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Magma Plumbing and Melt Aggregation beneath Mid-Ocean Ridges

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A wide diversity of melt compositions are produced during mantle melting beneath mid-ocean ridges due to both source heterogeneity and near-fractional polybaric melting processes. However, erupted melts are remarkably homogenous due to the mixing, or aggregation, of the diverse primary melts within the sub-ridge magma plumbing system. Although the aggregation process must begin immediately melt is produced, where within the plumbing system melts become fully aggregated is presently unclear. This is important as it provides a constraint on the process(es) of melt extraction from the mantle and because fractionation prior to full aggregation will lead to different end products than if fractionation only begins after full aggregation.

We will investigated the location of melt aggregation processes at mid-ocean ridges based on examples from the MARK area (Mid-Atlantic Ridges south of the Kane Fracture Zone) and the Oman ophiolite. Clinopyroxene and plagioclase trace element compositions within gabbros from these settings (analysed by ion probe and laser ICP-MS) record a wider range in parental melt compositions than is seen in the extrusives. This suggests the addition of incompletely aggregated melts to the lower oceanic crust and therefore that at least some of the melt aggregation occurs within the crust. Thus, melt extraction processes within the mantle cannot completely mix the diverse primary melts. In turn this suggests that not all melts are extracted from the mantle through conduits in equilibrium with mid-ocean ridge basalt (MORB; e.g. discordant dunites) or by pervasive porous flow through the upper mantle. Lower crustal processes must efficiently homogenise different batches of melt to account for the eruption of homogenous MORB compositions.

The addition of incompletely aggregated melts to the lower crust leads to fractionation trends which differ from those of fully aggregated melt compositions. This can be identified by the occurrence of clinopyroxene in oceanic gabbros with higher Mg-numbers than are grown in experiments on fully aggregated MORB. Also, plagioclase crystals more anorthitic than those that grow in these experiments are common in MORB again indicating the existence of more diverse melt compositions in the lower crust than are erupted. Modelling of the potential variation in melt compositions produced by fractionation prior to full aggregation will be presented.