Texture and diagenesis of Ordovician shales from the Canning Basin, Western Australia: implications for elastic anisotropy and geomechanical properties

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Microstructural and textural measurements from two Ordovician shale units (Goldwyer and Bongabinni formations) within the Palaeozoic–Mesozoic Canning Basin indicate that the former unit was affected by mechanical compaction and clay mineral transformation whereas the latter preserves an early fabric due to syn-depositional precipitation of authigenic dolomite and anhydrite. Conventional petrographic analysis coupled with quantitative mineralogy, electron micro probe analyses, X-ray Texture goniometry (XTG) and cathodoluminescence spectroscopy of core samples were used to decipher the post-depositional evolution of marine and supratidal facies in the Goldwyer and Bongabinni formations, respectively. Differences in diagenesis are strongly reflected in the orientation of clay minerals as quantified by XTG: in both cases the c-axes of illite diffract strongest normal to the bedding plane but the measurements clearly illustrate that shale in the Goldwyer Formation has a stronger preferred orientation relative to the Bongabinni Formation, with multiple of random distributions (m.r.d.) values of 5.77 and 2.54, respectively.

Laboratory measurements conducted at 10 MPa effective pressure also indicate distinct rock physics signatures: the Bongabinni Formation shows very low anisotropy, whereas the Goldwyer Formation displays a higher degree of elastic anisotropy in terms of both P- and S- waves. The crystallographic preferred orientation of illite, highlighted by the XTG, is likely to contribute to the significant difference in elastic anisotropy observed in the two units. Therefore, the Bongabinni Formation is mechanically stronger and stiffer than the Goldwyer Formation, likely due to the early dolomite and anhydrite cementation of the former providing a rigid microstructure framework.

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