How porosity and permeability vary with diagenetic minerals in the Scotian Basin, offshore eastern Canada: Implications for reservoir quality

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Reservoir quality is one of the key controls on prospectivity during petroleum exploration, and porosity and permeability are major indicators of reservoir quality. Detailed understanding of where to expect high porosity and permeability is important in risk assessment of a petroleum basin. Porosity and permeability depend on a range of parameters such detrital supply, lithofacies, tectonics and diagenetic processes. This study integrates plug porosity, permeability, diagenetic minerals and whole rock chemical analysis of 35 sandstone samples of lower Jurassic–early Cretaceous age from conventional cores from 20 wells in the Scotian Basin, to examine if there is a link between high reservoir qualities with diagenetic mineral assemblages on a basin-scale. Most samples are from thick sandstone beds of estuarine channel or river-mouth turbidite origin, known to be the principal reservoir sandstones. Image analysis of backscattered electron (BSE) images is used for mineral identification and modal counting, based on the different gray-scale brightness of different minerals, and is complemented by whole-rock X-ray diffraction (XRD). Correlation matrix and principal component analysis (PCA) are used to extract the main element variables (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, P, La, Eu, Y, Yb, Sc, Cr, Zr, Sr, and U) that control the large variation in whole-rock elemental composition, which can help to understand the roles of diagenetic processes and detrital supply. Then cluster analysis is also applied on porosity, permeability, and diagenetic minerals.

The study shows: (1) discrepancies between plug porosity and BSE image porosity resulting from the bias of using a single thin section for image analysis; (2) diagenetic mineral content analysed from BSE images is consistent with XRD analysis only for calcite, illite, and Fe-chlorite, as peaks of minor diagenetic minerals are severely overwhelmed by quartz in the diffractograms; (3) porosity negatively correlates with CaO (calcite) and positively with Ge, which is enriched in detrital organic matter. Permeability has a negative correlation with Al_2O_3, TiO_2, Na_2O, P_2O_5, Ga, Sc, and REEs; and (4) cluster analysis shows a strong cluster of carbonate cemented sandstones, with no systematic distribution with geography or depth. Highest porosity samples tend to be from shallower than 3000 m. Previous studies suggest the regional scale influence of provenance on sandstone mineralogy and diagenesis. However, in detail, major diagenetic minerals do not show strong variations with geography, facies or burial depth. This suggests that similar diagenetic processes occur throughout the basin, but variability is also strongly controlled by local factors.

Atlantic Geology, 2014, Volume 50, Number 1
Atlantic Geoscience Society Abstracts: 40th Annual Colloquium & Annual General Meeting 2014
doi: 10.4138/atlgeol.2014003