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Characterization of heterogeneities from core X-ray scans and borehole wall images in a reefal carbonate reservoir: influence on the porosity structure.

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Petrophysical properties of rocks can be largely influenced by heterogeneities. This is particularly true in reefal carbonates, with heterogeneities due to the primary structure of the reef, the degradation of that structure into a fossil form, and fluid circulations with associated dissolutions and recrystallization. We report here a study conducted on Miocene reefal carbonates drilled in the context of salt water intrusion in coastal reservoirs. Salt water intrusion along coastlines is highly influenced by geological and petrophysical structures. In particular, heterogeneities and anisotropy in porous media (karsts, vugs...) control fluid flow and dispersion. A new experimental site has been developed in the South East of Mallorca Island (Spain) in the context of the ALIANCE EC project (2002-2005). This project aimed at developing a strategy for the quantitative analysis and description of fluid flow and salt transport in coastal carbonate aquifers.

The site drilled the Miocene carbonate reef platform at Ses Sitjoles, 6 km inland, near the city of Campos. Sea water is found there at 60 to 80 m depth. The geological structure present multi-scale heterogeneities, often bound to either lateral variations of geological facies, or dissolution patterns. The Campos site provides a unique laboratory to study the heterogeneities of carbonate rocks with a saltwater intrusion and develop new borehole investigation methods in this context. The present study focuses on borehole geophysical measurements and images, and core scans. New image analysis methods have been developed to better characterize the presence of heterogeneities in terms of grain-size distribution, formation factor changes and porosity. Cores scans from RX tomography can lead to the extraction of petrophysical parameters from 3D images. For this, the AVIZO software was used here to represent the micro-porosity and vuggy porosity structure. Beyond core analyses, the optical and acoustic borehole wall images provide a direct look at meso-scale porosity beyond cm-scale heterogeneities, such as karstic channels and megapores.

The reefal complex is dominated by moldic secondary porosity, which in the upper part of the boreholes. These heterogeneities are characterized by large and elongated molds mainly detected by the acoustic images. In slope, corresponding to the lower part of the structure, moldic porosity is characterized by small and round shaped molds. Vuggy porosity varies mainly from 5 to 40% along 100 m deep boreholes. But, in the slope part, the porosity is about 0% although it can reach 90% in karstic area. In all, the distribution of pore types is strongly controlled by that of lithofacies and water paleo-levels, leading to extensive cementation processes with the resulting occlusion of pore spaces. The combined analysis of porosity with complementary methods in terms of spacial resolution leads to the quantitative determination and description of microstructural heterogeneities in carbonate porous media. It is a key to model the reservoir mesoscale structure and fluid flows within it.