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Variations in petrophysical properties of shales along a stratigraphic section in the Whitby mudstone (UK)

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In unconventional tough gas reservoirs (e.g. tight sandstones or shales) the presence of fractures, either naturally formed or hydraulically induced, is almost always a prerequisite for hydrocarbon productivity to be economically viable. One of the formations classified so far as a potential interesting formation for shale gas exploration in the Netherlands is the Lower Jurassic Posidonia Shale Formation (PSF). However data of the Posidonia Shale Formation is scarce so far and samples are hard to come by, especially on the variability and heterogeneity of the petrophysical parameters of this shale little is known. Therefore research and sample collection is conducted on a time and depositional analogue of the PSF: the Whitby Mudstone Formation (WMF) in the United Kingdom. A large number of samples along a $\sim$7m stratigraphic section of the Whitby Mudstone Formation have been collected and analysed. Standard petrophysical properties such as porosity and matrix densities are quantified for a number of samples throughout the section, as well as mineral composition analysis based on XRD/XRF and SEM analyses. Seismic velocity measurements are also conducted at multiple heights in the section and in multiple directions to elaborate on anisotropy of the material. Attenuation anisotropy is incorporated as well as Thomsen's parameters combined with elastic parameters, e.g. Young's modulus and Poisson's ratio, to quantify the elastic anisotropy. Furthermore rock mechanical experiments are conducted to determine the elastic constants, rock strength, fracture characteristics, brittleness index, fraccability and rock mechanical anisotropy across the stratigraphic section of the Whitby mudstone formation.

Results show that the WMF is highly anisotropic and it exhibits an anisotropy on the large limit of anisotropy reported for US gas shales. The high anisotropy of the Whitby shales has an even larger control on the formation of the fracture network. Furthermore, most petrophysical properties are highly variable. They vary per sample, but even within a sample on a mm-scale, large variations in e.g. the porosity occur. These relatively large variations influence the potential for future shale gas exploration for these Lower Jurassic shales in northern Europe and need to be quantified in detail beforehand. Compositional analyses and rock deformation experiments on the first samples indicate relatively low brittleness indices for the Whitby shale, but variation of these parameters within the stratigraphy are present. All petrophysical analyses combined will provide a complete assessment of the potential for shale gas exploration of these Lower Jurassic shales.