Integrated geochemical and microbiological study of Wilcox oils and gases of Northern Louisiana

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Methane can be produced and consumed by microbial processes in shallow subsurface environments. In oil bearing reservoirs, methane generated via hydrogenotrophic methanogenesis is often associated with the anaerobic biodegradation of crude oil [1]. In contrast, the consumption of methane typically involves the anaerobic oxidation of methane and reduction of sulphate in marine pore waters [2]. The $\delta^{13}C$ and δD signatures of methane is often used to determine which of these processes is controlling the abundance of methane in reservoired fluids. However, such an approach can lead to ambiguous results when these processes occur in a fluid that also contains thermogenic methane generated from source rocks in the oil window.

In this study, we investigate the fidelity of the methane clumped isotope thermometer to quantify contributions of biogenic and thermogenic methane in mixed fluids. This is integrated with observations of biodegradation from molecular analysis of oils and from 16s RNA based evidence for the presence of methanogens and/or methanotrophs in the associated fluids. To do this, we sampled formation water, oils and gases from wells that produce from Eocene-Paleocene Wilcox group reservoirs in the Searcy, Nebo-Hemphill and Olla fields of north-central Louisiana, USA. These fields were selected because previous studies suggested that these fluids represent mixtures of biogenic and thermogenic methane, and potential evidence exists for the anaerobic oxidation of methane in some of the fluids [3].

Methane clumped isotope signatures exhibit a wide range of temperatures consistent with compositions that are dominated by biogenic methane in some samples and thermogenic methane in others. We discuss these results in the context of molecular constraints on the thermal maturity and extent of biodegradation of the associated oils, as well as the microbial ecology of the formation waters associated with the hydrocarbon fluids.

[1] Jones et al. (2008), *Nature.* [3] Shelton et al. (2016), *Org Geochem.*