ZEK / Por Cu Descriptive Sandy

THE PORPHYRY COPPER PROSPECT AT PLESYUMI* NEW BRITAIN, T.P.N.G.

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INTRODUCTION

Mineralization, alteration, intrusions and the general lithological-structural environment common to western North American porphyry copper deposits occur on Metaselae Creek near the Metelen River in central New Britain, T.P.N.G. Interpretations of geology, based upon bed rock exposures in the creeks and diamond drill hole data, together with interpretation of lithology, alteration and mineralization from exposures of saprolite indicate than an intrusive-extrusive complex exists in which "typical" porphyry copper mineralization has taken place. Ore grade and tonnage has not yet been proven but zoning patterns based upon an interpretation of telescoping silicate-oxide-carbonate alteration, and upon base metal distribution point to an unexplored area where these critical economic factors may exist.

History

The prospect area was located from the results of a regional stream sediment geochemical prospecting program carried out by Placer Prospecting in 1968-1970. Anomalous stream sediment values at the mouth of Metaselae Creek on the Lae River, a tributary of the Metelen River, suggested the possible presence of copper mineralization. Subsequent exploration on Metaselae Creek, which included geological studies, further geochemical studies and ground-based geophysics established a basis for a drilling program which commenced in April 1970. The program terminated unsuccessfully in December of that year. Triako Mines acquired an interest in the P. A. which included the Plesyumi prospect and

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*Plesyumi; contrived pidgin contraction, "Ples bilong yumi" name assigned to the base camp by unknown Placer geologist(s).

an intensive field investigation was carried out during June, July, and August 1971, its purpose being a further evaluation of the area, particularly a large, mineralized, and contiguous block of ground which was, and is, untested. The presence of a large sulfide system, together with significant copper assays from outcrop, a "typical" rock suite, and runs of ore-grade mineralization in some of Placer's drill holes, combined to form a rationale for continuing interest in the potential of the prospect. At this stage of exploration, no statement regarding evaluation can be made regarding whether or not this porphyry copper occurrence is, indeed, a porphyry copper ore deposit. The present attitude, however, is one of "very cautious optimism."

Location and Terrain

The prospect site lies very near the topographic divide, at the east end of the Whiteman Mountains of central New Britain, and its rock suite is exposed along the length of Metaselae Creek. It extends northward across the Lae River and eastward to the Metelen River. Within this area of some three square miles, the relief is about 800 feet ranging from 700 to 1500 feet above sea level. Rainfall records for the area are incomplete but annual precipitation may be between 150 and 200 inches. Ridge and valley terrain predominates and the area is covered by dense jungle. Metaselae Creek, a subsequent drainage has developed along zones of intense bedrock fracturing and has exposed a deep window through which part of the bedrock complex may be viewed.

REGIONAL GEOLOGY

The Plesyumi prospect occurs along the central, uplifted, spine of New Britain, within or closely adjacent to that part of the island mapped by Ryborn (1969, unpublished) as Eocene, and Upper Miocene to Pliocene volcanic rocks, and Oligocene to Lower Miocene intrusive rocks (Fig.1). The Eocene units compose the older basement of New Britain. The rocks at Plesyumi are undated and, although they occur in the older terrain, it can not be stated for certain that they represent these older events.

The old basement rocks, chiefly andesites, are not exposed at Plesyumi so far as has been determined but they may be present as fragments found in both intrusions and intrusion breccias, and possibly in some pyroclastic units. The present, working interpretation of the environment at Plesyumi is that it represents the effects of a major igneous event which gave rise to quartz-rich, fine-grained phaneritic intrusions and was followed by continuing igneous and tectonic activity which developed a group of closely related porphyries, brecciated porphyries, and a variety of fine to coarse-grained brecciated and autobrecciated units, many if not most of which may be intrusive. Possibly cogenetic pyroclastic units occupy higher parts of the column. Unequivocal sedimentary rocks are absent, except for a few very thin sedimentary appearing clastics intercalated with volcanics or at their base at higher elevations.

This igneous complex is surrounded by the older rocks which it apparently crosscuts and which composed the older basement. It is virtually impossible at this time to reconstruct the cover which may have existed above the complex at the time of mineralization and alteration, and it will probably continue to be so until at the very minimum some absolute dates for a few of the rock units can be obtained. However, the presence of many discordant breccia bodies suggest that cover was not thick, possibly less than 5000 feet.

Regional tectonics are obscure and consequently little can be stated regarding phenomena of regional localization. However, on Ryborn's map, Plesyumi occurs in an area shown as diorites and less felsic intrusions and lies, with other intrusions mapped along or near the borders of the older volcanic-andesitic basement. It seems reasonable to suggest that some underlying fundamental control of these areas of intrusive activity exists but, to our knowledge it is not yet known. The northward-opening, arcuate distribution of the Eocene volcanics and the location of the intrusions at the edge of that arc may be more than coincidental. As a further point, the fact that outcrops of limestone are present on much of the higher terrain of the Nakanai Mountains of the eastern part of the island, and the fact that some of the limestone shows the effects of pyrometasomatism attests to two fundamental facts: Faulting and mineralization are both young. Continued activity along old structures and continuing but possibly intermittent mineralizing and altering activity must be considered in any geological evaluation of the mineral potential of the island.

PLESYUMI GEOLOGY

Two exposures of a fine-grained equigranular quartz-diorite or granodiorite predominate much of the exposure at Plesyumi. (Fig.2). Although the exposures may be parts of the same parent body, sufficient petrographic differences exist upon which mapping of them as separate bodies at this time can be justified. Partly enclosed by, but also extending away from the exposures of the granitic rocks is the pyrite-chalcopyrite-bornite bearing intrusion-extrusion complex which composes the rock body of chief interest.

The host rock complex consists of a variety of rock types which reflect an extremely complex history of formation, and tectonic and mineralogical modification. Chemically, most of these rocks could be described as ranging from diorite through quartz-monzonite but texturally and genetically they are extremely diverse. They range from strongly altered, possibly surface deposited pyroclastic volcanic units, through autobrecciated, possibly intrusive volcanic rocks, to distinct igneous intrusion breccias in which the effects of partial melting may be seen in some instances. The complex includes as well, concordant and discordant bodies of dacite and very quartz-rich dacite and rhyodacite porphyries.

Results of work so far completed have revealed no consistent pattern of zonation either fracture direction or of intensity. From a comparative standpoint, for example, the host rocks are not nearly so factured as the andesite host at Panguna, but the host rock complex is not so uniform as that at Panguna, either. Samples from some outcrops of comparatively weakly fractured rocks indicate that copper values may be just as high, locally, as the values at Panguna. We would ascribe this difference to the major difference in the pyrite-to-chalcopyrite ratios of the mineralization, high at Panguna, and low at Plesyumi. Slight variations of fracture intensity at Plesyumi seem not to have affected either copper grade or base metal distribution, both of which seem to display regional zoning, independent of properties of the host rocks.

Primary sulfide mineralization occurs in most of the unoxidized exposures and copper is almost ubiquitous at a low level of concentration. Significantly, high copper values attend low total sulfides in both outcrop and drill hole. The nature of mineralization varies from the isolated, presumably syngenetic or late magmatic sulfides in some of the intrusions to that which is vein-associated and clearly epigenetic. Chalcopyrite is most abundant of the ore minerals but rare veinlets of bornite and possibly chalcocite occur as well.

Silicate-oxide-carbonate hydrothermal alteration is present and takes many forms. Very weak propylitization expressed by development of small patches of epidote characterizes the quartz-diorite body in the headwaters of Metaselae Creek. The weak effects seen in fresh outcrop become progressively stronger with depth and the alteration is moderate in intensity at 500 feet in one drill hole in the intrusion. Exposures of the other intrusion along the Lae River reveal rather intense development of biotite which appears to be pseudomorphic after hornblende, a type of late magmatic or deuteric alteration not yet recognized as extensively developed in the Metaselae Creek body.

Alteration of the rocks in the complex varies considerably according to the rock type and to position. The most impressive type of alteration in both outcrop and drill hole is that of carbonate flooding. Virtually every rock studied in thin section reveals that carbonate, probably mostly calcite is almost ubiquitous in rocks other than the phaneritic intrusions. Although having the potential of being related to surface effects, rocks from deep drill holes reveal similarly intense development of this alteration type. It is accompanied to varying degrees by development of minerals of the propylitic suite, chiefly epidote. Superimposed upon the propylitic alteration assemblage is typical phyllic alteration, seen chiefly in the envelopes of quartz-sericite which enclose sulfide veins. Very rare development of feldspar has taken place, chiefly in association with sulfide mineralization.

One of the most striking of the alteration phenomena at Plesyumi is the sulfidation of magnetite. Alteration intensity in the silicate suite is reflected in the oxides by the progressive nature in which pyrite replaces magnetite. The change to more and more replacement as the mouth of Metaselae Creek is approached is a manifestation of both alteration zoning on a lateral scale and the idea that the alteration is epigenetic to the host rocks.

Zoning of the alteration is difficult to decipher and in view of the superposition of alteration types on the host rock complex, it is not unreasonable at this stage of investigation to postulate that Plesyumi is a fairly good case for telescoping of alteration. If telescoping of the silicates into the carbonate flooded rocks is the correct interpretation it implies very shallow intrusion and near surface effects of hydrothermal activity, a conclusion not forbidden by other evidence.

Above the creeks the rock is deeply weathered but the resulting saprolites retain sufficient detail to allow some generalizations regarding secondary processes. Assay results from some of the drilling suggest that copper enrichment, mostly in the form of oxides (tenorite?) and native copper has taken place. Rare cuprite is present. The enrichment seen so far is not economic and minor in scope but its presence has the potential, particularly on steep hill slopes and in the saprolites of modifying soil and auger sampling results. Enrichment factors of 3x to 4x have been interpreted from the data.

SUMMARY OF IMPORTANT CHARACTERISTICS

We should point out again that Plesyumi is not yet known to be an ore deposit. Because the term ore is dependent upon so many variables, among which is geography, we believe it worthwhile to underscore those geologic characteristics of this prospect which form a basis for the continuing interest rather than those economic factors which dictate whether or not it will ever be mined. Because no porphyry ore deposit is known in New Britain, no nearby genetic counterparts can be utilized as a basis for comparison. It can, however, be compared in some respects to the body on Bougainville and, of course, to the western hemisphere types. Such a comparison is valuable if gross characteristics are considered. If detailed comparisons are attempted, however, the results, for better or worse, are far less meaningful because of the wide variation in detail of the features of known deposits. Notwithstanding the models which have been proposed (James, 1971) and the "typical" deposits suggested (Lowell and Guilbert, 1970), both of which have been based largely upon the characteristics of western hemisphere deposits, sufficient significant differences in detail exist among those deposits to give rise to doubt as to the widespread applicability of the criteria or features considered typical. Further, although the western hemisphere characteristics provide a useful standard against which gross properties may be measured, extreme caution should be observed, at this stage of knowledge and understanding, in attempting to assess the favorability of certain details of western Pacific types by such comparisons.

The discussion which follows summarizes some of those characteristics which we feel significant on the basis of present knowledge and understanding. These are characteristics which we suggest to be possibly fundamental and in a general way are the features and phenomena which have established the basis of continuing interest in the prospect area. Many if not most are probably fundamental to an understanding of the genesis of the deposit.

Lithology

Rocks critical to the interpretation of the genesis and potential of this prospect are the porphyries and the breccias. Although neither is necessarily a harbinger of success, nor criteria for designation of the prospect as a porphyry occurrence, rocks similar to, if not identical with those at Plesyumi are common associates of the western hemisphere deposit. The prospect as it is now recognized would be considered a Wall Rock porphyry deposit, that is, the preponderance of known mineralization occurs in rocks other than a parent intrusion (Titley, In Press). The wall rock in this case consists of a column of extrusive rocks and intrusion breccias. The progenitor of the mineralization, if exposed has not been recognized. However, intrusions of quartz-diorite porphyry and dacite porphyry are abundant, even though of restricted size. A few bodies of an extremely quartz-rich (>35%) quartz diorite or granodiorite porphyry occur and their discordant character lends some hope that a parent body exists below. The rock types and associated mineralization, particularly the "quartz porphyry" are common to many of the porphyry copper bodies of the western hemisphere.

Breccia Bodies

Two large areas of breccia have been recognized at the surface. In addition, numerous small breccia dikes have been recognized cross-cutting all but the porphyries and the granodiorite. Granodiorite fragments, however, have been recognized in the breccias and fragments of the dacite porphyry have been observed in the breccia body near the mouth of the Metaselae Creek. They thus appear to postdate much of the recognized igneous intrusive activity. The matrix of most breccias appears to be composed of dark, fine-grained material, possibly rock flour, and much very fine-grained carbonate, probably calcite. Material taken from one of the breccias contains about 4% (volume) of sulfides of which about half is chalcopyrite in a matrix which appears to be microgranodioritic. This same breccia also contains fragments of strongly mineralized dacite porphyry.

Fragment size in the breccias ranges from fragments visible as broken, but still coherent, pieces under the microscope to angular blocks up to a foot in the shortest dimension. Within some of the finer-grained breccia units, fragment size varies gradationally from fractions of an inch to inches across outcrop distances of tens of feet. Possibly interpretable as the result of surface phenomena, the bodies appear to be discordant and the tentative interpretation of them is that they are igneous intrusion breccias. Insufficient good outcrop exists to clearly understand their geometrical properties but they are believed now to more likely be dikes than pipes. The mineralized intrusion breccia occurs in many western hemisphere bodies.

Mineralization

Sulfide mineralization occurs in all rock types present and the prospect can be considered a real sulfide "system." Regional reconnaissance is incomplete but it appears the the Plesyumi site is anomalous in this respect. Average sulfide content of the two phaneritic intrusions is probably around 1% or less (volume) but the sulfide content of the host complex is generally in excess of 2% and very commonly in excess of 3%. Drill hole data and information from outcrop suggest a zone of more-or-less continuous high pyrite content (>5%) which extends in a general northerly direction along the creek. Eastward, oxidized and leached capping suggest another belt of high sulfide content but the extent of this belt has not been determined. (Fig.3). The significance of this observation is that, as in many porphyries, sulfides are zoned, both with regard to composition and to abundance. As noted above, high copper values occur in rocks of low total sulfide.

Neither molybdenite nor gold assays have been noted in any significant amounts but both are present. High silver values attend higher lead-zinc values and these base metals are zoned with respect to copper. Copper to lead plus zinc ratios, as determined from assay of unoxidized outcrop, increase consistently and almost uniformly down the creek toward the Lae River. Ratios of an average of about 6 occur in the headwaters of Metaselae Creek and increase to 25 to 40 as the Creek mouth is neared. The ratios reflect a generally constant value of copper - that is, copper assays do not change drastically in that direction.

The presence of bornite is somewhat puzzling. Little can be made of it at this stage of knowledge except to note that it appears to be late and probably represents a sulfur deficient stage of mineralizing activity. Its presence in the western hemisphere bodies is in the deep or lateral fringes of mineralization. If, however, our interpretation of telescoping silicate alteration is correct, the presence of bornite late in the paragenesis would be consistent with that interpretation.

Alteration

Care must be exercised in comparing western Pacific porphyries with alteration patterns which have been worked out and reported for western hemisphere porphyry deposits such as those reported by Rose (1970) and Lowell and Guilbert (1970). The porphyry body which has been best studied and reported in this respect is San Manuel-Kalamazoo.(Lowell, 1968; Lowell and Guilbert, op.cit.). Although the zoning and alteration types which have been recognized there may be broadly applicable to the copper porphyry, two features of that aoccurrence deserve emphasis. The orebody reflects hydrothermal evvects over a vertical range of nearly 10,000 feet. Further, the zoning symmetry reflects a process which has acted in a mineralogically uniform environment, a quartz monzonite which has invaded and altered another quartz monzonite. In this respect, the orebody is an unusual Wall Rock type because of this closely similar mineralogy.

Although western Pacific porphyries may have developed and may have been altered over such a vertical range, there is no evidence yet that they have done so, certainly not at Plesyumi. As a second point, although the rock suite at Plesyumi may be more or less chemically uniform, it is certainly not uniform mineralogically or texturally. Consequently deviation from the model picture of alteration is to be expected. What departures are to be expected, however, are not known for certain. From the standpoint of accepted nomenclature, the alteration at Plesyumi is that of biotitization (or potassic) alteration of the granodiorite and widespread and probably intense propylitization of the host rock suite. In this respect, it is similar to the alteration reported at Panguna(MacNamara, 1968). Impressed upon the propylitically altered rocks, however, is phyllic alteration along veins. The zoning picture at Plesyumi thus does not reveal the discreteness of alteration that is recognized in the zoning of the western hemisphere type, but the mineralogy is the same. At this time, we can only suggest that we are viewing the results of a near surface process which resulted in overprinting of alteration types.

Genetic Considerations

Sufficient enough grade and tonnage can be seen and reasonably projected at Plesyumi that we feel fairly confident in stating that had the body been developed there and been exposed to the processes which affected the Laramide bodies of southwestern North America, it would probably be indistinguishable from many of the deposits of that region. Our reason for this comparison is that the primary grade is at least as high as the primary grade of western hemisphere deposits above which enriched blankets developed and that had the post-depositional histories been the same, those parts of the Plesyumi prospect which contain high pyrite content would certainly have been capped by such a blanket. In addition to the geological similarites, therefore, we feel justified as well on the basis of the "economics-that-might-have-been" in considering it a porphyry copper deposit and an important one to consider from the standpoint of genetic problems.

Copper and other sulfide mineralization postdate all but the uppermost deposits of ash, and there is no evidence to ascribe the mineralization as related to the phaneritic rocks present. Breccia intrusions occur, some cemented by a very fine-grained equigranular igneous material, others by finely ground rock flour. Both types of matrices are mineralized. Non-sulfide host rock alteration is telescoped. Both sulfide and non-sulfide alteration transgress rock type, in this respect, similar to Panguna.

Although not one of these criterion is sufficient itself to justify the conclusion that the Plesyumi sulfide system was evolved at shallow depth, we feel that taken together, there is some justification for such an assertion. The widespread carbonate flooding might also lend weight to such an idea if it could be proven that it reflects involvement with the system by ground water at the time of formation.

The presence of the discordant porphyry bodies suggests the presence at depth of a parent body. The origin of the copper, however, poses a different problem. We can not be certain that at least some of the copper has not been derived from the process of melting of a pre-existing column of volcanics and reconcentration of the metal-sulfide system as a separate phase of a larger body of melt. That copper and sulfur and iron were introduced into the Plesyumi system after rock emplacement is strongly suggested by the transgression of alteration and sulfide types across different host rocks and by the progressive way in which magnetite has been sulfidized.

In terms of regional localization, we can only refer again to the position of Plesyumi at the edge of the exposures of the old volcanics and suggest the continued reactivation of old structures along which this line developed.

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Figure 4. Typical rock textures of the Plesyumi porphyries. Most contain in excess of 2% sulfide and range from dacite porphyries (1,3) to porphyritic granodiorites (4,5,7) Brecciated quartz porphyries are 2,6.

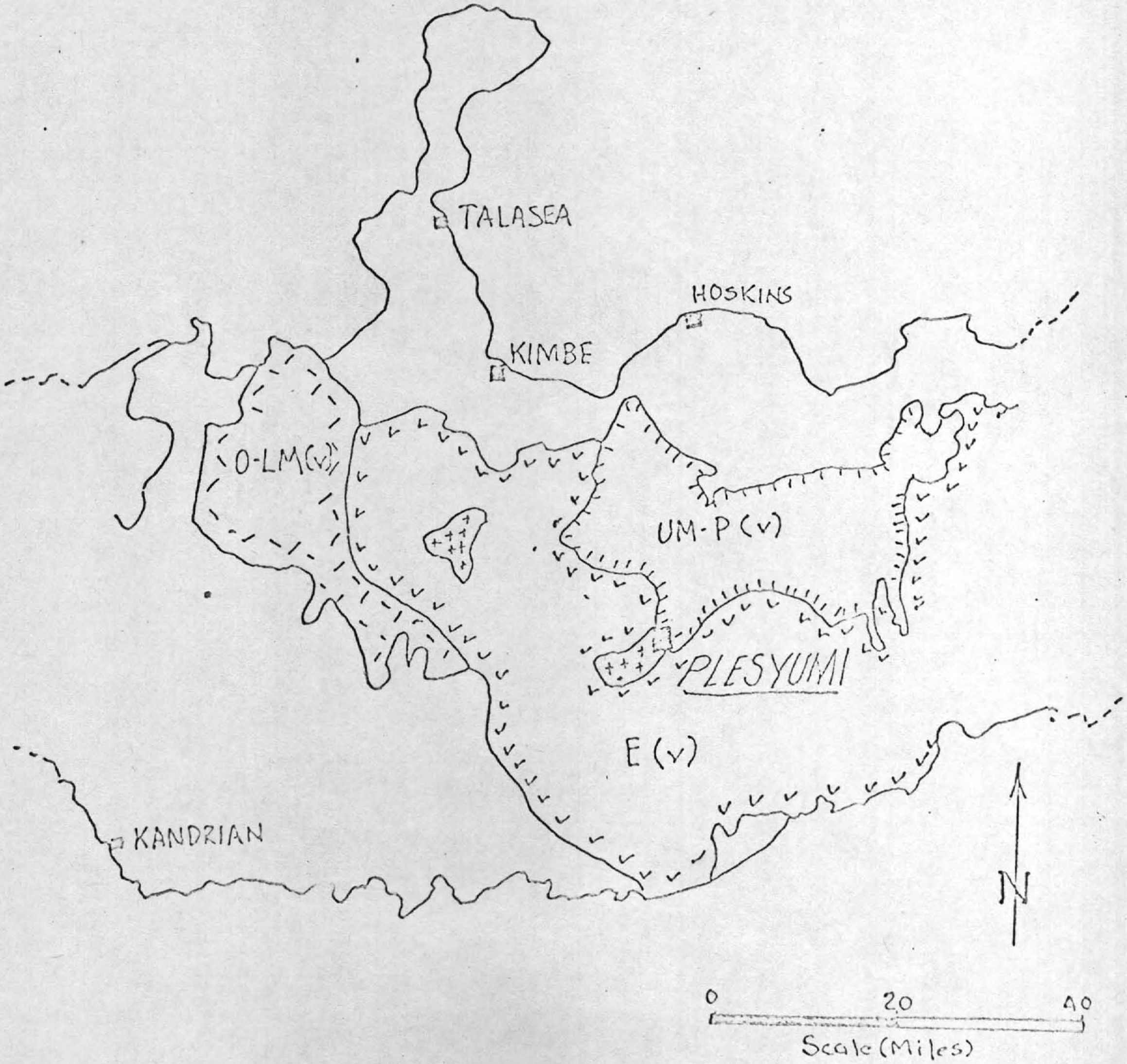
Figure 5. Biotite altered granodiorite (scale in inches)

Figure 6. Carbonate - rock flour cemented breccia dike in altered porphyritic granodiorite host rock.

Figure 7. Fine-grained altered "fragmental" igneous rocks, typical of what have been interpreted as intrusion breccias (1,2) and rocks with strongly reacted and possibly melted fragmental material. Matrices are mainly fine-grained quartz-feldspar with considerable replacement carbonate after feldspar.

LOCATION - GENERALIZED GEOLOGICAL MAP - PLESYUMI & CENTRAL NEW BRITAIN

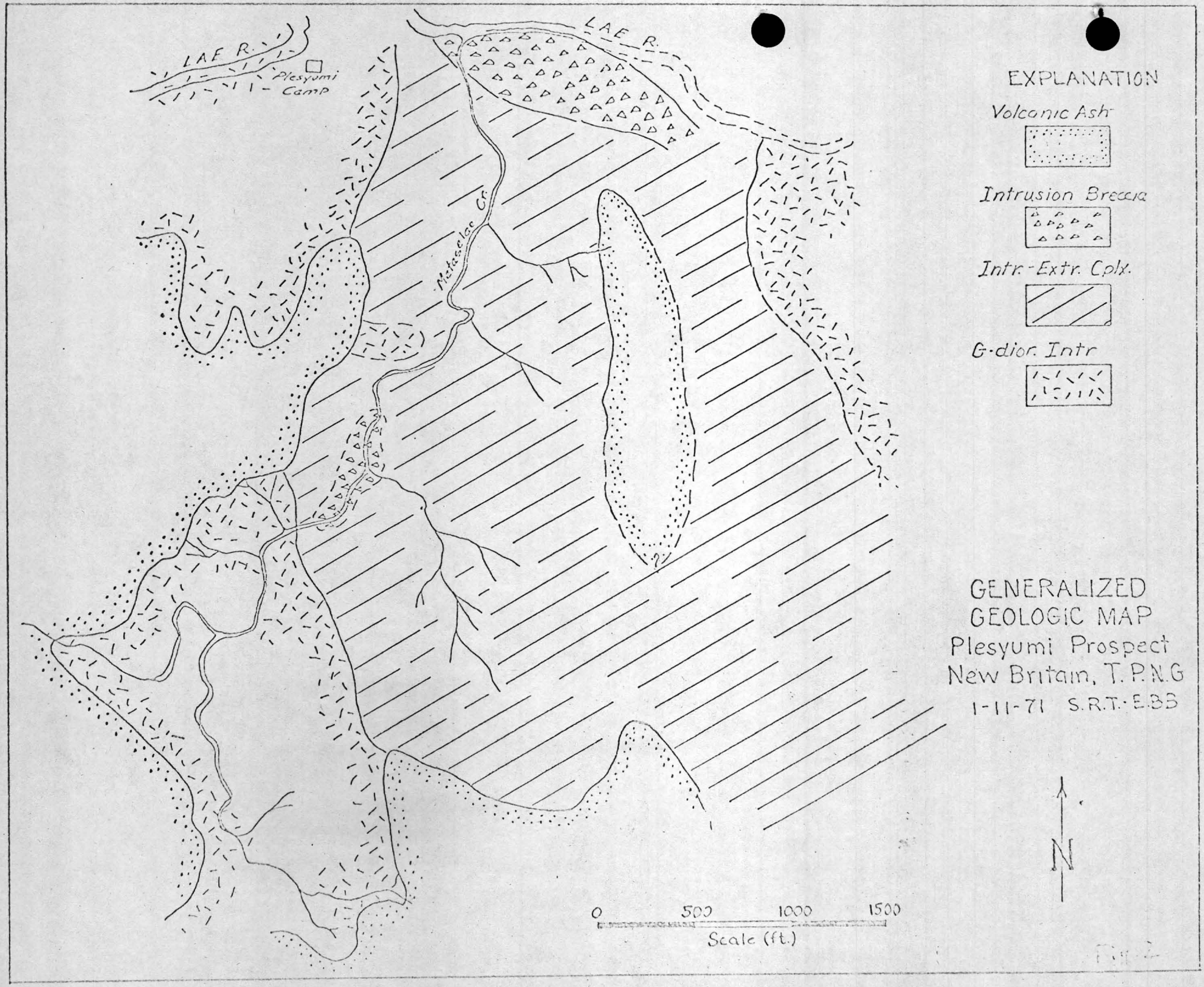
Geology after Ryborn (1969)



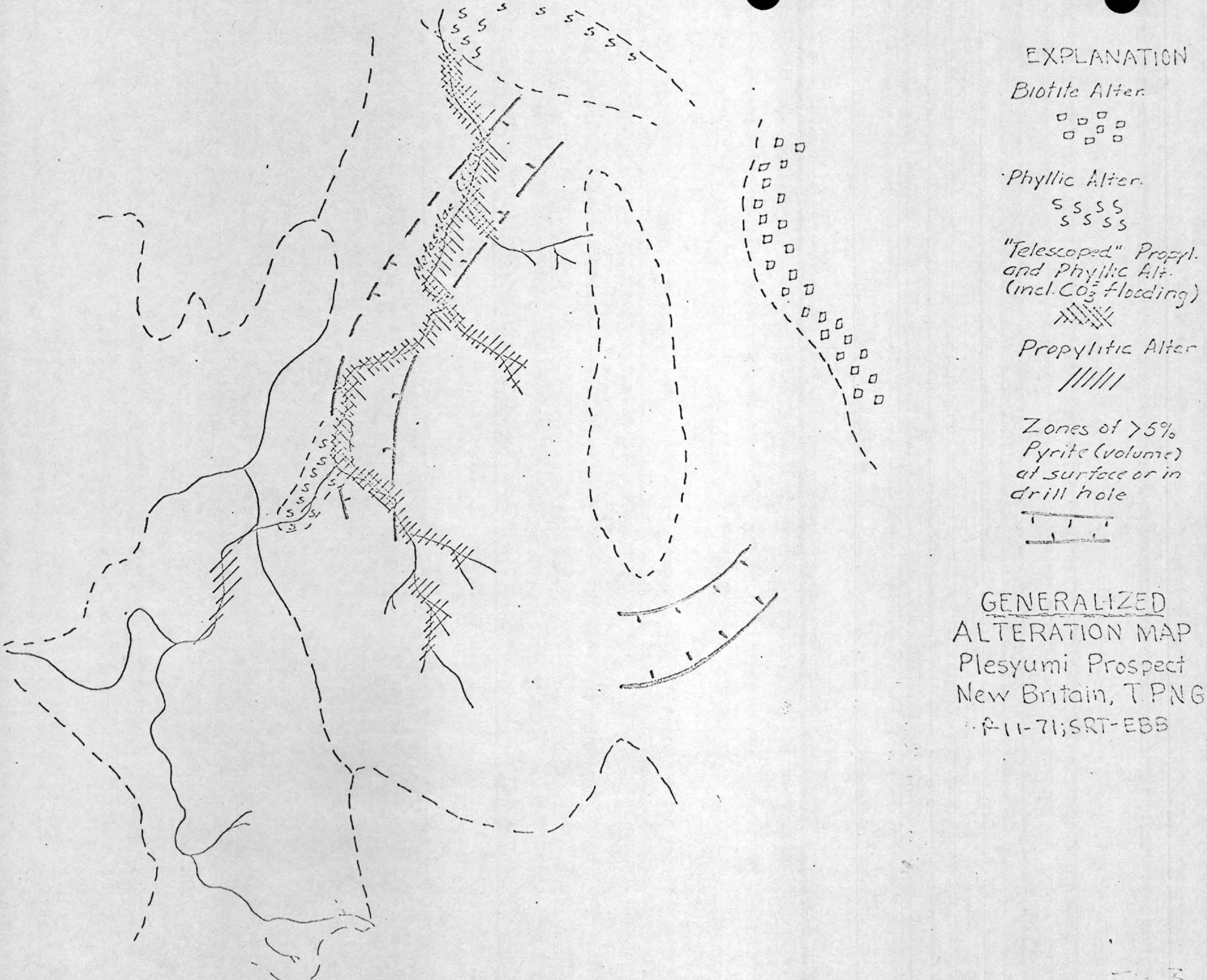
Explanation

- Younger Rocks & Limestone
- U-Mio-Plio Volcanics — UM-P(v)
- Olig-L-Mio Intrusions
- Olig-L-Mio Volcanics — O-LM(v)
- Eocene Volcanics — E(v)

Fig 1



EXPLANATION
Volcanic Ash
Intrusion Breccia
Intr.-Extr. Cplx.
G-dior. Intr
LAE R.
Plesyumi Camp
Metaselae Cr.
GENERALIZED
GEOLOGIC MAP
Plesyumi Prospect
New Britain, T.P.N.G
1-11-71 S.R.T.-E.B.B
N
0 500 1000 1500
Scale (ft.)



GENERALIZED
ALTERATION MAP
Plesyumi Prospect
New Britain, T.P.N.G
8-11-71;SRT-EBB

Fig 3

Amdex mining limited

57 York Street, Sydney, N.S.W. 2000, Australia. Telephone: 29 1643

EBB/BB

26th November, 1971

Dr. Spencer Titley,
6920 Taos Place,
TUCSON, ARIZONA, 85715,
UNITED STATES OF AMERICA

Dear Spence:

I feel that I really took advantage of your good hospitality in the so called joint paper on Plesyumi. Nevertheless, I thank you for your efforts and congratulate you on your usual excellent writing. I realise how this cuts into your time and delays the final report.

I returned from New Britain on Friday and found that I was scheduled to speak at 2.30 on Monday. Kathy had assisted me in summarizing the paper so I could deliver it in the 20 minutes required but I had to revise it considerably between a weekend of parties. I nearly cancelled out but in the end was induced to go ahead. In view of all the synthecising I remained as co-author but gave you full credit for the ideas. Along with the attached Abstract I gave them the complete text. It should appear in a Special Porphyry Copper Edition of G.S.A., we will send you a copy.

The talk was well received (surprisingly there were over 200 people) and resulted in about 30 minutes of questions. I was fortunate in following Hughes of C.R.A. who delivered a very negative and boring talk on the dark side of New Britain, generally inferring that their work at Waselau and Yau Yau, the thing northwest of Plesyumi that Hanna are interested in, proved that New Britain is sterile. They gave about four papers on Australia and New Guinea all essentially in the same vein, i.e., Don't explore there because it is no good.

Johan and I spent an arduous 10 days at Plesyumi walking the trails cut by Minefields. Some interesting Copper Zinc anomalies occur east of the Metelen from small creeks near the tops of ridges zincs are particularly interesting, with values over 1,000 p.p.m. and coppers to 500 p.p.m. The rocks visible are rhyolitic breccias with sulfide voids so it is interesting. We also cracked a lot of rocks along the Metelen River and at the mouth of Metaselae Creek. Very interesting chalcopyrite occurs in granodiorite on the east side of the big horseshoe shaped bend in the Metelen river. I also liked the highly chloritized zone at the mouth of Metaselae that you found.

../2

Dr. Spencer Titley 26th November, 1971

Scott Leslie hired a competent Miner, Alex McDonald, and we gave them a firm contract for 300 feet of adits to continue five of the locations we selected. They are doing the work for $25 per foot all inclusive. We will send you plans and Johan will prepare a sketch showing geochemical sampling of interest.

I gave Scott the $50 to select some good native artefacts when he was down prior to my visit there but he waited until my arrival to reconfirm what he thought you wanted. You should receive a letter from him shortly advising what he has selected.

We, the Bell family, have made tentative reservations to go home (the old country, U.S.A.) on December 19th. I hope to at least call you while there. We have no plans other than Reno-Elko at this time.

Thanks again for your manuscript. Ike sends his regards. Norma also joins me in wishing you and your good wife a Merry Christmas and a prosperous and happy 1972.

Sincerely yours,

E. B. Bell

Encl. (Annual Report - Triako)

DDH N-101 at Lady Annie is the best hole to date. Although subject to confirmation the assays are

930 to 1190' 260 ft. core length 14.7% Zn 7.5% Pb [illegible]
1380 to 1440 80 " " " 24.5% Zn 15% Pb [illegible]

11 November 71

Dear Shark:

Enclosed is the ms on the Plesyumi bit. I hope that you find it satisfactory. Please consider yourself welcome to modify, reshape, add, delete, or whatever on the thing. I have tried to bring out those points which I believe to be of interest to a group such as you have described and hope that you'll not find too much difficulty in the reading of it.

I sent in some 35mm to get some prints made to include with it but the damn things have not come back. I have had to substitute some slides that were not my first choice but they show, in a different way what I wanted to be seen. The only thing missing is a photo of three different types of breccias. The explanation with the paper is for the slides I have included. I'll stop by the photo people on the way to the mailbox with this and if the prints have arrived I'll throw them in as an after thought. In other words, if there are loose 3x5 prints in this envelope, they are the prints I really wanted to send but did not have in time. I am rushing this because I have to leave with the sun tomorrow to give a series of lectures in Reno tomorrow and saturday, and did not want to delay this posting any more than necessary.

Someday, I hope to have the report finished but I really think if I keep writing these short papers and the interim report, I'm not going to have too much new to say. It's been a tough thing to get at and stay with this semester between courses, students, apolb landing sides, and so on;

I've not mentioned anything about grade in the paper because I don't believe we really can be certain of what the exposed grade is. My average is about 0.20 to 0.25 for most of the part of the creeks sampled. overall, it may run about 0.15, the same as the primary grade at Ely, Mineral Park, Morenci, Safford, and Santa Rita. Include that if you want to. I trust I have not said too much - in rereading it, I get a funny feeling that maybe I am trying to draw too much out of the data for an area in which 1% is outcrop. I still feel though that this is the way I have to call it. By the way, if these proceedings are published, how about getting me a couple of copies. -- All for now - good luck, co-author, give 'em hell. My best regards to all, especially you and Ike.

Sincerely,

Cuajone largest new copper operation at full capacity

1958

RAY

JC Kinnison

The Ray Orebody

By Jaques Wertz

Foreword.

The geology of the area was first described by Ransome in 1919, later revised by him in 1923 in U.S.G.S. Professional Paper #115. It is a wonderful piece of work that still remains essentially correct. Valuable contributions to the Ray geology were later made by Spurr and Cox (private report, July 1909), C. L. Hoyt (private report, 1938) and Otis M. Clarke, (Arizona Geological Society Guidebook, 1952).

In the present work, the constant supervision of Mr. Donald D. Smythe, his continued advice and personal study of the deposit have largely increased our knowledge on the major structures with, as a result, a substantial increase in ore reserves.

The progressive policy observed by Mr. A. P. Morris, General Manager, keeps pace with the geological work by a well-planned and systematic drilling program, well worth mentioning.

Location.

Ray is located at the foothills of the Dripping Spring Mountains on Mineral Creek which flows South into the Gila River.

Geology. 1. Stratigraphy

The Stratigraphic sequence is first reviewed and the most important rocks are here briefly described. The basement consists of the Pinal Schist, old pre-Cambrian in age and contemporary to the Vishu Schist in the Grand Canyon. The formation generally shows a northeast-southwest schistosity, dipping to the NW from 30 to 60 degrees. Many local folds are observed in this formation which is composed of metamorphosed sedimentary rocks, generally showing an alternation of shaly and quartzose layers, and of intrusive rocks like rhyolite and what is locally called "amphibolite-schist".

The color of the Pinal Schist is generally gray with a bluish hue outside of the mineralized area turning naturally into different shades of brown within it.

The Apache group unconformably overlies the Pinal Schist and is also pre-Cambrian. The lower part of it is mainly composed of the Pioneer formation, generally a shale, the Barnes conglomerate, and the Dripping Spring quartzite. These rocks show in the vicinity of Ray a regional trend slightly east of north with a low dip, 10 to 20 degrees eastward.

The Pioneer formation, the Dripping Spring quartzite, and the Pinal Schist are at times quite difficult to differentiate, be it in the field on the surface geology, or in the examination of drill-core.

The tan-colored Mescal limestone is next in the sequence and is often seen in conjunction with dark brown basaltic flows that covered it.

The Troy quartzite, Cambrian in age, follows.

All these formations are abundantly found East of Ray.

The Martin, Escabrosa and Naco limestones of Paleozoic age occur only on the top of the Dripping Spring Range and do not appear near the orebody.

Long before Laramide time, heavy faulting occurred and incompetent rocks such as the Dripping Spring quartzite, were broken and fractured. Diabase was intruded shortly after, lifting the separate masses of quartzite and filling all existing fissures.

A specific fracture trending NNW and SSE with a dip of 45 degrees to the East has been filled with diabase: it is now conspicuously visible in the pit. To the East of Mineral Creek there is considerable diabase, some existing as sills between members of the Apache group and other portions underlying the whole series as an extensive mass. Another series of irregular fractures exhibit the same trend but they occur more vertically; in this group we have the Ray fault and the Mineral Creek fault.

Porphyry next intruded the area. The Teapot Mountain porphyry came first, exhibiting well formed felspar and quartz phenocrysts, and it was followed by the Granite Mountain porphyry. It appears that this latter porphyry forced its way through fractures that trend in an opposite direction to those previously noted;

NE

it is found along a NE-SW trend irregularly intruded but it also shows here and there as small stocks.

One interesting observation is the fact that the Teapot Mountain porphyry occurs North of an East-West line passing approximately through the pit, while the Granite Mountain porphyry definitely shows South of that line. Copper mineralization occurred simultaneously or slightly after the intrusion of the Granite Mountain porphyry.

After a presumably long interval of time, during which erosion and also secondary enrichment occurred, the country was covered by tertiary flows, tuffs, and conglomerates: Whitetail conglomerate, dacite flow, Gila conglomerate, then tuffs and volcanic breccias.

These are the main formations that we encounter in and around the Ray orebody.

2. Structure.

A major fault zone, particularly complex near Ray, extends along Mineral Creek exhibiting a Northwest-Southeast trend. It seems to show an en-echelon pattern with successive downthrows to the East, almost all steep.

The movement along this major fault area has been estimated by Ransome, Cox and Spurr, to amount to 1500 ft. and even 2000 ft. It started before Laramide time with a relative downthrow of the east block, later alternated with an upthrow and finally with a renewed and important downthrow again of the eastern area.

Recent Tertiary movement is well shown by the conspicuous offset observed in the dacite flow: some remnants occur on the Teapot Mountain to the Northwest at 4400 ft. elevation while a larger mass of dacite occurs near town (best seen at the bridge) at 2050 ft. elevation and more. Another obvious indication of this large offset is obtained from a look at the geologic map. It shows a solid area of Pinal schist west of the fault zone without any of the later sediments. This contrasts with later sediments found to the east, ranging from the Cambrian up to the Tertiary.

It is worth mentioning that while the west block has been disturbed relatively little, the eastern one shows a broken assemblage of formations that Ransome justly calls a mosaic. It is fortunate that stratigraphy can partially assist in deciphering this jumble; the Barnes conglomerate is of particular help here as a faithful and conspicuous marker.

The orebody, and particularly its limits, is largely controlled by structural factors. To the west, the West End fault appears definitely to indicate a structural termination. To the north the situation may be similar. The southern limit seems to be indicated by a rather sharp fade-out. Similarly to the east we are inclined to believe in a gradual fade-out beyond the fault zone.

The orebody can thus be represented roughly on a map by an irregular ellipsoid 8000 ft. long and 1500 ft. wide elongated along a direction east-west. This does not mean that this is a solid ore body: for instance, between the old Pearl Handle pit and the West pit the intervening hill, that is now being gradually stripped away, is almost all waste. The west block contains three major coordinate faults almost at right angle. Whenever they cut through the ore body there is no large offset in the latter.

It will be difficult for a long time to determine for certain which are the faults that pre-date or post-date mineralization; most of them probably antidated mineralization then recurrence of movement during and/or after mineralization blurred the whole picture.

Without any doubt the later fault movements have influenced the supergene orebody: for instance, the oxidation zone in the eastern block is much deeper than in the western zone because the water-table has followed the downward movement of that bloc.

A major structure observable in the pit is an over-thrust fault oriented N20W, dipping 15 degrees East. This truncated the main diabase dike, displacing its upper body toward the west; no remnant of the upper body has been found yet as it is probably all eroded. The lower body has been dragged close to the fault and extends irregularly toward the west as an elongated tongue.

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MINERALIZATION AND ALTERATION AT THE PIMA MINE A COMPLEX PORPHYRY COPPER DEPOSIT PIMA COUNTY, ARIZONA

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ABSTRACT

The Pima mine, 39,000 ton per day copper mine, is located 17 miles south of Tucson, Arizona.

The mine is in a sequence of Paelozoic and Mesozoic sediments striking east-northeast and dipping southeasterly intruded by a Tertiary quartz monzonite porphyry. The Paleozoic Permian(?) dolomites, limestones, and sandstones have been altered to calc-silicate skarn, marble and quartzite. The overlying Mesozoic Triassic(?) clastic sediments have undergone some recrystallization and hydrothermal alteration. The clastic metasediments are divided into three distinct lithologic units: lithic arenite, arkose, and interbedded and overlying black argillite. Three types of hydrothermal alteration in the clastic rocks are propylitic alteration (epidote, chlorite and quartz, with or without sericite), quartz-sericite alteration, and potassic alteration (K-feldspar and quartz, with or without sericite and chlorite). The porphyry has undergone potassic alteration.

Dominant structures are an east-west post mineral fault in the western part of the pit, and strong low angle faulting and shearing which truncates the ore body at depth. Two joint sets, one parallel to bedding and the other at right angles to bedding are prominent in the mine. Faulting is in two dominant directions, one striking northwest, dipping northeast and the other striking northeast, dipping northwest.

Mineralization is predominantly disseminated pyrite and chalcopyrite, and molybdenite-quartz veinlets. There are less important amounts of magnetite, hematite, sphalerite, galena, tennantite and bornite. Mineralization is believed to be both structurally and chemically controlled.

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INTRODUCTION

The deposits at Pima involve the intrusion of a quartz monzonite porphyry into sediments of Paleozoic and Mesozoic age, resulting in high grade mineralization of the Paleozoic rocks and disseminated ore in the younger Mesozoic sediments and quartz monzonite porphyry. Both types of deposits will be discussed, with greater emphasis given to the disseminated ores.

Geologic mapping of the exposed pit walls was conducted from June through mid-September of 1970. The mapping was done on a scale of one inch to two hundred feet using the existing engineers' map of the Pima mine as a base map. In addition to mapping, thin sections, polished sections and polished thin sections were examined to obtain more information about alteration and mineralization.

The term "Pima mining district" will be used here, as it was by Cooper (1960), to refer to the area on the east side of the Sierrita Mountains. The area includes the Pima, Mission, Twin Buttes, Esperanza and Sierrita open pit mines.

LOCATION

The Pima Mine, an open pit, "complex" porphyry copper deposit (Titley and Hicks, 1966), is located in Pima County approximately 17 airline miles southwest of Tucson, Arizona (Figure 1). The mine, which lies off the northeast flanks of the Sierrita Mountains, is in fairly flat, typical desert pediment terrain of southeastern Arizona, with an average elevation of 3,300 feet. The only areas with any appreciable topographic relief in the immediate vicinity are Mineral Hill, Helmet Peak, and the San Xavier East and San Xavier West hills. These topographic highs rise from 250 to 450 feet above the alluvium-covered pediment, and the hills are all underlain by sediments of Paleozoic and Mesozoic age.

The mine area can be reached from Tucson by traveling south on Interstate 19 and then southwest on the Pima Mine Road (Figure 1).

HISTORY AND PRODUCTION

The Pima mining district on the northeast flank of the Sierrita Mountains, has had a long history of intermittent production from several small underground mines. Total production from these small mines, however, has amounted to $20,000,000 in copper, lead, zinc, silver, gold, and molybdenum (Thurmond, Heinrichs, and Spaulding, 1954).

In 1950, following a study of the Mineral Hill area, geophysical work was begun by R. E. Thurmond and W. E. Heinrichs, Jr. of the United Geophysical Company which eventually led to the discovery of the Pima ore body. An initial magnetometer and electromagnetometer survey indicated anomalies which warranted diamond drilling. Upon completion of 16 diamond drill holes, sinking of the Pima shaft began in January, 1952, and was completed to 600 feet below the surface by April, 1953 (Thurmond, Heinrichs and Spaulding 1954).