Dynamical modeling of mantle flow and melt generation in the southern Ryukyu subduction zone

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Abstract

Magmatism with significant regional geochemical variations is observed in the southern Ryukyu subduction zone. Recent studies have indicated that various degrees of mixing between melts from different source components (e.g., the mantle wedge, the sediments, the hydrated continental lithospheric mantle and the asthenospheric mantle) contributes to the diverse geochemical characteristics of these magmatism. However, the mechanisms of the required anomalous melting in some regions and of the multiple melting opportunities remain uncertain. Previous proposed conceptual models invoke trench retreat, transition from collision to oblique subduction, back arc extension, effects of plate edge or discontinuity and the post-collisional lithospheric thinning. Here we present a multiple-disciplinary study in which we use geophysical, geochemical and geodynamical approaches in an attempt to better understand the evolution, the melt generation and the dynamical processes for this unusual tectonic setting. We first evaluate selected existing models by parameterized models for mantle deformation and estimate the correlative signatures (e.g., surface topography change and the melt generation) to better understand the dynamical and geological consequences and the limitation of these models. We then perform a set of 3D numerical experiments to model the thermal and stress fields for this region and calculate the corresponding geochemical and geophysical signatures. This is followed by comparison between the model results and data constraints including available isotopic signatures and seismic tomography for this region. This may help to gain a quantitative, more refined and self-consistent interpretation of melt generation and structure in the southernmost Ryukyu subduction zone.