Behaviors of Wet Plume Controlled by Olivine-Wadsleyite Phase Transition and Water Distribution

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Quaternary Intraplate volcanoes are sparsely distributed in Northeast Asia including Northeast China and Korean Peninsula and roles of the stagnant Pacific plate in the volcanoes have been studied. Recent geochemical studies suggest that the hydrated mantle in the mantle transition zone was incorporated in the wet plumes that were generated from the hydrated layer atop the stagnant slab, and the ascending wet plumes experienced partial melting in the shallow asthenosphere. To quantitatively evaluate the incorporation of the mantle in the transition zone into the wet plumes and their partial melting in the asthenosphere, we conducted a series of two-dimensional thermochemical numerical models by including the olivine-wadsleyite phase transition at the 410km discontinuity. The buoyancy is controlled by temperature, bound-water content and mineral phase. Viscosity reduction by the bound-water is added to the temperature-dependent viscosity. Particle tracers are used to track the incorporation of the mantle in the transition zone into the wet plumes. We vary the Clapeyron slope of the phase transition and water distributions in the mantle transition zone and hydrated layer of the stagnant slab to evaluate their effects on the behavior of the wet plumes. Results show that multiple wet plumes generated from atop the stagnant slab incorporate the hydrated mantle in the transition zone. Due to the endothermic phase transition at the 410 km discontinuity, the ascending wet plumes are retarded and laterally migrated beneath the 410 km discontinuity for several million years, and enter the overlying asthenosphere as merged large wet plumes. The ascending merged wet plumes laterally spread beneath the thermal lithosphere and experience partial melting, consistent with the interpretation based on the geochemical studies. The spacing of the merged wet plumes (~440 km) caused by the phase transition at the 410 km discontinuity is consistent with the sparse volcano distribution in Northeast China and Korean Peninsula.