Geophysical Research Abstracts
Vol. 12, EGU2010-12466, 2010
EGU General Assembly 2010

Propagation, deflection, and geometry of fluid-driven fractures in heterogeneous rocks

Ingrid Fjeldskaar Løtveit (1), Agust Gudmundsson (2), and Sonja L. Phillipp (3)

(1) TECTONOR, Stavanger, Norway (ifl@tectonor.com), (2) Department of Earth Sciences, Queens building, Royal Holloway University of London, Egham, Surrey, TW20 0EX, UK, (3) Department of Structural Geology and Geodynamics, Geoscience Centre, University of Göttingen, Germany

Permeability of many crustal rocks is mostly controlled by fractures, and depends much on whether the fractures are open, deformed in shear, mineral filled, or vuggy. The whole original aperture of an open fracture may transport fluid, whereas slickensides, gouge or breccia may reduce the permeability perpendicular to a deformed fracture. Fractures completely filled with minerals reduce permeability, whereas those partly filled resist closure (are stiff) and may have channels that contribute significantly to the fracture parallel permeability. Vuggy fractures are widened by dissolution into ellipsoidal fractures that are resistant to closure and may significantly increase permeability. Here we propose that propagation of fluid-driven fractures, that is, hydrofractures, is a basic mechanism to interconnect these various types of fractures, so as to reach the percolation threshold in a reservoir.

Analytical and numerical models, presented here, indicate that, for any significant fluid overpressure (net pressure), buoyant hydrofractures in a homogeneous, isotropic reservoir should rarely become deflected or arrested. By contrast, in a layered reservoir hydrofracture penetration through contacts and other discontinuities or, alternatively deflection and/or arrest at the contacts, depend on the variation in Young's moduli (stiffness) between layers and in the mechanical properties of the contacts themselves. In particular, different elastic properties (elastic mismatch) between layers across a contact may result in abrupt stress changes, as well as hydrofracture deflection and/or arrest at the contact. Considerations of the Dundurs elastic mismatch parameters as well as energy release rates suggest that contacts where the hydrofracture propagates from a stiff layer towards a compliant (soft) one have little effect on its path. By contrast, contacts where the hydrofracture propagates from a soft to a stiff layer encourage hydrofracture deflection and/or arrest.

In homogeneous, isotropic rocks the opening displacement (aperture) of a hydrofracture, where the internal fluid overpressure is the only driving force, varies as in a flat ellipse when the overpressure is constant. The aperture variation remains similar, but somewhat smaller, when the overpressure varies linearly (from a maximum in the centre of the fracture to zero at its tips), the same yields when the overpressure is represented by a Taylor series. However, when the host rock is layered, the hydrofracture aperture tends to be small in the stiff layers and larger in the soft (compliant) layers. The large apertures encourage flow channelling.