

Mantle melting and intraplate volcanism due to hydrous upwellings from the stagnant slab

Xiaogang Long (1,2), Maxim Ballmer (2), Antonio Manjón Cabeza Córdoba (2), and Chun-Feng Li (3)

(1) School of Ocean and Earth Sciences, Tongji University, Shanghai, China (longxg@tongji.edu.cn), (2) Inst. Geophysics, ETH Zurich, Zurich, Switzerland, (3) Department of Marine Sciences, Zhejiang University, Hangzhou, China

The study of intraplate volcanism contributes to our understanding of mantle composition and dynamics. While the origin of oceanic intraplate hot-spot volcanism is rather well understood, the mechanisms that sustain continental intraplate basaltic volcanism remain controversial. In several regions (e.g. E Asia, central Europe, W North America), continental intraplate volcanism is associated with slab stagnation in the underlying mantle transition zone (MTZ). Here, we explore the role of the stagnant slab and of an associated hydrous layer in the MTZ on the formation and evolution of intraplate volcanism using two-dimensional numerical models. We explicitly account for the effects of water on mantle density and melting behavior. Because of the intrinsic buoyancy of the hydrous layer atop of the stagnant slab, upwellings develop within a few million years and rise to \sim 410 km depth. At these depths, they lose some of their intrinsic buoyancy due to dehydration. However, they are readily entrained by sub-lithospheric small-scale convection to reach the base of lithosphere, and to support intraplate volcanism. The timing of upwelling and volcanism is controlled by mantle viscosity, as well as water content in (and thickness of) the hydrous layer. Water contents of \sim 2000 wt.-ppm (\sim 0.2 wt.-%) in a \sim 40 km thick layer atop the slab are sufficient for an early (<10 Myrs) onset of melting to account for the patterns of volcanism in e.g. NE China. We also explore effects of the lateral heterogeneity within the slab, and find that any heterogeneity (e.g. small age step (\geq 2 Myr) or subducted fracture zone) is sufficient for an early onset of upwelling and melting. Our models with 1.6% \sim 2.5% of basaltic materials in the hydrous layer can account for the geochemical signatures of NE-China volcanoes, which indicate melting of two mantle components (EM1-like and HIMU-like). We conclude that an interaction between (bottom-up) self-buoyant upwelling of a hydrated MTZ and (top-down) sub-lithospheric small-scale convection can sustain mantle melting soon after the slab reaches the MTZ.