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Thermodynamic testing of experimental hornfels formation in metapelites

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This study represents a comparison between thermodynamic calculations (pseudosections) and the results of the experimental investigations on low-P/high-T metapelite hornfels formation from the Southalpine domain by Tropper et al. (2016, in preparation). Pseudosection calculations were undertaken in the system KNCFMTiASH using the program THERIAK-DOMINO (De Capitani & Petrakakis 2010) with an updated version of the internally consistent data set of Holland & Powell (1998, data set tcdb55), and extended a-X models concerning the melt phase after White et al. (2001, 2007).
The hornfels experiments were conducted in a hydrothermal apparatus at a pressure of 0.3 GPa over a temperature range between 550°C to 780°C in order to experimentally simulate hornfels formation and compare it to metapelitic hornfelses from Franzensfeste/Fortezza (Wyhlidal et al., 2012) and Klausen/Chiusa (Zöll, 2014) in the Southalpine domain in northern South-Tyrol. As starting materials two natural Brixen quartzphyllite samples were used. One sample W shows a low content of Na2O (0.59 wt.%) and the other sample SP5 has a higher content of Na2O (1.72 wt.%) in its bulk rock composition. The agreement between the calculated and the observed mineral assemblages in the experimental series W is satisfactory since the claculations yield much more plagioclase as is actually present and predict an earlier formation of aluminium silicates (580°C instead of 730°C). Similarly in the SP5 experiments, plagioclase is calculated to be stable in much more experiments as has been observed and the predicted formation of andalusite has also not been observed. In both experiments the calculated formation of cordierite is >650°C which is clearly higher than observed in the experiments. On the other hand temperature of melt formation at 680°C agrees very well with the textural observations in both experimental series. It is also noteworthy that muscovite is more stable in both sets of experiments than in the pseudosection calculations. This discrepancy varies between 30°C and 110°C and could be due to minor F and/or Cl contents in the micas which we did not analyse. Major mineral chemical trends could also satisfactorely be reproduced except for Ti-contents in biotite. Overall the results indicate actually satisfactorial agreement between the observed and thermodynamically stable mineral assemblages but some discrepancies still occur which are mostly due to kinetical reasons (complete old garnet resorption did not take place, inhibited growth of andalusite).
Nonetheless these whole-rock experiments provide valuable information concerning the textural evolution of the natural hornfelses and thermodynamic testing not only helps to constrain equilibrium assemblages but also helps identifying certain non-equilibrium features in the experiments otherwise not detected (e.g. garnet, muscovite stability). The ultimate goal in constraining the metamorphic evolution of these high-grade hornfelses is to reconcile the experimental- and thermodynamic data with field- and petrographic observations. Only this comprehensive approach allows then drawing firm conclusions about the evolution of these high-grade metamorphic rocks.

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