

Identification of Sedimentary Facies by Electrofacies Classification of Ratawi Limestone in Kuwait

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Abstract

Identifying sedimentary facies is an essential element of reservoir characterization. Conventional cores provide the most reliable information regarding sedimentary facies. However, cores are generally limited and do not cover the entire reservoir section. In such cases, electrofacies are useful and can be used as a substitute for the sedimentary facies. The Ratawi Limestone of Lower Cretaceous age, dominantly comprises of skeletal wackestone to packstone with minor skeletal mudstone. It is a low permeability reservoir with a high degree of reservoir heterogeneity. In the present work, electrofacies classification of Ratawi Limestone has been carried out to construct facies model in order to understand the depositional environment and improve accuracy of permeability estimation. Multi-Resolution Graph-based Clustering (MRGC) method was used to automate the task of electrofacies identification. MRGC automatically determines several optimal numbers of clusters. Seven wells with good quality Gamma Ray, Density, Neutron, Sonic, Nuclear Magnetic Resonance and Spectroscopy logs were considered for electrofacies classification. Core data with detailed petrographic description are available in five wells. The core lithofacies description from different wells were merged under eight major classes and depth shifted to the log data. Log and core data of five wells were used as training data set to build the model. The selected curves were normalized and the normalized Euclidean distance was used to improve the accuracy of clustering. After normalization, MRGC algorithm was used to cluster log data of the cored sections and determine optimal number of clusters. Five final clusters sets were generated with different levels of resolution. The cluster set with most geologically meaningful resolution was selected and a lithofacies type was assigned to each cluster by integrating information from cores. Among the eight lithofacies described in the cores, five could be assigned to the clusters and the remaining three were disregarded because of fewer data points. The five assigned lithofacies include mudstone, wackestone, argillaceous wackestone, packstone and shale. After validation, the model was propagated, applying Kernel Nearest Neighbor (KNN) algorithm, to the uncored sections of the five wells used in the model, as well as to the remaining two wells for verifying the robustness of the model. The identified electrofacies were found to have a good match with the core lithofacies and were used to constrain three-dimensional facies model. Porosity-permeability relationship established for each electrofacies has improved the accuracy of permeability prediction for the reservoir. In general, the reservoir quality follows the facies. The facies model has helped to understand heterogeneity of the reservoir, their depositional environment and distribution of porosity and permeability.