Hydrocarbon Migration Modeling: Methodology and Applications

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ABSTRACT

Hydrocarbon migration is the process that controls the formation and distribution of oil and gas accumulations. Therefore its understanding is a critical factor in risk assessment of hydrocarbon exploration targets. However, the kinematic and dynamic description of this process generally remains on a qualitative level, resulting in inaccurate regional reserve assessments, as well as, erroneous identification of exploration targets.

Based on current understandings about secondary migration of hydrocarbons in carriers, insights in the mechanisms and processes of secondary migration were used to develop a numerical simulation method based on the invasion-percolation theory with an assumption that buoyancy is the main driving force. This model consists of 2-D networks, where the nodes represent pores and the links represent the throats in a carrier. The radii of pores and throats are assigned by a random-number generator that follows a Gaussian distribution; and the mean and standard deviation change according to the lithologic characteristics of the carrier. To illustrate the varying amounts of migrating hydrocarbons along pathways, combined effects of driving and resisting forces, properties of carrier beds, and rate of hydrocarbon supply were taken into account in the model. This simulator can be used to quantify the relationships between hydrocarbon source, driving and resisting forces, and migration pathways to provide basin-scale and regional quantitative estimation of pathway formation, amount of migrated oil in various directions, and areas of accumulation.

The basic properties of an invasion- percolation model make it applicable to model the balance between driving and resisting forces under geologically reasonable conditions at the core to basin scale. Hydrocarbon migration–accumulation system may be taken advantage of by migration simulation. Similar to petroleum system, HYMAS is also a petroleum geological research method or/and a tool, but is more suitable in tectonically superimposed basins. HYMAS is defined as the duration of a whole HC migration accumulation process, within an overpressured compartment, where HCs migrated from a source, through carrier, and accumulated in pools. Such migration modeling methods can be used in actual basins to quantify the relationships between hydrocarbon source, driving and resisting forces, and migration pathways, to provide basin-scale and regional quantitative estimation of the amount of migrated oil in various directions, and areas of accumulation.