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New Constraints on the Melting Conditions During the Northeast Atlantic Breakup: Preliminary Results From IODP Expedition 396

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In the last breakup phase of the supercontinent Pangea, voluminous magmatism off the coast of Norway contributed to the formation of the North Atlantic Igneous Province (NAIP). Elucidating the causes of this excess magmatism was one of the main goals of the IODP Expedition 396 [1]. Three main processes have been proposed: (1) a thermal anomaly due to the contribution of the Icelandic mantle plume, (2) small-scale convection at the base of the lithosphere, (3) heterogeneity of the mantle source.

We independently test for the roles of the melting regime and the presence of pyroxenite in the source using a modified version of Melt-PX [4]. We then apply geothermometers [2,3] on the MgO-rich basalts (> 8wt%) collected during the expedition to compare the potential temperature of the mantle (T_P) during the rifting process with the temperature of the Iceland plume today.

We show that the melting regime strongly influences the magmatic production: from a passive to an active melting regime, the generated crustal thickness is multiplied by ~2 at T_P = 1450°C and by ~3.3 at T_P = 1550°C. However, preliminary calculations of plume-driven upwelling suggest that the heat flux from the Icelandic plume alone cannot explain the size of the NAIP. Moreover, the addition of a pyroxenite component in the source does not necessarily increase the bulk magmatic productivity and highlights the importance of characterizing the nature (composition, phase assemblage, density) of the lithologies present in the source when modeling partial melting of a heterogeneous mantle. Finally, temperatures obtained assuming an anhydrous mantle source point towards a slightly higher thermal anomaly during rifting initiation than the one inferred beneath Iceland today. However, the contribution of volatiles could also accommodate this apparent change of T_P [2,5].

In future work, we will combine these results to quantify the contribution of each process (thermal anomaly, mantle flux and mantle heterogeneity) during the Northeast Atlantic continental breakup.

[1] Planke et al. (2022) doi: 10.14379/iodp.pr.396.2022; [2] Lee et al. (2009) doi: 10.1016/j.epsl.2008.12.020; [3] Herzberg & Asimow (2015) doi: 10.1002/2014GC005631; [4] Lambart et al. (2016) doi: 10.1002/2015JB012762; [5] Hole & Natland (2020) doi: 10.1016/j.earscirev.2019.02.011