Ultra-K: A New Term Used to Define the Fluid Behavior Driven by Hypogenic Dissolution Features in a Subsurface Carbonate Formation, Saudi Arabia

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Abstract

Objectives/Scope
Hypogenic modification of limestones formations in Saudi Arabia has led to extremely well-connected dissolution features in the subsurface that exhibit a large range in size and textures. These dissolution features are believed to be the major driver in the subsurface reservoir fluid dynamics, and are being distinguished and described as Ultra-Permeability (Ultra-K) zones. This study ties dissolution features to the bulk of lost circulation zones (LCZ) encountered while drilling and reflected on production logs as points of high inflow. Describing these features on borehole resistivity image logs has yielded textural and relative positioning of these voids which has allowed relationships to be developed to volumes of mud losses. This effort was undertaken to better characterize and distribute dissolution generated geo-bodies in our 3D static models by attributing them with realistic permeabilities. This has generated positive enhancements to modelling workflows.

Methods, Procedures, Process
The study was conducted in a number of fields and was based on the image interpretation and analysis of borehole resistivity image data from a variety of borehole imaging tools in both vertical and horizontal wells, which were cross referenced to core, drilling data, production logs as well as conventional wireline and LWD data. The dissolution features were identified, classified and captured in a database which was used to generate statistics and recognize trends in the relative position of these large-scale dissolution zones in the formation.

Drilling data was used to frame the relationships of LCZ to dissolution features, which has allowed for the successful deployment of Ultra-K to be distributed in our 3D geological models.

Results, Observations, Conclusions
Dissolution features were categorized into three main groups based on their borehole image appearance and size (Touching vugs; ramiform voids and cavities). Based on their presence and distribution, it was clear that the creation of these voids was part of the hypogenetic modification which utilized selective enlargement of infra- formational fractures to distribute etching fluids into the main body of the formation, within more susceptible rock units. The volume of mud lost while drilling in LCZ was used as a reference in the analysis of the dissolution zone permeability. It was important to identify these features beyond the depths of LCZ, as the main aim of the study was to capture the location of all dissolution features along the wellbore. Data from over 500 wells has allowed for the production of detailed geo-body reference sets with associated Ultra-K, that were incorporated into the 3D static models.

Significance/Novelty

Opportunities to review large data sets and advancements in technology, has enabled the introduction of new concepts based on the analysis of borehole image data, which was not available to earlier generations of hydrocarbon professionals. Taking advantage of large resistivity image data sets which were initially acquired for fracture identification, and integrating these with a fresh perspective, has added value to the reservoir knowledge by introducing new reflections from valuable and expensive logging data sets.