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Compaction-related Polygonal Fracture System and mechanical stratigraphy in the Campanian tight chalk of South Landing (Yorkshire, UK)

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The Santonian-Campanian Flamborough Head chalk cliffs (Yorkshire, UK) are an outstanding outcrop of once deeply-buried tight-chalk (until 1200 m). Flamborough Chalk showed that porosity ranges from 9 to 20% and permeability from 0.04 to 0.2 mD (e.g. Faÿ-Gomord et al., 2016; Sagi et al., 2013). These outcrops are likely to be representative of sub-surface chalk reservoirs in nearby onshore and offshore regions, e.g. the North Sea. The zone had been strongly affected by transpressive tectonic deformations during Tertiary; which has been widely studied (e.g. Bell et al., 1999; Starmer, 2013; Welch et al., 2014), but the precocious fracture network, far from these intense deformation zone, has not been investigated yet.

Evidence of synsedimentary faulting associated with polygonal-shaped fractures network was revealed by the observation of platform images (acquired at low altitude and used in photogrammetry). These features argue for isotropic horizontal state of stress during compaction. Thus, the measured multiple fracture orientations were active simultaneously and mechanically interacting, instead of the intersection of multiple regional sets of different ages reported in the literature. Compaction-related stylolitization occurred in chalk synchronously or soon after synsedimentary deformation, from 800m to 1200m, the maximum burial depth estimated for these outcrops, under the same stress field (sub-vertical σ_1 , and sub-horizontal σ_2 , σ_3). It results in numerous horizontal stylolitic planes and small cemented synsedimentary faults with small displacements often used as preferential pressure-dissolution planes with vertical stylolitic peak.

This fracture pattern, observed in high resolution aerial images and in the field, is also studied using a mechanical stratigraphy approach (e.g. D Jacquemyn et al., 2012). The mechanical units have been characterized using the DigiFract software on high resolution photogrammetry panoramas (Bisdorf et al., 2014). The mechanical interfaces have been defined and their strength quantified. It appears that sedimentological bedding is non-existent or invisible and that the fracture spacing is strongly controlled by the mechanical unit thickness. The mechanical units are mostly delimited by compaction features, such as stylolites and marl-seams, which accumulate insoluble residue, clay essentially. However not all insoluble residue layers behave as mechanical interfaces and the relationship between the thickness of the insoluble residues and the strength of the mechanical interfaces have also been investigated.

Keywords: chalk, synsedimentary faulting, Polygonal Fracture System, photogrammetry mechanical stratigraphy