A Note on Ti-Rich Secondary Biotite in the Hareidlandet Eclogite*

BJØRN MYSEN

Mysen, B.: A note on Ti-rich secondary biotite in the Hareidlandet eclogite. *Norsk Geologisk Tidsskrift,* Vol. 52, pp. 201–202. Oslo 1972.

Unusually Ti-rich biotites associated with magnetite and andesine in coronas around eclogite garnets have been analyzed by electron microprobe. The Ti content is correlated with the physical conditions of formation of the biotite-bearing coronas.

B. Mysen, Mineralogisk-geologisk museum, Sars gate 1, Oslo 5, Norway. Present address. Department of Geosciences, 228 Dieke Building, the Pennsylvania State University, University Park, Pa.16802, USA.

The eclogite around Ulsteinvik on Hareidlandet is essentially free from primary biotite. However, in the retrogressed amphibole zone along eclogite/gneiss margins, secondary biotite constitutes up to 5% (modal) of the mineral assemblage.

The biotite is a member of a reaction assemblage formed by a four-step breakdown of eclogite garnets (Mysen 1971) where the reaction leading to the major amphibolitization of the eclogite garnet and associated minerals also gives the reactants for the biotite-forming reaction. Biotite has probably been formed by a reaction of this kind:

$$\underset{\text{amphibole}}{2NaCa_5(Fe,Mg)_9AlSi_{12}Al_4O_{44}(OH)_4} + 2K_2O + 7Al_2O_3 + 8SiO_2 + \underset{\text{Ti–mt}}{(Fe,Ti)_3O_4} =$$
$$\underset{\text{biotite}}{2K_2(Fe,Mg)_6(Al,Ti)_2Si_6O_{20}(OH)_4} + \underset{\text{plagioclase}}{5CaAl_2Si_2O_8} + Na_2O + 6MgO + \underset{\text{mt}}{2Fe_3O_4}$$

where the amphibole + oligoclase + Ti-rich magnetite (sometimes ilmenite occurs instead) assemblage is transformed to biotite + andesine + Ti-poor magnetite. The reaction is characterized by a basification of the plagioclase and extraction of Ti from the oxide. The biotite formed is high in Ti (Table 1) and probably incorporated the liberated titanium. The Ti content is higher than commonly observed in biotites (Deer et al. 1963). Similar contents, however, were noted by Bhattacharyya (1970) and Leelandum (1970) in reaction biotites formed at relatively high pressure and at a temperature just below 500 °C in Indian charnockitic rocks. The reactant oxide, here called Ti-mt (titanium-rich magnetite), is often ilmenite with essentially no hematite solid solution. This ilmenite coexists with Ti-poor magnetite and reference to Lindsley's (1963) experimental work on Fe-Ti-oxides suggests $T \leq 500$ °C

---

* Publication No. 45 in the Norwegian Geotraverse Project.

Table 1. Electron microprobe analyses of secondary biotites in the Hareidlandet eclogite. Structural formulae are calculated on a dry basis.

	UA7014/2	UA7014/5
SiO_2	37.9	37.2
TiO_2	5.8	6.0
Al_2O_3	17.9	16.6
FeO*	9.7	11.4
MnO	0.05	0.05
MgO	16.7	15.1
CaO	n.d.	n.d.
K_2O	8.8	9.5
Sum	96.8	95.8
	Structural formulae (0=22)	
Si	5.39	5.43
Ti	0.62	0.66
Al	3.00	2.90
Fe	1.15	1.33
Mn	–	–
Mg	3.54	3.31
Ca	–	–
K	1.60	1.72

* Total iron as FeO.
n.d. Not detected.

and a very low oxygen fugacity ($< 10^{-15}$ atm) at the time of crystallization. The correspondence in temperature between this approach and the data from the Indian charnockite biotite is notable. The Hareidlandet eclogite biotites probably formed at pressures just below 5 kb at $P_{eH_2O} < P_L$ (Mysen 1971), which would also be comparable to the Indian biotites (Bhattacharyya 1970). It is suggested that the Ti content is a reflection of the physical conditions of formation of the biotite.

Acknowledgement. – The Norwegian Foundation for Science and Humanities (NAVF) supported the electron microprobe work.

September 1971

REFERENCES

Bhattacharyya, C. 1970: Pyroxene and biotite from the charnockitic rocks of the Garbham area, Srikakulam district, Andhra Pradesh. *Indian Mineral. Mag. 37,* 682–692.

Deer, W. A., Howie, R. A. & Zussman, J. 1963: *Rock-Forming Minerals. Vol. 3, Sheet Silicates.* Longmans, London. 270 pp.

Leelandum, C. 1970: Chemical mineralogy of hornblendes and biotites from charnockitic rocks of Kondapalli, India. *Jour. Petrology 11,* 475–505.

Lindsley, D. H. 1963: Fe-Ti-oxides in rocks as thermometers and oxygen barometers. *Carnegie Inst. Washington Yearb. 62,* 60–66.

Mysen, B. O. 1971: Petrology and geochemistry of eclogite and surrounding rocks around Ulsteinvik on Hareidland, Western Norway. Unpubl. cand. real. thesis, Universitetet i Oslo. 165 pp.