MicroCT Analysis of Porosity and Mineral Phases in Carbonate Reservoirs of Eastern Canada

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Ongoing research to produce a permeability atlas for petroleum reservoirs in eastern Canada includes analyses of carbonate material from both onshore (e.g. Ordovician – Silurian, Trenton – Black River of Québec and western Newfoundland) and offshore (e.g. Jurassic – Cretaceous reefs of the Scotian shelf, offshore Nova Scotia). Magnetic Resonance Imaging (MRI) is being utilized to image porosity and flow heterogeneity in core plugs (e.g. Gingras et al, 2002; Marica et al., 2006), but MicroComputed Tomography (microCT) currently affords better imaging resolution of the pore networks themselves.

Computed tomography is a non-invasive procedure for imaging the internal structure of opaque objects. It is possible to apply CT methods over a wide range of scales but the microCT technique provides image resolution on the order of μm for geologic samples that are up to 30 mm in maximum dimension. Specifically, it records spatial variations in the X-ray attenuation coefficient that may correspond to mineral and pore distributions in a rock. The attenuation co-efficient for a particular point in 3D space is assigned a corresponding grey-scale (or colour) value in a resulting image. The large differences between the attenuation of x-rays by solids, relative to that of air (i.e. pore space), ultimately permits the imaging and quantification of interparticle-, intraparticle- and fracture-porosity in a sample (see, for example, methodologies from articles in Mees et al., 2003). Where core plugs are being used for microCT analysis, it is possible to then scale the total computed porosity to that recorded by conventional core analysis and thereby obtain a quantitative determination of the pore distribution in 3D. Core plugs displaying a variety of carbonate textures are being analyzed in order to identify limitations and error ranges under differing analytical conditions using a Skyscan 1072 MicroCT scanner, with spatial resolution of approximately 10 μm.

Carbonate samples also tend to have a limited number of mineral phases present. This leads to the possibility of quantifying each phase by recognition of discrete grey-scale values. Preliminary microCT scans of a hydrothermal dolomite (Blissett et al., 2007) were undertaken at relatively low X-ray energy (< 100 keV). At such energies the photoelectric effect is primarily responsible for attenuation and the attenuation coefficient is a function of the effective atomic number (Z_{eff}), with attenuation increasing with Z_{eff}. Consequently, as well as porosity, carbonate minerals grains that are sufficiently large to be resolved by the instrument, and display contrasting Z_{eff} can be distinguished. In this case (Figure 1), the contrast in Z_{eff} between calcite (15.88) and dolomite (13.94) is sufficient to distinguish between the two minerals, though the presence of iron in ferroan dolomite decreases the Z_{eff} contrast.

Micro-CT analysis of samples from potential carbonate petroleum (or groundwater) reservoirs therefore has the potential to not only assist in the non-destructive quantification of porosity, but also to track variation in diagenetic overprinting.

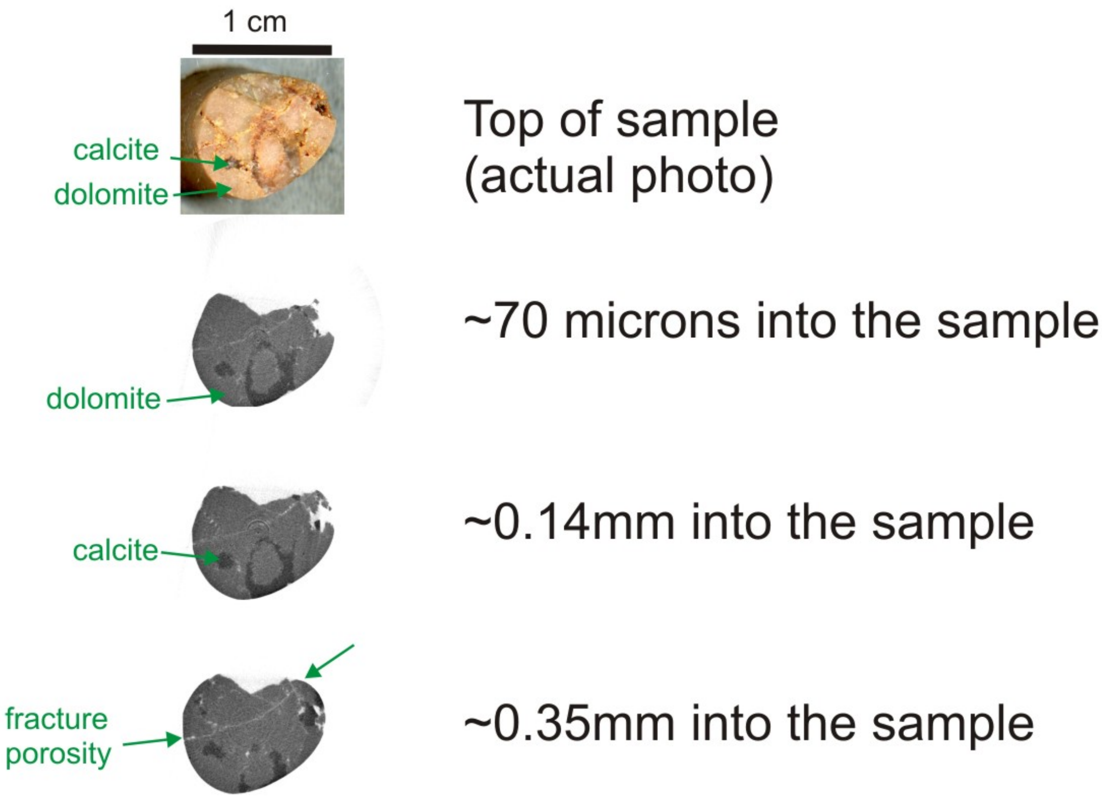

Figure 1. Distinction of porosity and mineral phases in a hydrothermal dolomite from Québec (from Blissett et al. 2007). Sectional images produced from the microCT analysis indicate the continuation into the sample of the mineral and pore phases identified in the actual photograph of the top surface of the sample.

References

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