PETROLOGICAL AND PETROPHYSICAL IMPLICATIONS OF MAGNESIAN CLAYS IN BRAZILIAN PRE-SALT DEPOSITS

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Abstract:

Marine carbonate reservoir formation evaluation is typically not concerned about the presence of clays, provided that the deposition of good quality carbonate platform facies is normally limited to clear waters. Conversely, the South Atlantic lacustrine Pre-Salt deposits contain abundant magnesian clays (e.g., kerolite, stevensite, mixed-layer kerolite-stevensite, sepiolite, and saponite), associated to the bioclastic and chemical carbonate reservoirs. These clay minerals precipitated under extreme alkaline environmental conditions, and are peculiar in terms of composition (e.g. kerolite - (Ca0,03Sr0,02Na0,01) (Mg2,88Al0,01) Si4.02 O10 (OH)2.nH2O) and occurrence, exhibiting laminated, massive, ooidal, peloidal, and coating habits. They are very distinct from the conventional detrital or common diagenetic clays that occur in siliciclastic reservoirs, requiring different petrophysical interpretation models. For instance, the conventional approach for clay content evaluation using gamma rays is not adequate, considering that Mg-clays are poor in radioactive elements such as potassium. Moreover, the density versus neutron cross-plot does not display a clear contrast pattern between clean reservoirs and clay-rich rocks. On the other hand, NMR logs exhibit a highly distinctive clay bound water relaxation time (<3ms) in Mg-clays-rich intervals, similar to a shale pattern, even though the proportion of such clays in relation to carbonates (calcite and dolomite) is rarely higher than 30%. In addition, Mg-clays strongly affect sonic logs, decreasing both shear and compressional velocities, which can be useful to identify them in cross-plots of density versus interval transit time. Mg-clays are quite unstable minerals, what resulted in their dissolution and/or replacement by other minerals. A reasonable amount of porosity within Pre-Salt reservoirs has been interpreted as secondary, formed by dissolution of these clays. They are absent in many wells. However, in some areas, Mg-clays-rich carbonates may be thicker than 200 meters. The intervals with abundant preserved Mg-clays are not considered reservoirs, as, despite their fair porosity, they have very low permeability (<.1mD). In contrast, preserved Mg-clays are scarce in the reservoir facies, indicating that either Mg-clays were not deposited in those areas and/or periods, or that they were dissolved soon after deposition, due to changes in the chemistry of the lacustrine fluids, or later during burial diagenesis. Therefore, the understanding, evaluation and prediction of Mg-clays occurrence are of paramount importance for the petrophysical interpretation in the exploration and development of Pre-Salt reservoirs.

Bio:

Ronaldo Herlinger Jr. is a Senior Petrophysicist for Petrobras S.A. in Rio de Janeiro, Brazil. He received his BSc (2005) and MSc (2016) degree in Geology from Federal University of Rio Grande do Sul, Porto Alegre, Brazil. He joined Petrobras in 2008, where he has developed petrophysical interpretation and integration with rock data.