The persistence of memory: experimental simulation of geodynamic processes using natural starting materials

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The metamorphic evolution of a rock can be deciphered using three approaches: 1.) the practical geothermobarometric approach (inverse modelling), 2.) the theoretical pseudosection approach (forward modelling) and 3.) the experimental approach. Whereas with the first two approaches it is possible to constrain several stages of the *P-T-X* evolution but how do we know what assemblage is actually present at desired *P-T* conditions and what is the mineralogical „memory" of a rock? Hence the experimental approach allows the detailed investigation of a distinct *P-T* condition of a rock. Therefore, experimental investigations should be viewed as a forward modelling technique and allow to put additional constraints on the evolution of a rock under defined *P* and *T* conditions and hence represents a snap-shot of a *P-T* point of the evolution of a given rock! For this purpose, simple experiments using natural rocks as starting materials can easily be conducted. The disadvantage of this method lies in the complex chemical compositions of natural rocks and the deviation from chemical end-member systems. Therefore these experiments need to be evaluated not only 1.) in terms of their ability to reproduce the natural observations but also 2.) in their ability to reproduce theoretical calculations. In this study experimental investigations of 1.) collision-related metamorphism of a muscovite-rich quartzphyllite sample (Grt_1 + Ms_1 + Ch1 + Bt_1 + Rt) and 2.) subduction-related metamorphism of a plagioclase-rich quartzphyllite sample (Grt_1 + Ab + Ms_1 + Chl + Ilm) were investigated. 10% of water was added to the experiments to facilitate sufficient reaction progress.

In the first set of experiments four different P-T conditions were chosen to represent a clockwise *P-T* loop: 400°C, 0.8 GPa, 600°C, 1.2 GPa and 500°C, 0.4 GPa. Each P-T condition lastet 8 days. In addition to the 32 days experiment, an additional experiment with a duration of 16 days was conducted, where all four *P-T* conditions were run subsequently. Both experiments yielded the mineral assemblage: $Grt_{2,3}$ + Sta + Ms_2 + Bt_2 + Chl_2 + Ilm. In addition four separate experiments were conducted to identify the characteristic mineral assemblages at each of these *P-T* conditions. Pseudosection modelling using DOMINO-THERIAK yields very good agreement between calculated and observed assemblages except for calculated chloritoid and observed staurolite.

In the second set of experiments a hypothetical P-T path with three different P-T conditions (8 days each) of 500°C 1 GPa, 600°C 1.8 GPa and 500°C 0.5 GPa was simulated experimentally for 24 days. The experiment yielded the complex newly-grown mineral assemblage: $Amp_{1,2,3}$ + Ms_2 + Rt. Ms_2 shows an increase in Si, amp_1 is a Ca-rich glaucophane, amp_2 is glaucophane and amp_3 is cummingtonite. Due to the low temperature, too little time and small amounts of fluid, only incomplete mineral reformations were observed. The comparison with the theoretically calculated paragenes using DOMINO-THERIAK is due to the lack of newly-grwon omphacite and garnet only moderate.

This study shows that forward modelling using whole-rock experiments does indeed yield a mineralogical memory that can be attributed to different P-T stages and thus allows the comprehensive characterization of metamorphic mineral assemblages in a given sample. Thermodynamic testing is still hampered by the complex nature of the bulk compositions of the starting materials.