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Impact of pore-space variations and orientation of layering on the flow properties of Coquina limestone

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In carbonate reservoir rocks, the pore system can be vary significantly with variations in the rock component texture and distribution as viewed at different length scales. Any textural variability is reflected in the associated permeability tensor and makes the evaluation of the hydraulic behaviour of this group of rocks very challenging. In this study, we investigated the impact of the core-scale layering orientation to imposed fluid movement direction together with the pore space variations resulting from textural characteristics (inside and outside the layers) on the petrophysical properties and flow behaviour of Coquina limestone. For this analysis, we combine a) X-Ray Tomography (XRT) images (40 µm voxel size resolution) from dry cores; b) Computational Fluid Dynamic simulations; and c) High-Speed Neutron Tomography (HSNT) images (200 µm voxel size resolution) from the same cores during fluid flow experiments. In particular, the 3D pore network extracted from the XRT images was used to characterise the spatial variation of its properties (e.g., porosity, specific surface area, tortuosity and connectivity). Then, the absolute permeability in a number of sub-volumes distributed along the full length of the sample was computed using the Lattice Boltzmann Method (LBM). In this way, the variations in absolute permeability along the sample's length were explored and correlated with pore network characteristics that were previously defined from the XRT. Finally, HSNT images, acquired during flow experiments (injection of heavy water into Decane saturated samples), were further processed to visualise in 3D and time flow patterns within samples containing layering oriented either parallel or perpendicular to the intended injection directions. Results from the pore network characterisation and the LBM simulation revealed significant variations in the pore network properties as well as the calculated absolute permeability of the layers and their surrounding regions. Those variations were attributed to the orientation of the layers and the textural characteristics of the rock within the tested samples. Two distinct flow patterns were recognized in coquina samples with similar porosity and permeability but with different layering orientation. When layering is oriented parallel to the sample's length (and in the injection direction), the dominant water flow is through the high permeability zones, which are separated from each other by lower permeability layers. This results in unstable advancement of fluid front, shorter breakthrough time and lower differential fluid pressures. On the other hand, when the layers are oriented normal to the intended flow direction the existence of cross-flow layers of reduced porosity and absolute permeability is found to stabilize the flow pattern (piston like) and cause higher differential fluid pressure.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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