Fracture and Stress Characterization in the Grosmont

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Introduction

This project is a unique opportunity to focus more on the understanding of the geomechanical aspects of the reservoir. The study is unique in that the abundance of wells and image logs in a small study area allow for a rare chance for analysis of the natural and drilling induced fracturing of the reservoir and therefore a study of the regional and local stresses in place. As the Grosmont deposit is shown to have high values of porosity, saturation and permeability (Buschkuehle et al. 2007) solidifying it's potential as an extremely economic reservoir and as stress directions and relative magnitudes of stress are more than useful in hydrocarbon recovery methods in a number of situations (Bell & Babcock 1986), this stress study may be useful for well project planning and in situ methods for hydrocarbon recovery.

Theory and/or Method

A Formation Micro-Imaging (FMI) tool is a resistivity borehole imaging tool consisting of 4 caliper arms with attached pads. The FMI resistivity pads are kept pressed against the borehole wall while logging (Ekstroml et al. 1987) and return a resistivity image of the borehole wall. The FMI tool returns a resistivity image of the borehole wall where typically darker colors represent areas of lower resistivity and lighter colors represent areas of higher resistivity. Typically fractures and borehole stress features are readily recognizable because the drilling mud will enter the formation fracture and the tool will image the dark identifiable trace of the fracture. FMI and other electrical imaging tools can only be used in non-oil-based muds due the low resistivity of the drilling mud. FMI logs provide high spatial resolution in both depth and borehole azimuthal directions and borehole micro resistivity variations have long been used for depicting and identifying small scale rock structures (Brudy & Kjørholt 2001). The images logs relate image color with resistivity of the downhole rock formation. The logs are displayed by having them “unwrapped” along the borehole azimuth and displayed vertically in depth and horizontally in borehole azimuth from 0-360°N.

Natural fractures are fractures existing in the in-situ rock before the borehole was drilled. Natural fractures occurring in the borehole rock can be identified in the image logs by their sinusoidal shape that cross cuts the entire azimuth of the log. Natural fractures appear sinusoidal in the “unwrapped” log because the trace of a dipping plane intersecting a cylinder runs downwards along both sides of the borehole circumference. As mentioned above, these events are identifiable due to their anomalous dark traces caused by the relatively more conductive drilling mud entering the formation fracture during well bore drilling. Natural fractures picked from the FMI data yield both the dip angle of the fracture and the azimuth it is dipping towards.

Drilling induced fractures are caused by the removal of rock and thus introduce changes to the pre-existing state of the stress of the formation rock during drilling. Induced fractures yield information about the orientation of native horizontal stresses in the area of drilling (Tingay et al. 2008). The removal of the native rock from the subsurface is said to concentrate the natural stresses and this can cause failure of the rock (Schmitt et al. 2012). Removal of rock can cause induced fractures such as drilling induced tensile fractures (DITF) or can cause borehole breakouts (BB). DITF are recognizable on FMI logs as 2 narrow vertical continuous low resistivity lines located ~180° azimuthally around the borehole. They are located in the azimuthal direction of the greatest principle horizontal stress. Borehole breakouts are an elongation of the borehole wall in cross-section due to stresses surrounding the borehole exceeding the rock strength to cause compressive failure (Tingay et al. 2008). Breakouts are recognizable on FMI logs by enlarged caliper readings in 2 directions located 180° azimuthally around the borehole as well as large poorly resolved areas of low resistivity. BB's enlarge the axis of the borehole in the direction of the least principle horizontal stress (Plumb & Hickman S. 1985).

Conclusions

Due to lack of leak-off or hydraulic fracture tests in the data, there is no way to directly measure the horizontal stress magnitudes. However the existence of DITF in the log data affirms that there are indeed areas in the subsurface where the hoop stress is less than the tensile strength of the rock. Furthermore since there is a lack of borehole breakouts in the data it's possible to approximate quantitative stress boundaries on the horizontal stresses presently acting on the formation.

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