Determining Oil Migration Using Rare Earth Elements And Cyclicity In The Pennsylvanian Southern Tyler Petroleum System, Williston Basin, North Dakota

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ABSTRACT

Cyclicity of the Pennsylvanian Tyler Formation is evident in the rapid lithology changes in core samples and in the sequence boundaries and parasequences that are identified in geophysical logs. In addition, changes in paleoenvironments are indicated by the distribution of Rare Earth Elements (REE) derived from sediment and oil samples, and in the two kerogen types exhibited in the sediments of the Tyler Formation. Extreme lithology changes observed in the cores range from terrestrial to deep oceanic sediments, indicate fluctuation in Tyler Formation depositional settings in Billings and Stark counties, North Dakota. Four cycles divided by three sequence boundaries were identified on well logs, as were ten third order parasequence cycles. The sequence boundaries can be identified and traced throughout the available geophysical logs in the gamma ray, resistivity, density and porosity. The Tyler Formation represents both source and reservoir for the accumulated oil, and is independent of other reservoirs and source rocks in the Williston Basin. REE provide an excellent tool for fingerprinting different paleoenvironments. The sediment rocks collected from the Tyler core samples depicted paleoenvironments from anoxic-euxinic with abundant organic material, to suboxic- anoxic with moderate total organic carbon (TOC) and moderate clay, to oxic with high clay content and very low TOC, to a very basic, high pH, oxic environment with high salinity. The REE distribution on ternary diagrams of the oils indicated two distinctly different paleoenvironments; a normal oceanic oxic water with basic pH and relatively high salinity, and a suboxic to oxic environment with moderate organic matter and terrigenous influence (more acidic). REE signatures of the Tyler oils compared with oil stained reservoir rocks demonstrate that the paleoenvironment of oil formation and sediment diagenesis are distinctly different from the paleoenvironment of the host rock.