ELK

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PRELIM. NOTES
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Table of Contents

Abstract

The Knob Hill property lies along the northern margin of a linear alteration zone of regional extent. Preliminary work ~~on the pr~~ failed to disclose any anomalous zones in the altered area. Subsequent drilling tested magnetic anomalies in relatively unaltered acidic to intermediate pyroclastics and flows. Evidence in the drill core indicates the possible presence of massive sulfide lenses within the volcanic sequence.

The nature and extent of the alteration belt are discussed. Its cause and reasons for localization are unclear.

A rock type noted in the lower section of DDH-1 and identified as argillite is believed to be identical with a type mistakenly identified by Utah geologists as andesite. This rock is a major host to copper at the Island Copper deposit. The discovery of the true nature of this rock implies that the Utah ore body may be essentially sedimentary, with later redistribution and local enrichment along the margins of a porphyry sill. On the basis of this interpretation, exploration for comparable deposits should be concentrated on the Parsons Bay Formation.

Report on Elk Group, Holberg, B.C.

Introduction

The following report deals with the Elk Group of mineral claims, situated on Knob Hill, north of Holberg, B.C. It is based on two visits to the property, a detailed examination of the core of four drill holes (3114' of BQ core) put down by West Coast Resources (see appendix for logs), an examination of data compiled by West Coast Resources and by Chevron Minerals, and extensive experience on northern Vancouver Island while in the employ of Utah Construction and Mining Company and later as an independent consultant.

History

Since the discovery of the Island Copper ore body in Feb. 1967, and its characterization as a "porphyry copper" type deposit, considerable effort has been devoted to the discovery of comparable deposits within the belt of Lower Jurassic Bonanza Volcanics which extends west and west-northwestfrom the Rupert Inlet area to the northwestern tip of Vancouver Island.

Now well exposed in the pit at Island Copper, and discontinuously exposed but apparently continuous(save for fault offsets) over the entire strike length of this volcanic belt there exists a spectacular zone of intense clay-silica alteration with a pyrite content generally exceeding 5%. Based on the probably reasonable assumption of a relation between this alteration zone and the occurrence of copper on the Utah property, later exploration has tended to concentrate largely around exposures of this feature.

The alteration zone is present, though very poorly exposed, along the southern edge of the Elk Group and its presence or inferred presence was probably a factor in West Coast Resources' decision to stake the ground. However, initial work by that organization (magnetometer and geochemical surveys) failed to indicate the presence of any anomalous areas proximal to the altered zone. Subsequent drilling was carried out about 6500' to the north to investigate two areas of high magnetic relief. No ecomonic mineralization was encountered, nor were any features noted which might indicate proximity to a concealed porphyry copper deposit.

In early 1973 I was requested to examine the drill core by Cities Service Minerals Corp. In the course of this examination I noted a number of factors which indicated the possible presence nearby of a massive sulfide lens. However Cities Service was unable to conclude an option agreement on the property, so the idea was not pursued.

The present work has reinforced my belief in the possibility of massive sulfide occurrences, and has, in addition, provided some new insights into the nature of the geology of the Island Copper deposit which require a reevaluation of exploration approaches in the general North Island area.

Geology

Stratigraphy

The Elk Group is underlain largely by a central belt of Lower Jurassic pyroclastics, flows and sills of acid to intermediate composition referred to the Bonanza Formation. This belt is intruded on the northeast by the Jurassic Nahwitti Batholith. To the southwest, the volcanics are overlain unconformably by the Lower Cretaceous Longarm Formation, which is composed largely of sandstone and conglomerate derived in part from Bonanza rocks which have undergone little or no chemical weathering.

In his mapping for West Coast Resources, Peter Folk outlined an area in the northwestern part of the claim group which is underlain by basalts. He believed these not to be a part of the Bonanza sequence, and suggested that they were an upfaulted block of Middle to Upper Triassic Karmutsen Formation

On the basis of mapping in areas adjacent to the Elk Group, the presence of the Upper Triassic Parsons Bay Formation can be inferred at depth. This unit is composed of greywackes, shales and calcareous rocks. A section of argillite encountered in the lower section of DDH-1 lends weight to this inference. The potential importance of this unit will be discussed later in this report.

Structure

Bedding attitudes are rarely obvious within the volcanic rocks which are poorly exposed at best. Interpretations of structure must rest on inferences made on the basis of the gross distribution of rocks of contrasting lithology, and upon regional trends. Some dip information has been obtained during the core logging, but should be used with the realization that initial dips may represent a substantial component in rocks of volcanic origin. Attitudes are most obvious in outcrop in a series of well-laminated rhyodacitic tuffs exposed in a creekbed about 4000' northeast of the Elk camp. However, this location lies within a few hundred feet of the margin of the Nahwitti Batholith, and the possibility of local deformation during intrusion should be kept in mind. To compound the uncertainties, my measurement at this location, which yielded a N-S strike and a dip of 45°W, is in disagreement with the attitude shown on Folk's map for this location, indicating a similar strike but a dip of 50° to the east. I believe the latter represents an error in drafting or transcription of data, since there are no outcrops outside the creek gulley, which both Folk and myself have traversed thoroughly.

With the foregoing qualifications, it appears that we are dealing with a southwest-dipping monoclinal sequence where dips range from about 30° in the argillite intersected at the bottom of DDH-1 to about 55°, a figure which seems to be general within the volcanic rocks. Gross distribution of the rhyodacitic rocks indicates a strike of approximately N35°W. Regional strike is about N45°W.

Structure (Continued)

The possibility that the sequence is overturned should be discussed, especially as the assumption of a right-side-up, southwest-dipping monocline yields a volcanic sequence which changes from acidic to intermediate with decreasing age, a rather unusual circumstance. Firstly, the sequence involved here is probably rather too restricted in thickness to be treated in terms of magmatic evolution. Secondly, Muller et al (1974, pp. 22,23) noted a similar trend in a section measured along the west coast of the island north of Quatsino Sound. Thirdly, graded bedding in tuffs intersected in the drill holes indicates that the sequence is right-side-up.

The margin of the Nahwitti Batholith is roughly parallel to ~~with~~ the N35°W strike inferred from the gross distribution of the rhyodacitic rocks to a point about 5500' northeast of the summit of Knob Hill. From this point the intrusive cuts sharply west into the region underlain by basalts, where it again resumes a trend slightly west of north.

The importance of faulting is difficult to estimate. Mr. D. Arscott has called my attention to a northwest-trending line which can be drawn bounding the west side of the Farm magnetic anomaly and the east side of the Knob Hill magnetic anomaly to the northwest, and has suggested that this line represents the trace of a fault which has offset adjacent parts of a once continuous zone of magnetic rock. I find this suggestion attractive for it offers an explanation for the presence of a distinctive medium grained intrusive diorite in DDH-4 in the southeast and DDH-3 in the northwest which is absent in the centrally located DDH-2. The intrusion of this diorite may be responsible for the development of the secondary magnetite in the overlying volcanics in DDH-3 and the volcanics in DDH-1 which lies close to DDH-4. Following Occam's razor, a single faulted intrusive is most likely.

Attitudes measured by Folk within the Cretaceous section show consistent north-south strikes and gentle western dips. However the outcrop pattern indicates that the boundary between the Bonanza rocks and the Cretaceous section trends northwest, in accord with the regional mapping.

It has been suggested , on the basis of topography and air-photo study, that Knob Hill represents an eroded volcanic dome. Although the coarser breccias in the area imply proximity to a volcanic vent, there is no presently known evidence for a circular pattern of lithological units which might support this interpretation.

Alteration

Mention has been made in the section on History of a belt of clay-silica-pyrite alteration which lies within the Bonanza rocks. This belt may have an outcrop width locally exceeding 2000'. It has been encountered by drill holes on the Riviera property east of Rupert Inlet, is well exposed in the Utah pit, outcrops spectacularly

Alteration (Continued)

at the Lafarge Cement Company quarry at Apple Bay, and is responsible for the brilliant red color of the cliffs on the Pemberton Hills. Utah has conducted drilling programmes within the belt at Wanokana and Hushamu Creeks and West Coast Resources and Cities Service have drilled it on the Red Dog property. Aside from the Island Copper deposit, significant amounts of copper seem to be present only in the Hushamu Creek area, but grades there are in the neighborhood of 0.2%. It is my impression that such copper as has been found in these various exploration programmes lies, not within the altered rock, but in relatively unaltered adjacent rock.

The origin of this alteration is puzzling. An intrusive mass is present at the head of Rupert Inlet and a dike (which may be part of that intrusive) within the Island Copper ore zone. Mapping by the G.S.C. shows a small stock in the Hushamu Creek area and another on Wanokana Creek, and there is a stock on the Red Dog property. These intrusives, however, are rather small, sporadically distributed occurrences, whereas the alteration is apparently continuously developed along an arcuate trend at least 34 miles in length. Too, there are numerous other small stocks and intrusive masses of apparently similar nature in the general region which have no associated alteration zones.

A plot of the outcrop pattern of the altered belt on the geological map of the Alert Bay-Cape Scott Map Area (G.S.C. Map 4-1974) shows that it does not lie at a consistent stratigraphic position within the Bonanza Formation. Its smoothly arcuate surface distribution in an area of sharply incised relief implies a steep dip, but at least one drill hole on the Island Copper property passed out of the alteration into unaltered volcanics at a depth of approximately 500'. Outcrop evidence on the Red Dog and adjacent Utah Expo claims is contradictory and can be interpreted to indicate both vertical and subhorizontal boundaries.

The apparently continuous nature of the belt in an area where deformation consists primarily of block faulting, tilting and cross faulting (Muller et al, 1974, p.50) implies a post-deformational age for the development of the alteration, yet the Lower Cretaceous rocks which overlie the belt on portions of the Elk Group show no signs of alteration whatsoever. Perhaps coincidently, the belt follows the erosional updip edge of the Lower Cretaceous Longarm Formation in the two areas along the belt where the Longarm overlies the Bonanza Formation.

It is tempting to speculate that the fluids responsible for the development of this belt were derived by dewatering and burial metamorphism of the thick sequence of Karmutsen basalts which underlies most of this region. Current research on low-grade metamorphic processes may shed more light on the relations of such alteration to the deposition of sulfides. More detailed mapping may assist in solving the problems associated with localization of the belt, but the mapping should be carried out on a regional scale.

Attention is called to a small area of somewhat similar alteration on the west shore of Kashutl Inlet north of Kyuquot. Pyrophyllite and natro-alunite occur on the Morris and Monteith properties. Pyrophyllite is sporadically developed throughout the belt of clay-silica alteration described above.

Massive Sulfide Possibilities

Massive sulfide deposits generally occur within volcanic sequences at a position within the stratigraphic column where there is an abrupt transition (up or down) from intermediate to acidic rocks. There is an association with coarse fragmental rocks which is interpreted as reflecting proximity to a volcanic vent. Intercalated sediments indicate that the rocks were deposited subaqueously.

Mapping by Peter Folk which I have rechecked in the field, and my examination of the drill core have led me to the conclusion that these factors are all present on the Elk Group. The following factors should also be considered. Both intermediate and acid extrusives in the transition zone outlined by mapping contain significant amounts of disseminated iron sulfides. In addition, breccias present in DDH-1 contain angular to subrounded fragments composed almost entirely of fine-grained pyrrhotite. One of these fragments also contains a small amount of chalcopyrite.

The presence of subrounded fragments of fine-grained sulfides up to several inches in size in an environment such as this is interpreted as evidence that massive sulfide lenses were deposited during deposition of the volcanic rocks and that these lenses were shortly thereafter disrupted by explosive episodes. No evidence is available to indicate the probable size of these lenses nor the likelihood that any may have survived the period of explosive disruption. No evidence has yet been noted in the form of float or in the basal till sampling to indicate that any lenses suboutcrop on the property. However, in view of the grid spacing involved in the till-sampling (800'x 400'), as compared with the area of a lens likely to be exposed at the erosion surface in a region of steep dips (45^{0}-50^{0}), it is probable that such a lens would go undetected. The fact that most lenses are conformable with the enclosing rocks, taken in conjunction with the fact that the short (400') spacing was aligned along strike, would exacerbate the problem of detection. Lenses which did not suboutcrop would, of course, go undetected regardless of grid spacing and orientation.

In order to overcome these difficulties, a low-level airborne E.M. survey is recommended. Line spacing should be very close (400' if possible) with lines oriented east-west, at right angles to strike. A magnetic survey should be carried out simultaneously as is customary, and should, by the separation of instrument from surface, overcome some of the shortcomings of the West Coast survey which was obviously affected by variations within the uppermost few feet of bedrock and possibly even by the presence of boulders in the till.

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Nature of the Island Copper Deposit and Its Relation to Exploration Strategy

During the logging of DDH-1 I noted a fine-grained dark rock below 664' which seemed to me to be macroscopically indistinguishable from one of the major host rocks at Island Copper. The rock was logged there as andesite based on characteristics observable under a 16x hand lens. (We had no access to facilities for petrographic studies.) Although only locally developed in the 54' section encountered in DDH-1, laminations indicate that the rock is undoubtedly a sediment. Petrographic work by Dr. D.L.Cooke (see appendix 3) confirms this judgement. Dr. Cooke classes the rock as an argillite composed largely of amphibole, alkali feldspar and chlorite. It contains the highest copper content (~~erratic~~) detected in the drilling programme (perhaps as much as several billion tons) now seems (>0.1%)

With this in mind, it ~~is obvious~~ now seems that most of the copper in the Utah deposit may occur in sedimentary rock, and that this sequence, which has been thought to be a moderately south-dipping sequence of volcanics, based on regional attitudes and faulty rock identifications, is probably a very steeply dipping sequence of intermixed mineralized sediments and largely (perhaps completely) unmineralized tuffs and breccias. Drilling in the general area has shown the presence of great volumes of 0.2% rock, some of which is definitely and most of which is probably sedimentary in nature. It now seems reasonable to conclude that the porphyry dike (which can be considered a sill in the light of the above ~~paragraphs~~ comments) has merely effected a local reconcentration in a pre-existing deposit which may be essentially sedimentary in nature. The pre-porphyry deposit may thus be comparable with the Granduc deposit, save for the differences in grade.

In the light of these considerations, attention ~~should pre-~~ might profitably be shifted from the volcanics of the Bonanza Formation to the underlying sediments of the Parsons Bay Formation. Drilling on the Island Copper property long ago showed the sedimentary section to be present far south of its position indicated on ~~the~~ G.S.C. Map 4-1974. The present work has only moved it a short distance further to the south.

As a final note, mention should be made of the Parsons Bay Formation west of Bonanza Lake, where black shale and argillite contains finely banded sedimentary pyrite. One specimen of rock from this area which I submitted for uranium and vanadium assays returned a vanadium assay in excess of 1%. At the time of my work there, I considered this unit to be comparable to the Urquhart Shale of the Mt. Isa region. I feel increasingly optimistic about its economic potential, and would suggest that it be studied on a regional basis.

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Appendix 1

Summary of Drill Hole Logging

DDH-1 (718')

Largely acid breccias. Magnetite and strongly magnetic pyrrhotite common. Some of the breccia fragments consist entirely of pyrrhotite. Lower section of hole passes through argillite of volcanic derivation, containing copper values up to 0.13%. Dips about 55° in volcanic section, about 30° in sedimentary section.

DDH-2 (759')

Tuffs and flow breccias of intermediate composition. Pyrite very common. Pyrrhotite very minor or absent.

DDH-3 (998')

Sericitized ash tuffs and trachyte sills near top. Magnetite and strongly magnetic pyrrhotite common in tuffs. Below lie acid tuffs and flows with minor intermediate units. Medium-grained intrusive diorite occurs at the bottom of the hole.

DDH-4 (698')

Andesitic tuffs predominate in the upper 200'. Most of the remainder of the hole is in medium-grained intrusive diorite identical to that in DDH-3.

General Observations

The magnetic anomalies in the vicinity of DDH-1 and DDH-3 are obviously due to the presence of the magnetite and pyrrhotite noted in the tuffs and breccias.

Alteration is generally uniform within any particular bed, but widely variable from one bed to the next. This is interpreted to mean that most of the alteration took place during the cooling of each unit in sequence. (Alteration is used here in the sense of reaction between fragments and groundmass as evidenced by the diffuseness of fragment borders.)

Numerous fragments show the development of secondary very-fine-grained light brown biotite. Although its occurrence in this mode may reflect a preferential alteration of certain lithologies present within the heterogeneous fragment content, I gained the general impression that the alteration predated the period of fragmentation which led to the development of the breccia.

The distribution of epidote, biotite, magnetite and pyrite, indicate that mineral zoning is present. Data are insufficient to allow any geometrical characterization at this time.

Appendix 2

Reported Occurrence of Andalusite

Petrographic section # 22168 was originally examined by Peter Folk who reported the presence of small crystals of andalusite (20%) in a groundmass of quartz (amount unspecified), sericite (50%), biotite (trace) and opaque minerals (5%). In view of this uncharacteristic setting for the occurrence of andalusite, Dr. D.L.Cooke was asked to reexamine the slide. His examination was brief and his volume estimates can only be considered as first-order approximations, but his mineral identifications are believed to be accurate. He reported as follows:

Rock appears to be an altered tuff.

40% sericite
20% fine-grained alkali feldspar
20% fine-grained secondary brown biotite
10% quartz as crystals 2-3mm.
8% disseminated pyrite
2% magnetite

It would appear that Folk mistook the fine-grained alkali feldspar for quartz and called the larger quartz grains andalusite.