Geophysical Research Abstracts
Vol. 13, EGU2011-10127, 2011
EGU General Assembly 2011

3D Modeling of Fracture Density and Connectivity Within Faulted Chalk Reservoirs – A Case Study From Flamborough Head, UK

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The anisotropic distribution of fracture density and connectivity in 3D across a fault zone can exert a strong control on fluid flow. However, fracture density and connectivity values are usually estimated quantitatively using 1D and 2D fracture datasets, which do not take into account the length/height aspect ratio of the individual fractures.

In this study fracture datasets derived from interpretation of LiDAR images were used to model the anisotropic distribution of fracture density and connectivity in 3D across a fault zone developed in a chalk reservoir. We modeled a range of fracture aspect ratios to test the control exerted by fracture dimensions on connectivity and its spatial variation. Finally, results obtained from 2D and 3D dataset analyses were compared to give a best-fit estimate on the real aspect ratio of the fractures.

The study focused on a complex normal fault with a total displacement of about 25 m, developed within low-porosity, fine-grained Upper Cretaceous chalk exposed in the Flamborough Head area (UK). The fault zone is comprised of two ENE-WSW-striking fault cores, 4-5 m apart. Each of the cores is up to 2 m thick, and made of fault breccias with intense calcite veining. The damage zones, developed on both sides of the cores contain thick (up to 15 cm) veins displaying coarse (5-6 mm) grain size crystals.

Detailed field-based structural observations and mesoscale data collection along 1D-, and 2D fault orthogonal transects were integrated with LiDAR data. The 1D- and 2D analyses showed that fracture density and connectivity in the damage zones are two times higher than in the cores. Within the damage zone a high fracture density/connectivity domain (ICDZ) has been identified next to the core and a high fracture density, low connectivity domain (WCDZ) located further away from the core.

Based on the LiDAR data, fractures of the fault zone were modeled in 3D using 5 different aspect ratios ranging from 1/1 to 1/8. Increasing the elongation of the modeled fractures caused higher fracture density and a greater degree of connectivity. The observed WCDZ and ICDZ domains gave closest match with the lowest aspect ratios (1/3 to1/8). The 3D model results that fits best with the observed fracture density/connectivity values from the 1D- and 2D analyses is the one with the 1/5 aspect ratio. This best-fit aspect ratio can then be used in fluid flow models to better define the fluid transmissibility across the fault zone.