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Using Different Imaging Techniques to Evaluate Bioturbated Reservoirs

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Bioturbation, which is disturbance of sedimentary fabric by organism activity (crawling, feeding, resting), has traditionally been overlooked when evaluating hydrocarbon reservoir properties. Instead, great effort has been devoted towards understanding how cementation, diagenesis, fracturing, and lithology impact reservoir quality at the core (meter) and thin-section (centimeter) scale. Recent investigations by academics and industry partners alike, however, have shown that many of the aforementioned parameters are also impacted directly though bioturbation. For instance, burrows formed by organisms are commonly infilled with sediment that differs lithologically and geochemically from the surrounding sedimentary media (e.g., dolomitized burrows in a micrite matrix). The end result is generally either an enhancement or reduction of the permeabilities and porosities in the burrows as compared to the unburrowed surrounding matrix.

Over the past decade, advancements in both academia and the petroleum industry have also been made to understand the distribution of porosity and permeability within reservoirs at the micron scale using high-resolution imaging techniques. The ability to assess rock samples using 2D and 3D imaging techniques has allowed geologists to better visualize the impact of bioturbation on reservoir quality. Perhaps just as important, improved environmental interpretation of the reservoir has also occurred as enhanced imaging techniques have allowed for identification of trace fossils that would have been indiscernible using visual observation alone. Herein, X-ray microtomography (micro-CT) and helical computed tomography (helical-CT) imaging techniques are used to highlight the porosity (density contrasts) associated with bioturbation at high resolutions (1 to 34 μm). Carbonate datasets from Western Canada (Mississippian Debolt Formation and Devonian Wabamun Group) and siliciclastic datasets from offshore Norway (Jurassic Ula Formation) and United Kingdom (Mesozoic reservoirs) are used as case studies.

Within the two carbonate and Ula Formation datasets, the micro-CT and helical-CT were used to differentiate the matrix and burrows in 2D and 3D. Permeability measurements, obtained via a spot permeameter, showed that the burrows are normally higher in permeability relative to the surrounding matrix. Together, the permeability measurements were linked with images from the micro-CT and helical-CT data to show where there are connected porous pathways. From this, more accurate numerical models regarding bulk reservoir permeability can be constructed at the reservoir scale. Within the Mesozoic reservoir dataset from the United Kingdom, highly saturated intervals made trace fossil identification difficult. Using helical-CT images, numerous trace fossils were identified that were previously unseen before. In doing so, the depositional environment interpretations were better constrained which ultimately allowed for improved understanding of the reservoir unit.