Thermodynamic Modeling of the Tso Morari UHP Eclogite, NW Himalaya

Pan, R.; Macris, C.A., Menold, C.A.

Thermodynamic modeling is an important technique to interpret metamorphic phase relations and calculate model pressure-temperature (P-T) paths for metamorphic rocks. This study uses representative, coesite-bearing eclogites from the Tso Morari UHP terrane of the NW Himalaya to simulate its prograde metamorphism using multiple modeling programs and thermobarometry. Our modeling yields a peak metamorphism P-T of ~32-33 kbar and ~560-570 °C by the THERMOCALC345 and Theriak-Domino programs (Green et al., 2016), which is ~5 kbar higher in pressure and ~15 °C lower in temperature than that determined by using THERMOCALC333 (White et al., 2007) (~27.8 kbar and ~580 °C). The significantly higher pressure obtained using the THERMOCALC345 and Theriak-Domino is likely a result of the upgrade of thermodynamic parameters of minerals (i.e. garnet $W_{py\text{-}gr}$ and a_{gr}) in the newer a-x relations. The modeled effective bulk compositions and mineral stabilities along the calculated P-T path show different patterns under the two modeling techniques. Modeling by the Theriak-Domino programs is preferred in this case because the results are more consistent with the measured mineral compositions of our rocks. Multiple thermobarometers by garnet-omphacite-phengite, garnet-omphacite, garnet-phengite on the garnet rim, high-Si phengite and matrix omphacite yield a peak metamorphism of ~ 28.5-29.0 kbar and ~ 650-728 °C, which is generally consistent with the modeled P-T path.

Based on our model calculations, the initial bulk composition measured by XRF does not represent the reactant bulk composition at the time of garnet nucleation, and this compositional discrepancy possibly is caused by the crystallization of pre-garnet minerals (i.e. hematite), reaction overstepping, or partial reequilibration. In summary, by implementing and evaluating multiple modeling strategies and considering the petrography and metamorphic mineralogy of the rocks, this study finds that the eclogite modeling using Theriak-Domino programs in the Tso Morari terrane provide more consistent metamorphic phase relations and more reasonable thermodynamic simulations regarding fractionation of the bulk composition and prograde metamorphism.

References:

Green et al. J Metamorph Geol 34, 845-869 (2016)
White et al. J Metamorph Geol 25, 511-527 (2007)