to be minimal.

The intrusion of the main Granite Mountain Porphyry stock southwest of the mine probably uplifted that area, causing a gravity slide that moved to the northeast over the Ray Mine area with a shallow northeasterly dip. Sometime later several porphyry masses intruded the Ray Mine area, moving upward through and mushrooming out above the Emperor Fault. It was this late intrusive event that provided the hydrothermal solutions that formed the bulk of the rock alteration and mineralization for the Ray Orebody. Further uplift on the Granite Mountain to the west and the downfaulting along the Diabase Fault to the east steepened the dip on the Emperor Fault causing additional minor movement. This mechanism would set the age of the main movement along the Emperor Fault at 60 to 61 million years ago. The generalized section on page 21 illustrates the present relationship of the Diabase and Emperor Faults.

North of the mine and extending up the Mineral Creek valley is a complex fault zone composed of several fault strands and may, in part, be an off-shoot of the Diabase Fault. The east dipping western-most fault strand is named the Livingston Fault; the term School Fault is reserved for that part of the Mineral Creek Fault zone which is composed of reverse faults that dip 30-60 degrees west and crop out east of the trace of the Livingston Fault. The School Fault is a low-angle reverse fault near the surface and is interpreted to steepen at depth. The Pinal Schist block on the west has moved up. The geometry



Generalized Geologic Section

of this fault is inferred from analogy to other basement uplifts of Laramide age. In the case of the Ray area, however, much of the Laramide style deformation is probably of Miocene age. It is an open question as to whether the School Fault is younger than the Livingston Fault or vice-versa.

The West End Fault, located on the west slope of the West Pit, strikes north-south with a steep easterly dip. This fault has economic significance since it essentially terminates the western extension of the chalcocite mineralization in the West Pit area.

The North End Fault forms a sharp boundary between rock alteration types in the Schist along the north side of the West Pit area. Quartz-sericite alteration to the south abruptly changes to a chlorite-epidote assemblage north of the fault. The North End Fault may be a westerly extension of one strand of the Diabase Fault.

At least four major fault systems, the Diabase, Emperor, North End and School-Livingston Faults, converge in the area of the northeast slopes of the Pearl Handle Pit creating an extremely complex structural zone. Large blocks of rock have been rotated and moved out of sequence. Attempts to make detailed drill hole correlations in this area have been very difficult.

SUMMARY

The Ray orebody was developed in older and younger Precambrian rocks. Stratigraphically, the highest unit of the Apache Group affected by the hypogene ore solutions appears to be the arkose member of the Dripping Spring Quartzite. The deposit is thought to be genetically related to the 60 to 61 million year old Granite Mountain Porphyry. Secondary copper mineralization is found in the Precambrian rocks (excluding the Ruin Granite), the Laramide intrusives, and the Tertiary conglomerate and volcanic units.

Supergene chalcocite mineralization formed above and lateral to the hypogene copper orebody, largely in the pyrite halo. The bulk of the silicate/oxide orebody formed in a low total sulfide-high chalcopyrite environment.

The bulk of the ore grade (at least 0.40%) copper mineralization occurs in the semi-reactive, mafic, Precambrian diabase host rock. Molybdenite mineralization favored the quartzose lithologies.

The Ray orebody is located in a very complex structural area. Several major structures have played an important role in the emplacement and subsequent displacement and secondary enrichment of the orebody. The high angle Diabase and the low angle Emperor Faults are the most important and obvious structures in the mine area. The Diabase Fault down dropped the western portion of the primary ore zone and terminates the eastward extension of the Emperor Fault. The Emperor Fault tends to define the lower limits of the chalcocite enrichment blanket in the Pearl Handle Pit area. The convergence of several major fault systems in the northeast Pearl Handle Pit area has created a very complex zone. Oxide type mineralization extends to greater depths within this area; either as the result of greater groundwater flow circulating through this zone or the down dropping of blocks containing copper minerals that were oxidized at higher elevations.

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