Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09136, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09136
EGU General Assembly 2008

Chimney-like porosity waves as a mechanism for fluid expulsion

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Porosity waves are one of the possible mechanisms for both segregation and trapping of fluids released by diagenetic and metamorphic reactions. They were suggested as an intermediate mechanism capable of bridging the extremes between pervasive and segregated transport explaining the initial stages of melt segregation [Connolly and Podladchikov, 2007]. Rheological asymmetry in viscous rocks was identified as cause of a mechanical channelling instability, which offers a mechanism both for collecting small amounts of melt and for disaggregation of the matrix to form a magmatic suspension. Here we explore similar effects at low temperature environments. Plastic and brittle rate independent yielding mechanisms replace the high temperature creep in these settings. Critical fluid overpressure and initial failure modes were recently considered by Rozhko et al. (2007). In this study, we investigate following non-linear evolution of these initial failure modes. Rocks possess macroscopic tensile strengths only order of 10 MPa and therefore the decompaction dominated by tensile yielding deformation is expected to be orders of magnitude weaker than compaction. We consider decompaction weakening and channelling instability in brittle-ductile porous media. Our analysis is based on the consideration of a single pore in the matrix with symmetric elastoplastic properties. We derive the effective rheology of a porous rock that exhibits different compactive and decompactive strength. The flow instability can nucleate from perturbations to an initially uniform porosity and grows to much larger amplitudes, than expected on the basis of symmetric compaction models. Similar to the high-temperature case, the waves grow by draining fluid from the background porosity but leave a wake of elevated porosity that localizes subsequent flow.

Connolly, J. A. D., and Y. Y. Podladchikov (2007), Decompaction weakening and channelling instability in ductile porous media: Implications for asthenospheric melt segregation, J. Geophys. Res., 112, B10205.

Rozhko, A. Y., Y. Y. Podladchikov, and F. Renard (2007), Failure patterns caused by localized rise in pore-fluid overpressure and effective strength of rocks, Geophys. Res. Lett., 34, L22304.