Tectonics and Deformations of the Kortrijk Clay Formation in the Princess Elisabeth Zone, Belgian Continental Shelf

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A thorough investigation of the subsurface structure is required for planning and risk assessment of the future wind energy developments in the Princess Elisabeth Zone (PEZ) on the Belgian Continental Shelf. The PEZ is underlain by the Kortrijk Clay Formation, of Eocene age, which is characterised by the presence of a dense and complex intraformational fault system (i.e., clay tectonics; Henriet et al., 1988). A detailed understanding of the fault properties (e.g., geometry, orientation, displacement, distribution) is essential for project planning but this remains insufficiently understood. Gaining insights into this fault system would also provide important clues on its origin and on the processes that have led to the deformation of this formation and the broader Belgian Continental Shelf.

We use ultra-high-resolution seismic reflection surveys with dense grid spacing to investigate the subsurface structures in four carefully selected study areas within the PEZ (Block A, B, C, and D), as part of the Clay Tectonics project. Detailed mapping reveals distinct variations and structural styles featured in these blocks, despite their proximity (~10 km apart). Block A features densely spaced faults (30 to 160 m spacing), with a predominant orientation of N75°E-N85°E, a minimum fault length of 0.5 km, an apparent dip from 38° to 45°, and a displacement of up to 3.3 m. Block B exhibits wider spaced faults (90-580 m spacing), oriented N355°E-N25°E, with a larger fault length (at least 1.1 km), a shallower apparent dip (25°-28°), and a larger displacement (up to 5 m). Block B also features folding structures, comprising a syncline and anticline with fold axes parallel to the fault orientation. The properties of the fault system in Block C are generally similar to those of Block B but with denser fault spacing (90-280 m). Block C also features folding structures, although these folds are oriented obliquely (~N130°) to the faults (N355°E to N10°E). Additionally, Block C also includes a major fault with considerable displacement, up to 16 m. Significant changes in structural styles from Block A to C will be further investigated using more recently acquired data from Block D, where these changes are likely located.

The preferred orientations of the faults suggest the possible influence of far-field tectonic stresses, in contrast to the commonly accepted deformation model for clay tectonics, which are interpreted as diagenetic-related polygonal fault systems. The alignment between fold axes and fault orientation in Block B also indicates possible control of pre-existing structures in fault distribution. However, this control appears limited, as evidenced by the obliquity between fold axes and fault orientations in Block C. Accordingly, further investigation into the deeper structure under the clay formation and the basement is necessary to understand the main parameters in controlling the fault system. Moreover, the variability of structural styles observed in the PEZ underscores the importance of detailed subsurface investigation prior to wind farm development. Therefore, investigating the fault distributions, properties, and the controlling process in their development is crucial for quantifying the risk associated with wind farm construction in the PEZ.

Henriet JP, de Batist M, Vaerenbergh W, Verschuren M (1988) Seismic facies and clay tectonic features of the Ypresian clay in the southern North Sea. Bulletin van de Belgische Vereniging voor Geologie 97: 457-472.