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Kennecott Exploration, Inc.

Exploration Services Department

Geologic Research Division

March 1, 1971

MEMO TO: Ralph C. Holmer

FROM: John C. Wilson

SUBJECT: Igneous Activity and Mineralization at B.C. Molybdenum, Ltd.

Bob Galbraith describes his current hypothesis for the relationship between intrusion and mineralization in the Lime Creek orebody at Alice Arm, British Columbia. Two intrusions, each with an associated triplet of vein types, form the portion of the stock observed at the surface and in the drill core. The first is a zoned diorite to quartz monzonite pluton, and the second is a system of closely spaced dikes of quartz monzonite.

Bob states that a third and youngest set of MoS_2-related veinlets is observed, but no intrusion is known to relate to this mineralization unless it is the so-called wipeout porphyry observed in DH-27, or the dike system is composed of two genetic parts. Ni and Co geochemistry are permissive of an additional nonoutcropping intrusion on the north-northeast side of the present pit.

This memo is a progress report on this research project and will be modified and fully documented as the investigation progresses.

John C. Wilson /gp

John C. Wilson

JCW:gp
Attachment

cc: R. M. Galbraith
D. L. Giles
C. T. Penney

February 24, 1971

MEMO TO: John C. Wilson

FROM: Robert M. Galbraith

SUBJECT: Igneous Activity and Mineralization at B.C. Molybdenum, Ltd.

The igneous intrusions and respective mineralization can be explained on the basis of experimental studies of the system $NaAlSi_3O_8$-$KAlSi_3O_8$-$CaAl_2Si_2O_8$-SiO_2. The only special condition necessary is that the magma be rich in calcium. This condition would enlarge the field in which plagioclase will crystallize and reduce both the K-feldspar field and the quartz field.

For purposes of this discussion, two intrusions will be referred to. The first will be called the original intrusion. This is the main stock in which mineralization occurs. It is bounded on the west, north, and east by hornfels. The south boundary is indefinite at present. It could be close to the south limit of mineralization or it could be the igneous hornfels contact farther to the south. Further study may indicate that the mineralization control on the south side of the orebody is an igneous contact. If so, the main stock described by earlier reports will have to be subdivided. The second intrusion referred to in this study is a porphyritic dike complex. The dikes are younger than the mineralization in the original stock but they are also mineralized.

The original intrusion is a classic zoned pluton. Chill effects along hornfels contacts have caused a diorite to crystallize. This is characterized by highly zoned plagioclase crystals growing in complex clusters which make up 70% of the rock. Hornblende and biotite make up 20% of the rock, with K-feldspar and minor quartz making up the rest. The K-feldspar appears to have crystallized slowly, for it often forms crystals up to three-eighths of an inch across. These crystals, however, do not produce a porphyritic texture. Instead, they are an intratelluric matrix surrounding plagioclase and mafic grains and having crystalline and optical continuity. These K-feldspars will not be seen in hand samples unless a cleavage surface reflection reveals its presence. Such crystals could only precipitate in a static, nearly isothermal, and relatively volatile-charged environment.

The composition of the original intrusion grades to a more acid composition toward its center. The overall bulk of the intrusion is a granodiorite; nevertheless, toward the center, the composition verges on quartz monzonite. Interestingly, the K-feldspar grains seen in the diorite become more conspicuous, although they never developed to the point of interrupting the fabric and changing the texture of the rock from equigranular to porphyritic. The large K-feldspars usually include fine bits of plagioclase or mafic crystals. The inclusion of these bits causes the overall equigranular appearance of the hand specimen to be uninterrupted by the K-feldspars.

Magma differentiation continued until a residual liquid of virtually nothing but quartz, K-feldspar, metallic sulfides, and a very minor amount of plagioclase remained. The cooling crystalline shell around this residual liquid cracked, releasing the liquid which rapidly cooled, filling the cracks with alaskite dikes which sometimes contain minor plagioclase and some MoS_2 mineralization.

The residual liquid after removal of the alaskite fraction was comprised of K-feldspar, abundant quartz, and metallic sulfides. These were used up as subsequent fracturing of the cooling shell took place. First, quartz veins with the remaining K-feldspar were formed. It was probably during this period that most of the clay alteration took place. This was followed by the formation of quartz veins with MoS_2 mineralization, which in turn was followed by the last bit of liquid, forming quartz veins with sporadic pyrite mineralization.

An important question has arisen as to the ability of a diorite magma to generate this much quartz, K-feldspar, and water through fractional crystallization. The answer is that it probably wouldn't, at least not to the degree seen in this mineral deposit. The additional quartz, K-feldspar, and water must have come from the Bowser sediments. The intrusion must have been at least partially emplaced through assimilation of the overlying rock. Evidence of this is demonstrated by the many xenoliths of Bowser sediments seen in the pit walls and drill core. Not all the sediments are of the right composition to be susceptible to digestion by this magma; however, many xenoliths were seen to be partially or almost entirely assimilated. The second enrichment mechanism was most likely through the development of convection cells in the meteoric water in the Bowser sediments. Such cells would be developed due to the heat of the magma. These cells would introduce water that would be at least partially charged with potassium and silica into the magma.

The second intrusion is probably derived from a magma similar to the first and in the same general locus. This magma, however, produced a series of dikes rather than a zoned stock at the present exposure level. The dikes all have an aplitic K-feldspar-quartz groundmass. The variation in porphyritic crystal assemblages is gradational in much the same fashion as the original intrusion. This is demonstrated by three characteristic assemblages, but intermediate assemblages indicate a continuous sequence. First, very highly zoned plagioclase crystals form complex clusters, and many small plagioclase grains are in the matrix. The second assemblage has moderately zoned plagioclase crystals, small rounded quartz grains or eyes, and K-feldspar crystals that include mafic and plagioclase bits with the outer rim containing quartz blebs. The third assemblage has small plagioclase grains with very little zoning, large K-feldspar crystals, and larger quartz eyes up to 4 mm.

The dikes cut both hornfels and the original intrusion, but were not found to cut each other. It is postulated that they were emplaced almost contemporaneously and that variations in the porphyry assemblage are due to fractionation of the parent magma during emplacement. These dikes are mineralized by a triplet of quartz-K-feldspar, quartz-MoS_2, and quartz-pyrite veins. It is not possible to distinguish these veins from the ones related to the original intrusion without the aid of an igneous contact truncating the older veins.

This petrologic concept explains all the features seen in the pit except one. There is a third triplet of quartz veins which is younger than the set associated with the second intrusion. This triplet differs from the other two in that sometimes the quartz-MoS_2 veins show multiple banding and are up to 2 inches wide.

A third intrusion genetically related to this third triplet may exist. This intrusion may be what has been referred to as the "wipeout" porphyry and was first noted in drill hole 27 on the northeast side of the pit. However, since drill hole 27 does not encounter ore-grade mineralization in the hornfels, it is difficult to say this porphyry is displacing mineralization. The intersection of the igneous hornfels contact in drill hole 27 is some 250 feet northeast of the igneous hornfels contact exposed in the pit, and some 150 feet northeast of the ore zone. This composite porphyry appears to be little different from the dikes of the second intrusion. This similarity and the lack of mineralization above it casts doubt on this rock being the source of the third triplet.

A more distinct possibility is that the dikes of the second intrusion are actually related to two magmas. Contacts are difficult to see in the pit, and we could have missed crosscutting relationships. However, everywhere we looked, the younger dikes had two sets of crosscutting quartz veins. Thus, the source of the last period of molybdenum mineralization is unresolved.

The distribution of lower grade areas in the ore zone seems to be related to the distribution of younger intrusive dikes. These dikes are mineralized by only two triplet sets of quartz veins. The best ore grades are where the original intrusion is mineralized by the alaskite dikes and three triplet sets of quartz veins. The density of porphyry dikes is greatest in the northern third of the ore ring. This is also the area where ore grades drop off and the ore zone as presently evaluated is only 150 feet wide.

Geochemical anomalies in Ni and Co indicate the possible presence of an intrusion under the hornfels on the north-northeast side of the present pit. Perhaps this is the source of the younger intrusive dikes. The possibility also exists that this is a third intrusion and the source of the last mineralization triplet. Hopefully, the drill core and hand samples in shipment from B. C. Molybdenum will lead to a solution of this quandary.

Bob

Robert M. Galbraith

RMG:ms