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Over the past five months my research has concentrated on differentiating between metamorphic and hydrothermal processes at the Trout Lake deposit. Over 70 samples were selected for thin section examination from the area surrounding the ore deposit, which I mapped during the summer of 1982. In a few cases it was apparent that rock types had been misidentified in the field: at sta. 82-24 "metavolcanic" is a calc-silicate schist, at sta. 82-51 "silicified biotite schist" is a calc-silicate schist, and at sta. 82-106 "phyllite" is a calcareous phyllite. These changes in lithology prompted a new geological map to be interpreted, a copy of which accompanies this report.

Three faults on Copper Chief, Lost Trail, and Main Creeks are necessary in order to explain the distribution of the carbonate unit. A well defined anticline exists between Main and Lost Trail Creeks, which was previously interpreted as a syncline. By considering the structure and topographic expression a syncline would be possible only if its plunge is significantly greater than forty-five degrees, which is not a likely explanation from the available structural data.

Mineral assemblages were identified from the thin sections I had prepared, and were supplemented by those collected by Psutka, Read, and Fyles in 1981. On the basis of the mineral assemblages metamorphic reactions were written and isograds interpreted. In general, reactions involving carbonate and calc-silicate minerals proved more useful. The main problem has been finding reactions that involve the non-calcareous silicified biotite schist, which hosts the ore deposit.

To date the most useful idealised reactions are for the system  $MgO$ ,  $SiO_2$ ,  $Al_2O_3$ ,  $K_2O$ ,  $CaO$ ,  $H_2O$ ,  $CO_2$ , and are listed below:

- 1)  $3 \text{ muscovite} + 4 \text{ calcite} + 8 \text{ quartz} = 2 \text{ zoisite} + 3 \text{ K-feldspar} + 4 \text{ CO}_2 + 2 \text{ H}_2\text{O}$
- 2)  $3 \text{ chlorite} + 10 \text{ calcite} + 21 \text{ quartz} = 2 \text{ zoisite} + 3 \text{ tremolite} + 10 \text{ CO}_2 + 8 \text{ H}_2\text{O}$
- 3)  $5 \text{ phlogopite} + 24 \text{ quartz} = 3 \text{ tremolite} + 5 \text{ K-feldspar} + 6 \text{ CO}_2$
- 4)  $\text{muscovite} + 2 \text{ zoisite} + 2 \text{ quartz} = 4 \text{ anorthite} + \text{K-feldspar} + \text{H}_2\text{O}$

In general these reactions are not driven to completion but rather the highest temperature assemblages found correspond to equilibrium conditions between all phases, although less commonly the lower temperature phases have been depleted (ie. the reactions have persisted over a range of conditions). In the field it was speculated that a chlorite-biotite isograd could be mapped. However, biotite in varying quantities has been found in all phyllites inspected. All four of the above reactions result in isograds of similar shape. A well defined aureole is developed around the quartz diorite dyke located between the Main and Lost Trail creeks. From the size of the aureole it can be

NB  
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NC

estimated that a pluton of at least 100 meters in diameter exists at depth. The oval shape of the aureole may be due to topographic effects, a pluton which plunges to the northwest, or a combination of both. The quartz diorite dyke is only 1 meter thick at surface which is much too small to cause the observed aureole. Because the orebody is at the intersection of the quartz diorite and granodiorite, the intersection of this small dyke with the speculated pluton at depth is a good exploration target. The result of AMAX drilling on the northwest side of Wilke Creek, where granodiorite was intersected, supports the hypothesis of a pluton at depth, and is an encouraging sign for the above exploration target.

Textural evidence such as clinozoisite reaction rims around pyroxene, and carbonate inclusions in chlorite suggests possible retrograde contact metamorphism. In examining the thin sections collected by Psutka, Read, and Fyles I conclude that in all cases the occurrence of diopside is due to hydrothermal processes, and thus it cannot be considered part of the metamorphic assemblage, but rather can only mark the extent of hydrothermal alteration.

Defining metamorphic aureoles around the actual deposit has proved more difficult owing to lack of suitable reactions in the silicified biotite schist, and lack of exposure east of the deposit outside the contact aureole. Contrary to conclusions made in the field, the rocks west of the Z fault appear to be of higher metamorphic grade, thus if any vertical movement has occurred along the fault the eastern block (mine slice) would have been downdropped. The plotting of the isograd from reaction # 4 results in the best defined isograd. However, this may be suspect because of the difficulty in distinguishing metamorphic from hydrothermal feldspars. Additional thin sections are now being prepared from locations closer to the ore deposit in an effort to define better any contact aureoles.

In order to solve the question as to whether the "biotite halo" around the deposit is of metamorphic or hydrothermal origin, chemical compositions of various biotites were determined by electron microprobe analysis. Samples were collected both from within the adit and from diamond drill core.

In porphyry environments hydrothermal biotites are characterized by  $Mg/Fe > 1.5$  (Beane, 1974). At the Henderson deposit, biotites of the potassic alteration zone have  $Mg/Fe$  of 0.92-1.13, and the hydrothermal biotites have  $Mg/Fe$  of 1.27-2.45 (Gunow, Ludington, and Munoz, 1980).

Biotites from within the "biotite halo" at Trout Lake have  $Mg/Fe$  of 0.63-0.81, with metasedimentary biotite from outside the deposit having  $Mg/Fe$  of 0.68. This suggests that all the biotite is metamorphic in origin, and is not part of a potassic alteration event. When seemingly different biotites from sample 4 Dr.S. 13 were analysed, the "halo" biotite in contact with a quartz-plagioclase vein was the same composition as the "metasedimentary" biotite, implying that no re-equilibration occurred during hydrothermal alteration, and that most biotite was formed during metamorphism.

The only exception to the low-Mg biotites is from sample 81-60 203.5m, where the  $Mg/Fe$  is as high as 1.86. Texturally, a



well developed biotite halo around a quartz vein also indicates a hydrothermal origin. However in this case the biotite is replacing tremolite therefore its composition may only reflect the composition of the mineral it has replaced, rather than representing any Mg metasomatism, but it is likely that K metasomatism ( potassic alteration ) has occurred in this case.

The flourine content of biotites was also determined, however the reproducibility is poor owing to concentrations of near background level. Results, if taken semi-quantitatively indicate that the flourine content in the biotites is not anomalous, as is the case for Climax-type deposits, and thus no attempt will be made to improve the analytical methods. It is interesting to note that the only biotite suspected of being hydrothermal ( 81-60 203.5m ) also has the highest flourine content, however this is still relatively low ( 1.1 wt% ) when compared to biotites from the Henderson deposit which range up to 7 wt% flourine ( Gunow, Ludington, and Munoz, 1980 ).

Current research is still addressing the problem of metamorphism versus hydrothermal alteration, and investigation into the origin and significance of the various feldspars at the deposit is in progress.

#### REFERENCES

- Beane, R.E., 1974, Biotite Stability In The Porphyry Copper Environment: Econ. Geol., vol. 69, p. 241-256.
- Gunow, A.J., Ludington, S., and Munoz, J.L., 1980, Flourine In Micas From The Henderson Molybdenum Deposit, Colorado: Econ. Geol., vol. 75, p. 1127-1137.

#### MICROPROBE ANALYSES OF BIOTITES

WT %	4 Dr.S 13m	81-60 203.5m	81-33 90m	820m	1346m	1498m
FeO	22.82	15.95	22.68	21.93	19.45	17.11
SiO <sub>2</sub>	32.17	37.08	34.70	34.76	35.09	36.09
CaO	0.04	0.01	0.08	0.01	0.00	0.00
TiO <sub>2</sub>	2.38	1.50	3.74	2.07	2.75	3.49
MnO	0.06	0.17	0.30	0.44	0.08	0.28
Al <sub>2</sub> O <sub>3</sub>	18.91	15.53	16.91	18.61	18.50	16.02
K <sub>2</sub> O	9.02	9.44	8.16	9.94	9.03	9.60
MgO	8.05	13.71	8.22	8.37	9.45	11.51
Cl	0.04	0.03	0.03	0.01	0.01	0.03
F	0.20	1.13	0.69	0.34	0.35	1.03
total	93.50	93.45	94.88	96.15	94.36	94.35

\* note F and Cl are not included in the wt % total because data is calculated for cation totals based on 22 oxygen atoms, addition of water + Cl + F ( approximately 4 wt % ) will give true totals.