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Link between Microporous Limestones and Elastic Properties in Tight Carbonates - A Case Study from the Lower Arab Formation (Upper Jurassic), Onshore United Arab Emirates

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ABSTRACT

The Lower Arab D Member (Kimmeridgian) in onshore UAE is typically characterised by a thick succession of homogeneous mudstones with local cm-scale interbedded bivalve-rich floatstones, which are thought to have been deposited in a low-energy mid-ramp setting. This sedimentological unit is located at the base of a sour gas reservoir that includes the oolitic grainstones of the Upper Arab D Member.

The pore system in these micritic deposits is dominated by matrix-hosted microporosity, along with open to partially cemented fractures, primary intraparticle macropores and rare biomoulds in the shell beds, hence a poor to very good porosity and extremely poor to rarely excellent permeability. Variations in porosity and permeability values appear to be strongly related to variations in the micritic fabric: both porosity and permeability increase when the micritic fabric evolves from anhedral compact with coalescent intercrystalline contacts (associated with very little and poorly connected micropores) to subrounded with facial to subpunctic intercrystalline contacts (with locally well-developed micropores). Micritic fabrics also clearly impact the elastic properties of the rock. Through analysis of elastic moduli calculated from standard density, and shear/compressional sonic wireline logs, the relationship between micritic fabric, porosity, permeability and geomechanical properties has been explored. With the evolution of micritic fabric from anhedral compact to subrounded, Young's Modulus decreases with increasing porosity and permeability, indicating a decrease in the overall stiffness of the mudstones. The implication of this observation is fundamental for the development of natural fractures within the Arab D, which are used as conduits for the vertical fluid flow. Indeed, stylolites with associated partially cemented tension gashes are commonly observed at the rheological boundaries, providing further secondary macroporosity and permeability anisotropy within the reservoir.

In this study, the observed link between micritic fabrics, log-derived porosity and elastic moduli within cored intervals has been used to predict micron-scale micritic fabric distribution in uncored wells from wireline logs only.