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DEFORMATION-DRIVEN MELT SEGREGATION AND ORGANIZATION IN THE MANTLE

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The strongest constraint on the dynamics of melt extraction is the observation that most transport occurs in chemically isolated channels. Replacive dunites clearly form by reactive porous flow and may constitute the major melt pathways in the mantle beneath spreading centers, as inferred from the Oman ophiolite. However, deformation and flow of the upwelling mantle beneath ridges and arcs may also be very important in both the initiation of melt segregation and in the organization of channels. With shear and torsional deformation experiments of partially molten rocks, we have demonstrated that deformation alone can drive melt to segregate. To apply this phenomenon to natural settings, we must understand 1) the dynamics of deformation-driven self-organization at the experimental scale and 2) the relations necessary for extrapolating to natural length and time scales. 1) Dynamics: The deformation-driven segregation process involves a positive feedback due to melt fraction-dependent weakening of the crystalline matrix, as discussed by Stevenson in 1989, coupled to (and counteracted by) the concentration of strain into melt-rich bands. The observed band orientation corresponds to the angle at which the pressure difference between melt in the band- and non-band regions is minimized. 2) Scaling: In experiments, band spacing scales with compaction length; this simplest of scaling relations predicts band spacings on the order of channelized-flow features observed in ophiolites (i.e., dunites), suggesting that deformation-driven and reaction-driven segregation processes may interact closely. Deformation can drive the channels to self-organize into connected (anastomosing) networks of melt-rich shear zones. These networks will act as transport pathways and will significantly reduce the effective viscosity of the partially molten regions. While trying to detect a melt-rich network with shear wave splitting is an im-

portant test, we ask further if there are unique and predictable differences between an organized network driven predominantly by reaction and one formed by deformation. For example, deformation driven segregation may be most effective on the flanks of the asthenosphere where shear stresses are elevated, whereas dissolution-driven segregation may be most effective in regions of highest solubility where upwelling is fastest.