Correlation of Permeability and Volume of Shale in Oil Sands: Improving Predictability in Low Permeability Zones of the McMurray Formation, Alberta, Canada

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Abstract

Conventional reservoir characterization workflows suggest that reservoir permeability correlates most closely to shale volume (VShale). However, the effect of geological complexity involved in oil sand reservoirs, as well as the facies dependency of permeability and VShale is not well understood. This uncertainty is particularly significant in facies with permeability < 500 millidarcy. We integrated multi-scale exploration data from a producing McMurray Formation reservoir to demonstrate the impact of centimeter-scale reservoir architecture on permeability. The study uses high-resolution 3D models of the near-wellbore region to characterize observed variability in percentage, orientation and dimension of mud laminae, breccia clasts and trace fossils.

Methodology

We approached the problem from a geological perspective, creating models that are based on the geological relationships observed in cores or field analogues. Using process-oriented modeling, realistic small scale sedimentary structures and their volumes are achieved. Analytical reservoir properties derived from core plugs were distributed on the basis of geological relationships in these 3D models, at a scale below the resolution of wireline logs. As a result, flow-based numerical upscaling of these models generates permeability and porosity values capturing the effects of heterogeneity at the lamina scale. To better evaluate the correlation between vertical permeability and VShale, these models were upscaled at an interval of one meter which was equivalent to VShale log sampling.

Conclusions

We have established a set of correlations between permeability and shale volume by applying geology-driven 3D near-wellbore models. These models assume the facies are a result of variation in volume, bedding structure, and bioturbation of sand and mud. The absolute permeability varied within a tight range in each of these end member facies. These correlations fill the gap between the core plug scale, where the absolute permeability of each end member can be accurately measured, and the reservoir scale permeability. These fine near-wellbore models provide a tool for proper averaging of the core data within a target scale. The study indicated that the correlations between permeability and shale volume are facies dependent. Two major correlations were identified which were a result of the variations in bedding and biological structures. The sensitivity study that was performed indicated that the vertical permeability is more sensitive to the continuity and volume of the shale than the absolute permeability of each end members; nevertheless, for a given percentage of volume shale, the absolute permeability of mud has a greater impact on the average permeability than the absolute permeability of sand.

Biography

Les Dabek (P. Geol.) graduated from Brandon University (Manitoba, Canada) in 1996 with a Bachelor of Science Degree in Geology. Les has worked for more than 12 years as geologist at Geomodeling Technology Corp, with 8 years as product manager for SBED and ReservoirStudio 3D earth modeling software. His recent work is providing SBED 3D permeability modeling services for petroleum-development of oil sands SAGD thermal projects.