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Lawrence,

Here is my file on this. It might be interesting to try and plot up the limits of the chalcocite blanket on a 7½ min. topo map. Gary

Red Mountain.

Richard Stern - Submittal right next to Red Mtn. Au in narrow fracture zones. (.02) range.

* Cu + Au Potential?

Soldier Basin
Santa Cruz County, AZ

Section 18
T23S, R16E

MLS
1/93

1/9 Talk w/ Justin Turner - Jones & Li (602) 884-9594
guy hasn't had much time to work on report what with holidays, etc. Will finish up computations this week, promise to have something to me by Friday Jan 18.
Still working on date for oral presentation, told him would be late in the month probably (in conjunction w/ Magma meeting?)

--↔ Deluxe Speedo - needs new head, is in dashboard
$115.00 - tune-up; valve adj.;

1/9 Talk w/ Pat P.
- Jim has taken out wall between storage units, is moving Skylie stuff today, will get one for Iron Valley tomorrow

---

1/10 - Talk w/ Bill Johns - Ken-McBee (405) 270-3326
Conoco Did 3 drill holes for assessment work, prior work was geochemical sampling
- he has handled Real Estate prop for years

- 36 patented, 446 unpatented claims.

call Conoco, talk - To speed up sending back deed
Conoco had buy-out option - thinks have 3-5 years time frame -

Project Questions to them
Harold Homberg - Ken-McBee - Pet. geologist - (405) 270-382
Bill Leedy - Ken-McBee - Sr. Geologist

Once Conoco deal is over with, waiting on deed to come back, they will stop property - said will get data package together and send to me!

T ~~S~~ Red Mtn.

T22S R16E

20, 21, 22

27, 28, 29

Chalcocite Chert

- Assume ~5000' EW

x 1500' N-S

x ~75' Thick

÷ 12.5 ~~D~~ tons

≈ 45,000,000 tons

- Addison Smith → ~~296-0077~~ (602) 623-1312 left message

Roy Shepis 290-9200 left ~~message~~ message

6/14/89 (405) 270-1313 Lynn Robbenoff ← lead person → - Karr McBee
- recently ventured out to Cominco -
- multiyear agreement, just starting the program
talking w/ K-M for about the last year,
finalized deal about 4 months ago

6/15 Frank Tolbert (219) 722-4343
- is sending info

6/15 Wyoming Geol. Survey - sending pub. list

6/15 (307) 235-1269 → William and Viola Kirkwood - Casper
- part owners of Copper King Mine near Cheyenne

6/15 Utah Geological Survey (801) 581-6831
send pub list.

6/15 New Mexico G.S. (505) 835-5420 send pub list

6/15 South Dakota Geol. Survey (605) 677-5895
will send pub list.

6/15 Colo. Geol. Survey (303) 866-2611

6/15 Kohatke - ~~Cyprus has~~ Village is firm in resistance to any more mining, don't want to be intruded upon - Cyprus has inquired and Addison has asked on their behalf, also other groups have inquired.

Talk w/ Addison Smith - re Nickel Mine.

GEOLOGY AND SILICATE-ALTERATION ZONING AT THE RED MOUNTAIN PORPHYRY COPPER DEPOSIT, SANTA CRUZ COUNTY, ARIZONA

James L. Quinlan
Kerr-McGee Corporation
Oklahoma City, Oklahoma 73125

ABSTRACT

The Red Mountain porphyry copper deposit located in southwestern Arizona (fig. 1) occurs within an altered complex of volcanic and intrusive rocks of Cretaceous and early Tertiary age. Silicate alteration, sulfide distribution, and assay data have been used to define the deposit.

As presently outlined, the deposit is divided into three parts: (1) a small, near-surface chalcocite blanket, (2) a near-classic, porphyry copper bulk sulfide deposit, 5,000 feet below the summit of the mountain and 3,500 feet below the chalcocite blanket, and (3) a deep-level breccia pipe in the core zone of the bulk sulfide deposit.

At least three major and distinct alteration and mineralization pulses are recognized at Red Mountain. Much of the alteration at the surface is the result of the supergene modification of a zoned and essentially copper-barren hypogene alteration system. Superimposed on the early hypogene system and recognized at depth is a smaller, more intense near-classic porphyry copper alteration zone with a partially defined copper-sulfide shell. The breccia pipe occurs within the core area of the shell and represents a later, even more restricted hydrothermal event. Silicate and sulfide zoning within the breccia pipe indicates that the pipe itself is a miniature zoned porphyry copper deposit.

The most obvious clue to the deep-level orebody at Red Mountain is the near-surface chalcocite blanket. The blanket deposit formed by secondary enrichment of copper in a low-grade halo or plume which extended upward from the deep-level deposit to the present surface, or at least 5,000 feet. Pyrite, largely from the phyllic zone of the early and essentially copper-barren alteration system, not only provided a favorable host environment in which the blanket could form, but also on oxidation provided much of the acid needed for the secondary enrichment process.

INTRODUCTION

Geologic Setting

Red Mountain is underlain by an altered complex of volcanic and intrusive rocks of Cretaceous and early Tertiary age. Figures 2 and 3 are generalized maps illustrating surface geology and alteration features. Figures 4 and 5 are diagrammatic cross sections showing geologic and alteration features.

Three layered volcanic units are recognized at Red Mountain. The upper, or tuff unit, consists mainly of tuffs, flow, and breccias of rhyolitic and dacitic composition. It crops out over much of the mountain and is up to 2,400 feet thick (figs. 2 and 4). It is essentially the same as the "Volcanics of Red Mountain" described by Drewes (1971a), which he correlates with the Gringo Gulch volcanics of Paleocene(?) age.

Underlying the tuff unit are approximately 3,000 feet of andesite and trachyandesite flows, breccias, sills, and dikes locally referred to as the andesite unit. Hornfels bands occur near the base of the unit. The andesite unit crops out on the flanks of Red Mountain and is cut in drill holes (figs. 2 and 4). It is part of the Upper Cretaceous trachyandesite or doreite (Ka) unit, mapped and described by Simons (1974). Simons reported a potassium-argon date of 72.1 ± 3 m.y. B.P. for a sample from the unit.

The lowest layered rock unit is the felsite-latite unit. It underlies the andesite unit and includes interlayered andesites near the top. It consists mainly of volcanic conglomerates and breccias, silicified tuffs, flow(?), interlayered and cut by latite sills and dikes. The unit crops out in Alum Gulch on the south side of Red Mountain and is recognized in deep drill holes on the south and west flanks of the mountain (figs. 2 and 4). It correlates with the Upper Cretaceous silicic volcanics (Kv and Kla Units) mapped by Simons (1974).

The layered rocks at Red Mountain are cut by several textural varieties of porphyritic rocks, which range in composition from granodiorite to quartz monzonite. The porphyries are recognized as dikes and irregular bodies in outcrop and drill holes (fig. 2 and 4).

The layered rocks generally strike north and dip 14° E. The dominant trend of local shears and fractures is N. 20° E. with steep dips toward the northwest and southeast. Less numerous are shears and fractures that strike N. 70° E. and dip steeply northwest or southeast. No large faults are recognized on the mountain, but several occur on its flanks (fig. 2).

Silicate Alteration

Silicate alteration at Red Mountain is easy to recognize but difficult to interpret. Near the center of the deposit, changes in the alteration assemblage

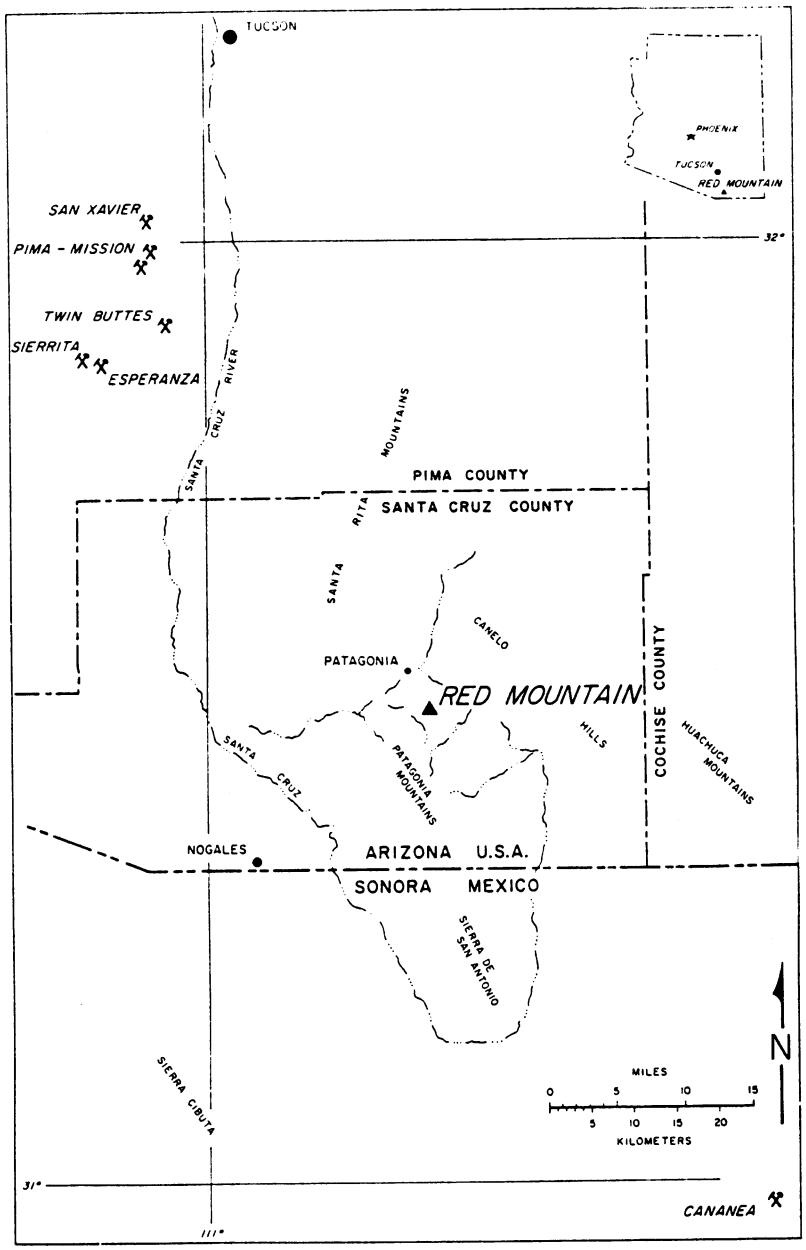

Fig. 1. Index map showing the location of the Red Mountain porphyry copper deposit. After R.M. Corn, Economic Geology, Vol. 70, No. 8, Dec. 75

with depth are most obvious (fig. 5). Lateral zoning at depth, which is a critical guide to ore, is much more subtle and to date has been best quantified by thin-section studies (fig. 6).

The strong vertical alteration zoning recognized at Red Mountain is partly controlled by differences in rock types with depth. Near the center of the system, the tuff unit is intensely altered to an assemblage of quartz-sericite-pyrite-kaolinite-alunite. The sericite content increases with depth, whereas the content of kaolinite and alunite decreases. At the tuff-andesite contact, the assemblage abruptly changes to quartz-sericite-chlorite-pyrite with minor hematite and kaolinite. With the exception of outlying Hole 158, the pyrite content rapidly decreases in depth through the upper part of the andesite unit (fig. 7). The alteration assemblage further changes with depth within the andesite through a biotite-magnetite-pyrite assemblage to a biotite-orthoclase-anhydrite-magnetite-chalcopyrite assemblage. Within the felsite-latite unit, the assemblage is orthoclase-quartz-anhydrite-chalcopyrite-biotite. The alteration within the porphyritic rocks is generally reflective of the adjacent intruded rock and depth. It is expressed by a quartz-sericite-pyrite-kaolinite assemblage at shallow depths and an orthoclase-anhydrite-biotite-chalcopyrite assemblage at greater depths.

The lateral changes in alteration are much more subtle. At the surface, hypogene alteration is strongly masked by supergene effects but is discernible. Within the tuff unit, the lateral zoning is expressed as a central core area of more abundant sericite, quartz veining, and limonitic stain (fig. 3). Outward from the core area, a more argillic zone is characterized by abundant clays and alunite with less sericite, silica, and iron. The transition from

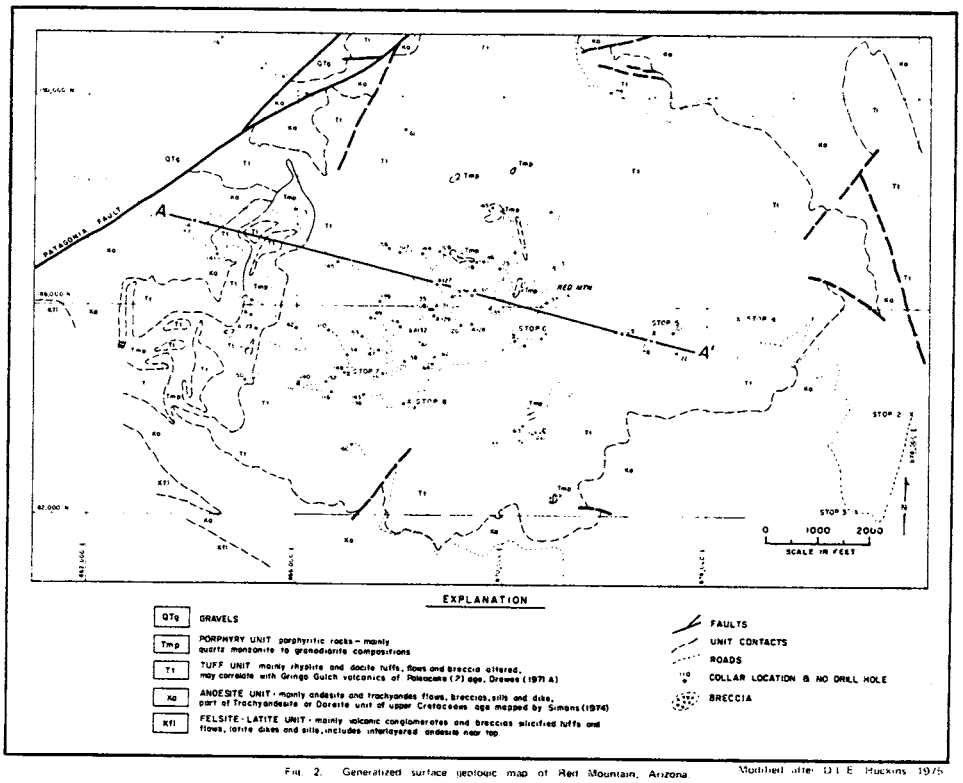

Fig. 2. Generalized surface geologic map of Red Mountain, Arizona

Modified after D.L.E. Huckins, 1975

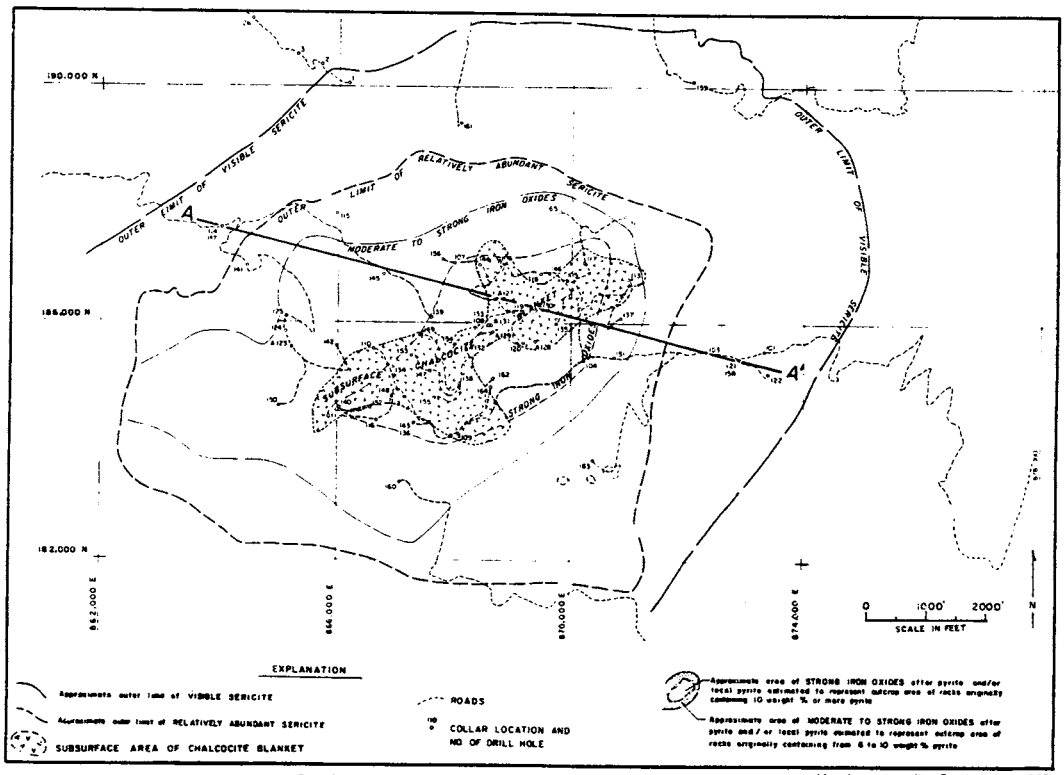

Fig. 3. Generalized surface alteration map of Red Mountain, Arizona

Modified after D.L.E. Huckins, 1975.

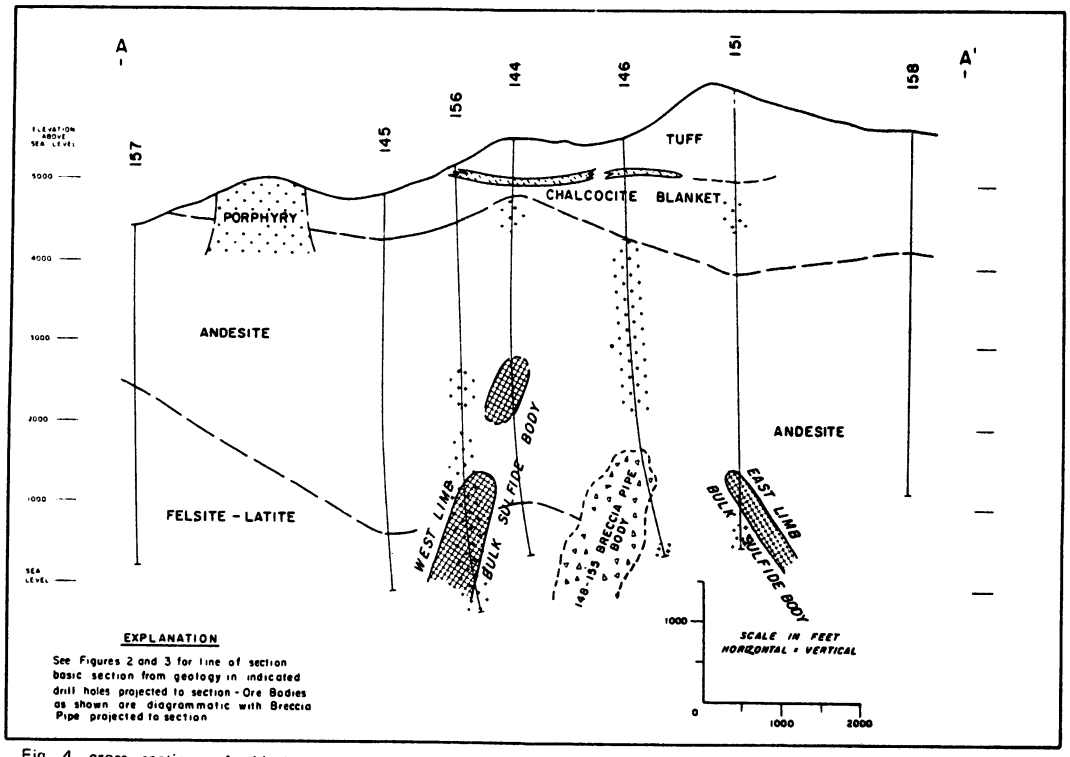

Fig. 4. cross--section A–A'. looking northeasterly, diagrammatically showing geology at Red Mountain, Arizona .

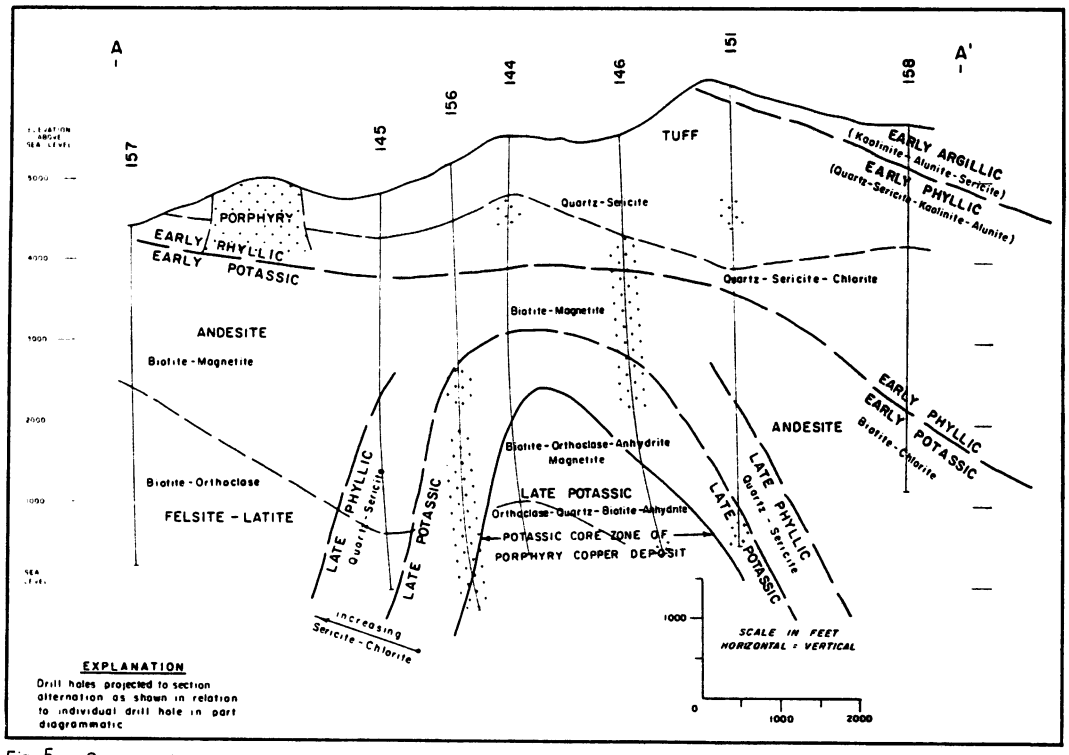

Fig. 5 Cross section A–A', looking northeasterly, diagrammatically showing silicate alteration at Red Mountain, Arizona.

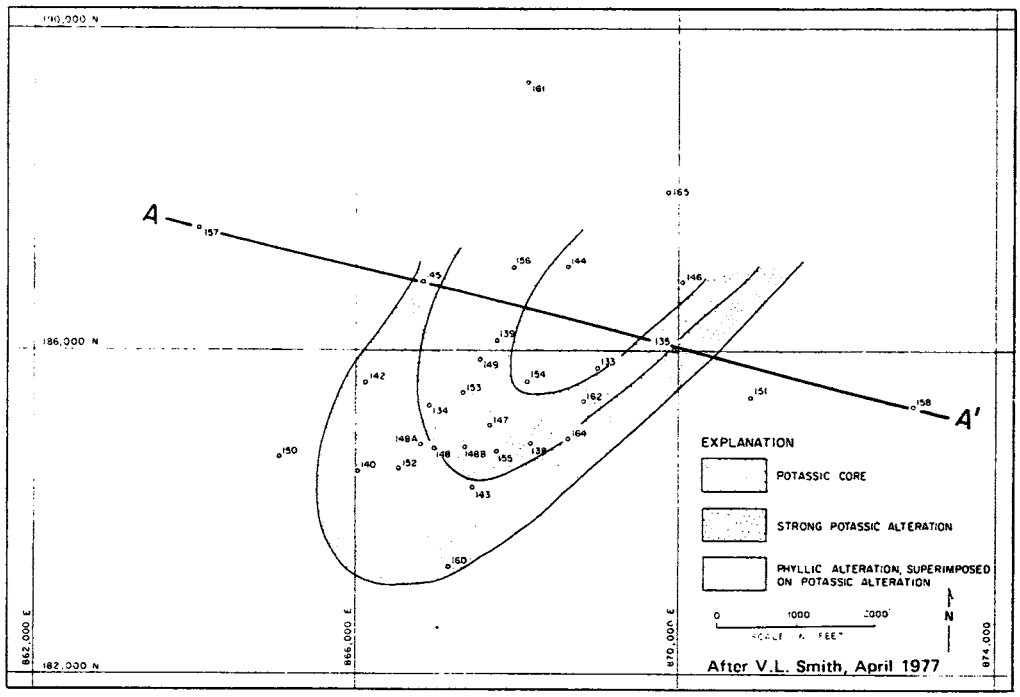

Fig. 6 Map showing silicate alteration between elevations 2,000' and 2,500' at Red Mountain, Arizona. Developed from petrographic study of thin sections from selected holes.

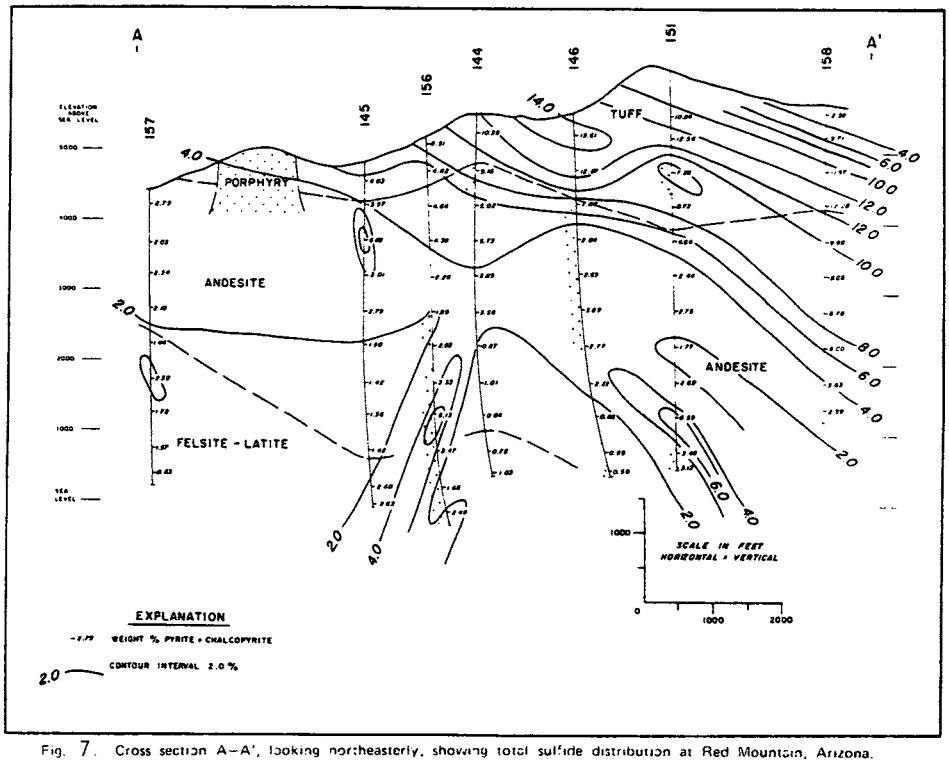

Fig. 7. Cross section A–A', looking northeasterly, showing total sulfide distribution at Red Mountain, Arizona.

sericitic-argillic alteration within the tuff unit to propylitic alteration in the surrounding andesite unit to the northeast, east, south, and southwest appears to be partly due to change in rock type. The suggestion is that the alteration mushroomed or extended farther laterally from a mineralization center in the tuff unit than in the underlying andesite unit. Within the andesite unit on the west and northwest flanks of the mountain an intense supergene argillic alteration is superimposed directly upon hypogene biotite-magnetite alteration. Within this area of relatively low original pyrite, chalk turquoise was formed as the more common supergene copper mineral within the argillized andesite.

At depth, the central core area is marked by an orthoclase-quartz-biotite-anhydrite alteration mineral assemblage. There is a general decrease in the amount of these minerals outward from the core area with increasing amounts of sericite and chlorite. This is illustrated on figure 6, which was developed from a study of thin sections obtained from selected holes between elevations of 2,000 and 2,500 feet.

Father out, as seen in Holes 157 and 161, a biotite-magnetite assemblage is recognized in the andesite unit. In Hole 157, this assemblage changes to biotite-orthoclase in the felsite-latite unit. Although the assemblage is potassic, the intensity of the potassic alteration appears much less than that recognized in the core area of the deposit. Locally, late quartz-pyrite veinlets enclosed in sericitic envelopes cut the previously described alteration features.

Figure 5 illustrates in cross section, my concept of the major silicate alteration features at Red Mountain; that is, a large early zone alteration system that accounts for most of the alteration recognized at the surface. The primary porphyry copper deposit lies in the potassic zone of this large early system. The alteration associated with the primary deposit has been superimposed on the early alteration system and zoning is similar to that described by Lowell and Guilbert (1970) and Rose (1970). It is suspected that the two silicate alteration systems are closely related in origin and time with the porphyry copper phase representing a late but more restricted event in the development of the complex Red Mountain hydrothermal system. The sulfide distribution data also clearly point to two distinct alteration phases as does the fluid inclusion data of Bodnar and Beane (1980).

Sulfide Distribution

The principal sulfide minerals at Red Mountain are pyrite and chalcopyrite. Secondary chalcocite is present, particularly in the blanket deposit. Bornite has been identified in deep holes near the center of the system and enargite in the upper part of holes overlying the deep orebody. Small amounts of molybdenite, tennantite, galena, and sphalerite have been identified locally.

The sulfide content of the rocks at Red Mountain has been estimated during core logging and in the deep holes has been determined on the basis of sulfur and sulfide sulfur assays.

For the purposes of the sulfide distribution studies, it has been assumed that pyrite and chalcopyrite are the only significant primary sulfide minerals in the Red Mountain system. The amounts of each below the zone of secondary enrichment are calculated from copper and sulfide sulfur data by assigning the amount of sulfide sulfur needed to convert the copper present in an interval to chalcopyrite and assigning the remaining sulfide sulfur to pyrite. Sulfate data have been converted to anhydrite equivalents where anhydrite is recognized in the deep drill holes.

The sulfide data have been assembled and posted in several different manners on plans and cross sections; that is, by rock type and as various elevation intervals. Most revealing are the bulk data when assembled and posted at elevation intervals of 500 feet or more. In general, plans and sections have been prepared showing pyrite, chalcopyrite, and total sulfide (combined pyrite and chalcopyrite) distribution, and pyrite to chalcopyrite ratios. Pyrite and total sulfide maps and sections are reflective of each other, and maps and sections showing pyrite distribution are not included in this report.

Plan illustrations accompanying this report show relative bulk chalcopyrite (fig. 8), total sulfide distribution (fig 9), and relative pyrite to chalcopyrite ratios (fig. 10) between elevations of 500 and 1,500 feet. All three maps show the same basic pattern and closely match the silicate alteration pattern shown in figure 6. Although drilling has yet to outline the entire system, available data indicate an elongate but nearly classic copper-sulfide shell. Thus all three plans, and in particular the ratio map (fig. 10), are useful in indicating where a drill hole lies within the system.

Cross sections prepared from the sulfide data, that is, data assembled at 500-foot elevation intervals, not only confirm the picture developed in plan but add to it. Total sulfide and chalcopyrite data have been assembled on Section A-A', which passes through the core area of the lower sulfide system as well as outlying Holes 157 and 158 (figs. 7 and 11). The section showing total sulfide distribution (fig. 7) clearly demonstrates a two-part system. A large primary sulfide high, mostly pyrite, is recognized near the surface in the upper parts of the central drill area and in Hole 158. This pyrite is within and generally an integral part of the intense quartz-sericite alteration assemblage recognized at the surface. The section also suggests that Hole 157 lies in the core area of the large primary sulfide system and would account for the potassic alteration recognized in the hole. It is also apparent that the strong iron oxides recognized on the upper western slope of Red Mountain (fig. 3) are related to the upper sulfide system.

The copper system recognized at depth in the central drill area and shown on the sulfide distribution and ratio maps (figs. 8, 9, and 10) is also apparent in the cross sections showing total sulfide and chalcopyrite distribution (figs. 7 and 11). Although the amount of total sulfides in the lower system (fig. 7) is less than that in the upper system, it is clear on figure 11 that the copper is associated with the lower system. Further, it is apparent in sections that the lower sulfide system closely follows the central area silicate system, and like the silicate system, is superimposed on the earlier and larger system.

THE ORE SYSTEM

For discussion purposes, the Red Mountain deposit is divided into three separate and distinct parts: (1) an upper-level chalcocite blanket deposit, (2) a deep-level bulk sulfide deposit, and (3) a breccia pipe deposit within the core area of the deep porphyry copper system.

Chalcocite Blanket

Chalcocite is recognized along fractures and as coatings on pyrite grains from the surface to a depth of 2,500 feet or more. Much of the chalcocite appears to be concentrated in a flat blanketlike deposit near an elevation of 5,000 feet and within the high pyrite

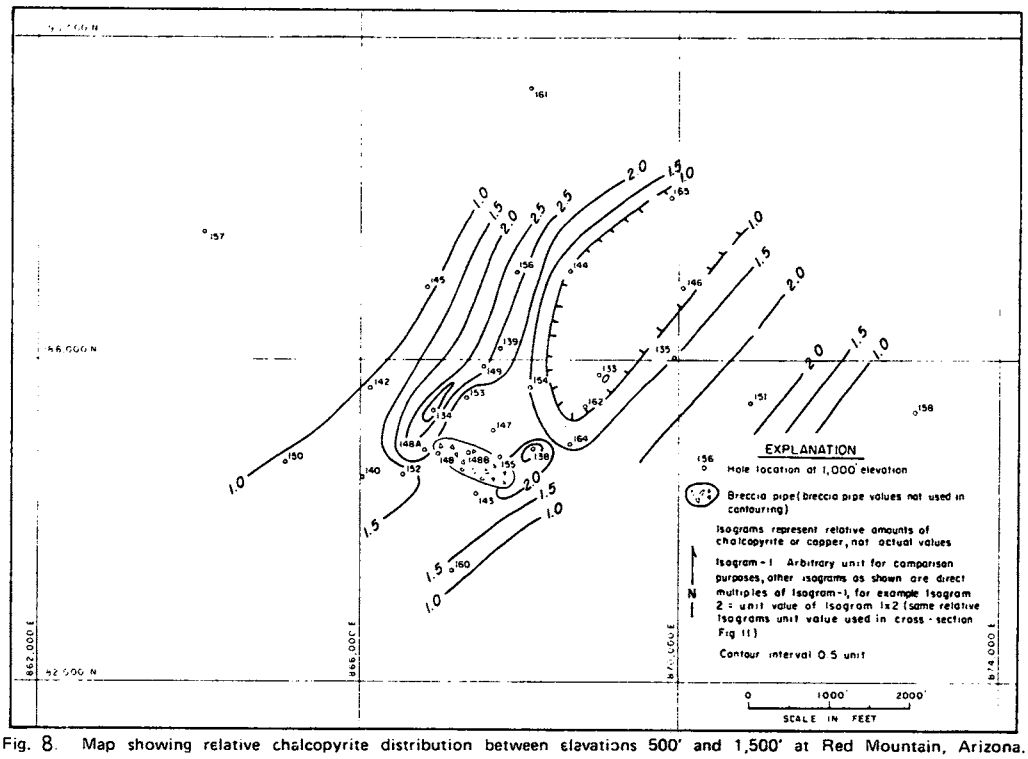

Fig. 8. Map showing relative chalcopyrite distribution between elevations 500' and 1,500' at Red Mountain, Arizona.

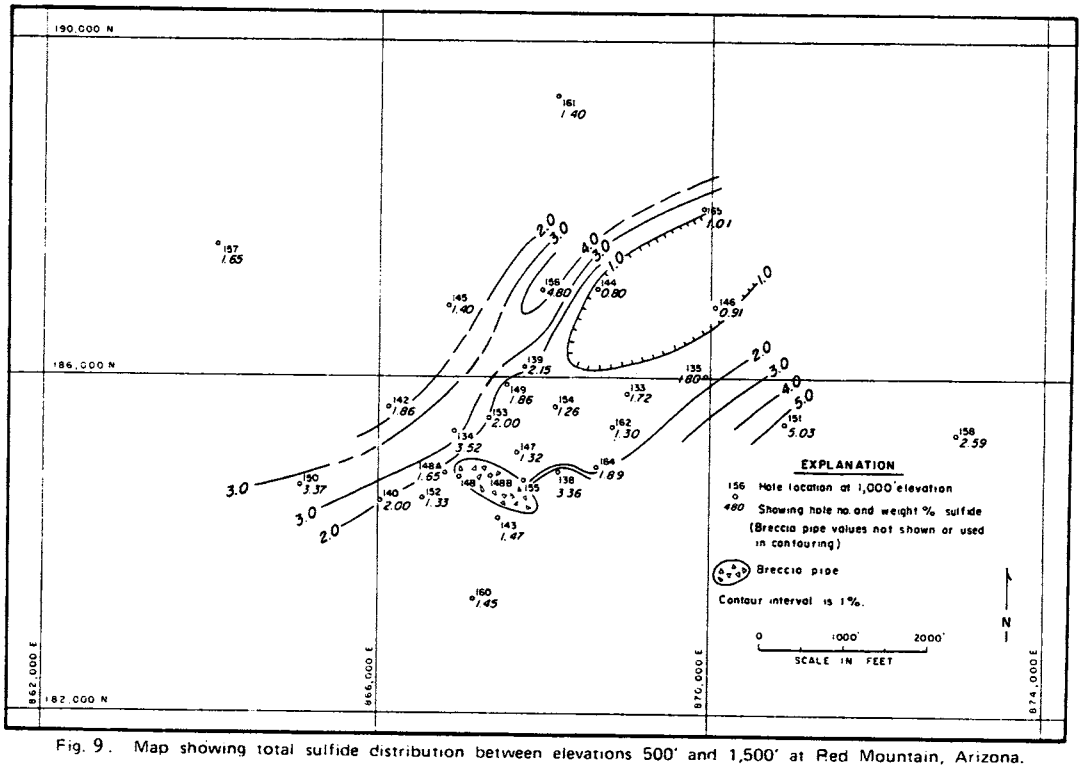

Fig. 9. Map showing total sulfide distribution between elevations 500' and 1,500' at Red Mountain, Arizona.

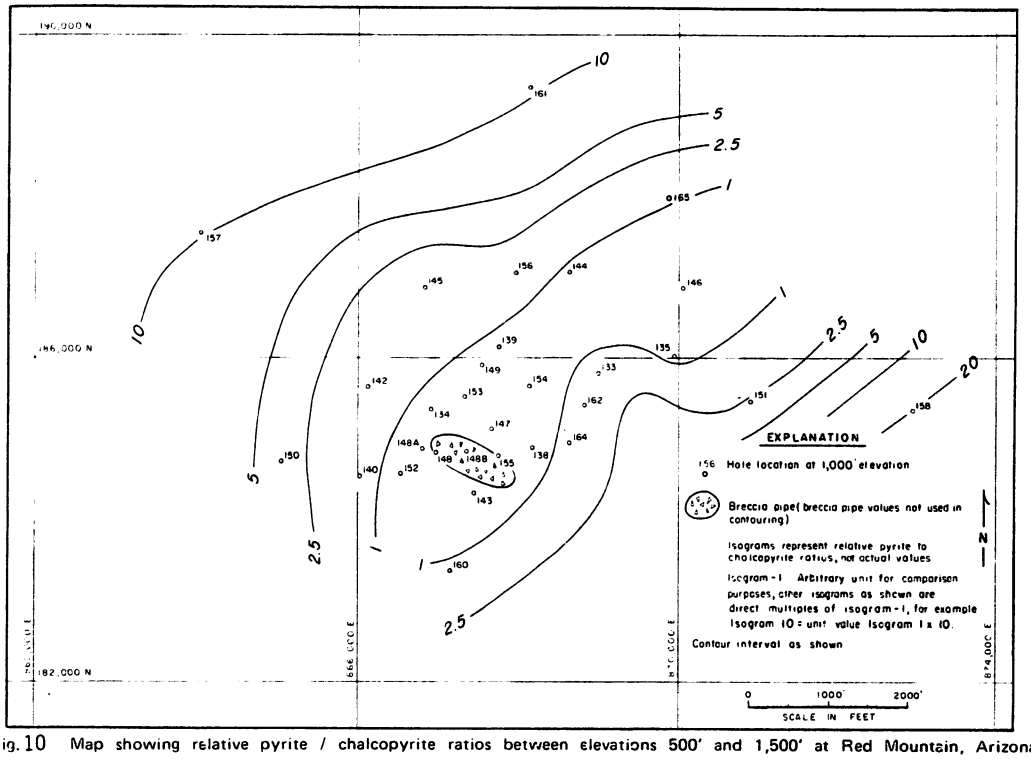

Fig. 10 Map showing relative pyrite / chalcopyrite ratios between elevations 500' and 1,500' at Red Mountain, Arizona.

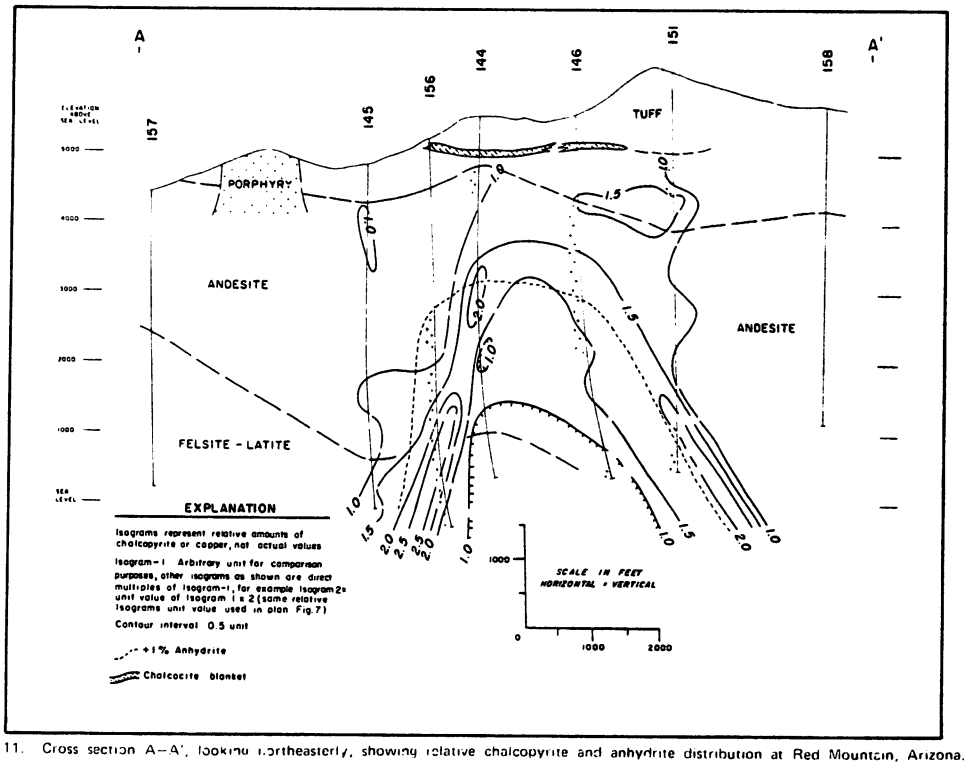

Fig. 11. Cross section A–A', looking northeasterly, showing relative chalcopyrite and anhydrite distribution at Red Mountain, Arizona.

zone of the early alteration system (figs. 10 and 11). As currently defined, the blanket ranges in thickness from 15 to 150 feet. It appears to be in the process of being destroyed by weathering and erosion. The deeper scattered chalcocite showings, which are usually controlled by fissures or shears probably represent recent copper migration.

The chalcocite blanket almost directly overlies the deep porphyry copper orebody (figs. 3 and 11). The distribution of copper above the deep porphyry copper system, as reflected by the relative copper or chalcopyrite values shown in figure 11, suggests that the blanket was formed by enrichment of a protore halo or plume extending at least to the present surface, or 5,000 feet above the main ore system. Pyrite from the early phyllic zone undoubtedly played an important part in the formation of the blanket. Not only did it provide a favorable host environment for deposition of chalcocite but also is the primary source of acid for the secondary enrichment process. Also, Bodnar and Beane's (1980) description of late-stage mineralization in a quartz-pyrite veinlet containing minor chalcopyrite and galena in a surface sample, RM 11, is evidence that the ore-stage primary mineralization extends far above the main deposit.

Deep-level Bulk Sulfide Deposit

The zone of deep-level porphyry copper mineralization at Red Mountain is an integral part of the copper shell as recognized in the alteration and sulfide study. Holes 146, 165, and the deeper parts of Hole 144 describe the low-sulfide, low-copper core of the system. A low-sulfide, low-copper tail extends from the core and is recognized in seven holes, 133, 135, 154, 147, 143, and 152. A breccia pipe is defined in Holes 148, 148B, 148C, and 155 and lies within the elongate tail area.

Nine drill holes are immediately peripheral to the core area and the elongate tail, and it is in the area of these nine holes that most of the deep-level copper outside the breccia pipe occurs. Seven of the nine holes contain thick and/or higher grade ore intervals. Ore is recognized on both the west and east limbs of the copper shell (fig. 4).

Much, if not most, of the deep-level copper occurs as chalcopyrite along veinlets and fractures, and only a small amount occurs as disseminated grains. From work to date, it is obvious that the area of the copper shell is not uniform in grade and not every where of interest. Local controls and structure apparently played an important part in copper mineralization within the shell area. For example, chalcopyrite enrichment is noted along both sides of andesite-porphyry contacts in several holes.

148-155 Breccia Pipe

The 148-155 breccia pipe recognized at Red Mountain has many features common to mineralized breccia pipes at other porphyry copper deposits. It is perhaps the deepest copper-molybdenum breccia pipe presently known anywhere in the world. Not only is it of potential economic interest because of the higher grade ore associated with it, but it is also of considerable scientific interest because of its depth, position within the system, and the mineralization and alteration associated with it.

The Dyna-drill has been used to control the direction of drill holes for a better evaluation of the pipe. In all, four holes (148-148B, 148C, and 155) have intersected the pipe (fig. 12).

The 148-155 breccia pipe, as envisioned from drill-hole data, is shown in plan and diagrammatic section in figure 12. Although in part diagrammatic, the plan and section represents a reasonable interpretation based on drill-hole intercepts within the pipe and the confining restrictions of adjacent holes. In plan, the intercepts in Holes 148 and 155 are about 800 feet apart and define the minimum dimension of the long axis of the pipe. The pipe has been assigned a long axis of 1,100 feet. The section better illustrates the available information. As shown, the top of the pipe is at an elevation of 1,750 feet or approximately 4,000 feet below the surface, and ore has been exposed over a vertical range of 1,300 feet. Hole 148 bottoms in ore within the pipe near sea-level elevation.

As mentioned before, the 148-155 pipe lies within the high-potassic, low-sulfide, and low-copper tail extending southward from the core of the deep porphyry copper system (fig. 10). The alteration within the pipe is separate and generally distinct from that of the surrounding rock. This is well exemplified in Holes 148B, 148C, and 155. These holes enter the pipe near its top from an area of low-sulfide, low-copper, and strong potassic alteration. At or within a few feet of the pipe contact, alteration abruptly changes to phyllic with abundant sericite and up to 30 percent by weight of pyrite. Strong phyllic alteration persists near the top of the pipe but gives way to potassic alteration with depth. Only in Hole 155 is a significant amount of possible mineralization leakage recognized above the pipe. Although the pipe contact is this hole is sharp and distinct, bands of pipe-type mineralization are evident for 40 feet above the pipe. Shears with chlorite, sericite, and quartz-sulfide veinlets similar to pipe mineralization are recognized up to 775 feet above the pipe.

Unlike many breccia pipes described in the literature, the mixing and movement of fragments great distances up or down the pipe has not been recognized in the 148-155 breccia pipe. Although fragments are broken and rotated, the composition of fragments, with but a few exceptions, appears to be similar to that of fragments in the immediate wall of the pipe. More detail is needed to substantiate this observation. It may also be noted that neither the contact between and andesite and felsite-latite units nor the thickest hornfels horizon appears disturbed or distorted near the breccia pipe.

The ore breccia generally consists of angular fragments of felsite and andesite in a matrix of orthoclase, quartz, anhydrite, chalcopyrite, and pyrite. Sericite is abundant near the top and is also recognized close to the sides of the pipe in deeper intercepts. Calcite, molybdenite, and a dark-gray sulfosalt, tentatively identified as tennantite, are accessory minerals. Breccia fragments are commonly an inch or less in diameter. The largest fragment recognized was 18 inches in diameter. Open vugs are common.

A distinctive unbrecciated but altered and mineralized quartz-eye porphyry intrusion occurs within the breccia pipe. Drilling intercepts, up to 65 feet long, suggest a dikelike structure. Brecciated fragments of the quartz-eye porphyry are recognized outside the main intrusive body but always near its margin. Sericite is the most common alteration product in the intrusion and and in areas of the pipe near where the intrusion is recognized. Within the intrusive body, the sericite is relic after plagioclase and biotite phenocrysts and also occurs as a major constituent in the altered fine-grained groundmass. Pyrite and chalcopyrite generally occur as fine disseminated grains within the intrusive body. These minerals are not nearly as abundant in the intrusion as in the brecciated areas of the pipe and generally constitute from about 1.5 to 3 weight percent of the rock. Though variable, the amount of pyrite generally exceeds the amount of chalcopyrite.

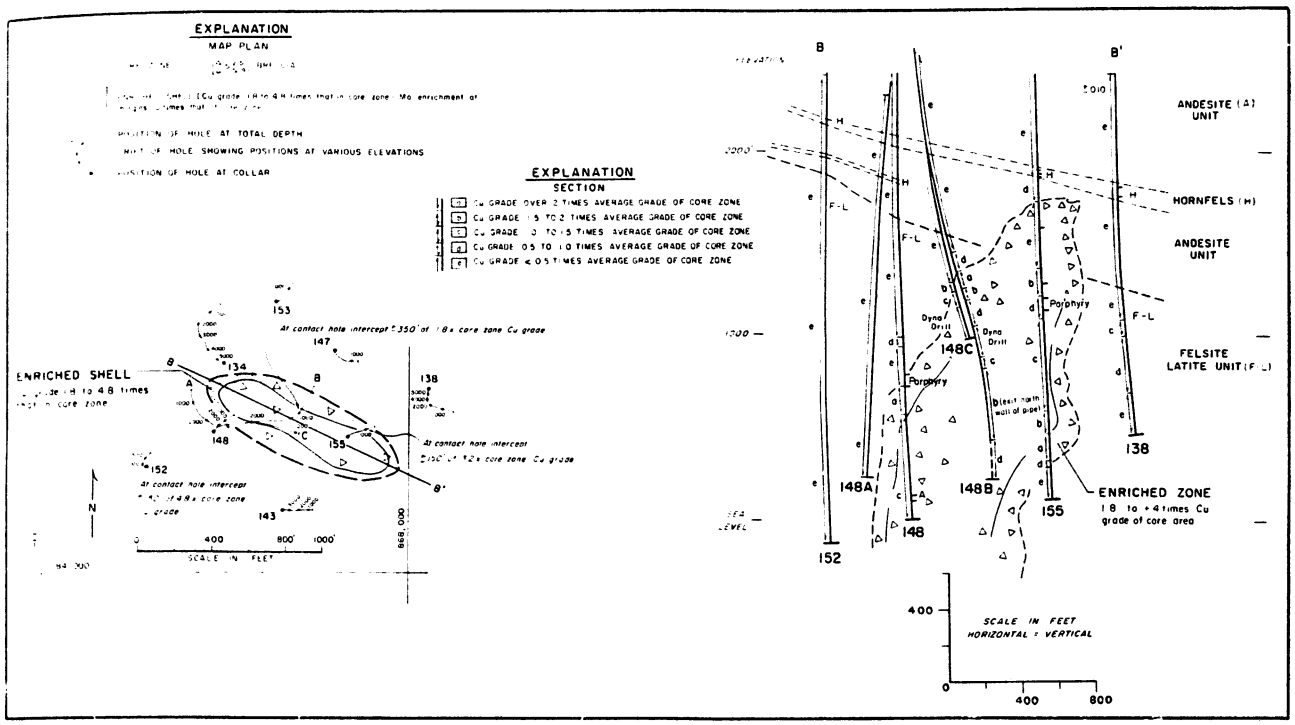

Fig. 12. Plan map and diagramatic cross section, looking northeasterly 148–155 breccia pipe at Red Mountain, Arizona.

A definite enrichment of copper, molybdenum, and silver is recognized at the pipe margin, particularly in the deeper intercepts. The enrichment is related to the concentration of chalcopyrite- and molybdenite-rich sulfide lenses at the margins. The grade of copper at the margins of the pipe is from 1.8 to 4.8 times that in the core area of the pipe. Molybdenum enrichment at the margins is ten times, and silver from two to four times that of the pipe core.

The silicate alteration and sulfide distribution pattern recognized in the pipe, though different in scale, is much the same as that recognized in many large porphyry copper systems, that is, a core area of strong potassic alteration with lower sulfide content. This is followed upward and to a lesser extent outward toward the pipe margins by a phyllic zone with increased sulfides. The suggestion is that the pipe itself may represent a more intense but miniature zoned porphyry copper system superimposed over the main or bulk phase of porphyry copper alteration and mineralization.

DISCUSSION

Silicate and sulfide alteration patterns have proved a useful guide to ore at Red Mountain. In particular, the use of copper and sulfide-sulfur assay data to estimate and study the approximate distribution of pyrite and chalcopyrite within the complex alteration zone has proved a valuable tool to define the deposit and as a guide for exploration.

The recognition of three separate, major, and distinct hydrothermal events at Red Mountain is believed significant. All three pulses appear to be closely related in time and origin to each other and to porphyry intrusions. The indicated sequence of hydrothermal events starts with the development and formation of a large, zoned, and essentially copper-barren silicate-sulfide alteration system, followed by at least two distinct alteration and copper-mineralization pulses. Each of these later pulses is more restricted and intense and formed a higher-grade deposit than its predecessor. This suggests that differentiation in the magma chamber may have played an important role in the segregation and enrichment of copper for the late-phase hydrothermal fluids.

More work is needed to confirm and expand on some of the implications and observed relationships in the 145-155 breccia pipe. Whereas the pipe contains open vugs, most evidence indicates that it formed with its top many thousands of feet below the surface. The presence of both brecciated and unbrecciated, altered, and mineralized quartz-eye porphyry within the pipe attests to the interplay between intrusion, brecciation, alteration, and mineralization. One suggestion is that volatiles or fluids from the magma may have played an important part in brecciation as well as alteration and mineralization in the pipe. A better understanding of the processes that formed the pipe would undoubtedly lead to a better understanding of porphyry copper deposits.

In conclusion, it should be stressed that the deep-level porphyry copper deposit at Red Mountain is a plum within a large and complex altered zone. The most obvious clue to the deep-level deposit is the chalcocite blanket that was formed by the secondary enrichment of copper in a low-grade plume that extended at least to the present surface, or 5,000 feet above the deep-level deposit.

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ROAD LOG

Richard Ahern, Consultant
Tucson, Arizona

Russell M. Corn. Consultant
Tucson, Arizona

Fleetwood R. Koutz
ASARCO, Tucson, Arizona

Mileage Cum.	Mileage Inc.	
0.0	0.0	START. Patagonia, Arizona, Post Office at the junction of State Highway 82 and county road leading to the San Rafael Valley, Harshaw, and Lochiel. Good view of Red Mountain on the right.
1.6	1.6	The Patagonia fault is exposed in outcrop across wash. Fault zone consists of several strands, with consolidated Tertiary gravels on northwest and Meadow Valley Andesite (72.1 ± 3 m.y.) on southeast side of fault zone. Bold outcrops on southeast side of outcrop area are silicified breccias along fault strand in Meadow Valley andesite.
2.7	1.1	STOP 1. Road-cut exposures of Meadow Valley Andesite. These exposures are typical of many Meadow Valley exposures outside of main Red Mountain alteration zone. Would call attention to purple color and propylitic alteration. In core of Red Mountain alteration zone, andesite is typically altered to a black, biotite-magnetite-rich rock. Clay and limonite are common along many fractures in the exposures and quartz veinlets and manganese oxides may be seen along some of the fractures.
4.7	2.0	STOP 2. Locations of Stops 2 through 8 shown on Figure 2. Turn off from San Rafael Valley-Harshaw-Lochiel county road onto road leading to Red Mountain. Will transfer from bus to four-wheel drive vehicles at this point. Outcrops in wash ahead are generally propylitically altered Meadow Valley Andesite. Local bleach zones are mainly controlled by linear structures. Clay, gypsum, and limonite are the most common minerals in these zones.
5.2	0.5	STOP 3. View of southeast side of Red Mountain. Would call attention to route of road leading up mountain, talus-covered landslide blocks and cliffs in upper layered tuff unit. This upper layered, altered tuff unit is much more resistant to erosion than the underlying andesite, and this accounts for the present topographic high at Red Mountain.
7.1	1.9	STOP 4. At outcrop in altered tuff unit 5,000 feet east of alteration center at

Red Mountain (see figs. 2 and 3). Rock is principally clay altered; also note alunite veinlets. Stop is at about outer limit of visible sericite in Red Mountain alteration zone.

7.5 0.4 STOP 5. At collar of Hole No. 158. Road cuts and outcrops of altered tuff unit ±2,000 feet closer to Red Mountain alteration center than at Stop 4. Note increase in sericite and pyrite (2 to 2.5 wt. %) content over that at Stop 4.

See map figures 2 and 3 and cross-section figures 4, 6, 10, and 11 illustrating geology, alteration, and sulfide changes at and between Stops 5 and 6.

8.4 0.9 STOP 6. Crest of Red Mountain ridge and near collar of Hole No. 151. Road cuts and outcrops of the tuff unit are inside the area of relative abundant sericite and iron oxides after pyrite. Adjacent drill-hole data show original pyrite content of up to 18 weight percent and an average content of from 10 to 12 percent (fig. 6).

8.8 0.4 STOP 7. At collar of Hole No. 148. Road, drill-pad cuts, and outcrops are in altered tuff unit, within zone of relatively abundant sericite and iron oxide. Note quartz and alunite veinlets in drill-pad cut. Will discuss and point out feature of deposit from viewpoint at this stop.

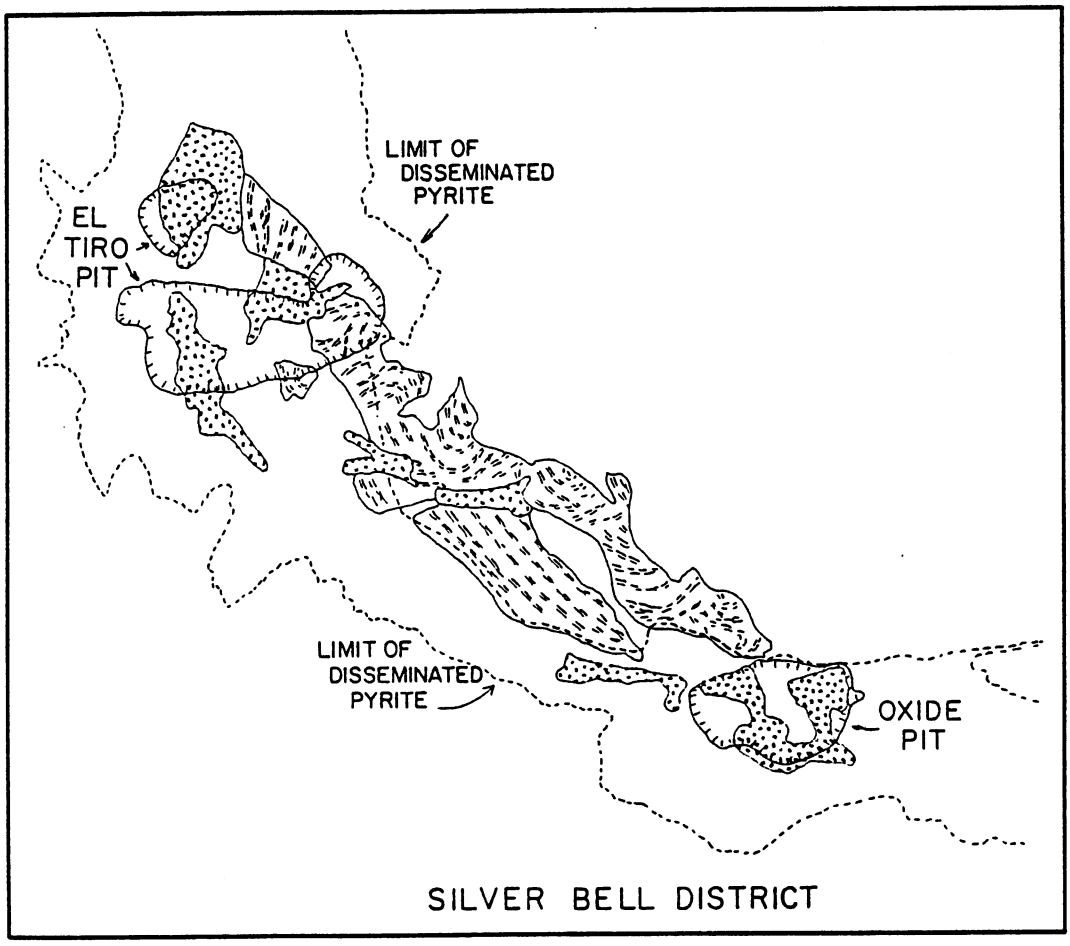
9.0 0.2 STOP 8. End of Red Mountain tour. View overlooking Hardshell or afternoon tour area. Return down Red Mountain to STOP 2 south on Harshaw Creek Road to Harshw Town Site (Lunch Stop). This is Stop A of the Hardshell half of the field trip guide as published in Arizona Geological Society Society Volume XV (1984), "The Hardshell Silver, Base-metal, Manganese Oxide Deposit, Patagonia Mountains, Santa Cruz County, Arizona: a Field Trip Guide," p. 199-217.

28th International Geological Congress

Porphyry Copper Deposits in the American Southwest

Field Trip Guidebook T338

Leader: Spencer R. Titley



Tucson to Globe—Miami, Arizona
July 19–23, 1989

JAN 28 1991

KERR-McGEE CORPORATION
KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

January 24, 1991

Mr. Gary Parkison, District Geologist
WESTMONT MINING INC.
4949 South Syracuse Street, Suite 4200
Denver, CO 80237

Re: Mineral Properties
Red Mountain Project (02-003-0000)
Santa Cruz County, Arizona

Dear Mr. Parkison:

Confirming our recent telephone conversation, we attach a Prospectus and duplicate originals of a proposed CONFIDENTIALITY AGREEMENT (Form No. 5839M-AZ) involving the properties available for sale or joint venture on a non-exclusive basis.

If the terms and conditions of this agreement are acceptable, then please execute and date the originals and thereafter promptly return same to me in the attached self-addressed and postage-paid envelope. Upon receipt we will have the orignals executed on behalf of Kerr-McGee and return to you one(1) fully executed original. If not acceptable, then please advise us of any suggested changes.

Additionally, please advise us whenever you will want to schedule a mutually acceptable date to review the data in our Oklahoma City offices.

If you have any questions, then please call either H. W. Holmberg (405/270-3820), L. A. Robbennolt (405/270-3975) or me at 405/270-3326. Thank you.

Sincerely,

KERR-McGEE CORPORATION
Minerals Exploration Division

W. K. John

W. K. John, CPL
Senior Staff Landman

WKJ:vk(5839M)

attachments

COPY

CONFIDENTIALITY AGREEMENT

In consideration for and as a condition of the furnishing to you by Kerr-McGee Corporation ("Kerr-McGee") of certain confidential and proprietary information relating to properties in the Red Mountain Project Area located in Santa Cruz County, State of Arizona (the "Properties"), you acknowledge the confidential and proprietary nature of such information and agree to hold and keep the same confidential as provided in this letter agreement.

As used herein, the term "Evaluation Material" refers to all information that has been or may hereafter be provided to you by Kerr-McGee concerning the Properties, including without limitation, financial, engineering, technical, title or other information, irrespective of the form of the communication.

You agree to exercise all reasonable steps to safeguard the confidentiality of the Evaluation Material and not to disclose any part of it or any information derived therefrom to any third person except to such limited number of your employees and advisors as (i) may require access to the Evaluation Material for the sole purpose of assisting you in evaluating a possible transaction with Kerr-McGee concerning the Properties and (ii) agree in writing to preserve the confidentiality of such Evaluation Material and to observe the other provisions hereof to the same extent as you agree herein. Further, you agree that, prior to entering into any agreement with any outside agent, consultant or advisor, you will inform Kerr-McGee in writing of the name of such person for Kerr-McGee's review of any potential conflicts of interest and approval, and you further agree that you will not enter into any such arrangement that Kerr-McGee does not approve. You agree that you will not copy or permit any of your outside agents, consultants and/or advisors to copy any of the Evaluation Material without the prior written approval of Kerr-McGee. Promptly upon the completion of your review of the information or upon the request of Kerr-McGee, but in no event later than ninety (90) days from the date hereof, you will return to Kerr-McGee all the Evaluation Material previously furnished to you, together with all copies of any of the same made by you or any of your employees or agents. Within such time period you will also destroy all notes, memoranda, reports, and documents generated by you, your employees or agents related to the Evaluation Material and/or any meetings or discussions concerning same and confirm such destruction in writing to Kerr-McGee.

You acknowledge that the Evaluation Material is being furnished to you solely to assist you in evaluating a possible transaction with Kerr-McGee related to the Properties, and you agree that you will not use the Evaluation Material or any information derived therefrom for any other purpose.

Also, you further agree, as a condition of your receiving this confidential and proprietary information that for a period of three (3) year(s) from the date hereof, neither you, your parent company, if any, nor any affiliates or subsidiaries of either will acquire, except by, through or under Kerr-McGee, any rights, directly or indirectly, involving the lands and properties located within the area known as "AREA OF INTEREST" depicted on the plat attached hereto as Exhibit "A" which by this reference is incorporated herein.

The term "Evaluation Material" does not include information, if any, which (i) becomes generally available to the public other than as a result of a disclosure by you or by other persons, including your employees and agents, to whom you have disclosed such information; (ii) was available to you on a non-confidential basis

prior to its disclosure to you by Kerr-McGee, provided that such prior disclosure and its non-confidential status are evidenced in writing and (iii) becomes available to you on a non-confidential basis from a source other than Kerr-McGee, provided that such source is not bound by a confidentiality agreement with Kerr-McGee.

You agree to be responsible for enforcing the confidentiality of the Evaluation Material provided, and you agree to take such action, legal or otherwise, to the extent necessary to prevent any disclosure by any of your agents or employees. You further acknowledge that Kerr-McGee shall be entitled to equitable relief by way of injunction if you breach or threaten to breach any of the provisions of this letter agreement. In the event Kerr-McGee deems it appropriate to initiate any action or enforce your obligations hereunder, you agree to reimburse Kerr-McGee for all costs and expenses, including reasonable attorney's fees, incurred by it in this regard.

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If you are in agreement with the foregoing, then please sign, date and return this letter which will constitute our agreement with respect to the subject matter of this letter.

By _____
H. W. Holmberg
Director-Metals Exploration
Kerr-McGee Corporation

ACCEPTED AND AGREED TO effective the
_____ day of _____, 19 91.

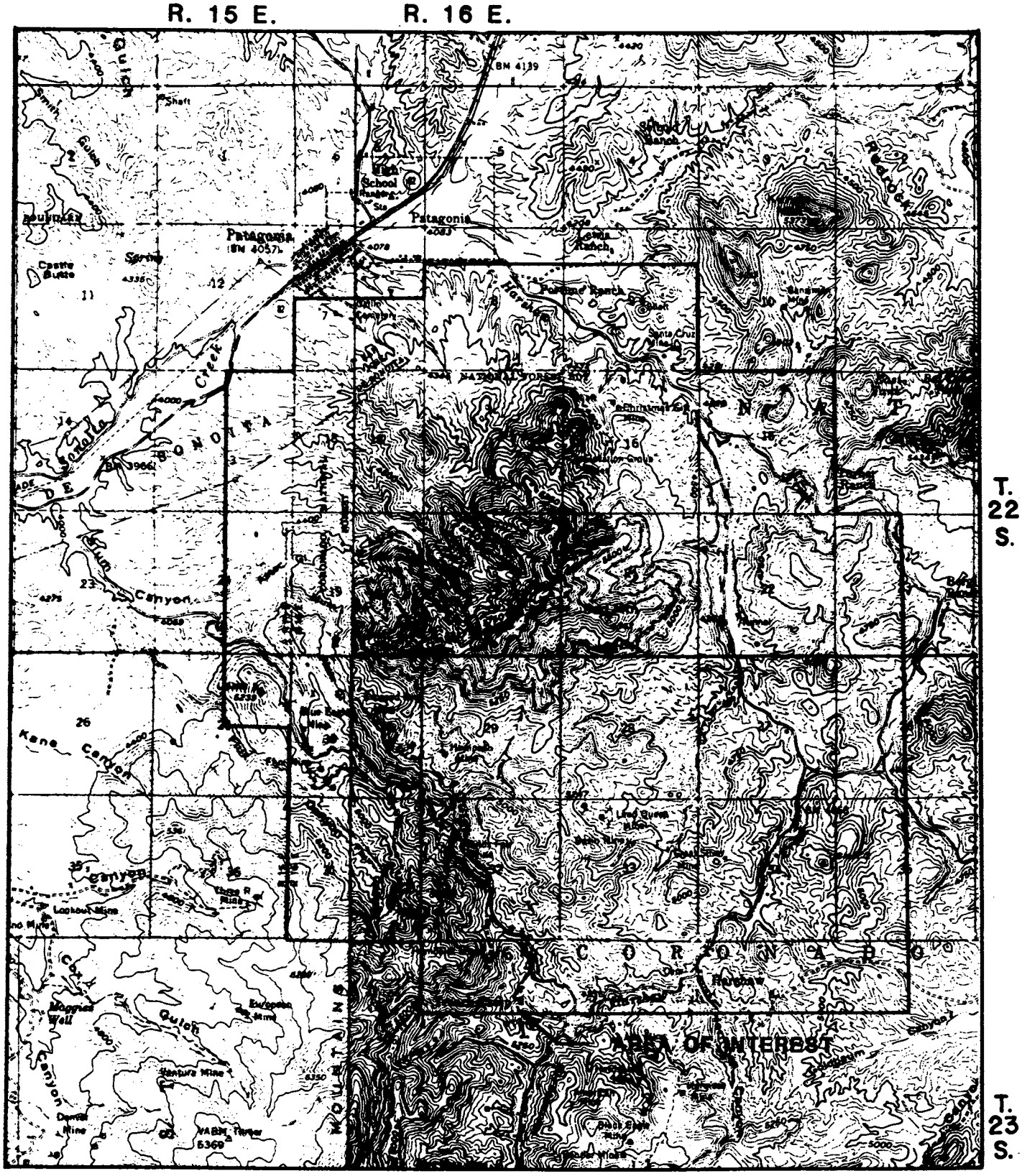
WESTMONT MINING INC., an Illinois corporation

By: _____
Paul S. Taylor

Title: Vice President - Exploration

5839M-AZ

EXHIBIT "A"
AREA OF INTEREST PLAT
ATTACHED TO AND MADE A PART OF THAT CERTAIN
CONFIDENTIALITY AGREEMENT
BY AND BETWEEN
WESTMONT MINING INC.
AND
KERR-McGEE CORPORATION



ORIGINAL #1

5839M-AZ

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By _____
H. W. Holmberg
Director-Metals Exploration
Kerr-McGee Corporation

ACCEPTED AND AGREED TO effective the
_____ day of _____, 19 91.

WESTMONT MINING INC., an Illinois corporation

By: _____
Paul S. Taylor

SIGN HERE Title: Vice President - Exploration

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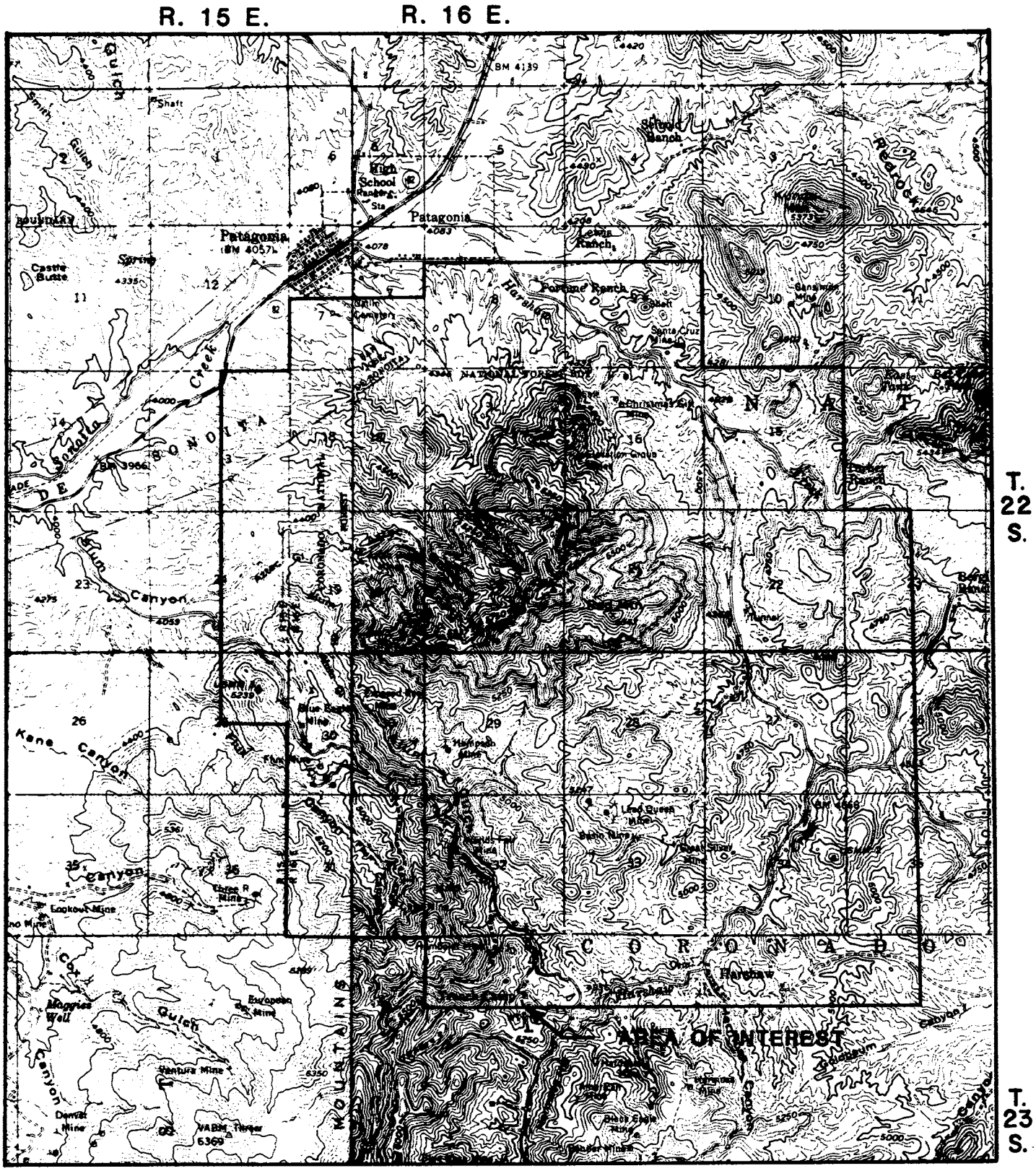

ORIGINAL #2

5839M-AZ

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By _____
H. W. Holmberg
Director-Metals Exploration
Kerr-McGee Corporation

ACCEPTED AND AGREED TO effective the
_____ day of _____, 19 91.

WESTMONT MINING INC., an Illinois corporation

SIGN HERE By: _____
Paul S. Taylor

Title: Vice President - Exploration

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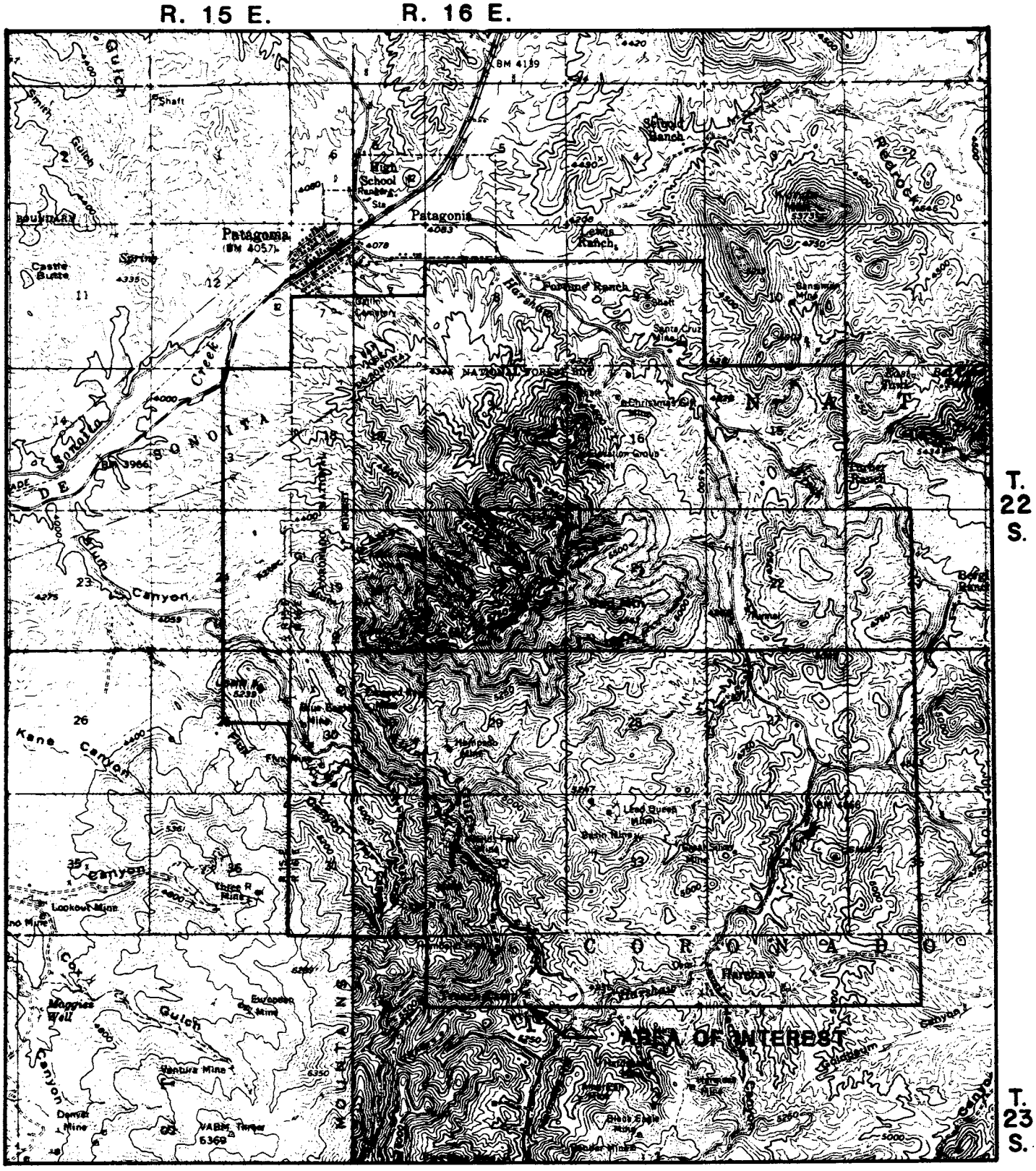

CAMBIOR USA, INC.

MEMORANDUM

To: Randy Moore

From: Gary Parkison GP

Date: December 28, 1994

Subject: Kerr-McGee's Red Mountain Copper Deposit, Arizona

At the 'Bootprints' Conference in Tucson in October, I ran into Bill Leedy who was soliciting interest on behalf of Kerr-McGee for their Red Mountain deposit (Leedy's résumé is enclosed, he most recently worked for Kerr-McGee at Red Mountain). As a result, I recently received this data package from Bob Roe of Kerr-McGee.

Last September, I talked with Lawrence about this property and sent her my file info for her to look at. This most recent information does not change my opinion of the property. While the chalcocite blanket at Red Mountain is the only thing of possible interest, the relatively small size of the minable portions of the deposit, probable high stripping ratios owing to steep topography, problems with location of heaps, dumps, etc., as well as serious permitting problems suggest no further action is warranted. In any event, this information is for your files. If you concur with my comments, somebody should contact Kerr-McGee.

GP/dj

WILLARD P. LEEDY
1533 Arabian Ave.
Rifle, CO 81650
(303) 625-2248

OBJECTIVE:

National or international senior level position in mineral exploration and evaluation building on accumulated knowledge and experience for discovery and acquisition of base and precious metal properties.

QUALIFICATIONS AND BACKGROUND:

25+ years of experience and expertise in a wide spectrum of mineralizing systems and metal commodities. Experience includes project management and evaluation of properties from grassroots exploration through development drilling and reserve assessment.

EXPERIENCE:

KERR-McGEE CORPORATION

Senior Minerals Geologist (1991 - 1994)

- Utilized professional and technical skills to evaluate mineral properties for acquisition.
- Technically evaluated joint venture properties which enhanced understanding and success of mineral discovery.
- Redefined and re-evaluated a Cu porphyry system which led to a 4-fold increase in the drill-indicated resource.
- Re-evaluated a carbonate-hosted Cu-Pb-Zn-Ag system utilizing metal ratios to define fluid conduits and structural and stratigraphic controls to identify new target zones.

Exploration Geologist (1980 - 1991)

- Initiated and managed exploration programs for base and precious metals in Arizona, California, Nevada, Oregon, Montana and Wyoming.
- Compiled regional geology to delineate favorable environments for mineral exploration.
- Supervised field crews and conducted regional and local reconnaissance programs, geochem surveys and geophysical surveys resulting in numerous targets identified and drilled. Discoveries include two properties with significant gold resources.

Senior Geologist (1974 - 1980)

- Managed hard rock uranium exploration programs in Maine and Wyoming.
- Conducted porphyry copper exploration in Arizona.

EDUCATION:

B.S. Colorado State University - 1967
Ph.D State University of New York at Buffalo - 1971

DEC 21 1994

KERR-McGEE CORPORATION
KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

SAFETY & ENVIRONMENTAL AFFAIRS DIVISION
H.W. Holmberg
Director - Minerals Exploration

December 14, 1994

Mr. Gary Parkinson
Cambior USA, Inc.
8101 E. Prentice Ave., Suite 800
Englewood, CO 80111

Dear Mr. Parkinson:

This is to advise you that Kerr-McGee Corporation is offering its Red Mountain and Thunder Mountain copper projects for sale or other mutually acceptable transaction. Kerr-McGee understands that Cambio has a sincere preliminary interest in pursuing a possible transaction for said projects. In order to advance your interest through review of detailed data, attached herewith are a Prospectus outlining significant features of said projects and two original Confidentiality Agreements for your review. Should you decide to pursue an in-depth data review, please execute one original Confidentiality Agreement and return it to my attention. Upon receipt, arrangements will be made to allow inspection of pertinent exploration data ("Evaluation Material") in Kerr-McGee Corporation's Oklahoma City office and to visit the properties.

Following your review of the Evaluation Material and completion of site visits, Kerr-McGee requests that you submit a detailed Proposal on or before March 31, 1995 including offering price and any additional requirements for completion of said transaction. Said Proposals will be reviewed and a decision made by April 30, 1995.

Please be aware that this offer is non-exclusive and that Kerr-McGee Corporation expressly reserves the right, in its sole and absolute discretion, to reject any or all Proposals at any time without providing any justification. Kerr-McGee Corporation also expressly reserves the right, without giving reasons, at any time and in any respect to amend the Process, terminate discussions with any or all Prospective Purchasers or to enter into exclusive negotiations with any party with respect to a transaction on said projects.

Please direct further inquires to either Mr. Bob Roe (405/270-3780) or me (405/270-3820) at the address shown on the Prospects (or fax 405/270-3010).

Thank you for your preliminary expression of interest and we look forward to reviewing Red Mountain and Thunder Mountain with you.

Sincerely,

KERR-McGEE CORPORATION
Safety & Environmental Affairs Division

H. W. Holmberg

H.W. Holmberg
Director - Minerals Exploration

HWH:nh
Enclosures

CONFIDENTIALITY AGREEMENT

In consideration for and as a condition of the furnishing to you by Kerr-McGee Corporation ("Kerr-McGee") of certain confidential and proprietary information relating to properties in the **Red Mountain** project located in **Santa Cruz** County, State of **Arizona** (the "Properties"), you acknowledge the confidential and proprietary nature of such information and agree to hold and keep the same confidential as provided in this letter agreement.

As used herein, the term "Evaluation Material" refers to all information that has been or may hereafter be provided to you by Kerr-McGee concerning the Properties, including without limitation financial, engineering, technical, title or other information, irrespective of the form of the communication.

You agree to exercise all reasonable steps to safeguard the confidentiality of the Evaluation Material and not to disclose any part of it or any information derived therefrom to any third person except to such limited number of your employees and advisors as (i) may require access to the Evaluation Material for the sole purpose of assisting you in evaluating a possible transaction with Kerr-McGee concerning the Properties and (ii) agree in writing to preserve the confidentiality of such Evaluation Material and to observe the other provisions hereof to the same extent as you agree herein. You agree that you will not copy or permit any of your outside agents, consultants, or advisors to copy any of the Evaluation Material without the prior written approval of Kerr-McGee. Promptly upon the completion of your review of the information or upon the request of Kerr-McGee, but in no event later than ninety (90) days from the date hereof, you will return to Kerr-McGee all Evaluation Material previously furnished to you, together with all copies of any of the same made by you or any of your employees or agents.

You acknowledge that the Evaluation Material is being furnished to you solely to assist you in evaluating a possible transaction with Kerr-McGee related to the Properties, and you agree that you will not use the Evaluation Material or any information derived therefrom for any other purpose.

The term "Evaluation Material" does not include information, if any, which (i) becomes generally available to the public other than as a result of a disclosure by you or by other persons, including your employees and agents, to whom you have disclosed such information; (ii) was available to you on a non-confidential basis prior to its disclosure to you by Kerr-McGee, provided that such prior disclosure and its non-confidential status are evidenced in writing; (iii) becomes available to you on a non-confidential basis from a source other than Kerr-McGee, provided that such source is not bound by a confidentiality agreement with Kerr-McGee.

You agree to be responsible for enforcing the confidentiality of the Evaluation Material provided, and you agree to take such action, legal or otherwise, to the extent necessary to prevent any disclosure by any of your agents or employees. You further acknowledge that Kerr-McGee shall be entitled to equitable relief by way of injunction if you breach or threaten to breach any of the provisions of this letter agreement. In the event Kerr-McGee deems it appropriate to initiate any action or enforce your obligations hereunder, and said action or enforcement is decided in Kerr-McGee's favor, you agree to reimburse Kerr-McGee for all costs and expenses, including reasonable attorney's fees, incurred by it in this regard.

Nothing contained herein shall be deemed to prevent the disclosure of any of the Evaluation Material if, in the written opinion of your counsel, such disclosure is legally required to be made in a judicial, administrative or governmental proceeding pursuant to a valid subpoena or other applicable order, provided, however, that you shall give Kerr-McGee at least ten (10) days' prior notice before disclosing any of the Evaluation Material in such a proceeding and, in making such disclosure, you shall take all reasonable efforts to preserve the confidentiality of the Evaluation Material.

You agree that neither you nor any of your employees or agents will, without the prior written consent of Kerr-McGee, disclose to any other person the fact that you are evaluating a possible transaction with Kerr-McGee relative to the Properties.

You understand that Kerr-McGee makes no representation or warranty as to the accuracy or completeness of the Evaluation Material. You agree that neither Kerr-McGee nor any of its employees or agents shall have any liability to you or any of your agents or employees resulting from your or their use of the Evaluation Material.

If you are in agreement with the foregoing, please sign and return one copy of this letter which will constitute our agreement with respect to the subject matter of this letter.

By _____
H.W. Holmberg
Director-Minerals Exploration
Safety & Environmental Affairs Div.
Kerr-McGee Corporation

Accepted and Agreed to this

_____ day of _____, 199__

By _____

Title _____

Company _____

CONFIDENTIALITY AGREEMENT

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By _____
H.W. Holmberg
Director-Minerals Exploration
Safety & Environmental Affairs Div.
Kerr-McGee Corporation

Accepted and Agreed to this

_____ day of _____, 199__

By _____

Title _____

Company _____

PROSPECTUS

RED MOUNTAIN PROJECT

ARIZONA

Kerr-McGee Corporation

Introduction

Kerr-McGee Corporation is seeking to sell or joint venture its Red Mountain property in Arizona. The property contains a drill-indicated copper resource whose tonnage, grade, and economic characteristics need to be more precisely established. Also, an opportunity for precious metal mineralization is suggested by the occurrence of anomalous gold over intervals of variable thickness within the shallow portion of several holes.

All data will be made available through a scheduled review upon execution and return of the attached Confidentiality Agreement to Mr. H.W. Holmberg, Kerr-McGee Corporation, P.O. Box 25861, Oklahoma City, Oklahoma 73125.

Location

The project is located in Townships 22 and 23 South, Range 16 East in the Harshaw Mining District, Santa Cruz County, Arizona. The property lies at the northern end of the Patagonia Mountains, two miles south of the community of Patagonia, Arizona and 18 miles northeast of Nogales, Arizona (Figure 1).

Property Position

The property consists of 36 patented lode mining claims and 446 unpatented lode mining claims totalling 9550.35 acres (mol.). Annual holding costs for assessment work and property taxes are $44,600 and $1,539.06 respectively (Figure 2).

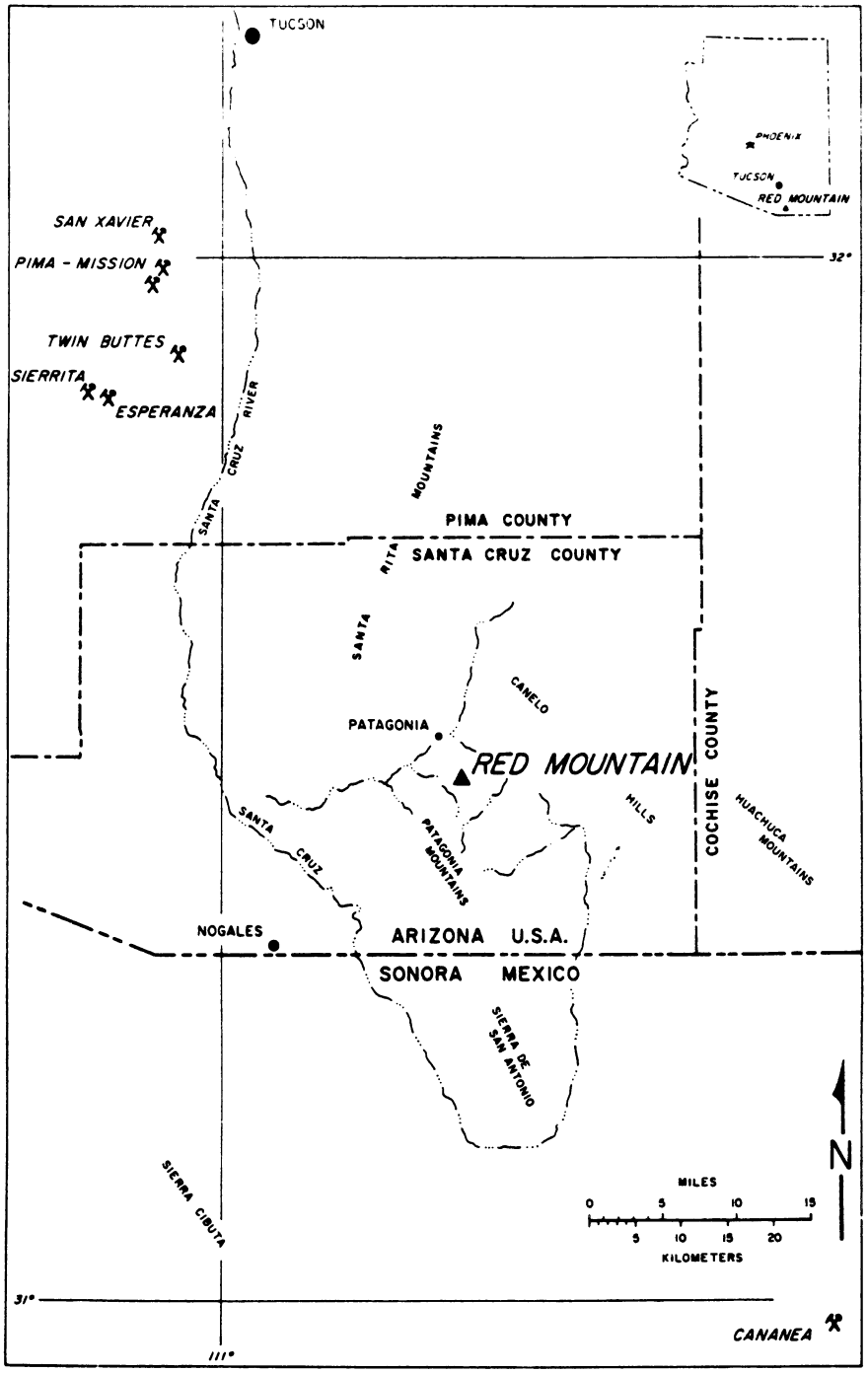
Exploration Data

Approximately 190,000 feet of drilling in 76 diamond core holes has been completed since exploration was initiated in 1961. Twenty-five holes exceed 5,000 feet in depth with the deepest being 5,790 feet.

Deviation and temperature surveys have been run on the deep holes and geochemical data have been obtained from samples taken at the surface and from drill cores. Detailed mapping of surface geology and alteration zoning have been compiled.

Geology and Mineralization

The geology of the Red Mountain area has been described by a number of authors, the most pertinent papers being: Schrader (1915), Drewes (1971 A & B and 1972 A & B), Simons (1971 and 1974), Corn (1975), Bodnar and Beane (1980), and Quinlan (1986).



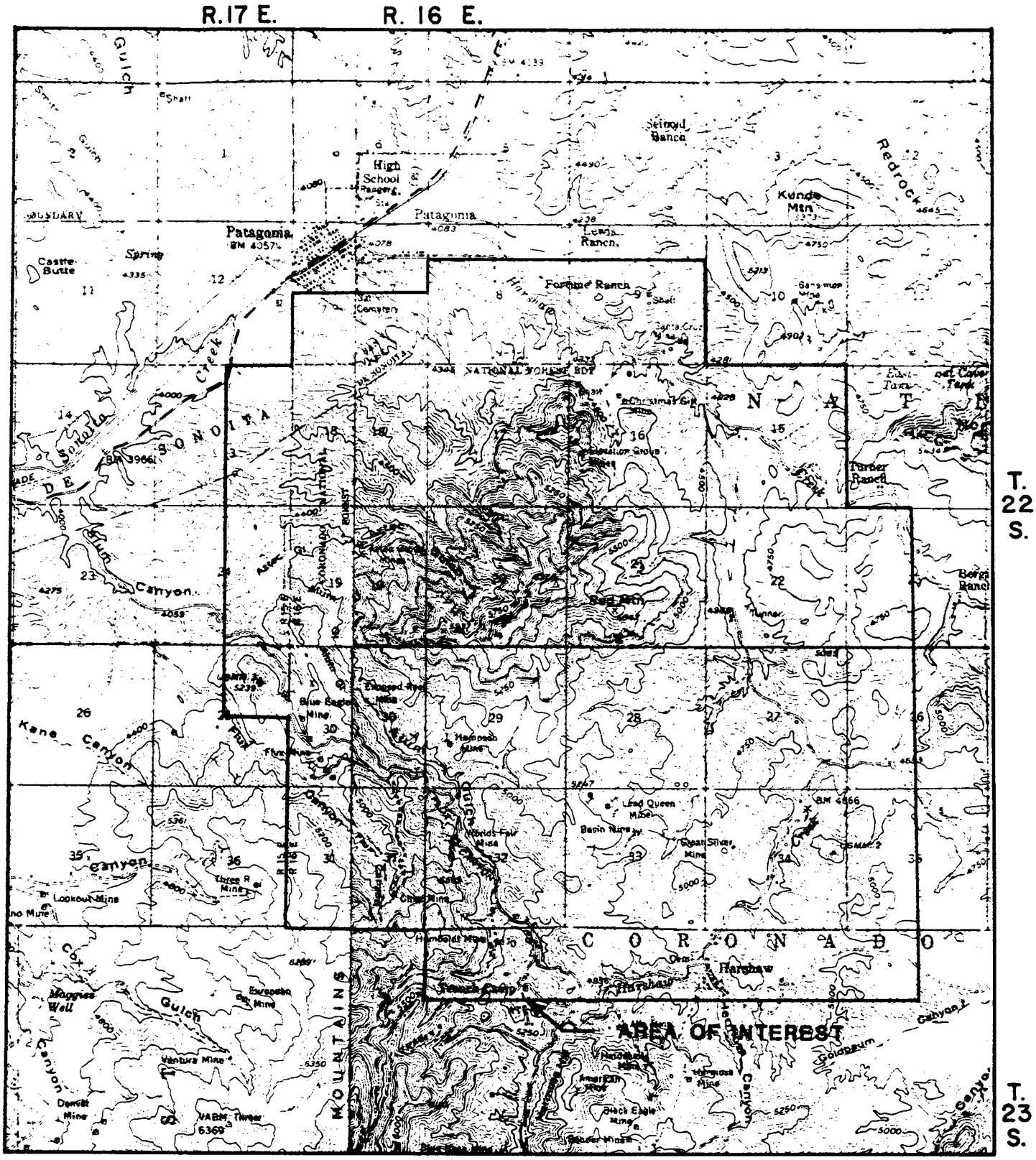
KERR-McGEE CORPORATION

RED MOUNTAIN PROJECT

INDEX MAP

SANTA CRUZ COUNTY , ARIZONA

FIGURE 1



RED MOUNTAIN PROJECT

LOCATION MAP

SANTA CRUZ COUNTY , ARIZONA

SCALE 1:62,500

FIGURE 2

Red Mountain is underlain by an altered complex of volcanic and intrusive rocks of Cretaceous and early Tertiary age. The volcanics are made up of three layered units. The uppermost unit, up to 2,400 feet thick, is referred to as the Tuff unit, and consists of rhyolitic to dacitic tuffs, flows, and breccias. Below that are about 3,000 feet of andesitic to trachyandsetic flows, breccias, sills, and dikes referred to as the Andesite unit. The lowest unit has not been completely penetrated by drilling and is referred to as the Felsite-latite unit. It consists of volcanic conglomerate and breccias, silicified tuffs, flows(?), interlayered and cut by latite sills and dikes. These units generally have a north strike and dip to the east at 15°.

The layered volcanics are cut by several varieties of porphyritic granodiorite and quartz monzonite. These occur as dikes and irregular bodies at outcrop and in drill holes.

Alteration is zoned laterally and vertically in relation to the copper mineralization and appears to be related to two hydrothermal events closely related in time and origin. It is more fully described in the enclosed paper by Quinlan (1986).

Copper mineralization at Red Mountain can be divided into three zones: (1) an upper level chalcocite blanket deposit, (2) a deep level bulk sulfide deposit, and (3) a breccia pipe within the core of the deep porphyry system. Principal sulfides are pyrite and chalcopyrite. Secondary chalcocite is present mainly in the blanket deposit.

Bornite and enargite have been identified in the drill core from the lower and upper portions of the system, respectively. Also present, but not common, are molybdenite, tennantite, galena and sphalerite.

In plan view the chalcocite blanket makes up an irregularly shaped body overlying the central portion of the deep level mineralization. It lies at an average elevation of 5,000 to 5,100 feet above sea level or 200 to 1,000 feet below the surface.

The deep level bulk sulfide deposit, although incompletely delineated, is roughly elliptical in plan with a low sulfide, low copper core appearing to be a nearly classic copper-sulfide shell. The axis of the ellipse trends northeasterly. The top of this deposit is generally at an elevation of 1,500 feet above sea level, or 4,000 feet below the surface.

The breccia pipe deposit lies within the southern part of the low sulfide, low copper, core of the deep level bulk deposit and appears elliptical in plan. It measures about 800 feet to 1,100 feet in plan diameter and extends downward from about 1,750 feet above sea level or 4,000 below the surface.

Copper Resource

Copper resources have been estimated for the three parts of the deposit as currently known, and total approximately 449 million tons grading 0.64% copper. The chalcocite blanket contains approximately 20 million tons grading 0.69% copper. The deep level bulk deposit contains approximately 380 million tons grading 0.58% copper, 0.009% molybdenum, 0.003 ounces gold per ton and 0.12 ounces silver per ton in the explored portion of the copper shell. The cutoff used was 0.3% copper. The breccia pipe contains approximately 49 million tons grading 1.14% copper, 0.025 molybdenum, 0.004 ounces gold per ton and 0.15 ounces of silver per ton utilizing a 0.3% copper cutoff.

Exploration Potential

Only one-half of the deep copper shell has been explored. The western limb of the deposit needs additional drilling to define the width and base of the copper shell. The open northeastern portion of the shell is considered very prospective. Additionally other breccia pipes may exist within the system and are highly attractive targets. With additional exploration it is possible that the copper resource at Red Mountain can be doubled.

A second area of untested potential may lie in the fact that anomalous gold is documented in the shallow portions of several of the holes drilled to date. Anomalous intervals, however, are composites over thick, randomly spaced sections of core and as such do not give a clear picture of the significance of this mineralization. Detailed core logging, sampling and geochemical analysis could identify precious metal opportunities in the Red Mountain area.

Selected Bibliography

Bodnar, R.J., and Beane, R.E., 1980, Temporal and spatial variations in hydrothermal fluid characteristics during vein filling in preore cover overlying deeply buried porphyry copper-type mineralization at Red Mountain, Arizona: Econ. Geol., v. 75, pp. 1437-1447.

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Simons, F.S., 1971, Mesozoic stratigraphy of the Patagonia Mountains and adjoining areas, Santa Cruz County, Arizona: U.S. Geol. Survey Prof. Paper 658-E.

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Arizona Geological Society Digest Volume XVI, 1986

GEOLOGY AND SILICATE-ALTERATION ZONING AT THE RED MOUNTAIN PORPHYRY COPPER DEPOSIT, SANTA CRUZ COUNTY, ARIZONA

James L. Quinlan
Kerr-McGee Corporation
Oklahoma City, Oklahoma 73125

ABSTRACT

The Red Mountain porphyry copper deposit located in southwestern Arizona (fig. 1) occurs within an altered complex of volcanic and intrusive rocks of Cretaceous and early Tertiary age. Silicate alteration, sulfide distribution, and assay data have been used to define the deposit.

As presently outlined, the deposit is divided into three parts: (1) a small, near-surface chalcocite blanket, (2) a near-classic, porphyry copper bulk sulfide deposit, 5,000 feet below the summit of the mountain and 3,500 feet below the chalcocite blanket, and (3) a deep-level breccia pipe in the core zone of the bulk sulfide deposit.

At least three major and distinct alteration and mineralization pulses are recognized at Red Mountain. Much of the alteration at the surface is the result of the supergene modification of a zoned and essentially copper-barren hypogene alteration system. Superimposed on the early hypogene system and recognized at depth is a smaller, more intense near-classic porphyry copper alteration zone with a partially defined copper-sulfide shell. The breccia pipe occurs within the core area of the shell and represents a later, even more restricted hydrothermal event. Silicate and sulfide zoning within the breccia pipe indicates that the pipe itself is a miniature zoned porphyry copper deposit.

The most obvious clue to the deep-level orebody at Red Mountain is the near-surface chalcocite blanket. The blanket deposit formed by secondary enrichment of copper in a low-grade halo or plume which extended upward from the deep-level deposit to the present surface, or at least 5,000 feet. Pyrite, largely from the phyllic zone of the early and essentially copper-barren alteration system, not only provided a favorable host environment in which the blanket could form, but also on oxidation provided much of the acid needed for the secondary enrichment process.

INTRODUCTION

Geologic Setting

Red Mountain is underlain by an altered complex of volcanic and intrusive rocks of Cretaceous and early Tertiary age. Figures 2 and 3 are generalized maps illustrating surface geology and alteration features. Figures 4 and 5 are diagrammatic cross sections showing geologic and alteration features.

Three layered volcanic units are recognized at Red Mountain. The upper, or tuff unit, consists mainly of tuffs, flow, and breccias of rhyolitic and dacitic composition. It crops out over much of the mountain and is up to 2,400 feet thick (figs. 2 and 4). It is essentially the same as the "Volcanics of Red Mountain" described by Drewes (1971a), which he correlates with the Gringo Gulch volcanics of Paleocene(?) age.

Underlying the tuff unit are approximately 3,000 feet of andesite and trachyandesite flows, breccias, sills, and dikes locally referred to as the andesite unit. Hornfels bands occur near the base of the unit. The andesite unit crops out on the flanks of Red Mountain and is cut in drill holes (figs. 2 and 4). It is part of the Upper Cretaceous trachyandesite or doreite (Ka) unit, mapped and described by Simons (1974). Simons reported a potassium-argon date of 72.1 ± 3 m.y. B.P. for a sample from the unit.

The lowest layered rock unit is the felsite-latite unit. It underlies the andesite unit and includes interlayered andesites near the top. It consists mainly of volcanic conglomerates and breccias, silicified tuffs, flow(?), interlayered and cut by latite sills and dikes. The unit crops out in Alum Gulch on the south side of Red Mountain and is recognized in deep drill holes on the south and west flanks of the mountain (figs. 2 and 4). It correlates with the Upper Cretaceous silicic volcanics (Kv and Kla Units) mapped by Simons (1974).

The layered rocks at Red Mountain are cut by several textural varieties of porphyritic rocks, which range in composition from granodiorite to quartz monzonite. The porphyries are recognized as dikes and irregular bodies in outcrop and drill holes (fig. 2 and 4).

The layered rocks generally strike north and dip 14° E. The dominant trend of local shears and fractures is N. 20° E. with steep dips toward the northwest and southeast. Less numerous are shears and fractures that strike N. 70° E. and dip steeply northwest or southeast. No large faults are recognized on the mountain, but several occur on its flanks (fig. 2).

Silicate Alteration

Silicate alteration at Red Mountain is easy to recognize but difficult to interpret. Near the center of the deposit, changes in the alteration assemblage

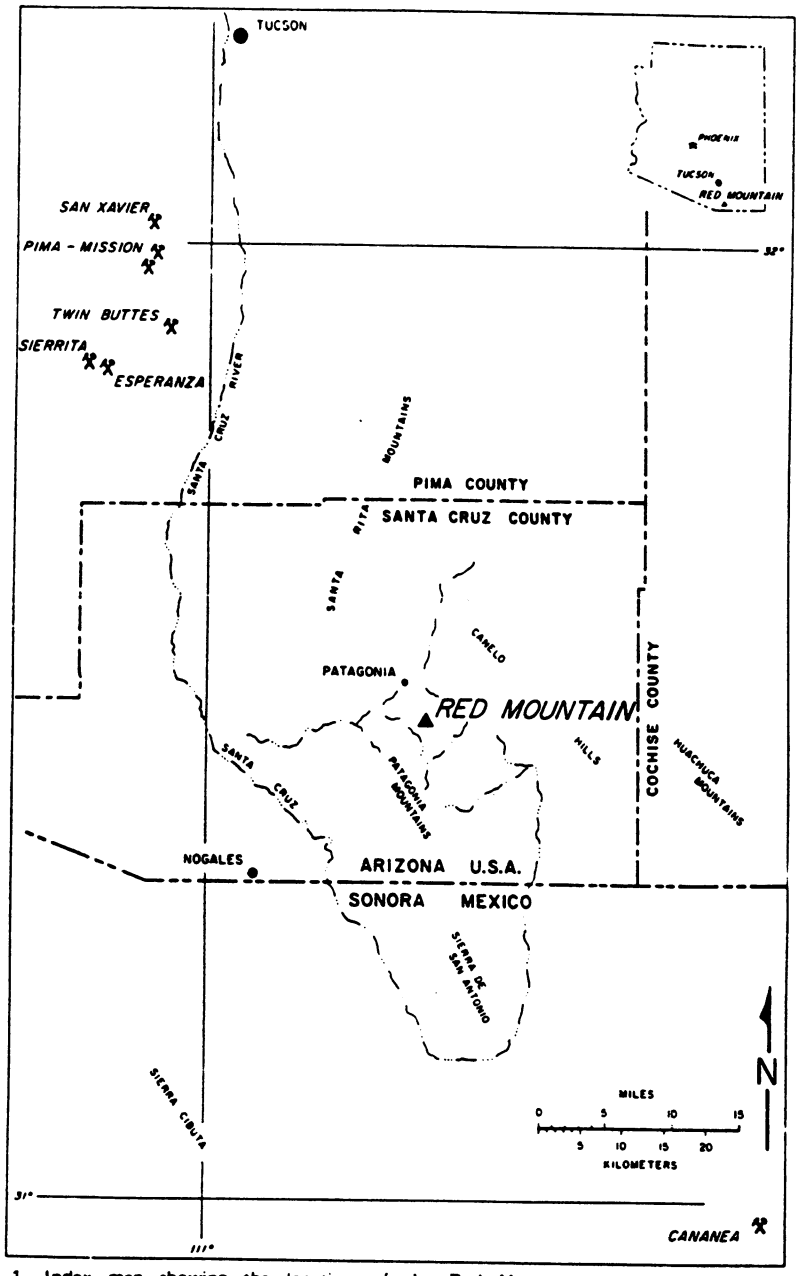

Fig. 1 Index map showing the location of the Red Mountain porphyry copper deposit. After R.M. Corn, Economic Geology, Vol. 70, No. 8, Dec. 75

with depth are most obvious (fig. 5). Lateral zoning at depth, which is a critical guide to ore, is much more subtle and to date has been best quantified by thin-section studies (fig. 6).

The strong vertical alteration zoning recognized at Red Mountain is partly controlled by differences in rock types with depth. Near the center of the system, the tuff unit is intensely altered to an assemblage of quartz-sericite-pyrite-kaolinite-alunite. The sericite content increases with depth, whereas the content of kaolinite and alunite decreases. At the tuff-andesite contact, the assemblage abruptly changes to quartz-sericite-chlorite-pyrite with minor hematite and kaolinite. With the exception of outlying Hole 158, the pyrite content rapidly decreases in depth through the upper part of the andesite unit (fig. 7). The alteration assemblage further changes with depth within the andesite through a biotite-magnetite-pyrite assemblage to a biotite-orthoclase-anhydrite-magnetite-chalcopyrite assemblage. Within the felsite-latite unit, the assemblage is orthoclase-quartz-anhydrite-chalcopyrite-biotite. The alteration within the porphyritic rocks is generally reflective of the adjacent intruded rock and depth. It is expressed by a quartz-sericite-pyrite-kaolinite assemblage at shallow depths and an orthoclase-anhydrite-biotite-chalcopyrite assemblage at greater depths.

The lateral changes in alteration are much more subtle. At the surface, hypogene alteration is strongly masked by supergene effects but is discernible. Within the tuff unit, the lateral zoning is expressed as a central core area of more abundant sericite, quartz veining, and limonitic stain (fig. 3). Outward from the core area, a more argillic zone is characterized by abundant clays and alunite with less sericite, silica, and iron. The transition from

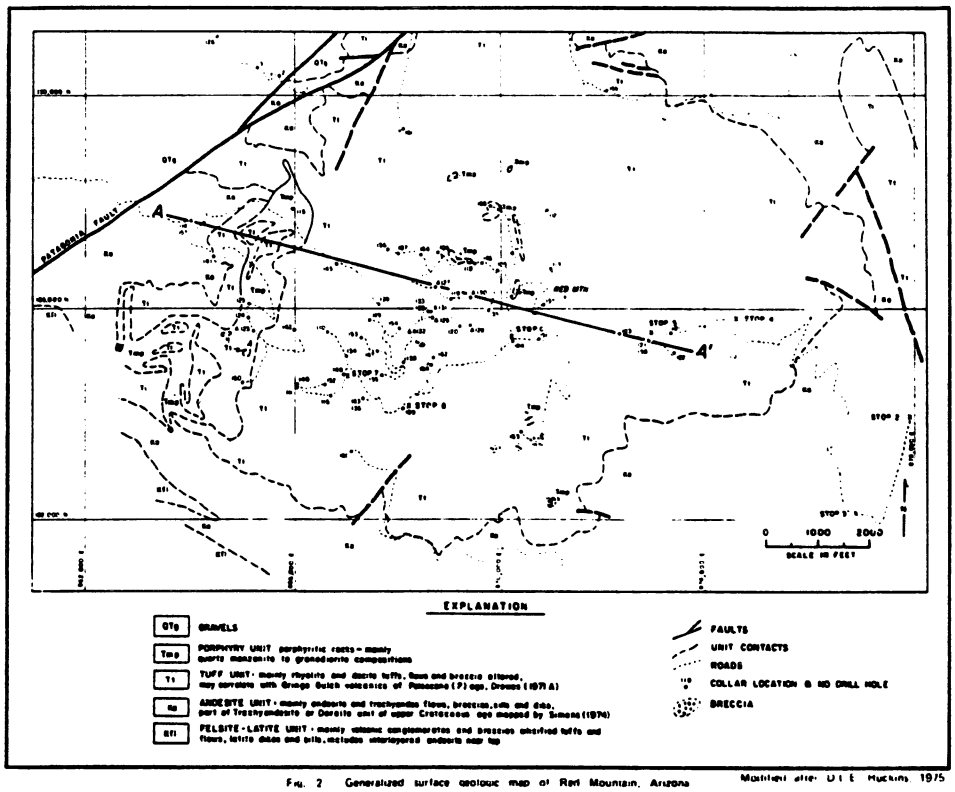

Fig. 2 Generalized surface geologic map of Red Mountain, Arizona

Modified after D.L.E. Huckins, 1975

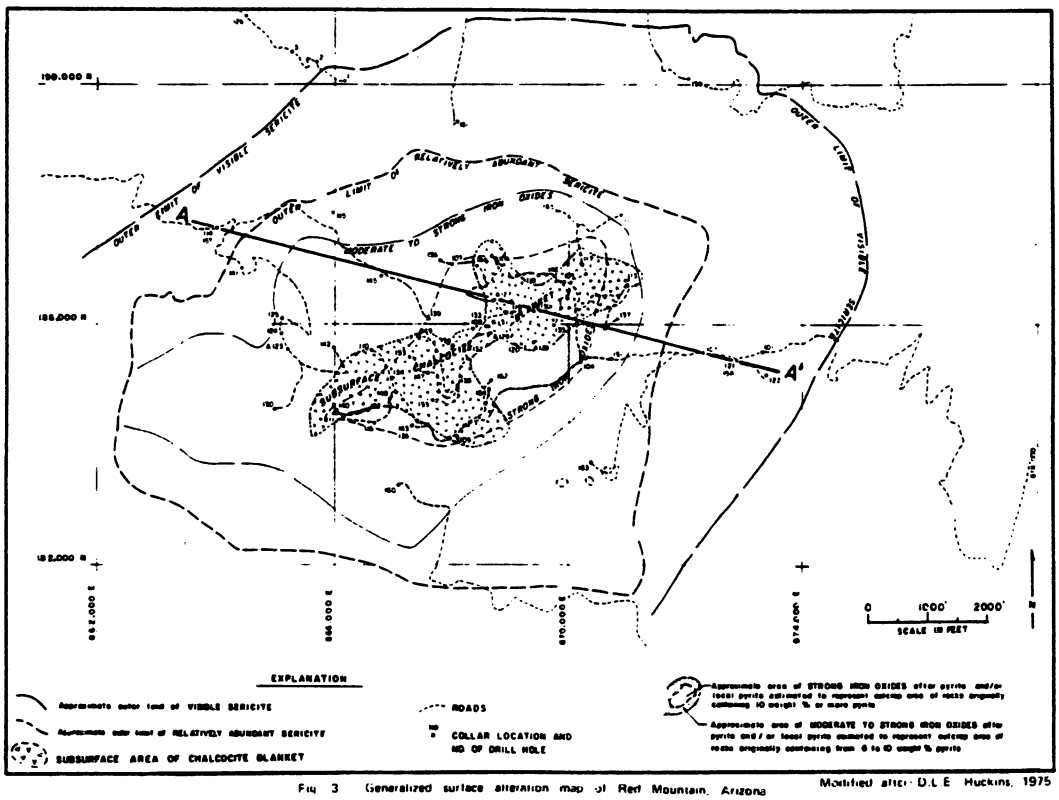

Fig 3 Generalized surface alteration map of Red Mountain, Arizona

Modified after D.L.E. Huckins, 1975

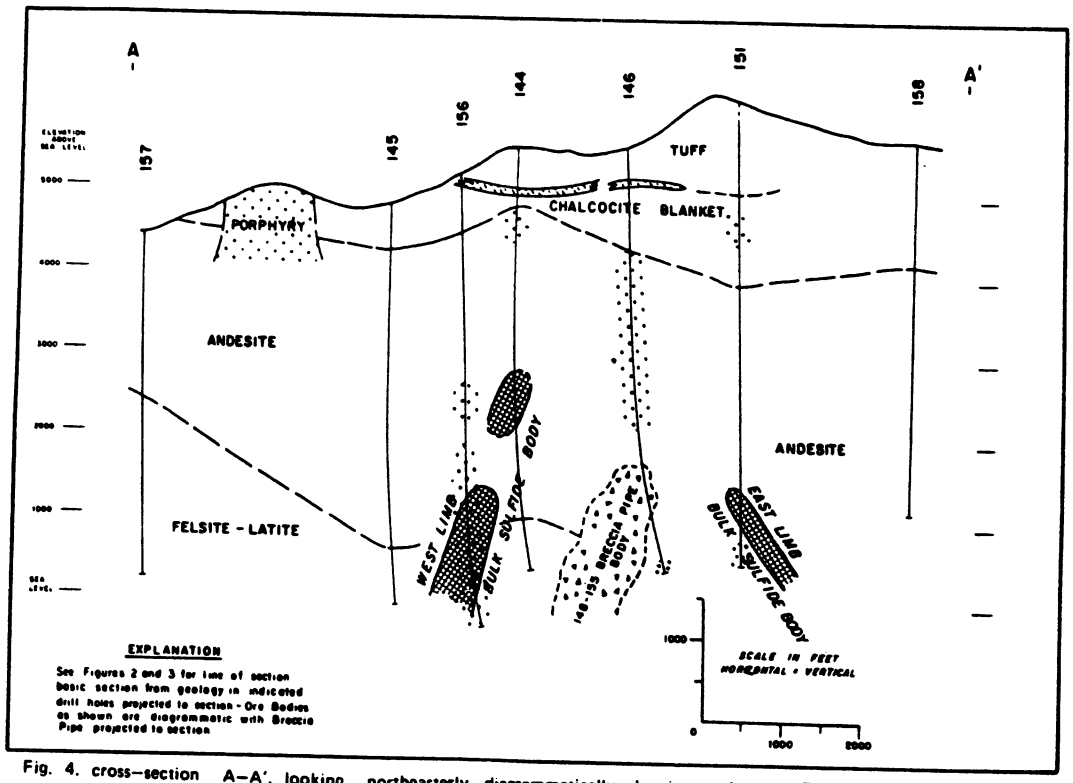

Fig. 4. cross-section A–A'. looking northeasterly, diagrammatically showing geology at Red Mountain, Arizona .

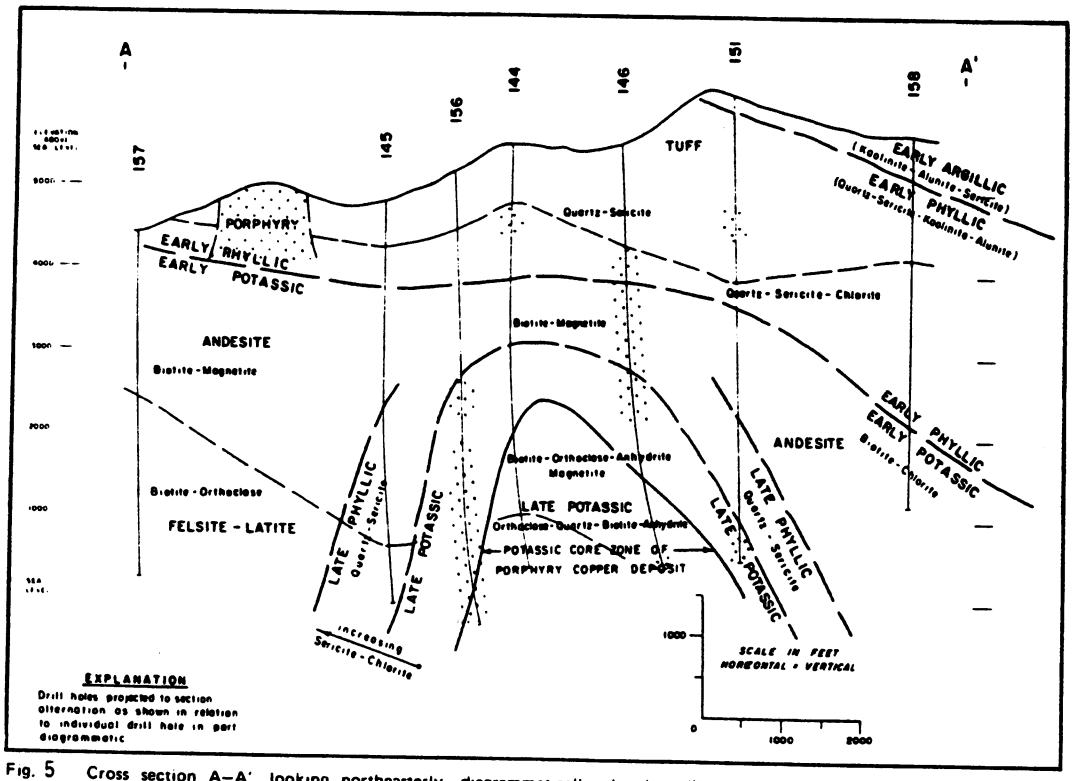

Fig. 5 Cross section A–A', looking northeasterly, diagrammatically showing silicate alteration at Red Mountain, Arizona.

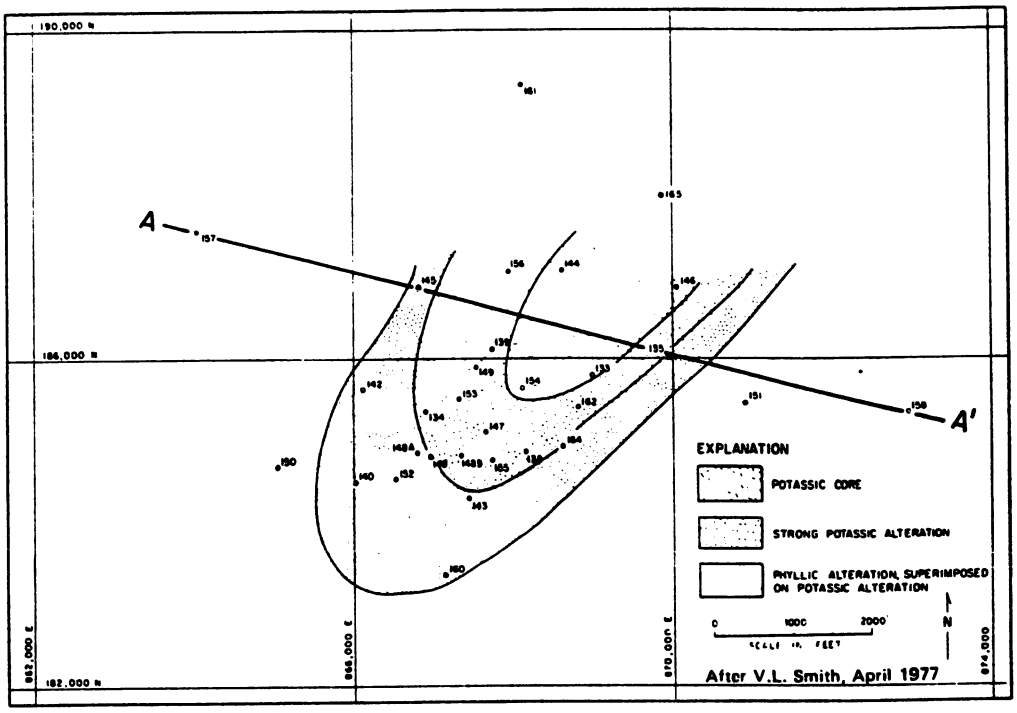

Fig. 6 Map showing silicate alteration between elevations 2,000' and 2,500' at Red Mountain, Arizona. Developed from petrographic study of thin sections from selected holes.

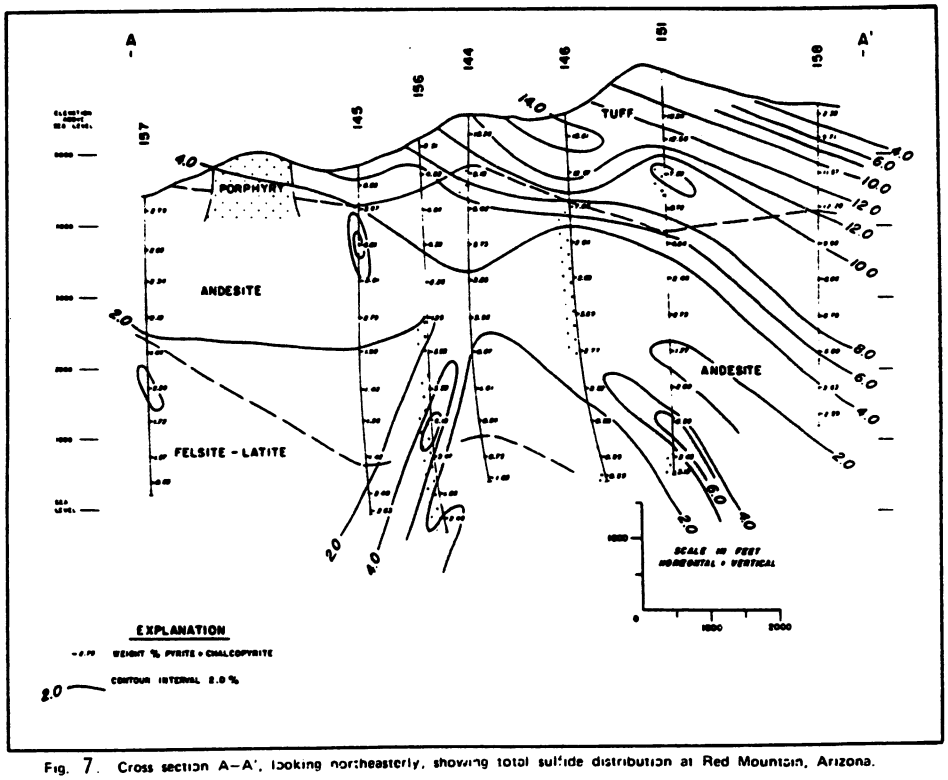

Fig. 7. Cross section A–A', looking northeasterly, showing total sulfide distribution at Red Mountain, Arizona.

sericitic-argillic alteration within the tuff unit to propylitic alteration in the surrounding andesite unit to the northeast, east, south, and southwest appears to be partly due to change in rock type. The suggestion is that the alteration mushroomed or extended farther laterally from a mineralization center in the tuff unit than in the underlying andesite unit. Within the andesite unit on the west and northwest flanks of the mountain an intense supergene argillic alteration is superimposed directly upon hypogene biotite-magnetite alteration. Within this area of relatively low original pyrite, chalk turquoise was formed as the more common supergene copper mineral within the argillized andesite.

At depth, the central core area is marked by an orthoclase-quartz-biotite-anhydrite alteration mineral assemblage. There is a general decrease in the amount of these minerals outward from the core area with increasing amounts of sericite and chlorite. This is illustrated on figure 6, which was developed from a study of thin sections obtained from selected holes between elevations of 2,000 and 2,500 feet.

Father out, as seen in Holes 157 and 161, a biotite-magnetite assemblage is recognized in the andesite unit. In Hole 157, this assemblage changes to biotite-orthoclase in the felsite-latite unit. Although the assemblage is potassic, the intensity of the potassic alteration appears much less than that recognized in the core area of the deposit. Locally, late quartz-pyrite veinlets enclosed in sericitic envelopes cut the previously described alteration features.

Figure 5 illustrates in cross section, my concept of the major silicate alteration features at Red Mountain; that is, a large early zone alteration system that accounts for most of the alteration recognized at the surface. The primary porphyry copper deposit lies in the potassic zone of this large early system. The alteration associated with the primary deposit has been superimposed on the early alteration system and zoning is similar to that described by Lowell and Guilbert (1970) and Rose (1970). It is suspected that the two silicate alteration systems are closely related in origin and time with the porphyry copper phase representing a late but more restricted event in the development of the complex Red Mountain hydrothermal system. The sulfide distribution data also clearly point to two distinct alteration phases as does the fluid inclusion data of Bodnar and Beane (1980).

Sulfide Distribution

The principal sulfide minerals at Red Mountain are pyrite and chalcopyrite. Secondary chalcocite is present, particularly in the blanket deposit. Bornite has been identified in deep holes near the center of the system and enargite in the upper part of holes overlying the deep orebody. Small amounts of molybdenite, tennantite, galena, and sphalerite have been identified locally.

The sulfide content of the rocks at Red Mountain has been estimated during core logging and in the deep holes has been determined on the basis of sulfur and sulfide sulfur assays.

For the purposes of the sulfide distribution studies, it has been assumed that pyrite and chalcopyrite are the only significant primary sulfide minerals in the Red Mountain system. The amounts of each below the zone of secondary enrichment are calculated from copper and sulfide sulfur data by assigning the amount of sulfide sulfur needed to convert the copper present in an interval to chalcopyrite and assigning the remaining sulfide sulfur to pyrite. Sulfate data have been converted to anhydrite equivalents where anhydrite is recognized in the deep drill holes.

The sulfide data have been assembled and posted in several different manners on plans and cross sections; that is, by rock type and as various elevation intervals. Most revealing are the bulk data when assembled and posted at elevation intervals of 500 feet or more. In general, plans and sections have been prepared showing pyrite, chalcopyrite, and total sulfide (combined pyrite and chalcopyrite) distribution, and pyrite to chalcopyrite ratios. Pyrite and total sulfide maps and sections are reflective of each other, and maps and sections showing pyrite distribution are not included in this report.

Plan illustrations accompanying this report show relative bulk chalcopyrite (fig. 8), total sulfide distribution (fig 9), and relative pyrite to chalcopyrite ratios (fig. 10) between elevations of 500 and 1,500 feet. All three maps show the same basic pattern and closely match the silicate alteration pattern shown in figure 6. Although drilling has yet to outline the entire system, available data indicate an elongate but nearly classic copper-sulfide shell. Thus all three plans, and in particular the ratio map (fig. 10), are useful in indicating where a drill hole lies within the system.

Cross sections prepared from the sulfide data, that is, data assembled at 500-foot elevation intervals, not only confirm the picture developed in plan but add to it. Total sulfide and chalcopyrite data have been assembled on Section A-A', which passes through the core area of the lower sulfide system as well as outlying Holes 157 and 158 (figs. 7 and 11). The section showing total sulfide distribution (fig. 7) clearly demonstrates a two-part system. A large primary sulfide high, mostly pyrite, is recognized near the surface in the upper parts of the central drill area and in Hole 158. This pyrite is within and generally an integral part of the intense quartz-sericite alteration assemblage recognized at the surface. The section also suggests that Hole 157 lies in the core area of the large primary sulfide system and would account for the potassic alteration recognized in the hole. It is also apparent that the strong iron oxides recognized on the upper western slope of Red Mountain (fig. 3) are related to the upper sulfide system.

The copper system recognized at depth in the central drill area and shown on the sulfide distribution and ratio maps (figs. 8, 9, and 10) is also apparent in the cross sections showing total sulfide and chalcopyrite distribution (figs. 7 and 11). Although the amount of total sulfides in the lower system (fig. 7) is less than that in the upper system, it is clear on figure 11 that the copper is associated with the lower system. Further, it is apparent in sections that the lower sulfide system closely follows the central area silicate system, and like the silicate system, is superimposed on the earlier and larger system.

THE ORE SYSTEM

For discussion purposes, the Red Mountain deposit is divided into three separate and distinct parts: (1) an upper-level chalcocite blanket deposit, (2) a deep-level bulk sulfide deposit, and (3) a breccia pipe deposit within the core area of the deep porphyry copper system.

Chalcocite Blanket

Chalcocite is recognized along fractures and as coatings on pyrite grains from the surface to a depth of 2,500 feet or more. Much of the chalcocite appears to be concentrated in a flat blanketlike deposit near an elevation of 5,000 feet and within the high pyrite

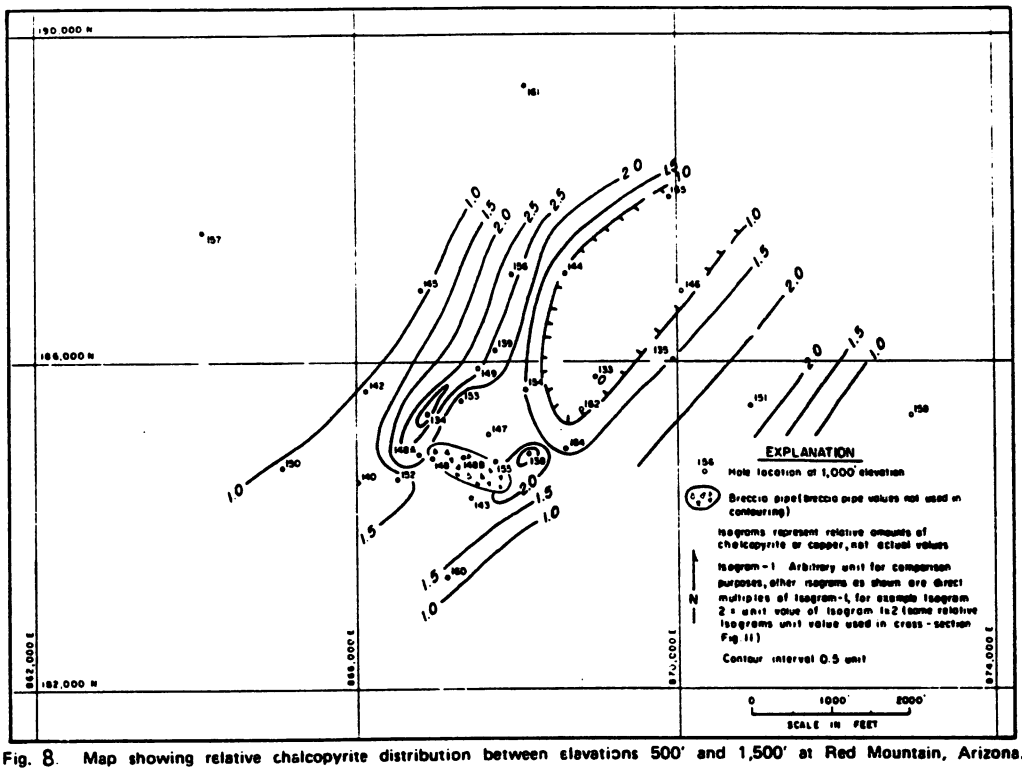

Fig. 8. Map showing relative chalcopyrite distribution between elevations 500' and 1,500' at Red Mountain, Arizona.

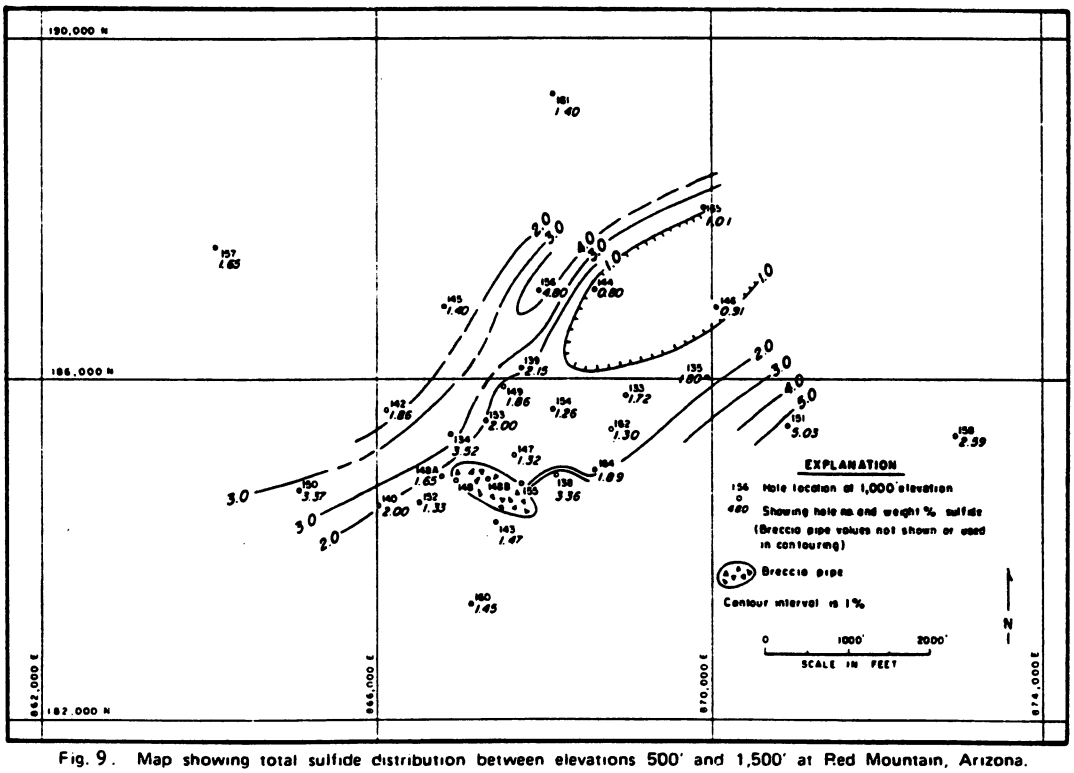

Fig. 9. Map showing total sulfide distribution between elevations 500' and 1,500' at Red Mountain, Arizona.

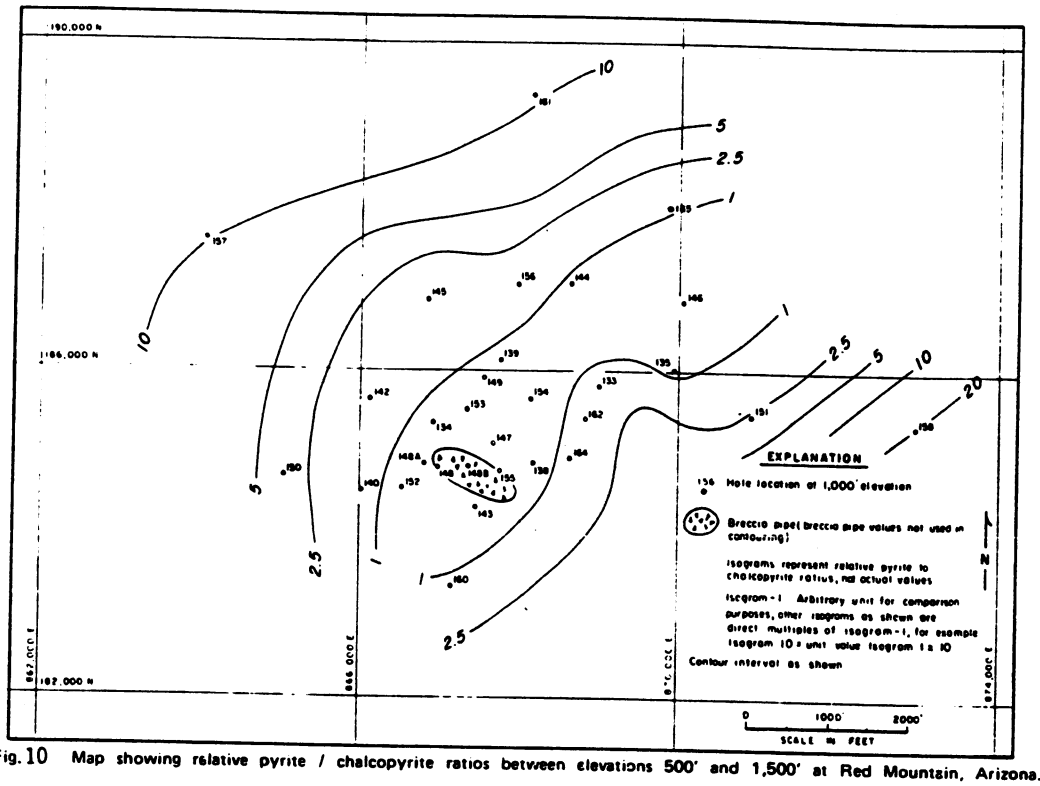

Fig. 10 Map showing relative pyrite / chalcopyrite ratios between elevations 500' and 1,500' at Red Mountain, Arizona.

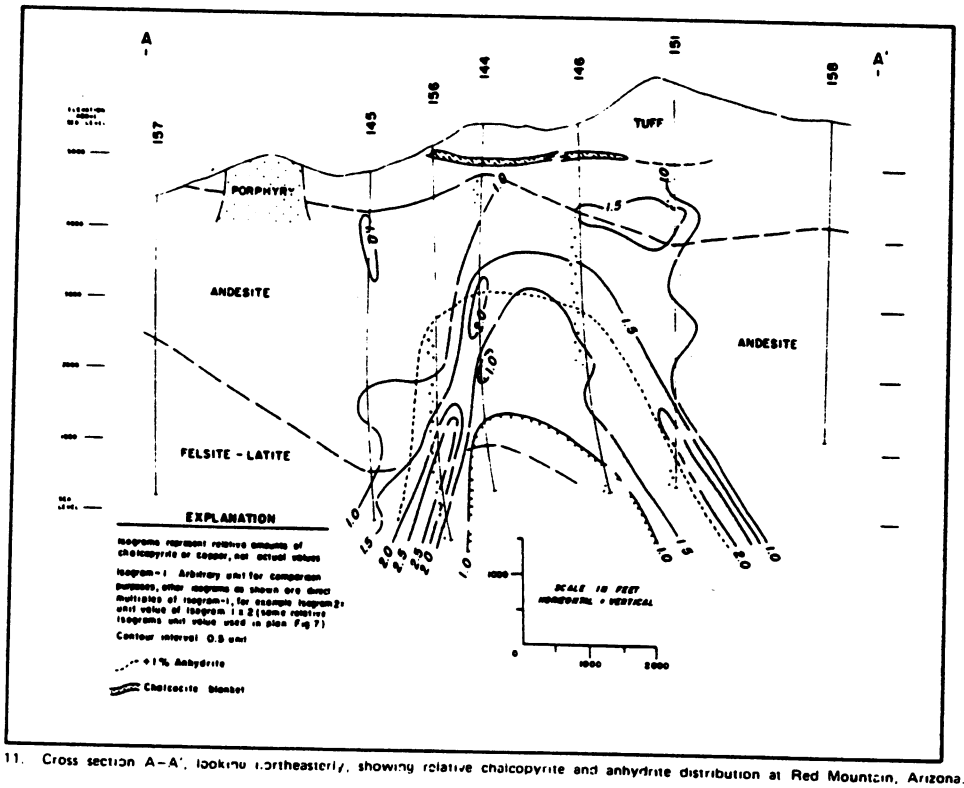

Fig. 11. Cross section A–A', looking northeasterly, showing relative chalcopyrite and anhydrite distribution at Red Mountain, Arizona.

zone of the early alteration system (figs. 10 and 11). As currently defined, the blanket ranges in thickness from 15 to 150 feet. It appears to be in the process of being destroyed by weathering and erosion. The deeper scattered chalcocite showings, which are usually controlled by fissures or shears probably represent recent copper migration.

The chalcocite blanket almost directly overlies the deep porphyry copper orebody (figs. 3 and 11). The distribution of copper above the deep porphyry copper system, as reflected by the relative copper or chalcopyrite values shown in figure 11, suggests that the blanket was formed by enrichment of a protore halo or plume extending at least to the present surface, or 5,000 feet above the main ore system. Pyrite from the early phyllic zone undoubtedly played an important part in the formation of the blanket. Not only did it provide a favorable host environment for deposition of chalcocite but also is the primary source of acid for the secondary enrichment process. Also, Bodnar and Beane's (1980) description of late-stage mineralization in a quartz-pyrite veinlet containing minor chalcopyrite and galena in a surface sample, RM 11, is evidence that the ore-stage primary mineralization extends far above the main deposit.

Deep-level Bulk Sulfide Deposit

The zone of deep-level porphyry copper mineralization at Red Mountain is an integral part of the copper shell as recognized in the alteration and sulfide study. Holes 146, 165, and the deeper parts of Hole 144 describe the low-sulfide, low-copper core of the system. A low-sulfide, low-copper tail extends from the core and is recognized in seven holes, 133, 135, 154, 147, 143, and 152. A breccia pipe is defined in Holes 148, 148B, 148C, and 155 and lies within the elongate tail area.

Nine drill holes are immediately peripheral to the core area and the elongate tail, and it is in the area of these nine holes that most of the deep-level copper outside the breccia pipe occurs. Seven of the nine holes contain thick and/or higher grade ore intervals. Ore is recognized on both the west and east limbs of the copper shell (fig. 4).

Much, if not most, of the deep-level copper occurs as chalcopyrite along veinlets and fractures, and only a small amount occurs as disseminated grains. From work to date, it is obvious that the area of the copper shell is not uniform in grade and not every where of interest. Local controls and structure apparently played an important part in copper mineralization within the shell area. For example, chalcopyrite enrichment is noted along both sides of andesite-porphyry contacts in several holes.

148-155 Breccia Pipe

The 148-155 breccia pipe recognized at Red Mountain has many features common to mineralized breccia pipes at other porphyry copper deposits. It is perhaps the deepest copper-molybdenum breccia pipe presently known anywhere in the world. Not only is it of potential economic interest because of the higher grade ore associated with it, but it is also of considerable scientific interest because of its depth, position within the system, and the mineralization and alteration associated with it.

The Dyna-drill has been used to control the direction of drill holes for a better evaluation of the pipe. In all, four holes (148-148B, 148C, and 155) have intersected the pipe (fig. 12).

The 148-155 breccia pipe, as envisioned from drill-hole data, is shown in plan and diagrammatic section in figure 12. Although in part diagrammatic, the plan and section represents a reasonable interpretation based on drill-hole intercepts within the pipe and the confining restrictions of adjacent holes. In plan, the intercepts in Holes 148 and 155 are about 800 feet apart and define the minimum dimension of the long axis of the pipe. The pipe has been assigned a long axis of 1,100 feet. The section better illustrates the available information. As shown, the top of the pipe is at an elevation of 1,750 feet or approximately 4,000 feet below the surface, and ore has been exposed over a vertical range of 1,300 feet. Hole 148 bottoms in ore within the pipe near sea-level elevation.

As mentioned before, the 148-155 pipe lies within the high-potassic, low-sulfide, and low-copper tail extending southward from the core of the deep porphyry copper system (fig. 10). The alteration within the pipe is separate and generally distinct from that of the surrounding rock. This is well exemplified in Holes 148B, 148C, and 155. These holes enter the pipe near its top from an area of low-sulfide, low-copper, and strong potassic alteration. At or within a few feet of the pipe contact, alteration abruptly changes to phyllic with abundant sericite and up to 30 percent by weight of pyrite. Strong phyllic alteration persists near the top of the pipe but gives way to potassic alteration with depth. Only in Hole 155 is a significant amount of possible mineralization leakage recognized above the pipe. Although the pipe contact is this hole is sharp and distinct, bands of pipe-type mineralization are evident for 40 feet above the pipe. Shears with chlorite, sericite, and quartz-sulfide veinlets similar to pipe mineralization are recognized up to 775 feet above the pipe.

Unlike many breccia pipes described in the literature, the mixing and movement of fragments great distances up or down the pipe has not been recognized in the 148-155 breccia pipe. Although fragments are broken and rotated, the composition of fragments, with but a few exceptions, appears to be similar to that of fragments in the immediate wall of the pipe. More detail is needed to substantiate this observation. It may also be noted that neither the contact between and andesite and felsite-latite units nor the thickest hornfels horizon appears disturbed or distorted near the breccia pipe.

The ore breccia generally consists of angular fragments of felsite and andesite in a matrix of orthoclase, quartz, anhydrite, chalcopyrite, and pyrite. Sericite is abundant near the top and is also recognized close to the sides of the pipe in deeper intercepts. Calcite, molybdenite, and a dark-gray sulfosalt, tentatively identified as tennantite, are accessory minerals. Breccia fragments are commonly an inch or less in diameter. The largest fragment recognized was 18 inches in diameter. Open vugs are common.

A distinctive unbrecciated but altered and mineralized quartz-eye porphyry intrusion occurs within the breccia pipe. Drilling intercepts, up to 65 feet long, suggest a dikelike structure. Brecciated fragments of the quartz-eye porphyry are recognized outside the main intrusive body but always near its margin. Sericite is the most common alteration product in the intrusion and and in areas of the pipe near where the intrusion is recognized. Within the intrusive body, the sericite is relic after plagioclase and biotite phenocrysts and also occurs as a major constituent in the altered fine-grained groundmass. Pyrite and chalcopyrite generally occur as fine disseminated grains within the intrusive body. These minerals are not nearly as abundant in the intrusion as in the brecciated areas of the pipe and generally constitute from about 1.5 to 3 weight percent of the rock. Though variable, the amount of pyrite generally exceeds the amount of chalcopyrite.

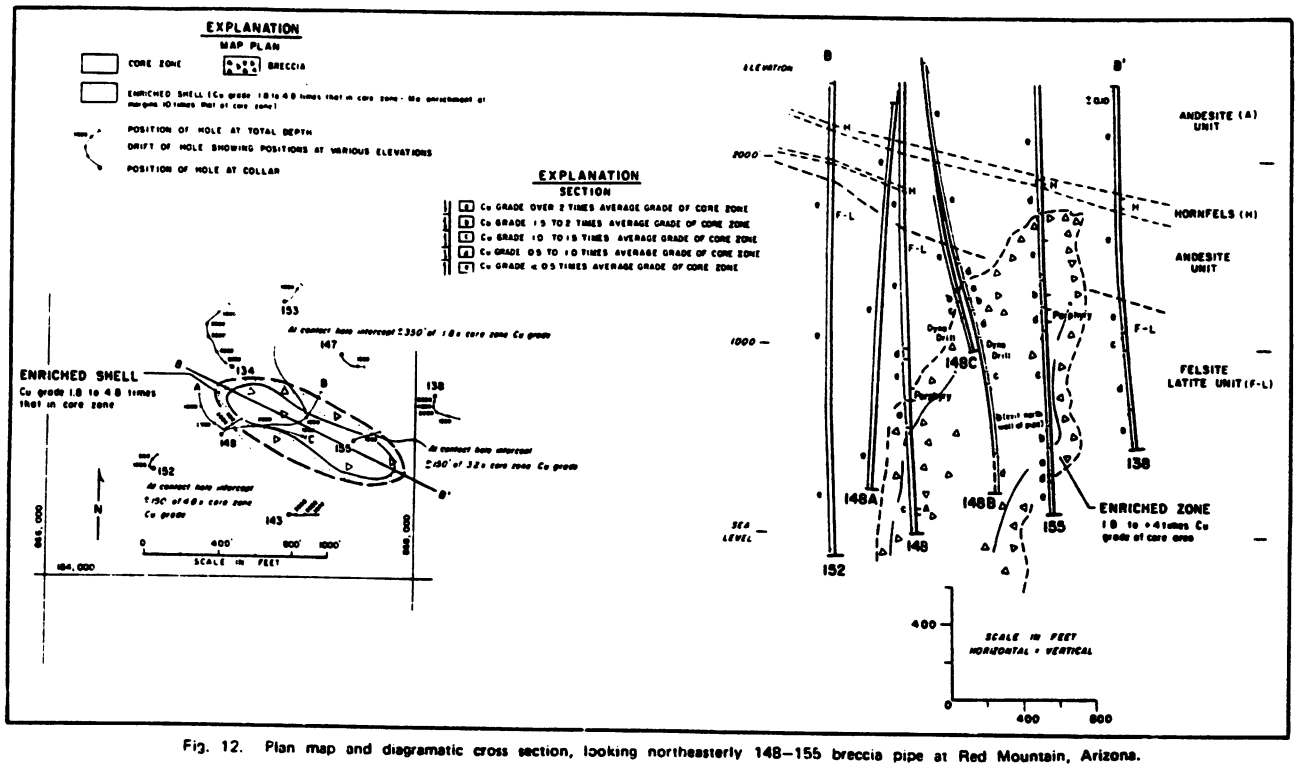

Fig. 12. Plan map and diagramatic cross section, looking northeasterly 148–155 breccia pipe at Red Mountain, Arizona.

A definite enrichment of copper, molybdenum, and silver is recognized at the pipe margin, particularly in the deeper intercepts. The enrichment is related to the concentration of chalcopyrite- and molybdenite-rich sulfide lenses at the margins. The grade of copper at the margins of the pipe is from 1.8 to 4.8 times that in the core area of the pipe. Molybdenum enrichment at the margins is ten times, and silver from two to four times that of the pipe core.

The silicate alteration and sulfide distribution pattern recognized in the pipe, though different in scale, is much the same as that recognized in many large porphyry copper systems, that is, a core area of strong potassic alteration with lower sulfide content. This is followed upward and to a lesser extent outward toward the pipe margins by a phyllic zone with increased sulfides. The suggestion is that the pipe itself may represent a more intense but miniature zoned porphyry copper system superimposed over the main or bulk phase of porphyry copper alteration and mineralization.

DISCUSSION

Silicate and sulfide alteration patterns have proved a useful guide to ore at Red Mountain. In particular, the use of copper and sulfide-sulfur assay data to estimate and study the approximate distribution of pyrite and chalcopyrite within the complex alteration zone has proved a valuable tool to define the deposit and as a guide for exploration.

The recognition of three separate, major, and distinct hydrothermal events at Red Mountain is believed significant. All three pulses appear to be closely related in time and origin to each other and to porphyry intrusions. The indicated sequence of hydrothermal events starts with the development and formation of a large, zoned, and essentially copper-barren silicate-sulfide alteration system, followed by at least two distinct alteration and copper-mineralization pulses. Each of these later pulses is more restricted and intense and formed a higher-grade deposit than its predecessor. This suggests that differentiation in the magma chamber may have played an important role in the segregation and enrichment of copper for the late-phase hydrothermal fluids.

More work is needed to confirm and expand on some of the implications and observed relationships in the 145-155 breccia pipe. Whereas the pipe contains open vugs, most evidence indicates that it formed with its top many thousands of feet below the surface. The presence of both brecciated and unbrecciated, altered, and mineralized quartz-eye porphyry within the pipe attests to the interplay between intrusion, brecciation, alteration, and mineralization. One suggestion is that volatiles or fluids from the magma may have played an important part in brecciation as well as alteration and mineralization in the pipe. A better understanding of the processes that formed the pipe would undoubtedly lead to a better understanding of porphyry copper deposits.

In conclusion, it should be stressed that the deep-level porphyry copper deposit at Red Mountain is a plum within a large and complex altered zone. The most obvious clue to the deep-level deposit is the chalcocite blanket that was formed by the secondary enrichment of copper in a low-grade plume that extended at least to the present surface, or 5,000 feet above the deep-level deposit.

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ROAD LOG

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Mileage Cum.	Mileage Inc.	
0.0	0.0	START. Patagonia, Arizona, Post Office at the junction of State Highway 82 and county road leading to the San Rafael Valley, Harshaw, and Lochiel. Good view of Red Mountain on the right.
1.6	1.6	The Patagonia fault is exposed in outcrop across wash. Fault zone consists of several strands, with consolidated Tertiary gravels on northwest and Meadow Valley Andesite (72.1 ± 3 m.y.) on southeast side of fault zone. Bold outcrops on southeast side of outcrop area are silicified breccias along fault strand in Meadow Valley andesite.
2.7	1.1	STOP 1. Road-cut exposures of Meadow Valley Andesite. These exposures are typical of many Meadow Valley exposures outside of main Red Mountain alteration zone. Would call attention to purple color and propylitic alteration. In core of Red Mountain alteration zone, andesite is typically altered to a black, biotite-magnetite-rich rock. Clay and limonite are common along many fractures in the exposures and quartz veinlets and manganese oxides may be seen along some of the fractures.
4.7	2.0	STOP 2. Locations of Stops 2 through 8 shown on Figure 2. Turn off from San Rafael Valley-Harshaw-Lochiel county road onto road leading to Red Mountain. Will transfer from bus to four-wheel drive vehicles at this point. Outcrops in wash ahead are generally propylitically altered Meadow Valley Andesite. Local bleach zones are mainly controlled by linear structures. Clay, gypsum, and limonite are the most common minerals in these zones.
5.2	0.5	STOP 3. View of southeast side of Red Mountain. Would call attention to route of road leading up mountain, talus-covered landslide blocks and cliffs in upper layered tuff unit. This upper layered, <u>altered</u> tuff unit is much more resistant to erosion than the underlying andesite, and this accounts for the present topographic high at Red Mountain.
7.1	1.9	STOP 4. At outcrop in altered tuff unit 5,000 feet east of alteration center at

PROSPECTUS

RED MOUNTAIN
and
THUNDER MOUNTAIN

Santa Cruz County, Arizona

Kerr-McGee Corporation

• *Introduction*

Kerr-McGee Corporation, as sole owner and operator of the Red Mountain, Arizona copper project, hereby offers the property for sale or other mutually acceptable arrangement on a non-exclusive basis.

Kerr-McGee holds thirty-six (36) patented lode mining claims at Red Mountain totalling approximately 493 acres. These are maintained indefinitely via county taxes which currently total $1,946 per year. At Thunder Mountain, Kerr-McGee holds thirty-seven (37) unpatented lode mining claims totalling nominally about 585 acres.

The properties are located at the northern end of the Patagonia Mountains, two miles southeast of the community of Patagonia, Arizona and 18 miles northeast of Nogales, Arizona/Nogales, Sonora. It is located in Township 22 South, Range 16 East in the Hardshaw Mining District, Santa Cruz County, Arizona.

Kerr-McGee has controlled the Red Mountain/Thunder Mountain properties since the early 1960's. At Red Mountain, approximately 190,000 feet of drilling in 76 diamond core holes and five rotary drill holes have been completed. Twenty-five holes exceed 5,000 feet in depth, at a maximum depth of 5,790 feet. At Thunder Mountain, 25 holes totalling 31,312 feet have been drilled, to a maximum depth of 5,677 feet.

Exploration data are extensive and include: drill lithology/alteration logs and drill sample geochemistry, detailed mapping of surface geology and alteration (by numerous workers), and preliminary resource calculations, engineering and leachability studies. This prospectus is designed to summarize the exploration data, and the reader is advised that Kerr-McGee nor any of its employees or agents shall have any liability to you or any of your agents or employees resulting from your or their use of the prospectus.

All data will be made available through a scheduled review upon execution and return of the attached Confidentiality Agreement to:

Mr. H.W. Holmberg or Mr. R.R. Roe
Kerr-McGee Corporation
P.O. Box 25861
Oklahoma City, OK 73125
(Fax 405/270-3010)

RED MOUNTAIN

• *Geology and Mineralization*

Red Mountain is a high-sulfidation porphyry copper system with a vertical zonation of alteration and mineralization of over two vertical km. The deposit is hosted by a Late Cretaceous-Early Tertiary stratovolcanic complex of which three layered units are recognized. The uppermost unit, up to 2,400 feet (730 m) thick, is referred to as the Tuff unit, and consists of rhyolitic to dacitic tuffs, flows, and breccias. Below that are about 3,000 feet (915 m) of andesitic to trachyandesitic flows, breccias, sills, and dikes referred to as the Andesite unit. The lowest unit has not been completely penetrated by drilling and is referred to as the Felsite-latite unit. It consists of volcanic conglomerate and breccias, silicified tuffs, flows(?), interlayered and cut by latite sills and dikes and is interbedded with the lower portion of the Andesite unit. All units generally have a north strike and dip to the east at about 15°.

The layered volcanics are intruded by porphyritic granodiorite and quartz monzonite which occur as dikes and irregular bodies in outcrop and drill holes. The most volumetrically significant intrusion is an irregularly shaped monzonite porphyry stock on the western edge of the porphyry system.

Alteration is zoned laterally and vertically in relation to the copper mineralization and appears to be related to three hydrothermal events closely related in time and origin. It is more fully described in the paper by Quinlan (1986).

Copper mineralization at Red Mountain can be divided into three zones: 1) an upper level chalcocite blanket deposit, 2) a deep level bulk sulfide deposit, and 3) a breccia pipe within the core of the deep porphyry system. The chalcocite blanket is hosted by the Tuff Unit, the deep level sulfide deposit is hosted by the Andesite and Felsite-latite unit, and the breccia pipe is hosted dominantly by the Felsite-latite unit. Principal hypogene sulfides are pyrite and chalcopyrite. Bornite and enargite have been identified in the drill core from the lower and upper portions of the system, respectively. Also present, but not common, are molybdenite, tennantite, galena and sphalerite.

Secondary chalcocite is present mainly in the blanket deposit, within the pyritic plume of the porphyry system. The chalcocite blanket is an irregular, east-northeast trending tabular zone that contains several distinct enrichment horizons.

The blanket lies at an average elevation of 5,000 to 5,100 feet (1,525-1,555 m) above sea level, approximately 2,500 feet (760 m) higher than the top of the deep sulfide deposit. The blanket resource is 0-1,000 feet (0-305 m) below the present erosional surface.

The deep level bulk sulfide deposit, although incompletely delineated, is roughly elliptical in plan with a low sulfide, low copper core which appears to be a nearly classic copper-sulfide shell. The axis of the ellipse trends northeasterly. The top of this deposit is generally at an elevation of about 1,500 feet (460 m) above sea level, or 4,000 feet (1,220 m) below the surface.

The breccia pipe deposit lies within the southern part of the low sulfide, low copper, core of the deep level bulk deposit and appears elliptical in plan. It measures about 800 feet to 1,100 feet (245 × 335 m) in plan diameter and extends downward from about 1,750 feet (535 m) above sea level to 4,000 feet (1,220 m) below the surface.

Gold mineralization in the Red Mountain porphyry system was first noted in routine assays of drill hole composite samples collected for evaluation of shallow copper potential. Random intercepts ranging in thickness from a few feet to a few tens of feet with values ranging from 0.02 opt to 0.06 opt gold were encountered above and roughly coincident with the chalcocite blanket in an area measuring roughly 500 × 1,000 feet (150 × 300 m). Gold mineralization occurs at the base of totally oxidized, hematically stained rocks that form the oxidized cap, generally near the uppermost zone of chalcocite enrichment. Chalcocite mineralization occurs in the zone of partial oxidation characterized by jarosite ± hematite + sulfides.

The geology, alteration, and mineralization of the Red Mountain area has been described by a number of authors, and much information is publicly available. A selected bibliography is presented below.

- ***Copper Resources***

Copper resources have been estimated for the three parts of the deposit as currently known, and total approximately 449 million short tons grading 0.64% copper. The chalcocite blanket contains approximately 140 million short tons @ 0.34% Cu, including 19 million tons @ 0.69% copper. The chalcocite blanket mineralization is believed to be SX leachable, based on preliminary tests. The deep level bulk sulfide deposit contains approximately 380 million short tons grading 0.58% copper, 0.009% molybdenum, 0.003 ounces gold per ton and 0.12 ounces silver per ton in the explored portion of the copper shell, using a cutoff of 0.3% copper. The breccia pipe contains approximately 49 million short tons grading 1.14% copper, 0.025 molybdenum, 0.004 ounces gold per ton and 0.15 ounces of silver per ton utilizing a 0.3% copper cutoff.

- ***Exploration Potential***

The chalcocite blanket resource is still in the early stages of exploration. Additional drilling is required to verify and possibly expand the current resource. Additional core logging and sampling may also identify precious metal concentrations and exploration opportunities which could enhance the economics of the blanket resource.

Only about one-half of the deep copper shell has been explored. The western limb of the deposit needs additional drilling to define the width and base of the copper shell. The open northeastern portion of the shell is considered very prospective. Additionally, other breccia pipes may exist within the system.

THUNDER MOUNTAIN

- ***Geology and Mineralization***

A distinctly separate porphyry copper system at Thunder Mountain includes: 1) a deep, hypogene disseminated/fracture controlled pyrite-chalcopyrite deposit at depths below 2,500 feet (760 m), 2) a carbonate Pb-Zn-Ag zone on the east side of the porphyry system, and

3) two areas of secondary chalcocite mineralization above the deep porphyry. Kerr-McGee's Thunder Mountain claim block includes the deep porphyry and the overlying chalcocite mineralization, but not the adjacent Pb-Zn-Ag skarn mineralization.

The deep porphyry is hosted by quartz feldspar porphyry and quartz feldspar porphyry breccia which is interpreted (Graybeal, 1994) as a diatreme about 5,000 feet (1,525 m) in diameter. The upper levels of the inferred diatreme include Early Tertiary lapilli tuff and related volcanics. A funnel-shaped hydrothermal alteration zonation is centered on the quartz feldspar porphyry stock and includes a potassic alteration core at depths of greater than 4,000 feet (1,220 m), surrounded by phyllic and argillic alteration.

The upper-level chalcocite mineralization is hosted by breccia zones within the Early Tertiary pyroclastics and brecciation spatially related to the porphyry-volcanic contact region. The chalcocite is accompanied by covellite, which locally appears to exceed chalcocite in abundance. Enargite and bornite are also noted. Both chalcocite zones are irregular, blanket-like deposits, and both are partially exposed at the bottoms of drainages. Adjacent steep hillsides, however, indicate overall high stripping ratios. The majority of the chalcocite resource lies at elevations of 5,000 to 5,200 feet (1,525-1,585 m), but mineralization locally extends to 4,600 feet (1,400 m).

- ***Copper Resources***

Several hundred million tons averaging about 0.6% Cu, 0.02% Mo, and 0.15 oz Ag are identified starting at a depth of about 4,000 feet (1,220 m) in the deep porphyry deposit. This resource is located within a much larger system of perhaps >3 billion tons @ ~.2% Cu.

The two chalcocite (covellite) blanket deposits contain an aggregate of about 33 million short tons @ .3% Cu.

- ***Exploration Potential***

The chalcocite blanket resource, although low grade, is of possible interest as a compliment to the Red Mountain chalcocite resource. The Thunder Mountain deposit is less than three miles from Red Mountain and the deposits could be mined in conjunction. The Thunder Mountain chalcocite blanket deposits have been penetrated by 16 drill holes, and additional drilling would be required to completely explore the deposits.

The Thunder Mountain deep porphyry deposit is of more remote exploration potential, but undiscovered, higher grade breccia zones are conceptually possible.

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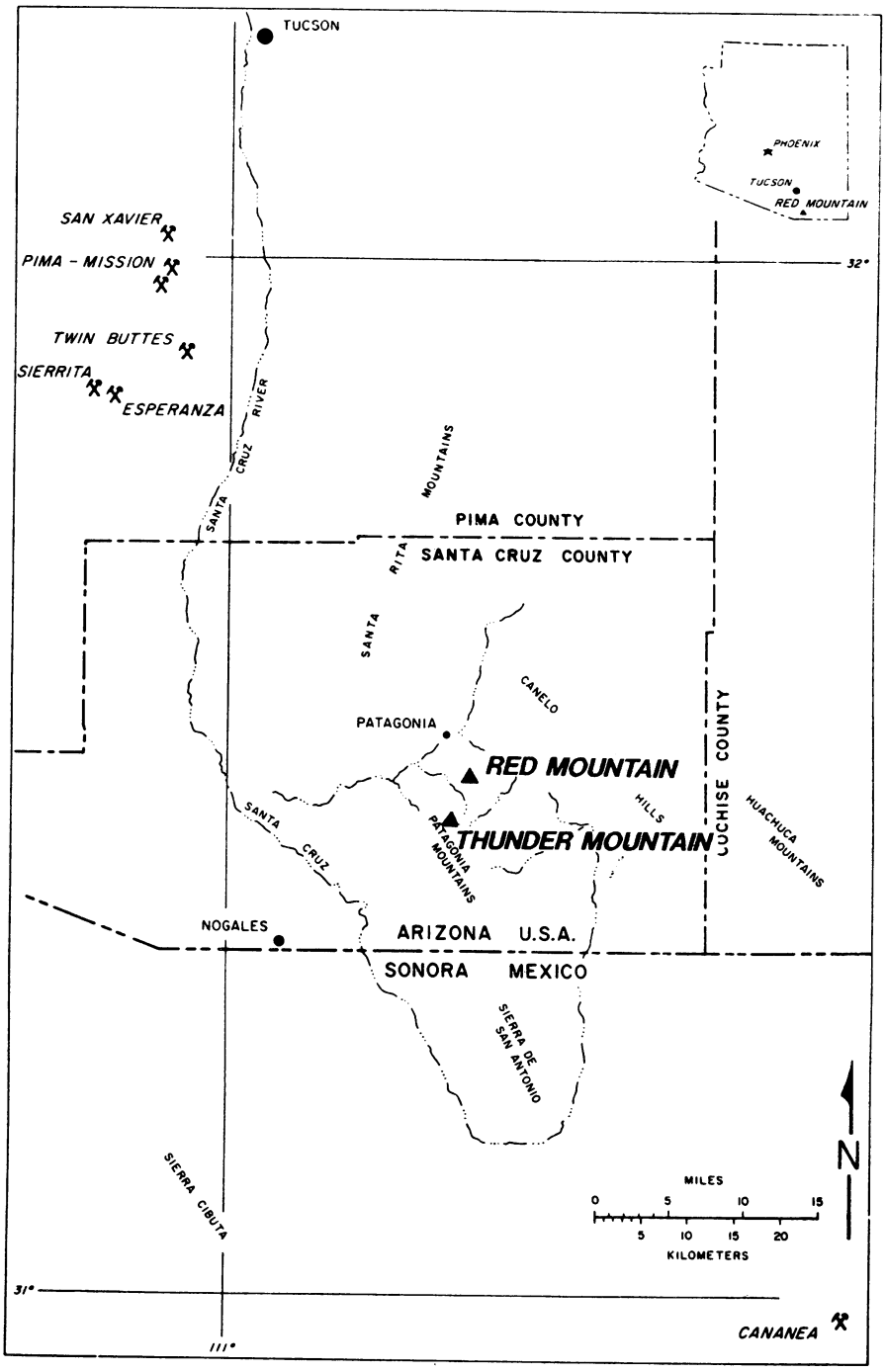
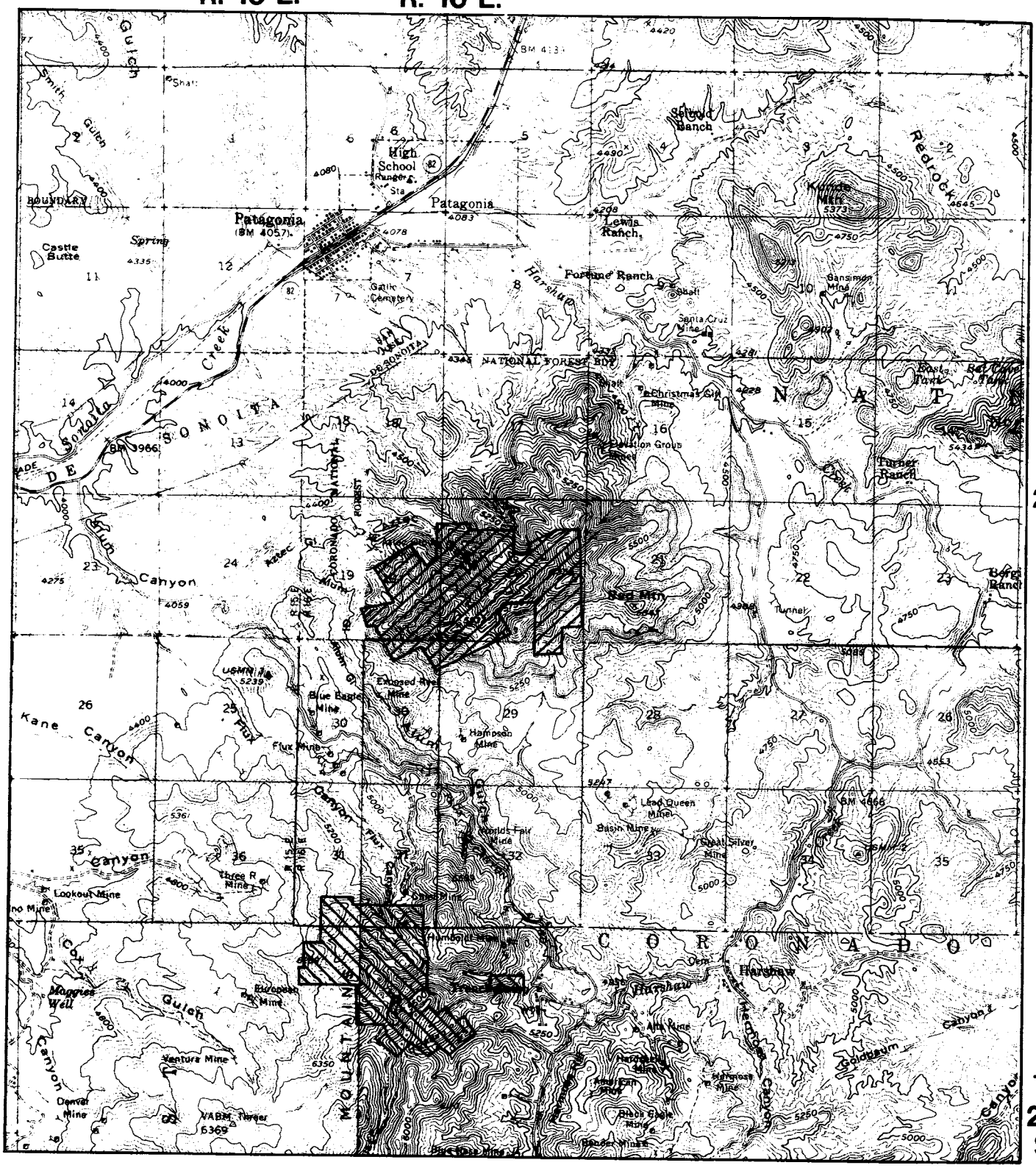


INDEX MAP
TO LOCATION OF RED MOUNTAIN-THUNDER MOUNTAIN

SANTA CRUZ COUNTY, ARIZONA

KERR-McGEE CORPORATION



APPROXIMATE KERR-McGEE LAND

RED MOUNTAIN: PAT. LODE CLAIMS

THUNDER MOUNTAIN: UNPAT. LODE CLAIMS

RED MOUNTAIN - THUNDER MOUNTAIN PROPERTY MAP
SANTA CRUZ COUNTY, ARIZONA

SCALE 1:62,500

OPOGRAPHIC BASE FROM USGS 15' QUADRANGLE MAPS
LGIN (1958), LOCHIEL (1958), NOGALES (1958), MT. WRIGHTSON (1958)