Upscaling Core Plug Data to Reservoir Modelling Grid: A Small-Scale Heterogeneity Modelling Approach

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Summary

Core plugs are direct measurements of reservoir rocks and, therefore, represent the most quantitative information about the reservoir. However, using core plug data in reservoir models is a major challenge because of sample bias (a core plug represents a tiny fraction of the reservoir). Petrophysical properties at the core-plug scale are primarily controlled by mm- to cm-scale bedding structures. Conventional reservoir modelling workflows integrate core plug data into full-field grids by statistical methods that ignore the effects of mm- to cm-scale heterogeneity. To increase the accuracy of reservoir property models, we developed a workflow for upscaling petrophysical models from core plug scale to simulation grid scale.

Method

The modelling method consists of two steps. First, we simulate bedding structure grids by modelling bedform migration, deposition, and erosion processes. Second, we populate the bedding structure grid with rock properties, such as porosity and permeability, that can be derived from core plug data and high-resolution well log data.

The process of stacking different bedding structures can generate a near wellbore heterogeneity model with a grid cell size of about 1 mm^3. The net-to-gross ratio and porosity data can be conditioned to core or log data. Directional permeability (kx, ky, kz) and relative permeability at the bedding structure scale (0.1 to 1 m) are calculated by upscaling the mm-scale model using fixed, linear, or periodic boundary conditions. Rock type curves, facies-dependent kv/kh, and effective property values can be derived from the upscaling results of multiple bedding structure realizations.

Conclusions

Since a litho-facies is an association of bedding structure types, the upscaled properties from the bedding structure models can be assigned to full-field facies model grids. The resulting models account for small-scale heterogeneity and can be applied to flow simulations. Case studies demonstrate that small-scale modelling and upscaling can improve the accuracy of reservoir simulations and production profile forecasting.

References

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