Fractured Reality: Lateral Variations in Fractured Shales at Outcrop, Application for Subsurface Analogues

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ABSTRACT

The efficiency of fracking stages in a low permeability unit can potentially be enhanced by exploitation of the natural fracture network. The use of outcrop analogue studies can be an effective strategy to provide sufficiently rich datasets to predict fracture properties away from a wellbore. Nevertheless, characteristics such as average fracture length and spacing can vary laterally across 10s of metres within a single shale bed, such that the fracture-connected distances and fracture-bound volumes vary greatly. This study describes and quantifies lateral variations in fracture parameters from an outcrop analogue for a potential UK unconventional play. Clean cliff and foreshore exposures of the Lower Jurassic Whitby Mudstone Formation (WMF), North Yorkshire, UK, have been studied to characterise the natural fractures, and, where possible, to understand the spatial variations in fracture characteristics. The WMF is a useful analogue for both the poorly exposed, time-equivalent Posidonia Shale of the Netherlands, and potential shale oil strata in Weald basin, southern England. The study focuses on shales of a single stratigraphic unit within the WMF, across a stratigraphic thickness of ~20 m and lateral extent of ~ 350m2. Detailed fracture data have been acquired using digital and manual methods. Two systematic fracture sets with subsidiary sinuous cross joints are identified. A range of fracture properties are noted, with two end-member length distributions observed at different sample sites for one of the dominant fracture sets: one site has a significantly higher proportion of longer fractures than the other site, defining different distributions on a length-intensity plot. The positions on this plot correspond with the mean spacing / mean fracture length ratios per site, thought to be linked to the saturation of fracture system. The most saturated fractures define the upper bound of the relationship linking length and intensity. In application of analogue outcrops to subsurface data (e.g. to allow optimal exploitation of natural fractures for a fracking stage), comparison of fracture properties observed at the well bore (e.g. fracture spacing, thus 1D intensity, and fracture interactions) with the ranges of properties observed at outcrop can be used to predict the likely fracture properties away from the wellbore. We shall discuss possible relationships that can be useful in such circumstances.