

Migration Simulation in Heterogeneous Clastic Carrier Beds and a New Perspective in Petroleum Geology

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Abstract

The heterogeneity of sedimentary strata is universal and hierarchical. However, in studies of petroleum migration and accumulation at the basin scale, the heterogeneities in rock composition, sedimentary structure, and porosity and permeability within the carrier beds have not been emphasized, so that the mode of migration is relatively simple. This limits the application of migration and accumulation models in exploration. We analyzed reservoir data from boreholes and outcrop bituminous sandstones to establish carrier bed models with architectural heterogeneity. The characteristics of migration pathways and hydrocarbon accumulation in such models were simulated using an invasion percolation simulator. The results are verified with the observed phenomena. The heterogeneity of clastic strata is controlled by sedimentary structures. Significant differential diagenesis occurred during shallow burial before hydrocarbon migration. Permeable rocks are separated by low permeability barriers to form architectural heterogeneity within carrier beds. As a result, the morphological characteristics of migration pathways and accumulation patterns are significantly different from those based on traditional concepts. Hydrocarbons generally migrate upward, but they are blocked by intervening low-permeability barriers, resulting in variable migration direction and complex pathways. Accumulation can occur anytime and anywhere, although traps in the up-dip direction are still the ultimate destinations and favorable targets of accumulation. Individual accumulations along migration pathways are very small, but abundant

and widely distributed. So that the total amount of accumulation in structural lows and slopes is much larger than that in reservoirs in the up-dip traps. Our results provide a new dynamic perspective in petroleum geology. More in-depth understanding of the elements in petroleum system, such as reservoir, caprock, trap, as well as the processes of hydrocarbon migration and accumulation, is imperative. Explorations should aim at a wider range of targets, including those in structural lows and slopes.