

IMPACT AND CORRECTION OF ISOTOPIC RECYCLING IN MUD GAS LOGGING

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Currently, quantitative concentrations and isotopic compositions of methane (e.g. $\delta^{13}\text{C}-\text{C}_1$, Niemann et al. 2010, Breviere et al. 2014) and other gases can be measured continuously from circulating drilling mud. However, a fraction of each gas species does not fully degas from the drilling fluid before it is re-injected into the well being drilled. The composition of the recycled gas, whether fractionated at the surface or not, may differ from the gas in subsequently drilled formations. Mixing of both gases at the bit can therefore modify the true value of $\delta^{13}\text{C}-\text{C}_1$ of a formation gas. Typically, we observe that the re-injected gas is ^{13}C -enriched, implying isotopic fractionation during surface degassing.

Isotope recycling effects can be observed in field operations, for instance, as the reappearance of recycled, fractionated C_1 peaks in recirculating mud during non-drilling intervals. Furthermore, while drilling and logging through thin-bedded stratigraphic sections, variable contributions of formation gas and the recycled C_1 , can influence the $\delta^{13}\text{C}-\text{C}_1$ measured in mud gas exiting the well. Such preliminary field observations enable derivation of the fractionation factor $\alpha^{13}\text{C}$ for the re-injected C_1 caused by surface mud degassing. The resulting Rayleigh fractionation curve, together with observed typical recycling levels of C_1 , allows one to estimate the expected $\delta^{13}\text{C}$ offset for the recycled C_1 . This recycled mud gas can offset isotope logs as well as routine isotope mud gas spot samples.

An isotope recycling model was developed using a range of values for input parameters observed in the field (Figure 1). A sensitivity study was performed considering the following controlling parameters of isotope recycling effects: i) the fraction of retained C_1 in mud at the surface prior to re-injection; ii) the fractionation factor $\alpha^{13}\text{C}-\text{C}_1$ of mud degassing at the surface; iii) the mixing ratio of recycled C_1 and C_1 from the drilled formation; and iv) the difference in $\delta^{13}\text{C}-\text{C}_1$ between recycled C_1 and C_1 from the formation. Using moderate values for these input parameters we were able to match data from two independent recycling events in a single well.

Consequently, a correction procedure was developed in order to obtain unbiased $\delta^{13}\text{C}-\text{C}_1$ of the formation gas without the impact of isotope recycling. The correction method involves measurements of C_1 concentration and $\delta^{13}\text{C}-\text{C}_1$ from mud coming out of the well (C_1 OUT) and from mud injected back into the well (C_1 IN), both extracted from mud at the same thermodynamic conditions (Frenchin and Breviere 2008). Alternatively, the correction can be performed with only C_1 OUT, but it requires additional parameters, such as: degassing rate of C_1 out of mud, associated $\alpha^{13}\text{C}-\text{C}_1$ of mud degassing at surface, and time at the surface of each portion of mud prior to re-injection. These parameters can vary during drilling, hence the more straightforward approach with quantitative and continuous C_1 OUT & and C_1 IN measurements is recommended.

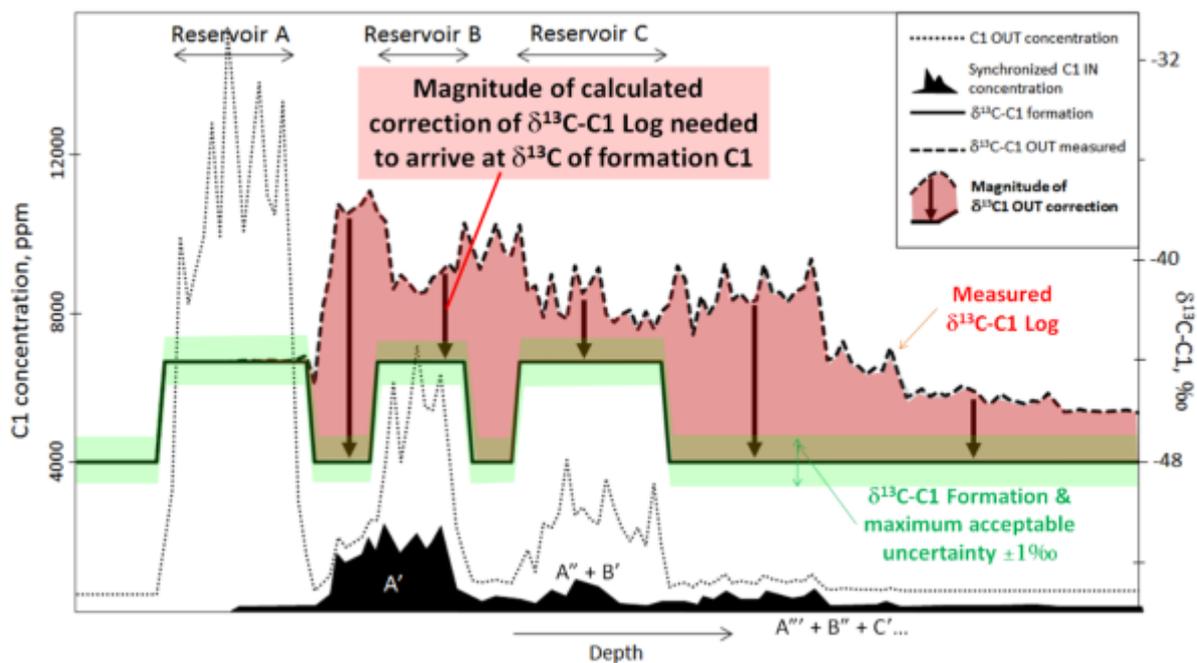


Figure 1 Illustrative synthetic model of three reservoirs containing C_1 with constant $\delta^{13}C-C_1$. The diagram illustrates the magnitude of correction for the isotope recycling effect of the $\delta^{13}C-C_1$ measured from mud gas coming out of the well (C_1 OUT). The model utilizes typical field-observed values for the level of recycling of C_1 (C_1 IN) and $\alpha^{13}C$ fractionation during degassing of the mud at surface.

References

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