Shear-Induced Melt Bands with Anisotropic Viscosity and Implications for Melt Extraction at Mid-Ocean Ridges

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Introduction

Melt at mid-ocean ridges is produced over a broad lateral area but is mostly extracted in a narrow region in the vicinity of the ridge crest. Geochemical evidence also indicates that it is extracted rapidly, necessitating a mechanism to focus melt towards the ridge axis. When systems of partial melt are subjected to an externally driven strain-rate, melt segregates into bands of low and high porosity provided that the viscosity of the solid matrix decreases with increasing porosity and that the system is larger than the material compaction length. These bands have been suggested as candidates for focusing melt flow towards the ridge axis[1]. Experimental investigations of these systems have shown that the bands form at roughly 25° to the direction of maximum compression, regardless of the degree of strain-rate dependence of the matrix viscosity. In contrast, numerical and theoretical investigations show that bands should grow fastest if they are oriented parallel to the direction of maximum compression of the background flow if the viscosity is strain-rate independent and isotropic. Recently, it has been suggested that the matrix viscosity should be anisotropic because of the anisotropic arangement of melt at the grain scale caused by stress and that this anisotropy could result in low angle bands as observed in the experiments[2]. In this contribution, I will present numerical simulations of melt bands with anisotropic viscosity.

Results

When matrix viscosity is anisotropic with orientation appropriate for the orientation of grain-scale melt seen in experiments at low strain, the bands do form at angles that are consistent with those seen in experiments. However, in experiments at high strain, the melt in seen to reorient and the resulting viscosity anisotropy results in simulated bands that are not consistent with those seen in experiments.

The effects of buoyant interstitial fluid are also investigated and it is found that a large degree of buoyancy results in two sets of band orientations and short wavelength bands.

[1] Katz R.F., Spiegelman M., Holtzman B., (2006) , *Nature*, 442, 676-679.
[2] Takei Y, Holtzman B., (2009), *J. Geophys. Res*., 114, doi:10.1029 /2008JB005852.