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Quantification of Fractures using Helical CT Scan Technology

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ABSTRACT

Fracture type, aperture, and mineralization create heterogeneities that can profoundly influence reservoir performance within a naturally fractured reservoir. Fracture analysis in conventional core can decrease uncertainty by characterizing fracture attributes. One of the most essential measurable attributes is fracture aperture. Yet, fracture aperture is often partially or fully cemented. Distinguishing between kinematic aperture and effective aperture is essential, however irregular mineralization patterns make it difficult to accurately obtain effective aperture from visual inspection.

Helical CT scanning (HCT) is a non-destructive tool that has yet to be fully exploited for core analysis. HCT image slices give a three-dimensional view of core through a fractured interval, and HCT datasets can be used to quantify fracture characteristics, including effective aperture.

The data being presented were acquired using a third generation Toshiba Aquilion™ 64-slice medical scanner, which was modified for scanning core samples. This scanner is capable of imaging samples in a range of sizes from plugs to whole core, with a data acquisition time of approximately one minute per one meter section of core. The scanner provides a 3D distribution of X-ray attenuation values (Hu) with a maximum voxel resolution of .28x.28x.30 mm. Data from these scans were imported into Avizo® Fire, a software package designed for 3D materials analysis. This software provides tools for core visualization, as well as quantitative analysis of the 3D dataset.

In a typical study, detailed fracture analysis of core is first conducted in order to determine the dominant fracture sets, types, and orientations. Representative fractures within the dominant sets are then isolated using Avizo® Fire. The interior of the fractures are partitioned further into mineral fill with a relatively high CT number and pore space with a relatively low CT number. This process yields volumes of mineral fill and pore space. These volumes are used to calculate a representative porosity within a fracture set to be used in fracture models. Due to the proprietary nature of core datasets, this method was tested on partially calcite-filled fractures within a sample of the Cretaceous Niobrara Formation from the CEMEX Quarry near Lyons, Colorado.

The analyzed sample is from a highly fractured zone with anastomosing, opening-mode fractures with kinematic apertures ranging from 0.05 to 20.00 mm. Three fractures were examined in this fracture network with kinematic aperture ranges from 1.0 to 3.6 mm. Preliminary results from volume analysis suggest that the onset of significant fracture porosity preservation occurs in kinematic apertures of approximately 1.6 and 2.0 mm. Measurements of a representative fracture over 30 slices show a linear relationship between kinematic aperture and pore width. The ratio of pore width to kinematic aperture within this system shows that effective aperture peaks at 70% (of the kinematic aperture) at 2.6 mm kinematic aperture.

This preliminary study illustrates that HCT is a valuable fracture-analysis tool. It is not only capable of defining the geometry of fracture systems, but can routinely quantify fracture properties such as effective aperture in an individual fracture network.