Alteration and destruction of hydrocarbons in Devonian of the Western Canada Sedimentary basin: evaluating process through organic geochemistry and organic petrology

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Three main processes are generally considered as being effective mechanisms for the alteration and/or destruction of hydrocarbons within Devonian reservoirs in the Western Canada Sedimentary Basin (WCSB): biodegradation of oils (including water washing), thermal cracking of oils, and thermochemical sulphate reduction. Other processes such as tectonic uplift of reservoirs and multiple charge of hydrocarbons into reservoirs may also play an important role, but currently their impact may be under-estimated. Using examples from the WCSB, this presentation will discuss organic geochemical and organic petrological criteria which can help to recognize and discriminate between these alteration processes in oil and gas reservoirs. For the case of biodegradation of crude oils, a loss of n-alkanes and aromatics in the gasoline range hydrocarbons is initially observed followed by progressive removal of the C15+ saturate fraction with increasing degradation, ultimately ending with a hump of unresolved compounds in the saturate fraction and distinct peaks from compounds most resistant to biodegradation (e.g. hopanes). Petrographic evidence for biodegradation of oils is sometimes preserved paragenetically in diagenetic minerals where relatively high gravity, unaltered hydrocarbon fluid inclusions (hcfi) are post-dated by altered, lower gravity hcfi and oily 'solid' bitumens.

Thermal cracking of oils typically results in a decrease in oil density and amount of high molecular weight hydrocarbons, an increase in the saturate to aromatic ratio, and an increase in gas content. Monitoring changes in biomarker ratios which are sensitive over the oil to gas range of maturation for a single oil family may also be useful for evaluating oil to gas transformation in reservoirs. The reflectance of asphaltene-derived, isotropic solid bitumens produced during oil to gas cracking within reservoirs (e.g. Strachen-Ricinus; Simonette; Pine Northwest, Gilby) can provide an indirect method for estimating the level of maturity in terms of vitrinite reflectance equivalent and potentially be used as a basis for evaluating biomarker ratios in terms of 'absolute maturity'.

Thermochemical sulphate reduction (TSR) has accounted for the vast majority of H_2S within Devonian reservoirs of the WCSB. TSR processes can be separated from normal thermal cracking of oils by noting a decrease in oil gravity and saturate to aromatic ratios, and the formation of new sulphur-compounds in the oils. With increasing TSR and H_2S generation, the $\partial^{13}C$ values of oils and condensates become closer to the $\partial^{13}C$ values of anhydrites within the formation. In addition carbon isotopes of individual gasoline range hydrocarbons show greater shifts in the $\partial^{13}C$ for TSR altered oils compared with oils that have been mainly altered by thermal maturation. Petrographically, pyrobitumens which formed during TSR are sulphur-enriched, show unique fine needle-like optical textures, or a shift toward lower anisotropy and finer-grained mosaic microtextures.

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