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Long term cavity closure in salt using a Carreau viscosity model.

Jan Cornet (1), Marcin Dabrowski (1,2), and Daniel Schmid (1)
(1) UIO, PGP, Oslo, Norway (jscornet@hotmail.fr), (2) Polski Institute Geologiczny, Wroclaw, Poland

The problem of a pressurized hole in an infinite homogenous body is one of the most classical problems in geoscience. The solution is well-known when the rheology is linear but becomes much more complicated when applied to formations such as salt that can behave nonlinearly. Defining a constitutive law for the steady state deformation of salt is already a challenge and we rely on two deformation mechanisms - dislocation creep and pressure solution - to do that. More precisely, we use a Carreau model for viscosity to take into account in a single and smooth manner a linear and a nonlinear process. We use this rheology to revisit the classical two-dimensional problem of a pressurized cylindrical hole in an infinite and homogeneous body under general far field loads.
We are interested in characterizing the maximum closure velocity at the rim. We provide analytical solutions for pressure and far field pure shear loads and we give a proxy for the general case based on the two end members. Using this general approach, we show that adding pressure solution to the constitutive law is especially important when studying long term hole closure under low pressure loads or when the grain size is in the order of 0.1 mm. Only considering dislocation creep can lead to underestimating the closure velocity by several orders of magnitude. Adding far field shear stress also dramatically enhances hole closure. The stress situation in salt bodies is often considered as isotropic but some shear exists at the interface between moving salt bodies and cap rock so pressurized holes in these regions experience increased closure. The analytical approach adopted in this study enables us to better understand the influence of all the input parameters on hole closure in salt.