Three-dimensional Characterization of Fractures in Fine-Grain Rocks Using X-ray Tomography

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Introduction: We have examined a total of 48 fine-grain rock samples using three-dimensional x-ray tomography. Data acquired has a voxel resolution of 6.5x6.5x6.5 microns and no chemical information is available. Almost half the samples are from 3 wells in the North Sea. Other samples are from the Gulf of Mexico, Gulf of Thailand, and Unita Basin. X-ray tomography, like seismic data, provides a 3D image of the interior of the sample. The primary information derived is the spatial distribution of x-ray absorption, which is related to sample density and composition. X-ray absorption is useful in detecting either open or filled fractures. Open fractures are less dense than the surrounding clay material. Fractures filled with diagenetic minerals, such as quartz, are denser than the surrounding clay minerals.

Methods and Materials: A tomography instrument is conceptually quite simple. Briefly, a sample is illuminated with x-rays and a CCD camera records its projection onto a flat scintillator screen. The sample is rotated by small angular increments and the new projection is recorded. A series of projections over the range of 0-180° can later be recombined to yield the 3D structure of the interior of the sample. Fine grain rock samples from geopressured sedimentary basins provided by the oil and gas industry were either cored or shaved with a razor blade into small cylinders with a diameter of 3.5 mm and lengths ranging from 2 to 10 mm. Core length depended on the strength of the rock sample. Samples often split perpendicular to coring direction as the sample was removed from the coring drill bit. The small core size was necessary to insure that the sample was completely penetrated by x-rays and that the sample was narrower than the width of the x-ray beam. Where the rock sample was large enough and bedding was apparent sample cores were taken both parallel and perpendicular to bedding.

Results: We have found numerous examples of open or filled fractures in our samples. Diagenetic minerals line many of these open fractures. This indicates fluid flow and chemical sealing of the fractures over time. The orientation and shape of the fracture sets is consistent with tensional stresses or hydrofracturing due to very high fluid pressures. In addition to simple fracture sets, we have found some examples of tubular shaped zones of mineralization. These features are substantially thicker than the fractures. Finally, We have found a spatial correlation between fractures and grains of very high-density material. SEM and microprobe analyses are ongoing to determine the mineralogy of these grains.