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Thermal effects of metamorphic reactions in a three-component slab

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Thermal evolution of a subducting crust is of primary importance for understanding physical properties, phase transformations, fluid migration and melting regimes at convergent plate boundaries. Various factors influencing the thermal structure of a subduction zone have been considered previously: age, geometry and rate of subducting lithosphere, shear stress across the subduction interface, radioactive heating, etc. Recently, emphasis has been placed on significant heating of the slab due to rheologically favourable convection in the mantle wedge. However, substantial heat production or consumption can occur due to metamorphic reactions, including endothermic devolatilization. We investigate enthalpy budget in a subducting slab using a self-consistent thermodynamic model. Petrological model of a subducting slab consists of three layers: oceanic subducting sediment (GLOSS), oceanic basalt (OB), and moderately serpentinized harzburgite (SHB). These layers are examined over the range of pressure-temperature conditions of interest by computing metamorphic phase diagrams and retrieving whole-rock thermodynamic properties. Our results suggest that metamorphic reactions consume a significant amount of slab heat budget and induce substantial cooling. In contrast to previous thermal models of subduction zones, actual slab temperatures may be lower by as much as 250 °C.