The Effective Diagnostic Capability of Pulsed Neutron Logging for CCS Monitoring Purposes

by Saida Machicote (ENI)

Abstract:
The actual importance of Carbon Capture and Storage (CCS) projects requires in-depth studies on several disciplines. In particular, Measurement, Monitoring and Verification (MMV) plans include critical activities at the so-called spy wells for the proper understanding of carbon dioxide (CO_2) plume development far from the injectors. In this respect, time-lapse Pulsed Neutron Logging (PNL) represents a mainstay for the quantitative evaluation of fluid saturation changes behind casing. However, the latter task can be not straightforward in case CO_2 injection is performed into depleted gas reservoirs. This paper deals with a deep study to evaluate the diagnostic capability of various PNL measurements for fluid identification and saturation monitoring purposes in CCS projects.

First, accurate analytical and numerical modeling of typical PNL responses of mixtures of water, reservoir gas and CO_2 has been performed. These include fast neutron interactions, inelastic/elastic scatterings, and capture, together with their dependence on pressure, temperature, and acquisition environment. The outcomes of the first step lay the groundwork for the definition of the most effective PNL interpretation approach, as appropriate. In detail, after the selection of fit-for-purpose curves and their physics-based models, a joint inversion is performed to reconcile models and actual measurements to solve for water saturation, reservoir gas and CO_2 fractions in selected cases. The uncertainty of the outputs is also quantified by means of an ad-hoc Monte Carlo approach, starting from the standard uncertainties of the input PNL data.

In turn, two real case studies are presented. For both, baseline PNL acquisitions have been performed in spy wells to fix the water saturation scenarios before CO_2 injection and to calibrate the PNL model parameters. Several simulations of PNL response have been performed to forecast the deviation from the acquired baselines, according to the possible arrival of plumes composed by reservoir gas-CO_2 mixtures with different relative concentrations, in case displacing different amounts of water volume fractions, and at different pressure and temperature regimes coming from the available dynamic reservoir models. Therefore, random errors have been generated for the simulated PNL curves to be used for the subsequent uncertainty quantification in obtaining the desired water saturation and reservoir gas-CO_2 relative concentrations, mimicking future time-lapse interpretations. The latter represents a useful template to understand real PNL monitoring capabilities in such environments and the best subset of neutron interactions to exploit for the purpose. This information is fundamental for the MMV plan to schedule the proper time-lapse PNL campaign.

Bio:
Saida Machicote graduated in Physics at the University of Perugia in 2015 and she has 2nd Master degree in Petroleum Engineering and Operations from Politecnico di Torino. Her experience in Eni started in 2017 during her Master's thesis where she worked on a new NMR-based method for the determination of trapped gas saturation on rock samples. She joined Eni in 2018 and she was involved in various research activities, R&D projects and Business Unit supports in the areas of geomechanical and petrophysical laboratory studies. She is now a Production Petrophysicist in the advanced well characterization department. Her activity is mainly focused on cased-hole formation evaluation, wellbore integrity analysis and monitoring studies mostly applied to CCUS and UHS projects.