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Shear enhanced decompaction weakening and its effects on formation of seismic chimney

Lawrence Hongliang Wang (1), Viktoriya Yarushina (1), and Yury Podladchikov (2)

(1) Department of Environmental Analyses, Institute of Energy Technology, Norway (hongliang.wang@ife.no), (2) University of Lausanne, Institute of Earth Sciences, Lausanne, Switzerland

Fluid flow instability in viscously deforming porous rocks commonly known as solitary porosity waves has been used to explain formation of seismic chimneys, which are one of the most important expressions for the localized fluid flow in the subsurface. Experimental data show that volumetric deformation of rocks is strongly coupled with shear deformation, which leads to shear-induced decompaction at low confining pressure and shear-enhanced compaction at higher confining pressure. Decompaction weakening during the volumetric deformation is an important factor in chimney formation. A simple weakening factor of R is usually introduced for the decompaction weakening when the effective pressure is negative. While this approach has successfully reproduced the channelized fluid flow in the numerical models, it doesn't consider the effect of the shear deformation on the bulk viscosity. In this study, we use a new viscoplastic rheology that takes account on different compressive and tensile strengths (different critical pressures for the onset of pore collapse and pore generation) and the shear-enhanced weakening of the bulk viscosity. The partial difference equations of the two-phase flow are solved with a matrix free approach using pseudo-transient method. Our model produces fluid channels similar to previous studies that use a simple weakening factor of R for decompaction. Without considering the shear-enhanced effect, a tensile strength that is 10∼50 times lower than the compressive strength is required for chimney formation in our model. Our preliminary results on the shear-enhanced effects show that it could introduce significant weakening of the bulk viscosity during the opening of the pore-space at the channel front. This suggests that the shear-enhancement of volumetric deformation might be of key importance for the initializaiton and propagation of fluid channel, especially at a tectonic active area.