3D visualisation of core-forming melts

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The mechanism of metal-silicate segregation is key to constraining core formation processes in the early Earth. Experiments performed at conditions of core formation in terrestrial planets have generally found metallic melts to be immobile in a solid silicate matrix. This implies that a liquid silicate ‘Magma Ocean’ was required for efficient differentiation to occur. There is some doubt as to the applicability of this model to other planetary bodies, particularly those with smaller radii, which may not have been heated to silicate melting temperatures. Recent experimental work has found that deformation can enhance permeability of melt through a solid silicate system without the need to melt the surrounding silicate. We have conducted a series of deformation experiments in the rotational Paris-Edinburgh Cell (roPEC), which allows controlled deformation at simultaneous high pressures and temperatures over a large range of strain rates. Textural analysis confirms melt is interconnected at a grain scale. This implies core formation could have taken place earlier and more rapidly than previously believed, affecting inferred geochemistry of the core and mantle. We use 3D reconstructions of the sample interior from Computed Axial Tomography scans to characterise melt network geometry in order to constrain melt migration rates and permeability.

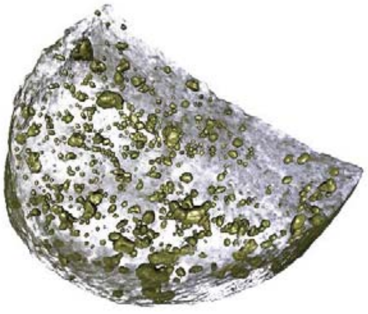

Figure 1: Preliminary tomographic reconstruction of undeformed sample. Sample diameter is 2mm. High density Fe_3S shown in gold, grey-transparent areas are olivine.

Petrogenesis of voluminous silicic magma in northeast Iceland

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Neogene silicic volcanic complexes in the greater Borgarfjörður eystri area, NE-Iceland, are the focus of a petrological and geochemical investigation. The region contains the second-most voluminous occurrence of silicic rocks in Iceland, including caldera structures, inclined sheet swarms, extensive ignimbrite sheets, sub-volcanic rhyolites and silicic lava flows. Despite the relevance of these rocks to understand the generation of evolved magmas in Iceland, the area is geologically poorly studied [c.f. 1, 2, 3].

The voluminous occurrence of evolved rocks in Iceland (10-12 %) is very unusual for an ocean island or a mid-oceanic ridge, with a typical signal of magmatic bimodality, often called “Bunsen-Daly” compositional gap [e.g. 4, 5, 6]. The Bunsen-Daly Gap is a long-standing and fundamental issue in petrology and difficult to reconcile with continuous fractional crystallization as a dominant process in magmatic differentiation [7]. This implies that partial melting of hydrothermally altered crust may play a significant role. Our aim is to contribute to a solution to this issue by unravelling the origin, timing and evolution of voluminous evolved rhyolites in NE-Iceland.

We use a combined petrological, textural, experimental and in-situ isotope approach on a comprehensive sample suite of intrusive and extrusive rocks, ranging from basaltic to silicic compositions. We are performing major, trace element and Sr-Nd-Hf-Pb-He-O isotope geochemistry, as well as U-Pb geochronology and Ar/Ar geochronology on rocks and mineral separates. Zircon oxygen isotope analysis will be performed in conjuction with zircon U-Pb geochronology for further assessment of the role of processes such as partial melting of hydrated country rock and/or fractional crystallization in generating Icelandic rhyolites. In addition, high pressure-temperature partial melting experiments aim to reproduce and further constrain natural processes. Using the combined data set we intend to produce a comprehensive and quantitative analysis of rhyolite petrogenesis, and of the temporal, structural and geochemical evolution of silicic volcanism in NE-Iceland. The chosen field area serves as a good analogue for active central volcanoes in Iceland, such as Askja and Krafla, where interaction of basaltic and more evolved magma has led to explosive eruptions.

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