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Isotope Analyses in Reservoir Assessment, Production Allocation and Monitoring: From Microbial Gas Plays to Heavy Oil Columns,

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Gases in the young basins with Tertiary sections up to 25,000 ft like the Columbus Basin in the Caribbean are pervasively charged with mixtures of early formed microbial gas and later migrating mature to post-mature thermogenic gas resulting in large variations methane ($\square^{13}C_1$ = -70 to -53 ‰) and ethane ($\square^{13}C_2$ -32 to -24 ‰). In such settings mudgas isotope analyses are sensitive monitors for assessing reservoir communication and compartmentalization. Because thermogenic gas is a late migration product, ethane isotopes are particularly useful. In combination with gamma ray logs we can show that most faults are sealing and sands across faults have different isotope signatures. Lack of communication is easily established, however a positive diagnosis of communication through similarity of isotopes is more difficult and requires the combination of Mudgas isotopes with formation pressure gradients. The major sands in the Caribbean are not in vertical communication. To the contrary, gases in sands only 1000' feet apart contain very different gases based on carbon isotope data: the gas in the shallow sand is predominantly bacterial in origin whereas a deeper sand contains more than 50% thermogenic gas. This proximity of different gases in closely stacked sands suggests lateral rather than vertical charging of the thermogenic component in the gases.

In wells in the West Canada Basin which penetrate heavy oil columns we calculate the isotopes of ethane and propane, the components which are most affected by biodegradation from the measured methane isotopes using calibrations from various isotope models. Downhole plots of the isotopic difference of measured and calculated ethane and propane values provide a detailed profile of the intensity of biodegradation. The C2+ components are quantitatively removed in the most severe biodegraded part of the oil column. We do not see evidence for secondary microbial methane.

Frac backflow allocation in a commingled open hole production can be accomplished using matrix mathematics with special precautions needed for isotope mass balance. We developed and tested our own algorithms as we found that commercial allocation software does not work for gas isotopes. Systematic production allocation can help improve a frac program as it can identify the best producing zones without expensive production logs. In some cases, geochemical allocation is more specific than production logging.
Production monitoring can be a very important field management tool as we founding a domestic tight gas project that the contribution of individual fracs in wells can change within months.

Frequent commingled flow analysis can, therefore, indicate early on well performance problems and with allocation calculations of the changed commingled flow, we can provide to clients an early precise diagnosis reason of the flow problems. In some fields such diagnosis can be perfectly made with gas composition analyses only.

Geochemical techniques will be more and more important in extended horizontal wells where wireline data are limited. In the North Sea, mudgas isotope analyses are successfully used for prediction of pressure changes along the well after penetrating major faults. If mineralogy and TOC analyses are added to isotope analyses, geochemical geo-steering will be a future in horizontal well drilling.