Geophysical Research Abstracts
Vol. 20, EGU2018-4702, 2018
EGU General Assembly 2018

Coupling between mantle melting and surface process: Implications on the formation of volcanic rifted margins

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Volcanic rifted margins are formed where breakup of continental lithosphere is associated with the intrusion and extrusion of voluminous magma. Type characteristics of volcanic margins include seaward-dipping reflectors (SDRs) and a high-velocity lower crust body beneath SDR. While SDRs are known to comprise of interlayers of volcanic flows and sediments, the mechanism how they are formed, and why they are seaward dipping, remain much debated (e.g. Buck, 2017; Geoffroy, 2001; Paton et al., 2017). Proposed end-member scenarios for SDR formation include (1) fault infill model, in which roll-over due to continentward-dipping normal faults accommodate the emplacement of extrusive magma flow, and (2) volcanic flexure model, which assumes local isostatic compensation of volcanic loading. In this study, we use high-resolution 2-D forward thermo-mechanical models coupled with melt prediction and surface processing to investigate volcanic margin formation. Equivalent melt thickness is calculated assuming a vertical melt extraction scheme, which is then used in the surface processing model that deposits "igneous sediments" back into the thermo-mechanical model. Our results reveal that both mantle temperature and crustal strength have significant influence on volcanic margin formation. Models with a weak crust result in differential rifting with earlier rupture of mantle lithosphere, which essentially produce voluminous magmatism at passive margin and develop seaward-dipping layering due to volcanic deposition on the weak crust. By comparing with natural observations, we suggest that a weak crust and moderate excess temperature ($\sim$100 °C) may explain observed SDRs at North Atlantic volcanic margins.

References:
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