Constraining Oil Charge Rates and Oil Reservoir Residence Time: Key Variables in Prospect Analysis and Heavy Oil Fluid Property Prediction

Larter, Stephen [1]; Adams, Jennifer J.[2] (1) PRG, Geoscience, University of Calgary, Calgary, AB, Canada. (2) PRG, UoC Calgary; Now....., ConocoPhillips, Houston, TX.

Timing of petroleum charge and seal development, petroleum charge rate to a trap and reservoir oil residence times are the key variables in assessing trap prospectivity in that they determine the volume of petroleum in a trap in the context of trap integrity including spilling and leakage phenomena. Constraining oil residence time would also allow for basin prospectivity estimates based on assessment of fraction of total basin charge trapped. We review advances in biodegradation modelling, as an example of an area needing charge rate data and discuss possibilities for petroleum charge dating methods based on molecular analysis of reservoir fluids to directly constrain petroleum system dynamics and basin models.

Recently we synthesised geological, geochemical and microbiological information to suggest in-reservoir crude oil degradation is an anaerobic process, occurring at the base of the oil column, with CH4 production being the terminal process (Jones et al, 2008). Biodegradation combined with advective and diffusive oil mixing, produces gradients in oil composition and fluid properties (Larter et al, 2006, 2008) which are perturbed by intra-reservoir baffles with gas and oil leakage via top seals required to maintain active biodegradation (Adams, 2008). A self consistent calibrated model of crude oil biodegradation rate in reservoirs has been developed which relates biodegradation extent and oil properties to a biodegradation flux related to reservoir temperature history and evolution of water leg volume and oil composition (Adams, 2008).

Oil charge mixing, charge rate and oil reservoir residence time, are the key variables controlling reservoir fluid properties. Definition of geological biodegradation rates allows pre-drill definition of fluid properties if oil charge histories can be constrained with changes in net oil charge rates to traps of X2, resulting in API gravity changes of up to +12API units. The net level of biodegradation of an oil depends on the in-reservoir residence time yet currently no practical analytical route to defining the timing of oilfield charging or the length of time a given oil charge has been in a trap exists! Forward basin models provide estimates, but errors at order of magnitude level are likely. We review existing oil charge dating concepts and introduce two new conceptual approaches to direct dating of oil charge based on analysis of trapped oil compositions and charge related compositional gradients.