POROELASTIC DIFFUSION DURING FLUID INJECTION

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Fluids are known to play a role of prime importance in rock deformation and seismicity, for example by changing the effective stress state which in turn governs failure. However, fluid-rock interactions are complex phenomena, so fluid effects cannot be accounted for by simply adding an extra parameter in a deformation/ rupture model. In particular changes in effective stress caused by changes in pore pressure can also affect fluid flow patterns in a deformable porous medium. We present here a 2-D finite-element model where both stress state and fluid flow are calculated separately and, then, coupled via poroelasticity equations. Non-linearity is introduced by feedback between the local effective stress and rock permeability This results in a non-linear, anisotropic, pore fluid pressure diffusion, in response to a pulse injection at the source. The anisotropy is due primarily to (a) the tectonic stress field orientation but also possibly (b) material heterogeneity.

With such a model, according to the chosen parameters and, hence, to the relative influence given to stress anisotropy and non-linearity, it is possible to observe a kind of pulse of fluid flow, with a non-linear diffusion velocity much faster than that expected from linear Darcy-type flow. It can then provide a possible explanation for some observations of fast anisotropic fluid diffusion in oil fields, including the observation of long-range correlations between injector and producer wells now documented in several oilfields. The model can now be adapted to study fluid flow effects on seismicity, either by introducing a failure criterion determined by the effective stress state, or by modelling the behaviour of faults introduced a priori, governed by a friction law that explicitly takes into account pore fluid pressure.