Why do melts stall?

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Seismic evidence indicates that the Continental crust is characterised by a felsic upper crust and a more mafic lower crust. When and where is the chemical stratification we observe in the continental crust formed? Geochemical evidence indicates that formation of continental crust occurs in arcs. Observations from exposed arc section document that the arc crust is already significantly stratified in a more felsic and more mafic part prior to the amalgation to continents. This is also confirmed through seismic observations in some arcs (Izu-Bonin). The presence of this stratification implies that felsic melts are dominantly trapped in upper crustal levels whereas more mafic melts stagnate in the lower arc crust. Accordingly, in order to understand the origin of the chemical stratification of the continental crust and thereby the origin of the continental crust itself, we need to understand why melts stall in the crust. Here I investigate possible mechanisms for melt stagnation in the arc crust through field observations in the Kohistan arc section. First, I constrained the chemical stratification of the entire arc crust. The results clearly document that chemical differentiation in arcs occur dominantly only in the deeper arc crust which is characterised by mafic cumulates, whereas the upper, more felsic crust, is dominated by plutonic rocks with a near liquid composition (e.g. frozen liquids). This implies that melts stagnation occurs at two principal location in the arc crust: mafic melts get trapped in the lower arc crust whereas more felsic melts get stuck in the upper arc crust. I calculated the density structure of the entire arc section using ~220 whole rock compositions. The densities of the rocks are compared to the density of melts. Contrary to the general believe, the results show that no line of neutral buoyancy exists in the arc crust at which melts are becoming denser than surrounding rocks. Accordingly, density filters are absent in the arc crust and can not play any (significant) role for melt stagnation.

In the absence of a density filter, I will focus on the role of viscosity controlling melt stagnation in the upper crust. I used existing hygrometer and barometers to constrain the melts emplacement depth, water content and viscosity and propagation length. These observation are used to constrain a model of melts emplacement differentiation throughout the arc crust.