Textural impacts on anisotropic elastic moduli of presalt carbonates from Santos Basin, Brazil

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Summary

This study introduces micro-CT images for 7 core-plugs in data set, taken from a presalt well (Santos Basin, Barra Velha Fm.), characterized as bivalve grainstones from the high-energy environment (samples SMPs1 to 6), and an arborescent shrub (SMP7). Information about mineralogy, porosity, P- and S-wave transmission velocities are available. Helium-gas porosity ranges from 9.7 to 18.1%. Permeability is variable due to mineralogy and pore complexities, ranging from ~0 to 265 mD. The XRD analysis and Rietveld method quantify calcite, dolomite, and quartz minerals, showing a wide mineralogy dispersion and dolomite cementation occurrence. The micro-CT images are performed aiming to understand a possible correspondence between pore system and anisotropy information of samples from Lima Neto et al. (2023), such anisotropic parameters were computed by the vertical and horizontal TI (transversely isotropic) method using P-S1-S2 waves from triaxial measurements for vertical and horizontal dry samples under confining pressure, based on a “weak anisotropy approach”. A cone-beam micro-CT (Bruker SkyScan1173) was employed for image acquisitions and the reconstructed volume was treated by: 1) to crop a representative volume for pore analysis, avoiding border scatter and noise, including Gaussian blur and bright & contrast filters, and 2) perform images Thresholding guided by an interpreter to identify pore system and matrix. Finally, the segmentation isolated and quantified pores to compute properties as area and diameter, considering the pore area resolution ~589.52 µm². Thus, the results are suitable for recognizing meso to megapores, assuming micropores < 500 µm² (Anselmetti et al., 1998). This micro-CT image technique brings the advantage of preserving the recognized pores at the plug scale, similar to the laboratory measurements. All isolated pores from each data volume were evaluated by the ellipsoid adjustment in the same area, allowing the estimating of a representative mean diameter, and analyzing the pore impact in the texture and elastic anisotropy. The mean pore diameter expressed a similar tendency for similar textures. However, the detected differences in the maximum pore occurrence may impact the elastic anisotropy as SMP4 - a megapore higher than other samples was associated with a detected vuggy porosity, and a notable solid part that was not observed in others. The heterogeneities that may close pores tend to increase the matrix rigidity, impacting the elastic anisotropy when detected in the isolated portions of the plug sample. The P- and S-wave velocities and the apparent wave anisotropy are crossplotted showing the SMP4 as the most anisotropic. Fast and slow velocities display a tendency for anisotropy increase and best grouping samples with similar results, denoting the SMP4 as the highest detached from the others. An integrated analysis suggests that the pore diameter (a geometry pore property) cannot alone explain the effects of the elastic anisotropy. Although results for SMP4, other samples did not show a direct correspondence between pore diameter and the elastic anisotropy. The pore distribution onto the solid matrix reflects the textural impacts on the elastic wave, alerting us to the cementation effects and/or plug areas that have low pore occurrence as observed for SMP4.