EGU2020-19194
https://doi.org/10.5194/egusphere-egu2020-19194
EGU General Assembly 2020

Testing geodynamic models with major elements geochemistry: implications for Edge-Driven Convection and Mantle plumes

Antonio Manjón-Cabeza Córdoba[1], Maxim D. Ballmer[1,2], Chelsea Allison[3], and Esteban Gazel[3]
[1]ETH Zurich, Institute of Geophysics, ERDW, Zurich, Switzerland (antonio.manjon@erdw.ethz.ch)
[2]UCL London, Earth Sciences
[3]Cornell University, Earth and Atmospheric Sciences

Numerical modeling facilitates the exploration of geodynamic mechanisms that are inaccessible to direct geological sampling. However, quantitative comparison of geochemical signatures predicted by models with real petrological analyses remains restricted. On one hand, efficient melting parameterizations are limited in the information that they provide, on the other, thermodynamic models are not optimized for 3D geodynamic codes. In the Eastern Atlantic, several archipelagos are located near the continental margin, e.g. the Canaries, Cape Verde, Cameroon Volcanic Line, but the origin of this volcanic activity remains poorly understood. Suggested origins range from mantle-plume activity (deep origin) to Edge-Driven Convection (EDC, shallow origin), or an interaction of both mechanisms. To test and constrain these models, we use a recently developed parameterization, which can constrain major-element geochemistry of primary magmas in the form of wt% as a function of the P-T path, together with regional numerical models of EDC with or without plumes. In this work, using the finite-element code CITCOM, we explore 3D models with a step of lithospheric thickness (or “edge”) and with variable distances between an imposed plume and the edge. We predict characteristic compositional trends that depend on model parameters, such as plume temperature or distance of the plume from the continental edge, and compare them with actual melt-inclusion data from the Canary Islands and Cape Verde. We find geochemical trends ranging from alkalic – for the models without thermal anomalies or with weak plumes – to more tholeiitic – for the cases with vigorous plumes. In turn, EDC alone cannot explain the volcanic fluxes observed at the Canary Islands or Cape Verde, with predicted melting rates well below 1 km^3 Myr^{-1}. Comparison with melt inclusions points towards the importance of CO_2, but a thermal anomaly (plume) is also needed. We use the obtained major elements together with the melt volumes and the plume buoyancy flux to constrain the most likely set of mantle properties that originate the aforementioned islands. Our preferred model is a weak, relatively cold plume ($\Delta T < 150$ °C), moderately rich in volatiles, that is affected by the nearby EDC pattern.