**Unrecognized ‘fracture caging’ could make shale drilling safer and more profitable**

Ruud Weijermars (TU Delft, The Netherlands), Xi Zhang (CSIRO, Australia), and Dan Schultz-Ela (Colorado Mesa University, USA) explain how they independently happened on the previously unrecognized phenomena of ‘fracture caging’ which, if identified during drilling operations, could increase substantially the potential output from shale formations. A detailed paper on the findings will be published in a forthcoming issue of *First Break*.

Drilling operations around the globe have been riskier than even the experts realized. A new analytical stress function study has revealed that underbalanced wellbores may unintentionally enlarge as a result of concentric tension fractures, which may occur when drilling into over-pressured rocks. Numerical models confirmed the circumferential tension fractures grow exactly as predicted by the new analytical theory.

This finding will be one of the subject areas being taken up by Delft University of Technology, which is forming a consortium to develop techniques that can frack shale formations in a more controlled and smarter way. The TU Delft research on Smart Fracking Technology Solutions (part of UGRI; see Weijermars et al., 2011) integrates tools, theory, and experiments to exploit the manipulation of well pressures such that fracture cages help drilling engineers to make drilling and fracking operations more accurate, cheaper, and safer.

The new study (Weijermars et al., 2012) demonstrates a ‘fracture caging’ effect, not previously recognized but highly relevant for avoiding problems in well completions and reducing the risk of well failure. Failed fracture treatments are costly: incomplete understanding of risk, shape, and size of borehole-induced fractures can even result in loss of well control.

Dramatic examples of lost well control in over-pressured formations are provided by the Macondo well blowout (DHSG, 2011) and Lapindo mud volcano (Davies et al., 2009). Numerous smaller incidents and many near failures have occurred in past drilling operations (EPA, 2010). Improved control over well performance can reduce future risk of well loss and helps to improve the economics of oil and gas extraction from tight reservoirs. Fracture propagation from the well bore must be fully understood, and improved well control is important to pre-empt public concerns about the safety of hydraulic fracturing.

The so-called ‘fracture cage’ is a potential drilling hazard that directs induced fractures to curl around wellbores (Figure 1). An international team led by Ruud Weijermars, a Dutch geoscientist at Delft University of Technology, has now demonstrated that the phenomenon occurs in so-called underbalanced boreholes, where fractures cannot escape outward from a ring of rock enclosed in the fracture cage. Instead, the fractures will tend to enlarge the borehole. Radial fractures that could arrest the growth of such concentric fractures cannot form in this fracture cage region. Fractures can only escape from the fracture cage zone when the initial fracture extends far enough to pierce the fracture cage boundary (Figure 2).
What at first seemed an odd analytical prediction by Weijermars (2011) was almost simultaneously modeled in numerical computer simulations by Xi Zhang and co-workers at CSIRO, Australia (Zhang et al., 2011). The puzzling curling of hydro-fractures was presented independently by the two research teams at the 45th US Rock Mechanics Symposium (ARMA) held in San Francisco last June. The analytical and numerical results matched perfectly. The forthcoming joint study (Weijermars et al., 2012) quantifies when these fracture cage stress patterns arise. The width of the fracture cage becomes larger when the pressure of the penetrated formations rises – such over-pressured rocks are known to be hazardous when drilled.

The practical implications of the newly recognized fracture caging effect could be enormous, according to the study authors. Not only will this make drilling safer and more precise, it can also improve access to new oil and shale gas resources. The extraction of hydrocarbons from tight reservoirs (sands, coal beds, and shales) (NPC, 2011) requires up to several hundred times higher density of boreholes per resource volume as compared to conventional reservoirs (King 2010). Nearly every hole needs to be fracked by hydraulically applied pressure on the wellbore, to stimulate fracture propagation and thus enlarge the drainage volume of the well (Economides and Martin, 2008).

Optimum control of frac jobs is required to minimize risk of well failure and aquifer contamination, something shale gas critics and recent government studies around the globe have been critically monitoring (Weijermars and McCredie, 2011). Hydraulic fractures are crucial for stimulating oil and gas flow from shale and tight sandstones. The discovery of the fracture cage stress can now be exploited to develop better fracking techniques.

References


Note: Our Special Topic on Unconventionals and CCS starts on p. 66.