3D Characterization of Pore Geometry, Connectivity and Mineral Phase in Carbonates from the Weyburn Oilfield

Chad Glemser[1], Tom Kotzer[2], and Chris Hawkes[1]

Successful reservoir characterization rests on the ability to accurately describe the spatial distribution of petrophysical properties, such as porosity and permeability that directly influence hydrocarbon recovery. Synchrotron X-ray Computed Microtomography (CMT) is a powerful imaging technique that utilizes coherent and brilliant synchrotron light to produce high-resolution, three-dimensional physically realistic images of reservoir-quality rocks, non-destructively, with micron-scale (50µm-0.1µm) resolution. Tomographic images of rocks collected at this scale permit identification, visualization and quantification of minerals and pore structure (i.e. volume, shape, connectivity and throat radii) that can be used to obtain and understand petrophysical properties such as permeability, capillary pressure and formation factor.

In this study, CMT analyses have been carried out on Mississippian limestone and dolostone samples obtained from the Weyburn Reservoir, site of EnCana Corporation's CO_2-miscible Enhanced Oil Recovery (EOR) project. Sections of carbonate core collected prior to CO_2 injection have been imaged with synchrotron CMT at a spatial resolution of 7 to 10µm. Total porosity information obtained from CMT on the carbonate cores will be compared with mercury porosimetry results on the same sections of core to resolve the submicron porosity existing below the CMT image resolution and, for apparent pore diameters ≥10µm, to provide a direct comparison with pore size data extracted from the CMT analyses. Theoretical permeabilities derived using empirical relationships based on porosity and pore network geometry will be compared with conventional laboratory based gas and liquid permeability measurements on identical sections of carbonate core to elucidate the validity of these relationships in carbonate lithologies and potential application of CMT as a new formation-evaluation tool.

Additionally, the sensitivity of CMT to density-related differences within the carbonate cores permits the identification of minerals. Using transmitted light microscopy, electron probe micro-analysis (EPMA) and backscattered electron images, compositional information has been obtained and integrated with differences in X-ray attenuation from CMT to delineate the relationship between mineral phase and X-ray attenuation (LAC). However, CMTs dependence on density contrasts within a sample minimizes visualization of different sedimentological and ichnological textures occurring in the same mineral phase.

[1]University of Saskatchewan, Saskatoon, SK
[2]Canadian Light Source Inc., Saskatoon, SK

Chad Glemser is currently a M.Sc. student at the University of Saskatchewan in the Department of Geological Sciences. His thesis research is focused on applying synchrotron X-ray computed microtomography and conventional laboratory-based measurements for the petrophysical and geochemical evaluation of carbonate reservoir rocks. He has received awards from the CSPG, CIM and SGS for his thesis research. Chad has recently accepted a full-time position with Nexen Inc. in Calgary and has held previous summer positions with Nexen Petroleum International Ltd. and Shell Canada Limited. Email: ctg682@mail.usask.ca