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# NEW DEVELOPMENTS AT THE CHRISTMAS MINE, ARIZONA

By

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## INTRODUCTION

The Christmas Mine, located in the Banner Mining District, is in the southwestern corner of Gila County, Arizona, approximately 10 miles to the north of Winkelman along State Highway 77. The mine is situated on the eastern slope of the Dripping Springs Range about one mile to the west and 900 feet above the Gila River. Elevations range from 2100 feet at the Gila River to 4250 feet at the crest of the prominent ridges above the mine.

Discovered in the 1880's the mine has passed through the control and ownership of various mining companies. The isolated location of the property, and the fluctuation of metal prices caused intermittent operations until World War II. According to mine records, production through 1954 was 1,554,500 tons for a total of 54,969,573 pounds of copper.

The ore bodies at Christmas have drawn the interest of many mining companies and several exploration programs were initiated. Of these earlier programs, the exploratory work in the deeper horizons below the 800 level by the United States Bureau of Mines is most significant.

During the present three and one-half year program of development, preparation for a new shaft has been started; the No. 3 shaft has been deepened 534 feet with stations cut at the 1100, 1300, and 1400 levels; 16,800 feet of drifts and raises have been driven; and 73,060 feet of diamond drill holes have been completed.

## GEOLOGIC SETTING

Rocks in the Dripping Springs Range are represented by pre-Cambrian and Paleozoic sediments, intrusive diabase of Cambrian (?) age, extrusive adesite of Cretaceous age, intrusive quartz mica diorite of early Tertiary age, and intrusive basaltic and andesitic dikes of late Tertiary age.

Sediments of the Pre-Cambrian Apache Series outcrop to the northwest of Christmas and are the oldest rocks exposed in the area. Above the Mescal formation of the Apache group are Cambrian sediments composed of the coarse pebbly Troy quartzite with a thickness of approximately 400 feet, succeeded by about 175 feet of fine-grained, argillaceous, and limy quartzites. Uncomformably overlying the Cambrian quartzites are approximately 265 feet of Devonian Martin limestone comprised of shaly and dolomitic limestones in the basal member, massive limestone in the middle horizon, and shales and shaly limestone in the upper member. Above the Devonian Strata are 550 feet of massive Mississippian Escabrosa limestone, followed by approximately

1,000 feet of Naco limestone of Pennsylvanian and Permian (?) age consisting of interbedded shaly limestones, shales, and limestones with local cherty and quartzite layers.

Intruded into the Mescal limestone and the Troy quartzite are irregular masses and sills of diabase. No exposures of diabase cutting rocks above the Troy have been noted in the area.

Resting on the Paleozoic sediments are a thick series of undifferentiated volcanics consisting of andesitic flows, tuffs, flow breccias, and conglomerates. In the vicinity of Christmas, the volcanics are fine to medium grained andesites consisting essentially of feldspar phenocrysts set in a matrix of fine, dark ferromagnesian minerals.

All the earlier rocks are cut by a generally east-west series of quartz mica diorite dikes. Numerous sills and irregular apophyses extend out into the surrounding rocks. These intrusives occur with several textural variations and are composed primarily of quartz, feldspar, and biotite. Generally, the smaller bodies contain varying amounts of hornblende and biotite. In the Christmas area, the most common quartz mica diorite occurs as a light gray, coarse-grained, even-textured rock becoming porphyritic near the outer margins with large phenocrysts of quartz and feldspar in a fine-grained, dark ground mass. Some narrow quartz mica diorite porphyry dikes cut irregularly through the main intrusive masses, probably representing a late phase of the same magma.

In the Christmas mine, narrow post-mineral dikes of basalt and andesite cut through the Paleozoic sediments and the diorite intrusives. They commonly trend from slightly west to east of north with steep, irregular dips. Two dikes along the north contact, varying from the general trend, strike approximately N60°E and dip steeply northwest.

## STRUCTURE

The Dripping Springs Range is indicated by Ransome (2) to be a complexly faulted, anticlinal structure. The dominant structural features of the region are the generally east-west trending quartz mica diorite dikes, and the series of major northwest-trending faults. The orientation and distribution of the diorite dikes suggest that they were intruded along a system of steep, N70°W - N70°E trending fissures approximately parallel to the axis of the regional deformation. The major faults are normal faults of the Basin and Range type with their hanging wall or down-thrown sides towards the valleys.

At Christmas one of these major structures, the Christmas fault, separates the area into two geologic settings. To the west, Naco limestone, capped by andesite, forms the prominent outcrops along the steep ridges above the mine, and on the east side andesite comprises the predominent rock eastward to and across the Gila River. The surface outcrops of the quartz mica diorite, intruding the limestones to the west and the volcanics to the east, form an irregular elliptical outline with the long axis trending about N70°E across the Christmas fault zone. Development work underground indicates the intrusive to consist essentially of two thick dikes, converging to the west towards No. 3 Shaft and to the east towards No. 4 Shaft, with numerous branching sills and interfingering smaller dikes. In the footwall of the Christmas fault, the greatest mass of quartz mica diorite is centered to the east of No. 3 Shaft between the 500 and 1100 levels where several thick sills and numerous irregular apophyses extend into the adjoining limestones.

The sediments surrounding the intrusive contacts have generally south to southeasterly dips of 10° - 20°. Much of the original structure is obscured by later post-mineral faulting and by the intrusion of the quartz mica diorite, but it is apparent that some deformation preceded the intrusives. Along the south contact zone, the diorite cuts across the north limb of a small anticlinal fold, and the downward steepening of the sedimentary beds near the north contact suggests that the North dike intruded along the flank of a small flexure. Compressional stresses are also indicated by minor bedding-plane slips, small thrust faults, and local rolls along the bedding.

Pre-mineral fractures are evidenced by the numerous steep-dipping sulphide and quartz stringers in the diorite and in the surrounding rocks. These occur along definite conugate pre-mineral fracture systems, one set consisting of essentially parallel fractures along the intrusive contacts, and the other set comprising of fractures approximately at right angles to the contacts.

Underground the Christmas fault is exposed on the 300, 400, and 800 levels on the north contact, and at the portal of the 400 level on the south contact. This fault, with a normal displacement of approximately 1200 feet down to the east, strikes generally N20° - 25°W and dips 65° - 75° northeast. Movement occurs along a 10 to 20 foot crushed zone with brecciated blocks and fragments of diorite, andesite, and limestone between several fault strands. Another paralleling structure, the Joker fault, has been discovered on the 800 level, 900 feet to the east of the Christmas fault. It strikes N10° - 25°W and dips 75° northeast with a normal displacement down to the east of an unknown distance. Numerous smaller faults occur throughout the three major fault blocks. The majority, with normal movements of a few inches to 40 feet, have north to northwesterly strikes, trending obliquely to or parallel to the major structures. In the footwall area of the Christmas fault, two prominent east-west structures form the borders of a characteristics graben. On the north side, the 1301 fault strikes generally N70° - 75°W and dips 55° - 60° southwest with movement down 60 feet to the south. The No. 3 Shaft fault along the south border strikes approximately N85°W and dips 60° - 70° northeast with a displacement of about 150 feet down to the north.

The age of faulting, particularly that of the major structures, has been the subject of much discussion. There can be no argument that at least part of the displacements along the Christmas and Joker faults are post-mineral, and evidence points strongly, both on a regional and a local scale, to the fact that probably the major part, if not all, the movement was later. Displacements along the 1301 and the No. 3 Shaft faults appear to be post-ore, but may reflect later post-mineral movement along pre-mineral fault or shear zones. The smaller northeasterly to northwesterly striking faults are definitely post-ore in age, cutting and displacing the sedimentary strata, the mineralized beds and stringers, the post-mineral basic dikes, and the diorite intrusive dikes and sills.

## ORE DEPOSITS

The known ore bodies of the Christmas mine are classified as pyro-metasomatic in type, occurring as replacements in metamorphosed limestones of the Naco, Escabrosa, and Martin formations. The relationship of the ore deposits to the intrusive is almost diagrammatic. The type and intensity of mineralization varies with distance from the intrusive contacts, with the degrees of metamorphism, with the physical and chemical properties of the sedimentary rocks, and with the intensity of pre-mineral fracturing and shearing.

The sedimentary rocks near the intrusive contacts are highly altered and metamorphosed. In the Naco and Escabrosa limestones, garnet and marble are the principal contact-metamorphic products along with lesser amounts of epidote, wollastonite, idocrase, chlorite, and serpentine. In the Martin limestone, the lower beds are highly altered to serpentine, diopside, tremolite, and chlorite with garnet sparingly present. Shale beds like the upper member of the Devonian are altered to fine-grained, banded hornfels and, in some of the thin-bedded limestones, silicification is almost complete. The numerous steep stringers and seams of sulphides which cut the ore deposits attest the fact that much of the metallization took place after development of the lime silicate minerals. Mineralizing solutions, undoubtedly traveling along the pre-mineral fracture zones near the limestone-diorite contacts, formed the extensive replacement ore bodies at intersections with favorable horizons in the metamorphosed limestones.

The principal metallic minerals are chalcopyrite, bornite, magnetite, pyrite, sphalerite, and pyrrhotite. Small amounts of galena and specular hematite are commonly present near the outer margins of the mineralized zones. Some minor molybdenite occurs sparsely in the mineralized beds, generally localized in the siliceous and silicified zones. Magnetite increases with depth, becoming a predominant constituent in ores in the Escabrosa and Martin limestones. Oxidation was almost complete above the 300 level, and extends locally to below the 800 level. Supergene ore minerals include chalcocite, native copper, copper oxides, and copper carbonates.

## Naco Limestone

Production up to 1953 was principally from the middle member of the Naco limestone. The deposits occur as gently dipping, tabular replacements in garnetized zones between thin shale and shaly limestone beds. Peterson and Swanson (1) identify nine distinct ore bearing horizons along the north contact, and eleven beds on the south side. Viewed on a horizontal projection (Plate I), mineralized bodies in these favorable horizons yielded ore along the entire lengths of the main intrusive contacts. The individual ore-bearing beds range from 5 to 12 feet in thickness and extend laterally 150 to 200 feet away from the contacts. Oxidation masks much of the character of the primary mineralization, but it is apparent that magnetite and pyrite were predominant against the intrusive contacts, yielding to chalcopyrite and bornite in the intermediate zone, and grading to chalcopyrite, pyrite, and sphalerite with minor galena along the outer margins.

Ore bodies in the Naco limestones to the east of the Christmas fault are known only from diamond drill hole intersections and from a few exposures on the 800 level, but they show the same characteristics of the deposits to the west. A 1290 foot diamond drill hole, drilled from the 800 level near the center of the block between the Christmas and Joker faults, cut 955 feet of sediments which definitely can be identified as typical Naco beds.

## Escabrosa Limestone

Ore bodies in the Escabrosa limestone, in contrast to the tabular flat-lying deposits in the Naco limestone, occur as irregular, massive replacements near the quartz mica diorite contacts. Generally, the vertical dimensions are greater than the horizontal thicknesses, the ore bodies terminating abruptly into marbleized limestone away from the contacts. The known ore deposits, separated by a thick diorite sill, are in the upper and lower part of the formation.

Ore bodies developed in the Escabrosa upper horizon on and below the 800 level show the common characteristics of these deposits. Intrusive relationships are generally complex with ore deposition occurring in blocks of limestone completely or almost surrounded by diorite. Other deposits occur as replacements of limestones in embayments between diorite dikes projecting westward from the main intrusives, and as thick, shell-like masses against the outer intrusive borders. The ores are usually higher in grade than those of the Naco with chalcopyrite, bornite, pyrite, magnetite, and sphalerite occurring in a garnet gangue. Magnetite and pyrite commonly predominate near the intrusive contacts with sphalerite localized in the outer margins.

In the lower part of the Escabrosa, ore bodies are known only from diamond drill hole intersections, but they show the same characteristics of deposition peripheral to the intrusive contacts. Other important deposits occur between the main intrusive masses.

Experience indicates that wherever the Escabrosa limestones are in contact with the main intrusives, sizeable ore bodies can be anticipated.

### Martin Limestone

The most extensive of the replacement ore bodies is found in the lower part of the Devonian limestones. Mineralization in this horizon, extending north and south from the main intrusive dikes, occurs as a flatly-dipping, massive tabular deposit. These lower limestones, developed to the north on the 1300 level (Plate 3) and to the south on the 1400 level (Plate 4) have proved to be consistently mineralized over an area 2700 feet in width across the intrusives, and 1400 feet in length along the intrusive contacts. Diamond drilling to the east and west of the developed area indicate extensions to 3000 feet along the south contact and to 2000 feet along the north contact. The lower 30 feet of the Martin limestone, consisting of thin-bedded dolomitic and shaly limestones, is the most favorable zone for replacement. However, adjacent to the intrusives, where the intensity of metamorphism and mineralization was greatest, the ore replaces up into the lower part of the massive limestones of the middle member.

Along the south contact, the deposit lies along the south limb of a small anticlinal fold which plunges gently to the west. Mineralization extends throughout a thickness of 65-80 feet for at least 1300 feet along the strike and for 600 to 850 feet down-dip, thinning abruptly to the south and to the west. Adjacent to the north dike, the thicker mineralization extends with a thickness of 55-75 feet for 1600 feet parallel to the intrusive contact, and for 200-400 feet up-dip along the bedding, becoming thinner to the northwest. Between the dikes the more favorable, thin-bedded, impure limestones are replaced, but mineralization above is spotty.

Magnetite forms the predominant metallic mineral throughout the deposit, comprising from 15 to 25 per cent of the total content. Steep-dipping seams of anhydrite and gypsum are common, and local occurrences of fluorite are noted. The sulphide minerals commonly show both a vertical and lateral zonal arrangement. Laterally the mineralization grades from a pyrite-chalcopyrite zone near the intrusive borders, to a chalcopyrite-bornite intermediate zone, and to a pyrrhotite-pyrite-sphalerite-chalcopyrite outer zone. Vertically in the thicker sections, pyrite, chalcopyrite, sphalerite, and sometimes galena generally border a chalcopyrite-bornite central zone.

## CONCLUSION

Inspiration Consolidated Copper Company has developed sufficient tonnage of ore to warrant a mine operation. Plans and preparations have been made for a new shaft in conjunction with a 2500 ton-per-day mill. Culmination of these plans is expected if and when the present copper situation improves.

## ACKNOWLEDGEMENTS

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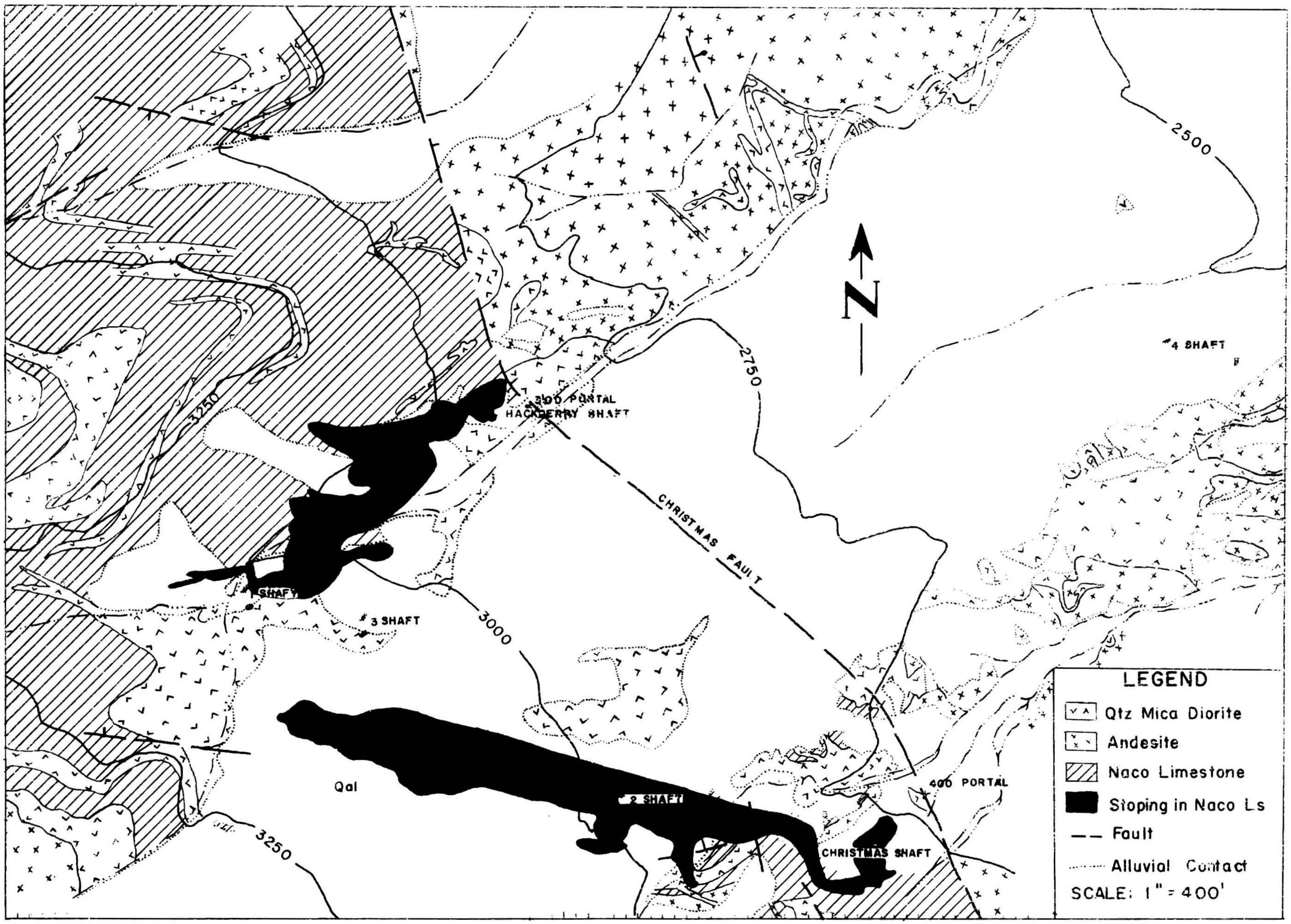


PLATE I, GENERALIZED SURFACE GEOLOGY, CHRISTMAS MINE, I.C.C.COMPANY

After Peterson and Swanson, USGS, with additions by Company Geological Staff and Anaconda Exploration Dept.

**PLATE 2, GENERALIZED STRATIGRAPHIC SECTION IN VICINITY CHRISTMAS MINE WEST TO TORNADO PEAK. Compiled from Diamond Drill Hole Data and Surface Geological Mapping.**

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| CRETACEOUS | +1000' Andesite volcanics. |
| | 60' Medium grained quartz hornblende diorite sill, persistent throughout most of the area. |
| NACO LIMESTONE (PENN. & PERMIAN) | 400' Thick bedded light to dark gray crystalline limestone with thin shaly layers and local chert nodules and lenses. |
| | 500' Thin to medium bedded limestone and shale, locally cherty and abundantly fossiliferous. |
| | 63' Thin bands granular quartzite separated by thick bedded gray crystalline limestone with local shaly beds. |
| | 50' Fine to coarse grained crystalline limestone, locally cherty with 3–5 dark shale at base. |
| ESCABROSA LS. (MISSISSIPIAN) | 400' Massive, light gray, fine to coarse grained crystalline limestone, locally thin bedded and cherty in the upper part. |
| | 120' Coarse grained quartz mica diorite sill persistent over whole area, locally thicker in Christmas vicinity. |
| | 130' Light to dark gray, fine to medium grained crystalline limestone. |
| MARTIN LIMESTONE (DEVONIAN) | 20' Thinbedded shaly limestone, silicified near contacts. |
| | 45' Argillaceous and calcareous shale, generally highly silicified and altered to hornfels near contacts. |
| | 170' Massive light gray, fine grained crystalline limestone, thin quartzite beds in the upper part. |
| | 30' Thin bedded shaly and dolomitic limestone. |
| CAMBRIAN | 175' Argillaceous and calcareous quartzite. |

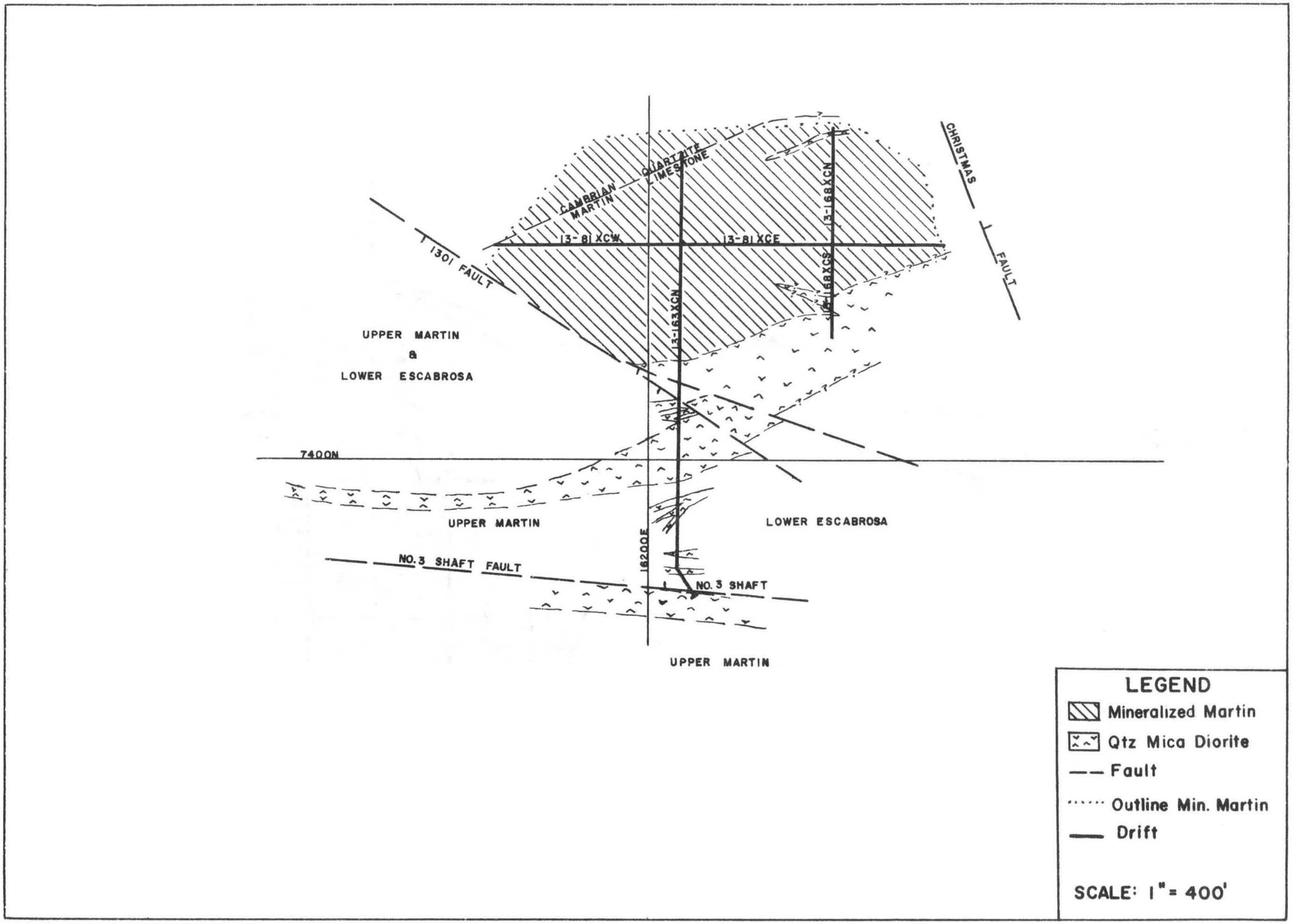


PLATE 3, GENERALIZED 1300 LEVEL GEOLOGY, CHRISTMAS MINE, I.C.C. COMPANY

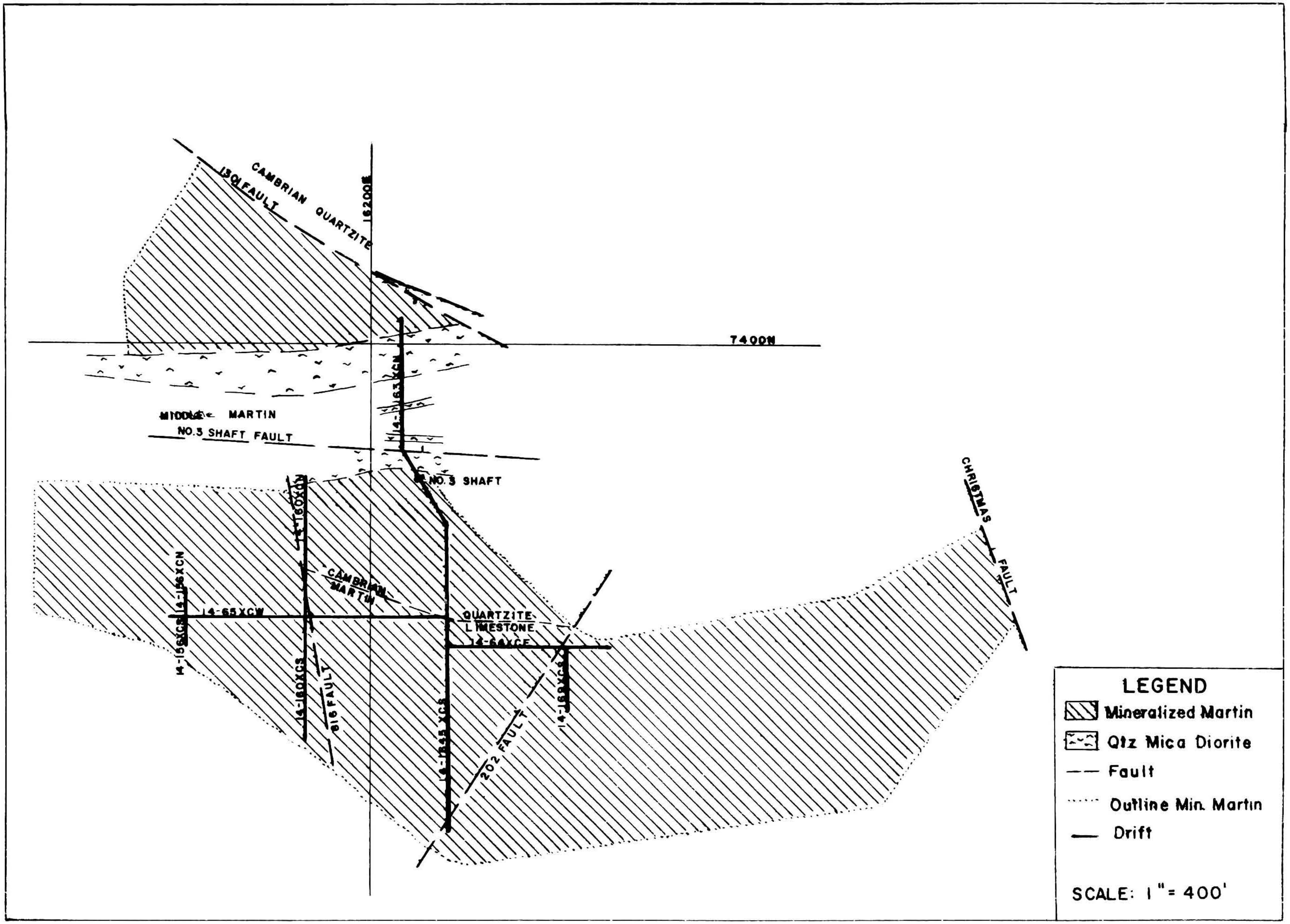


PLATE 4, GENERALIZED 1400 LEVEL GEOLOGY, CHRISTMAS MINE, I.C.C. COMPANY

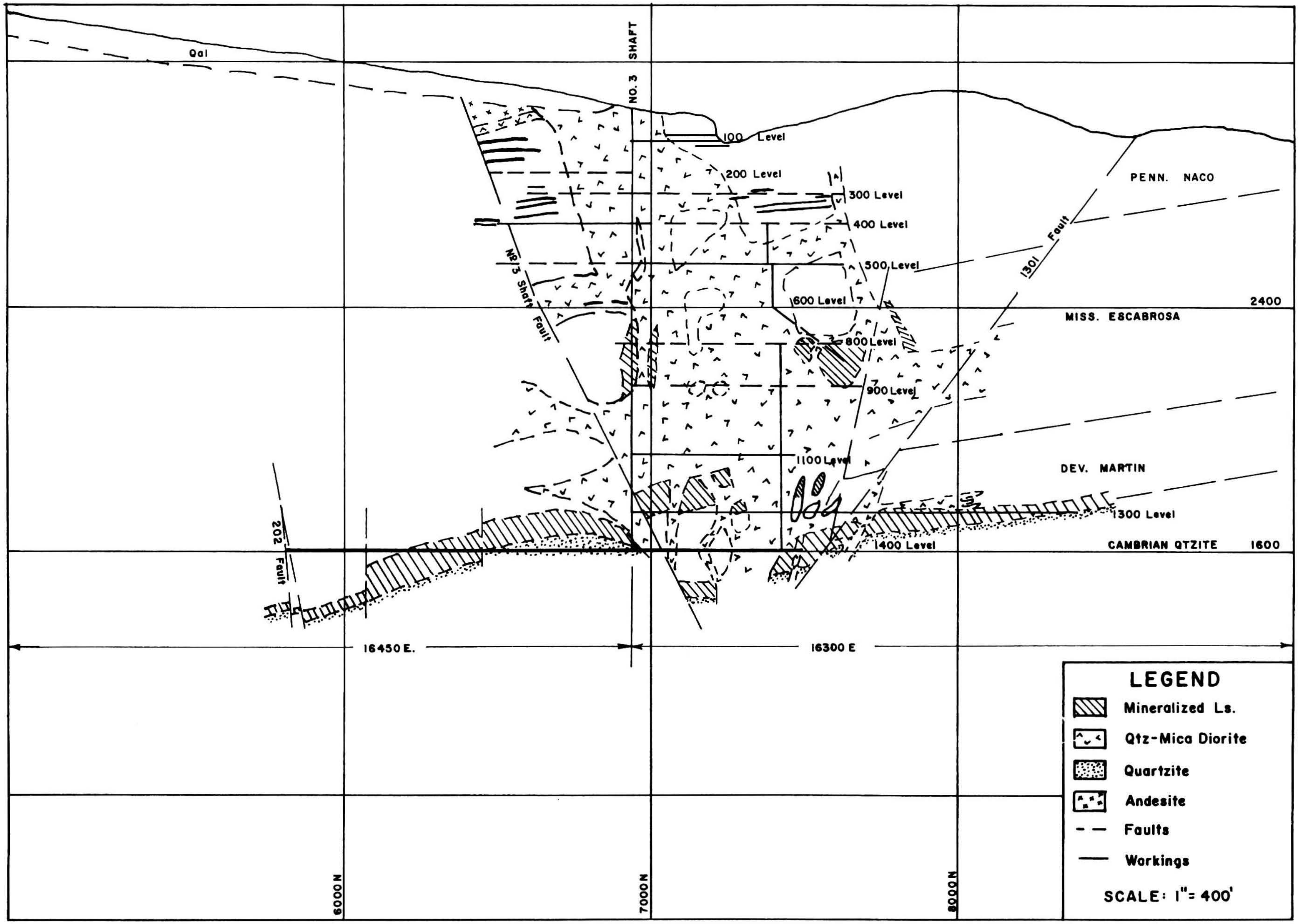


PLATE 5, GENERALIZED N-S SECTION THRU NO. 3 SHAFT, LOOKING WEST; CHRISTMAS MINE