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Comparing experiments and pseudosections: testing thermodynamic data bases and constraints on mica activity relations in the high-P/high-T granulites in the Southern Bohemian Massif

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Large bodies of felsic high-P/high-T granulites with the assemblage quartz + ternary feldspar (mesoperthite) + garnet + rutile ± kyanite occur in the Southern Bohemian Massif. They are thought to have formed during the Variscan orogeny in a Carboniferous subduction setting, at 950 – 1050˚C and 1.5 – 1.9 GPa, from granitic protoliths. In order to assess the processes of high-P/high-T granulite formation, fluid-absent piston cylinder experiments were conducted. We used a granitic gneiss as starting material with the assemblage K-feldspar + plagioclase + quartz + biotite + muscovite, whose chemical composition almost perfectly matches the main granulite type of the Southern Bohemian Massif. The experimental conditions were chosen to simulate the metamorphic P-T path determined for the granulites, with runs at 750˚C/1.6 GPa, 800˚C/1.6 GPa, 850˚C/1.6 GPa, 900˚C/1.6 GP and 1000˚C/1.6 GPa (prograde path) and 950˚C/1.4 GPa, 900˚C/1.2 GPa and 800˚C/1.2 GPa (retrograde path). The experiments in the temperature range of 850 – 1000˚C all yielded the typical granulite assemblage garnet + ternary feldspar + quartz ± kyanite ± rutile. The melt-forming reaction observed in the experiments is: biotite + plagioclase + quartz = garnet + ternary feldspar + melt. At pressures of 1.6 GPa, this reaction commences at temperatures >750˚C and goes to completion between 800˚C and 850˚C. In the isobaric section at 1.6 GPa, both biotite and muscovite are present at 750˚C and 800˚C. Up to 850˚C, two feldspars are present in the experiments, albeit with a strong decrease in the modal amount of plagioclase from 18 vol.% at 750˚C to <1 vol.% at 850˚C. In runs at 900˚C

and 1000˚C, Na-rich alkali feldspar is no longer stable and a K-rich alkali feldspar appears instead as the only feldspar phase. Experiments at 1.2 GPa show assemblages and textures similar to runs at 1.6 GPa with biotite being stable at 800˚C and plagioclase consumed by partial melting between 800˚C and 900˚C.

In order to compare the experimental results with theoretical predictions, pseudosections with the program PERPLEX (Connolly & Petrini, 2002) and the database of Holland and Powell (1998) were calculated. The calculated phase relations are in good agreement with the experimental results. The only discrepancy lies in the stability of biotite, which is grossly underestimated in the calculations (prediction is 100˚C lower at 1.6 and 1.2 GPa). Electron microprobe analyses showed that biotite contains up to 5 wt.% TiO_2 and 2 wt.% F. Although Ti contents can be considered empirically in Ti-biotite activity models, no biotite activity model involving F yet exists. The onset of melting also disagrees between the experiments and the theoretical calculations, since melting is in the experiments observed at temperatures 800˚C at 1.6 GPa, whereas calculated phase relations predict melting to start at 700˚C at these pressures. This discrepancy could be due to the application of the melt model to pressures above 1 GPa.

K-rich feldspars are close to $Ab_{28}Or_{72}An_0$ at 750˚C/1.6 GPa and change to $Ab_{48}Or_{47}An_5$ at 1000˚C/1.6 GPa. Coexisting Na-rich feldspars are stable up to 850˚C/1.6 GPa and change from $Ab_{92}Or_2An_6$ at 750˚C/1.6 GPa to $Ab_{63}Or_{30}An_7$ at 850˚C/1.6 GPa. The phase relations and the compositions of the coexisting feldspars are also in agreement with the ternary models used by SOLVCALC (Wen and Nekvasil, 1994) except at 850˚C and 1.6 GPa where SOLVCALC predicts the closing of the alkali feldspar solvus.

References:

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