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Integrated Reservoir Petrophysical Characterization and 3D Modeling: a Deep-Water Turbidite Reservoir Case Study

L Ruvo, M. Calderoni, M. Cesaro, F. Fonnesu, I. Franco, A. Lyne, S. Tommi, Eni E&P

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Abstract

Core data and logs - wireline and while-drilling - were processed and integrated with a sedimentological model to provide consistent log-facies classification and petrophysical characterization as input to a 3D geological model of an off-shore deep-water turbidite reservoir.

The studied reservoir belongs to a channel system, and consists of channel sands cut into background shaly deposits, and of thin beds that can be ascribed to levee and crevasse-splays. Chaotic slump deposits are also found locally. A complex fault system, related to mud-diapirs, subdivides the reservoir into hydraulically separated blocks, thus resulting in multiple hydrocarbon accumulations.

Log curves from five different wells were environmentally corrected, depth-shifted and calibrated at the reservoir scale in order to ensure the overall consistency of log recordings. They were used as input to a quantitative log evaluation process that resulted in the computation of the volumes of mineralogical components (sand, silt, shale) and effective porosity along the wells. The computed curves were in turn statistically processed (cluster analysis) and compared with the sedimentological description of cores, to provide a classification of the reservoir into five log-facies, each with a well-defined sedimentological meaning. The results of NMR log interpretations and a detailed thin layer analysis carried out on high-resolution resistivity curves - available on different subsets of the studied wells - were also integrated, eventually leading to a thorough petrophysical characterization (distributions of porosity, permeability, irreducible water saturation) of each log-facies.

Finally, the full-field sedimentological model - derived from 3D seismic data - and the above described petrophysical characterization provided the input for a 3D geostatistical reservoir model that was built with an object-based approach. The statistics calculated from a large number of realizations allowed a probabilistic quantification of the OHIP distribution for use as an input for future field development scenarios.

Introduction

Hydrocarbon production from 'easily characterized and produced' reservoirs has slowly declined worldwide in the last decades: as a consequence, exploration and production targets progressively shifted towards more challenging environments and/or more 'difficult' reservoirs. Turbidite deposits in deep and ultra-deep water offshore are a typical example. Besides their overall architectural complexity (amalgamated channels, channel-levee systems, channel-lobe systems), some of these deposits include heterolithic facies consisting of thin, cm- or mm-sized, alternating horizons of sandstone, siltstone and mudstones, which deserve accurate petrophysical characterization.

This paper describes a facies reservoir characterization workflow whose objective is the integration of core data and log curves with different vertical resolutions. The workflow was applied to a deep-water turbidite reservoir. The resulting characterization proved to be a useful guide in the construction of the 3D geocellular model. In the beginning, the reservoir structural setting and the sedimentological conceptual model are presented. Next, the integrated petrophysical characterization workflow is presented: the quantitative interpretation of conventional logs, the interpretation of NMR logs, and a Thin Layer Analysis carried out on high resolution resistivity curves are first discussed; then, the log-facies classification and characterization relying on log and sedimentological interpretation is discussed. Finally, the construction of the 3D geological model is presented.