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Fracture propagation and reservoir permeability in limestone-marl alternations of the Jurassic Blue Lias Formation (Bristol Channel Basin, UK)- a multidisciplinary approach

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The rhythmic limestone-marl alternations (LMA) of the Blue Lias Formation (Bristol Channel Basin, UK) are layered because of (1) depositional changes and (2) diagenetic processes. Both layering and bedding are recognizable as changes in facies (e.g. grain size, mineral content and cements). These features commonly influence the mechanical rock properties (e.g. stiffness and strengths) and therefore also the behavior and number of fractures. For this reason, they are very important for rock permeability. Permeability in turn influences the fluid flow in reservoirs, so that layering and its effects on fracturing has implications for geothermal, hydrocarbon and groundwater exploration.

Despite its importance the relationship between sedimentary, diagenetic and mechanical characteristics of LMA has not been studied in detail previously. There are some studies on fracture propagation in LMA. These studies, however, focus on structural geology and do not consider petrography and mineralogy (e.g. facies, grain/matrix-ratio, grain size, mineral content). Therefore we use a multidisciplinary approach and combine (1) sedimentological (macro- and microfacies, e.g. grain size and grain/matrix-ratio) and (2) mineralogical (mineral content, e.g. calcite/clay-ratio) with (3) fracture parameters (e.g. fracture geometries, -paths, -frequencies, -connectivity). Our study is based on sedimentological sections, quantitative structural geological measurements as well as sample material from three outcrops.

The lithology of the Blue Lias Fm differs remarkable between the outcrops. The results show that fracture propagation is different as well; section with a limestone-dominated alternation and with laterally persistent limestone beds has a lower fracture frequency, whereas section with a marl-dominated alternation and more lenticular or nodular limestone beds has a lower fracture frequency. This implies that a high marl thickness results in a high fracture frequency. Beside this, only 53% of the fractures in the limestone-dominated section are stratabound (restricted to individual layers), while 84% of the fractures in the marl-dominated section are stratabound, indicating that a high marl thickness leads to fracture arrest and thus more stratabound fractures).

Our results suggest that marl not only has a very low matrix permeability, but is also characterized by a more complicated fracture behavior. Moreover, the high number of stratabound fractures leads to a relative poor connectivity between fractures and thus to a lower overall permeability. Despite the fact that limestone-dominated LMAs commonly have lower fracture frequencies, their permeabilities are usually higher than in marl-dominated LMAs. This apparent discrepancy results from the larger percentage of non-stratabound fractures.

The relationship between sedimentary processes, diagenetic processes, and fracture propagation should be investigated in greater detail. These studies allow numerical modeling of fracture propagation and associated fluid flow in rocks and reservoirs.