USING OFFLINE ISOTOPIC ANALYSIS TO UNDERSTAND THE REPRESENTATIVENESS OF MUD GAS SAMPLES COLLECTED DURING DRILLING

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Introduction

Offline isotopic characterization of mud gas samples collected during drilling operations generates key data that can be used to interpret gas origin, recognize gas mixtures, determine hydrocarbon fluid type, flag fluid alterations, characterize source rock and the fluid’s thermal maturity. Data can also be utilized in correlation studies and for reservoir continuity assessment (Schoell, 1983; Chung et al., 1988; Berner and Faber, 1996; James, 1983; Whiticar, 1994; Prinzhofer and Battani, 2003). During drilling operations, gas can enter the mud system by different means. and the gas liberated from the formation by bit crushing is generally considered representative of formation gas (FG). However, during operations performed at static wellbore conditions, gas can infux into mud by various other mechanisms, including tripping (trip gas, TG), when mud pumping is stopped (pump off gas, POG), including to perform connections (connection gas, CG), or during hole cleaning (e.g. high-viscosity sweeps (Hi-vis)). We compared the molecular and carbon isotopic composition of mud gas samples collected during various drilling operation procedures, as well as solution gas from bottomhole samples (BHS), and discuss the representativeness of these different sample types.

Results

The set of mud gas samples was collected during drilling, tripping and high-viscosity cleaning from units U1, Upper U2, Lower U2 and U3. Solution gas flashed from BHS was collected from three depths from the Upper U2 unit. Molecular and isotopic composition results indicate gas of thermogenic origin, associated to black oil (U1 and Upper U2), volatile oil/condensate and dry gas (Lower U2 and U3), with maturity increasing with depth (Figs. 1a–1c). Based on C₂⁺ carbon isotope composition, the sample set can be divided into three main groups: 1) Upper U2 FG and CG assigned to the U1 unit, with average δ¹³C of C₂ of ~34.5‰, 2) TG assigned to the Upper U2 and Lower U2 units, Hi-vis gas assigned to the Lower U2 unit, Lower U2 FG, and solution gas from the Upper U2 unit, with average δ¹³C of C₂ of ~28.8‰, and 3) Hi-vis gas assigned to the U3 unit and U3 FG with average δ¹³C of C₂ of ~26.1‰. The isotopic composition of methane generally shows larger variations. The close match of the isotopic composition of all TG samples with the BHS gas suggests that TG corresponds to produced gas from a unique reservoir layer. Interestingly, the isotopic composition of BHS gas collected from the Upper U2 Fm. do not match mud gas samples from the same interval (FG), but it matches the composition of the mud gas sample from the Lower U2 Fm. A possible explanation is that gas is produced from the Lower U2 Fm. and moved through preferential dual permeability paths, while the Upper U2 FG is not mobilized during bottomhole sampling but only via crushing of the rock by the drill bit. The Upper U2 FG seems to correspond to an earlier lower-maturity charge and is not a flowing phase, whereas a more mature secondary charge from the Lower U2 Fm. may be occupying large drainage volume (larger pores or fractures), enabling it to be sampled as BHS and to be released by the formation during pumps off and tripping operations, causing decreased pressure of the mud column. In this example, hole cleaning Hi-vis gas samples appear representative of the FG in the corresponding interval, as increased mud density allowed again only produced gas release from the highest-pressure
mature gas reservoir near bottom of the well (U3). Even when TG isotope data matches the BHS, representative of flowing reservoir fluid, the molecular ratios are often strongly affected due to alterations such as phase separation of the produced gas during pumps off or trips. Still, isotope data remains a valid fluid-typing tool because isotopic fractionation during these processes is expected to be negligible.

References


