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# Integrated Model Assisted Characterization of Karst Reservoirs

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## ABSTRACT

Evaluating resource size and dynamic performance uncertainty in carbonate reservoirs with karst is a fundamental challenge that impacts business decisions across the asset life cycle. Based on experience with multiple fields we present an efficient practical workflow, with three tenets, for karst characterization. (1) Multidisciplinary characterization of static and dynamic subsurface reservoir data: Emphasis is placed on calibration of image logs using conventional core and systematic integration with wireline logs, well tests, PLTs, and drilling data to identify zones of anomalous storage or flow. (2) Genetic process-based interpretation of karst features: Analysis focuses on identifying causes and controls on karst formation and developing conceptual models describing field-wide karst distribution. (3) Model Assisted Karst Characterization (MAKC): A quantitative approach to generate multiple karst scenarios using sector models to address inherent uncertainty. The methodology allows rapid exploration and testing of alternative conceptual models to derive porosity and permeability. We present two different applications of MAKC. A first example investigates the flow significance of karst features smaller than a full field model cell. Object Based Modeling and Multiple Point Statistics are used to populate different styles of karst. Flow-based scale averaging is used to calculate effective properties. Results show that <5% of karst in a geological model cell can significantly modify permeability. The second example is the application of Discrete Fracture Networks to estimate karst pore volume in caverns interpreted as flank margin caves. Caves are modeled as two sub-horizontal parallel plates where cave height is based on image log observations (0.2-5m) and length and width are based on data from modern analogs. The resulting “discrete karst” model is evaluated for consistency with karst intensity interpreted from wells and cave morphometrics. The calculated cave pore volume (potential open porosity) in this reservoir is up to 7% with a mean of 2.7 %, which agrees well with studies of modern karst environments. The DFN-based approach has the advantage of simultaneously modeling karst and fractures to determine effective reservoir properties for Dual Porosity, Dual Permeability flow simulations. In both applications a karst intensity property is distributed in a full field model to reflect the conceptual models and to populate reservoir properties.