2 A northeast trending structural deformation zone near North Hinder

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ABSTRACT

A northeast trending sequence of structural deformations east of North Hinder on the Belgian continental shelf and adjacent areas seems to be the surface expression of deeper faults, cutting across the whole width of the London-Brabant Massif in the axial zone of the eastern Channel. These fractures have probably been reactivated in a wrench-fault style in Tertiary times.

INTRODUCTION

Detailed and systematic high-resolution seismic investigations carried out in recent years in the Southern Bight of the North Sea have shed some new light on the tectonic setting of the offshore extension of the London-Brabant Massif. A classical view is that this Palaeozoic basement high behaved throughout post-Hercynian times as a rigid unit, unaffected by the major Mesozoic deformation phases which left their scars along its periphery.

Some doubts may however be cast on this model, particularly in view of the recent seismic observation of a sequence of troughs and faults in the Mesozoic and Early Cenozoic cover of the Brabant Massif, trending in a northeastern direction a few kilometres east of the North Hinder sand bank. The fact that this sequence apparently has eluded the scarce former seismic observations in this region may probably be attributed to its coincidence with the Channel traffic separation lanes, a traditionally hostile environment for seismic activities.

THE NORTH HINDER STRUCTURE

The seismic-stratigraphic subcrop map of the Palaeogene substratum (figure 1) reveals a N50°E-trending alignment of three major synclinal depressions, roughly circular in shape, affecting the Eocene sequences over a total distance of at least 25 to 30 km.

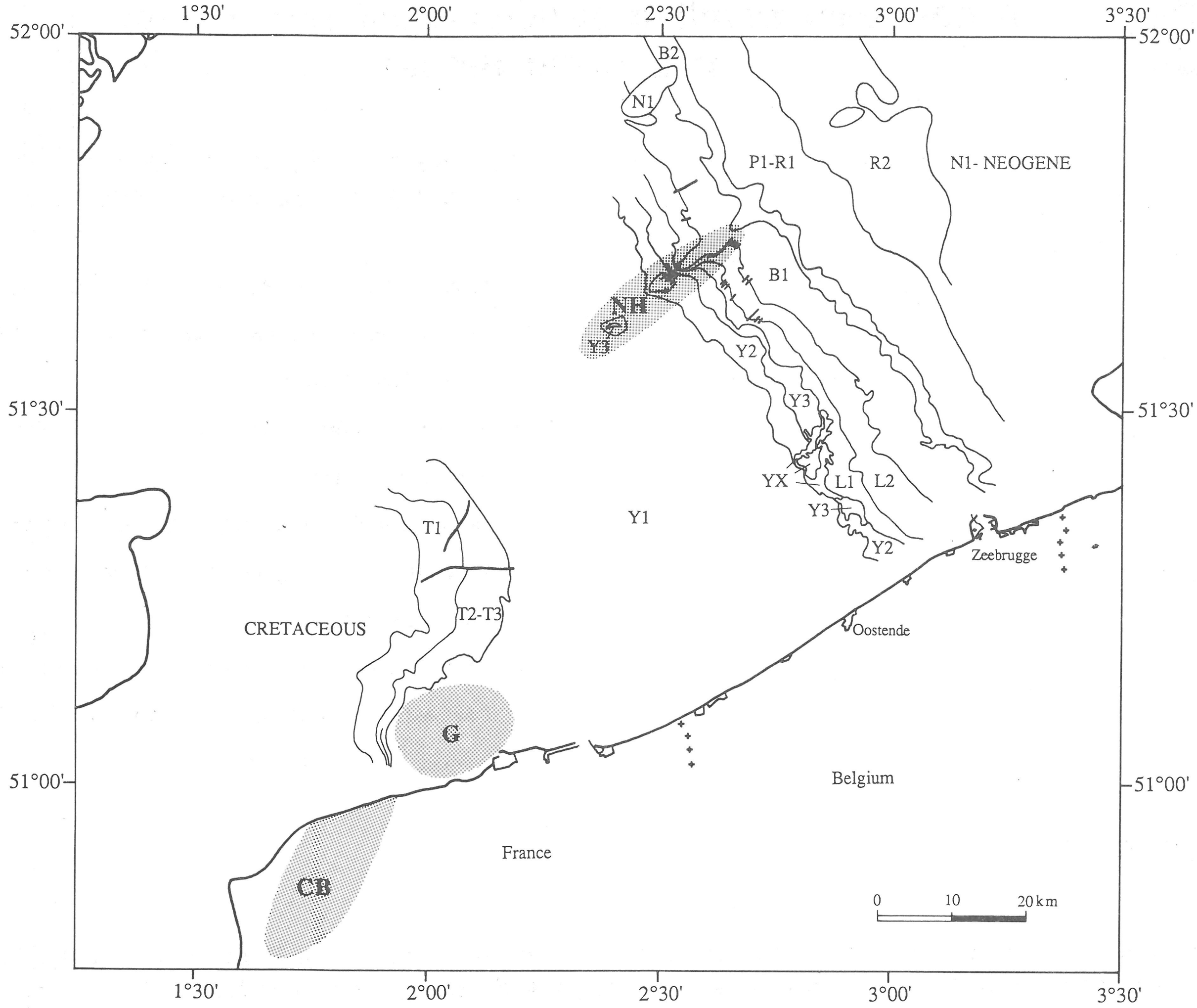

Figure 1. Seismic-stratigraphic solid map of the Southern Bight Palaeogene deposits (HENRIET *et al.*, this volume), with localization of structural anomalies.
NH = North Hinder structures. G = Gravelines structure. CB = Calais Basin.

The southwestern depression stands out as an isolated feature, with an observed amplitude of some 150 m at its deepest point. It is bordered to the east by a fault, throwing about 50 to 60 m.

The central and northwestern depressions seem to be more or less structurally connected, forming a complex, elongated and asymmetric synclinal trough. Its amplitude decreases towards the northeast to a few tens of meters.

A pattern of smaller-scale deformations under the form of dense block-faulting is superimposed on the main folds, a phenomenon which is particularly prominent in the central depression. This might find its origin in a reactivation and amplification of pre-existing clay-tectonic deformations (HENRIET *et al.*, 1988).

On some cross-sections the synclinal depressions observed in the London or Ieper Clay seem to develop vertically out of a system of major faulted an tilted blocks in the underlying Palaeocene deposits (figure 2). Locally, such faults can be traced through the Cretaceous chalk cover down to the top of the Palaeozoic basement. The exact configuration and trend of these basement faults could not be ascertained yet.

A remarkable observation in the surface depressions is a weakly defined east-west elongation, making an angle of 30° to 45° with the dominant trend of the alignment, thus creating an "en échelon"-pattern.

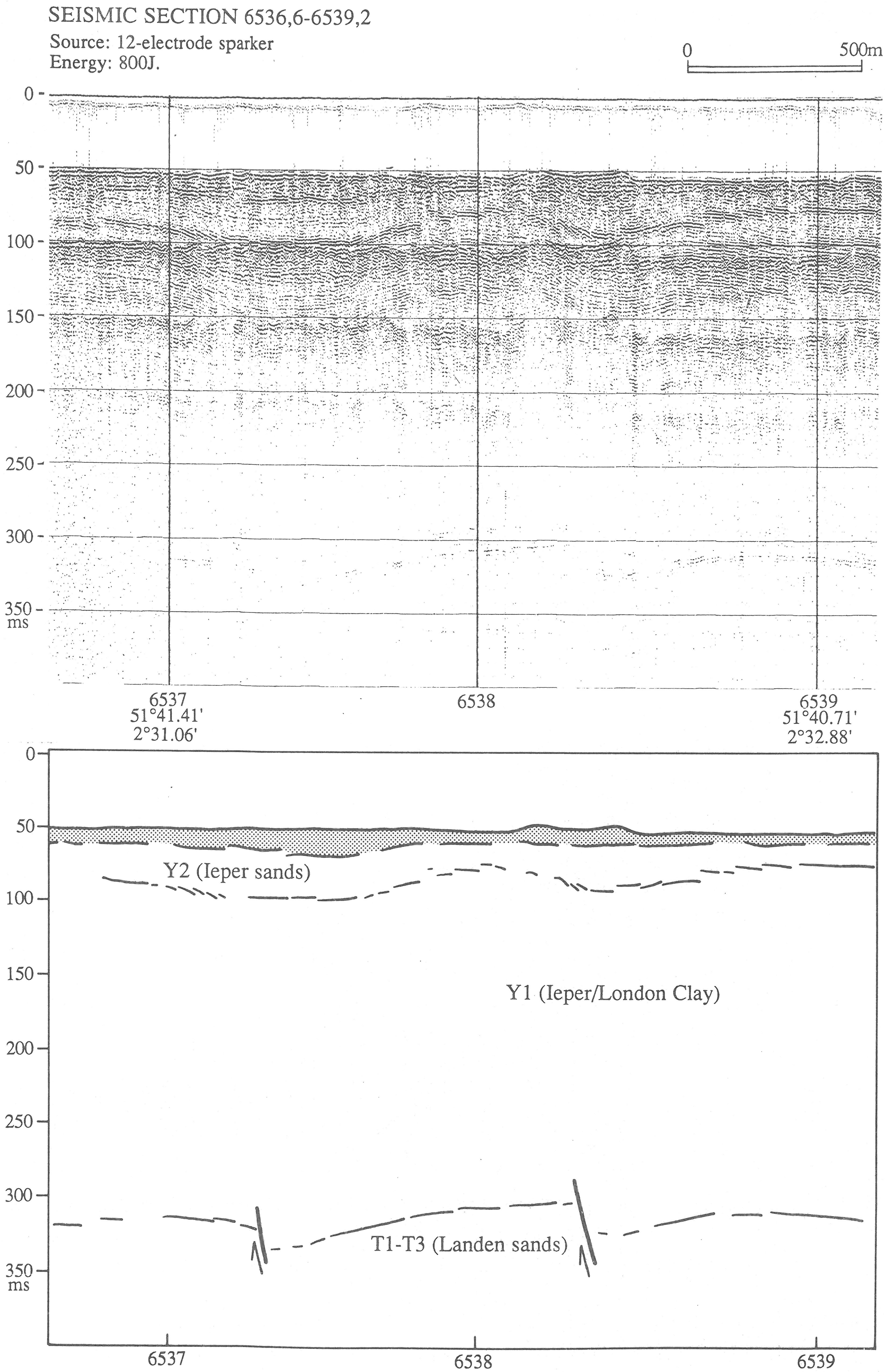

Figure 2 Analog-recorded watergun section and interpreted line-drawing showing the relation between Cretaceous-Palaeocene block-faulting and overlying synclinal deformations in Eocene deposits.
Vertical scales in ms are two-way time.

THE GRAVELINES STRUCTURE

Further south, off Calais, another major deformation structure can be observed : a northeast trending trough affecting Mesozoic and Cenozoic beds. It is best developed off Gravelines, where it shows as a deep, nearly circular depression with an amplitude of about 120 m. The southward extension of this feature in the onshore region is traced down to the Palaeozoic basement, as shown by the isobath map (figure 3) of the top of the Brabant Massif (LEGRAND, 1968).

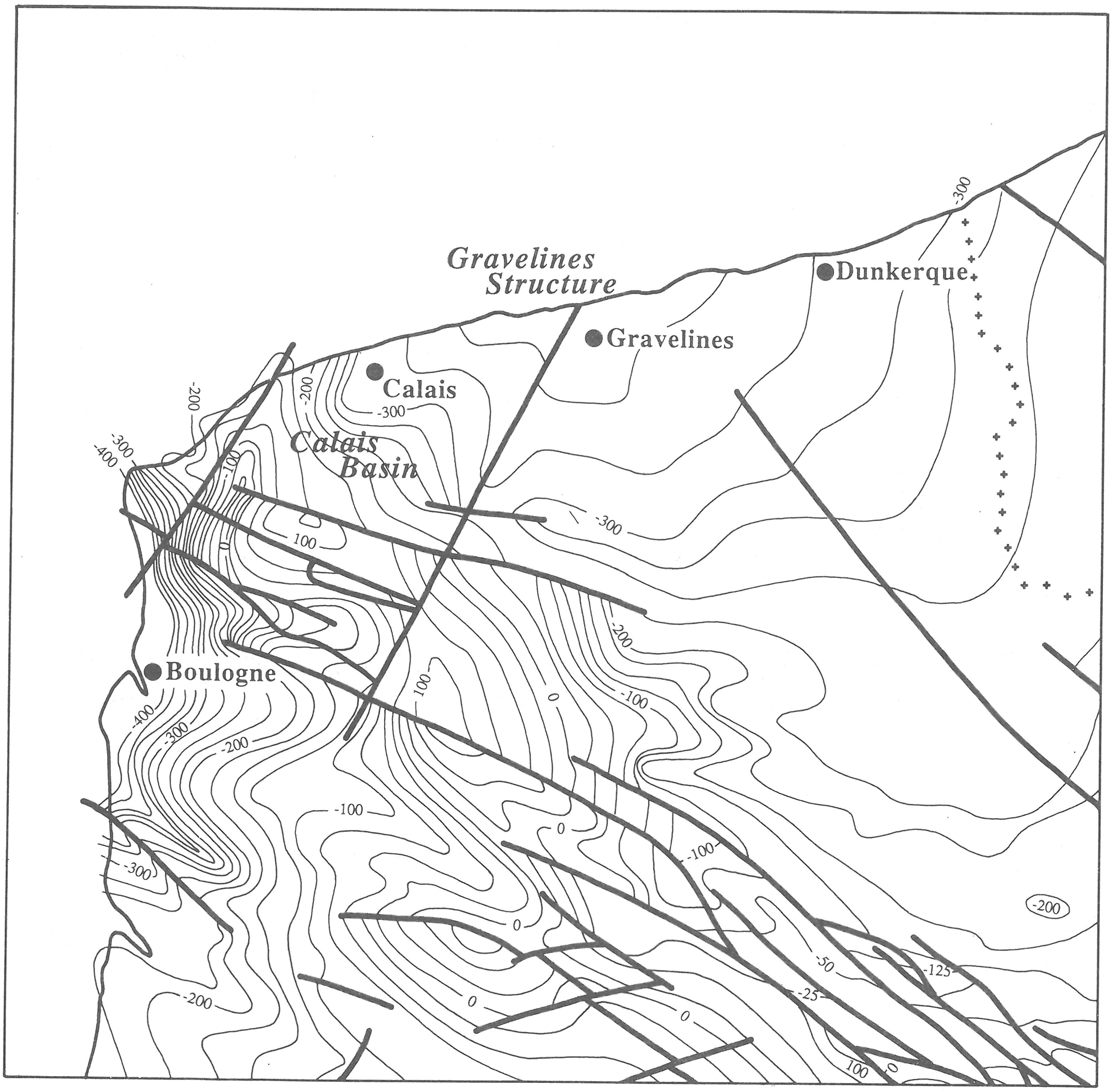

Figure 3 Isohypse map of the top of the Palaeozoic basement in the Calais region (LEGRAND, 1968).

The Gravelines depression is indeed located on top of the supposed offshore extension of the Hercynian Calais Basin, a riftlike structure shown on the geological map (figure 4) of the top of the Palaeozoic basement, compiled by a group of French oil companies (C.F.P.(M) *et al.*, 1965).

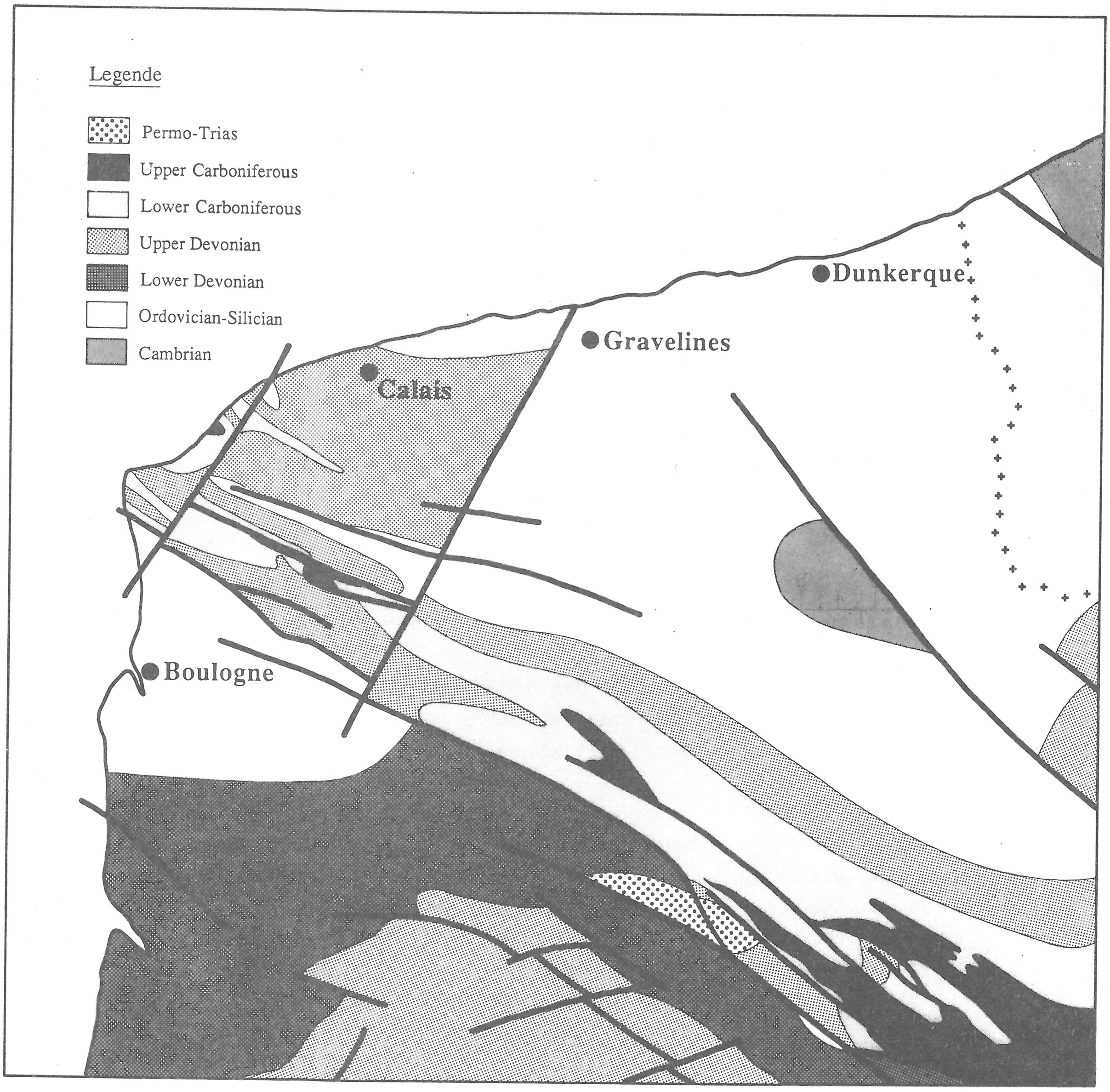

Figure 4 Geological map of the top of the Palaeozoic basement in the Calais region (LEGRAND, 1968 ; C.F.M.(P) *et al.*, 1965).

The Calais Basin has a pronounced asymmetric character, with a major downward slip displacement along its eastern border, the Ardres-Gravelines fault. This northeast trending fault separates the comprehensive Devonian to Lower Carboniferous stratigraphic sequence of the rift basin from the Silurian rocks of the London-Brabant Massif.

FRAMING THE NORTH HINDER STRUCTURE IN SPACE AND TIME

Considering the apparent alignment - possibly with some offset - of a number of structural anomalies, ranging from the Palaeozoic Calais Basin with its northeast trending border faults, the depression off Gravelines and the cluster of deformations near North Hinder, it is tempting to speculate that all these features belong to one major, northeast trending deformation zone.

The deformations of the cover sediments of the London-Brabant Massif should be younger than Eocene. A weak unconformity at the base of the Bartonian deposits observed in a syncline in the eastern part of the Belgian continental shelf suggests a first pulse of tectonic activity. The main tectonic phase however cannot be more accurately described than ranging between Oligocene and Present in age, due to the fact that all deformations are observed within an area of outcropping Eocene deposits, discontinuously covered by undeformed Quaternary sediments. A fair guess for the main deformation period might be the Miocene phase of peak Alpine compressive stresses, also experienced in other places of the Northwest European continental crust.

At this level it might be useful to mention that the hypothesis of a fracture zone cutting through the London-Brabant Massif has already been advanced by COLBEAUX *et al.* (1980), who assumed a possible fault control of the Pleistocene opening of Dover Strait. Also the apparent offset of geological units on both sides of Dover Strait has been cited by various authors as an argument for axial wrench-faulting (WALLACE, 1968 ; DESTOMBES and SHEPHARD-THORN, 1972 ; SHEPHARD-THORN *et al.*, 1972).

The observation or induction of faults cutting across the London-Brabant Massif and displaying activities possibly ranging from Late Palaeozoic times to Present should not be surprising. It would indeed be hard to explain how for instance the Eocene cover deposits near North Hinder could have been deformed under Late Cenozoic tectonic stresses, known as relatively moderate in these regions, if they had not been located on top of older scars in the otherwise rigid Palaeozoic basement. It should be noted here that most of the Tertiary deformations in the Channel and southern North Sea are considered as reactivations of zones of crustal weakness (ZIEGLER, 1981).

It is thus postulated that the North Hinder deformation zone forms the surface expression of deep-seated faults, possibly of Late Palaeozoic age, which have been reactivated at least in Late Cenozoic times.

The presence of deep, inherited faults cutting across the London-Brabant Massif are not only corroborated by the rift structure of the Calais Basin, but possibly also by the analogy with other transversal basement ridges in the North Sea transected by - often more developed - rift structures.

The "en échelon"-pattern of the slightly elongated depressions suggests that the Tertiary stress fields probably reactivated the deep faults underneath the North Hinder anomalies in a dextral wrench-fault mode. A more detailed structural analysis will however be required for assessing the behaviour of these faults under stress fields, which may have considerably changed both in amplitude and orientation throughout Cenozoic times (BERGERAT and GEYSSANT, 1980).

CONCLUSIONS

Reflection seismic investigations carried out in the northern part of the Belgian continental shelf have revealed a northeast trending sequence of structural deformations, affecting the Mesozoic and Cenozoic overburden of the London-Brabant Massif.

Although further detailed reflection seismic investigations and structural analyses will be required for defining the exact tectonic style and regional context of these deformations, there is little doubt that these features are the superficial expression of deeper scars, cutting across the London-Brabant Massif in the axial zone of the eastern Channel.

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