Experimental study of dehydration melting of F-bearing biotite in model pelitic compositions

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Introduction

Biotite in granulite facies gneisses is typically F- and Ti- rich, which suggests that these components have a significant effect on its high temperature stability limit. Both field and petrographic observations and experimental work point towards dehydration-melting reactions marking the upper temperature breakdown limit of biotite under relatively low a_{H_2O} granulite facies conditions. We describe results of an experimental study of the F- effect on biotite thermal stability.

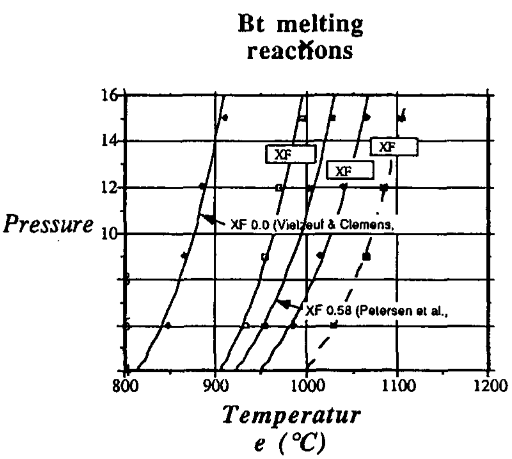
Experimental Results

Dehydration melting experiments of F-biotite with variable F/OH ratio have been carried out to evaluate the F-effect on the thermal stability of Mg-rich biotite (Mg/Mg + Fe = 0.75) in a model pelitic composition with excess quartz, sillimanite and K-feldspar.

Finely ground mixes containing synthetic F-biotite (F/F+OH= 0.1, 0.3, 0.6) were run with seeds of natural Mg-rich garnet and sapphirine.

The three mixes with variable F/OH were run simultaneously in $Ag_{30}Pd_{70}$ capsules in a 3/4 inch piston cylinder apparatus. Run durations were 200-400 hrs at 850-950°C.

The fine grained run products were examined



optically and by SEM. Changes in the relative proportions of minerals were monitored by X-ray powder photography.

At 9 kbar biotite disappears at 950, 1015 and 1045°C with increasing F/F+OH of 0.1, 0.3 and 0.6 respectively (see Figure; note that the curve for pure OH-biotite, Carrington & Harley (in prep.) lies about 30°C above the phlogopite + quartz curve of Vielzeuf and Clemens, 1992).

At low temperature, the assemblage biotite-sillimanite-K-feldspar-quartz-minor garnet is found. Cordierite appears and K-feldspar disappears at about 930°C, suggesting partial melting starts between 900 and 930°C. Cordierite disappears and sapphirine grows in the presence of quartz at 1000°C in the the most F-rich mixes, but cordierite persists to 1000°C in the F-poor mix, in which sapphirine appears only at 1025°C. Orthopyroxene is found in addition in most sapphirine-bearing runs.

The occurrence of osumilite is erratic. It was found with biotite at 950°C and 7kbar and with garnet and orthopyroxene at 1025°C and 9kbar, but only in one mix in each case.

The exact stability ranges of these various assemblages which coexist with liquid and excess quartz and sillimanite are currently under investigation.

The early disappearance of K-feldspar in these experiments suggests that the melting reaction may involve this phase on the low temperature side, ie. biotite + sillimanite + K feldspar + quartz = H_2O undersaturated liquid + cordierite + garnet.

Application to granulite facies rocks

All of the assemblages encountered in this study are found in the very high temperature granulites of the Napier Province and the Rauer Islands (review in Harley and Hensen, 1990), eastern Antarctica and several other such terranes. These rocks may all have lost a low melting fraction during prograde heating when biotite progressively broke down to melt plus garnet, cordierite, orthopyroxene and sapphirine with increasing temperature. At pressures below 10 kbar osumilite appears in very magnesian bulk compositions as one of the products of biotite breakdown (this work, and Carrington & Harley in prep.).

The effect of F is to extend biotite stability to significantly higher temperature. The actual biotite composition in the melting interval in each mix remains to be determined. The data indicate that biotite can be stable up to 1000°C and 9kbar with sapphirine and quartz in rocks of appropriate bulk composition by the fractionation of available F into biotite during partial dehydration melting. The wide spread occurence of biotite even in the highest temperature rocks does not therefore imply these rocks did not reach the high temperatures indicated by their anhydrous mineral assemblages, eg. sapphirine-quartz and aluminous orthopyroxene-sillimanite-quartz.

References

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