

Integrated Characterization of Fracture-Vuggy Carbonate Carriers for Hydrocarbon Migration: A Case Study on Central Uplift of Tarim Basin, China

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ABSTRACT

Carriers are important elements in petroleum systems, which offer paths for hydrocarbon migration and accumulation between sources and traps. Applicative characterization of fracture-vuggy carriers in Central Uplift of Tarim basin is a stiff challenge because of heterogeneities of such reservoirs, and in particular, because of important burial depths that are generally deeper than 5500 m. Main quasi-layered fracture-vuggy carriers developed nearby the multi-ordered Ordovician unconformities, and geometry of these carriers was irregular. Based on geological studies, a multi-scale analysis approach was proposed to characterize the carriers for hydrocarbon migration. And the Petrel Software was used as a main tool to realize the workflow.

Based on previous works on the carbonate sedimentation and diagenesis processes during basin's evolution, as well as works on reservoir characterization, it is considered that the carbonate carriers in the study area may be observed and analyzed in 4 scales. Firstly, the caves, vugs and fractures were recognized in the quasi-layered paleokarst systems by using cores, well logging, seismic and production data. And then the outline of the carrier framework at megascopic scale (10~100m) was delineated. Secondly, by analyzing the observed results on thin sections and core samples (<2.5cm), twelve Petro-Geological Groups were identified from sedimentology, petrophysics and associated logs responses; then their spatial distributions were identified with seismic data and characterized in four Ordovician members. Thirdly, using well logging, petrophysical and production data, macroscopically averaged porosity and permeability (in a scale of 0.2~5m) were measured and then the probability density functions of the twelve PGGs were drawn. After then the carriers macroscopic porperm model in Ordovician strata were built. At last, based on the percolation model, the three main hydrocarbon migration processes were simulated in the macroscopic porperm model.

The results showed the hydrocarbon migration in Ordovician strata was affected by the fracture-vuggy carriers significantly. (1) The faults acting as vertical migration pathways, and the fracture-vuggy systems acting as lateral pathways, the four quasi-layered fracture-vuggy paleokarst systems and faults made up the three dimensional hydrocarbon migration frameworks. (2) The faults controlled distributions of favorable carriers. The fault-crossing areas, releasing and horsetail splay parts of NE trended strike-slip faults were favorable for hydrocarbon accumulation. (3) The simulation results showed that three periods of hydrocarbon migrations formed obvious oil and gas mixed phenomenon; the NE trends strike-slip faults controlled the hydrocarbon filling area and amount of natural gas.