CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the Roland Mulchay Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

OCT 1 1965

THE ANACONDA COMPANY
151 S. Tucson Blvd. — Room 221
TUCSON, ARIZONA 85716

ANACONDA
from mine to consumer
REG. U.S. PAT. OFF.

Geological Department
Southwest Office

September 29, 1965

Mr. Roland B. Mulchay, Asst. Chief Geologist
The Anaconda Company
809 Kearns Building
Salt Lake City, Utah

Dear Mr. Mulchay:

Enclosed is a copy of the information distributed at the annual Spring Field Trip of the Geology Section of A. I. M. E. during the May, 1965 trip to the Ithaca Peak operation of Duval Corporation near Kingman, Mohave County, Arizona. You may retain this information for your file.

Best regards.

Yours very truly,

G.A. Barber

G. A. Barber

GAB:je

Encl.

THE MINERAL PARK ORE DEPOSITS

by Harrison A. Schmitt

ABSTRACT

Like the Esperanza Mine and of course many others, Ithaca Peak and the Mineral Park area had a long if not very productive mining history. At Mineral Park four different attempts were made to develop porphyry copper ore, two of these were on and around Ithaca Peak.

The regional setting of Mineral Park and the Kingman mining area is of possible interest. I place the area on the extreme west side of the Wasatch-Jerome orogenic belt and just north of the north side of the Texas orogenic belt. Ajo, as I read it, is also on the west side of the meridianal belt but on the south border of the Texas belt.

The extensive sampling work done tends to support the "rule" that the bigger the sample the more nearly the assay approaches the average assay.

Claims located Dec., 1958 - Jan., 1959 - started drilling May, 1959.

Bill Roper,
Leary,
Connover

Utah Copper drilled Ithaca Peak in 1910.
Calumet-Arizona " near " " 1915.
Anderson(?) churn drill holes 1950.
Bear Creek - 6 holes 1951
2 in ore body
4 outside edge.
Thomas - Cal. Tech. thesis - noted probable porph. Cu
1951 - U.S.G.S. report

Recon. of capping determined outline - governed drilling.

A CASE HISTORY OF COPPER AND MOLYBDENUM GEOCHEMICAL PROSPECTING AT THE MINERAL PARK MINE OF DUVAL CORPORATION

By Donn M. Clippinger

ABSTRACT

At the outset of the exploration program at Mineral Park, Mohave County, Arizona a geochemical survey was planned. It was decided that this prospecting method might aid in delineating the areas of highest metal concentrations and reflect the ultimate potential area.

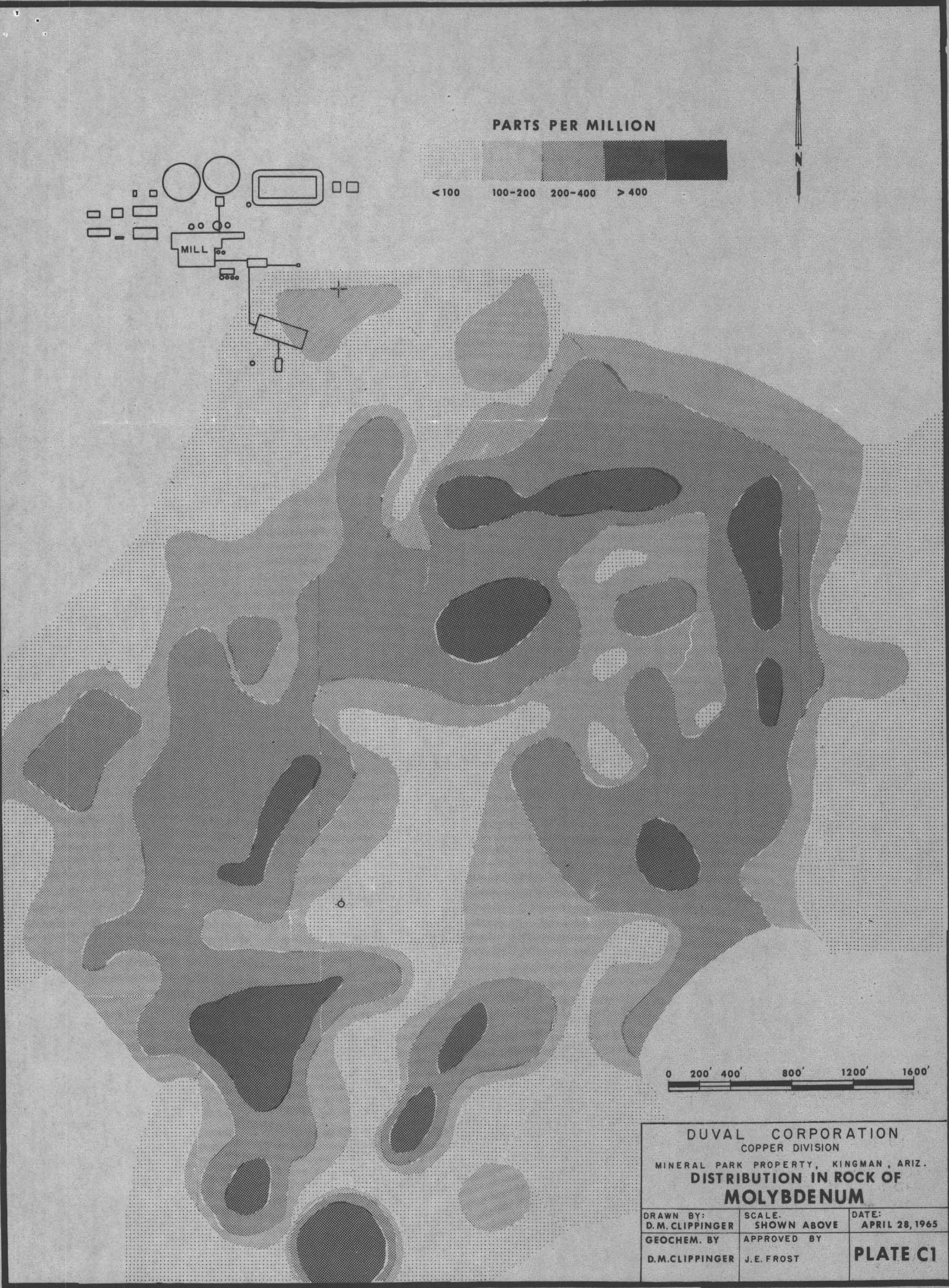
Methods chosen were sampling of rock outcrops, and of shallow soils. Geobotanical sampling, under similar conditions, had been found impractical so was not employed. Copper and Molybdenum, the economic metals concerned, were selected for analyses.

A 400-foot equilateral triangular grid pattern was sampled over an area of approximately one and three-quarter square miles. At each site the samples were taken as follows : (1) About one and one half pounds of soil was taken at depths not exceeding one foot. (2) Approximately twenty-five pounds of rock was obtained, by blasting, from the nearest outcrop within a radius of fifty feet. (3) A few ounces of rock chip specimens were selected for identification and reference. The minus 65-mesh screen fraction of the soil was used for soil analyses. All sample preparation and analytical work was done by laboratory methods. Analyses of both copper and molybdenum were determined colorimetrically by means of an electronic colorimeter.

At Mineral Park the distribution of molybdenum in either rock outcrops or soils serves as an excellent guide to exploration. Molybdenum does not migrate significantly. Rock samples are nearly as high in tenor as the underlying sulfide ores. The orebearing areas are found to be overlain by rock containing >300 p.p.m. and residual soil containing >150 p.p.m. of molybdenum.

Copper distribution in rock outcrops and in the residual soils is misleading. Factors such as structure of contemporaneous minerals, permeability, pH, soil development, and petrology infulence the migration and localization of copper. More data are required concerning the behavior of copper in the form of oxidation and soil development.

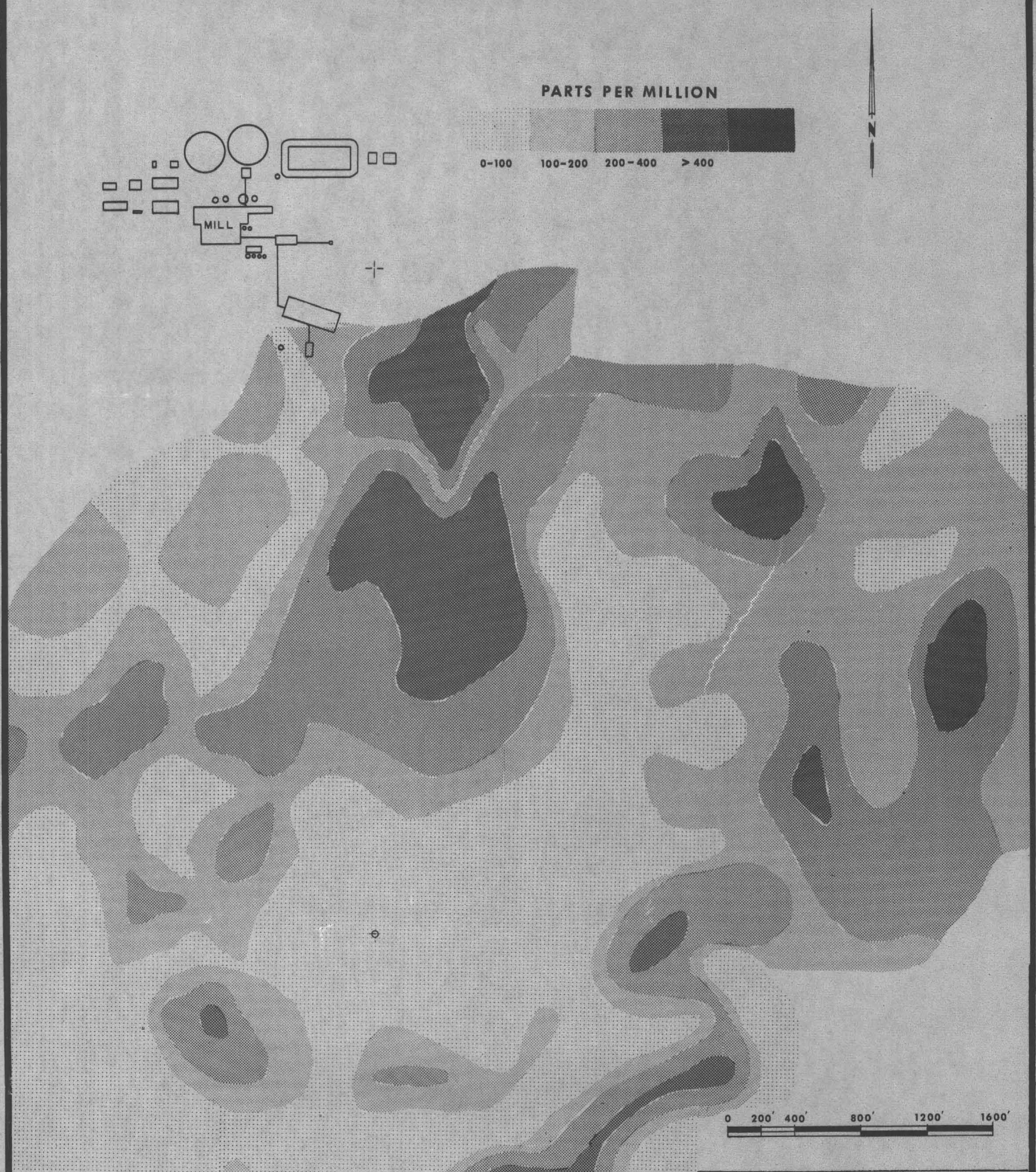
The combined molybdenum and copper rock analyses show a pattern (>400 p.p.m.) that can be used as ore guides in the Mesozoic (?) intrusive rocks.



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

DISTRIBUTION IN ROCK OF
MOLYBDENUM

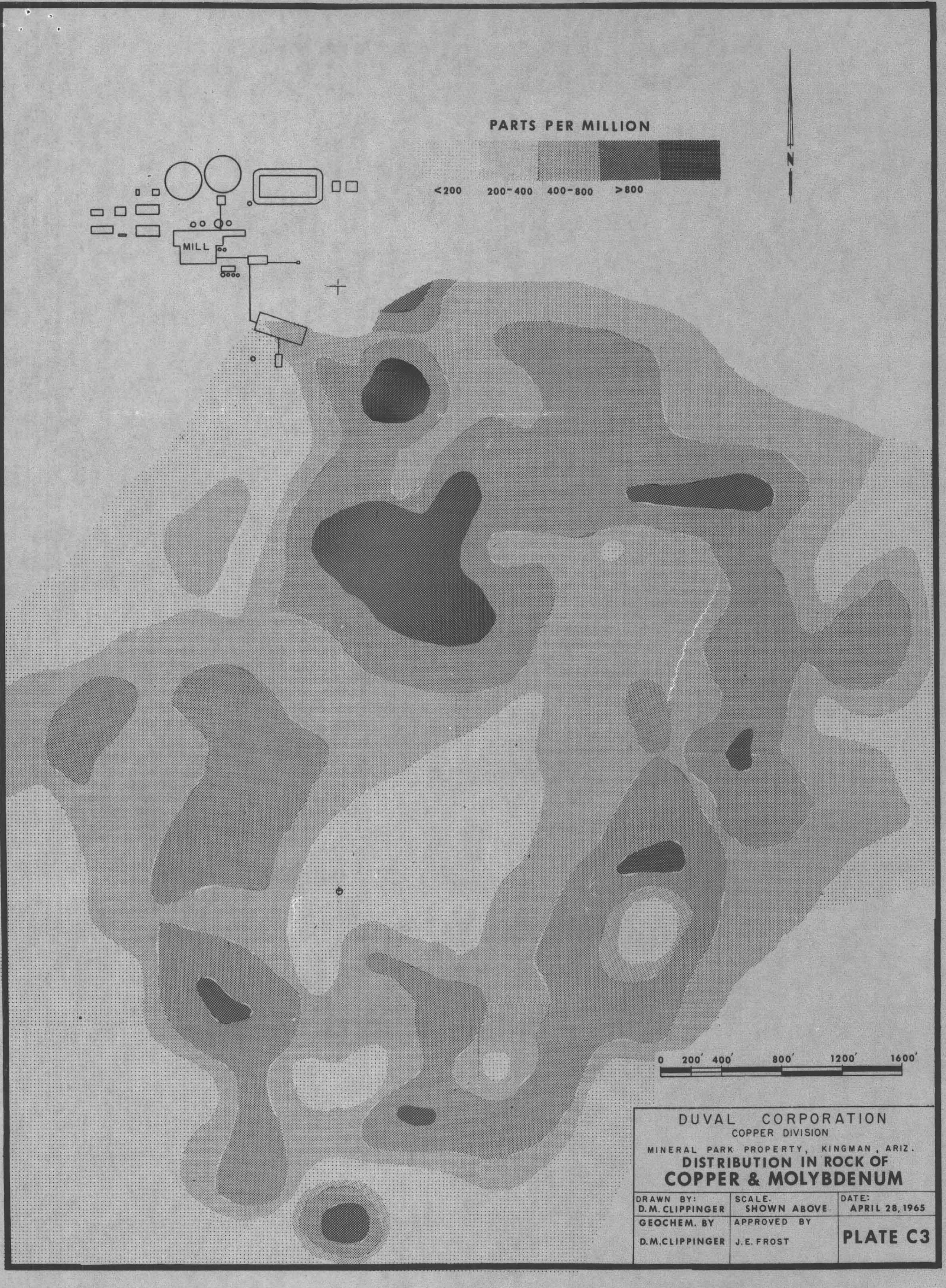
DRAWN BY: D. M. CLIPPINGER	SCALE. SHOWN ABOVE	DATE: APRIL 28, 1965
GEOCHEM. BY D.M.CLIPPINGER	APPROVED BY J. E. FROST	**PLATE C1**



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

DISTRIBUTION IN ROCK OF
COPPER

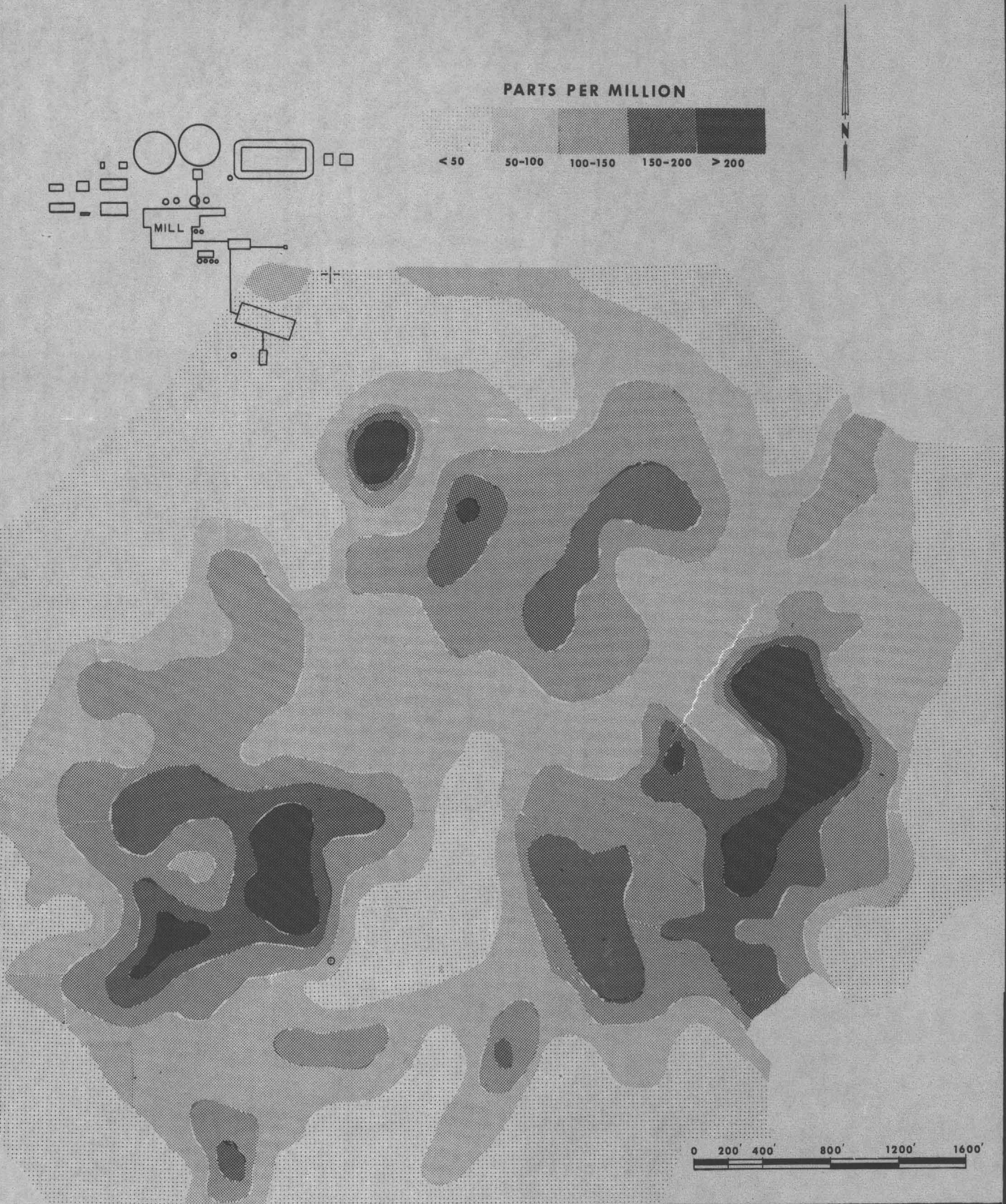
DRAWN BY: D. M. CLIPPINGER	SCALE. SHOWN ABOVE	DATE: APRIL 28, 1965
GEOCHEM. BY: D.M.CLIPPINGER	APPROVED BY J. E. FROST	PLATE C2



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

DISTRIBUTION IN ROCK OF
COPPER & MOLYBDENUM

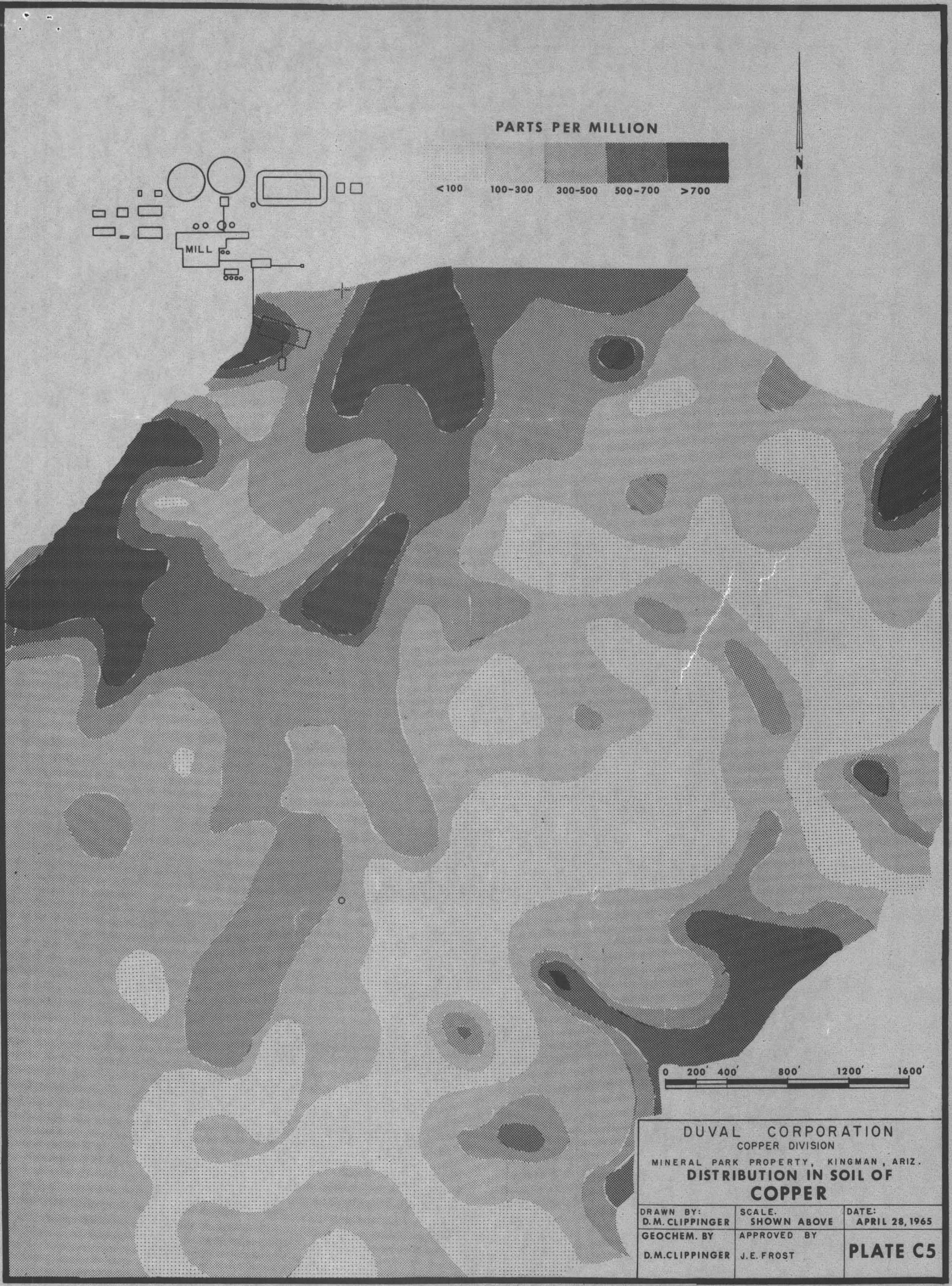
DRAWN BY: D.M. CLIPPINGER	SCALE. SHOWN ABOVE	DATE: APRIL 28, 1965
GEOCHEM. BY D.M.CLIPPINGER	APPROVED BY J.E. FROST	**PLATE C3**



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

DISTRIBUTION IN SOIL OF
MOLYBDENUM

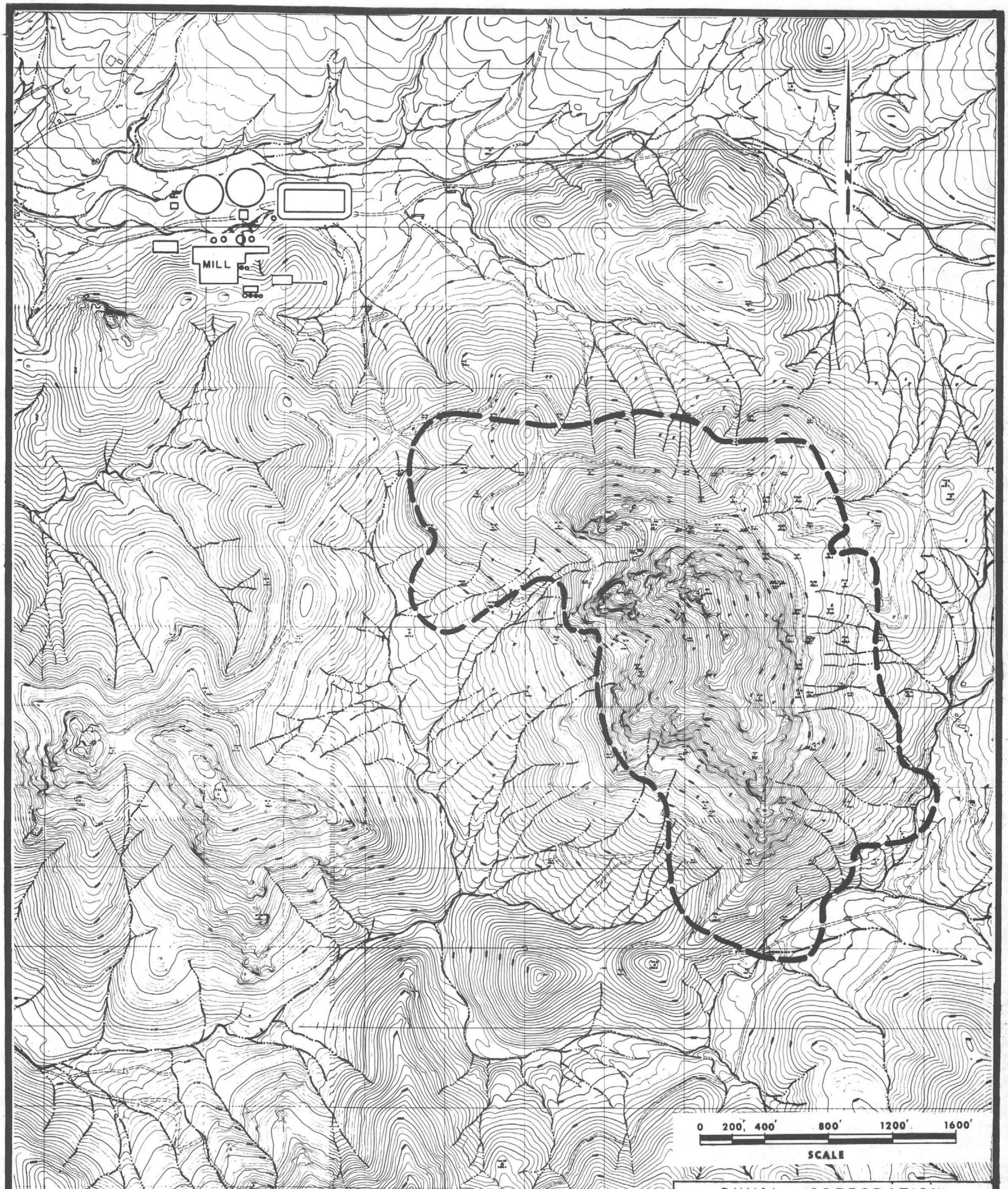
DRAWN BY: D. M. CLIPPINGER	SCALE. SHOWN ABOVE	DATE: APRIL 28, 1965
GEOCHEM. BY D.M.CLIPPINGER	APPROVED BY J. E. FROST	PLATE C4



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

DISTRIBUTION IN SOIL OF
COPPER

DRAWN BY: D. M. CLIPPINGER	SCALE. SHOWN ABOVE	DATE: APRIL 28, 1965
GEOCHEM. BY D.M.CLIPPINGER	APPROVED BY J. E. FROST	**PLATE C5**



DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

TOPOGRAPHIC MAP
SHOWING PIT PERIMETER

DRAWN BY	SCALE: ABOVE. 10' CONTOUR INTERVAL	DATE AUGUST 15, 1960
PHOTOGRAMMETRY BY AERIAL MAPPING COMPANY	APPROVED BY J.E. FROST	PLATE C6

The

CRYSTALLIZATION, ALTERATION, and MINERALIZATION

of the

ITHACA PEAK INTRUSIVE

WALLAPAI MINING DISTRICT, MOHAVE COUNTY, ARIZONA

J. James Eidel

TABLE of CONTENTS

GEOLOGY

Igneous Petrology:

HYDROTHERMAL MINERALIZATION AND ALTERATION

INTRODUCTION

Duval Corporation's Mineral Park property is located in the Wallapai Mining District approximately 16 miles north of Kingman, Arizona and 24 miles west of the Grand Wash Cliffs. The triumvirate of quartz monzonite intrusives, Ithaca Peak, Gross Peak, and Turquoise Mountain, form the core of the elliptical district whose axes trend 5 miles northeast and 20 miles northwest.

The earliest mining in what is now the Wallapai Mining District was for turquoise by Indians. Charcoal and stone hammers are still found in workings on Turquoise Mountain.

Gold was discovered in 1863 and concerted efforts to mine gold and silver began in the 1870's. The rich oxide zone silver chloride's were nearly depleted by the turn of the century and attention was diverted to argentiferous galena and sphalerite ores at depth.

Approximately $24,000,000 worth of gold, silver, lead, and zinc were produced through 1946. The Keystone Mine in Mineral Park was the last of over 225 mines and 1,000 prospects to close in 1948.

The porphyry copper-molybdenum mineralization at Mineral Park was first drilled in 1906; the first production, however, was in November 1964 by Duval.

The present mining operation is confined to Ithaca Peak, which was the highest at 5,200' and the easternmost of the above mentioned triumvirate of intrusives. This discussion will also be confined to Ithaca Peak and will be concerned with the petrology, theory of origin, mineralization, alteration, and structure of the Ithaca Peak intrusive.

ACKNOWLEDGEMENTS

The speaker wishes to emphasize the fact that the majority of the surface mapping was done by D. Clippinger and J. E. Frost. K. Martin, I. B. Gray, R. Sayers, and E. H. Lewis also contributed to the early mapping and logging. Dr. H. A. Schmitt

supervised the exploration phase. Discussions with J. E. Frost, D. Clippinger, H. A. Schmitt, and W. J. Roper have influenced the interpretation presented in this paper.

GEOLOGY

General

Quartz monzonitic magmas have intruded the Precambrian chlorite-biotite schists, amphibolite, and granite gneiss which comprise the Cerbat Complex. The copper-molybdenum mineralization is confined to the intrusives and their immediate environs.

The contacts of the Ithaca Peak stock with the Cerbat Complex are steeply dipping. The quartz monzonite magma was not chilled and is not foliated at the contact. The Cerbat Complex metasediments were deformed at the contact. These facts indicate that the quartz monzonites were forcibly intruded and then differentiated and crystallized in place.

The quartz monzonitic Ithaca Peak stock was extensively deuterically altered; it was then shattered and mineralized and altered by hypogene and supergene solutions. Finally, northwest trending vein-faults which are characteristic of the entire district were formed. These silver-lead-zinc veins also transect the Ithaca Peak stock.

The intensity of the deuteric, hypogene, and supergene alteration has made it impossible to obtain modal analyses to date.

GEOLOGY

Igneous Petrology:

Quartz diorite (?)

The quartz diorite (?) consists of small discordant injections into the Cerbat Complex and of a 5 to 10 foot rim containing inclusions of the Cerbat Complex. Weathered exposures of the quartz diorite (?) have been exposed at the north and northeast contacts of the Ithaca Peak stock and the Cerbat Complex. It should be emphasized that the volume of the quartz diorite (?) is very small when compared to the volume of the Ithaca Peak stock.

The quartz diorite (?) has a medium grained, subhedral granular texture. It is composed of red-brown biotite and/or hornblende, calcic plagioclase, and minor orthoclase and quartz.

The igneous texture, the presence of euhedral accessory minerals characteristic of igneous rocks, and the presence of inclusions of the Cerbat Complex attest to the igneous origin of the quartz diorite (?). The compositional differences between the quartz diorite (?) and the quartz monzonites suggest that the quartz diorite (?) is a facies of the quartz monzonite that was contaminated by reaction with the Cerbat Complex.

GEOLOGY

Igneous Petrology:

Quartz monzonite and quartz monzonite porphyry

The quartz monzonite and quartz monzonite porphyry form a continuous intermediate zone, 250 - 1,000' thick, between the quartz diorite (?) rim and the quartz porphyry core.

There are no significant textural differences between the quartz diorite (?) and the quartz monzonite. The quartz monzonite and quartz monzonite porphyry are equivalent units but due to subtle variances in grain size, they have not been differentiated in the field.

The quartz monzonites and the quartz porphyry (described below) contain sericite pseudomorphs after euhedral micas and sericite and/or clay pseudomorphs after subhedral plagioclase in a matrix of fine grained, anhedral quartz and orthoclase. Pervasive sericitization and argillization has replaced all the primary plagioclase and mica in the quartz monzonites and in the quartz porphyry.

A biotite facies of the quartz monzonite occurs adjacent to a large xenolith or septa of Cerbat Complex metasediments near the north end of Ithaca Peak. This facies crops out for a distance of 2 to 200 feet normal to the contact with this xenolith. The biotite facies of the quartz monzonite is similar in all respects to the quartz monzonite with the exception of the presence of red-brown biotite and somewhat stronger argillization. The biotite either is disseminated throughout the quartz monzonite or is restricted to the margins of veins leaving intravein areas that are void of biotite.

The restriction of the biotite to vein margins in some cases and its occurrence in the proximity of the Cerbat Complex suggest that the stability of the biotite may be due in part to contamination by the Cerbat Complex.

Accessory minerals in the quartz monzonites are rutile, apatite, and zircon.

GEOLOGY

Igneous Petrology:

Quartz porphyry

In contrast with the sometimes vaguely porphyritic quartz monzonite, the quartz porphyry forms the distinctly porphyritic core of the Ithaca Peak stock. The core is roughly elliptical with a northeast trending major axis of 2,000' and a northwest trending minor axis of 1,400'. Roughly in the center of the quartz porphyry is an elliptical area 700' by 500' which contains numerous quartz, aplite, and orthoclase pods and irregular veins as well as crenulate quartz veinlets in a matrix of quartz porphyry.

The quartz porphyry is characterized by quartz phenocrysts which range in size from 2 mm at the contact with the quartz monzonites to 15 mm, 20' to 100' from the contact. The sericitized and/or argillized plagioclase phenocrysts range from 5 to 10 mm and the sericitized mica phenocrysts are somewhat smaller. The grain size of these phenocrysts is greater than that of the quartz monzonites. The phenocrysts are contained in a matrix of fine grained, anhedral quartz and orthoclase.

Accessory minerals are rutile, apatite, and zircon.

Two small bodies of a biotite facies of the quartz porphyry are similar to the biotite facies of the quartz monzonite. The similarities suggest that these bodies may be almost completely digested xenoliths of the Cerbat Complex metasediments.

THEORY OF DIFFERENTIATION AND CRYSTALLIZATION

The consideration of the differentiation and crystallization of the Ithaca Peak stock is necessarily based upon evidence gathered from exposures in an essentially horizontal plane through what was the upper portion of a much larger igneous mass. This discussion is, therefore, restricted to a closed, planar system. No mobile components are assumed to have been introduced into this system until the late deuteric and hypogene stages. The successive igneous units are considered in the order in which they crystallized from the periphery toward the center of the stock.

The lack of significant disparity in grain size between the quartz diorite (?) and the quartz monzonites indicates that the quartz diorite (?) was not chilled at the contact with the Cerbat Complex metasediments. Significant reaction between the metasediments and the melt resulted in the disparity in the compositions of the quartz diorite (?) and the quartz monzonites.

Following this period of reaction with the Cerbat Complex, the melt was encased in a solid quartz diorite (?) rim and underwent normal differentiation following Bowen's reaction series. The composition of the quartz monzonites, disregarding the ferromagnesian components lay within the system $Or-Ab-An-SiO_2$. The micaeous texture of the fine grained sericite pseudomorphs after primary mica indicate that only hydrous ferromagnesian phases precipitated. As biotite and calcic plagioclase crystallized, the melt was gradually enriched in potash, silica, water and other low melting constituents. The vapor pressure within the melt gradually increased as the concentration of volatiles was increased in the remaining melt.

During the late stages of quartz monzonite crystallization, the composition of the melt approached the system $Ab-Or-SiO_2-H_2O$ and the melt became supersaturated with respect to silica. Rounded quartz phenocrysts precipitated with alkali feldspars (composition inferred due to the intense alteration of the feldspars) and biotite. The quartz phenocrysts increased in size as the melt was enriched in silica. A crystal mush developed within the nearly solid quartz monzonite shell. The composition of the remaining liquid approached the system Or-SiO_2-H_2O. No ferromagnesian components remained in the melt.

When the crystal-liquid ratio~~n~~ in the mush contained within the solidified quartz monzonite shell was approximately 2:1, the vapor pressure exceeded the load pressure of the overlying and surrounding Cerbat Complex metasediments. The quartz monzonitic shell and the Cerbat Complex metasediments were ruptured. Potash and silica rich residual fluids were injected into the fractures and the groundmass of the quartz porphyry crystallized. Pressure equilibrium was rapidly attained; thermal equilibrium was not significantly disturbed. (?)

The rapid decrease in pressure caused the remaining melt to quickly crystallize yielding a eutectic mixture of fine grained, anhedral quartz and orthoclase.

The extruded fluids, on the otherhand, crystallized as aplite and pegmatite veins in the quartz monzonite and the surrounding rocks. The lack of chilled margins at the contacts of these veins suggests that thermal equilibrium existed between the injected fluids and their wall rocks within the vicinity of Ithaca Peak. Movement of the semisolid pegmatite masses created marginal leucocratic gneisses along the pegmatite contacts. The rhyolite dikes characteristic of the western portion of the Wallapai Mining District may represent chilled fluids of the same origin and composition as the aplites and pegmatites.

THEORY OF DEUTERIC CRYSTALLIZATION AND ALTERATION

Upon reviewing the use and definition of the term deuteric since its original definition by Sederholm in 1919, Robertson (1962, p. 1264) applied a more exacting definition to the term, one which was applicable to the silicic Boulder batholith and which is equally applicable to the Ithaca Peak stock. The high temperature limit of deuteric crystallization in intermediate and silicic igneous rocks is defined by "postgroundmass potassic feldspar crystallization".

Following the crystallization of the quartz-orthoclase groundmass of the quartz porphyry at Ithaca Peak, an aqueous intergranular phase existed in equilibrium with "pockets" of remaining, trapped liquid. These "pockets" of liquid crystallized as isolated masses of coarsely crystalline quartz and orthoclase with vague altered contacts with the wall rocks due to reaction with them.

The intergranular fluids deuterically altered the quartz porphyry groundmass forming oikocrysts or postgroundmass deuteric porphyroblasts of orthoclase which included groundmass quartz and orthoclase, and the mica and plagioclase phenocrysts. These oikocrysts have single dimensions as great as 6 inches.

Optically continuous quartz overgrowths on the primary quartz phenocrysts are also considered deuteric.

The large amounts of silica in the central portions of the quartz porphyry may represent the first mobile components introduced from below the system being considered or silicic fluids that were the final differentiate in place of the planar system described. The concentration of the gray-white quartz at the center of the quartz porphyry seems to favor the latter explanation. The pod-like and irregular configuration of the quartz masses suggests intrusion into what may have been semi-consolidated quartz porphyry. The dimensions of the quartz masses are tens of feet. The quartz contains trace amounts of pyrite and molybdenite.

Silica, in the vicinity of the quartz masses was also apparently injected into the quartz porphyry as sub-parallel, 1 - 3 mm thick, crenulate veinlets. These veinlets also suggest that the quartz porphyry may have been semi-consolidated at the time of their inception. Intergranular recrystallization within these veinlets, shearing of irregular protrusions from the veinlets, slightly biaxial quartz, and microfaults are all evidences of stress applied during and after the formation of the crenulate textures. The proximity of the crenulate quartz to the gray quartz masses suggests that they may have had a common origin by post differentiation injection.

HYDROTHERMAL MINERALIZATION AND ALTERATION

The lower temperature deuteric-hypogene boundary "is defined by the change from a stable-feldspar assemblage to an unstable-feldspar assemblage involving the alteration of feldspar to sericite and clay minerals" (Robertson, 1962, p. 1264). At Ithaca Peak the change from a stable to an unstable orthoclase assemblage is coincident with the first rupturing of the Ithaca Peak stock as a unit yielding a stockwork of throughgoing veinlets. The deuteric-hypogene boundary at Ithaca Peak is, therefore, both chemical and structural.

Three types of hypogene mineralization are recognized. Each succeeding type of mineralization occurs in fractures which transect the preceding type. Each succeeding type of mineralization was presumably precipitated at a lower temperature.

First Type: (Pyrite, replacement quartz)

Following the late-deuteric precipitation of minor amounts of pyrite and molybdenite in quartz pods and masses, vapor pressures again exceeded the load pressure and the now exposed portion of the Ithaca Peak stock ruptured, forming the first stockwork.

These earliest veinlets contain millimeter thick pyrite which filled the entire open space and is enclosed within bands of replacement quartz or soak silica and sericite. Orthoclase adjacent to the pyrite veinlets was replaced by sericite, probably yielding most of the replacement quartz. Some potash was introduced and lime and soda were removed from the quartz monzonite and the quartz porphyry. The primary micas were altered to white mica containing primary rutile and hydrothermal rutile, sphene, ilmenite and quartz.

The removal of iron from the primary micas provides a probable source for much of the iron in the pyrite veinlets. Part of the iron may, then, have been syngenetic and may have reacted with introduced sulfur.

Some molybdenite and probably some chalcopyrite were precipitated during this first period of mineralization.

HYDROTHERMAL MINERALIZATION AND ALTERATION

Second Type: (Pyrite, quartz)

The second type of mineralization followed a second period of rupturing which was, in general, areally coincident with the first period of rupture.

The second type of fractures contain quartz and pyrite. Quartz forms crude comb textures the center of which is filled with pyrite, coarse white mica, or supergene turquoise. The quartz in all cases preceded pyrite, chalcopyrite and molybdenite precipitation.

During the alteration associated with the second type of mineralization, iron, soda, and lime were leached from the stock and sulfur and potash were introduced.

The iron in solution may have reacted with introduced sulfur as suggested by the first type of mineralization. Pyrite which was less soluble than calcium sulfates in alkaline solutions, filled the vugs in the quartz veins.

Coarse white mica precipitated in some of the remaining open space.

Molybdenite was precipitated along the quartz vein selvages. Smaller amounts of molybdenite were precipitated in vugs in the quartz veins and within strongly altered vein margins. Chalcopyrite occurs as minute blebs and veinlets within the coarse grained pyrite.

The distinction between the first and second types of mineralization may be physical and not chemical. Pyrite, molybdenite, and probably chalcopyrite were deposited during both periods of mineralization. The extent and intensity of the associated alteration does differ between the two types of mineralization. The first type contains a small volume of fracture fillings with varied thicknesses of replacement quartz adjacent to the fractures in contrast to the much larger volume of fracture fillings with negible replacement quartz adjacent to the fractures of the second type.

It is suggested that the differences between the first two types of mineralization may be a function of the reaction time of the hydrothermal solutions with the wall rocks. A lack of intensive replacement, therefore, may suggest throughgoing solutions, which did not have time to react with the wall rocks.

HYDROTHERMAL MINERALIZATION AND ALTERATION

Third Type: (Argentiferous galena, cupiferous sphalerite)

The third type of mineralization occurs within the Ithaca Peak stock as well as throughout the Wallapai Mining District. Within the Ithaca Peak stock several northwest trending veins contain sphalerite with exsolved chalcopyrite, argentiferous galena, minor covellite, and pyrite. The veins, in general, contain brecciated pyrite with post-brecciation sphalerite and galena; they represent the lowest temperature and latest hydrothermal mineralization within the Ithaca Peak stock.

The Wallapai Mining District is roughly a laterally zoned district with a peripheral zone of gold and silver mineralization, an intermediate zone of lead, zinc, silver, and minor gold mineralization and an intrusive core of copper-molybdenum mineralization with superimposed lead-zinc-copper-silver mineralization. This zonal distribution suggests that the mineralization of the northwest trending fissures was controled by thermal gradients and that as temperatures decreased later, lower temperature lead-zinc mineralization were superimposed upon the earlier, higher temperature copper-molybdenum mineralization.

SUPERGENE ENRICHMENT

Late movement brecciated the pyrite in some of the veins and veinlets in the northern and southern portions of the Ithaca Peak stock, exposing a much greater surface area of pyrite to supergene solutions, than in the veins and veinlets which suffered no movement. The chalcocite which coated pyrite surfaces is, therefore, the richest in the areas of brecciated pyrite.

Nearly all chalcopyrite was totally replaced by chalcocite within the blanket of enrichment.

The supergene enrichment has formed in irregular blankets, the top of which roughly conform to the topography of Ithaca Peak.

Roughly horizontal barren zones between thin blankets perched approximately 500 feet above the present water table have been explained by Schmitt (1962, p. 6) as attempts by the blanket to reach equilibrium during uplift. Schmitt (1962, p. 7) tentatively correlated the initial enrichment to a peridd of Late Miocene and Early Pliocene quiescence and the uplift to the Early Pliocene to Pleistocene uplift of the Colorado Plateau. Damon has suggested (1964, p. 1) that similar porphyry enrichment occurred during an Early Tertiary quiescent period preceding mid-Tertiary orogeny. The possibility remains that the ore body was exposed twice, which may explain some of the irregularities in the enriched zone. Erosion has dissected the initial blanket and the blanket migrated downward as evidenced by the thinner blankets now present. The fact that the blankets are now perched is evidence that equilibrium was never attained.

SYNOPSIS OF STRUCTURE

The Ithaca Peak, Gross Peak, and Turquoise Mountain intrusives may have been regionally controlled by the inferred Grand Wash fault 24 miles east of Mineral Park or by a parallel structure or structures. They may also have been influenced by other major Laramide lineaments.

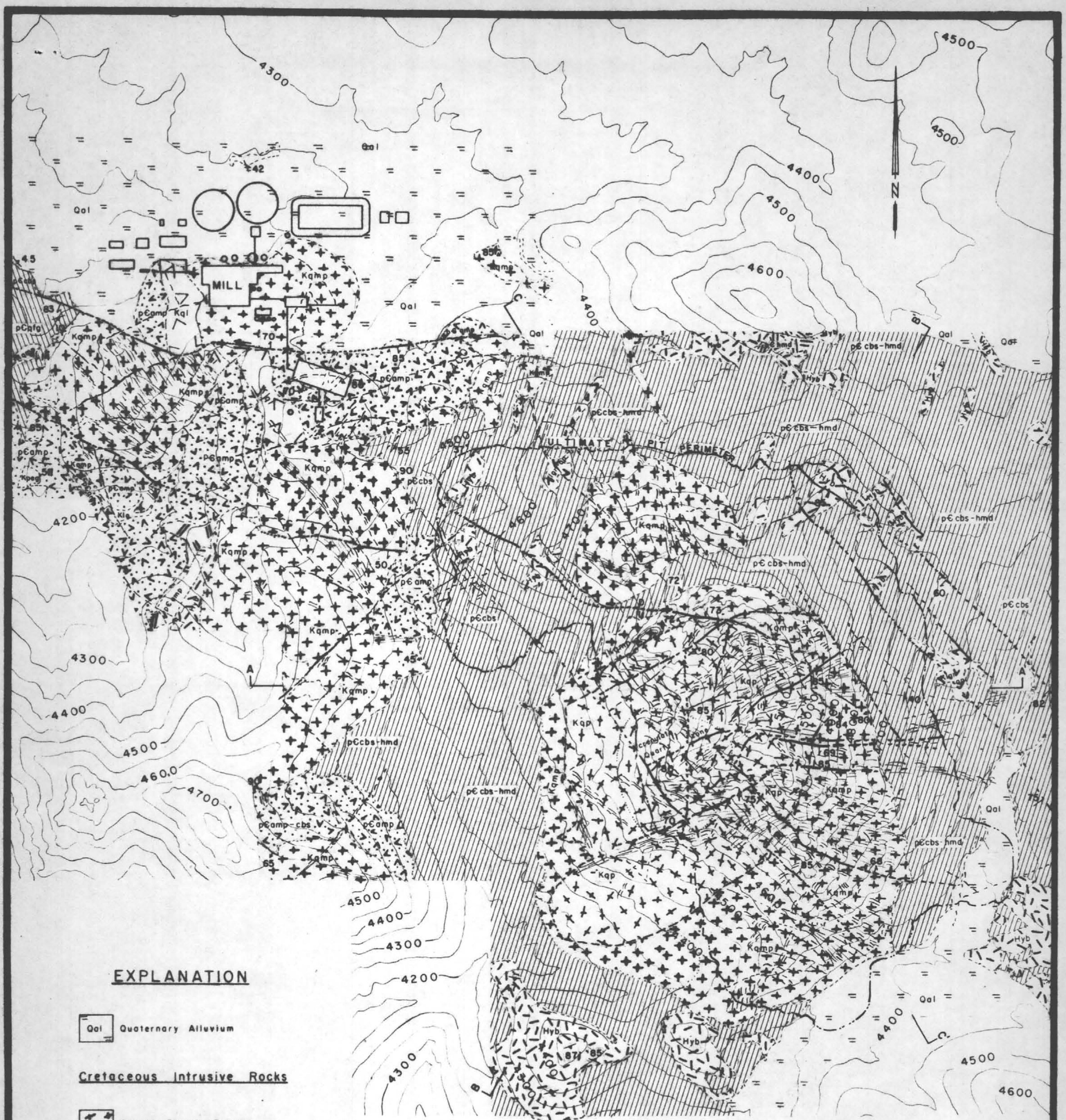
At Mineral Park the intrusives may have been localized by the intersection of dominantly northwest trending foliation and northeast and northwest trending faults. Fold axes in the Cerbat Complex metasediments may also have localized the intrusives.

The intrusion and the crystallization of the monzonitic intrusives took place in a dynamic environment of regional stress. Local stress, however, developed during magmatic intrusion and later during crystallization due to increased vapor pressures.

Following the monzonitic intrusions, rhyolite intruded regional NNW-NNE trending structures in the western part of the district. Aplites and pegmatites discordantly and concordantly intruded the Cerbat Complex metasediments in the vicinity of Ithaca Peak.

The Ithaca Peak stock itself was probably ruptured by stress developed by the crystallizing magma. The resultant stockwork is comprised principally of steeply dipping NE, NW, and EW trending veins and veinlets. The movement on the veins and veinlets in the northern and southern parts of Ithaca Peak was predominantly vertical. The central part of the intrusive underwent little movement.

The northwest trending vein-faults which occur throughout the Wallapai Mining District continue through the monzonitic intrusives. The vein and veinlet patterns of the stockwork are displaced by these vein-faults. These facts indicate that following the hydrothermal "healing" of the stockwork, the monzonitic intrusives and the Cerbat Complex metasediments reacted as a unit to regional stress. The pre-existing northwest trending structures in the Cerbat Complex were reopened, extended through the monzonitic intrusives, and then mineralized.



EXPLANATION

Qal Quaternary Alluvium

Cretaceous Intrusive Rocks

Kqp Quartz Psuedo-Porphyry

Kqmp Quartz Monzonite Porphyry

Kql Quartz Latite

Kpeg Pegmatite

Klgn Leucocratic Gneiss

Kap Aplite

Hyb Hybrid Rock (Kqmp & pЄcbs)

pЄ Cerbat Complex

pЄqfg Quartz-Feldspar Gneiss

pЄcbs Chlorite-Biotite Schist

pЄamp Amphibolite

pЄhmd Hornblende Metadiorite

Structural Symbols

Fault, dashed where inferred

Contact, dashed where inferred

Shear Zone

Schistosity

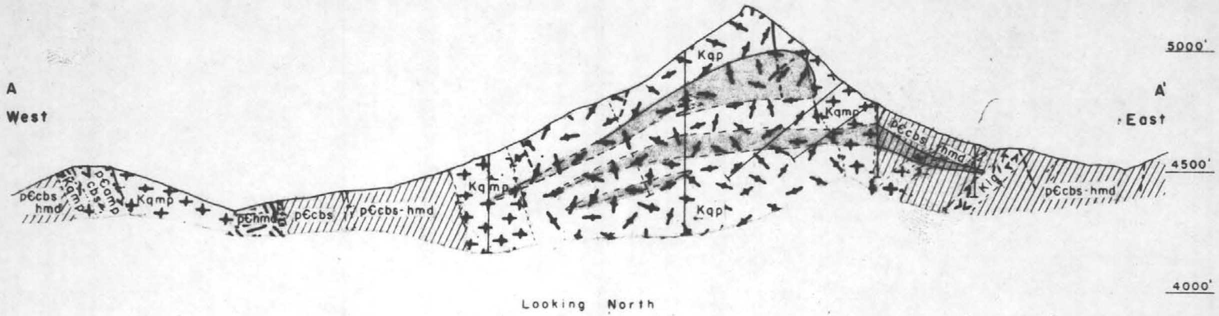
SCALE 1" = 800'

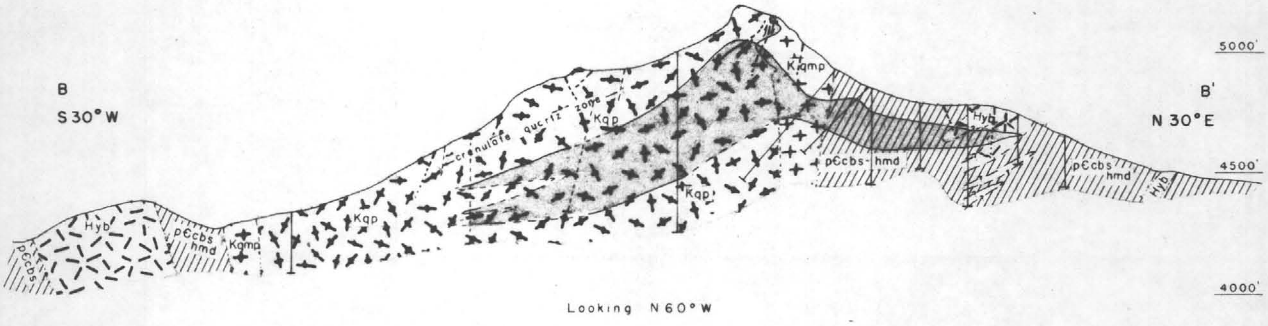
0 200 400 600 800 1200 1600

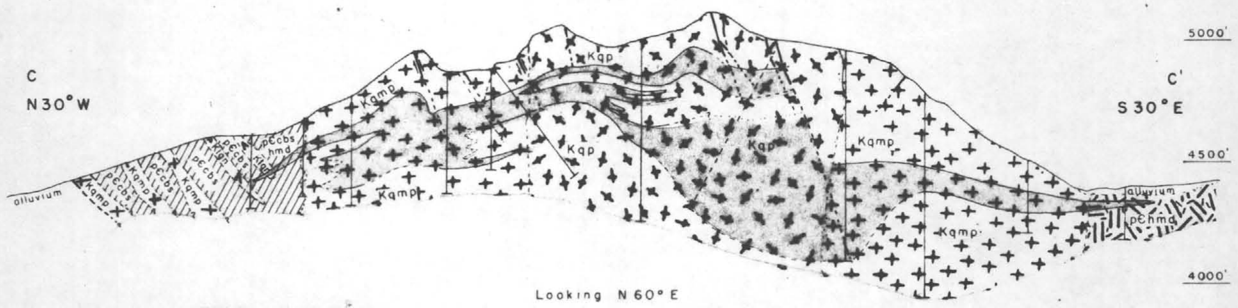
DUVAL CORPORATION
COPPER DIVISION
MINERAL PARK PROPERTY, KINGMAN, ARIZ.

SURFACE GEOLOGY

DRAWN BY	SCALE	DATE
W.G.L.	1" = 800'	Sept. 1, 1964
GEOLOGY BY J.E.F. D.M.C. J.J.E.	APPROVED BY J.E. FROST	







EXPLANATION

Cretaceous Intrusives

- Kqp Quartz Psuedo – Porphyry
- Kqmp Quartz Monzonite Porphyry
- Klgn Leucocratic Gneiss
- Kap Aplite
- Hyb Hybrid Rock (Kqmp & pЄcbs)

pЄ Cerbat Complex

- pЄcbs Chlorite - Biotite Schist
- pЄamp Amphibolite
- pЄhmd Hornblende Metadiorite

- Fault, dashed where inferred
- Contact, dashed where inferred
- Drill Hole
- Ore Body

SCALE 1" = 800'

0 200 400 600 800 1200 1600

DUVAL CORPORATION

COPPER DIVISION

MINERAL PARK PROPERTY, KINGMAN, ARIZ.

VERTICAL SECTIONS

DRAWN BY W.G.L.	SCALE 1" = 800'	DATE Sept. 1, 1964
GEOLOGY BY J.E.F. D.M.C. J.J.E.	APPROVED BY J.E. FROST	

some enrichment under jarosite to east.

ABSTRACT

WATER RESOURSES OF THE KINGMAN AREA, MOHAVE COUNTY, ARIZONA

A PROGRESS REPORT

Craig B. Bentley, U.S.G.S.

A project by the Water Resources Division of the U. S. Geological Survey, financed on a matching fund basis by state and federal funds, is underway in the Hualapai and Sacramento Valleys, Mohave County, Arizona. The purpose of the project is to determine the quantity and quality of ground water in storage in the two valleys, depths to water, hydrologic characteristics of the aquifers, amount of water being added to and taken from the aquifers through natural recharge and outflow respectively, and the amount and characteristics of surface-water runoff in the drainage areas of the two valleys. To date, a ground-water inventory of all known springs and wells has been completed; water level recorders have been installed on four key wells; stream gages have been installed on several streams (washes) in the area; and a reconnaissance study of the geology, including some seismic work, is 50 per cent complete.

The geology of the area is typical of that of the Basin and Range Province, with tilted fault blocks of Precambrian granite and metamorphic rocks forming north-south trending mountains. The intermontaine Hualapai and Sacramento Valleys have been filled with Tertiary and Quaternary alluvium to depths in excess of 2,000 feet. Valcanics up to several hundred feet thick are present in the mountains and are interbedded with the alluvium in the valleys. Several hundred feet of saline deposits have been found in the Hualapai Valley. Ground water occurs in minor amounts in the volcanics and Precambrian rocks and at shallow depths in the alluvium on the pediments around the mountains, but most of the ground water lies in the alluvium in the valleys at depths of 200 to over 1,200 feet in the Sacramento Valley and from 250 to 600 feet in the Hualapai Valley. Of the 200 wells in the area, most are small stock and domestic wells in the

mountains and on the pediments. Few of these wells produce over 10 gpm, although some produce up to 100 gpm. Approximately 15 deep wells produce water from the valley alluvium. Yields from these wells vary from 200 to over 1,000 gpm. Little is known of the quality of the water except that it is quite hard, especially in the Sacramento Valley. Salt water has been found in one or two deep wells in the Hualapai Valley. Additional geologic, seismic, drill hole, and pump test data will supply information on the thickness, extent, and transmissibilities of the water-bearing alluvium in the valleys and on the amount of ground water flowing out of the valleys toward the Colorado River. Runoff and infiltration studies will indicate the amount of natural recharge to the aquifers.

Rock Type Sample Number Location Mineral	K%	Ar^{40} radiogenic $\times 10^{-10}$ moles/gram	Ar^{40}/K^{40} $\times 10^{-3}$	Ar^{40} atmos %	Apparent Age in m.y.	Reference
phlogopite-molybdenite rock[1,2] RM-4-64 La Colorada Ore Body 30°58.9'N., 110° 17.6'W, Cananea, Sonora, Mexico phlogopite	7.70	8.13	3.50	29.7	58.5 ± 2.1	This work
quartz diorite[2] PED-39-60 Torreon-Cananea Road 30° 57.78'N, 110° 34.73'W., Sonora, Mexico biotite	6.91	8.39	4.02	22.5	67.2 ± 2.2	Damon et. al. 1964
quartz diorite[2] RM-7-63 Patagonia Mountains 31°23.2'N., 110° 43.1'W., Santa Cruz Co., Ariz. biotite	6.26	7.23	3.83	17.3	63.9 ± 2.0	th~~r~~is work
granodiorite[2] RM-6-63 Santa Rita Mountains 31° 42.9'N., 110°52.5'W., Santa Cruz Co., Ariz. biotite	7.13	8.76	4.07	18.3	67.9 ± 2.1	This work

$K^{40} = 1.21 \times 10^{-4}$ grams/gram K
$\lambda_\beta = 4.76 \times 10^{-10}$ yr.$^{-1}$
$\lambda_e = 0.589 \times 10^{-10}$ yr.$^{-1}$

Constants used to calculate results from the Univ. of Arizona Lab.

1. contains copper sulfides
2. on Cananea - Kingman zone

quartz monzonite [1,2] RM-3-64 Anazanda Co. Property Twin Buttes Area 31°55'N.,111°02' W., Pima Co., Ariz. biotite	7.69	7.41	3.19	28.7	53.5 ± 1.9	This work
phlogopite-sericite rock[1,2] RM-1-62 Esperanza Pit, Duval Corp. Twin Buttes Area 31°52.0'N., 111° 07.7'W., Pima Co. Ariz. phlogopite	8.37	9.46	3.75	19.1	62.6 ± 2.0	Mauger, 1965, in prep.
muscovite-quartz veinlet[1,2] RM-3-62 Esperanza Pit, Duval Corp. Twin Buttes Area 31°52.0'N., 111° 07.7'W., Pima Co. Arizona muscovite	7.74	8.47	3.62	10.8	60.6 ± 1.8	" "
granodiorite[2] PED-8-62 Twin Buttes Area 31° 53.95'N., 111° 06.95 W., Pima Co. Ariz. biotite	7.71	8.17	3.51	9.4	58.7 ± 1.8	Damon, etl al. 1964

albite-muscovite-quartz-pegmatite[2] RM-9-63 Twin Buttes Quad 31° 59.1'N., 111°07.8'W Pima Co., Arizona muscovite	8.99	8.25	2.96	7.1	51.0 ± 2.7	Mauger, 1965, in prep
granodiorite[2] PED-11-63 Tucson Mountains 32° 17.67'N., 111° 09.77'W., Pima Co., Ariz. biotite	6.66	8.78	4.46	12.0	72.9 ± 2.2	Bikerman and Damon, 1965, in press
granophyre[2] PED-12-63 Tucson Mountains 32° 17.63'N., 111° 09.77'W., Pima Co., Ariz. biotite	7.08	9.63	4.51	5.3	75.1 ± 2.2	" " "
granite[2] PED-3-64 Tucson Mountains 32° 16.37'N., 111° 12.37'W., [redacted] Pima Co., Ariz. biotite	5.16_5 5.16_5	6.36 6.99	4.08 4.49	34.6 27.8	71.4 ± 3.3 ave.	Bikerman and Damon 1965 in prep
granodiorite[2] MB-10-64 Cocoraque Butte, Roskruge Mountains 32° 13.10'N., 111° 20.62'W., Pima Co., Ariz. biotite	7.34_5	9.12	4.11	19.2	68.6 ± 2.2	Bikerman, 1965 in prep

alaskite[2] PED-22-59 Silver Bell District 32° 24.82'N., 111° 33.10'W., Pima Co., Ariz. biotite	6.26	7.31	3.87	28.8	64.6 ± 2.5	Mauger, et. al 1965
quartz monzonite[2] PED-21-59 Silver Bell District 32° 23.87'N., 111° 31.77'W., Pima Co., Ariz. biotite	5.54	6.72	4.02	35.3	67.1 ± 2.7	" " "
quartz monoznite[1,2] PED-3-63 Silver Bell District El Tiro Pit 32° 25.67'N., 111° 32.22'W., Pima Co., Ariz. biotite	6.88	8.15	3.92	19.7	65.5 ± 2.0	" " "
quartz monzonite[2] PED-20-64 Slate Mountains 32° 32.6'N., 111° 53.2'W., Pinal Co. Ariz. biotite	7.61_5	9.07	3.95	66.5	65.9 ± 6.6	This work
quartz monzonite[1,2] PED-17-64 Bagdad Copper Co. open pit Bagdad, Yavapai Co., Ariz. 34° 35.0'N., 113° 12.5'W., biotite	6.87_5	8.82	4.25	21.9	70.9 ± 2.3	This work

Quartz monzonite[1,2] RM-5-65 Mineral Park Pit Duval Corp., Kingman, Ariz. 35° 22.70'N., 114° 08.55'W., Mohave Co. phlogopite	7.70	9.96	4.29	29.2	71.5 ± 2.6	This work
quartz monzonite[1] PED-4-64 Lone Star District Graham Co., Arizona plagioclase and sericite	3.41_5					
quartz-orthoclase-biotite[1] pegmatite, RM-2-62 New Cornelia Pit Ajo, Arizona 32° 21.52'N., 112° 52.00'W., Pima Co. biotite	5.97_5	6.81	3.77	28.6	63.1 ± 2.2	Damon, et.al., 1964
Schultze Granite Globe-Miami District Gila Co., Ariz. biotite	7.32	7.77	3.41	not listed	58 57.8 - Univ. Ariz.	Creasey and Kistler, 1962

Schultze Granite PED-5-59 2 miles west of Miami, Arizona on U.S. Highway 60-70. 33° 23.00'N., 111° 54.17'W., Gila Co. biotite	7.01_5	7.31	3.45	19.7	57.8 ± 1.8	Damon, et.al. 1964
Lost Gulch Quartz Monzonite[1] Miami District Gila Co., Ariz. biotite	7.24	8.36	3.7	not listed	62	Creasey and Kistler
Granite Mountain Porphyry[1] Ray District, Pinal Co., Ariz. biotite	6.86	7.96	3.72	not listed	63	" " "
quartz diorite porphyry Christmas District Gila Co., Ariz. biotite	6.49	7.39	3.66	" "	62	" " "
quartz monzonite[1] Chino, New Mexico 32° 47.5'N., 108° 04.2'W., biotite	6.77	7.76	3.76	" "	63	Schwartz, 1959
biotite-augite monzonite porphyry Bingham stock Bingham, Utah 40° 31.17'N., 112° 07.00'W., biotite	5.67	5.00	2.90	24	49^{+7}_{-2}	Armstrong, 1963**

** Argon analysis by neutron activation

— Small, cool faster, preserve older ages than main mass ??

If age of minlz'd. porph. is either older or ident. to princ. Laramide mass.
(Twin Buttes compared w/ Esperanza)

or

age of minlzd. porph. is distinctly younger

field evidence.