FUNNELLING MELTS INTO MID-OCEAN RIDGES THROUGH MODIFIED COMPACTION THEORY

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Mid-ocean ridges (MORs) are the longest mountain ranges on Earth [1]. Found along every ocean, they are one of the most obvious Earth surface expressions of life-sustaining plate tectonics, missing on all other terrestrial planets. They act as a heat valve releasing heat from the Earth's interior to the surface, thus stabilizing the internal temperature of the planet. This mechanism is found to be extremely efficient. Melt velocities under MORs, inferred both from observational [1] and experimental [2] evidence, are around 10-100 m/yr on average. Classical models [3] address melt focussing to MORs [4-6] but only obtain the lower limit of the observed extraction velocities (around 2 m/yr) as extreme end-members of the physical mechanisms assumed [7]. Here, we show that the formation of high velocity melt channels funnelling magma to the ridge can be the natural result of newly discovered channelling instabilities [8], which can develop in a nonlinear solid matrix with interstitial melts subject to a thermal stress field. A dendritic network of channels is found to accelerate melt towards the MOR, reaching observed velocities near the apex of the MOR (Fig. 1).

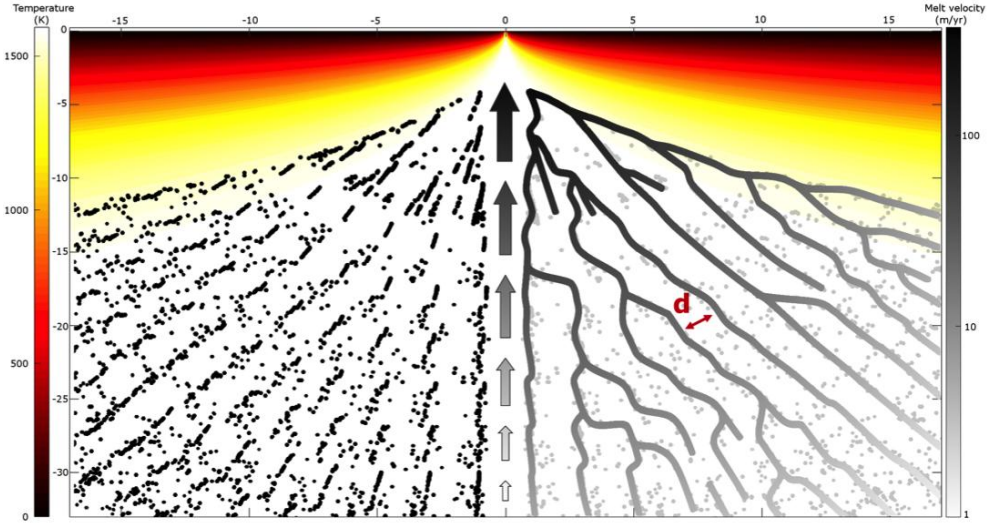

Figure 1. Schematic dendritic network of channels under MORs. The left-hand side shows the localised solution for melt fraction follows defining narrow areas where 100% melt fraction is reached. The locations of these melt pockets are shown enlarged by individual dots. These have been calculated using the above 1-D solution along the η-direction and they therefore do not consider 2-D interaction along η. A number of channels are defined by the alignment of dots. They are regularly spaced throughout the primary melting area with constant spacing. The right-hand side shows an interpretation of the connected dendritic network shaded by predicted melt velocity. Velocity magnitudes are given on the right-hand side of diagram, reaching velocities of 100's of m/yr at the apex. Arrows in the centre illustrate speed towards the surface.

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