Generation and evolution of channels due to the Melt Chennel Instability.

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We investigate melt transport in partially molten rocks under different stress fields under hydrous and anhydrous conditions. We model such aggregates with the 2D-FD code FDCON [1] by means of a porous deformable matrix with melt to clarify the following key questions: Could channeling occur in a matrix containing a random melt distribution under a given stress field? How do channels evolve during finite simple shear? Is it possible to achieve a focussing of melt towards an MOR (dykes)? How does a Plume influence the orientation of dykes?

In a deforming partially molten aggregate, weakening of the solid matrix due to the presence of melt creates an instability in which melt is localized by the following mechanism: regions of initially high melt fraction are areas of low viscosity and pressure, so that melt is drawn into these regions from higher pressure surroundings. This further enhances the melt weakening, producing a self-excited localization mechanism [2]. For both, simple as well as pure shear, the growth rate α for an inclined 1D sine pertubation is highest for an orientation parallel to the direction of the maximum compressive stress (MCS). α is proportional to the applied stress, the reverse of the Melt Retention Number [1] and the wavenumber k of the 1D sine. This also confirms the theoretical growth rate α found by Stevenson [2].

Small-scale simulations ($\approx 1\,km \times 1\,km$ box dimensions) with inclined 1D sine, 1D single channel-like pertubations, 2D ellipses, random fields and large-scale Plume-MOR simulations are investigated. In our isothermal models we found that the influence of water reduces the growth rate, in contrast to non-isothermal models of Hall [3].

Under simple as well as pure shear (small-scale simulations), melt channels evolve from an irregular melt distribution (mean porosity $3 \pm 0.5\%$) at angles parallel to the MCS (45° and 0°, resp.). Upon further straining in the simple shear case they slightly rotate out of the orientation of maximum growth rate and partly disrupt. Even at later stages the mean channel orientation of the disintegrated melt inclusions shows an orientation parallel to the MCS. For this reason, it is sufficient to calculate the orientation of the MCS of a given model to determine the mean channel orientation. Applied to large-scale Plume-MOR simulations shows, that the majoroty of the ascending melt will reach the bottom of the lithospere at distances of $\leq 80\,\mathrm{km}$ from the MOR. From these distances melt could percolate towards the MOR due to the form of the lithospere ($\sqrt{t}$-law) [4]. On the distant side ($> 80\,\mathrm{km}$), melt could either be deposited on the bottom of the lithospere or recycled back to lower regions of the plumehead, from where it may try once more to reach the MOR.

References:

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