Modeling of solitary porosity waves with new effective viscosity laws

Janik Dohmen[1], Harro Schmeling[1]
[1] *Goethe University Frankfurt, Institute of Geoscience, Frankfurt (Main), Germany*

Magmatic phenomena such as volcanic eruptions on the earth's surface show, among others, that melt is able to ascend from partially molten regions in the earth's mantle. The melt initially flows through the partially molten source region and then through the unmolten lithosphere until it eventually reaches the surface. The governing processes in this source region are poorly understood. Since McKenzie (1984) introduced his equations for two-phase flow, which include a fluid phase (melt) and a porous deformable matrix, the physics of this region are of broad interest. One of the studied features is the emergence of solitary porosity-waves, whose ascent is the main focus of this work. By now most analytical and numerical solutions for these waves used strongly simplified modells for the shear- and bulkviscosity. They were too high or neglected the porosity-dependence of the bulkviscosity. Further studies show that this porosity-dependence has a great influence on the dispersion-behaviour of the wave but has a minor influence for very small meltfractions (Richard et al., 2012).
In this work the viscosity-laws from Schmeling et al. (2012) are taken, which predict that the viscosity decreases very rapidly for small meltfractions. We use them for numerical modelling of these solitary waves. These modells are carried out with FDCon, a 2D finite difference mantle convection code with two-phase flow.
As there are no analytical solutions for the shape of solitary porosity-waves in 2D, Gaussian-like belle-shaped curves as first approach for the initial wave are used. The phase velocity and the amplitude of these waves are taken and used for comparison in dispersion-curves. The results show that shortly after starting the model the bell-shaped curves emerge into a solitary wave. These waves, with smaller viscositys, are still comparable with the simplified analytical and numerical solutions but also show significant differences.
Between the small realistic viscositys there are different waves for the meltgeometries, which vary in there width, but change the velocities just slightly.
Further influences of the viscosity on the matrix velocity were observed, which give velocities in the opposite direction of the phase velocity for softer viscositys.

References:

McKenzie, D. A. N. (1984). The generation and compaction of partially molten rock. Journal of petrology, 25(3), 713-765.

Richard, G. C., Kanjilal, S., Schmeling, H. (2012). Solitary-waves in geophysical two-phase viscous media: a semi-analytical solution. Physics of the Earth and Planetary Interiors, 198, 61-66.

Schmeling, H., Kruse, J. P., Richard, G. (2012). Effective shear and bulk viscosity of partially molten rock based on elastic moduli theory of a fluid filled poroelastic medium. Geophysical Journal International, 190(3), 1571-1578.