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Ronald Wynn Sheets  
November 19, 1994

Dr. Robert Boyd  
Chairman, Cordilleran Roundup  
Suite 500  
1090 W. Pender  
Vancouver, B.C. V6E 2N7

Dear Dr. Boyd:

First, I must apologize for our conversation on the telephone. I was mistaken about the format of the Cordilleran Roundup. During our conversation I was under the impression that your meeting was soliciting talks from all groups working on mineral deposits in B.C. I am sorry about the misunderstanding. Our group is interested in presenting posters regarding our research on the porphyry Cu (Mo) deposits in west-central B.C. I have included a couple of abstracts outlining some of our recent findings. The group is headed by Dr. Bruce Nesbitt with the research being conducted by myself, as a postdoctoral fellow, and Mr. Henry Tebar, a Ph.D. candidate. My research includes investigating the geological and geochemical similarities and differences between the Babine Lake porphyry Cu deposits and prospects to see if there exist recognizable differences between highly mineralized and poorly mineralized to barren porphyritic intrusions. Mr. Tebar is investigating the transition from porphyry style mineralization to epithermal mineralization by investigating the Berg porphyry Cu deposit, Equity Silver, as an example of intermediate style mineralization, and the Silver Queen epithermal system. Maybe you could pass this information along to the person in charge of the poster sessions for us. Thank you for your assistance.

Sincerely,

*Ronald Wynn Sheets*  
Ronald Wynn Sheets

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No 24734

## BIOTITE CHEMISTRY AND OXYGEN ISOTOPE RATIOS FROM PORPHYRY-STYLE MINERALIZATION, NANIKA SUITE, WEST-CENTRAL B.C. (CANADA)

TEBAR, Henry J., NESBITT, Bruce E. and MUEHLENBACHS, Karlis, Department of Geology, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3

Microprobe and oxygen isotope analyses were conducted on Carter's (1981) biotite specimens from three ~50 Ma quartz monzonite stocks in west-central B.C. The intrusives, which belong to the Nanika Plutonic Suite, host minor (Equity Silver) and major (Berg) porphyry Cu-Mo, and major (Red Bird) porphyry Mo-type mineralizations. At Equity Silver, a major Ag-Cu-Au-Sb porphyry-epithermal ore body lies ~1.6 km from the stock. Texturally, the biotites range from small euhedral laths to highly corroded poikilitic tabular grains. The biotites have been subdivided into two groups: Group I biotites are present in potassic and propylitic alteration assemblages, and Group II biotites are hosted by phyllic alteration assemblages. In all deposits, as the TiO<sub>2</sub> contents of the biotites increases from 3.0 to 5.0 wt.%, Group I biotites decrease in X<sub>Mg</sub> from 0.6 to 0.5 and Group II biotites increase in X<sub>Mg</sub> from 0.6 to 0.7. In addition, the TiO<sub>2</sub> contents of the biotites always decrease from weak to strong porphyry Cu-Mo to porphyry Mo. The decreasing TiO<sub>2</sub> trend is also accompanied by increasing δ<sup>18</sup>O ratios from 4.6 to 5.8‰ (Group I biotites) and from 2.6 to 5.1‰ (Group II biotites). However, the porphyry Mo has distinctly higher X<sub>F</sub>/X<sub>Cl</sub> and lower X<sub>Cl</sub>/X<sub>OH</sub> ratios, compared with both the weak and strong porphyry Cu-Mo, which show similar F and Cl molar ratios. There is only a small variation in the Cl content of biotites from the cores towards the edges of the individual deposits, particularly in the porphyry Cu-Mo, which differs from observations on the porphyry deposits of the Babine Suite, west-central B.C. (Sheets et al., 1994). The results indicate consistently different "within-suite" mineralogical and isotopic variations between porphyry Mo and Cu-Mo mineralizations, but no clear-cut differences between strong and weak porphyry Cu-Mo mineralization.

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## **Comparative Geology and Mineral Chemistry of Mineralized and Barren Plutons of the Babine Lake Suite.**

Ronald Wynn Sheets and Bruce Nesbitt

Department of Geology, University of Alberta, 1-26 Earth Science Building, Edmonton, Alberta, Canada T6G 2E3

Porphyry Cu ( $\pm$ Mo $\pm$ Au) mineralization in the Babine Lake area of west-central British Columbia is genetically related to biotite-(hornblende)-feldspar-porphyry (BFP) intrusions of the Eocene (48-55 Ma) Babine Lake Suite. More than a dozen copper-bearing deposits and prospects are known to occur in the Babine Lake area. Although most of the copper-bearing zones have sub-economic grades, two (Bell and Granisle) have been mined with a combined production of over 150 million tons with grades averaging 0.5% Cu. An additional five deposits have copper grades between 0.4% (Morrison) to 0.1% (Nak Lake, Dorothy, Old Fort and Trail Peak) and the remainder contain only traces of copper. Unmineralized BFP intrusions and their extrusive equivalents have been identified throughout the Babine area.

Babine intrusions are comprised of a number of small stocks, plugs and dike swarms localized at the intersection of regional NW and NE sets of graben related faults. Initially near circular quartz diorite to quartz monzonite intrusions were emplaced in Jurassic to Cretaceous sedimentary and volcanic host rocks. These intrusions were followed in quick succession by a large number of phases of the granodioritic BFP intrusions, which are evident in each copper-bearing zone by cross-cutting relationships. These intermineral BFP intrusions are chemically equivalent to one another and differ only in appearance due to different abundances of phenocrysts and of groundmass grain size. The typical BFP consists of a crowded porphyry containing 35 to 50% phenocrysts of biotite, hornblende and zoned plagioclase in a fine-grained matrix of plagioclase, quartz, K-feldspar, and minor biotite. Apatite and titaniferous magnetite occur as accessory minerals.

Alteration of the Babine Lake copper zones is consistent with the classic Lowell and Gilbert model. Potassic alteration is characterized by the addition of dark brown, medium- to coarse-grained biotite that forms pseudomorphs after amphibole and occur disseminated throughout the groundmass in the inner potassic zone and greenish, fine-grained and slightly chloritized biotite in the outer potassic alteration zone. The occurrence of brown, coarse-grained biotite corresponds to the high grade mineralization ( $>0.3\%$  Cu, chalcopyrite+bornite) with green biotite corresponding to lower grade mineralization ( $<0.3\%$  Cu, chalcopyrite only). Original biotite phenocrysts in the potassic alteration zone exhibit only slight alteration on the rims. Potassium feldspar and hydrothermal amphiboles occur in the potassic alteration assemblage of the Granisle and Nak Lake deposits. Phyllic alteration assemblage consists of sericite-carbonate-pyrite $\pm$ quartz which replaces most mafic minerals and feldspar, however rare biotite phenocrysts may survive. All copper zones have extensive sericite-carbonate alteration, but only Bell has a true phyllic (sericite-quartz) alteration which overprints the potassic alteration. Propylitic alteration consists of an inner zone where mafic minerals are partially to completely replaced by chlorite+carbonates and an outer zone of partial chlorite replacement.

The mineral chemistry of biotite from both mineralized and barren intrusions has been measured using the electron microprobe. Biotite phenocrysts are characterized by high TiO<sub>2</sub> ( $\geq 4.0$  wt.%), low Mg/(Fe<sup>+2</sup>+Mg) [0.51], Al<sup>IV</sup> deficiencies and low Cl contents [ $\log(X_{OH}/X_{Cl})=-2.3$ ]. Hydrothermal biotite, which is texturally distinct from magmatic biotite, has low TiO<sub>2</sub> ( $<4.0$  wt.%), high Mg/(Fe<sup>+2</sup>+Mg) [0.75] and high Cl [ $\log(X_{OH}/X_{Cl})=-1.6$ ] all of which decrease away from the high grade ore zone. Brown

hydrothermal biotite has higher  $\text{TiO}_2$  and  $\text{Mg}/(\text{Fe}^{2+}+\text{Mg})$  than green hydrothermal biotite, but both have essentially the same Cl content. The biotite phenocrysts and hydrothermal biotite in the potassic alteration assemblage have re-equilibrated to a single Cl content and this value is the same for all copper zones irrespective of the economic grade. Resetting of the Cl concentration for magmatic biotite occurs without any change in texture or major element oxide chemistry. The zonation of Cl concentration from highest in the high grade zone to lowest at the deposit edge is also consistent for all deposits studied irrespective of economic grade.

Previously published Cl chemistry for biotite in porphyry Cu and Mo deposits have shown that all biotite, both magmatic and hydrothermal, equilibrated with a single fluid at a single temperature. These previously published results are from deposits that are meteoric-fluid-dominated systems during late stage alteration. The Babine Lake area is unusual in that the Cl content of biotite appears to map either changes in fluid chemistry or changes in alteration temperature across each copper-bearing zone. This implies that high temperature biotites in the Babine Lake area did not continue to exchange halogens with late stage fluids. Thus the Cl content of biotite may provide additional constraints, with stable isotope geochemistry, for distinguishing between magmatic and meteoric fluid components of the Babine Lake copper-bearing zones.