Secondary Migration by Stokesian Flow of Metastable Clusters of Petroleum in Water: Implications for Carrier Bed Properties

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ABSTRACT

The popular hypothesis for secondary migration of petroleum as a continuous separate phase flow has many problems. To circumvent these, I proposed (Stainforth, 2012) that secondary migration of petroleum mainly occurs as colloidal clusters in water in the metastable region between true solution and continuous separate phases. The governing law is Stokes' rather than Darcy's, and the controlling viscosity is that of the pore water rather than the petroleum. As a result, the mechanism works equally well for all petroleum mixtures from the heaviest to the lightest and is generally much faster than Darcy flow of a separate phase. So long as the clusters are smaller than the pore throat size, there is no capillary resistance. At any one time, the volume fraction of petroleum in the pore water in the secondary migration pathways is very small (0.001 or less), and the losses of petroleum are negligible. Another enormous advantage of the mechanism is its ability to self-adjust the flux rates over at least six orders of magnitude, which is required by the focusing of flow in secondary migration systems.

In this paper, I combine drainage area analysis with fractal stream laws to compute petroleum mass fluxes in different parts of a secondary migration system. This allows the sizes of the petroleum clusters, and thus the minimum pore throat sizes in the carrier beds, to be computed. These pore throats sizes are translated into Darcy permeabilities for reference purposes, even though the controlling flow law is not Darcy. The mechanism points to the lithological and diagenetic limits for adequate carrier beds in secondary migration systems.