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SUMMARY REPORT OF 1974 EXPLORATION ACTIVITIES
ORANGE HILL, ALASKA

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ABSTRACT

Investigations carried out at the Orange Hill property during the 1974 field season included major stratigraphic, structural, alteration, and geochemical studies in an effort to define ore controls and localization of copper and molybdenum mineralization. Major emphasis was placed upon Mo-porphyry potential during the season as opposed to earlier considerations of a Cu-porphyry target.

Stratigraphic analyses were concentrated within the metavolcanic assemblage exposed on the southern end of the property and were initiated in an effort to correlate favorable stratigraphic horizons for Cu enrichment and determine structural displacements within the area.

Evaluation of major structural trends from stratigraphic work resulted in a deformational sequence which brackets known mineralizing events and expands the previously acknowledged exploration potential in the southern end of the property.

Detailed examination of intrusive breccias encountered in diamond drill core and subsequent analysis of their orientation, distribution, and projection were attempted in an effort to define their point of origin and relation to molybdenum mineralization.

Hydrothermal alteration encountered in outcrop and core was reevaluated in respect to its correlation with independent Mo and Cu centers.

Geochemical sampling on the southern end of the property was undertaken in an effort to define the localization of possible hidden targets in the area.

Detailed analysis of ore mineral distribution and sequence in outcrop and core was carried out for correlation with alteration, structural, and intrusive elements.

SUMMARY

The Orange Hill property is considered to be a two-phase copper-molybdenum porphyry prospect, with initial copper mineralization being attributed to a hydrothermal system related to the emplacement of the biotite quartz diorite and superposed molybdenum mineralization associated with a later quartz porphyry event. Copper mineralization within the biotite quartz diorite is both pervasive and vein-restricted, the later of which is dominantly due to redistribution during the molybdenum event. Molybdenum mineralization is vein-restricted or in stockworks within and about quartz porphyry intrusives.

Superposed alteration patterns related to the two hydrothermal events have resulted in complex and apparently metastable assemblages of both the pervasive and vein-restricted types. Interpretations based upon a singular hydrothermal event are misleading with regard to localization of the hydrothermal source and proximity of mineralization. Pervasive alteration associated with copper mineralization includes propylitic, argillic, and sericitic; pervasive silicic and potassic alteration have not been encountered in core or outcrop. Vein-restricted alteration associated with molybdenum mineralization includes propylitic, argillic, sericitic, silicic, and potassic, with fluorine metasomatism (topaz-mineralization) being associated with sericitic, silicic, and potassic types.

Favorable stratigraphic horizons for copper enrichment within the metavolcanic assemblage are restricted to the meta-andesite flow units intercepted in diamond drill core adjacent to biotite quartz diorite contacts near the Southend Gulch-Quartzite Creek lineament. Porphyritic meta-andesites which are enriched in biotite due to the proximity of the

intrusive contact are found to be the most susceptible to later hydrothermal copper enrichment along cleavage related fracture planes. Limestone unconformably overlying these meta-andesite units is also found to be a favorable host adjacent to intrusive contacts; however, the combined intrusive, stratigraphic, and structural requirements leading to this environment's favorability are not fully understood at this time inasmuch as it has only been observed in DDH 121.

Structural offsets bearing upon localization of mineralization on the property are related to both the consequent repositioning of favorable stratigraphic units as well as the down-dropping of potentially mineralized targets: pre- and syn-mineral offsets acting as conduits to the hydrothermal fluids, and post-mineral offsets resulting in the down-dropping of mineralizing intrusive centers. Both copper and molybdenum distribution may be affected by the major structural offsets on the property since the later molybdenum event has had a relocalizing influence on the copper. The only faulting which appears to be contemporaneous with biotite quartz diorite emplacement is on the N 10° W trend and probably includes the cataclastic zones observed in outcrop and core. The N 60° E faulting on the Southend Gulch-Quartzite Creek lineament post-dates emplacement of the biotite quartz diorite and the related copper event, but its timing relative to molybdenum mineralization remains obscure. The N 80° E fault near Rubble Gulch is mineralized along paralleling minor offsets and fractures and is considered to be pre-mineral with respect to the molybdenum event.

RECOMMENDATIONS

On the basis of investigations carried out on the Orange Hill property during the course of the 1974 field season and interpretations formulated from the data collected, the following recommendations for future work are considered essential for a complete understanding of economic mineral distribution and localization on the property.

In respect to molybdenum mineralization, the two target sites defined by the intrusive breccia study should be tested to establish the validity of a Mo-porphyry center on the property. In addition to these two tests, a third site based on surficial geochemical evidence located approximately 800 ft east of Porphyry Peak in structural block C is recommended to evaluate the potential of Mo mineralization south of the N 60° E fault. This third test site should be considered from the standpoint of encountering possible pervasive main-stage alteration at depth.

Areas of interest with regard to copper mineralization are restricted to test sites within the cataclastic zone on the western edge of structural block C and stratigraphic tests for copper enriched metavolcanics below the metasediments outcropping in block C. The high Cu assays derived in DDH 121 provide strong argument for offset holes near the intersection of the cataclastic zone and the N 60° E fault as well as stratigraphic tests to the south.

In addition to diamond drilling, continuance of the geochemical sampling program initiated during the 1974 field season is considered important to further delineate redistribution of copper mineralization about quartz porphyry centers and possible target areas. The continued program should emphasize fracture-scrape sampling inasmuch as the present work indicates it to be the most promising technique in the metasedimentary and metavolcanic units.

The reestablished stratigraphic and structural framework outlined during the 1974 season should be refined by means of continued detailed geologic mapping on the property. The prime objective in this effort should be to more closely define fault offsets and favorable stratigraphic horizons within and between the major structural blocks.

The apparent difficulty experienced in the determination of pervasive K-spar alteration and topaz-rich zones while logging core during the drilling season may most economically be overcome by field staining techniques, although X-ray diffraction methods should be considered for complete quantitative analyses of alteration assemblages in complex core.

INTRODUCTION

This report represents a summary of exploration activities engaged in during the summer field season, 1974. Resolution of data collected and subsequent interpretations regarding the present-day economic potential of the property are presented under the heading of Economic Significance in each major section and are correlated in terms of their overall control and implication on economic mineralization in the concluding section of the report.

The geologic and geochemical considerations presented in the report represent the work of two consultants on the property during the 1974 program, Dr. Donald Bryant and C. M. Trautwein; however, interpretations and recommendations based upon our combined efforts have been relegated to Trautwein and for which I take sole responsibility. Although many discussions regarding various aspects of ore potential on the property have undoubtedly influenced interpretive statements made herein, there is no implied agreement on all relationships, interpretations, and conclusions.

METAVOLCANIC STRATIGRAPHY

Stratigraphic analyses at Orange Hill during the course of the 1974 summer field program were restricted to the southern end of the property between the Southend Gulch-Quartzite Creek lineament and Nikonda Creek and were concentrated on the metavolcanic section in that area. The metavolcanic stratigraphy was studied in an attempt to correlate certain favorable host units intersected in diamond drill core with their relative structural positioning. The most notable of these units, with regard for its favorability for copper enrichment, is the "dark, fine-grained, porphyritic diorite" which has been previously interpreted as a late border phase of the predominantly dioritic Monte Cristo Batholith (Moerlein, 1964; Linn, 1973).

The rocks in the metavolcanic assemblage have been previously interpreted as probable remnants of an early Mesozoic arc-trench environment (Richter and Linn, 1973) and are characterized by gabbroic intrusives, andesitic flows, flow breccias, and tuffs, rhyolitic flows and tuffs, and interbedded sedimentary units. According to Linn (1973) the assemblage is of probable early Triassic age and, consequently, represents the oldest known lithologies exposed in the Orange Hill area. An inferred correlation of the metavolcanic sequence at Orange Hill with the regionally recognized Nikolai Greenstone (Linn, 1973) has resulted in a possible explanation for copper enrichment in the local biotite quartz diorite phase of the Monte Cristo Batholith (Richter, 1973; Bryant, 1974). This explanation relies upon the assimilation of the geochemically enriched andesites and/or Cu-bearing massive sulfides possibly included within the assemblage and subsequent redistribution and enrichment of copper in the biotite quartz diorite along its intrusive contact with the metavolcanics. Geochemically anomalous copper concentrations along this intrusive contact reported in regional studies may allude to this interpretation; however, in lieu of the scant stratigraphic and structural evidence supporting this argument, the explanation is considered to be quite conjectural and potentially misleading in terms of copper genesis.

This section of the report relates the presently known metavolcanic distribution and internal correlations at the Orange Hill property to the paleo-environmental setting and consequent copper "source bed" potential of the assemblage.

Outcrop Distribution

Metavolcanic stratigraphy at Orange Hill is undoubtedly best exposed in the southern half of the property stratigraphically and topographically below the limestone horizon outcropping along Lime Ridge. The dominant lithologic unit exposed within the area is the porphyritic andesite flow unit which composes the greater part of both Little and Big Nikonda Knobs. A gabbroic intrusive unit exhibiting a discordant contact with the andesite flows along Contact Creek is exposed from the east side of Big Nikonda Knob to its discordant contact with metarhyolite flows 2000 ft west of Ridge Gulch. Major metarhyolite units are exposed between Porphyry Creek and Ridge Gulch; however, several rhyolite units of minor importance are noted approximately 800 ft northwest of Porphyry Peak, on the south side of Rubble Gulch at the 3250-ft elevation, and near the limestone contact on "J" Creek.

Exposures of the overlying limestone-metavolcanic contact along Lime Ridge exhibit an unconformable relationship with an angular disparity of 26 degrees between bedding in the metavolcanic units and limestone. The overlying limestone in these exposures strikes approximately N-S and dips 10-30 degrees to the east; whereas, the underlying metavolcanic units strike N 60-80° W and dip 20-40 degrees to the southwest. The unconformity is marked by occasional basal conglomerates in the limestone and calcite fracture and joint fillings in the underlying metavolcanics. Some channeling in the top of the metavolcanics along this contact infers a possible subaerial erosional interval prior to submergence and initiation of limestone deposition.

Major traverses in respect to stratigraphic positioning of metavolcanic units include the Quartzite Creek traverse between DDH 118 and the 4250-ft elevation contour, "F" and "J" Creek traverses, and the Nikonda Knob traverse beginning at Little Nikonda Knob and continuing due east to Ridge Gulch.

Subsurface Distribution

Metavolcanic units intercepted in the twenty-two diamond drill holes examined by C. Trautwein during 1974 confirmed the broad areal distribution of the metavolcanic section to the north of the outcropping exposures at the south end of the property. A 120-ft interval of metarhyolite in DDH 113 (the northernmost core recovered on the property) resolves to approximately 8000 feet of apparent continuity in metavolcanic stratigraphy from the southern exposures. This apparent continuity will, in the following section of this report, be shown to be significantly offset by a major N 60-70^{o} E fault. Tabulated intercepts of metavolcanic units in other diamond drill holes on the property are given in Table 1 as follows:

Table 1: Metavolcanic Intercepts in Diamond Drill Holes, Orange Hill, Alaska.

DDH	Lithology(s)	Interval	Elevation	Upper Contact	Lower Contact
104	Andesite	100-110	3380-3370	QFP-LMS	---
	Latite	110-120	3370-3360	---	QFP
	And. Tuff	140-150	3340-3330	QFP	---
	Rhyolite	150-250	3330-3230	---	BQD
105	Andesite	300-350	3110-3060	BQD	BQD
107	Rhyolite	110-260	3399-3249	BQD	BQD
110	Dacite	110-140	3649-3619	Gravel	BQD
	Dacite	230-250	3529-3509	BQD	BQD
113	Rhyolite	260-380	3704-3612	BQD	BQD

Table 1: (continued)

DDH	Lithology(s)	Interval	Elevation	Upper Contact	Lower Contact
115	Andesite	20-630	3332-2760	Gravel	BQD
	Andesite	700-750	2693-2646	BQD	BQD
	Andesite	800-887	2600-2517	BQD	---
116	Andesite	167-591	2747-2632	BQD-LMS	---
117	Andesite	195-208	2716-2703	Gravel	POD
	Andesite	400-422	2511-2489	BQD	BQD
	Andesite	436-440	2475-2471	BQD	BQD
	Andesite	470-476	2441-2435	BQD	BQD
	Andesite	540-546	2371-2365	BQD	BQD
	Andesite	604-849	2307-2062	BQD	BQD
	Andesite	862-878	2049-2033	BQD	BQD
	Andesite	908-913	2003-1998	BQD	BQD
	Andesite	940-1028	1971-1883	BQD	BQD
	Andesite	1052-1107	1859-1804	BQD	BQD
118	And. Tuff	11-366	3689-3334	Gravel	---
	Andesite	366-691	3334-3009	---	---
120	Andesite	190-205	3150-3135	QFP	BQD
	Andesite	368-598	2972-2742	QFP	BQD

Correlations between metavolcanic units intersected in diamond drill holes in the northern block of the property and outcropping units in the southern block were greatly hampered by intrusive contacts and "mixed zones" in which partial resorption and alteration of metavolcanics by the biotite quartz diorite has partially masked the identity of the units. The most significant unit, in respect to correlation between core and outcrop, was intersected in DDH 115 at 885 ft down-hole (2519 ft elevation). The unit is identical with an amygdaloidal andesite exposed in Quartzite Creek approximately 120 ft above DDH 118 (outcrop = 3820 ft elevation). Assuming stratigraphic continuity on the bases of compositional, textural, and upper contact similarities, the 1800-ft elevation difference in the horizon is probably reflecting offset rather than bedding attitude between the two sites. As is indicated in Table 1 above, the major metavolcanic lithology intersected during diamond drilling is meta-andesite; however, positioning of any meta-andesite within the stratigraphic sequence developed in the southern block is dominantly dependent upon overlying and underlying lithologies which, with the exception of DDH 104, are not encountered in core. The textural similarities of outcropping meta-andesites within different stratigraphic units of the southern block far outweigh any differences that might be employed in correlating andesites intersected in cored holes. The most common textural type of meta-andesite intersected is a porphyritic-aphanitic type which, as has been pointed out earlier in this section, is in all probability the "dark, fine-grained, porphyritic diorite" of earlier workers. The porphyritic meta-andesite, in this context, is usually encountered in close proximity to biotite quartz diorite contacts and the aphanitic matrix is pervasively recrystallized and enriched in biotite. Inferences of this lithology's metavolcanic affinities are found in occasional structural and textural relicts such as foliation and amygdales which have survived partial resorption and alteration affects. Although stratigraphic positioning of this rock type is tenuous, exposures at the base of Little Nikonda Knob and approximately 1000 ft east of Porphyry Peak display the most similar, unaltered, textural features.

Composite Metavolcanic Correlations

Correlation of metavolcanic units, as mentioned in the foregoing paragraph, is based primarily upon lithologic sequence inasmuch as individual lithologies tend to be similar in respect to their compositional and textural attributes. Stratigraphic units, from this standpoint, are defined on the basis of lithologic sequences with basal andesites and overlying differentiates; the basal andesite of each unit resting upon a dacite, latite, rhyolite, or sedimentary member of the underlying unit and the upper members of each unit being either more siliceous metavolcanics or metasediments with intercalated siliceous metavolcanics. The insistence on metavolcanics of a more felsic composition than the andesites rather than metasediments at the contact between units is due to the lateral discontinuities of metasediments being less reliable in correlation efforts than the continuity of siliceous metavolcanics (especially tuff members).

The stratigraphic sequence illustrated in Figure 1 is based upon traverses made in the southern end of the property and is most applicable to correlation work in that area. The absence of any complete units being intersected in the northern block drill core (see Table 1) makes correlation difficult at best, and this point should be kept in mind in constructing cross sections employing the presently developed stratigraphic section.

The only discordant lithologic units mentioned in the foregoing subdivisions of this section are the gabbroic complex east of Big Nikonda Knob and pre-metamorphic dikes which transect much of the concordant metavolcanic stratigraphy. Of these two lithologic units, only the gabbroic complex is considered as a viable stratigraphic unit in respect to its compositional and textural uniqueness as a mappable and correlatable lithologic entity.

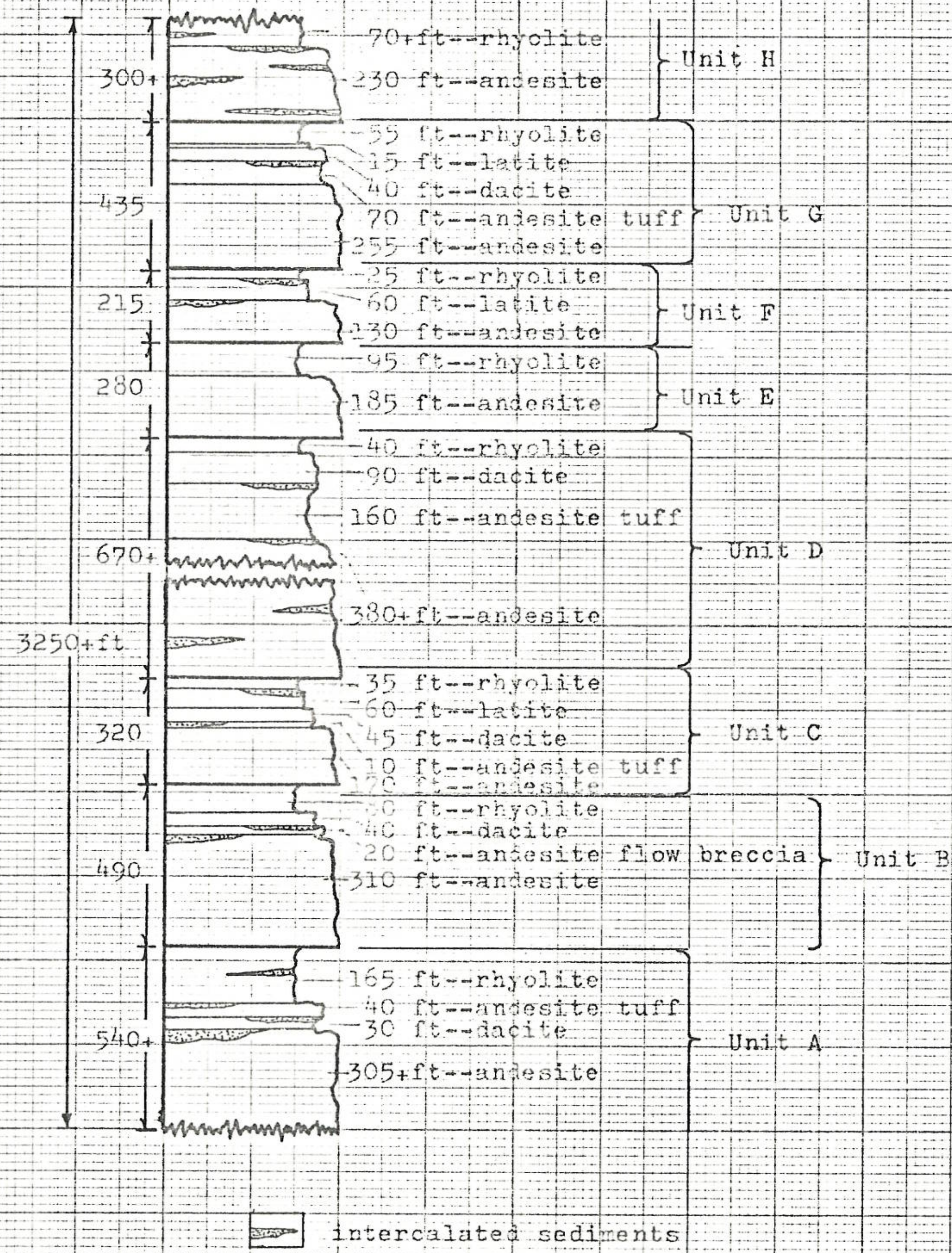

FIGURE 1: Composite Metavolcanic Section, Orange Hill, Alaska

Environmental Interpretation

Stratigraphic relationships at Orange Hill, in respect to a detailed analysis of the Triassic metavolcanic assemblage on the property, are interpreted as being indicative of a shallow marine, back-arc environment which was in close proximity to a cratonic terrain of granitic composition. The lack of any recognizable volcanic centers or associated pyroclastic breccias and presence of sporadically distributed arkosic metasediments of probable cratonic provenance are macroscopically consonant with this setting. In addition to the lithologic characteristics of the back-arc environment, all amygdaloidal andesitic flow rocks contain quartz and/or epidote-filled vesicles ranging in diameter from 2 to 4 mm which, according to Moore's (1965) work, indicates a maximum water depth of less than 100 meters. Besides the shallow water interpretation derived from this observation, the relative invariability of vesicle size throughout the stratigraphic section implies basin subsidence to be in near equilibrium with deposition.

With regard to volcanogenic affinities in the back-arc environment, parental magma types tend to be of a high-alumina or alkalic composition (tholeiitic magmas usually being restricted to the fore-arc or arc-trench environments). Although no whole-rock chemical analyses are available for the Orange Hill metavolcanic suite and petrographic analyses are of little value in ascertaining magmatic affinities due to metamorphic reconstitution, the rhyolitic members within the stratigraphic sequence exhibit at least one inference of alkalic affinity. In this respect the rhyolites containing blue "quartz eyes" are found to be enriched in titanium in relation to inclusions. Mineralogically, the blue color is due to microscopic inclusions of rutile, TiO_2. High TiO_2 content in residual differentiates is common only to plutonic and volcanic assemblages of alkalic affinity and it is, therefore, inferred that the Orange Hill assemblage is also of this derivation. Since the Orange Hill metavolcanics display both mesoscopically and microscopically visible quartz in late stage differentiates and uncontaminated alkalic differentiates are usually undersaturated with respect to SiO_2, the resultant volcanic assemblage on the property probably represents a sialically contaminated, calc-alkaline assemblage of alkaline parentage.

Economic Significance

Significant aspects of the presently understood metavolcanic stratigraphy at Orange Hill are restricted to the economic copper potential of the property from both "source bed" and "enrichment" standpoints.

Source bed considerations, in respect to the paleo-environmental interpretation of the assemblage, are remote for the known copper mineralization at Orange Hill. Although volcanogenic massive sulfide deposits are affiliated with volcanic complexes of alkalic parentage, they are dominantly enriched in lead and/or zinc and deficient in copper. In addition to this general tendency of metal distribution in sequences of alkalic parentage, the localization of sulfide mineralization is usually found to be within, or contemporaneous with, the products of rhyolitic volcanism. On the bases of stratigraphic relationships within the metavolcanic assemblage at Orange Hill, the sequence is interpreted as being a highly improbable host for volcanogenic massive sulfide mineralization and/or geochemical "source bed" for copper introduced by assimilation into the biotite quartz diorite. Criteria that substantiate this interpretation are given as follows:

1. Lack of volcanic center or dome complex
2. Lithologic units are generally thin and repetitive and do not indicate derivation from a single cycle differentiation trend
3. Paucity of metarhyolites relative to andesites
4. Minimal pyroclastic activity
5. No associated iron-formation within the assemblage
6. No known massive sulfide lenses within the assemblage
7. Shallow marine environment within the reach of effective wave base and strong current action (i.e.,

destructive environment relative to preservation of syngenetic sulfide muds)

8. Assemblage displays alkalic affinities (i.e., Cu deficient)

Considerations of copper-enrichment in "key" stratigraphic units within the metavolcanic assemblage are apparently limited to porphyritic meta-andesite flow units which are either in close proximity to biotite quartz diorite contacts or have been engulfed and partially resorbed by the diorite magma. As has been pointed out earlier in this section, a common enrichment in copper is associated with altered varieties of this lithologic type. If the biotite quartz diorite has penetrated structural blocks C and D (which as yet have not been tested to sufficient depth), the possibility of economically feasible copper values may be of special interest for future evaluation work. At present, only the partially resorbed and altered meta-andesites of structural block A have been tested (see cross-sections A-A' through D-D' on plate 5) to sufficient depth with favorable results. DDH 116 exhibits the best examples of hydrothermally copper-enriched meta-andesites engulfed within altered biotite quartz diorite.

STRUCTURAL RELATIONSHIPS

Six major structural blocks have been recognized on the Orange Hill property during the 1974 field season. These blocks (illustrated on Figure 2) are distinguished on the basis of three parameters:

1) mesoscopically observable structural offsets,
2) apparent lithologic and/or stratigraphic discontinuities between diamond drill holes or outcrops,
3) macroscopic geophysical discontinuities (airborne magnetics).

In this report the structural blocks will henceforth be referred to as blocks A, B, C, D, E, and F as related on Figure 2.

The deformational sequence which has resulted in characterizing these structural and stratigraphic domains has been developed in an effort to determine possible post-mineral faulting which may have disguised potential ore-target areas by down-dropped vertical displacement and consequent lack of recognizable alteration guides. In addition to post-mineral faulting, pre- and syn-mineral displacements are of equal interest with respect to the resultant positioning of favorable stratigraphic horizons for Cu and/or Mo enrichment.

Previous structural studies on the property have resulted in major emphasis being placed on the Bryner Fault and trend-related fracture systems as major ruptural elements within the area. The only alleged plastic deformation on the property has been inconclusively inferred by the outcropping limestone unit which strikes approximately N-S in the southern end of the property and changes abruptly to an E-W strike east of Adit E. Dip reversals for this limestone unit within these two trends, easterly dipping on the N-S strike and southerly dipping on the E-W strike, infer fold geometry to be overturned to the northwest and plunging north-northeasterly. The

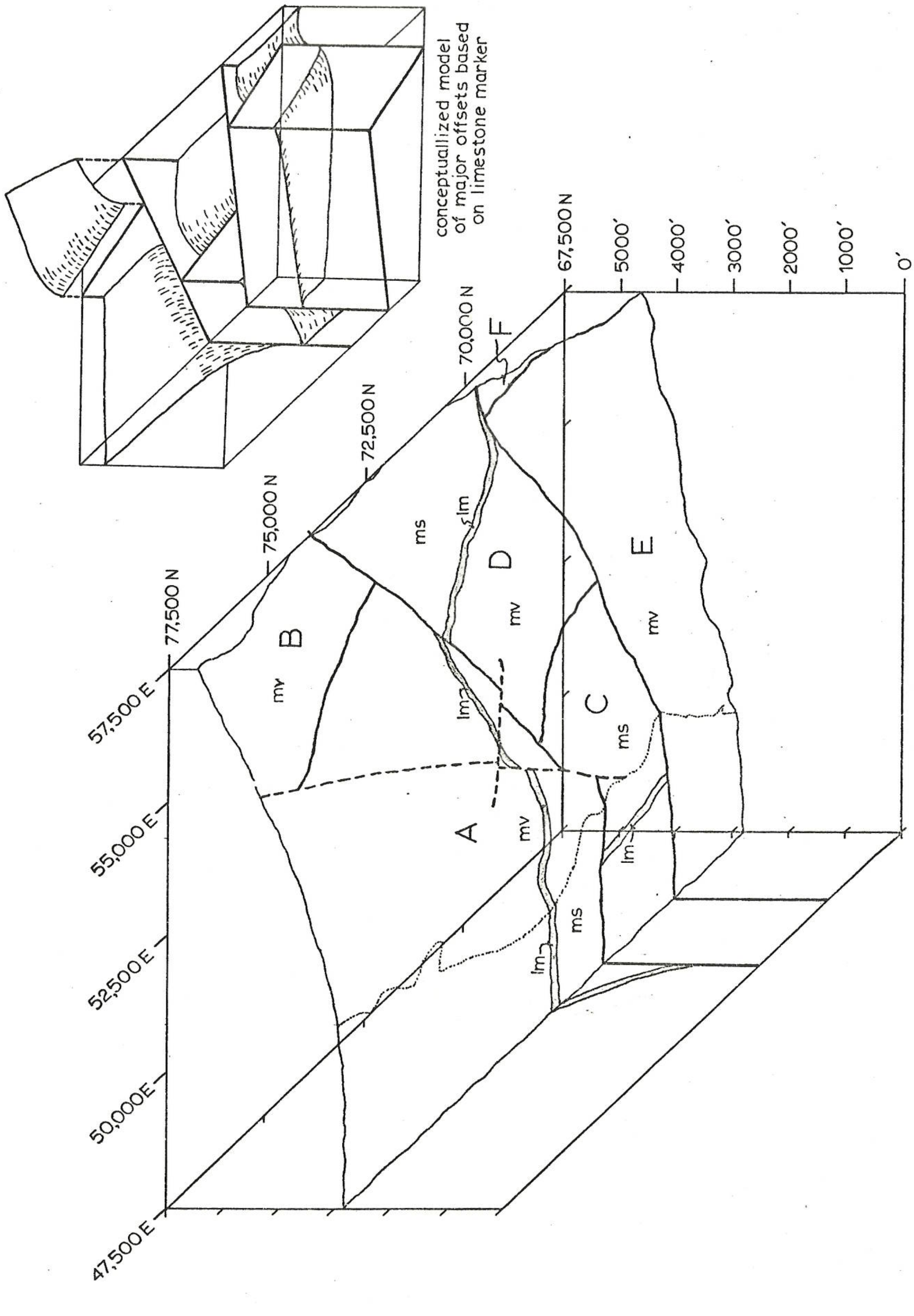

FIGURE 2: Major Structural Offsets,
Orange Hill Property, Alaska

conspicuous absence of parasitic minor folds in the relatively incompetent limestone unit adjacent to the proposed hinge line detracts from the fold-hypothesis. The only mesoscopically observable plastic deformation discernable on the property is restricted in outcrop to the cataclastic zone partially extending from the mouth of Southend Gulch to Rubble Gulch along the Nabesna River Valley floor. The folding in this area consists of tight intrafolial folds with their axial planes parallel to the cataclastic foliation and plunging in the direction of the cataclastic lineation.

Major Structural Elements

The six major structural blocks on the property (A, B, C, D, E, and F) are defined by three early fault breaks with major displacements. The initial faulting in this sequence is distinguished by major stratigraphic offsets and airborne magnetics. The fault trends approximately N 10° W and is responsible for the positioning of the metasediments of Block C adjacent to the metavolcanics of Block D, the former being downdropped about 1000 ft (see cross-section E-E' on Plate 5). This faulting appears to be nearly vertical with a negligible strike slip component. Possibly related cataclastic deformation paralleling this trend will be discussed under the following subheading in this section.

A second major fault trend in sequence strikes approximately N 80° E and is defined by the abrupt contact of metasediments in block C with metavolcanics of block E and the absence of the limestone marker at their trace of juncture. Additional evidence of a fault contact on this trend is derived from the metavolcanic stratigraphic offset between blocks D and E and the limestone offset between blocks D and F. An apparently significant strike-slip component of movement is inferred by drag effects in the cataclastic zone on the western extremity of the fault trace and in the block D limestone along the eastern end of the trace, the movement picture being left-lateral. The apparent dip-slip component may exceed 800 feet (see cross-sections A-A' and B-B' on Plate 5). Mineralized fractures paralleling this trend and displacement of the N 10° W fault trace along the trend suggest its timing within the deformational sequence.

The third major offset on a N 60° E trend is characterized by an airborne magnetic lineament and weak topographic lineament between Southend Gulch and Quartzite Creek. Parallel structures along Quartzite Creek are observed to crosscut mineralization and thereby infer its post-mineral age. Drag effects on the cataclastic zone and minor structures along Quartzite Creek indicate a strong right-lateral strike-slip component of movement. The fault is interpreted to have been responsible for the attitude of the adjacent limestone in block A (the southerly dipping limestone being attributed to drag). Apparent dip-slip movement exceeds 1000 feet in cross-sections A-A' and B-B' (on Plate 5) between blocks A and D but may well be on the order of several thousand feet between blocks A and C (see cross-section C-C'). If this faulting is post-mineral, as is inferred by cross-cutting relationships along Quartzite Creek, the significance of the movement picture and possible preservation of ore reserves to the south is apparent.

Minor Structural Elements

Aside from major structural offsets which control much of the presently known stratigraphic distribution pattern on the property, several minor structural features with negligible or comparatively minor displacement have also been observed. Included under this subheading are cataclastic zones of questionable offset and fracture patterns which appear to be related to major faulting and intrusive activity.

The cataclasis at Orange Hill is restricted to several zones which are offset by later brittle fracture along major fault zones. Reconstruction of pre-fault positioning of these zones resolves to two major cataclastic breaks which predate all known post-metamorphic structures on the property. The most prominent exposure of cataclastically deformed rocks in the area is located along a narrow cliff-face outcrop between Southend Gulch and Rubble Gulch. This cataclastic zone is characterized by its conspicuous schistosity, intrafolial folds, and quartz rodding that are pervasively distributed within the zone. The attitude of schistosic foliation is N 22° E @ 85° NW at its northern exposure on the south wall of Southend Gulch and changes uniformly to N 35° W @ 70° SW approximately 200 ft north of the entrance to Rubble Gulch. Lineations defined by fold axes, quartz rods, microcrenulations, and biotite streaks are noted within the plane of the cataclastic foliation and plunge 20° to the north. The statistical agreement of all linear features in the zone reflects a consistent and singular origin for the fabric. The apparent recrystallization and absence of mesoscopic rupture within the zone are probably due to a deep-seated environment of formation. The change in strike of the cataclastic zone south of Southend Creek is interpreted as being due to drag along the right lateral, N 60° E fault on the Quartzite Creek lineament. Likewise, the attitude north of Rubble Gulch is probably influenced by drag along the N 80° E fault in that area.

Cataclastic fabrics at other sites on the property are noted occasionally and are found to be syn-mineral with respect to chalcopyrite-molybdenite veinlets which are kinked and folded without associated rupture or offset. Cataclastic foliation is also noted occasionally within the biotite quartz diorite where it appears to have been induced both during (late) and after consolidation of the magma. These cross-cutting relationships between the cataclasis, biotite quartz diorite, mineralization, and later faulting may be related to several readjustments within the zones. It should be pointed out that the cataclastic deformation and the initial faulting on the N 10° W trend may be synchronous inasmuch as the N 60° E fault cross-cuts both structures and they appear to be on the same trend.

The Bryner Fault and trend-related fracturing are considered under this subheading due to their comparatively minor effect on stratigraphic positioning. The Bryner system consists of two major breaks as are illustrated on the geologic map (one across Orange Hill and a second, the Bryner Fault, to the east of Orange Hill). Both faults are roughly parallel and trend approximately N 10-30° E. Apparent offsets at the southern end of Orange Hill are less than 400 feet where the limestone unit is transected and assuming a dominant dip-slip component of movement and the attitude of the limestone total displacement must be less than 500 feet.

The last offsetting feature observed on the property occurs along a N 65° W fault which cross-cuts the Bryner and N 60° E faulting as is illustrated in the center of the geologic map. A right-lateral strike-slip component appears dominant from slickenside striae near DDH 118 where the lineation plunges 15° to the southeast.

Both the Bryner system and N 65° W faulting are post-mineral and, apart from the minor stratigraphic offsets attributable to them, are considered to be of minimal importance relative to repositioning of mineralization.

Deformational Sequence

In considering the sequence of structural events responsible for observed stratigraphic relationships on the Orange Hill property, the most critical parameters of timing are mineralization and cross-cutting relationships (including displaced stratigraphic and intrusive units).

The earliest deformational elements presently recognized in the area appear to be the faulting and possibly related cataclasis on the N 10° W trend. The initial movement within these zones is considered to be pre-diorite with minor post-diorite adjustments between structural blocks A and B (see geologic map). Parallel fractures in quartz feldspar porphyries of blocks C and D infer that this later readjustment may be nearly contemporaneous with faulting on the N 80° E trend.

The N 80° E faulting cross-cuts the N 10° W fault and displaces the trace approximately 3700 ft. Considering the nearly vertical dip on the N 10° W fault, this offset approaches the true strike-slip component along the left-lateral N 80° E fault. The absence of quartz porphyry in structural block E (with the possible exception of minor late? dikes) infers the age to be post-quartz porphyry. Both the N 10° W and N 80° E trends are mineralized however, and are clearly pre-mineralization (at least with respect to molybdenite).

Faulting on the N 60° E trend is inferred to be post-mineral based on cross-cutting relationships with mineralized veins on Quartzite Creek above DDH 118. Quartz feldspar porphyry dikes occasionally parallel this trend but have not been observed to cross it. A pre-existing zone of weakness may be responsible for dike emplacement adjacent to the fault trace (as along Quartzite Creek); however, the post-mineral timing and observation of mineralized quartz porphyry are considered ample evidence for its third order in the sequence.

Subsequent to these three major deformational events, movements along the Bryner trend (N 10-30° E) occurred displacing the trace of N 60° E faulting. Definite post-mineral movement attributed to this event is evidenced by granulation of sulfides within gouge intersected in diamond drill core.

The last recognizable ruptural event transects and displaces both the Bryner and N 60° E traces along its N 65° W trend. The 100- to 200-ft right-lateral strike-slip offset is approximately correct considering the near vertical attitude for the two displaced faults.

Economic Significance

The economic significance of structural offsets on the property is restricted to the possible post-mineral relocation of ore horizons and pre-mineral positioning of favorable host-stratigraphic units.

With regard to post-mineral displacements, the only potentially relevant major faulting is on the N 60° E trend (the Bryner system being considered of minor magnitude by cross-cutting relationships). The most significant structural blocks offset are C and D which are estimated to have been downdropped in excess of 1000 feet. Pre-quartz porphyry movement along the N 10° W fault separating the two blocks appears to have a dip-slip component in the order of several thousand feet but is inconsequential relative to alteration and ore positioning. The inferred magnitude of offset along the N 60° E trend is considered sufficient to conceal much (if not all) of the alteration envelope of potential mineralization in the southern end of the property. The abrupt change in alteration intensity and grade across the Southend Gulch lineament lends support to the prospect of encountering mineralization at deeper levels in blocks C and D. Whether the grade of mineralization would be sufficient for economic recovery is open to conjecture, but geochemical results infer its proximity.

Pre-mineral offsets along the N 10° W and N 80° E trends are considered from the standpoint of positioning of major porphyritic meta-andesites inasmuch as they appear to be significantly favorable for copper enrichment. The downdropped structural block C is considered to be the most interesting target area for future exploration. Stratigraphic relationships derived from DDH 117 and 121 infer the depth of the limestone-metavolcanic unconformity to be at least 1000 feet from surface east of the cataclastic zone. Favorable assays in DDH 121 are considered sufficient to warrant the deep testing required to evaluate the potential in this area.

INTRUSIVE BRECCIAS

The significance of intrusive breccias encountered in diamond drill holes on the Orange Hill property was first recognized by Don Bryant early in the 1974 field season. His analysis of Orange Hill breccias and previous experience with breccias of similar origin contributed in large part to a conversion of the summer's exploration activities from a copper-porphyry-oriented program to a potential molybdenum-porphyry endeavor. Fragments of relatively high-grade molybdenite-quartz mineralization and particulate molybdenite within a generally fine-grained matrix in many of the intrusive breccia intervals alluded to the possibility of a local but undefined source at depth. The apparent lack of any significant copper mineralization incorporated within these breccias was interpreted as an indication of its paucity, if not a complete absence of copper, at the source of the molybdenite mineralization.

The breccias, as interpreted by Dr. Bryant, represent a post-ore intrusive event during which fragments of adjacent lithologies were fluidized and transported along pre-existing fractures. The intrusive center responsible for the fluidization of these breccias was considered to be adjacent or in close proximity to the mineralizing center, but of independent origin.

LOCALIZATION OF INTRUSIVE BRECCIA SOURCE

Definition of the source of these breccias was considered to be of prime importance in describing the relative azimuth as well as depth range of the mineralized center postulated by Bryant. A somewhat unique solution to the problem of breccia-source localization was initially attempted by

C. Trautwein while on the property and later refined to its present state (as presented herewith).

Assumptions

The technique employed, in an attempt to localize the source of the intrusive breccias, is based upon structural relations of the breccias' disposition relative to their source and relied on the statistical definition of this source by the distribution of intersections of projected breccia intercept on common datum planes. The assumptions necessary for the application of this technique are given as follows:

(1) the intrusive breccias are relatively contemporaneous

(2) the breccias are related to a singular source (intrusive center)

(3) the distribution and disposition (orientation) of breccias encountered in drill holes is dominantly controlled by fracturing genetically related to the intrusive activity at their point of origin.

The validity of these assumptions relative to the presently understood structural and intrusive histories at Orange Hill is undoubtedly conjectural; however, the material justifications for their application in this instance are related under the following headings.

A. Contemporaneity:

(1) breccias are the most recent structural elements encountered in core and cross-cut bedding, foliation, and veining in all but a few cases.

(2) breccias contain fragments of all known lithologies present at Orange Hill including the youngest quartz porphyries.

B. Singular Source:

(1) fragmental lithologies in breccias appear to be restricted in their distribution relative to possible in-situ points of origin.

(2) no foreign lithologies have been noted (i.e., intrusive breccia center is local to Orange Hill).

C. Fracture Control:

(1) a common major variation in intrusive breccia contact angles to core axis between different diamond drill holes.

(2) a common minor variation in breccia contact angles within individual holes (when more than one breccia is encountered).

(3) common divergence, and consequent lack of correlation, with any observable pre-existing structural attitudes within core.

Evidence for contemporaneity, therefore, resolves to the breccias being the most recent structural and lithologic units encountered in core, although absolute dating is impossible. Arguments for a singular source of the breccias may only imply a local, but not necessarily singular, source. Justifications for a common, genetically-related fracture control of breccia localization are centered on the constancy of structural attitudes for breccias within individual holes which, when taken collectively, appear to systematically vary over a relatively broad range between holes and on the lack of any apparent correlation of breccia attitudes with observable pre-induced structure (the latter of which represents a negatively induced argument at best).

In spite of both positive and negative aspects of the assumptions, the technique does in fact act as a partial check on their validity.

Fracturing

With fracturing being considered the dominant control for intrusive breccia distribution relative to source, the characterization of the type of fracture system which may be genetically related to the intrusive center is a requirement of the technique.

In Figure B-1 two types of fracturing related to intrusive centers are shown, both of which have been defined at Orange Hill. In addition to the two types illustrated, a well-defined radial system has also been noted on the property. With respect to the distribution of intrusive breccias encountered in cored holes, the conical or concentric fracture pattern shown in Figure B-1a appears to be the most probable control.

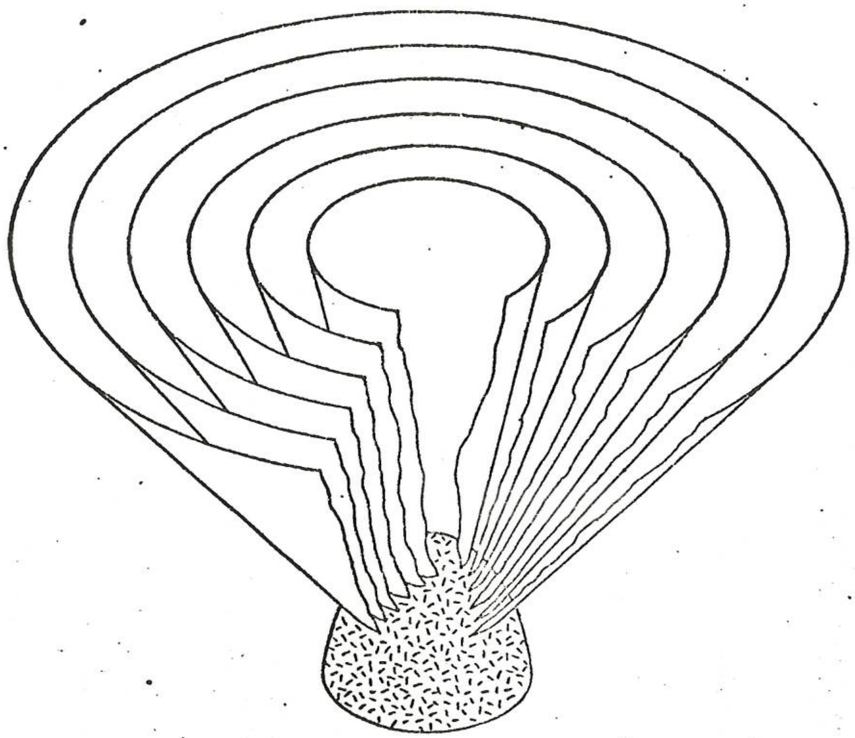

FIGURE B-1a: Cut-away block diagram of conic or concentric fracturing related to intrusive center. Model illustrates the probable fracture pattern control on intrusive breccia distribution.

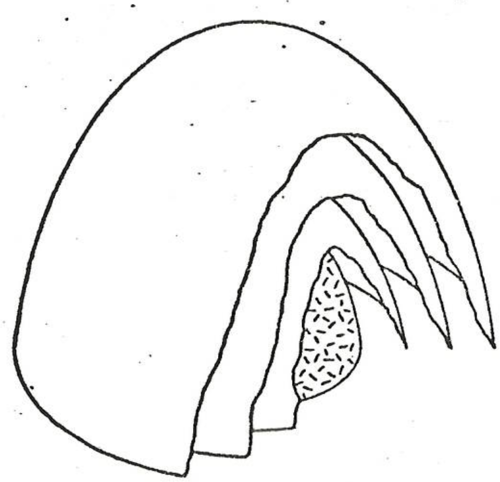

FIGURE B-1b: Cut-away block diagram of domical fracturing related to intrusive center. Model illustrates the probable control on late dikes and possible fracture control on main-stage mineralization.

Evidence in support of this system's dominance during intrusive breccia emplacement involves (1) the systematic variation of breccia contact angles to core axes, resulting in (2) the focusing of these breccias to a centralized source, and (3) the theoretical implications of hydrostatic/lithostatic pressures and consequent fracturing during the initiation of the fluidization process.

The great variability of breccia contact angles encountered in core discounts the influence of a radial fracture control on breccia distribution due to the consistent high dip angle and resultant low contact angle (in vertical holes) which would be expected in radial systems. The focusing of breccia projections to a common center would preclude fracture control by the domical system illustrated in Figure B-1b which diverges from the center with depth. (The method of determining this focus will be dealt with subsequently.) Theoretical aspects of fracture control are based upon the nature of intrusive breccia formation and Anderson's (1924) theory for the formation of the fractures occupied by ring-dikes and cone-sheets. In Anderson's model two sets of conditions may be anticipated in the intrusive environment that relate directly to pluton-induced fracturing. The first case assumes that the hydrostatic pressure of the magma exceeds the lithostatic pressure of the surrounding rocks and the intrusive induces the greatest principal stress axes in a radial array outward from the magma reservoir. Tension fractures form parallel to this stress field with a resultant distribution as depicted in Figure B-1a. The second case in Anderson's model assumes that the hydrostatic pressure of the magma is less than the lithostatic pressure in the surrounding rocks with the resultant greatest principal stress axes and sympathetic tension fractures forming a pattern as illustrated in Figure B-1b. Of these two cases, the former appears to be the most probable when considering the increased pressure of the vapor phase required for the fluidization and transport of breccias. The resultant system may then act as a vent for the supercharged vapor phase with the consequent development of fluidized breccia transport and implacement.

Technique

Since strike orientation of any breccia was impossible to determine in the unoriented core (and surface outcrops of intrusive breccias are not known), projection of possible breccia orientations down to a common datum (level) was allowable only by using the contact angle of the breccia relative to the core axis to define the locus of all points that may be intersected by the plane of the breccia on a given datum. Diagrammatically, this is shown in Figure B-2. In this illustration the intrusive breccia intercept in DDH (a) is projected down to level A on the basis of its contact angle. In effect the contact angle only defines a line which lies in the plane of the breccia, the line being the true dip vector. Without strike information, this projection describes a circular array of points, any one of which may be in the breccia plane on the level of projection. In respect to the breccia intercept with the core axis, the circular projection at any level defines a cone, as shown for DDH (a). Considering many holes with intrusive breccia intercepts, the projections will converge with depth if the conic or concentric fracture pattern shown in Figure B-1a is the dominant control on breccia orientation. If this indeed be the case, the converging projections of the breccias will focus on the intrusive center responsible for both the fracture pattern and breccias. By contouring the density of projection intersections at each level, the focus appears as a high density point on the contour map. If any other type of fracture control is responsible for breccia distribution, this focusing will not be attained with depth.

Plates B-I through B-V and their overlays show the projections and contoured intersections, respectively, on the 2000-, 1500-, 1000-, 500-, and 0-ft levels for breccia intercepts at Orange Hill. Data required for these projections are given in

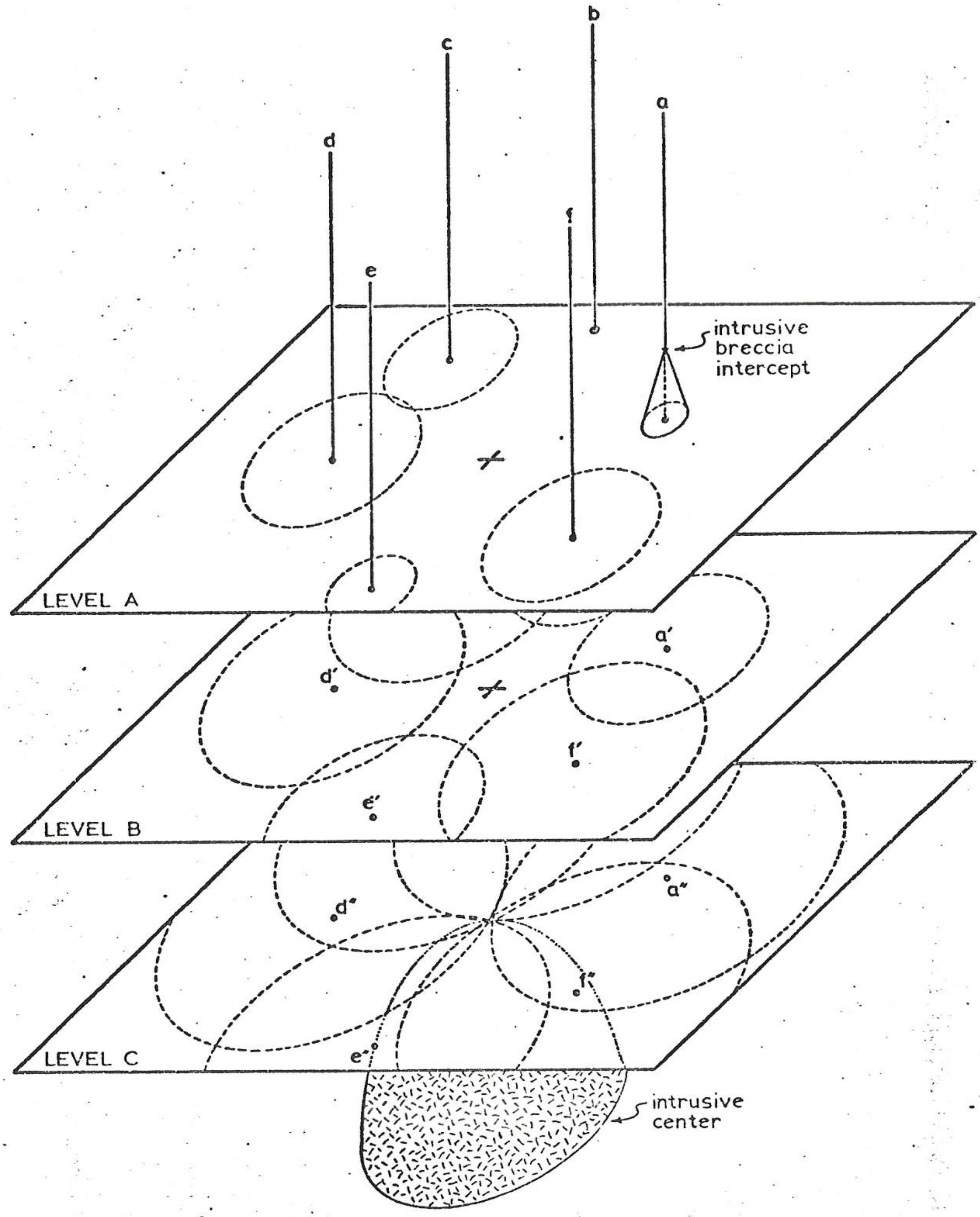

FIGURE B-2: Block diagram illustrating the convergence of intrusive breccia projections with depth. DDH (a) depicts the method of conic projection for an intrusive breccia intercept on plan level A. Note the increasing density of projection intersections with depth and subsequent focusing on the intrusive center.

Tables B-3 and B-4 (Table B-3 demonstrating the data requirements for vertical holes where only circular projections are rendered for breccia intercepts and Table B-4 illustrating data requirements for angled holes where elliptical or parabolic projections are the result). As may be seen on these plates (or more specifically, on their overlays), the high density contour fields define an elliptical concentration of intersections on the 2000-ft level which through 500-ft increments focuses to one high density point on the 500-ft level. The coordinates of this focus are 72,250 N and 52,250 E.

Conclusions

The focusing of intrusive breccia intersections on the 500-ft level confirms the postulated control by a conic or concentric fracture pattern as illustrated in Figure B-1a. The singular focus on this level represents the most probable site of intrusive activity responsible for the generation of intrusive breccias. With regard to both the elliptical distribution of intersections on the 2000-ft level and the shift in the centers of high density fields with depth (center coordinates 71,700 N and 51,700 E on the 2000-ft level and 72,250 N and 52,250 E at focus on the 500-ft level), the intrusive breccia source is believed to be oriented such that it intruded from the northeast on a bearing of approximately S 45° W at an inclination of about 60° to the horizontal and was stabilized at an elevation of 500 ft above sea level.

RELATIONSHIP OF INTRUSIVE BRECCIA CENTER WITH POTENTIAL Mo-CENTER

The relationship of the intrusive breccia center with potentially economic Mo mineralization (according to Dr. Bryant's hypothesis) is non-genetic and is concerned with the mechanical transport of materials from point of origin to point of emplacement. In this model, as has been pointed out previously, the path taken by the intrusive breccias is of utmost importance. Figure B-5 illustrates the conceptualized

TABLE B-3: Projection data for intrusive breccia study (vertical DDH only).

TABLE B-4: Projection data for intrusive breccia study (angled DDH only).

the definition of a restricted Mo-dispersion field. If this model is confirmed by diamond drill hole data, two possible explanations must be confronted. One explanation for this type of dispersion would be a random, and probably uneconomic, distribution of Mo-bearing veins on the property which, when transected by the mobile breccias, are fragmented and distributed in a broad, unrestricted dispersion field. The other explanation relates both the Mo-mineralization and intrusive breccias with the same intrusive center. In this instance a confined shell (or shells) of high-grade molybdenite-quartz mineralization overlies and, to some extent, envelopes the intrusive center. At a late- or post-mineral stage of the intrusive's activity, the vapor phase within the magma chamber segregates and becomes confined in the upper limits of the reservoir with the subsequent initiation of fluidization of materials within and adjacent to the intrusive. With the generation of a concentric fracture system, the breccia is vented from source incorporating fragments of the enveloping mineralization and disperses Mo-bearing breccias in a radial array outward from the intrusive center. The apparent random (unrestricted) distribution by this explanation is due to the near-coincidence of the mineralization and breccia source.

INTERPRETATION OF Mo-BEARING BRECCIAS AT ORANGE HILL

On the basis of the character of molybdenite mineralization incorporated within intrusive breccias at Orange Hill, all interpretations of the relationship between the intrusive breccia center and a potential Mo-center (as presented in the foregoing section) may be applied with some degree of validity. Data relevant to the interpretation of molybdenite distribution in intrusive breccias are given as follows:

(1) fragmental molybdenite-quartz mineralization incorporated in breccias is restricted specifically to DDH 112 and DDH 116.

(2) fine-grained, particulate molybdenite in the matrix of intrusive breccias is found in many of the breccia intervals in widely spaced holes, which when related

model of intrusive breccia distribution and the relationship of Mo-bearing breccia intervals in diamond drill holes and the mineralized center to the intrusive breccia source. In the plan view on this illustration, the intrusive breccia source is represented by an intrusive center located off to one side of the mineralized center. Breccia transport from this intrusive center should, ideally, follow the concentric fracture system (see Figure B-1a) and should be distributed in a radial array outward from the center as depicted by the transport vectors (arrows). Cross-section A-A' illustrates transport directions relative to breccia intercepts in diamond drill holes. In this model the only anticipated intervals of Mo-bearing breccia to be encountered in diamond drill core would be distributed within the Mo-dispersion field; in all other holes the breccia intervals should be barren of fragmental and/or particulate molybdenite mineralization. The azimuth of potential Mo-mineralization, in this model, is defined by the localization of the intrusive breccia center and its alignment with holes containing Mo-bearing breccias. The effective target localization on this azimuth extends from the intrusive breccia center to the first hole containing a Mo-bearing breccia. The target depth range of potential Mo-mineralization, on this basis, is restricted to the vertical extent between the deepest Mo-bearing breccia interval and the depth of the intrusive breccia center. If additional holes are located along the line of azimuth between the defined intrusive breccia center and the closest hole containing a Mo-bearing breccia interval, they may further restrict target localization both horizontally and vertically (provided they contain barren breccia intervals within the path of effective Mo-dispersion; for example, DDH (g) in Figure B-5).

A second model, with dominant genetic overtones, is brought out by a random distribution of Mo-bearing breccia intervals in diamond drill holes. In this case Mo-bearing fragments and particulate molybdenite in breccia matrix is dispersed randomly from the intrusive breccia center without

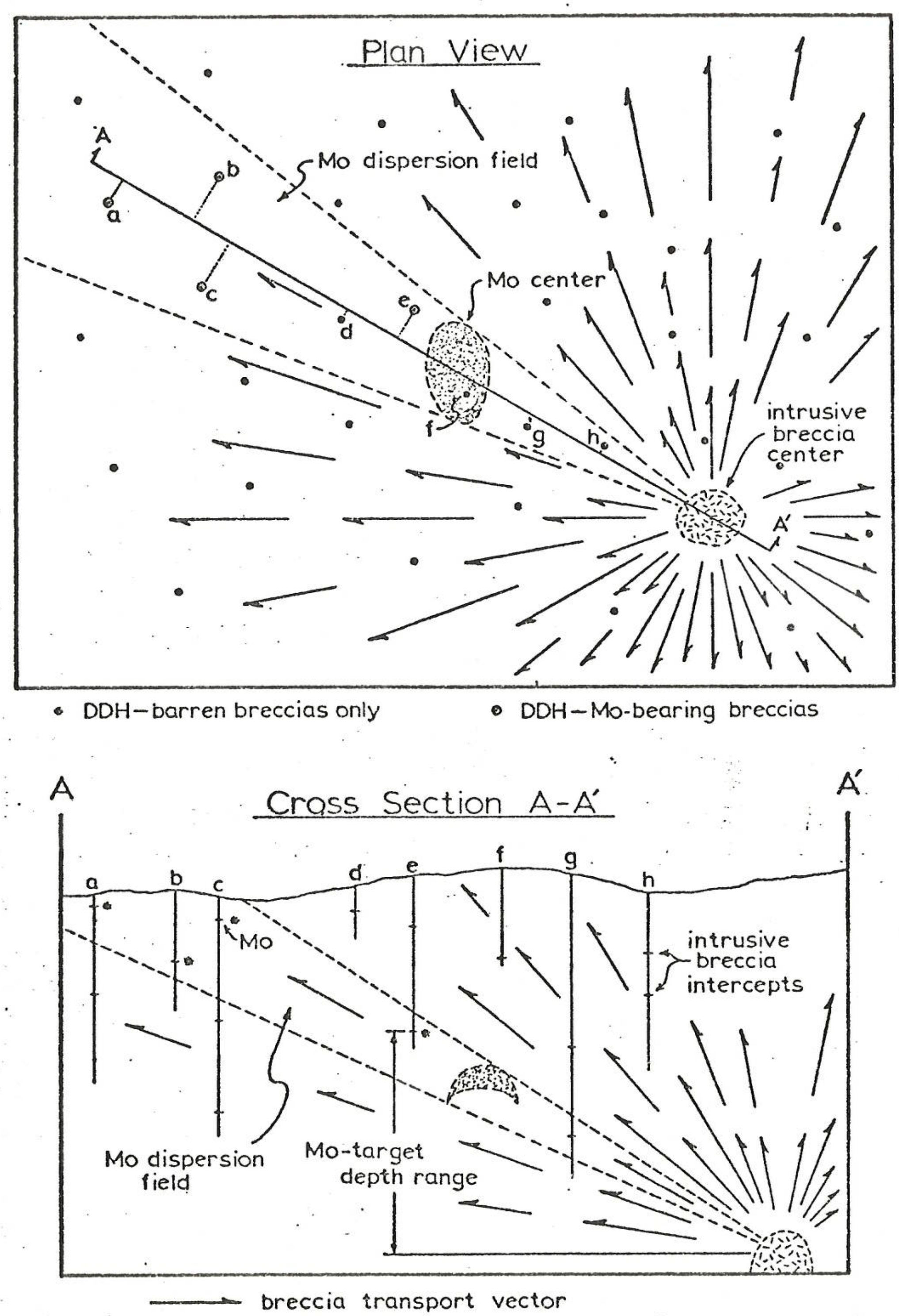

FIGURE B-5: Plan and cross-section views illustrating the conceptuallized relationships of the intrusive breccia center, Mo mineralization, and breccia intercepts in DDH a-h. Azimuth and target depth range for Mo mineralization relative to intrusive breccia center are shown.

to the defined intrusive breccia center, result in an apparent random dispersion pattern.

(3) medium- to coarse-grained, vein-type molybdenite in otherwise weakly altered rock types is noted over a broad areal extent at Orange Hill in both drill core and outcrop exposures.

(4) the only deep alteration picture that has been defined at Orange Hill is restricted to the quartz porphyry encountered in DDH 119 and DDH 120 (both holes being vertical and exceeding 2000 ft in depth); however, the alteration type has been alternatively interpreted as deuteric, root-zone, and flank-type by consultants on the property at the close of the 1974 field season.

(5) with the exception of DDH 119, 120, and possibly DDH 122, the only pervasive alteration types recognized in outcrop and drill core are a dominant propylitic and weak argillic alteration (the latter being of disputed origin); phyllic and potassic alteration are vein-restricted and sporadically distributed in outcrop and core.

(6) fragmental lithologies incorporated in breccia intervals exhibit a complete range of pervasive alteration types including propylitic, argillic, phyllic, silicic, and potassic.

Molybdenite mineralization incorporated within the intrusive breccias at Orange Hill may well be representing two modes of occurrence. The fragmental molybdenite-quartz mineralization in the breccias of DDH 112 and DDH 116 may, in this respect, be representative of primary main-stage mineralization which was dispersed from a Mo-center in a manner similar to that depicted in Figure B-5. The size of mineralized fragments and their concentration within the breccias of these two holes allude to minimal transport and consequent minor dilution and are interpreted as being relatively close to source. The fine-grained particulate molybdenite incorporated within the matrix of intrusive breccias which is sporadically but broadly distributed may be derived from molybdenite mineralization that is encountered in both outcrop and drill core as molybdenite-rich veinlets (also associated in what has been termed "friable quartz" veins as noted in California Gulch) and, thus, be considered a second mode of occurrence.

Alternatively, both fragmental molybdenite-quartz and particulate molybdenite mineralization incorporated within breccias may be considered unimodal, as opposed to statements in the foregoing paragraph. In this instance, all incorporated mineralization may be either (1) related to a centralized Mo-source in near-coincidence with the intrusive breccia center or (2) related to a probably uneconomic system of sporadically distributed veinlets. In respect to the degree of fragmentation and dilution, the incorporated mineralization may only be reflecting transport distance from source.

Interpretation of molybdenite distribution in the intrusive breccias at Orange Hill cannot be properly derived without considering the comparisons and contrasts of the presently understood alteration picture on the property. As brought out in a previous section of this report, the apparent lack of any pervasive alteration other than propylitic and a questionable argillic type in all but a few holes on the property correlates well with the distribution and character of the fine-grained particulate molybdenite within breccia matrix. If this type of incorporated molybdenite mineralization is the result of dispersion from sporadically distributed Mo-rich veinlets, its associations in the intrusive breccias are entirely consonant with its field relationships (i.e., low concentrations of particulate molybdenite and quartz in matrix with weakly altered fragmental lithologies). The occasional occurrence of pervasively altered fragmental lithologies (including silicic and potassic types) in the same breccia intervals as this type of incorporated mineralization alludes to the possibility that at least some of the mineral may have been derived from a deep, centralized source with a well developed alteration halo. If this possibility can be substantiated by future work, the centralized Mo-source should be in near-coincidence with the intrusive breccia center owing to the broad distribution pattern of both the incorporated mineralization and the pervasively altered fragmental lithologies. The disputed deep alteration picture developed in DDH 119, DDH 120, and possibly DDH 122 may further restrict the localization of a centralized Mo-source. On the basis that the alteration in DDH 119 and DDH 120 has been generated on the flank of a mineralizing center and is not due to deuteric or sub-mineral processes, Mo-bearing breccias may, indeed, be related to an enveloping Mo-source over the intrusive breccia center defined in this section of the report. DDH 119 and DDH 120 are, respectively, 1200 ft S 60° W and 1500 ft N 85° W of the defined intrusive breccia focus with DDH 119 containing many near-vertical high-grade molybdenite-quartz veins in the lower 1200 ft of the hole. Since DDH 119, relative to the intrusive breccia center, is the closer of the two, the type of alteration and mineralization encountered in the hole supports this interpretation. Also, DDH 122, although much shallower than either DDH 119 or DDH 120 (only reaching to a depth of 761 ft), showed a very pervasive argillic alteration and moderately pervasive sericite-quartz-pyrite alteration in the comparative quartz porphyry unit in the upper part of the hole. In DDH 123 (1700 ft @ N 30° W of the intrusive breccia center) a comparable quartz porphyry was also encountered, but which contained a dominantly vein-restricted alteration type. The flank alteration projected between DDH 119 and DDH 120 in this interpretation may be related to a mineralized center either enveloping the intrusive breccia center or located between these two holes and DDH 112 and DDH 116. The latter of these two possibilities is derived from the near-proximity of source suggested by the fragmental Mo-mineralization incorporated in breccias in DDH 112 and DDH 116. (The weak potassic alteration near the bottom of DDH 116 may strengthen this possibility.)

In summation, the correlation between alteration and molybdenite mineralization incorporated in intrusive breccias at Orange Hill is interpreted as restricting a possible Mo-center to either the intrusive breccia source or between DDHs 119, 120, and 112 and 116. The depths at which mineralization should be expected at these two sites are approximately 3000 ft (maximum) at the intrusive breccia center (coordinates 72,250 N and 52,250 E) and 1350 ft at 71,750 N and 50,500 E.

HYDROTHERMAL ALTERATION

The alteration at Orange Hill has been an important point of controversy throughout the 1974 field season and remains so at the time of this writing. Attempts to correlate the alteration zoning with copper and/or molybdenum mineralization have been hampered by several superposed relationships noted in field studies and core analyses. Of these superposed relationships, the most critical aspects, with regard to the utility of alteration as an exploration guide, are outlined as follows:

1) the great variability of rock types on the property and their consequent lack of uniformity in displaying a diagnostic alteration pattern
2) the low grade of metamorphism recognized in the metasedimentary and metavolcanic assemblages and the difficulties encountered in mesoscopically distinguishing it from propylitically altered equivalents
3) the superposition of quartz-porphyry induced, vein-restricted alteration on biotite quartz diorite, pervasive alteration and the lack of adequate recognition of their cross-cutting and genetic relationships in earlier studies
4) the overlapping occurrence of deuterically, hydrothermally, and ground-water induced clay and their difficult mesoscopic distinction and consequent interpretation with regard to main-stage hydrothermal argillization
5) metastable alteration assemblages due to superposed hydrothermal events and resultant difficulties in accurately defining alteration type.

Under the subheadings in this section, alteration types will be described on the basis of their cross-cutting relationships and will be separated relative to pervasive and vein-restricted or stockwork distribution.

Propylitic

The pervasive propylitic assemblage consisting of chlorite, calcite, and epidote (± magnetite) is the most common and widespread alteration type on the property. Chlorite after biotite in the biotite quartz diorite is conspicuous in both core and outcrop throughout most of the northern end of the property extending from the Southend Gulch-Quartzite Creek lineament to Cross Gulch. Quartz porphyry exposed about 800 ft east of Porphyry Peak also displays a weak, pervasive chlorite after biotite over most of the outcrop, but compared to equivalent alteration in biotite quartz diorite, the quartz porphyry is negligible. The metasedimentary and metavolcanic units exposed on the southern half of the property, particularly in structural blocks C and D, display metamorphic mineral assemblages that are similar to the pervasive propylitic assemblage; however, the low-grade albite-epidote-chlorite assemblage of metamorphic origin is distinguishably overprinted by a subsequent hydrothermal event. The overprinting is microscopically displayed by randomly-oriented hydrothermal chlorite cross-cutting the planar-oriented metamorphic chlorite. Close to the Southend Gulch-Quartzite Creek lineament this relationship is pervasive, but outcrops located beyond 1000 ft south of this lineament exhibit a decrease in the pervasiveness of the hydrothermal chlorite and it becomes restricted within and adjacent to fractures.

Quartz-epidote-pyrite and/or magnetite veining within both igneous and metamorphic units is the common, vein-restricted, propylitic alteration assemblage. Distribution of this type of propylitic alteration appears to be spatially related to quartz porphyry intrusion; whereas, the pervasive assemblage is dispersed within and about biotite quartz diorite and displaying no recognizable localization relative to quartz porphyry centers. In the metasedimentary and metavolcanic units a distinction is made between this type of veining and similar veining of metamorphic origin on the bases of (1) pyrrhotite rather than pyrite as the major sulfide phase, (2) deformation and cross-cutting relationships, (3) annealing and recrystallization (coarser grain-size) in veins of metamorphic origin, and (4) tendency of metamorphic veining to be parallel to foliation. Calcite is also encountered in propylitic veining of hydrothermal origin; however, it is always accompanied by quartz in outcrop, which serves to distinguish it from secondary leaching and redistribution of carbonate from overlying limestone near the limestone contact with metavolcanic units.

Argillic

Pervasive argillic alteration is gradational with propylitic assemblages and is characterized by the partial destruction of biotite and complete alteration of plagioclase in the biotite quartz diorite and occasionally in quartz porphyries (the pervasive argillization of quartz porphyry possibly being due to coalescence of vein-restricted argillic alteration inasmuch as veining is usually intense where "pervasive" argillization is encountered). At least three distinct clay types are mesoscopically recognized on the basis of color, one of which appears to be pervasive. Pervasive argillization results in the development of a grey clay after biotite and plagioclase which is uniformly distributed throughout the altered lithology. Opposed to this pervasive type are green and white clays which are more restricted in their distribution. The grey argillic alteration is spatially related to pervasive chalcopyrite buildup in the biotite quartz diorite.

Argillic alteration related to fracturing and veining is mesoscopically divisible into a molybdenite association (green clay) and a barren, post-mineral, fault association (white clay). The buildup of green clay adjacent to quartz-molybdenite veins within core is a conspicuous and common relationship. The argillization of this association from the vein wall outward consists of (1) complete green argillic alteration with no discernible textural relicts, (2) green clay and recognizable quartz and tan, partially argillized biotite, (3) quartz, chloritized biotite, and green clay replacing plagioclase. The thickness of the green argillic alteration envelope about the Mo veins varies directly with vein thickness and may extend as far as several feet from major systems. A white clay type encountered in core is restricted to zones of post-mineral shearing and within fault gouge. This clay type is usually found near surface (less than 300 ft from hole collar) and appears to be controlled by the water table. Sulfide mineralization is only accidentally associated in most holes where this clay type is encountered and is believed to be derived from the granulation of mineralized lithologies within the shear. Some sulfide may, however, be supergene in origin. By and large, this alteration is considered economically insignificant.

Phyllic

Pervasive phyllic alteration has not been observed in either outcrop or core on the property and on the basis of recognized pervasive alteration types is possibly at deeper levels than have been penetrated in the drilling to date. The lack of a pervasive phyllic zone may also be due to its incorporation with what has been termed "argillic" alteration insofar as fine-grained sericite is difficult to mesoscopically distinguish from true clay when dispersed in matrix. Intense phyllic alteration, however, should be accompanied by complete textural destruction of the altered lithology, and this criterion has not been met on a pervasive scale.

Vein-restricted phyllic alteration is noted within and in close proximity to quartz porphyry and consists of sericite, quartz, and pyrite usually associated with quartz-molybdenite veining. High-grade Mo intervals at 1100 ft and 1500 ft in DDH 119 display this association extremely well. In these instances the molybdenite veining is enveloped by texturally destroyed quartz porphyry for up to 20 ft from mineralized intervals. Phyllic alteration in these environments grades into argillic alteration of texturally recognizable quartz porphyry away from prominent veining.

<u>Silicic</u>

Silicic alteration at Orange Hill consists of at least three phases of quartz veining and local silicification of host matrix as determined by cross-cutting relationships.

An initial system of barren quartz veins is observed extensively over the northern end of the property transecting biotite quartz diorite as far north as Cross Gulch. These early, barren quartz veins are notably exposed along Moose and California Gulches where they are cross-cut by later mineralized veins. Silicification of matrix in host lithologies due to quartz flooding within these veins is not noted. This initial veining is characterized by turbid greyish-white quartz and the complete absence of any metallic sulfide or oxide phases.

This initial silica flooding is locally cross-cut by a second system of chalcopyrite-pyrite-rich quartz veins and magnetite-quartz veins. The quartz in this system is considerably more translucent and may invade host lithologies within a few millimeters of vein walls. Associated sulfide mineralization in this system is consistently molybdenite deficient and Cu:Mo ratios are in excess of 10:1.

A third system of molybdenite-bearing quartz veins is superposed on the two earlier systems and appears to be spatially related to quartz porphyry centers. Cu:Mo ratios in veins of this system are commonly 1:1 or less and contain notably more pyrite than earlier chalcopyrite-rich veins. Alteration envelopes about these veins are sericitic and/or argillic types and local silicification of enclosing lithologies may extend into matrix for several inches or completely coalesce with adjacent vein-restricted silicification to produce an apparently pervasive silicification on a local scale. Exposures exhibiting intense silicification of this type are found on the southern end of Orange Hill and within the cataclastic zone south of Orange Hill.

Later movements along these veins result in what has been termed "friable quartz-pyrite veining." Outcrops at the head of California Gulch and on Moly Gulch display this reactivated equivalent of the third period of silicic alteration. Molybdenite and pyrite within these reactivated systems is generally very fine-grained and restricted to shear planes within quartz veins. The quartz is white compared to unsheared equivalents (the white color being due to intense microfracturing and recrystallization).

A tentative fourth generation of silica flooding is represented by late, barren quartz veins which cross-cut molybdenite-bearing quartz veins in quartz porphyry. Cross-cutting relationships between this system and the quartz-molybdenite system are not well defined and considerable overlapping of the two episodes is interpreted as indicating their near contemporaneity.

Potassic

Potassic alteration represented by hydrothermal K-spar (orthoclase) and biotite is weakly defined with regard to pervasive development. The lower intervals of DDH 116 exhibit some occasional secondary K-spar within biotite quartz diorite which may be reflecting pervasive potassic alteration; however, adjacent diamond drill holes fail to display any continuity of these zones.

Vein-restricted orthoclase is developed over much of Orange Hill and may be observed in outcrop as quartz-orthoclase veining, some of which exhibits open-space filling and a consequent vuggy appearance. The orthoclase in these veins is generally coarse-grained and displays a high degree of euhedrality on and adjacent to cavity walls.

A possible explanation for the open-space filling of these orthoclase-bearing veins is a near-surface, low pressure environment of infilling where a distinct gas phase would be separated from the hydrothermal phase. Fluid inclusion studies within quartz of these open-space veins exhibit a two phase (liquid-gas) interface within inclusions which homogenize to a single gas phase at 310°C (± 10°C). Also plausible would be the near-surface leaching of gypsum and/or anhydrite from these veins leaving a vuggy appearance and apparent open-space genesis for the more stable, remnant mineralization.

Orthoclase restricted to silicic veining in quartz porphyry intercepts in diamond drill core and on outcrops is weakly developed adjacent to vein walls within sericitic envelopes; however, K-spar distributed within vein-fillings is seldom encountered. Staining of samples from DDH 119 has resulted in the observable lack of any well-defined K-spar pattern relative to associated mineralization.

Fluorine Metasomatism

Indications of active fluorine metasomatism within the alteration assemblages on the property are manifested by the recognition of topaz as a definite associate within restricted cored intervals. The topaz appears to be related to vein-restricted alteration and is encountered in several preferential sites which are dependent upon host lithologic type.

In quartz porphyry hosts (i.e., DDH 119) the topaz is localized within and about feldspars with primary orthoclase phenocrysts being more susceptible to alteration than plagioclase. In orthoclase the microscopically discernible topaz appears to replace the original phenocryst by degree which is relative to proximity of prominent veining. From vein wall outward, topaz (1) completely replaces orthoclase while retaining both morphology and color of the original grain, (2) superficially attacks and penetrates orthoclase along prominent cleavage planes, and (3) merely surrounds orthoclase and weakly attacks surface. The near-vein pseudomorphism of topaz after orthoclase is mesoscopically recognized by the greater hardness of the replaced grain and the pronounced development of only one principal cleavage direction (as opposed to three directions in unaltered orthoclase). Plagioclase phenocrysts exhibit similar characteristics relative to vein-proximity but are much subdued in the completeness of replacement reactions.

Biotite quartz diorite hosts (i.e., DDH 117) which are devoid of orthoclase display topaz principally within plagioclase and in minor association with biotite. The plagioclase replacement is similar in detail to that found in quartz porphyry hosts; however, biotite replacement is solely confined to cleavage planes (surficial and complete attack not being noted).

The topaz completely replacing orthoclase close to vein walls in quartz porphyry occurrences has been X-rayed by powder technique and, on the basis of line spacing, resolves to approximately $Al_2SiO_4(F_{.90}, OH_{.10})_2$. The high percentage of fluorine in samples relative to hydroxyl alludes to fluorine activities which are more compatible with main-stage hydrothermal activity than with deuteric or pegmatitic environments.

Fluorine metasomatism also results in the formation of fluorite in vein environments where it has been noted in DDH 117 in association with anhydrite-quartz-molybdenite veining in sericitically altered biotite quartz diorite.

The topaz is noted within three vein-restricted zones of alteration: sericitic, silicic, and potassic. Dr. Bryant has also noted topaz incorporated within intrusive breccias as a matrix phase (personal communication).

The definition of topaz zonation in diamond drill core recovered from the south end of Orange Hill resolves to a domical distribution within and surrounding the major quartz porphyry encountered in DDH 119.

Economic Significance

The economic significance of the type, distribution, and association of alteration with mineralization at Orange Hill has not been sufficiently tested in diamond drilling with respect to overlapping alteration haloes attributable to the two distinct hydrothermal events. Efforts to-date have stressed zones of intense silicification as the most promising areas of potential mineralization. Investigations carried out during the 1974 field season, however, have distinguished several generations of silica flooding which apparently are not collectively correlated with the same hydrothermal event. Any overlap of these systems, with consequent reinforcement of quartz veining, may be misinterpreted as being related to a single event. Subsequent drilling on the premise of a single event encompassing both mineralization and associated alteration should not be expected to develop significant information relating proximity of ore occurrence unless a more detailed analysis of specific alteration types and timing is undertaken.

Topaz localization at the south end of Orange Hill is significantly restricted with regard to Mo distribution and may be inferring proximity to centralized mineralization in the area. The pervasive propylitic alteration noted on the property appears to be the only zoning that is specifically delineating with respect to known copper mineralization. The overlapping of at least two apparently independent events and the resultant destruction or reinforcement of alteration attributable to the later event upon the former leaves the question of the utility of alteration as an exploration guide open to debate. The only obvious solution to the problem of alteration significance may be developed by a complete relogging of vein-restricted alteration in core and a reexamination of outcrop veining to determine intensity relative to each specific event. Logging accomplished during the 1974 season did not reveal a bimodal genesis for alteration until well into the season and at which time relogging was not feasible.

With respect to the presently understood alteration distribution on the property, the following table outlines the most significant relationships:

Table : Significant Aspects of Hydrothermal Alteration at Orange Hill.

Hydrothermal Event	Alteration Type	Zoning P	A	S	Q	K	T	Associated Mineralization
I	Vein	o	o	o	+	?	o	none
IIa	Pervasive	+	-	-	?	o	o	Cu dominant
IIb	Vein	+	o	o	+mp	?	o	
IIIa	Vein	?	+	+	+p	-	-	Mo dominant
IIIb	Vein	o	o	o	+	o	o	

Explanation:

P = propylitic
A = argillic
S = phyllic
Q = silicic
K = potassic
T = fluoric (topaz)

o = absent
? = questionable
- = present
+ = dominant
m = magnetite associated
p = pyrite associated

GEOCHEMICAL ASSOCIATIONS

Geochemical investigations at Orange Hill prior to the 1974 field season consisted of rock-chip and stream-sediment sampling on both regional (Wilson, Mancuso, and Potter, 196?; Moerlein, 1964) and semi-detailed (Moerlein, 1961) scales. Due to the limited sample populations of these early reconnaissance surveys, anomalies were neither focused nor correlated with alteration or lithologic types sampled. Consequent to the lack of definition attributed to these programs, subsequent detailed geochemical surveys were not implemented.

Prior to leaving the property in July, 1974, Dr. Bryant outlined a rock-chip sampling program to be carried out at some time during the remainder of the field season. The program required major outcrop sampling with individual samples to be composited on 300-ft centers across the property (the composited chips being collected within a 150-ft radius of each center). Due to the timing of other required duties, only the southern end of the property received this coverage.

In addition to the rock-chip sampling outlined in Bryant's program, fracture-scrapings were also systematically collected in the southern block to further define vein-restricted alteration patterns. This sampling program was designed by Trautwein in an attempt to correlate Cu-Mo distribution relative to quartz porphyry intrusives and metavolcanic-metasedimentary units which are well exposed in the area.

The final program that was carried out resulted in the collection of 128 composited outcrop samples (rock-chip) and 58 fracture-scrape samples, both of which were analyzed for Cu and Mo with spot checks on Pb, Zn, and Ag in rock-chip composites. The survey encompassed the bulk of the southern end of the property and extended from the Southend Gulch-Quartzite Creek lineament south to Nikonda Creek and from outcrops along the east flank of the Nabesna River valley eastward to the outcropping limestone horizon along Lime Ridge.

Rock-Chip Analyses

Composited rock-chip samples from outcrops within the southern block were predominantly taken from the metavolcanic units, although metasediments and quartz porphyry were also included in the survey on a limited basis (the bias being due to outcrop distribution). A summary of the number of samples collected from each major lithologic type is given as follows:

Metavolcanic Units (86 samples)
- Gabbro = 11
- Andesite = 56 (flows--37, flow-breccias--8, tuffs--11)
- Rhyolite = 19 (flows--13, tuffs--6)

Metasedimentary Units (33 samples)
- Graywacke and Subgraywacke = 25
- Limestone = 5
- Argillite = 3

Quartz Porphyries (9 samples)

Of the 128 rock-chip analyses in the area, the 119 combined metavolcanic-metasedimentary samples were found to be unimodal in respect to both Cu and Mo distributions regardless of rock type or proximity to quartz-feldspar porphyry outcrop. Figure illustrates the frequency-distribution of Cu and Mo values in the rock types analyzed. The lack of any apparent anomalous trends may be interpreted as an indication of background control. Turekian and Wedepohl's (1961) averages for Cu and Mo content in basaltic rocks and calcic granites also substantiate this interpretation. In their compilation, Cu and Mo in basalts average 87 ppm and 1.5 ppm respectively; whereas, the average calcic granitic rock contains 30 ppm Cu and 1.0 ppm Mo. Compilations by Trautwein (unpublished) of several differentiated oceanic alkalic suites are also in agreement with Cu values obtained from Orange Hill metavolcanic analyses (i.e., alkali basalts and gabbros = 82 ppm Cu, trachyandesites = 57 ppm Cu, and quartz trachytes = 33 ppm Cu). Correlation coefficients for Cu-Mo in rock-chip samples displayed a strong agreement between both elements when restricted to individual rock types but only weak correlation for unrestricted metavolcanics and no agreement when all rock types were included. Considering the sample distribution--both areally and lithologically, this relationship may also confirm "background control" for values obtained. It is important to note that alteration in these samples is considered to be metamorphic in origin from earlier petrographic work and is not recognized as a main-stage mineral-related type.

The nine quartz porphyry analyses display a weak bimodal distribution when taken collectively; however, the age relations between the outcropping intrusives sampled remains unclear and correlations may, in part, be artificial. In this instance, timing of quartz porphyry intrusions relative to possible main-stage mineralization and/or alteration is critical to the interpretation. Figure displays the bimodality for both Cu and Mo in quartz porphyries sampled. Although cross-cutting relationships between quartz porphyries were not observed on the outcrops sampled, fracture-scrape data (summarized under the following heading in this section) does imply a genetic relation between Cu and Mo distributions and quartz porphyry intrusion. Whether this relationship involves a two-stage hydrothermal process with an initial Cu-rich phase and secondary Mo-rich phase or partial remobilization of an earlier Cu component remains to be clarified by a more detailed sampling program; however, anomalous Mo contents are restricted within and in close proximity to the major quartz porphyry outcrops sampled.

Fracture-Scrape Analyses

Post-metamorphic fracture fillings were sampled at 58 sites within the southern block; these samples constitute what have been termed "fracture-scrape samples" or "fracture-scrapings" in the geochemical reconnaissance program. The 58 samples analyzed were restricted to quartz-orthoclase and quartz-epidote veinlets cutting both metavolcanic and meta-sedimentary units exclusive of the limestone. The fracture scrapings did show a positive correlation between Cu and Mo with respect to proximity of quartz porphyry outcrop; the earlier quartz-epidote filled fractures exhibiting a significant Cu anomaly, and later quartz-orthoclase filled fractures--Mo anomalies centered on quartz porphyry exposures. Anomalous values were considered to be equal to or in excess of twice background for the host lithology (i.e., meta-andesites with 50 ppm Cu background containing anomalous fractures with at least 100 ppm Cu in scrapings).

MINERALIZATION

Mineralization at Orange Hill is considered to be bimodal with respect to its distribution and genesis. Chalcopyrite, molybdenite, sphalerite, galena, and bornite are the major phases of economic importance, although an unidentified silver specie has been encountered in core (possibly tetrahedrite-tennantite). Localization of ore mineral assemblages within biotite quartz diorite, quartz porphyry, and metasedimentary-metavolcanic units has previously been related to a single hydrothermal event which is presently considered an erroneous hypothesis. On the basis of alteration studies carried out during the 1974 field season, copper mineralization is shown to be related to an early event which has been superposed by a later molybdenum event.

Copper Distribution

The earliest exploration target on the Orange Hill property was confined to high-grade bornite-chalcopyrite mineralization within thermally metamorphosed limestone outcropping along Lime Ridge. Adits E, F, and J were driven on podiform mineralization of this type. Samples collected from these exposures during 1974 contain normal tactitic calc-silicate assemblages (i.e., grossularite, tremolite, epidote, etc., in recrystallized calcite) which have been selectively replaced by copper-iron sulfides (dominantly bornite) and minor sphalerite and galena. Several samples from Adit J display unaltered grossularite garnet within a matrix of bornite (the grossularite being the most resistant specie to effects of the mineralizing fluids). Localization of high-grade mineralization in this environment is undoubtedly due to chemical favorability of the host as well as the "textural priming" of the unit due to biotite quartz diorite contact effects ("textural priming" in this instance referring to the coarser grain size developed during recrystallization). Continuity of these lens-like replacement bodies has been insufficient for development and mineralization appears to be introduced along major fault and fracture zones which cut the unit.

Pervasive and vein-restricted copper mineralization within the biotite quartz diorite is developed in propylitically altered facies on the northern half of the property. Chalcopyrite dispersed along intergranular boundaries between plagioclase and chloritized biotite is common. Pyritization of primary magnetite appears to accompany the introduction of chalcopyrite in the system on the north end of Orange Hill. Molybdenite is conspicuously absent in association with the pervasive chalcopyrite. Vein-restricted chalcopyrite within biotite quartz diorite appears in close association with its pervasive equivalent; however, minor amounts of molybdenite are noted. Chalcopyrite in veins containing magnetite, pyrite, and minor molybdenite is commonly characterized by Cu:Mo ratios of approximately 10:1 and is notably absent in quartz porphyry.

Metasedimentary and metavolcanic units on the property are found to be dominated by vein-restricted copper mineralization which is usually within quartz-chalcopyrite-pyrite/magnetite veins or as chalcopyrite-pyrite along hairline fractures. The most susceptible units for copper enrichment are found to be in close proximity to biotite quartz diorite contacts and exhibit recognizable textural and compositional adjustments due to the intrusive contact.

The effects of hydrothermal activity associated with copper mineralization are more redistributive than additive. Earlier pervasive and vein-restricted copper mineralization is noted to be purged from contact zones about quartz porphyry and relatively enriched in aureoles between 300 and 1000 ft surrounding the intrusion. Observations supporting the contention that the later quartz porphyry related hydrothermal extent is responsible for remobilization of early copper mineralization include the increase of molybdenite content in veins within the enriched zone, the control of zone localization by quartz porphyry, and the superposition of later, vein-restricted, high-grade alteration on earlier lower grade assemblages within the zone.

Molybdenum Distribution

Molybdenite at Orange Hill appears to be dominantly controlled by a hydrothermal event which is, at least, spatially related to quartz feldspar porphyry centers. The molybdenum mineralization is exclusively vein-restricted and is associated with pyrite and minor chalcopyrite with Cu:Mo ratios seldom exceeding 1:1 and commonly less than 1:5. Alteration indicative of proximity of higher grade Mo-veins is sericitic and may be observed in upper California Gulch, Moly Gulch, on the south end of Orange Hill, and in DDH 119 (all of which are in quartz porphyry hosts). A notable increase in pyrite content within these vein-alteration envelopes is also consistent with the molybdenite-quartz veining. Molybdenite veining in biotite quartz diorite is localized about quartz porphyry but, as opposed to the strong sericitic alteration associated within quartz porphyries, the mineralization is commonly related to a greenish argillic alteration envelope about veins in the diorite host.

Molybdenite in metasedimentary and metavolcanic units is restricted to the E-W striking assemblage in the northern half of the property; southern exposures only relate geochemically anomalous fractures with respect to Mo. The northern units display definite chemical favorability toward molybdenum distribution with metasediments being the most favorable hosts, metavolcanics being second most, and limestone being the least favorable (with molybdenite being absent in most instances).

Coarse molybdenite is also noted along reactivated NNW faults and fracture systems as observed east of Porphyry Peak, in California Gulch as "friable quartz-molybdenite-pyrite veins," and in the southeast corner of the property below Lime Ridge. These exposures are notably devoid of chalcopyrite and based upon their dominant structural control and cross-cutting relationships probably represent mineralization during a late-stage of the molybdenum event.

Economic Significance

The economic significance of the bimodal distribution of mineralization at Orange Hill is found in past exploration practices based upon a singular genetic model for target localization. Discrimination of intensely silicified areas on the property and the search for related higher-grades of alteration corresponding to a mineralized target has resulted in only limited success. Cross-cutting relationships between mineralization and alteration dictate a major reevaluation of exploration philosophy on the property and consequent programming.

The close association of copper distribution with biotite quartz diorite intrusion and its related hydrothermal event and the association of molybdenum mineralization with the later quartz porphyry event add to the potential of the property if the two mineralizing centers can be localized. The destruction of the former copper target by the molybdenum event appears to be offset by the inferred remobilization of copper about quartz porphyry centers. The remobilization has resulted in an enriched aureole of chalcopyrite mineralization that may be related directly to the hydrothermal center associated with the Mo event rather than a simple thermal purging of copper during quartz porphyry intrusion. The association of molybdenite in these remobilized copper veins appears to justify this interpretation.

The targets which now are considered economically significant on the property based upon the distribution of copper and molybdenum mineralization are threefold:

I. Copper Target--in association with an initial hydrothermal event affecting biotite quartz diorite, metasedimentary, and metavolcanic units which is surficially characterized by a pervasive propylitic alteration halo.

II. Molybdenum Target--in association with a second hydrothermal event affecting quartz porphyry and biotite quartz diorite which is surficially characterized by vein-restricted alteration including argillic, phyllic, and silicic types.

III. Copper-Molybdenum Target--in association with superposed hydrothermal events affecting an enriched aureole which is surficially characterized by molybdenite and remobilized chalcopyrite veining within argillically altered biotite quartz diorite.

CONCLUSIONS

Conclusions regarding the Orange Hill property and its present-day economic potential as a porphyry-type Cu-Mo target are founded upon the synthesis of relationships outlined in this summary report. The sequence of geologic events, as is presently understood, is listed in chronologic order below:

	Event	Economic Significance Direct	Indirect
1)	Deposition of Triassic volcanic sequence in back-arc environment and subsequent intrusion of gabbroic and andesite dikes	Passive	Active
2)	Emergence and erosion (unconformity)	Passive	Inactive
3)	Submergence and deposition of siliceous dolomitic limestone	Passive	Active
4)	Conformable deposition of pelitic sediments, arenites, and rhyolitic tuffs	Passive	Active
5)	Continued deposition (?) and burial	Passive	Inactive
6)	Low-rank, greenschist facies regional metamorphism	Passive	Active
7)	Early cataclasis and faulting (?) on N 10° W trend	Passive	Active
8)	Intrusion of biotite quartz diorite with contact metamorphic effects and subsequent barren quartz veining	Passive	Active
9)	Hydrothermal Event I (Cu-rich)	Additive	Active
10)	Intrusion of quartz-feldspar porphyry	Passive	Active (?)
11)	Faulting on E-W trend and reactivation of N 10° W trend	Passive	Active
12)	Hydrothermal Event II (Mo-rich)	Additive	Active
13)	Intrusive breccia genesis and emplacement	Passive (?)	Active

	Event	Economic Significance Direct	Indirect
14)	Faulting on N 60° E trend	Passive	Active
15)	Faulting on Bryner trend and emplacement of late dikes	Passive	Active (minor)
16)	Recent glaciation		Active (minor)

A systematic reappraisal of this sequence in terms of its direct additive, passive, or negative influence on Cu or Mo introduction in the area is carried out in respect to ore controls and consequent anticipated localization of mineralization. The sequence is also evaluated on the basis of its indirect active or inactive role in preparing the system for later mineralizing events.

Stratigraphic stages 1-5 appear to have been passive with respect to any significant additions of copper and/or molybdenum to the system at Orange Hill. Metavolcanic stratigraphy is decidedly not compatible with massive sulfide deposition, and environmental analysis of overlying assemblages indicates aerobic conditions in which sulfides would not have been stabilized. Primary geochemical trends within the stratigraphic sequences are insufficient to account for the distribution of known mineralization on the property. With respect to bulk chemical composition, the assemblages afforded active hosts for subsequent mineralizing solutions with the limestone and andesites of the volcanic sequence being prone toward copper enrichment and overlying pelitic and arenaceous units being susceptible to molybdenum mineralization.

Low-rank regional metamorphism (stage 6) of the greenschist facies has been passive in relation to mobilization of trace copper in stratigraphic units, although epidote-filled fractures of probable metamorphic origin in the metavolcanic units have been found to contain minor pyrrhotite mineralization. The only possible active affect on subsequent mineralization is the associated recrystallization of metamorphic components and consequent enhancement of host favorability.

Early cataclasis (stage 7) and possibly associated N 10° W faulting are genetically passive, but indirectly active in affording conduits (i.e., permeable structures) for mineralizing fluids and with regard to positioning of favorable hosts for subsequent enrichment.

Intrusion of the biotite quartz diorite phase of the Monte Cristo Batholith (stage 8) was passive in introducing known mineralization into the system, but definitely active in preparing contacted and incorporated stratigraphic units for later mineralizing events. Tactitic hornfels developed by thermal affects of the intrusion are noted as being the most susceptible hosts for copper enrichment. The biotite quartz diorite also contains approximately 3% primary magnetite which undoubtedly contributed to the formation of iron-bearing sulfides during the subsequent hydrothermal events.

The initial main-stage hydrothermal event (stage 9) is considered to be the first additive process for the distribution of known copper mineralization on the property. Partially destroyed alteration zoning related to this event has been reduced to widespread, pervasive propylitic alteration and remnant argillic and phyllic assemblages. Pervasive copper mineralization associated with the event is confined well within the propylitic halo; whereas, vein-restricted mineralization has been localized by structure and favorability of potential host lithologies within and about the recognized alteration envelope.

Intrusion of quartz-feldspar porphyry (stage 10) appears to have been questionably active with respect to the partial remobilization of copper mineralization introduced during the initial hydrothermal event, but completely passive with regard to any associated additive mineralization.

Faulting on an E-W trend in the southern end of the property (stage 11), and reactivated equivalents of the earlier N 10° W faulting, is mineralized, but related to the molybdenum rather than the copper event. In this respect, the faulting was probably indirectly active in affording conduits to later mineralization. Both fault systems locally cross-cut quartz porphyry and are placed in the sequence on this basis.

Hydrothermal activity associated with the emplacement of molybdenite mineralization (stage 12) was definitely additive. This event has actively effected redistribution of earlier copper mineralization as is related by chalcopyrite-molybdenite veining in which chalcopyrite is commonly fragmented and appears to have been mechanically transported. Within quartz porphyry chalcopyrite is notably deficient (if not completely absent) in molybdenite veining which further substantiates the post-copper timing of the intrusion. Hydrothermal alteration associated with the event has been dominantly vein-restricted as is all related molybdenite mineralization. Molybdenite appears to be associated with sericitic alteration envelopes in quartz-feldspar porphyry and intense argillic alteration in biotite quartz diorite and metasedimentary hosts.

Generation and emplacement of intrusive breccias within the sequence (stage 13) has apparently been controlled by igneous activity and consequent fracturing related to the molybdenum event. The question of whether the breccias are late syn-mineral or post-mineral with respect to this event is still open to conjecture. The appearance of fragmental quartz-molybdenite mineralization, fine-grained, particulate molybdenite in breccia matrix, and pervasively altered lithologies (including quartz porphyry) within these units indicates their active role in redistributing at least a minor portion of the Mo mineralization.

N 60° E faulting on the Southend Gulch--Quartzite Creek lineament (stage 14) has had a passive influence on mineralization based upon outcropping exposures. Parallel minor offsets are non-mineralized and are interpreted as being post-mineral in age. The probability of an indirect active role in displacing mineralized targets in the southern end of the property is justified on the basis of major stratigraphic offsets across the zone (the southern block being downdropped at least 1000 ft).

Late dikes paralleling the Bryner Fault system (stage 15) are definitely post-mineral and are passive with respect to known mineralization. The dikes, which range in composition from dacite to basalt, are observed to have played an inactive role in remobilizing either copper or molybdenum. The Bryner Fault has locally displaced and reworked mineralization along its extent, but is considered inactive due to its post-mineral cross-cutting relations and comparative minor offset.

Recent glaciation, subsequent to major igneous and structural activity related to mineralization, has resulted in probable minor supergene mineralization below the north end of Orange Hill, but by and large is not considered to have significantly effected major redistribution of known mineralization.

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PROJECTION DATA FOR INTRUSIVE BRECCIA STUDY -- VERTICAL DDH ONLY

DDH	Coordinates	Collar Elev.	Bottom Elev.	Intrusive Breccia Data: Core Intercept Elevation	Contact Angle to Core Axis	Departure/1000' (vertical)	Datum Level Projection Radius 2000'	1500'	1000'	500'	0'
102	75115 N	3416	2149	2898	50°	1192	1070	1666	2262	2858	3454
	52022 E			2877	60°	1732	1519	2385	3251	4117	4983
				2827	50°	1192	986	1582	2177	2773	3369
				2765	?						
103	74294 N	3472	2926	3314	15°(?)	268	352	486	620	754	888
	52625 E										
104	72771 N	3480	2833	3414	35°	700	990	1340	1690	2040	2390
	52860 E			2955	15°	268	256	390	524	658	792
				2874	15°	268	234	368	502	636	770
105	73040 N	3410	2910	3077	45°	1000	1077	1577	2077	2577	3077
	50765 E										
106	71795 N	3321	2610	2911	60°	1732	1578	2444	3310	4176	5042
	51781 E										
107	74903 N	3509	2802	n.d.	--	--					
	52400 E										
109	73515 N	3342	2839	3216	80°	5671	6896	9732	12568	15404	18239
	51862 E										
110	75187 N	3759	3123	n.d.	--	--					
	53326 E										
111	74422 N	3786	3034	n.d.	--	--					
	53349 E										
114	72634 N	3353	2545	3163	15°	268	312	446	580	714	847
	52200 E			2652	25°	466	304	537	770	1004	1237
				2641	?						
117	70669 N	2911	1666	2563	45°	1000	563	1063	1563	2063	2563
	49656 E			2513	60°	1732	888	1754	2620	3486	4352
				2109	?						
118	72234 N	3700	3009	3273	20°	364	463	645	827	1009	1191
	53470 E										
119	71635 N	3248	1227	2764	80°	5671	4333	7168	10004	12840	15676
	51170 E			2428	?						
120	72440 N	3340	1326	2714	70°	2748	1962	3336	4709	6083	7457
	50820 E			2291	25°	466	136	369	.602	835	1068
121	70540 N	2915	2420	2730	45°	1000	730	1230	1730	2230	2730
	50169 E										
122	72378 N	3339	2578	2869	30°	577	501	790	1079	1367	1656
	51455 E			2755	55°	1428	1078	1792	2506	3220	3934
123	73763 N	3302	2286	3196	80°	5671	6782	9618	12454	15289	18125
	51470 E			3062	40°	839	891	1310	1730	2150	2569