Variations in intraplate melting regimes during Earth's evolution

CRAIG O'NEILL[1] AND SIQI ZHANG[1]

[1]CCFS ARC Centre of Excellence, Macquarie University, Sydney, Australia.

The antiquity of diamond source regions within cratonic lithosphere suggests opportunities for sampling this material may have varied significantly over Earth's history. Varied plume flux, evolving internal heating rates, and transitions in tectonic regime, all potentially impact both the formation and survival of cratonic roots and their host diamonds, and also their sampling due to low-volume intraplate magmatism. The geodynamic controls on these magmatic events ultimately depend on the convective state of the mantle – which is a function of Earth's history, viscosity structure, and tectonic state. Here we present high-resolution mantle convection simulations of an evolving Earth, which incorporate varying heat production, a coupled core model, and evolving tectonic regimes, to understand how the mechanisms of intraplate volcanism have altered throughout Earth's history. We demonstrate that plume numbers are strongly contingent on the coupled evolution of the core, and tectonic activity, and that on the early Earth plumes may have been both more numerous, but comparatively weaker. We also show how small-scale convective instabilities in the upper mantle, which form preferentially in the absence of large lateral tectonic motions, eg. central to a long-lived supercontinent, or in a stagnant-lid regime, can give rise to widespread, low-volume magmatism, as seen in the metasomatism of many mantle roots, which may ultimately result in the destabilization of cratonic lithosphere.