

## Faulting in the Kortrijk Clay Formation in the Princess Elisabeth Zone, Belgian Continental Shelf

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A detailed investigation of subsurface structures is essential for planning and risk assessment of future wind energy developments in the Princess Elisabeth Zone (PEZ) on the Belgian Continental Shelf. The PEZ is underlain by the Eocene-aged Kortrijk Clay Formation, characterised by a dense and complex intraformational fault system, commonly associated with clay tectonics. This fault system's geometry, orientation, displacement, and spatial distribution remain poorly understood, posing challenges for project planning. Additionally, understanding these fault systems provides insights into their origin and the processes driving deformation within the formation and the broader Belgian Continental Shelf.

Using ultra-high-resolution seismic reflection surveys with a dense grid spacing, we investigated subsurface structures in four study areas within the PEZ (referred as Blocks A, B, C, and D). Detailed mapping revealed significant spatial variations in faulting styles and distribution despite the proximity among the blocks. In Block A, the fault system is densely spaced (50–160 m) with ENE-WSW orientation (N75°E–N85°E), dips of 60°–70°, fault lengths of up to 0.8 km, and displacements of up to 3 m. Block B features a contrasting fault system, with wider spacing (90–580 m), NNE-SSW orientation (N355°E–N25°E), shallower dips of 35°–45°, larger displacements (up to 5 m), and fault length of up to 1.7 km. Additionally, Block B contains fold structures (syncline and anticline) with fold axes aligning with fault orientation. Block C exhibits similarities to Block B, including fault orientation (N355°E–N10°E) and folding structures, but features denser fault spacing (90–240 m). A significant obliquity between fold axes and fault orientation is also observed. Notably, Block C includes a major fault with a displacement of up to 16 m and parallel to the other faults in the block. Moreover, Block D showcase an abrupt transition between the structural styles in Block A and C.

These findings contradict the diagenetic-related polygonal faulting model for faulting in clay formation, which predicts faults with no preferred orientation. The distinct partitioning of fault orientations and distributions, particularly the preferred orientations (i.e., ENE-WSW in Block A and southern part in Block D; and NNE-SSW in Blocks B, C, and northern part of D), suggests the potential influence of far-field tectonic stresses. The alignment between fold axes and fault orientation in Block B implies possible control by pre-existing structures, though this influence appears limited in Block C, where folds and faults are oblique. The presence of a major fault in Block C, parallel to other faults, further suggests tectonic influences. The observed variability in structural styles highlights the necessity of further investigation into deeper regional structures and the basement underlying the Kortrijk Clay Formation. Such studies are crucial to identifying the primary controls on fault system development and the potential risks associated with wind farm construction in the PEZ.

### Keywords

Clay Tectonics; Kortrijk Formation; Faults