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Field laboratories integrating Geology, Petrophysics and Geophysics: Late Jurassic siliciclastic rocks (Boulonnais, northern France)

Seismic imaging is one of the most important geophysical tools to visualize subsurface sediment architecture and reservoir properties. Since seismic images are non-unique they require continuous calibration and ground truthing by geology. Boreholes do provide in situ measurements of acoustic properties but lack the spatial attributes of the depositional system. A late Jurassic (Kimmeridgian to Tithonian) interval was used as a 'field laboratory' that links 2D geology, cliff, and nearby high-resolution 3D subsurface seismic data through shallow boreholes.

This paper, as a first step, documents the close relationship between acoustic properties and geology. Acoustic properties are controlled primarily by porosity but the contribution by clay, silt/sand, carbonate particular material and cement explains the remaining variation in acoustic properties. Ternary plots show that clay - and carbonate content have opposite and overlapping effects on the acoustic properties: the influence of clay content progressively increases with decreasing carbonate content and visa versa. With increasing carbonate content the variation of acoustic velocity at a given porosity value increases to nearly twice of that in the clay-dominated sediment. The dominant areas of acoustic properties are closely correlated with the mode of deposition. As a result, these quantitative relationships can be used to predict the 'mechanical' stratigraphy and impedance changes associated with changes in depositional regime, and visa versa.

This study may have important implications for porosity and lithofacies prediction from wireline logs in similar sediment mixtures and provide a direct link from acoustic properties to the primary depositional system and sequence stratigraphy.