A GEOLOGIC RECONNAISSANCE AND MINERAL EVALUATION
WHEELER WASH AREA, HUALPAI MOUNTAINS,
MOHAVE COUNTY, ARIZONA

by

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PREFACE

In the sense of the word reconnaissance, this thesis represents a preliminary survey to gain information. This information, concerning a preliminary field survey of the Wheeler Wash area, was used to make an appraisal of the potential occurrence of economic mineral deposits. The descriptions and conclusions herein are not supported by comprehensive petrographic, geochemical, etc., studies. As such, the present title is more appropriate in describing the thesis contents than the familiar title of "The Geology and Mineral Resources of . . ." which implies a more complete, substantiative, and exhaustive study. Nevertheless, pertinent observations and conclusions documented here, probably represent a thorough study as possible from existing data.

The field work was conducted for Cerro Corporation - Cerromin Division, while the author was in their employ during the summer of 1970. All internal, corporate reports concerning exploration in the Wheeler Wash area by previous investigators, including the more recent work completed by Cerro Corporation and later by Norandex Incorporated, remain confidential and unavailable for this writing. Views expressed here are those of the author, based on his work alone. They do not necessarily reflect the opinions of the geologists and management of previous investigators.

ACKNOWLEDGMENTS

Gratitude is expressed to the management of Cerro Mineral Exploration Company for allowing the writer to use a portion of his work, while in their employment, as a thesis problem.

Special thanks are due to Dr. Thomas S. Nye, then District Geologist for Cerro's Tucson office, for introducing and suggesting the problem. Dr. Thomas W. Mitcham, also of Cerro Mineral Exploration Company, granted permission to use most of the geological information compiled by the author for the purpose of drafting thesis maps. During June, 1972, Mr. Horace P. Miller, Geologic Consultant to Cerro Corporation, and Mr. Alfred E. Wandke, President of Cerro Mineral Exploration Company, gave the latest and final consent to use the area as a thesis problem.

Appreciation is expressed to Mr. Ron Karvinen, former District Geologist of Norandex Incorporated, and Dr. Robert J. M. Miller, Vice President of Norandex Incorporated for financial assistance in the preparation of the thesis and for permission to use some of the geologic information they acquired through negotiations with Cerro Mineral Exploration Company.

The author also wishes to express his appreciation to the faculty of the Department of Mining and Geological Engineering, The University of Arizona, for their advice and encouragement during this writing. Foremost among this faculty list is Dr. W. C. Peters who was the author's advisor and thesis director. Drs. T. J. O'Neil and

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ABSTRACT

A geologic reconnaissance of the Wheeler Wash area was performed to evaluate the region for the potential occurrence of economic mineral deposits.

Basement metamorphic rocks have been intruded by Precambrian and Laramide (?) granitic plutons. Much of the base and precious metal mineralization is thought to be associated with the younger intrusions. Northwest trending structures are the most favored for sulfide mineralization. Other major structural trends strike north-south, east-west, and east by northeast. Regionally there is a notable metallogenic zoning of vein deposits. The innermost zone contains molybdenum-tungsten veins. Outward, the zones progress to copper-molybdenum, lead-zinc-silver, and gold-silver bearing veins.

Mineralization, metallization, and wall rock alteration suggest that several locations contain mineralized bodies that typify a porphyry copper-molybdenum deposit. It is concluded that these mineralized exposures represent either two separate deposits or a single deposit that has been displaced approximately 4,500 feet right laterally along an east-northeast fault zone.

Two other areas are deemed favorable for exploration. A photo linear analysis suggests a possible anomalous structural zone north of, and adjacent to the Wheeler Wash study area. A buried pediment area to the west is inferred to possibly contain a faulted segment of one of the exposed mineralized bodies and possibly host other concealed deposits.

Exploration programs are proposed which would evaluate the three areas more thoroughly.

CHAPTER 1

INTRODUCTION

Objectives

Originally, the basic geologic map at a scale of 1 inch equals 1,000 feet was intended to be used in selecting one or more localized areas in which to do a detailed thesis study. Because funding for the Wheeler Wash project was under serious consideration for cut-back and possibly total withdrawal during the latter part of the summer, 1970, the author elected to use his existing field data to design a thesis problem in lieu of personally financing any further field work.

The principal objectives are, 1) to emphasize mineralization and alteration features, their relationship to structure and other possible controlling factors, 2) to delineate potential target areas for further exploration, and 3) to recommend exploration programs which would test the selected target areas. Expanding on the geologic data, separate maps have been prepared showing wall rock alteration and economic geologic features. Production record data of past mining operations have been analyzed to see if there is any metallogenic zonal relationships in the district. Local and regional photo-linear analyses have been prepared to augment the mapped structures.

In selecting potential target areas and designing exploration programs, consideration is given the type and size of mineralized bodies which would be of practical benefit to the serious exploration engineer and geologist. The potential for the occurrence of massive sulfide and large, lode vein deposits within the Maynard district is minimal. Surficial exposures have been exploited and the cost of exploring for concealed deposits, similar in size and grade to the known deposits, would probably equal or exceed the value of contained metals. From the standpoint of economic success, a bulk, low-grade "porphyry" deposit is a more reasonable type of mineralization for which to explore. Thus, in the Wheeler Wash area, a porphyry copper-molybdenum deposit is sought.

Procedures

Uncorrected, black-and-white aerial photographs were used as a base for field mapping. Mylar overlays were attached to the photographs for the purpose of plotting geologic features. The computed photo-scale is 1 inch equals 1,000 feet, approximately. Due to the locally rugged terrain most geologic features plotted on the map were from the more accessible outcrops along ridge crests, stream drainages and road-cut exposures. Approximately 4½ square miles were mapped in a cumulative time of 20 days, during the months of July and August, 1970.

Photo linears of the Wheeler Wash area were plotted from stereo views of the same photographs used during field mapping. Regional photo linears were plotted from a single stereo pair of Government flown photographs whose approximate scale ratio is 1 inch to 2,000 feet.

Regional metallization was plotted on a base map (General Highway Maps - County Series) published by the Photogrammetry and Mapping Division of the Arizona State Highway Department, at a scale of 1 inch equals 2 miles.

Throughout most of this report, descriptions of rock types, minerals, and wall rock alteration is based on hand lens and megascopic observations. Major structural trends and metallization ratios were determined from visual estimations rather than statistical tabulation.

Previous Work

The earlier published geologic reports of the general area were by Lee (1908) and Schrader (1909). More recent geologic reports and descriptions of some mineral deposits in the Maynard Mining District were written by Hewett et al. (1936), Wilson (1941), and Dale (1961). Many unpublished and confidential reports by various mining companies and an assumed number of professional consultants remain unattainable to the author. It is known, however, that Union Carbide Corporation and Bear Creek Mining Company (personal communication with personnel of Norandex Incorporated and Cerro Mineral Exploration Company) have done extensive exploratory and evaluation work prior to the studies conducted by Cerro Corporation.

Prior to employment with Cerro Corporation and before the author became familiar with the Wheeler Wash area, Mr. William W. Jenney, Jr., former geologic consultant to Cerro Mineral Exploration Company, and other Company geologists had mapped small portions of the thesis area. The author did not include this previous mapping in his work because the present study was to remain unbiased from earlier brief examinations by Cerro geologists.

CHAPTER 2

LOCATION AND ACCESSIBILITY

The Wheeler Wash area is located in the Maynard Mining District, Mohave County, approximately 15 airline miles southeast of Kingman, Arizona (Fig. 1). Situated on the northeast flanks of the Hualpai Mountains, most of the mineralized area of interest lies in the eastern half of T.20N., R.15W. More precisely, the mapped area is in sections 13, 23, and 24, T.20N., R.15W. and portions of sections 14, 22, 25, 26, and 27, T.20N., R.15W.

Since completion of the field mapping, topographic maps covering that northeast portion of the Hualpai Mountains have been published by the U. S. Geological Survey. They are the Dean Peak and Hualpai Peak NE, 7½ minute quadrangles.

From Kingman, the prospect area can be reached by traveling east on Interstate 40 to the Hualpai interchange, approximately 10 miles from town center. Turn south from the interchange and proceed about 7 miles on the old Phoenix highway to the graded, Odle Ranch Road. Continue south on this graded dirt road for an additional 5 miles to the Odle Ranch on Wheeler Wash. The Odle Ranch is approximately 22 miles distant from Kingman by this route at an average driving time of ½ hour.

The area is generally accessible by car for most of the year, except during short periods of flash flooding. Four-wheel drive

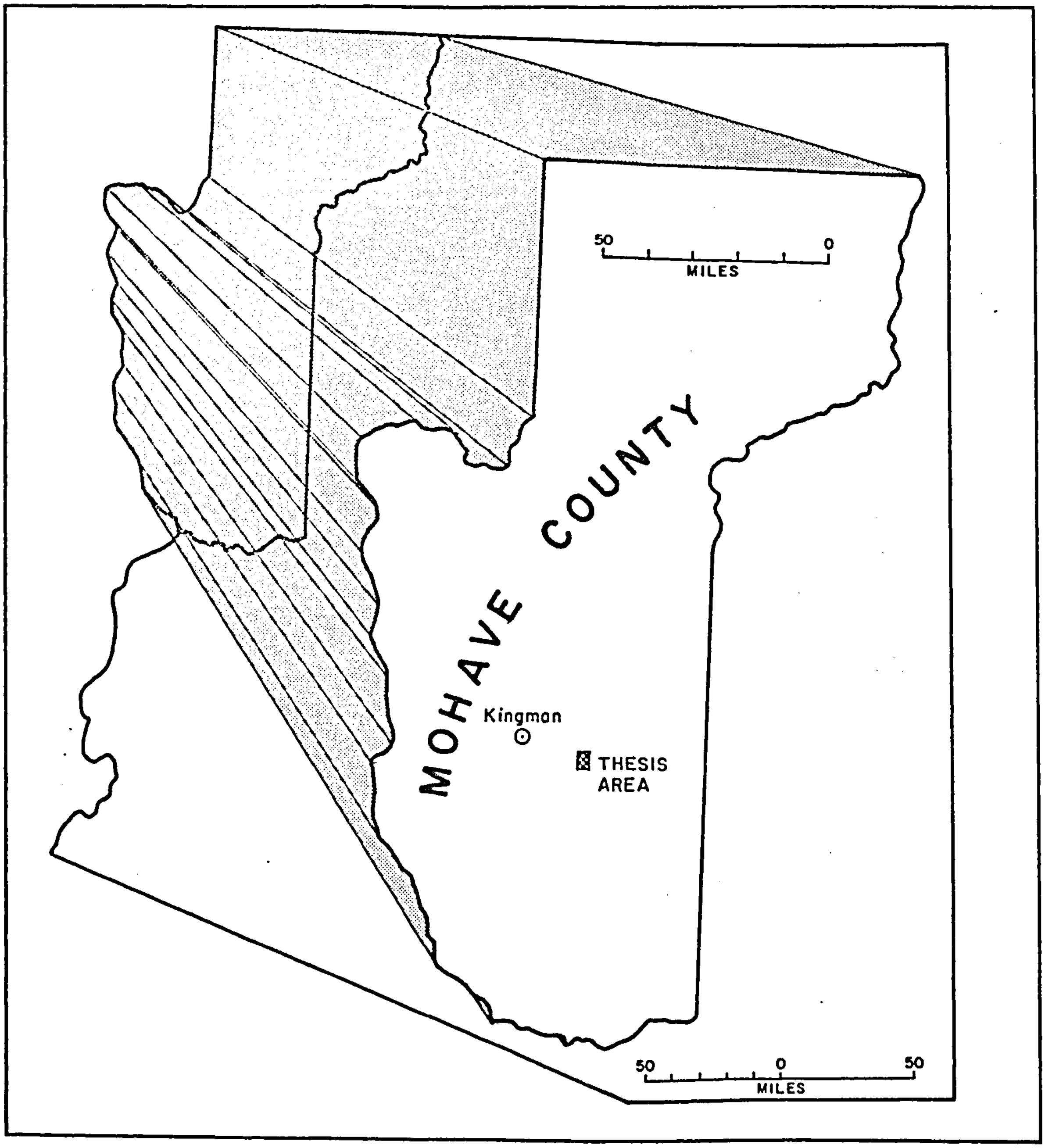

Fig. 1. Location Map

vehicles are recommended for travel in the district when driving off the graded roads and during flash flood season.

CHAPTER 3

LAND TENURE

Land in the Wheeler Wash area is under public, private, and State control. Much of the ground between Wheeler Wash and McGarry's Wash is covered by unpatented lode claims. The complexity of locating exact claim positions in the field is compounded by large groups of over-staked claims and overlapping claim groups. Most fractions and previously unclaimed areas are now covered by large blanket claim groups sequentially located by Bear Creek Mining Company, Union Carbide Corporation, Cerro Corporation, and Norandex Incorporated.

A detailed study of the Mohave County Courthouse records is necessary to resolve the latest property situation. Other major claim groups in the report area are listed under the claimant's names of Messrs. Bagg and Van Marter, Cochrane, Dewey, Murphy, Odle, Poyner, and White. Norandex Incorporated is the most recent organization to negotiate for acquisition of mineral rights in the area.

CHAPTER 4

HISTORY

According to Schrader (1909, p. 139) the first reported mineral discovery in the Maynard mining district was in 1865 by a group of prospectors led by John Moss. Wheeler Wash was named for Lieutenant Wheeler of the U. S. War Department, who led a reconnaissance team into the area in 1871. The district was named after Lafayette Maynard, an elected recorder and member of a group of prospectors who had arrived during the stay of Lieutenant Wheeler's party.

Mining continued to prosper between 1871 and 1904 (Schrader 1909, p. 139) on the rich, near surface, oxidized ore deposits. Sporadic activity persisted to 1928 (Hewett et al. 1936, p. 16). In the mid 1930's, through the 1950's, several mines were reworked for short periods of time to mine the sulfide ore zones. Except for the recent exploration activities, the district has remained relatively idle for the past 15 years.

Production

Prior to 1904, the value of silver mined in the Maynard district is said to be "several hundred thousand dollars" (Hewett et al. 1936, p. 16). The recorded production for the district during the years 1904-1932 is: "3,982 tons of ore yielding 643.22 oz. Au, 90,093 oz. Ag, 3,149 lbs. Cu, 104, 248 lbs. Pb, valued in all at $103,669."

Available production records for the Maynard district were examined from file data at the Arizona Bureau of Mines and in references noted in the Selected Bibliography. It is estimated from these references that the total production value would range from several hundred thousand dollars to a million dollars, and the total ore tonnage mined would approximate 40,000 tons. In both ore tonnage mined and in dollar value, the metal commodities in decreasing importance are: gold-silver, lead-zinc a close second, copper a significant third, and molybdenum-tungsten a minor fourth.

In the thesis area, only the Standard Minerals (Telluride Chief) mine and the Century Mine had any significant production. Intermittent mining of molybdenum and tungsten veins was from short adits, shallow shafts, and prospect pits. The Telluride Chief produced gold, silver, copper, molybdenum, and tungsten from underground workings accessible by shaft and adits (Wilson 1941, pp. 14-15). Early production commenced in 1916 and except for the first few prosperous years, the property was worked only intermittently thereafter. During its history, there was a 100 tons-per-day mill in operation. Dale (1961, p. 94) reports that additional mine development was done during the 1950's.

Development

Most preexisting mine workings have been abandoned since the late 1950's. Headframes and mills have been removed, nearly half the adits have caved portals, and only periodic maintenance has been performed on the old access roads.

Some of the large claim-group holders have maintained a few access roads in performance of their annual assessment work. Since the recent exploration interest of the large mining companies, drill roads and drill pads have been constructed. Numerous percussion drill test holes of 150 feet or less in depth have been drilled to validate claim groups and about six diamond drill holes of between 800-1,600 feet in depth have been drilled during the last 10-15 years (personal communication with Norandex Incorporated personnel). Geochemical and geophysical surveys have also been conducted over the thesis area. Results of these surveys and tests are not available to this report.

CHAPTER 5

GEOGRAPHIC SETTING, ENVIRONMENTAL AND PHYSICAL FEATURES

Topography

The Hualpai Mountains are a northwest to north trending range in south-central Mohave County, situated in the Basin and Range physiographic province. This mountain range is flanked by the Sacramento Valley to the west and by the Big Sandy Valley to the east. High peaks along the northern ridgeline average 8,000 feet in elevation.

Elevations in the thesis area range from 4,500 feet in Wheeler Wash, east of Odle ranch, to 6,700 feet in upper Soap Wash. Rugged relief prevails in the upper drainage areas where slopes of 25° to 30° are common. Gentle slopes of the foothills extend eastward from the County road towards the Big Sandy River.

Generally, drainages are ephemeral in lower basin areas. Upper basin areas of some of the large washes are fed by small springs. Minor, but continuous flowage is common throughout most of the year in these headwater regions (personal communication with various local ranchers.)

Climate

The Kingman-northern Hualpai Mountains climate (Gillespie and Bentley 1971, p. 7) varies from a semiarid, high desert valley with an annual precipitation average of 11 inches to mountain summits where 15 to 20 inches of annual precipitation can be expected.

During the winter months of December through March approximately 45 per cent of the annual precipitation is derived from Pacific Ocean based storms (Green and Sellers 1964, p. 237). Snow can always be expected on the higher peaks and, for a few days of each winter season, at the lower valley elevations.

Violent summer electrical storms, typical of the Southwest, originate from warm moist air derived from the Gulf of Mexico. Flash flooding in the main drainages is common during these storms.

Green and Sellers (1964, p. 237) have tabulated the average temperatures for the Kingman area in degrees Fahrenheit. Depending on elevation, the winter lows range in the 20's to 30's, but may reach a high in the 40's to 60's during the afternoons. Summer lows range in the 50's to high 60's with daytime highs in the 90's at lower elevations.

Except for short intervals of time, local weather conditions should not restrict exploration work.

Vegetation

Vegetation in the valley area is typical of high-semiarid sections of the Mojave desert. Common varieties include sage, yucca, creosote, mesquite, and several types of cactus. At elevations above 4,000 feet, pinon pine, juniper and scrub-oak dominate the hillsides. Ponderosa pine is more abundant above 6,500 feet, but can be found at lower elevations in canyons where shade and moisture are readily available.

Land Use

Open range grazing is the main land use in the report area. Only two occupied ranch sites exist in the thesis area, and they are located on the perimeter of exposed sulfide mineralization. A few acres of forage have been cultivated in a basin along McGarry's Wash. The Hualpai Mountain County Park occupies approximately 3.5 square miles on the ridgeline at the head of Wheeler Wash, outside the known limits of the mineralized area.

Water

Mountain springs and shallow wells supply local water needs. Care should be exercised when working in the area to avoid contamination or disruption of water sources for domestic and livestock use.

For drilling purposes, permission must be acquired from local residents before using water from stock tanks, stream ponds, and spring seepage, especially during the dryer summer months. In most instances, water haulage to drill sites will be less than a mile and rarely over 3 miles. Under drought conditions, water may have to be hauled from the Kingman area or the Big Sandy Valley.

Gillespie and Bentley (1971, pp. 9-10) have found that volcanic rocks in the mountainous areas are the important aquifers. The Precambrian igneous and metamorphic basement is the lowermost barrier for groundwater movement.

Wells drilled in the fractured volcanic and metamorphic rocks generally yield 1 to 5 gallons per minute (gpm) (Gillespie and Bentley 1971, pp. 34-35). Shallow wells of 200 feet or less depth in the thin veneer of alluvium near the mountains generally yield 10 to 50 gpm. Deeper valley wells of 200 to 900 feet, in saturated older alluvium, were found to yield 25 to 1,500 gpm depending on well construction and local aquifer conditions.

Wells drilled in bedrock, T.20N., R.15W. (Davidson 1973, Plate 2) had a depth to water of about 150 feet or less during 1969. In adjacent alluvial covered areas of T.20N., R.14W., wells had similar depths to water. West of the report area and in the Big Sandy flood plain, wells averaged about 100 feet in depth to water.

Power--Supplies--Labor

Kingman, largest metropolitan community in northwest Arizona, is the regional supply center for basic goods, power and construction material. With a population of over 7,000 (1970 census) and its proximity to active mining operations, Kingman is also a potential source for skilled workers and a place to house workers from outside the region.

El Paso Natural Gas Company has a main pipeline into the Kingman area which passes as close as 7 miles north of the Odle ranch. Two high-voltage transmission lines also pass close to the property area. A 230 kilovolt line lies 10 miles north of Odle ranch and a 345 kilovolt line parallels U. S. Highway 93, 7 miles west of the Odle ranch. Rural electrical power service exists in the thesis area. Power and telephone lines parallel the graded county road to Odle ranch.

Transportation Service

Greyhound and Continental Trailways Bus Lines offer service to Kingman. The main line of the Santa Fe Railroad passes through Kingman. Mohave County (Kingman) airport is serviced by Hughes Airwest and Cochise Airlines. Airport runways are about 6,700 feet in length at an average elevation of 3,400 feet above sea level.

CHAPTER 6

REGIONAL GEOLOGY

A portion of the Mohave County geologic map (Wilson and Moore 1959) shows the Wheeler Wash area to consist of Older Precambrian metamorphic and igneous rocks. A granitic crystalline mass has intruded a granite gneiss which forms the core of the Hualpai Mountains. Westerly from the district, on the northwest flank of the Hualpai range are Tertiary and Quaternary volcanic rocks. Wilson and Moore also depict two Laramide crystalline rock masses near the thesis area. These intrusive plutons are shown to lie south of Wheeler Wash.

Sedimentary rocks which cap Precambrian rocks in the Aquarius Mountains 30 miles to the east and northeast are absent in the Hualpai range.

Foliation in the gneiss dips steeply southeast near Wheeler Wash and moderately northwest on the western flanks of the Hualpai range. Quaternary volcanic rocks have shallow westerly dips. No other structural symbols are shown in this portion of the Mohave County geologic map.

Neither the County geologic map nor any of the early geologic studies of the region describe the geology in much greater detail. Lee (1908, p. 14) believes that Precambrian granite with localized phases of gneiss forms the core of the Hualpai Mountains. Schrader (1917, pp. 196-198), supplementing his 1909 geologic study of portions of Mohave

County concluded that older rocks of the region consisted of a coarse, porphyritic granite, gneissic granites, and related schists. He also suggests that the metamorphic complex rocks are igneous in origin and have been subjected to various grades of metamorphism. Following the Precambrian events but preceding the Tertiary volcanic accumulations are a series of silicic intrusives which Schrader suggests to be Cretaceous in age.

Structural descriptions are also rather limited. Lee (1908, pp. 25, 50-52) recognizes the Hualpai range to be a fault block tilted eastward. The west bounding fault roughly parallels the west mountain front and the east bounding fault conforms to the Big Sandy drainage channel. Davidson (1973, p. 11) in his diagrammatic section of the Big Sandy Valley and adjacent mountains shows the valley to be series of nested graben faults. Thus, the Hualpai range's east bounding fault is possibly a series of normal faults commencing near the bedrock-valley fill contact, with other parallel faults lying in succession towards the Big Sandy River.

Structural features characteristic in Precambrian schists (Schrader 1909, p. 29) trend N. 30° E. with near vertical to vertical dips.

Lithology

Rock samples representative of the different lithologies seen in the field were identified by hand lens and megascopic observations. Field classifications assigned to the following rock descriptions are used throughout the remainder of this text.

Most rocks shown on the Geologic Map (Fig. 2, in pocket) formed during the Precambrian and Mesozoic eras. Paleozoic sedimentary rocks common to the Colorado Plateau and adjacent mountainous region are not known to exist in the Hualpai range. Paleozoic rocks outcrop to the northeast in the Cottonwood Cliffs region, easterly in the Aquarius Mountains, and to the south in the Rawhide Mountains. Moore (1972, Fig. 7a) in a modified Paleozoic isopach map shows approximately 4,000 feet of sediments which possibly could have been deposited in the thesis area. It is likely that Paleozoic sedimentary rocks did cover the region now occupied by the Hualpai Mountains but they have since been removed by erosion. It is assumed that most of this erosion process took place after the uplift of the range.

Cenozoic sediments cover bedrock easterly from the east margin of the mapped area.

Precambrian Rocks

Older Precambrian crystalline rocks cover the south-center portion of the Geologic Map (Fig. 2) and also exist as roof pendants and xenoliths in younger crystalline intrusive rocks. These older Precambrian rocks, which are probably the oldest regional rocks, are a high-grade metamorphic complex consisting of gneisses, aplites, pegmatites, and schist.

A younger, granite pluton has intruded this metamorphic complex in the western half of the map area. This granite is a very coarsely crystalline body shown as a Precambrian stock on the Geologic Map of Mohave County (Wilson and Moore 1959). It contains aplite and pegmatite pods and dikes up to 500 feet in width. Davidson (1973, plate 1) shows two outcrops of what is probably correlative to this Precambrian granite, 2 and 4½ miles westerly from the bedrock-valley fill contact.

Diabase dikes up to 300 feet in width were seen to cut the granite stock along the western margins of the map area. Since most diabase intrusions in Arizona are assigned a Precambrian age and field evidence was not found to suggest a younger age, the diabase dikes are placed as the youngest exposed Precambrian unit.

Granite Gneiss. (gn) Light brown to brownish gray; medium grained, equigranular grains 0.2 inch long and 0.1 inch in diameter; locally porphyroblastic with potash feldspar porphyroblasts to 0.4 inch in diameter; estimated mineral composition is 20-35 per cent quartz, 40-60 per cent potash feldspar, 0-25 per cent plagioclase, 5-15 per cent biotite; occurs as a regional pluton with local inclusions of chlorite-biotite schist parallel to the gneissose lineation, probably pre-metamorphic form as a granitic intrusion of a basement schist.

Aplite/Pegmatite Granite Gneiss. (gn/ap) Lithologic description similar to granite gneiss except for local concentrations of aplite and simple-pegmatite phases parallel to gneissose lineation, and a general lack of schist inclusions; occurs in physical contact with granite gneiss noted in one location (Fig. 2, grid B-4) and may represent zones of late-stage crystallization from parent igneous material of granite gneiss; however, direct field relationships to the granite gneiss were not established and therefore, the aplite/pegmatite granite gneiss remains as a separate map unit; aplite/pegmatite phases generally are more siliceous than host gneiss and weather topographically higher.

Quartz Diorite Gneiss. (qd gn) Medium to dark gray; medium to course grained, equigranular grains 0.2-0.4 inch long and 0.2 inch in diameter; estimated mineral composition is 10-20 per cent quartz, 0-10 per cent potash (?) feldspar, 35-45 per cent plagioclase, 35-45 per cent biotite; occurs as a pluton size body most of which lies in grids A-4, B-4, and C-3 (Fig. 2) and as xenolithic masses within younger intrusive rocks; elongation dimensions of quartz diorite gneiss outcrops generally parallel regional foliation trends within the gneiss; inclusions of altered granite (?) gneiss were noted in several localities along outcropping contact margins; probably pre-metamorphic form as a silica rich, dioritic intrusion.

Granite. (gr) Reddish brown to brownish gray; coarse grained, equigranular to prophyritic, euhedral to subhedral orthoclase grains to 0.4 inch in diameter and 0.8 inch long, subhedral to anhedral quartz and biotite grains to 0.3 inch in diameter; estimated mineral composition is 20-35 per cent quartz, 30-50 per cent orthoclase, 5-20 per cent biotite; occurs as a stock which contains roof pendants and xenolithic blocks of metamorphic complex rock; stock also contains aplite and pegmatite (ap) dikes, pods, and lens-like bodies that were not seen to cut rocks of the metamorphic complex, one of these aplite dikes (Fig. 2, grid B-2) is cut by a diabase dike and an andesite dike; this granite stock probably is related to igneous activity attributed to the culmination of Older Precambrian times in Arizona; the description of the Granite (gr) unit closely fits Thomas' (1949, p. 666) description of the Diana Granite, located near Chloride, 25 miles northwest; reported age date of the Diana Granite (Damon and Giletti 1961, p. 448), is 1350 million years; it is suggested that this date may approximate the age of the Granite (gr) unit.

Diabase. (db) Dark green to dark greenish gray; medium grained, diabasic with anhedral to subhedral pyroxene (augite?) grains 0.1-0.2 inch in diameter enclosed by subhedral to euhedral plagioclase laths 0.1 inch in diameter and 0.2 inch long, locally porphyritic with pyroxene phenocrysts to 0.3 inch in diameter; estimated mineral composition is 35-40 per cent pyroxene, 60-65 per cent plagioclase; occurs as dikes that cut Precambrian granite in the western part of the map area (Fig. 2, grids A-3, B-2 and 3); weathers topographically low in relief; no field evidence was seen to indicate an age younger than Precambrian and it is herein grouped with the latest Precambrian events in accordance with general consensus concerning the age of most diabase in Arizona.

Mesozoic Rocks

A large intrusion is exposed in the eastern half of the map area with a smaller exposure of a porphyritic stage along its northern margin. This pluton has intruded the Precambrian granite and the Precambrian metamorphic complex. Field exposures of this intrusion suggests that it is an unmapped continuation of the Laramide crystalline rock shown in the Geologic Map of Mohave County, in the northeast corner of T.19N., R.15E. (Wilson and Moore 1959).

Andesite dikes up to 200 feet in width cut Precambrian granite. Actual field relationship between andesite and the Mesozoic intrusive has not been determined; however, a cursory examination of some of the drill core taken from an exploratory hole near the center of the map area has showed that a slightly-hydrothermally altered andesite (?) dike contained quartz-sulfide veins. Since the Mesozoic plutons are the youngest rocks to contain sulfide mineralization, the andesite dikes, for a lack of better evidence are assigned a pre-Laramide to Laramide age, and are specifically labeled as Cretaceous on the Geologic Map (Fig. 2).

Andesite. (Ka) Dark greenish gray; 40 per cent aphanitic groundmass, 60 per cent fine grained, equigranular, anhedral to euhedral grains to 0.05 inch in diameter; porphyritic phase with phenocrysts to 0.2 inch in diameter; estimated mineral composition is 0-5 per cent quartz, 10-15 per cent potash (?) feldspar, 40-45 per cent plagioclase, 35-40 per cent amphiboles (hornblende?), 5 per cent olivine (?); occurs as dikes cutting Precambrian granite.

Quartz Monzonite. (Lqm) Medium gray; medium grained, equigranular, anhedral to euhedral grains 0.1-0.2 inch in diameter; estimated mineral composition is 20-25 per cent quartz, 15-25 per cent potash feldspar, 30-40 per cent plagioclase, 20-25 per cent biotite; occurs as linear pluton in outcrop, elongated in a north-south direction; contains blocks of Precambrian granite and quartz diorite gneiss; aplite dikes cut pluton in grid C-4 (Fig. 2).

Quartz Monzonite Porphyry. (Lqmp) Light brown to light brownish gray; porhpyritic; fine to medium grain groundmass of equigranular grains, subhedral to euhedral grains 0.05-0.1 inch in diameter, phenocrysts of subhedral to euhedral quartz and orthoclase to 0.5 inch in diameter; estimated mineral composition is 25-30 per cent quartz, 40-50 per cent orthoclase, 20-30 per cent plagioclase, 0-5 per cent biotite; occurs as a small intrusive body outcroping along the northern margin of the quartz monzonite pluton in grid C-1 (Fig. 2), contact relationships not established, may represent an elongated intrusive pod or a porphyritic phase of the quartz monzonite pluton.

Cenozoic Rocks

Except for scattered terrace gravels in the larger stream drainages, Cenozoic rocks are only seen along the eastern edge of the geologic map and consist of gravels and conglomerates derived from the Hualpai range. Field time did not permit their examination and consequently only the contact along the northeast edge of the quartz monzonite pluton was plotted. According to Davidson (1973, pp. 21-22) these basin fill gravels are probably Pliocene in age since they include the Big Sandy Formation of Sheppard and Gude (1972) who have established a definite Pliocene to probably Late Pliocene age to this formation.

Structure

Photo linear maps were prepared at two different scales to correlate structural features as determined from remote sensing analysis to those features actually mapped. As one might expect, drainage patterns and linear and arcuate features seen on aerial photographs were helpful in relating small surface structures with larger, regional trends. Also, the photo studies indicated the potential existence of other major structural features that normally may not have been given consideration by ground truth methods alone.

Photo linear and arcuate features plotted in this study generally include faults, the larger joint groups and shear zones, and abrupt changes in topographic phenomena. Plotted in less frequency are dikes, large veins, and any large rock fabric trends visible on the aerial photographs.

Regional Photo Linears

Linears noted in the regional photo study (Fig. 3) align in five directional trends. These trends are north-south, east-west, N.65°E., a fourth set that sweeps from N.50°E. to N.30°E., and a final set that varies from N.15°W. to N.45°W. (Fig. 3, in pocket).

A north-south zone approximately 3,000 feet wide shows as a major linear feature south of Wheeler Wash in section 25, T.20N., R.15W. Except for a sinuous north-south trend that conforms to a topographic break between the mountain range-basin interface and roughly parallels the township line separating Ranges 14 and 15 West, the density of north-south linears in this zone diminish abruptly in the Wheeler Wash Canyon area.

Channeling in Wheeler and McGarry's Wash, the two major drainages in the area, appears to be structurally controlled in the east-west direction. Although most drainage from the northeast flank of the

Hualpai Mountains is from east to west, few are as linear in that direction as are the Wheeler and McGarry's Wash drainages. However, the Wheeler Wash trend, is segmented and offset by northeast linears in its upper basin region.

A northeast linear trend approximately one mile wide strikes N.65^{o}E, through upper McGarry's Wash and the Century mine area. Relative movements along this northeast trend are not clear on the regional scale.

Largest of the regional linear trends is a zone approximately one mile wide that crosses the upper drainage basin of Wheeler Wash striking N.50^{o}E. gradually altering its strike to N.30^{o}E. in the vicinity of the Standard Minerals Mine where it eventually becomes covered by basin-fill alluvium. It is this northeast linear zone that offsets east-west structures in Wheeler Wash and obscures much of the north-south features.

Northwest structures are persistent over much of the region. Consistent strikes noted are N.15^{o}W. and N.45^{o}W. Regionally, the northwest structures are stronger in the area of the Enterprise mine, the Century mine and much of the terrain between McGarry's and Tungsten Washes. It is not clear at this regional scale if there are displacements of, or offsets caused by, the northwest structures.

Arcuate features appear to surround an area between the Enterprise and Century mines. Local drainage patterns outline a rough circular zone corresponding to the area of arcuate features. This area is outlined by dashed lines as the northern most anomalous feature recognized in Fig. 3. Three other circular areas are outlined in Fig. 3 as having anomalous photo-tone patterns and/or concentrated photo linear features. Of the four, the largest is also the southern-most feature which appears to be terminated by the east-west linear of Wheeler Wash.

Other than the aforementioned drainages with unusual configuration or obvious structural control, most of the other remaining drainages are consistent with regional dendritic patterns commonly developed over granitoid rocks and parallel patterns developed over basin-fill gravels. There are, however, two other noteworthy drainage phenomena that may be of interest in relationship to local geology. Easterly flowing Soap Wash makes a sharp southerly bend in sections 23 and 24 of T.20N. R.15W. This abrupt change in direction was not clearly understood in the regional photo study. In the second occurrence, eastward flowing drainages crossing the area near the common corner of sections 19 and 30 of T.20N., R.14W. and sections 24 and 25 of T.20N., R.15W. turn at right angles that coincide with an inferred north-south linear feature.

Local Photo Linears

In Fig. 4 (in pocket), photo linear trends are not visibly obvious as they were in the regional analysis of Fig. 3. Lower altitude stereo coverage did, however, enhance many features of smaller detail.

Although much of the north-south linear feature that straddles the township line separating Ranges 14 and 15 West is inferred, it remains remarkedly consistent to the similar feature of Fig. 3. Since the north-south trend of Fig. 4 is the most visible feature and since it is drawn to the same scale as the Geologic Map (Fig. 2), a comparison to mapped outcrops was made. It is noted that this north-south feature generally overlies outcrops of Laramide quartz monzonite, as well as paralleling the mountain range-basin interface.

East-West linears display some apparent control of the Wheeler and McGarry's Wash drainages, but their persistency over the entire drainage length is not as recognizable as in the higher altitude photos. Younger and offsetting structures have slightly disturbed the general east-west trend and in the lower altitude imagery, these smaller features overshadow some of the regional linears.

A northeast trend that crosses McGarry's Wash at the southern boundary of grid C-1 (Fig. 4) would appear to correspond to the N.65°E. linears of Fig. 3. However, average strikes noted in Fig. 4 suggest that the N.30°-50°E. features may be superimposed on the N.65°E. trend. Again, relative offsets between this trend and other linear sets are not consistent enough to determine age relationships and relative movements.

The sweeping N.50°-30°E. trend appears to be more narrowly confined (Fig. 4, grid B-4 and C-3) than it had in Fig. 3. As it transects the township line north-south structure, the number and length of the linears diminish. Essentially, when compared to the Geologic Map (Fig. 2), this N.50°-30°E. trend is quite strong in the Precambrian granite gneiss and quartz diorite gneiss, corresponding to local foliation trends. It diminishes however, in the area of the quartz monzonite stock.

Two areas containing northwest striking linears appear to be more significant locally than they appeared to be from a regional viewpoint. Northern-most is a trend which sweeps through grids B-1, C-2, and D-3 (Fig. 4) with an average strike of N.45°W. The southern trend passes through grids A-3 and B-3 to the southern limits of the map area also at an average strike of N.45°W. Relative displacements along the northwest trend could not readily be discerned from the air photos. The N.45°W. trends cross all rock contacts but appear strongest within the Precambrian granite.

A linear concentration outlined in Fig. 3 west of the Standard Minerals mine, manifests itself again in Fig. 4 as a arcuate feature centered around the common corner of grids B-2 and 3 and C-2 and 3. There are other arcuate features in Fig. 4 just north and east of the common corner of sections 11, 12, 13, and 14 of T.20N., R.15W. that may correspond to the smallest anomalous area outlined in Fig. 3 which straddles McGarry's Wash. Linear densities are greater in the area adjacent to and between Soap Wash and Wheeler Wash. This closely fits the largest of the outlined anomalous areas of Fig. 3.

The southward turn of Soap Wash is now clearly seen to be controlled by northeast and northwest linear features. The inference that eastward flowing drainages made abrupt, nearly right angle turns upon reaching a north-south linear along the common township line separating Ranges 14 and 15 West is now substantiated by drainage patterns of Fig. 4.

Geologic Structures

Generally, most fault strikes, major joint sets, and foliation trends are in agreement with plotted photo linears. Notable exceptions are also discussed within the context of the following paragraphs describing the geologic structures of Fig. 2.

<u>North-South Structures</u>. North-south, mountain front faults probably represent a Basin and Range fault zone along the Hualpai's eastern flank. Recall that Davidson (1973, Fig. 4, p. 11) shows the Big Sandy River Valley as being a graben structure which cuts Tertiary lower basin fill material. The lower basin fill includes the Big Sandy Formation which " . . . is definitely Pliocene and probably late Pliocene in age" (Sheppard and Gude 1972, p. 9). It is reasonable therefore, to assume that some of the north-south bounding faults are Basin and Range in age. Fig. 2 shows major joint sets and faults to dip 65°-75° westerly and 75°-80°easterly. Only in the southern half of grid C-2 and the northern half of grid C-3 (Fig. 2) do north-south structures show as prevailing features of possible correlation to the township line linear feature noted in Figs. 3 and 4.

North-south features are weakest in density along the northwest margins of the map area. Elsewhere they are more or less uniform in density. A north-south fracture zone about 600-1,000 feet wide transcends Precambrian rocks in the eastern half of grids of B-3 and 4. This fracture zone with steep westerly dips is a highly visible feature due to the presence of quartz veins and oxidizing sulfide mineralization. Its southern and northern limits were not delineated during field work.

A majority of the mapped north-south faults also dip steeply in a westerly direction. Significant displacements due to north-south faults were not noted. The area of north-south linears in Fig. 3, south of Odle Ranch, may not have been expressed in Fig. 2 due to the lack of detailed mapping in that area.

East-West Structures. East-west trends, more pronounced in the photo linear studies, are not seen as major structures in the area of Wheeler and McGarry's Washes. However, east-west joint sets are more prevalent south of the number 2 grid squares (Fig. 2). In the Precambrian granite gneiss (Fig. 2, grids B-3 and 4), a strong east-west foliation trend dips steeply south to vertical. East-west striking joint sets and east-west striking faults are also more prevalent in the south half of the map area. The east-west photo linears of McGarry's and Wheeler Washes are thought to be initially manifested by an eastward tilt of the Hualpai fault block. This tilting imparted an eastward flowing drainage which locally may be superimposed over east-west structures. Displacements on east-west faults were not noted.

Northeast Structures. Two northeast trends are noted in joint sets, faults, and foliation structures. One set that averages N.65°E. is more prevalent in the southern half of the map area. The major axis of the largest quartz diorite gneiss exposure is aligned in this direction as are most of the steeply dipping foliation trends within the quartz diorite unit. Faults of the N.65°E. trend appear more in grids B-3 and C-3 (Fig. 2) than elsewhere in the study area. Based on probable displacements of quartz diorite gneiss outcrops in Soap Wash, there may be a 400 to 500 feet of right lateral movement locally where this N.65°E. fault zone traverses Soap Wash. A significant number of joint sets and faults striking N.65°E. dip steeply towards this Soap Wash fault zone. Although important vertical displacements were not observed on the faults during field mapping, these structures suggest the potential existence of a graben in the Soap Wash fault zone. Because the Soap Wash fault zone appeared to be an important structure in resolving the geologic history and economic potential of the area, a subsequent review of aerial photos and a brief field examination were undertaken. Reinterpretation of photo linear features has fortified the theoretical existence of an extensive Soap Wash fault zone (Fig. 2). Sulfide bearing quartz veins similar in appearance, strike, and dip to the large quartz veins shown in the center of the east ½ of grid B-3 (Fig. 2) were located during a later field examination in a wash approximately in the center of the south ½ of grid C-2 (Fig. 2). If these large, north-south striking quartz veins are the northward extensions of the quartz veins seen in Soap Wash and southward, then there is a strong case for a minimum of 4,500 feet of right lateral movement along the Soap Wash fault zone.

In the northern half of the map area, the dominant northeast trend averages N.30°E. compared to a stronger N.65°E. trend south of the Soap Wash fault zone. This may explain the aforementioned regional photo linear's (Fig. 3) apparent sweep from N.50°E. to N.30°E.

Northwest Structures. Analysis of regional photo linears did not suggest a strong northwest set of structures south of McGarry's Wash.

The local photo linear study, however, did establish a definite northwest trend. Field mapping has showed that the northwest structures are at least equal in density to the northeast structures.

Once again, the Soap Wash fault zone manifests itself as a divider between similar structural features of the northern and southern halves of the Geologic Map (Fig. 2). The dominant northwest trend is N.30°-45°W. South of the Soap Wash fault zone, major northwest striking faults and most northwest striking joint sets dip steeply towards an inferred graben center whose axis would trend N.45°W. through the approximate midpoint between the common corner of sections 23, 24, 25, and 26, and the quarter corner common to sections 25 and 26. North of the Soap Wash fault zone, a counterpart (?) N.30°W. graben is inferred with a central axis that passes through a point near the common corner of sections 11, 12, 13, and 14. If the inferred northwest striking structure zones are indeed the same feature, only displaced, then the right lateral separation along the Soap Wash fault zone may approximate 6,000 feet.

Metallogenic Zoning in District Vein Deposits

Lateral metallogenic zoning in the Maynard mining district (Fig. 5, in pocket) is evident from vein deposit production records. A peripheral gold-silver bearing lead-zinc zone surrounds an intermediate zone of copper-lead-zinc veins bearing various amounts of precious metals. An inner zone contains tungsten, molybdenum, and copper with minor precious metal associations.

As a basis for selecting zones of metallization, the zone lines of Fig. 5 are drawn to show distribution and the extent of a metal or group of metals where production records indicate that the particular metal(s) ceased to be a significant commodity of a deposit. Production records were examined from the files of the Arizona Bureau of Mines and from various texts listed in the Selected Bibliography.

Admittedly, the validity of the gold-silver outer ring and the extended tungsten core is questionable. With respect to gold and silver, published records are scant and early production reports often neglected quantitative values concerning base metal contents of the ore. Also, the gold production from a small prospect nearest Kingman may be due to post-Laramide mineralization since the approximate location plot on the Mohave County Geologic Map (Wilson and Moore 1959) shows this to be an area covered by Tertiary volcanic rocks.

The southwesterly extension of the tungsten zone may represent mineralization of an earlier age. Limits to Laramide vein mineralization have not been established in the district, especially in the buried pediment area; and production from these tungsten properties was from Precambrian host rocks. This inner tungsten zone depicted in Fig. 5 may represent a Precambrian tungsten belt that has had Laramide mineralization superimposed upon it.

Schrader (1909, p. 139) reports that the northeastern slopes of the Hualpai Mountains contain most of the district's deposits. They are "strong and persistent fissure veins," from one inch to three feet in width and are similar, in strike and probably similar in age to those vein deposits in the Cerbat range. Most published reports describing deposits in the Maynard district (Schrader 1909, pp. 140-141; Wilson 1941, p. 15; Dale 1961, p. 90) agree that the northwest trend is the preferred direction for vein mineralization, although there is some local favoring of north and northeast directions.

Geologic History

An exact sequence of geologic events is not known. Development of geologic historic events presented here is based on Wilson's "A Resume of the Geology of Arizona" (1962), the Geologic Map of Mohave County (Wilson and Moore 1959) the early works of Lee (1908) and Schrader (1909, 1917), and the author's field observations.

Precambrian granitic and dioritic magmas intruded basement rocks during the "Mazatzal Revolution" (Wilson 1939). Invaded rocks near the intrusives were metamorphosed to schist while the granitic and dioritic magmas developed gneissic features. A regional metamorphism, subsequent to these plutonic intrusions, could also account for the gneissic structure. Northeast striking foliation trends, joint sets, and regional faults were probably produced during Mazatzal time as well as some of the north-south and east-west faults and joint sets. Northwest structures may also have had some development during the Precambrian. It is suggested that northeast structures were well developed prior to the intrusion of the coarse grained granite pluton as exposures of similar granitic plutons southeast of the thesis area are elongated in a northeast direction (Wilson and Moore 1959). The coarse-grained granite intruded the existing gneiss and schist complex. Uplift and erosion probably followed the Mazatzal Revolution removing nearly all traces of the basement schist. Culminating the Precambrian Era were diabase intrusions, most of which favored the established northeast trending structures. Although not definitely established, the suggested early phase of tungsten mineralization may have had its beginnings during Precambrian time.

Paleozoic and Mesozoic sediments which may have existed in the area were probably removed by subsequent folding, faulting, and erosion.

North-south and northwest structures were better developed by the beginning of the Laramide interval. It was during Laramide times that the quartz monzonite pluton invaded Precambrian rocks, favoring a general north-south direction in elongation. Although molybdenum-copper and tungsten mineralization associated with the Laramide pluton shows preference to northwest and north-south structures, pre-mineral northeast structures were also mineralized. East-west veins are least abundant in the thesis area. Post-mineral strike-slip faulting and/or shearing has taken place along some northwest structures, and suggestively larger strike-slip movements occurred on northeast structures, namely within the Soap Wash fault zone.

If late Mesozoic and Cenozoic volcanic rocks and/or sediments covered the area, they have been removed predominantly by erosion, during and after the "Basin and Range" orgeny. Basin and Range faulting in a general north-south to north-northwest strike raised the Hualpai Mountain horst block high to the west with an easterly dip. The general easterly drainages were altered somewhat by northeast and northwest structures, more locally by north-south and east-west structures. Continued erosional processes exhumed post-ore covering rocks and portions of mineralized host rocks. As a consequence of this continued erosion and Basin and Range faulting, a pediment surface was cut 4½ to 5 miles into the Hualpai Mountain block's eastern flank and subsequently covered by what is purported to be probably less than 2,000 feet of alluvial material.

CHAPTER 7

ECONOMIC GEOLOGY

The exposed mineralized zone, as delineated by a nearly pervasive, pyritic halo (Fig. 6; Figs. 7 and 8, in pocket) is an elliptical shaped area whose long axis is approximately 20,000 feet in length and strikes north-northeast. Width dimensions for the pyritic halo average 10,000 feet near the south end, but narrow to 3,000 feet in the north.

Four areas of concentrated economic mineralization are interpreted from the Geologic and Alteration Maps (Figs. 2 and 7). Their dimensions range from 1,000 x 1,500 feet to 2,000 x 6,000 feet. These mineralized areas are shown (Figs. 6 and 8) as overlapping zones of hydrothermal alteration and sulfide mineralization that occur as veinlets and disseminations. The majority of mining properties with recorded production and the larger mineral prospects lie within the four areas outlined in Figs. 6 and 8.

Primary Mineralization

Hydrothermal mineralization exists as large fissure veins, veinlets, and disseminations. Three stages of mineralization are suggested from field observations, from drill core examinations which indicated some cross cutting relationships, and from the early reports of Schrader (1909) and Wilson (1941).

Quartz veins containing pyrite, molybdenite, and often containing wolframite and scheelite, with local occurrences of chalcopyrite,

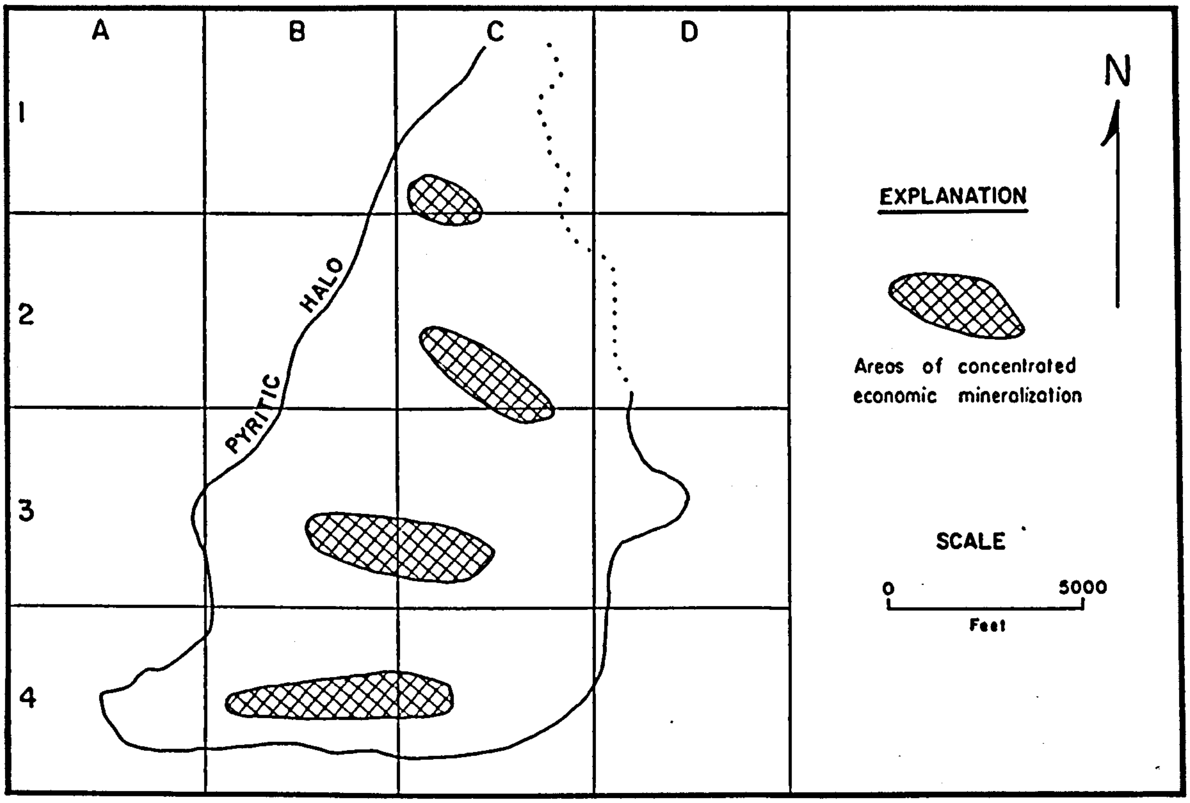

Fig. 6. Sketch Map Simplifying Figs. 2, 7, and 8

comprise the first stage of mineralization. Veins of the first stage strike in all of the major structural directions and dip steeply. They are weakest in the east-west striking directions and possibly strongest in the north-south direction. North-south quartz veins up to four feet in width, sometimes containing recoverable amounts of tungsten and molybdenum, occur in the eastern half of grids B-3 and 4 (Fig. 2) and have considerable exploratory work in the way of small adits and test pits performed on them. A possible separate stage of barren quartz or quartz-pyrite mineralization may exist but its distinctness as a separate stage and its relationship to the other mineral stages are not known. Dale (1961, p. 90) reports that veins of similar description to the barren quartz veins parallel what is described here as veins of the first stage. By structural association, the barren quartz or quartz-pyrite vein system may be a phase of first stage mineralization.

The age of formation for these first stage minerals has not been resolved and arguments for Precambrian, Laramide, or both ages can be presented. Anderson, Scholz, and Strobell (1955, pp. 79-80) concluded that the tungsten mineralization of the Bagdad area, 50 miles southeast, was associated with the intrusion of the Precambrian Lawler Peak granite. Wolframite with local associations of scheelite occur in northwest striking quartz veins up to 12 feet wide. Virtually all the tungsten mineralization in the Hualpai range nearest the thesis area is hosted in Precambrian rocks.

With regard to tungsten mineralization at Mineral Park, 25 miles northwest, Eidel, Frost, and Clippinger (1968, p. 1270) concluded that the earliest mineralization containing trace amounts of molybdenite, wolframite, and pyrite formed with large quartz masses during late stage crystallization of the central core of the Laramide, Ithaca Peak quartz monzonite magma. Tungsten mineralization is also associated with the Laramide (?) pluton in the thesis area at the Telluride Chief (Standard Minerals) mine (Wilson 1941, p. 15).

A third possibility for the present occurrence of tungsten mineralization would be for the Laramide activity to have superimposed its own mineral deposition over a Precambrian tungsten occurrence with a potential to have partially or completely remobilized the tungsten metallization locally.

Second stage mineralization consists of quartz-pyrite-molybdenite-chalcopyrite veins and veinlets and local sulfide disseminations. In more intensely mineralized areas second-stage veins and veinlets strike northwest and northeast, dipping steeply. The northwest direction appears to be the overall preferred direction. Veinlets and pervasive disseminated sulfides are localized in four separate areas as outlined in Fig. 8. Often there is a distinct decrease in intensity of mineralization in topographically high areas relative to mineral intensity in canyon bottoms. Therefore, the four intensely mineralized areas of Fig. 8 may be separate in part due to an erosional effect. As was suggested earlier, post-mineral; right lateral strike-slip movement along the Soap Wash fault zone may account for some separation. About 70 per cent of the sulfides occur as fracture fillings.

Third stage mineralization of veins, and locally veinlets, containing quartz, pyrite, chalcopyrite, galena, and sphalerite are more prominent in areas peripheral to the mineralized zone. Although vein strikes in all major structural directions are represented, the preferred strike is northwest. Properties outlying the thesis area with recorded production (Schrader 1909, pp. 140-141) indicate that the veins of mineralization similar in description to the third stage veins also accounted for much of the gold and silver production in the district. Arizona Bureau of Mines file data and Wilson (1941, p. 14) also record precious metal production in lead-copper-molybdenum ore from the Standard Minerals mine. Surface mineralization at the Standard Minerals property, however, did not indicate the presence of mineable copper-lead bearing veins at depth.

District-wide, the most favored strike direction for mineralization is northwesterly. All rock types except the noted peripheral diabase dikes contain sulfide mineralization. Veinlets and veins range in width from 0.05 inch to nearly 6 feet. In the intensely mineralized areas veinlet density is estimated to average one veinlet per inch.

Chalcopyrite is probably the second most widely distributed sulfide next to pyrite. Molybdenite is more fracture controlled and is not seen to be pervasively disseminated. Much of the disseminated pyrite in the strongly mafic Precambrian quartz diorite gneiss and granite is seen to replace biotite. Actual total sulfide content over the more strongly mineralized zones of Fig. 8 has not been quantitatively determined, but a visual estimate indicates a maximum of 5 per cent and a reasonable average of 3 per cent. This average 3 per cent sulfide content contains a mineral ratio of pyrite:chalcopyrite:molybdenite that is estimated to be 15:2:1. Rough calculations indicate metal concentrations in these areas might average as high as 0.15 per cent copper and 0.10 per cent molybdenum. Outward from these zones the estimated total sulfide content diminishes to 1 per cent at the limit of pyritization (Fig. 8) where pyrite comprises virtually all of the sulfide mineralization.

Wall Rock Alteration

Hydrothermal alteration of wall rock in the Wheeler Wash area exists for the most part as envelopes enclosing fracture filled systems. In many observations, fresh rock is seen between veins. Outward from a vein, the alteration extends from 0.1 inch to a few inches. Localized exceptions occur in areas where vein/veinlet density allows for overlapping of outer alteration envelopes. In such instances, pervasive alteration is generally consistent with the outer envelope.

Fig. 7 shows alteration products in wall rock for the areas traversed during geologic mapping. As with the Geologic Map (Fig. 2) blank areas do not necessarily indicate a lack of outcrop exposures, but rather that the area was not mapped due to difficult accessibility or a lack of field time.

With regard to those alteration products listed in Fig. 7, a few comments of clarification are presented. Rocks examined during mapping were subject to various stages of weathering. Whenever possible, the least weathered specimen was examined for wall rock alteration. It should be considered however, that some clay development on feldspars and mica (sericite)-like minerals can be found in a supergene environment and be mistaken in hand specimen for argillic and sericitic alteration, respectively.

A pyritic zone appears to cover the district. In Fig. 7 the pyritization was defined by actual observations of pyrite, iron oxide pseudomorphs after pyrite, and other iron oxide stained casts and fractures which visually were identifiable as staining after pyrite and which did not have stain characteristics similar to those seen on weathering, mafic rock-forming minerals. Inferred positions of the outlined pyritic halo were determined by using colors distinctive of iron oxide after pyrite as a guide and plotting the observable extent of those rocks stained by the distinctive colors. All of the pyritic halo in unmapped areas was defined by this process.

Alteration Zones

Four alteration zone boundaries are depicted (Fig. 8) within the pyritization halo. These zones designate the general extent of each alteration mineral assemblage used in megascopic identification of a particular zone. Thus, any alteration envelope enclosing a sulfide vein may contain one or more alteration assemblages, but when certain assemblages are no longer dominant or cease to exist, it is considered to be the limiting extent, hence the zone boundary, for that particular alteration assemblage. As with defining the zones of intense mineralization, the topographic effect, i.e., the depth of erosion in local areas, may mask continuity between alteration zone boundaries. Field observations did not indicate that rock type interfaces had significant effect on alteration boundaries; but this is not to be taken as conclusive evidence for any absence in rock type effect because a detailed and systematic petrographic study is lacking. Naming of the four alteration zones, potassic, sericitic, argillic, and propylitic is suggested from recognized mineral assemblages compared to wall rock alteration descriptions of Meyer and Hemley (1967) and Lowell and Guilbert (1970). Due to an overall, conditional megascopic basis for identifying the zones and an overlapping of mineral assemblages, the wall rock alteration boundaries drawn in Fig. 8 are subject to further interpretations.

Potassic Alteration Zone. Two types of potassium feldspar alteration envelopes are noted. One type consists of quartz-sulfide veinlets, with thin selvages of sericite, and potassium feldspar replacement of plagioclase that extends into the wall rock at a distance nearly equaling twice the veinlet thickness. A second type exhibits a sericite zone whose thickness equals the potassium feldspar replacement zone, but here the sericite selvage lies outward from the potassium alteration instead of being adjacent to the quartz veinlet as in the first type. Also, some chloritization of biotite and clay development on wall rock feldspars was noted along the outer margins of the sericitic alteration. Introduced (?) biotite occurs locally, accompanied by trace amounts of anhydrite (?).

Sulfides associated with the quartz veinlets fit the description of second-stage type mineralization of pyrite, chalcopyrite, and molybdenite. Approximately half of the sulfide content of host rocks in the potassic zone occurs as disseminations.

Sericitic Alteration Zone. Within the sericitization zone most host rock minerals have been sericitized outward from a quartz vein/ veinlet to a distance equal to, or greater than, one-half of the fracture fill thickness. In more intensely altered areas, pervasive sericitic alteration extends for hundreds of feet in length and width. Biotite is often partially pyritized, especially in the more mafic quartz diorite gneiss and granite. Sericitic alteration commonly grades outward into argillic alteration. When vein/veinlet density is high enough, plagioclase within the intervening wall rock is argillized.

Quartz veinlet filling consists of sericite, pyrite, molybdenite, and chalcopyrite. Most of the high molybdenite content seen in the area lies within the sericitic zone. Also, veinlet mineralization here generally exceeds disseminated mineralization and the total sulfide content approaches its estimated maximum of 5 per cent.

Contact between the sericitic zone and potassic zone is not sharply defined in field observations and can be considered gradational over several tens of feet to a few hundreds of feet. Immediately outward from the sericitic zone is the argillic zone. This contact is also poorly defined in the field and may be gradational over several hundreds of feet.

Argillic Alteration Zone. Argillization of plagioclase feldspars extends outwards from quartz-pyrite-sericite veinlets at a distance which generally exceeds veinlet widths by a factor of three or less. Some chloritization of biotite can usually be found in this zone. As veinlet density increases, argillic alteration takes on a pervasive nature. In areas of low veinlet/vein density, propylitic alteration can sometimes be seen extending outwards from the argillic envelope and in many instances, fresh rock persists between alteration envelopes.

This is the first alteration zone that is interpreted as completely surrounding all four areas of intense mineralization (Fig. 8). Away from the areas of high density sulfide veins and veinlets, argillic alteration of wall rock is erratic. Since such small zones of argillic alteration are ill-defined in the field and difficult to plot at the map scale used, the outer boundary for this zone was arbitrarily set where epidote was seen to be common with sulfide mineralization. Thus, the drawn contact between the argillic-propylitic zones represents a very gradational field.

In the more intensely mineralized portions of the argillic zone, sulfide mineralization, where exposed, consists of pyrite, chalcopyrite, and molybdenite. Mineralization of the third phase, i.e., veins bearing copper, lead, zinc, is found closer to the bordering propylitic zone. Total sulfide content decreases from the high of 5 per cent in the more intensely mineralized areas to an average of 2 per cent or less near the propylitic boundary. The ratio of pyrite to chalcopyrite is high; estimated ratios would range from 10:1 to 15:1.

<u>Propylitic Alteration Zone</u>. In this zone, epidote is associated with pyrite in quartz veins and is often observed pervasively over distances of hundreds of feet in host rocks. Some chloritization of biotite and the presence of iron oxides after pyrite were noted. The

outer limit of this zone is not clearly defined, but can be roughly interpreted as approximating the line of pyritization.

The larger base metal fissure veins of the third stage mineralization occur predominantly here. Overall sulfide content is fairly uniform at 2 per cent or less, and except for the metal content of the base metal veins, nearly all of the sulfide content is pyrite.

Secondary Mineralization and Alteration

Although the ratio of pyrite to other sulfides is adequate to liberate enough sulfur available for acid leaching and transporting of copper ions, secondary copper enrichment is not expected to be of importance in evaluating the economic potential in the area of outcropping mineralization. Surface observations suggest that the average content of copper in the weathered zone is low and possibly inconsistent. Calcocite coatings were not observed in the more favorably appearing mineralized areas and "limonite" colors indigenous to cellular boxworks indicate oxidation after pyrite in most instances. Weathering of mineralized rocks has produced little in the way of "copper oxide" staining or paint. The more conspicuous secondary copper minerals are seen in some of the exposed, base metal fissure veins. It is herein assumed that the estimated overall low surficial copper content of this mineralized area would prohibit much staining of host rocks. Also, the best exposures of copper mineralization are in stream channels which are subject to periodic flushing. Observed secondary copper mineralization, although not positively identified, was limited to small specimens of chrysocolla and malachite.

Secondary molybdenum minerals were not recognized during mapping. However, conspicuous greenish yellow staining was observed near and sometimes surrounding blebs of molybdenite. It is suspected that these stains are at least in part due to oxidation products of the molybdenum mineralization. Often larger areas of the host rock appeared to be stained with this same greenish yellow coloration.

Iron staining is widespread over the district. Obvious weathering of mafic rock-forming minerals are clearly visible in the less hydrothermally altered areas. Generally, this oxidation of iron bearing silicates and oxides impart colorations of brick-red, brownish red, and yellowish brown over most strongly weathered rock surfaces and most unmineralized fractures. Remnant iron staining after sulfides generally were colored shades of deep reddish brown and dark brown to nearly black. "Limonite" after sulfides consisted of indigenous, fringing, and exotic mineralization. Much of this limonite is suspected to be hematite with substantial amounts of goethite and possibly more rarely, jarosite.

In some areas, it was observed that certain colors were distinctive locally in staining weathered rock surfaces. It was considered that local sulfide mineralization, when oxidized, may impart distinctive staining colors in this district and that these recognizable colors may be of use in exploration. Two areas were selected for geochemical sampling in zones of intense alteration and high density mineralization. The areas selected lie about 4,000 feet from one another. In each area, weathered rock chips of less than one inch in diameter, containing "limonite" stained fractures, were sampled for analysis. Care was taken to select rock chips for each sample that contained one distinctive color stain. Four visually distinct color ranges were selected at each collection area and therefore four samples, one for each color range, were collected at each of the two sites. The samples were analyzed by a commercial lab for copper and molybdenum content measured in parts per million (ppm). Table 1 is a summary of the analysis.

Since background values of these metals are assumed to be high in a copper-molybdenum district, individual sample values were not considered to merit as much significance for using fracture stain colors as an exploration guide than did relative comparisons of the values between separate color classifications. Even with this limited data, correlation between metal values and fracture stain colors appears valid. The two red colors seemingly have little bearing for determining metal concentrations unless the deepening brown coloration is an indication of decreasing molybdenum content. Copper and molybdenum both appear to maintain high values in those fractures stained greenish yellow to greenish orange. The dark brown colors probably indicate areas of low molybdenum values, but their significance to copper metallization is not too clear because of the wide range in values (90 ppm - 440 ppm) between the two samples.

Secondary alteration, i.e., supergene alteration of host rock minerals, probably accounts for some clay and mica-like minerals that have been interpreted as hydrothermal argillic and sericitic alteration.

TABLE 1

ROCK CHIP GEOCHEM ANALYSIS OF SELECTIVE COLOR-STAINED FRACTURES

Color of Stain on Fractures	Copper Value Range in ppm	Molybdenum Value Range in ppm
Greenish Yellow to Greenish Orange	380-490	90-370
Light Brownish Red (Brick-Red)	60-120	60 (Both Samples)
Dark Brownish Red (Maroon)	65 (Both Samples)	12-45
Dark Reddish Brown (Seal Brown) to Blackish Brown	90-440	6-8

CHAPTER 8

SUMMARY

It seems likely that mineral resource potential within the Wheeler Wash and adjacent areas has not been thoroughly evaluated. Earlier exploration ventures, which were eventually abandoned, do not present a totally negative image towards further examinations. The existence of one or more economic mineral deposits of the base-metal porphyry type appears probable, and a comprehensive evaluation proposal can be justified. Contents of this chapter should provide a basis from which to formulate a more conclusive evaluation program.

Wheeler Wash Mineral Deposit

Mineralization in the Wheeler Wash area conforms to a general description ascribed to a base-metal prophyry mineral deposit. It covers a large area and therefore is a bulk deposit. It contains low tenor copper and molybdenum metallization, most of which occurs in sulfide minerals as disseminated blebs and in small veins and veinlets. There is noticeable lateral zoning of wall rock alteration outward from areas of high density mineralization. The deposit configuration, type of mineralization and alteration, and estimated metal content suggest a mesothermal copper-molybdenum deposit which may be considered a "high molybdenum, porphyry copper" target.

Comparing the Wheeler Wash area mineralization to Lowell and Guilbert's (1970) typical porphyry copper deposit, it is possible to model several processes which would account for the present configuration of the mineralized zones. A first assumption in the modeling process allows for a mineral deposit of economic tenor to be partially exposed but not delineated by previous exploration. The second assumption also employs a partially exposed mineral deposit, but it is of low tenor, possibly protore, which earlier examinations failed to discover. Thirdly, the deposit is assumed to be of ore grade, but post-mineralization erosion has removed much of this deposit leaving only the low tenor "roots" exposed. A fourth possibility embodies a theory of faulting on the east flank of the Hualpai range that cuts a portion of the deposit, preserving the mineralization in the down-thrown block and exposing the upthrown black to erosion.

The first two assumptions stipulate that a mineralized body is only partially exposed. Testing of these models can be pursued by core drilling in areas considered to lie within the ore/protore zone. This implies that correct interpretations of the surficial geology are necessary to properly select drill sites. The latter theories assume that only the "roots" of a mineral body are exposed. Again, correct geologic interpretation is imperative to either encourage exploration for potential targets or to recommend abandonment of further work.

Geologic Interpretations

A great deal of data has been amassed in Figs. 2, 4, and 7 and when they are compared one to the others, some geologic interpretations tend to be lost in the detail. Fig. 8 represents a composite study emphasizing economic geology and illustrating a simplification of the geologic interpretations.

Some of this simplification needs to be clarified before proceeding. A line delineating the areal extent for the majority of observed sulfide veins has not been smoothed to conform to a curve for the specific purpose of emphasizing the author's suggestion that post-mineral faulting has imparted the irregular extent to observable mineralization. It is acknowledged, however, that post-mineral cover along the map area's eastern edge and the lack of deep erosion over the deposit in the far western portion of the map, obscures the true extent of sulfide mineralization.

Other conclusions pertaining to mineralization, alteration, structural trends, and topographic effects imparted to the interpretations have been discussed in previous sections. Occasionally there will be brief repetition of certain conclusions within this chapter to elucidate a discussion.

Evaluation of Mineral Deposits

The remaining discussion of this section is devoted to comparing known geologic features of the mineralized zone to a typical "porphyry" mineral deposit and to formulate conclusions pertaining to the potential discovery of economic mineral deposits. Interpretations of wall rock alteration zones shown in Fig. 8 suggest that perhaps the potassic alteration is not well exposed, but that locally, the sericitic zone is. North of the proposed Soap Wash fault zone sericitic alteration partially encloses the area of disseminated mineralization. South of this fault zone sulfide mineralization is more extensive in its areal distribution.

Associated tungsten mineralization may indicate a higher formational temperature and thus a greater depth of exposure into the mineralized body. However, since there is doubt concerning the age of the tungsten mineralization and since there is tungsten-molybdenum associated with the upper-central core of the Mineral Park deposit, the relationship of tungsten mineralization to depth of exposure in the Wheeler Wash deposit is unclear.

Another confusing issue concerning depth of exposure for the Wheeler Wash area deposits is the seemingly consistent low metal content. The estimated surface values of copper and molybdenum metallization would, by 1974 standards, place the mineralization in a marginal or protore classification. Several major exploration companies have drilled three core holes in the areas of highest indicated mineralization to depths purported to lie between 1,000 and 1,600 feet. Since these companies have abandoned their holdings one might assume that subsurface changes in mineralization and alteration encountered in the deeper drill holes did little to encourage further exploration. Without knowing the corporate policies which resulted in the abandonment of the Wheeler Wash area, these discouraging implications should not deter others from a more aggressive exploration attitude and a more complete evaluation of the area.

By removal of the topographic relief effect on mineralization and alteration it is plausible to envision the northern two zones of sulfide mineralization (Fig. 8) as being part of the same mineral deposit. The same reasoning could be applied to the southern two zones of sulfide mineralization. If the Soap Wash fault zone theory is accepted, then the four mineralized areas of Fig. 8 may represent a single mineral deposit separated by a right-lateral, post-mineral fault. Reconstruction of the mineral deposit would suggest an original oval cylinder or elongate domal shape whose dimensions would approximate 5,000 feet east-northeast by 12,000 feet northwest. Porphyry mineral deposits of these dimensions attain thicknesses or depths to 5,000 feet and contain an average of 500 million short tons of rock in the sulfide bearing zone. An alternative to this single deposit model is to consider two distinct centers of mineralization and hence, two mineral deposits. Both deposits of this alternative model have similar geometry, each of which approximates an elongate oval 5,000 feet east-northeast by 6,000 feet northwest. Total tonnage of both mineral deposits would emulate that of the single deposit model. The two deposit model does not include extensive right-lateral movement in the Soap Wash fault zone.

Depths of exposure in the two mineralized areas are difficult to ascertain. Since evidence for supergene enrichment was not observed during field mapping, it is surmised that much of the leached capping and enriched layer, if they existed, have been eroded or faulted away to the level of primary mineralization. There are, however, several hypotheses which can describe the present mineralization--alteration relationships from available evidence. The north deposit could be exposed to a low tenor core zone which may be surrounded by higher grade metallization at greater depth. In this situation much of the sulfide mineralization has been protected from supergene processes. There is also the possibility that the north deposit has been faulted and eroded to a lower level where mineralization is weak and consistent in low tenor.

Similar levels of exposure may be ascribed to the south deposit if there is indeed a low tenor core in the mineralized bodies. Because sulfide mineralization of the south deposit extends beyond the sericitic zone, it is believed that a somewhat deeper level of erosion exists if it is the upper portion of the south deposit that is exposed, but not quite so deep as the "root" zone if it is the bottom portion of the deposit that is exposed.

The mineral deposit(s) may not contain a low tenor core. Under such conditions the depth of exposure theory essentially remains the same for the north deposit. If the south deposit is consistently low in tenor, the exposure depth is deep within the mineral body. If the south deposit had an ore grade central region, we are probably seeing the "root" zone in outcrop.

Description of Mineral Deposit Models

Fig. 9 shows in plan view the possible placement of a two deposit model. Fig. 10 is a plan view of a single deposit, separated by a right lateral fault. The sequential development stages show how a single deposit model could account for most of the geologic simularities noted in the two deposit model. Based on the present inconclusive data,

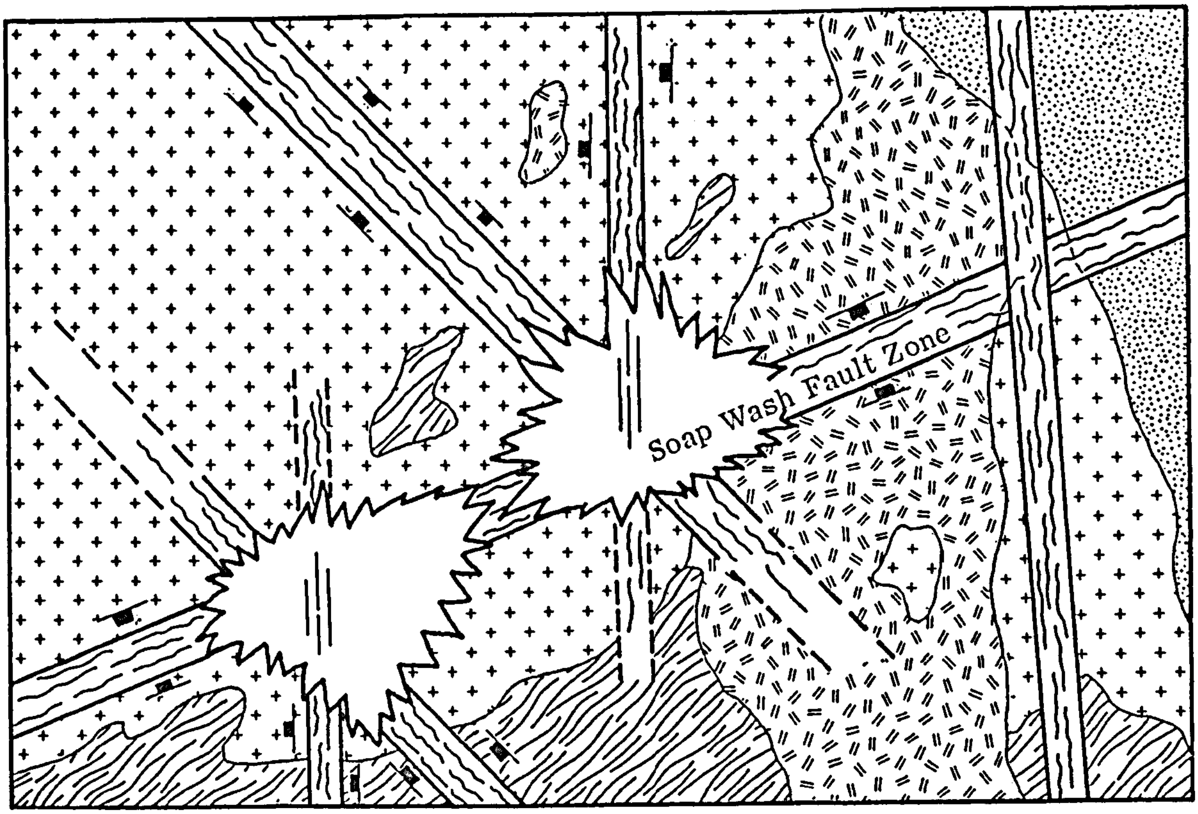

Fig. 9. Schematic Plan View Illustrating a
Hypothetical Two Deposit Model of Porphyry Mineralization

Explanation

Alluvium	Porphyry Mineralization
"Laramide" Pluton	Large Quartz Veins
Precambrian Granite	Conjectured Structural Zones
Precambrian Gneiss Complex	Joint Fracture; Strike and Dip

Fig. 10. Schematic Sequential Plan View Illustrating Hypothetical Development of Fault Separated, Single Deposit Model

A. Precambrian Terrane and Pre-mineral Structures

B. Emplacement of "Laramide" Pluton and Porphyry Deposit

C. Post-mineralization Right-Lateral Faulting

D. Basin and Range Faulting and Present Erosional Surface

Explanation

Alluvium

Porphyry Mineralization

"Laramide" Pluton

Large Quartz Veins

Precambrian Granite

Conjectured Structural Zones

Precambrian Gneiss Complex

Joint Fracture; Strike and Dip

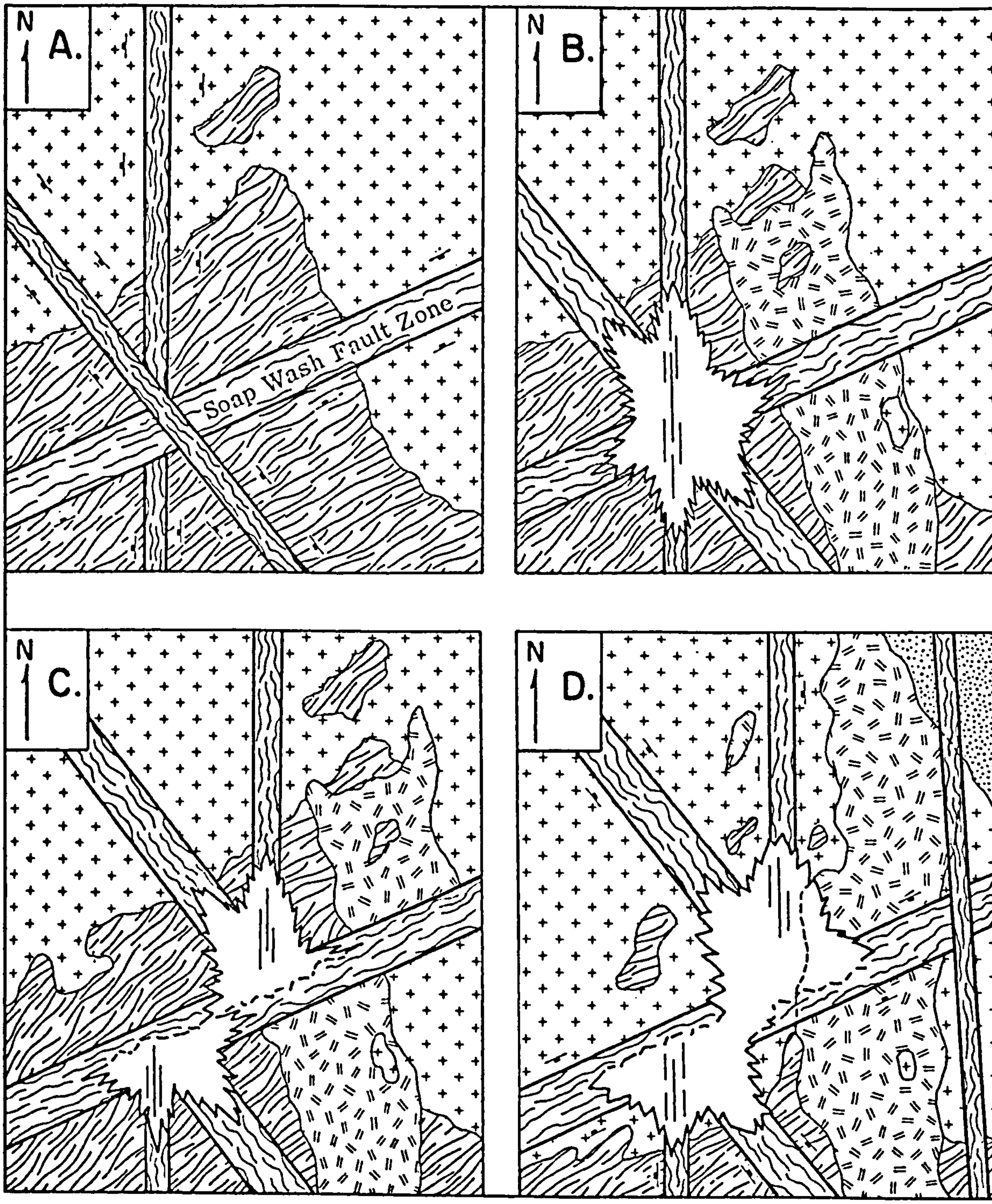

Fig. 10. Schematic Plan View--Single Deposit Model

both models would appear to be reasonable interpretations. At the time of this writing, the author favors the single deposit model, but planning an evaluation program to test this hypothesis is equally applicable to test the two deposit model. Fig. 11 shows theoretical east-west cross sections through both the north and south mineral deposits. The cross sections include the possible regional eastward tilt to the mountain block, post-mineral faulting along the mountain front, and subsequent exposure of mineralization by erosion. Also indicated in the cross sections is the potential for other mineral deposits to occur in the buried pediment area.

Potential Exploration Targets

Past exploration efforts are not documented and this present study indicates the potential for economic mineralization to occur within and surrounding the study area. Specifically, there is definite merit to a further and more complete mineral evaluation of the Wheeler Wash deposits and adjacent areas to the north and west. Such a program is described in detail within the Recommendations chapter of this text.

Contributions to Mineral Evaluation Philosophy

To optimize a mineral evaluation--exploration program, it is stressed that the initial accumulation of geologic data should include as much detail as time allows, plotted on at least two different, but appropriate scales for analysis. Also, this geologic analysis should not be limited or biased by one conventional analytical method; that is, concentrating on local theories and ignoring regional theories, or

Fig. 11. Schematic East-West Cross Sections of the North and South Mineral Zones, that Illustrate Hypothetical Tilting, Erosional Levels, Potential Faulting, and Potential Occurrence of Concealed Deposits

Explanation

Alluvium

Porphyry Mineralization

"Laramide" Pluton

Large Quartz Veins

Precambrian Granite

Conjectured Structural Zones

Precambrian Gneiss Complex

Joint Fracture; Strike and Dip

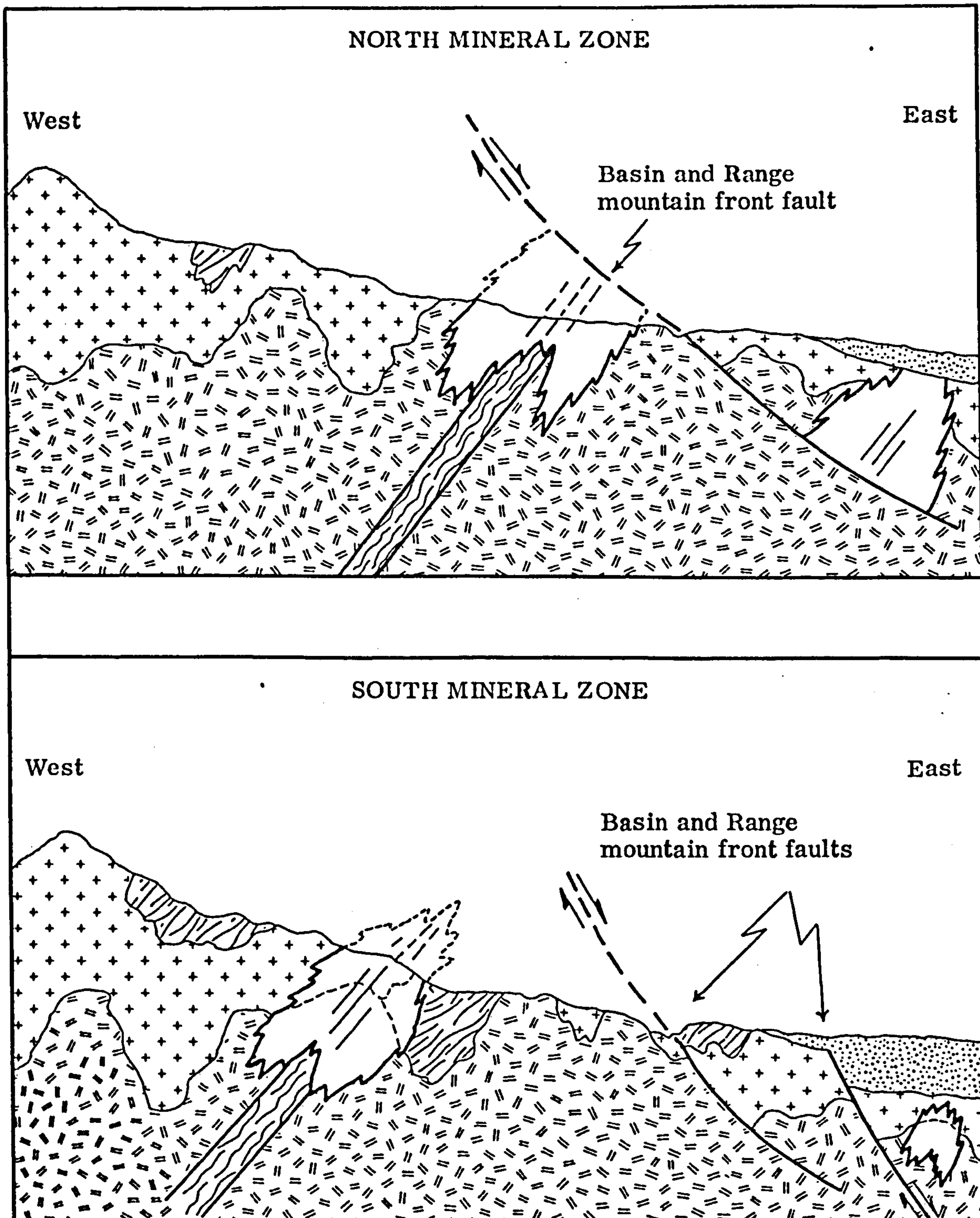

Fig. 11. Schematic
East-West Cross Sections of Mineral Zones

interpretations based on observational data opposed to interpretations based on statistical data, or conclusions founded on field examinations versus those conclusions founded on laboratory experiments.

For this study, much of the examinations were field and megascopic oriented. A special geochemical analysis, however, suggested a basis for using iron oxide stain colors as a megascopic exploration guide. Admittedly, petrographic and mineragraphic studies would have facilitated and clarified the lithologies and mineral genesis. However, these laboratory procedures were not essential in this preliminary study to recommend exploration methods. Interpretations of major structural trends certainly could have been duplicated by statistical analysis of the structural symbols plotted on the geologic map. Yet a visual interpretation was selected to discern local, subtle variances in structural trends. This visual interpretation is the basis for one of the hypothetical mineral deposit models. In order for a statistical analysis to reproduce the same findings, several fortuitously selected domains within the geologic map would have to have been analyzed separately. Utilizing different scale maps containing geologic data was also vital to the development of many of the conclusions of this report. Extracting pertinent data from these maps to compile a composite, but simplified interpretative map was useful in delineating where economic mineralization may potentially occur.

It is believed that the various methods of geologic analysis and the regional-district-local map scales containing the data for analysis were advantageous to the development of a multiple, working hypothesis concerning mineralization in the Wheeler Wash area.

CHAPTER 9

RECOMMENDATIONS

Proposals presented here have been designed to evaluate those areas concluded to merit pursuance of an exploration program. Each of those areas, the Wheeler Wash region, the area adjacent to and 1.5 miles north of McGarry's Wash, herein called the north-side area, and the buried pediment region will be treated separately for proposed recommendations. Also, area program costs with itemized listings are estimated for the convenience of the exploration engineer and geologist, and presented in Table 2. Many mining companies spend an approximate average of $25 million in exploration costs per discovery for a porphyry copper deposit of the size suggested for this region. The suggested cost of the evaluation budget in Table 2 represents approximately 1 per cent of this industry average. Since this would allow a mining company the examination of 100 such targets, it would seem to be a reasonable value to apply towards evaluation of the Wheeler Wash region.

Two general suggestions are offered before discussing area proposals. First and foremost is land acquisition. Several small, but valid claim groups exist in the area. Most of them are unpatented. To complicate matters, there have been several large, blanket type claim groups that over-stake preexisting claims. These blanket groups have periodically lapsed into forfeiture. Consolidation of existing groups and restaking the blanket groups has been a standard, workable solution

TABLE 2

PROPOSED BUDGET FOR RECOMMENDED EXPLORATION PROGRAMS

	Unit Cost	Total Cost
<u>Wheeler Wash Area</u>		
Topographic map reproductions for base map plots, enlargements, drafting, prints	--	$ 150
Geologic mapping, scale 1" = 200', 2.5 square miles; collecting approximately 50 petrographic samples;		
project geologist, 25 man days in field	$150*/day	3,750
project geologist, 3 man days office preparation	$ 90*/day	270
Geochemical sampling, 16 sample lines each averaging 8,000' in length, sample interval of 500'; technical field assistant, 10 man days	$ 95*/day	950
Analysis of approximately 260 rock-chip samples for Cu, Mo, Pb, & W	$ 5/sample	1,300
Petrographic sample preparation, commercial laboratory; 35 thin sections;	$3.50/ea.	123
15 polished sections	$5.00/ea.	75
Petrographic study; project geologist, 10 man days in office	$ 90/day	900
Geologic--geochemical interpretations and report; project geologist, 12 man days in office	$ 90/day	1,080
Other clerical and drafting assistance for all the above	--	500
Diamond core drilling, 3 NX size holes, 3,500' average total depth each, unit cost includes overall costs; e.g., mobilization, drilling, water haul, cementing, casing, downhole chemicals and additives, etc.; approximately 10,500' drilling	$ 20/ft.	210,000
Project geologist, 84 man days (4 months field time if 3 drill rigs operating)	$150/day	12,600

TABLE 2--PROPOSED BUDGET FOR RECOMMENDED EXPLORATION PROGRAMS--Continued

Drill core assays, estimate 2,500' of core per hole, 10' composite samples; approximate total number assay samples is 750, analyze for Cu, Mo, Ag, Au	$ 8/Assay	$ 6,000
Drill core geochemical analysis, estimate 1,000' of core per hole, sample at 50' intervals; approximate total number of samples is 60, analyze for Cu, Mo, Pb, W, Au, Ag	$ 10/sample	600
Access road-clearing and/or construction less than 2 miles, site construction, D-8 Bulldozer or equivalent w/ripper for 10 days; unit cost includes mobilization and miscellaneous expenses . . .	$300/day	3,000
Petrographic sample preparation of drill core, commercial laboratory;		
20 thin sections	$3.50/ea.	70
10 polished sections	$5.00/ea.	50
Petrographic study; project geologist, 5 man days in office	$ 90/day	450
Drilling log-assay/geochem interpretations and total project report; project geologist, 8 man days in office	$ 90/day	720
Drafting and clerical assistance for drilling phase	--	500
Wheeler Wash Project Area Subtotal		$243,088

<u>North-Side Area</u>

Topographic map reproductions for base map plots, enlargements, drafting prints	--	$ 75
Geologic mapping, scale 1" = 1,000', 1.25 square miles; project geologist, 5 man days in field	$150/day	750
2 man days office preparation	$ 90/day	180
Geochemical sampling, 6 sample lines, each averaging 6,000' in length, sample interval of 500'; technical field assistant, 3 man days	$ 95/day	465
Analysis of approximately 70 rock-chip and residual soil samples for Cu, Mo, Pb, W	$ 5/sample	350

TABLE 2--PROPOSED BUDGET FOR RECOMMENDED EXPLORATION PROGRAMS--Continued

Geologic-geochemical interpretations and report; project geologist, 5 man days in office	$ 90/day	$ 450
Other drafting and clerical assistance for all of above	--	350
North-Side Project Area Subtotal		$ 2,620
Buried Pediment Area		
Topographic map reproductions for base map plots, enlargements, drafting, prints	--	$ 75
Geologic mapping, scale 1" = 1,000', 36 square miles (bedrock outcrop); project geologist, 15 man days in field	$150/day	$ 2,250
2 man days office preparation	$ 90/day	$ 180
Bulldozer trenching, D-8 or equivalent, for 5 days; unit cost includes mobilization	$300/day	1,500
Magnetic survey, ground, detail, off road, 13 lines, each averaging 6 miles in length, with 200' stations; approximately 78 miles of survey lines, cost includes mobilization and interpretations	$ 55/line mile	$ 4,290
Geochemical sampling, estimate 50 rock chip and/or residual soil samples; project geologist, included with mapping time;	--	--
approximately 50 samples analyzed for Cu, Mo, Pb, W	$ 5/sample	$ 250
Geochemical sampling, stream sediment, approximately 68 miles of drainages, sample interval of 1,000' approximate; technical field assistant, 10 man days;	$ 95/day	$ 950
Analysis of approximately 350 stream sediment samples for Cu, Mo, Zn	$3.50/sample	$ 1,225
Induced Polarization survey, 2 areas, 3 survey lines each, 6,000' line length, 200' stations; approximately 7 line miles with mobilization and interpretation costs included	$550/line mile	$ 3,850

TABLE 2--PROPOSED BUDGET FOR RECOMMENDED EXPLORATION PROGRAMS--Continued

Geologic-geochemical-geophysical interpretations and report; project geologist, 7 man days in office	$ 90/day	$ 630
Other drafting and clerical assistance for all of above	--	$ 350
Buried Pediment Project Area Subtotal		$ 15,550
BUDGET PROPOSAL TOTAL		$261,258

*Per diem pay scales from the following basis:

Project geologist	@ $20,000 annual salary; about	$ 80/day
	Fringe Benefits	10/day
	Office Subtotal	$ 90/day
	Field Operations overhead	35/day
	Room and Board	25/day
	Total Field Scale	$150/day
Technical Field Assistant	@ $10,000 annual salary; about	$ 40/day
	Fringe Benefits	10/day
	Field Operations overhead	25/day
	Room and Board	20/day
	Total Field Scale	$ 95/day

to land acquisition. Judging from the number of claim posts in the area bearing location notices of different dates, it is difficult to determine in short order which blanket claim groups are still valid. If time is an important factor for field work, a complete over-staking program may be warranted. Claim validation work should be anticipated for a period of at least two years to accommodate the time span allotted for the evaluation programs. Costs of claim purchases, staking new claims, and validation work not considered as part of the exploration programs, are not included in the budget of Table 2.

The second suggestion, although rather obvious, bears mentioning. Avoid duplicating efforts of other exploration programs if the results are available for purchase or trade, and if the data is of value, useful, and accurate.

In the following recommendations, all values pertaining to sample intervals, line spacing, drill depths, etc., metals suggested for analysis, and sample/drill hole locations were selected on the basis of practicality and economics applied to this particular project.

Wheeler Wash Area

Included within the Wheeler Wash area is all the region shown in the Geologic Map (Fig. 2) and some land fringing the western margin of the map area.

Preparation of a geologic map of certain areas in and surrounding mineralized zones, scale of 1 inch equals 200 feet, is intended to resolve issues concerning major tilting or fault displacement of the mineral deposits and to more clearly delineate the mineral deposits.

Rock samples should be collected for petrographic and mineragraphic studies. These microscopic studies are intended to define the district's paragenesis and relationship to wall rock alteration. Collection of samples will be at the discretion of the mapping geologist. This detail map study should at least include appropriate portions of Fig. 2 in the south ½ of grid C-1, grid C-2, south ½ of grid B-3, and north ½ of grid B-4.

Geochemical sampling may be useful in defining the location of mineralized bodies within the region. Care must be taken to use a datum reference in sample collecting. Topographic relief may greatly effect metal values over a very local area. It is suggested that rock sample lines start at the upper drainage regions of all major eastward flowing streams, and that each sample line be maintained as close to a level as possible, or perhaps parallel to an imaginary horizontal plane of the tilted mountain block; i.e., a variation of contour sampling. Rock-chip samples should be tested for their contained metal content of copper, molybdenum, lead, and tungsten. In addition to comparing reported metal values, the metal ratios of copper:molybdenum, and molybdenum:tungsten may enhance the metal zoning picture. Sixteen east-west sample lines are recommended, spaced at 1,000 feet intervals and commencing from Wheeler Wash northward. Line lengths will probably average 10,000--12,000 feet in the south and 5,000--6,000 feet in the north. Recommended sample interval is 500 feet.

Three drill sites are selected for the purpose of testing mineralization and wall rock alteration in the Wheeler Wash area. The site selections are based on information contained within this report and are intended to be used only if drilling is to commence before the detail geologic studies are complete. Coring is recommended as soon as technically feasible to obtain as much sample as possible in the third dimension. If sulfide mineralization is not visible, geochemically sample the core at 50 feet intervals and test for the same elements as the surface geochemical sampling and add gold and silver to the metal list. Core with visible sulfides should be split and one-half assayed for copper, molybdenum, gold, and silver over composited 10 foot intervals. Appropriate sections of core should be retained for microscopic analysis of mineralization and wall rock alteration.

The preferred core diameter is the NX size which should be maintained as long as technically feasible. Total drilling depths recommended for the test holes are in the range of 3,000 to 3,500 feet. Drill site locations in order of decreasing priorities are: 1) northwest corner of grid B-4 + 1,200 feet east + 200 feet south, 2) southwest corner of grid C-2 + 2,000 feet east + 1,400 feet north, and 3) southwest corner of grid C-1 + 1,500 feet east + 500 north. All location distances are approximate. All drill holes should be vertical or at least steeply inclined. Angle holes should have an easterly to northeasterly bearing and a dip of not less than 60 degrees from the horizontal.

North-Side Area

Most of the south-half of section 1 and the north half of section 12, T.20N., R.15W., and adjacent areas west of these sections (Fig. 3) comprise the North-Side area.

Geologic mapping, at the reconnaissance mapping scale of 1 inch equals 1,000 feet, should be extended in this area to adjoin the existing map of Fig. 2. Understanding the regional geology and correlating between the North-Side area and the Wheeler Wash area may be enhanced by this mapping extension.

Geochemical rock-chip sampling is also recommended for this area. This geochemical analysis should be used in conjunction with the geologic map to assist in delineating any possible targets of anomalous mineralization. Since most of the area has a low range of topographic relief, establishing a datum level for the purpose of sample collection would not be practical. If an area is lacking in outcrops and a residual soil cover of 50 feet or less is theorized, soil samples of minus 80 mesh fraction may be collected in lieu of rock chips. Analysis of the North-Side area samples should be conducted similar to the Wheeler Wash geochemical program outline. Six east-west sample lines are spaced at 1,000 feet intervals, progressing northward from the Century mine area. The western boundary for the sample lines should commence approximately 3,000 feet west of the Century mine and continue eastward for 5,000 to 7,000 feet, depending upon outcrop exposure. The sample interval recommended here is also 500 feet.

If the geologic reconnaissance and geochemical sampling suggest a potential occurrence of anomalous mineralization, then an evaluation program similar to that conducted in and recommended for the Wheeler Wash area should be considered.

Buried Pediment Area

That portion of the gravel covered pediment lying within T.20N., R.14W. and adjacent portions of T.20N., R.15W., comprises the Buried Pediment area. The distance from the mountain front and pediment edge is estimated to be approximately 4 to 5 miles, thus the study area covers approximately 30 square miles. For the purpose of working with a limited exploration budget, the area of study may be restricted to the region where there is a greater probability for the occurrence of a faulted mineralized deposit and/or a faulted supergene enrichment zone. This area lies within and adjacent to section 18, T.20N., R.14W.

Geologic inference suggests that burial thicknesses in local areas do not prohibit practical use of certain geophysical and geochemical exploration methods which are described in later paragraphs. Also, depths to bedrock in some areas would not prohibit the mining of mineralized bodies that lie near this gravel/bedrock interface by methods in current practice.

Preliminary work in this area should include scouting all major drainages for outcrops. An outcrop, geologic map of the area at the same reconnaissance scale of 1 inch equals 1,000 feet is suggested. Some bulldozer trenching may be warranted to expose bedrock for geologic information and sampling.

At the discretion of the field geologist, rock-chip samples may be collected at small outcrop locations. A 500 feet square grid system is advised for application to larger outcrops for the purpose of collecting rock-chip samples. Metals to be analyzed are identical to the other recommended rock-chip sample surveys.

Secondary dispersion of metals may develop as hydromorphic halos in the barren alluvium overburden. Since anomalous metal values are capable of extending upwards for only a few tens of feet, they would have little chance to be detected by surface, soil geochem surveys. Down slope, lateral hydromorphic halos, if present, may be exposed by incisement of stream channeling. It is therefore recommended that a stream-sediment soil survey be conducted in the Buried Pediment area where bedrock surface configuration suggests that such a survey would be effective. For budget calculation purposes, a survey which would test all major drainages is introduced. Major drainages are to be sampled at 1,000 feet intervals and the larger tributaries at a location a few tens of feet upstream from their confluence with the major drainage. It is expected that contamination from the Wheeler Wash area mineralization will not influence the effectiveness of this survey beyond a distance of 2,000 feet from outcropping mineralization. Minus 80 mesh fractions will be analyzed copper, molybdenum, and zinc.

A gravity, magnetic, or seismic geophysical survey over the township will be useful in determining buried bedrock relief, the mountain-block fault boundary, and perhaps other buried, major structures. East-west survey lines should be spaced at half-mile intervals.

Bedrock configuration and depth of burial calculations should be of use in selecting stream drainages where geochemical sampling may be effective and for correlating anomalous geochem stream-sediment samples to their possible source.

Induced polarization should be considered as a geophysical method to locate any potential sulfide deposit indicated by the geochemical survey or geological reconnaissance. East-west lines are recommended at 1,000 feet intervals for a detail study. For the purpose of the evaluation budget (Table 2) costs for induced polarization surveys over two potential mineralized targets are presented.

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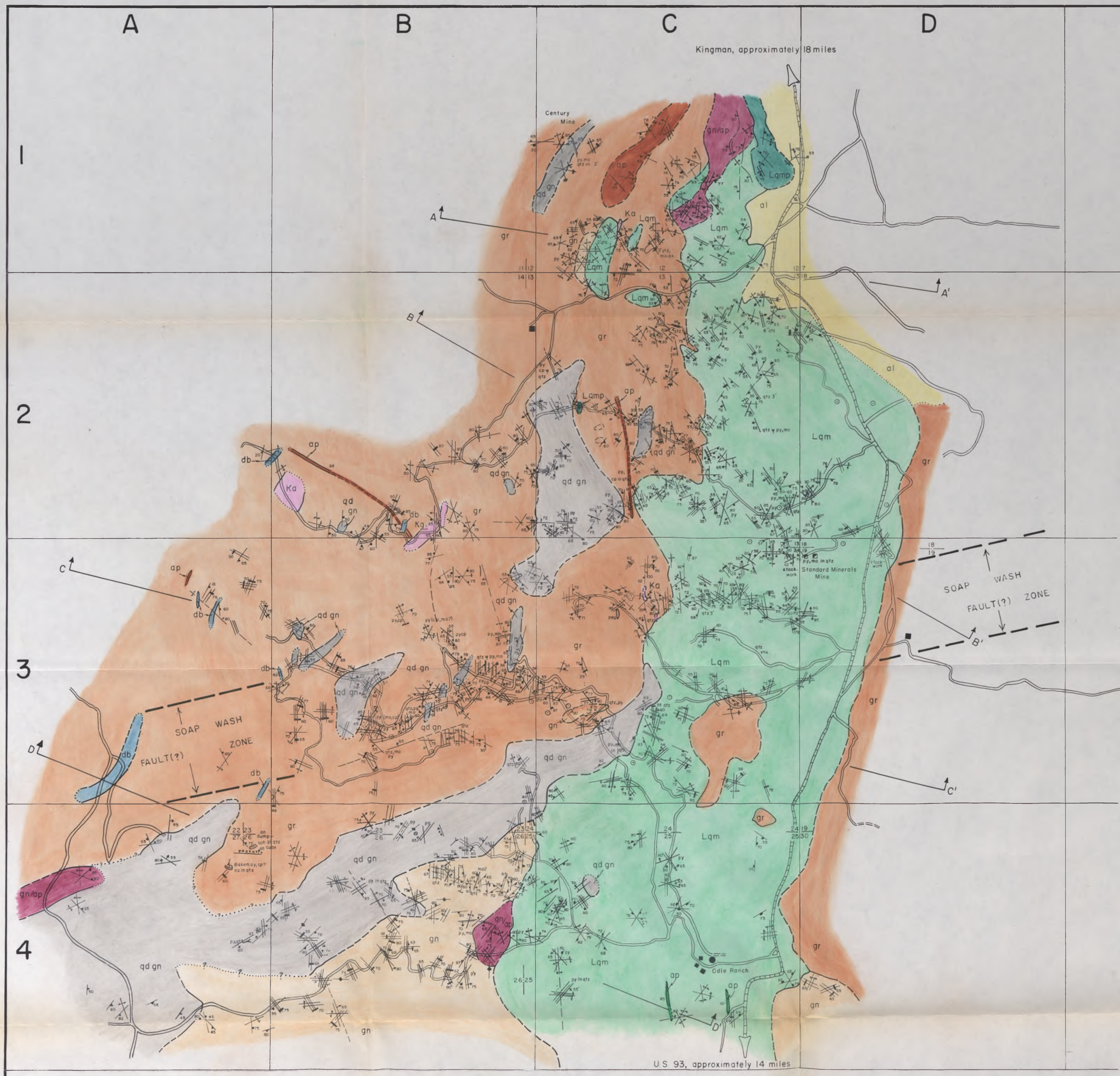
6

Maps



(1968)

EXPLANATION

al	alluvium	Cenozoic
Lqmp	quartz monzonite porphyry	Laramide (?)
Lqm	quartz monzonite, with aplite dikes	Laramide (?)
Ka	andesite dikes	Cretaceous (?)
db	diabase	Precambrian
gr/ap	granite, with aplite dikes and pods	Precambrian
qd gn	quartz diorite gneiss	Precambrian
gn/ap	aplite / pegmatite granitic gneiss	Precambrian
gn	granitic gneiss, with localized schist inclusions	Precambrian

SYMBOLS

Contact, dashed where inferred, dotted where concealed or unknown

Faults, showing strike and dip, dashed where inferred

Mineralization, showing strike and dip, dashed where inferred, pyritized unless otherwise noted as:

(veins) (inclined) (vertical) (disseminated)

qtz	quartz
CuOx	copper oxides
Cp	chalcopyrite
py	pyrite
mo	molybdenum
sph	sphalerite
gl	galena

(veinlets)

Low intensity, <2 fractures per 10 feet

Moderate intensity, approximately 2 to 5 fractures per 10 feet

High intensity, >5 fractures per 10 feet

Joints (unmineralized), showing strike and dip, intensity as above (inclined) (vertical)

Foliation, showing strike and dip (inclined) (vertical)

Adit

Shaft

Drillhole

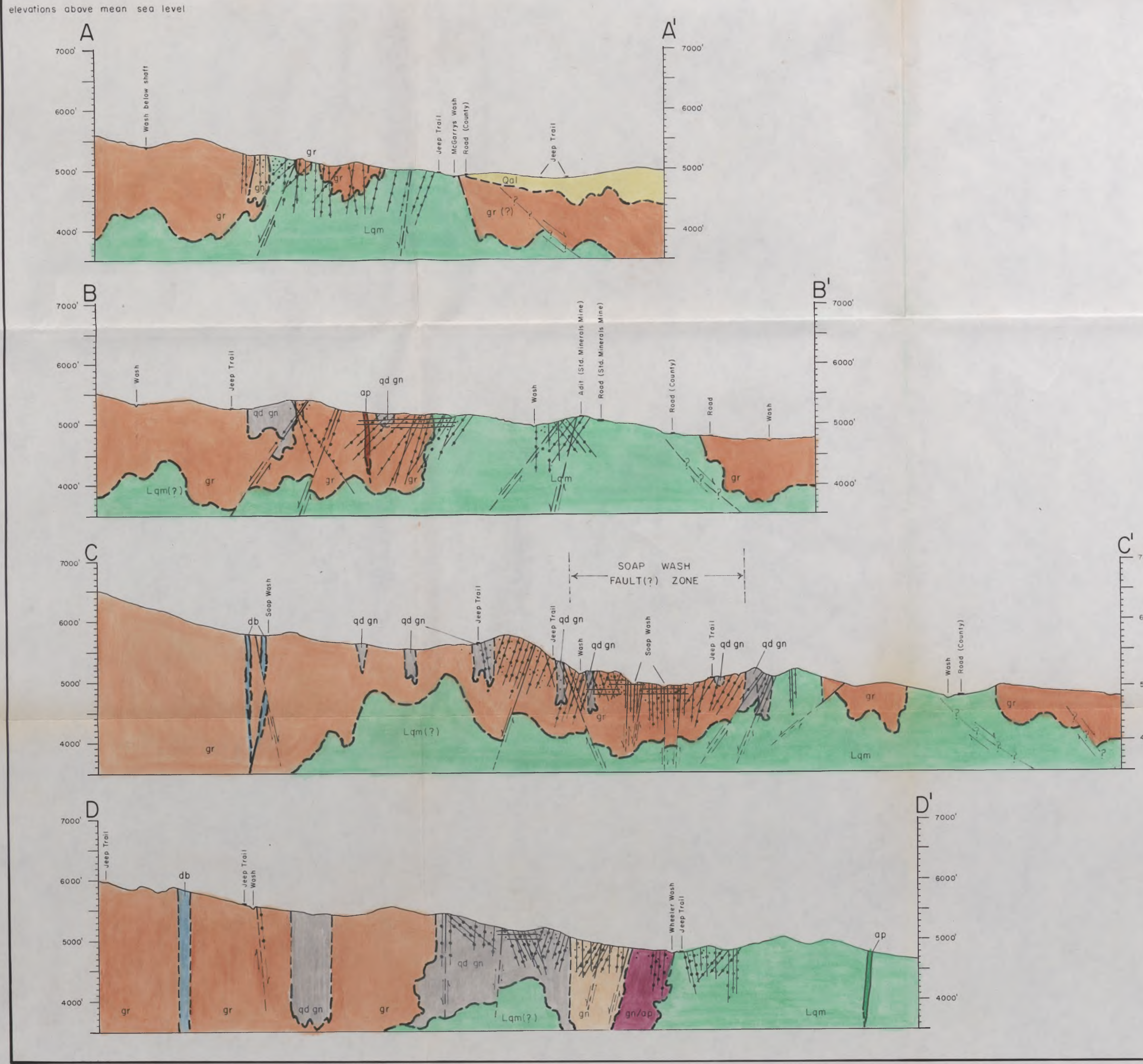
Section corner

Quarter corner

Roads (county) (other)

Cross-section line

elevations above mean sea level



CROSS SECTION EXPLANATION

Attitude and subsurface extent of faults, veins and mineralization are generalized in cross section views.

Mineralized structures

Fault, arrows indicate relative movement on faults.

OTHER SYMBOLS AS ABOVE

FIGURE 2

WHEELER WASH, MOHAVE CO., ARIZONA

GEOLOGIC MAP & CROSS SECTIONS

John S. Vuich

0 500 1000 2000 3000 feet

Scale Approximate

Horizontal scale equals vertical scale

Grid interval: 5000 feet

Vuich, 1974
Thesis, Geological Engineering

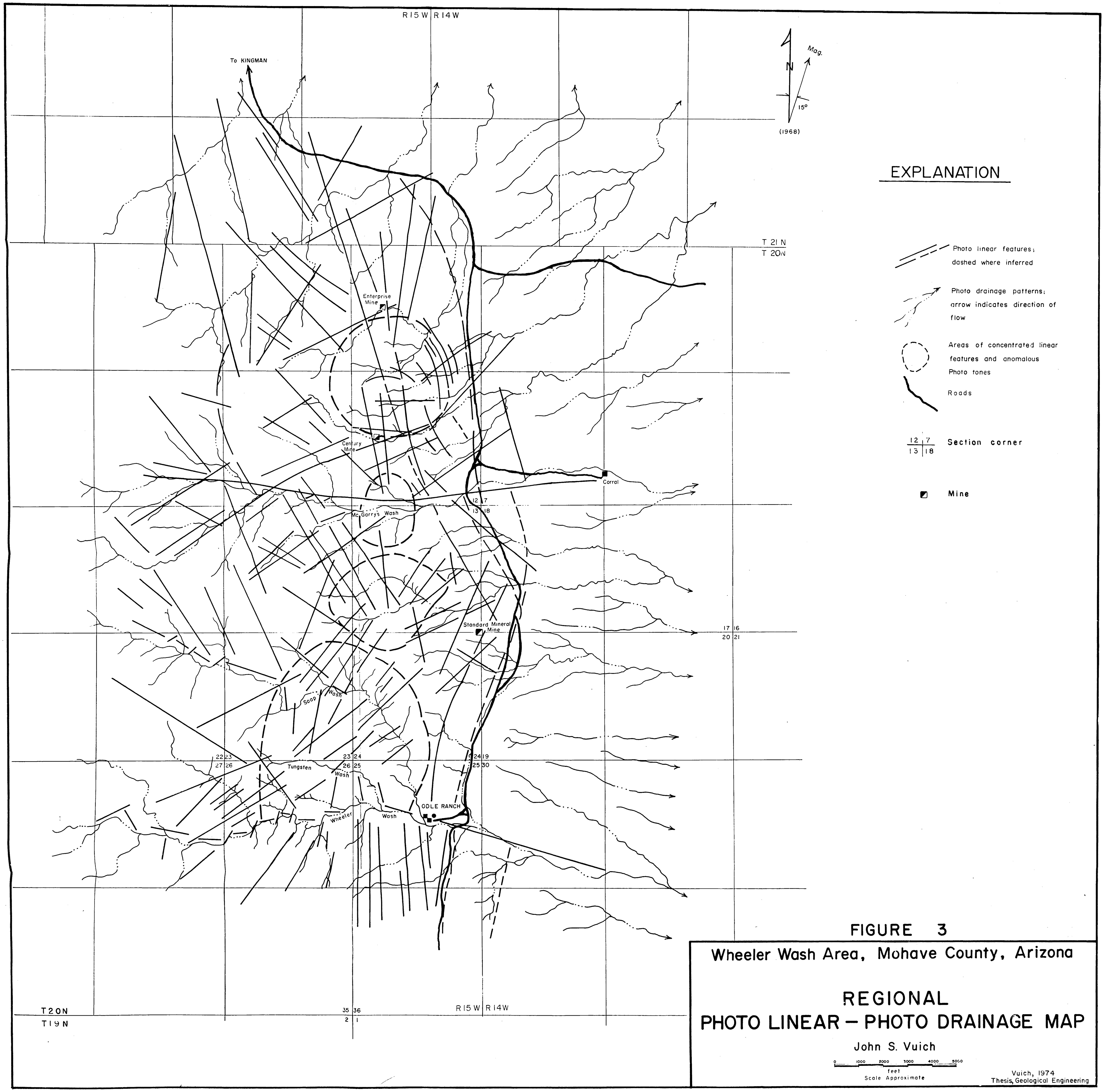


FIGURE 3

Wheeler Wash Area, Mohave County, Arizona

REGIONAL
PHOTO LINEAR – PHOTO DRAINAGE MAP

John S. Vuich

0 1000 2000 3000 4000 5000
feet
Scale Approximate

Vuich, 1974
Thesis, Geological Engineering

FIGURE 4

Wheeler Wash Area, Mohave County, Arizona

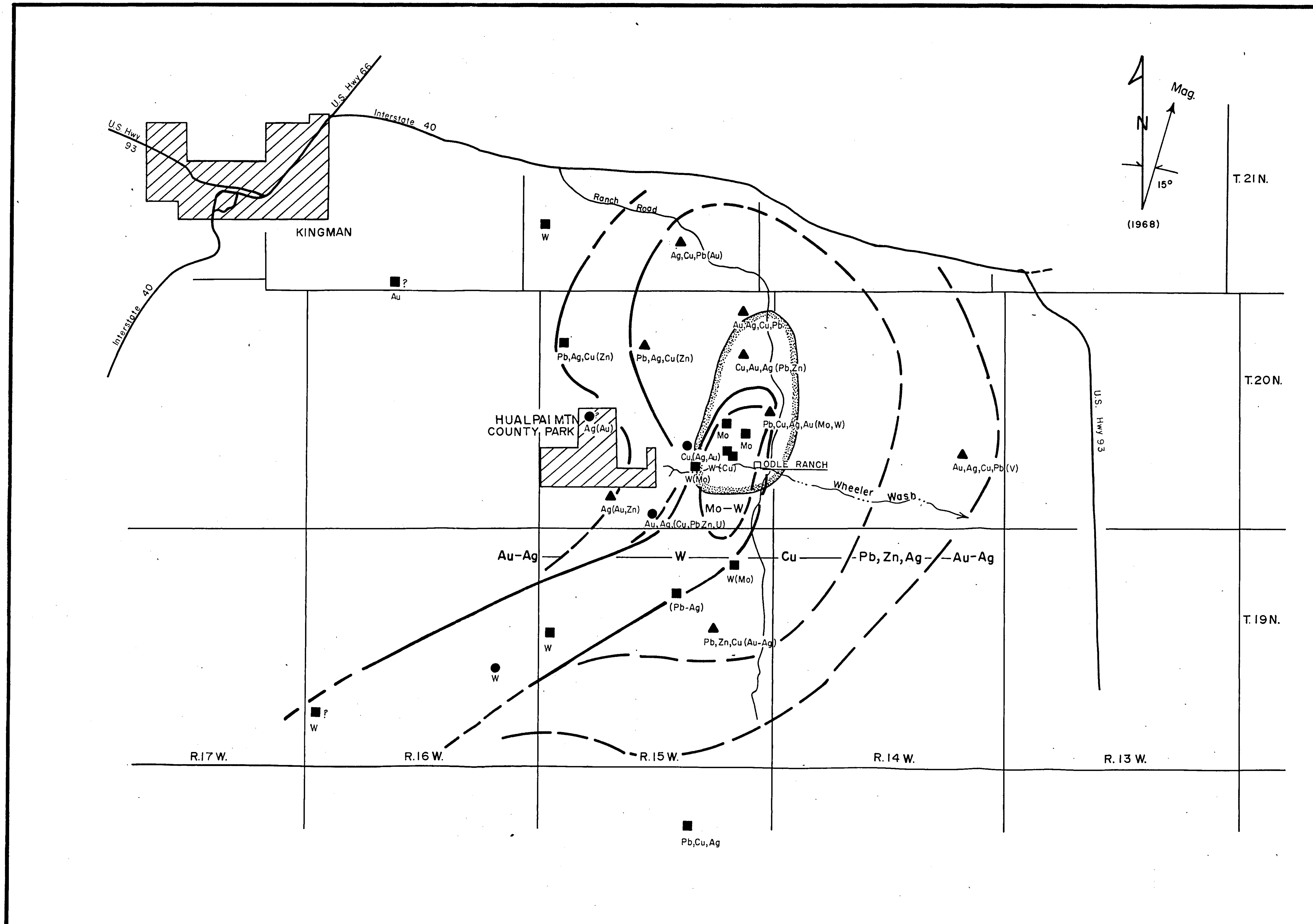
PHOTO LINEAR–PHOTO DRAINAGE MAP

John S. Vuich

Vuich, 1974
Thesis, Geological Engineering

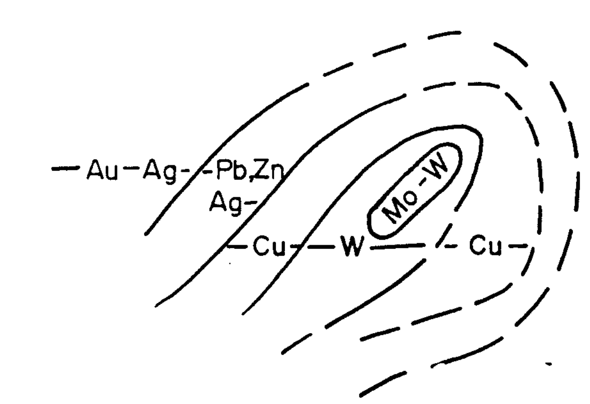
E9791
1974
402

VUICH



EXPLANATION

Wheeler Wash thesis area



Metal zoning; lines are dashed where data is less certain or absent

ORE PRODUCTION

■ < 100 tons

● 100 – 1000 tons

▲ > 1000 tons

● ? Location is approximate

Cu, Pb Major production metals

(Cu, Pb) Minor production metals

FIGURE 5

METALLOGENIC ZONING IN VEIN DEPOSITS

MAYNARD MINING DISTRICT

MOHAVE COUNTY, ARIZONA

John S. Vuich

SCALE

0 1 2 3 4 5

miles

Vuich, 1974

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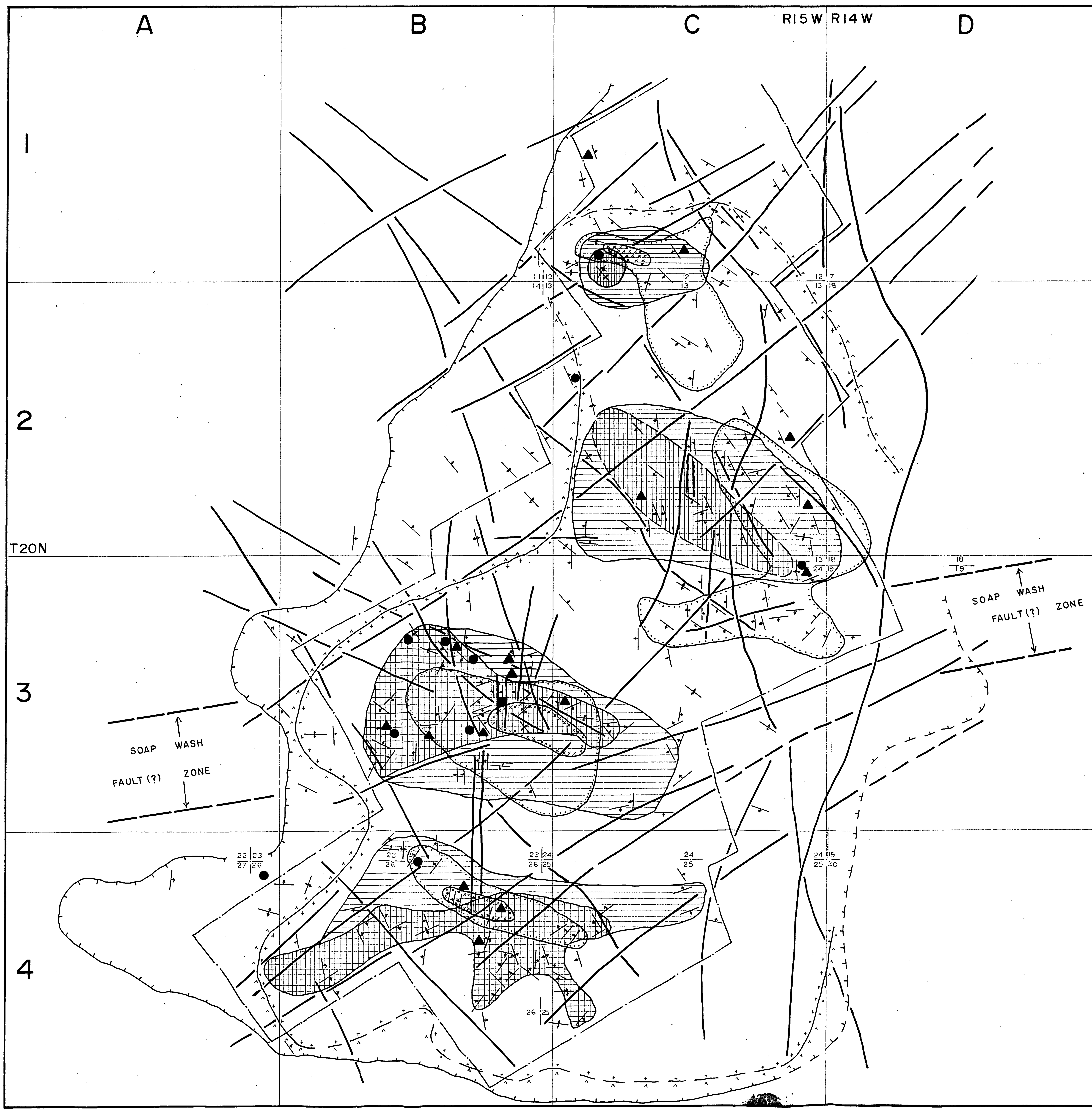
VUICH

FIGURE 7

Wheeler Wash Area, Mohave County, Arizona

ALTERATION MAP

John S. Vuich



N
Mag.
15°
(1968)

EXPLANATION

MINERALIZATION

- ● Copper
- ▲ Molybdenum

{ location of large exposure, prospect, or minor production

areal extent for the majority of veins (sulfide veins and gange minerals)

sulfide veins and veinlets

disseminated sulfides and veinlets

mineralized fractures; strike and dip trends

ALTERATION

all lines are dashed where inferred

Propylitic

Argillic

Sericitic

Potassic

Pyritization; probable extent based on iron stained fractures

NOTE : Alteration is generally confined within close proximity to mineralized fractures and is not necessarily pervasive throughout its respective zone; thus the lines limit the extent of localized alteration facies

OTHER

major structural trends (air photo and ground interpretations)

23|24 / 26|25 27|26 section corner and quarter corner

FIGURE 8

Wheeler Wash Area, Mohave County, Arizona

ECONOMIC GEOLOGY MAP

Interpretative Composite of the Geologic, Alteration, and Photo Linear Maps

John S. Vuich

0 500 1000 2000 3000
feet
Scale approximate

Grid interval: 5000 feet

Vuich, 1974
Thesis, Geological Engineering