

WELL INTEGRITY ASSESSEMENT USING CARBON AND HYDROGEN ISOTOPIC COMPOSITIONS FROM HYDROCARBONS AND H₂ OCCURRING IN WELL ANNULII: SUCCESS AND LIMITATIONS.

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Introduction

Molecular composition and compound specific stable isotope data are widely used in Exploration and Production studies. They provide also valuable information in case of well integrity issues. The pertinence of the biomarker and isotopic signatures to assess the origin of the leaking hydrocarbon liquid fraction was largely demonstrated. The molecular composition and compound specific carbon and deuterium isotopic composition provide relevant information about the gaseous hydrocarbon origin (reservoir or overburden). Regarding the H₂ origin it is more challenging.

Results

At TOTAL, the acquisition of a gaseous hydrocarbon reference vertical carbon isotopic profile is now mandatory for any potentially developable new reservoir or overburden compartment of a field and it has been formalized as a company rule. Compound specific carbon isotopic compositions of gaseous hydrocarbons are considered as efficient natural tracers and can be used as a correlation tool when a gas leak occurs in or out the well architecture. Mixing and secondary alteration processes must be taken into account to identify the leaking layer.

Various annulus gas samples from different well locations were analysed and evidenced significant dihydrogen (H₂) concentrations and very negative $\delta D-H_2$ values. The main objective was to help investigation on the origin of the H₂ encountered. Several options were investigated as possible sources of H₂ like electrolysis, radiolysis, chemical corrosion, thermal decomposition of the completion fluid, deep source, microbial origin or from the reservoir section.

On-site measurements and laboratory tests were performed to rank the possible sources of H₂ in the well annuli and also explain the very negative $\delta D-H_2$ values. As already observed by Horita (1988), hydrogen isotope exchange between H₂O and H₂. The isotope fractionation at equilibrium influence the $\delta D-H_2$ values. In case of re-equilibration, observed isotopic values would not necessary reflect the isotopy of the process involved in the generation of H₂ and would be the result of re-equilibration with water in annulus spaces at well temperature conditions (Coveney et al.,1987).

However the equilibration kinetics was not evaluated in the context of well annuli (completion fluid composition, casing types, role of the catalysts, temperature). The time scale of equilibration is key to assess since periodic annulus purges could reset the isotopic signature.

Our understanding from the literature is that in the absence of a catalyst the re-equilibration can occur within days to weeks – but no one has ever done equilibrium measurements in equivalent annulus conditions. So indeed it is an issue of concern to assess the process involved.

Experimental results will be presented. According to the results and to the context at well locations, interpretation will be proposed. The results will be included in the well remediation plan and the monitoring strategy.

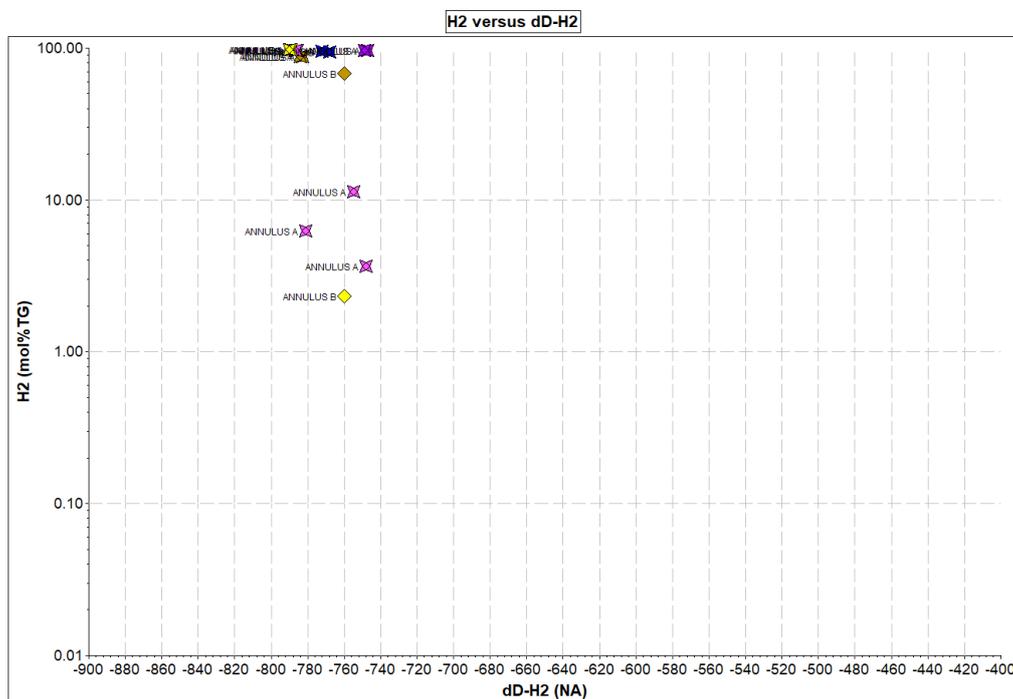


Figure 1 This is an example of a the [H₂] and dD-H₂ encountered in well annulii (colors are related to wells, symbols are associated to corresponding annulus).

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