Stratigraphic Variability of Mineralogy, Rock Types, and Porosity of the Wolfcamp Formation Using Multi-Mineral Petrophysical Analysis and Machine Learning, Northwest Shelf, Delaware Basin

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

The Wolfcamp Formation on the Northwest Shelf of the Delaware Basin is a self-sourced hydrocarbon-bearing reservoir, composed of sandstone, dolostone, limestone, and mudstone. Active tectonism and high-frequency changes in sea level during the early Permian influenced its reservoir quality. Heterogeneities within the Wolfcamp Formation are reflected in its stratigraphic architecture, rock types, porosity, and their spatial distribution. Thus, the Wolfcamp Formation is informally divided into four stratigraphic zones, each with different reservoir quality. Through seismically constrained reservoir characterization and modeling, relationships are established among rock types, porosity, and acoustic impedance to map their spatial distribution within the Wolfcamp Formation. The study area is west of Carlsbad, New Mexico and data include a 93 mi^2 (240 km^2) 3D seismic survey, logs from 45 wells within the seismic survey that penetrate the entire Wolfcamp Formation, and associated production data. Rock types are classified in non-cored wells with photoelectric logs by using lithology cross plots to estimate the mineral abundance of quartz, dolomite and calcite. In wells lacking photoelectric logs (PE), machine learning techniques were used to estimate PE curves using existing well logs. Total porosity, shale volume, effective porosity, and water saturation logs are calculated for each well. Cross plots of total porosity and acoustic impedance were analyzed per zone to evaluate the stratigraphic variability in porosity. A

probability map constructed from the acoustic impedance was used as a constraint to map the lateral variability in porosity. Across the study area, the Wolfcamp dips to the southeast (SSTVD -3300 to -6100 ft [-1006 to -1860 m]; and varies in thickness from 1200 to 1600 ft (366 to 488 m). The Wolfcamp stratigraphic framework was interpreted and represented by a detailed 3D model grid. Three dimensional rock type and porosity models that are constrained to the stratigraphic framework, upscaled well logs, seismic attributes, and variogram parameters illustrate the stratigraphic and proximal to distal variability of petrophysically significant reservoir rock types within the Wolfcamp Formation.

AAPG Datapages/Search and Discovery Article # 91200 © 2020 AAPG Annual Convention & Exhibition Online, Sept. 29- Oct. 1.