Fluid dynamics of magma reservoirs at mid-ocean ridges

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Mid-ocean ridges are underwater mountain ranges formed by numerous eruptions of basaltic magma. The magma cools to form new oceanic crust which spreads away from the ridge. Mid-ocean ridge basalt (MORB) is the most abundant magma on Earth, and understanding the physical and chemical processes that create MORB is fundamental to a broader understanding of the Earth's tectonic cycle. It is widely accepted that MORB is generated beneath mid-ocean ridges by decompression melting of upwelling mantle, evolves chemically in lower crustal magma reservoirs and then erupts onto the seafloor.

The chemical evolution of MORB is typically assumed to occur via fractional crystallisation, in which the crystals formed during cooling of the magma are denser than the surrounding liquid, so they settle out of suspension under gravity. Fractional crystallisation requires a largely liquid-filled magma reservoir. Yet geophysical imaging shows that magma reservoirs at mid-ocean ridges comprise a liquid-poor 'mush' (a pile of crystals with liquid present in the pore spaces) rather than a liquid-rich 'slurry' (a liquid containing suspended crystals). The fluid dynamics of these magma reservoirs remain almost entirely unexplored.

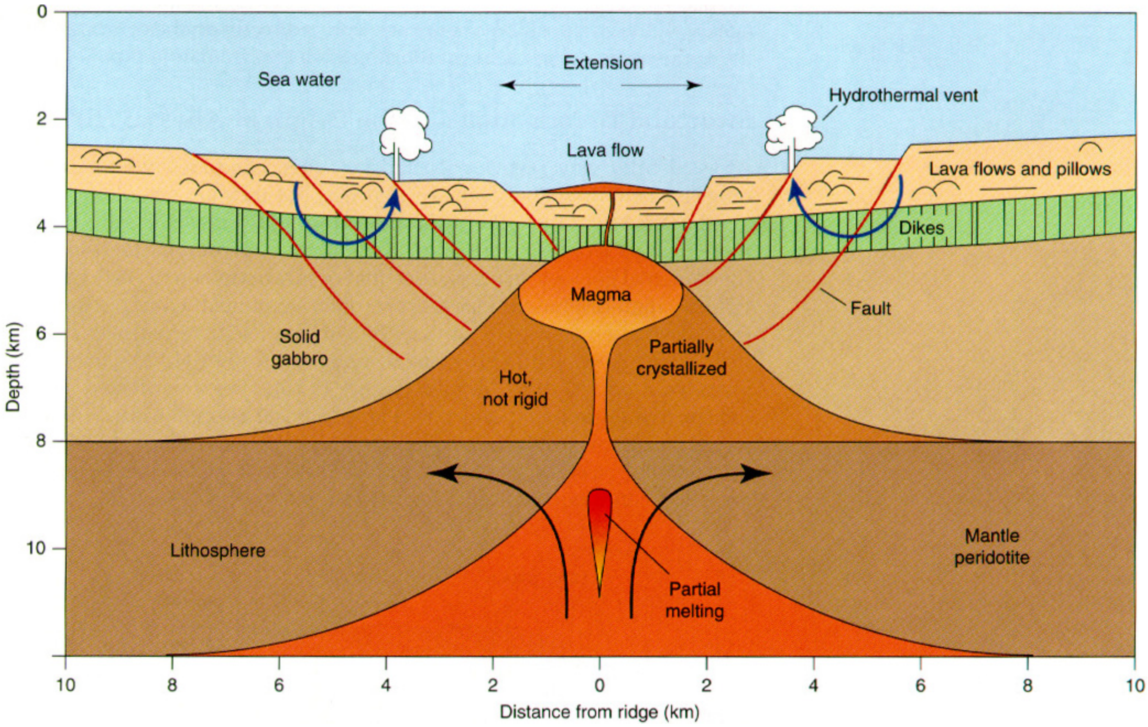

Figure 1. Typical textbook image of a mid-ocean ridge. Geophysical imaging shows that the magma reservoir beneath the ridge comprises a liquid-poor 'mush' of crystals with melt present along grain boundaries. This project will investigate the fluid dynamics of such reservoirs.

The aim of this project is to investigate and model the fluid dynamics of mid-ocean ridge magma reservoirs, addressing key questions which include (1) How does melt present in the pore-spaces of a magma mush collect to form eruptible MORB? (2) How does the chemical composition of the melt evolve to match erupted MORB compositions? (3) What processes control the key rates, time-scales and length-scales? These questions are fundamental to understand why and how MORB is delivered to mid-ocean ridges.

The project will involve the development of new computational fluid dynamical models of mid-ocean ridge magma reservoirs, building on novel methods developed for other CFD applications. The models will be tested and calibrated against measured data. The CFD models developed will capture a wide range of fluid dynamical processes in magma reservoirs, including multi-phase porous media flow of melt and volatiles such as water, heat transfer and phase change, reactive flow, and compaction and buoyant overturn of the mush. The successful applicant will join a broad, cross-disciplinary group developing, and applying, novel methods in computational fluid dynamics. The research will deliver fundamental new understanding of mid-ocean ridge processes, and also contribute to the development of new tools and techniques in CFD.

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