Permeability Index of Vugs and Fractures in Heterogeneous Carbonate Gas Reservoirs From High-Resolution Electrical Images

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ABSTRACT

In the carbonate gas reservoirs of the Precambrian Dengying Formation, Sichuan basin, Southwest China, the production performance does not match the reservoir properties obtained by conventional formation evaluation. A few wells with good reservoir properties have poor production performance, but some wells with general reservoir properties have good gas production. The carbonate reservoir storage is predominately from secondary development of vugs and fractures. Therefore, the conventional formation evaluation method is not applicable to these complex heterogeneous carbonate gas reservoirs. A new method that determines the permeability index of vugs and fractures was used for the reservoir characterization of the heterogeneous carbonate gas reservoir in 38 wells. The associated data were conventional openhole logs and electrical image logs; core data were available from seven wells. The permeability index from electrical images correlates to the unfilled vugs and fractures on the images. Conductive vugs and fractures from electrical images could be filled with mudstone or conductive materials. Core observation of the unfilled vugs and fractures are used to create a dataset of the conductivity value of unfilled vugs and fractures from electrical images. The dataset is used to automatically recognize the unfilled vugs and fractures in the electrical images. Image processing techniques are used to extract a quantitative measure of important reservoir properties from high-resolution borehole electrical images by the calibration of electrical image logs to core. The 38-well production performance indicates that most of the reservoir zones with higher permeability index correspond to good gas production and water breakthrough, and all of the reservoir zones with lower permeability index have poor productivity or produce nothing. The seven-well core data analysis shows that the permeability index from electrical images is proportional to reservoir rock permeability. However, the dataset of the conductivity value of unfilled vugs and fractures from electrical images should be further improved by coring in a new well.