Implications of Linearly Correlated Oxygen and Hydrogen Isotopic Compositions for Kaolinite and Illite in the Magnus Sandstone, North Sea

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Abstract: Authigenic kaolinite and illite are important diagenetic minerals in the Magnus Sandstone, a giant oil reservoir in the northern North Sea. These clay minerals, separated from three wells, show considerable ranges in their oxygen isotopic composition ($\delta^{18}O_{SMOW}$ = +9 to +16‰) and hydrogen isotopic composition (δD_{SMOW} = -55 to -105‰). The variations in $\delta^{18}O$ and δD are positively linearly correlated with a high degree of statistical significance for both kaolinite and illite: Kaolinite: n = 12; $\delta D = 6.1\ \delta^{18}O - 169$; r = 0.66(>95%) Illite: n = 11; $\delta D = 5.9\ \delta^{18}O - 159$; r = 0.78(>99%). Formation of the clays in a pore fluid of uniform isotopic composition over a range of temperatures appears unlikely. It is suggested that the observed relationships between clay mineral $\delta^{18}O$ and δD are perhaps best explained by a model of precipitation at more or less constant temperature from pore fluids which varied isotopically across the oilfield. The isotopic composition of the formation waters would then lie along the line: $\delta D_w = 6.2\ \delta^{18}O_w - 50$. This is most plausibly interpreted as a mixing line with suggested minimal endmembers at ($\delta^{18}O$, δD) values of (+4, −24) and (−4, −76). The first of these represents reasonable isotopic values for Magnus Sandstone formation waters. Although $\delta^{18}O$ of the second is compatible with an evolved Cretaceous meteoric water, its δD value is difficult to understand in the context of the model.

Key Words: Illite • Kaolinite • Stable isotopes • Porewater

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