PERSISTANCE OF BIOGENIC METHANE AND ITS MIXING WITH THERMOGENIC FLUIDS: OBSERVATIONS AND CONSEQUENCES

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Introduction

Advanced mud gas logging (AMGL) allows quantitative analysis of light hydrocarbon formation gases during the drilling process with continuous well coverage, improving real-time workflows for understanding fluids distribution and properties very early in the exploration process. With the addition of analysis of the carbon isotope composition of methane with a good accuracy (+/-1permil), real-time hydrocarbon fluid analysis provides fast and reliable information to confirm existence and basic fluid properties of the petroleum system and guide sampling strategy.

Results

Extensive real-time fluid logging in a large range of sedimentary basins frequently shows the presence of primary biogenic methane persisting deeper than the zones of active methanogenesis. For example, in thick organic-lean shale packages, the biogenic gas signature may show no variation over a large depth range or may mix with thermogenic hydrocarbon charge entering the biogenic gas zone. Biogenic gas may also leak vertically or horizontally into thermogenic gas charge zones. As a result, the properties of the resulting petroleum fluid may be very different from the original thermogenic end-member, e.g. increased gas-oil ratio (GOR) and more ^{13}C depleted methane. Additionally, whether via leakage or incorporation into thermogenic fluids, the variable contribution of biogenic methane can affect the capability of early accurate identification of the thermogenic fraction of the mixture when relying solely on gas molecular composition. Incorporation of the $\delta^{13}C$-C_1 log in addition to advanced mud gas logging (AMGL) allows identification of such mixing scenarios, assessment of the proportions of each end-member and differentiation of biodegradation of petroleum fluids in-place.

Conclusions

The use of modified Schoell (Schoell 1983) and Bernard (Bernard et al. 1976) diagrams, along with other interpretative tools (log tracks, cross-plots, and star-plots), provide a near-real time workflow for continuous flagging of fluid types, alteration processes, and their distribution along the wellbore path. Examples include: fluid migration/leakage, mixing, and secondary reservoir processes. Early access to such information helps to optimize the analysis programs of mud gas spot samples and/or bottom-hole fluid sampling (BHS) programs. In a multiwell data set, this interpretative toolkit shows fluid distribution, providing important early confirmation and understanding of the petroleum system on geological and production time-scales.

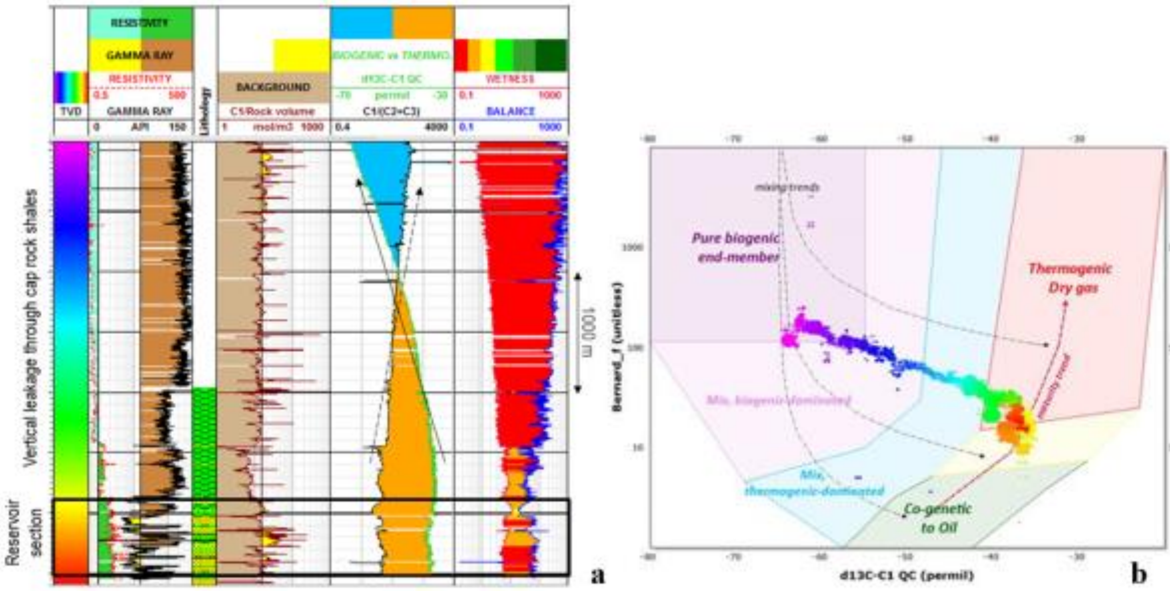

Figure 1: ***a)*** *Illustrative example of simple leakage throughout a thick non-source rock shale package of several thousand meters from a reservoir section containing a pure thermogenic end-member. From left to right we can see typical petrophysical logs, lithology, amount of methane in rock, Bernard ratio and* $\delta^{13}C\text{-}C_1$ *crossover track, and classical wetness (Haworth 1985) and balance crossover track.* ***b)*** *Bernard diagram showing clear diffusion-leakage trend, same data as a), colored by depth.*

References

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