Submission code: 7A88P547AY

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Application of rock physics models to evaluate dispersion and attenuation in carbonate rocks

Marcus Corrêa (LENEP/FACC), Marco Ceia (UENF)

Application of rock physics models to evaluate dispersion and attenuation in carbonate rocks

Introduction

This study analyzes the dispersion and attenuation effects on P-wave velocity in carbonate rocks, based on laboratory characterization of samples from two distinct geological settings: the pre-salt interval from well A in the Santos Basin and the coquinas from Alagoas Sub-basin. The methodology applies rock physics modeling, using the Gassmann equation and the Geertsma-Smit model for fluid substitution, to assess the behavior of elastic properties under different frequency regimes and saturation conditions.

Method

X-ray diffraction (XRD) analysis identified calcite, dolomite, and quartz as the dominant minerals. The mineral bulk moduli were estimated using effective medium models (Voigt-Reuss and Hashin-Shtrikman). P-wave velocities were measured under dry and brine-saturated conditions at confining pressures of 22.1 MPa, using ultrasonic tests at 1.3 MHz to represent the high-frequency regime. A permaporometer (coreval) provided the static bulk modulus, representing the low-frequency limit.

The study applied the Gassmann equation to predict the effect of fluid substitution on P-wave velocity, assuming a homogeneous, isotropic, monomineralic porous medium. However, experimental results showed significant deviations, especially in the coquinas, highlighting limitations of the model in heterogeneous lithologies. To address this, the Geertsma-Smit model incorporated dispersion and attenuation as a function of frequency, using Biot and White frequency reference models. Model parameters were calibrated based on fluid properties (brine, oil, and air), porosity, permeability, viscosity, and sample geometry.

Results and Conclusions

Results demonstrate that the choice of frequency reference model strongly influences dispersion and attenuation predictions. The White model, which accounts for mesoscale fluid flow between heterogeneities, better matched the pre-salt samples, while the Biot model, sensitive to macroscale flow, showed good agreement in selected coquina samples. Quality factor (Q) analysis revealed substantial variability across samples. Sample 91H from the pre-salt showed high Q under all saturation conditions, likely due to the interface between silexite and shrub, residual oil, and a complex pore system. Its extremely low permeability (<0.1 mD), similar to that of a coquina sample, suggests a strong influence of permeability on Q values in heterogeneous carbonate rocks. The Geertsma-Smit model using White frequency also accurately predicted the observed dispersion in the experimental frequency range.

This study highlights the acoustic complexity of carbonate rocks, where mineralogical and structural heterogeneities significantly impact seismic response. Combining theoretical models with laboratory data enables more accurate assessment of elastic properties, improving reservoir-scale property prediction.