Thermodynamic modelling on the UHP metamorphism and fluid infiltrations of the Tso Morari coesite-bearing eclogite in NW India

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The Tso Morari terrane within the Himalayan orogeny underwent ultrahigh-pressure (UHP) metamorphism due to northward subduction under the Eurasian continent during the early Eocene. The advancement of computational petrology and availability of relevant thermodynamic databases provide the mechanism to more precisely quantify metamorphic processes. In this study, we model the eclogite's prograde pressure-temperature (*P-T*) path as well as multiple fluid infiltration events during exhumation using Theriak-Domino with dataset ds 62 and garnet (White et al., 2007) and other metabasic mineral activity-composition relations. The effect of garnet fractionation on the rock's effective bulk composition is considered in simulating prograde garnet growth. A "fishhook" shape clockwise *P-T* path is obtained with a peak pressure of ~28.5 kbar at ~563 °C, followed by a peak temperature of ~613 °C at ~24.5 kbar (Pan et al., 2020).

Thermodynamic modelling using *P-M*(H_2O) pseudosections on Tso Morari eclogites indicates three distinct phases of fluid infiltration during exhumation. Fluid infiltration I occurs at ~610 °C and ~23.5 kbar with ~3.1 mol % fluid expulsion due to the destabilization of lawsonite. The modelling results are consistent with petrographic observations in the eclogite: we found ~6.0 vol % epidote and ~21.0 vol % amphibole and the possible pre-existence of lawsonite evidenced by its pseudomorph (as epidote and paragonite paragenesis) in a garnet core and rim (St-Onge et al., 2013), and CNASH modelling on the epidote and its inclusion paragonite. Fluid infiltration II occurs at ~9.2 kbar and ~608 °C with >2.6 mol % fluid infiltration at amphibolite-facies. This phase of fluid infiltration is characterized by aggressive amphibolization from the boudin core to rim. Fluid infiltration III (local hydration) occurs at ~610 °C and ~8.7 kbar, caused by breakdown of phengite as predicted through modelling the symplectitic association (plagioclase, biotite, and amphibole) surrounding omphacite. In summary, this study not only illustrates the application of thermodynamic modelling in quantifying metamorphic processes, but also the need of comparison between modeling predictions and petrographic observations.

White *et al. (2007) J Metamorph Geol* **25**, 511–527.
St-Onge *et al.* (2013) *J Metamorph Geol* **31**, 469–504.
Pan *et al. (2020) Contrib Mineral Petrol* **175**, 1–28.