

THE INVERSION OF PART OF THE SOUTHERN BORDER OF THE CENTRAL GRABEN IN SOUTH LIMBURG DURING THE LATE CRETACEOUS¹

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ABSTRACT

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During the Late Cretaceous Sub-Hercynian tectonic phase, transitory inversion of movements took place in the Central Graben. This NW-SE running graben is limited in the NE by the Peelrand Fault and in the SW by the Feldbiss (Fig. 1). During this period the graben floor became uplifted. Inversion first occurred in the SW part of the graben north of the Feldbiss and the Heerlerheide Fault during the deposition of the Vaals Formation (Campanian) and spreaded further south, during the deposition of the Vaals and the Gulpen Formation (Campanian to Maastrichtian) to the faults blocks north of, respectively, the Benzenrade – the Kunrade – and the Schin op Geul Fault and its southeastern extension into Germany, the Laurensberg Fault. These conclusions are based on the study of the formation thicknesses and age on opposite sides of the respective faults. On the base of similar facts it has been deduced that the inversion has been discontinued during the deposition of the Maastricht Formation (Kunrade facies) after which the Central Graben became a sedimentation area again.

INTRODUCTION

South Limburg is situated east of the Brabant Massif (Fig. 1). This massif has been a structural high since the Early Devonian (KIMPE ET AL., 1978). The Ardenno-Rhenish Massif is present to the south. The Hercynian orogenesis followed after the geosynclinal development of the Devonian and Carboniferous. Denudation and erosion took place since the Late Carboniferous. Since that time the Ardenno-Rhenish region can be considered as a massif. During the Hercynian orogenesis some block-faulting occurred as a consequence of the Asturian tectonic phase which probably took place in the Westphalian (BLESS ET AL., 1976).

A number of northwest-southeast running faults dipping about 60°-80° have been established, of which the Feldbiss and Peelrand Fault are the most important ones (Fig. 1). Both border the so-called 'Central Graben', in Germany called the 'Rurtal Graben' which runs to the southeast into the Lower Rhine Embayment (ILLIES, 1977). The block-faulting probably started in connection with the Asturian tectonic phase and these faults have been active since then and largely influenced

the sedimentation and erosion in South Limburg (BLESS, 1976).

There are three 'anticlinal' structures put on the map (fig. 1). The Waubach 'anticline' and the Hamm 'anticline' already influenced the Lower Westphalian sedimentation in South Limburg and the Visé-Puth 'anticline' seems to be an older structure (BLESS, 1977). During the Alpine tectonic phase only epeirogenetic-faulting took place, possible with some tilt.

Triassic sediments only occur north of the Heerlerheide Fault. Jurassic and Lower Cretaceous sediments are not known in South Limburg. During the Late Cretaceous transgression even the northern flanks of the Brabant Massif became covered by sediments and the transgression subsequently reached South Limburg and the Ardenno-Rhenish Massif. The folded Carboniferous rocks are overlain by flat-lying Upper Cretaceous sediments which dip to the northwest at an angle of about 1/2°.

DISTRIBUTION OF UPPER CRETACEOUS FORMATIONS

When considering the distribution of the Cretaceous formations in South Limburg (KUYL, 1980), the following can be observed. The (Santonian?) Aken Formation (Fig. 2) is mainly limited to the southeastern part of the area, where it is

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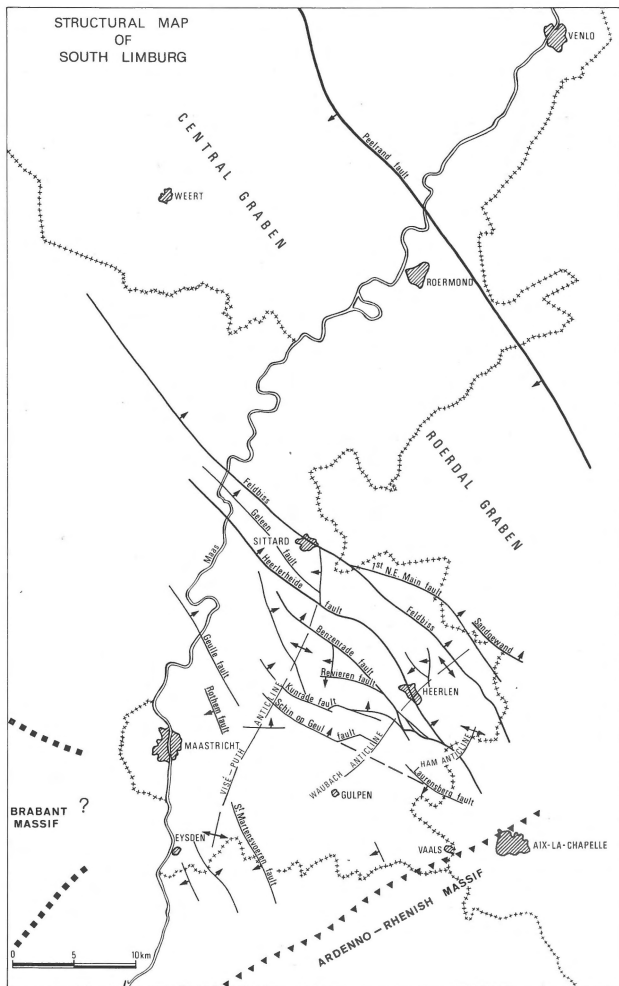


Fig. 1. Structural map of South Limburg.

absent in the deepest part of the Geul Valley because of Quaternary erosion and along the Selzerbeek because of erosion by the transgressive deposition of the Vylen Chalk (Fig. 7). The Hergenrath Clay, the lower member of the Aken Formation directly covers Carboniferous sediments. It consists of sandy and silty clays with intercalations of sands. Thin lignite beds are present. The Aken Sands, the upper member of the Aken Formation, consists of grey marine sands with cross-bedding, sometimes bioturbations and silicified wood fragments.

The lower boundary of the overlying Vaals Formation is a basal conglomerate, consisting of quartz pebbles, sandstone and quartzite. This suggests a transgression after deposition of the Aken Formation which has eroded the larger part of the Aken Formation.

The Vaals Formation (Fig. 3), mainly marine glauconitic sands, is generally present south of the Heerlerheide Fault. Exceptions are the deeper parts of the Geul and the Selzerbeek valleys and the area of Eysden, south of Maastricht on the Dutch-Belgian border, probably because of the

presence of the Visé-Puth 'anticline'. Remnants of the Vaals Formation were met with in a few wells south of Heerlen to the northeast of the Heerlerheide Fault.

The Gulpen Formation (Fig. 4) is mainly a fine grained chalk, occasionally glauconitic, which contains flint nodules. The distribution is limited to the area south of the Geulle Fault, the Schin op Geul Fault and its southeastern extension, the Laurensberg Fault (Fig. 1). The Gulpen Formation is absent in the Gulp and Geul valleys and in the neighbourhood of Vaals, west of Aken (Aachen) where the Dutch, Belgian and German borders meet. The lower member, Zeven Wegen Chalk, has a Campanian age, the overlying Beutenaken Chalk is Early Maastrichtian and is followed by the Vylen Chalk, the Lanay Chalk and the Lixhe Chalk. The Zeven Wegen Chalk is limited to an area south of the line Gulpen-Vaals. (Fig. 1).

The Maastricht Formation (Fig. 5), overlying the Gulpen Formation, consists of two facies. The Maastricht Chalk with flint nodules, situated in the western part of South Limburg and the Kunrader Limestone, an alternation of hard limestones and marly chinks in the eastern part. The Maastricht Formation extends further north than the Gulpen Formation (Fig. 5). It is missing in the southern part of the area because of erosion and solution of the chalk; fossils from the Maastricht Formation have been encountered in the flint eluvium near the Dutch-Belgian border south of Heerlen.

THE SECTION ACROSS THE SCHIN OP GEUL FAULT NEAR SCHIN OP GEUL

In order to obtain a better insight in the Cretaceous stratigraphy across the Schin op Geul Fault four boreholes have been drilled by the Geological Survey, of which one on either side of the fault reached the Carboniferous. The result of the investigation is represented in figure 6 which consists of two parts: (A) a section with an exaggeration of the vertical scale of the 2½ times and (B) a section in which the horizontal and vertical scale are the same. (A) gives the lithology, lithostratigraphy and the results of dating with foraminifers (MEESSEN, 1980). (B) represents a summary of the lithostratigraphic interpretation.

Borehole 62A-309 shows a complete section of the Vaals Formation of 107 m which can be divided into three zones (MEESSEN, 1980). North of the fault in borehole 62A-306 only a small portion of the lower zone of the Vaals Formation had been met with, about 10 m. The boundary Campanian-Maastrichtian has a downthrow of about 95 m north of the fault. The top of the Carboniferous has on the contrary a downthrow of about 18 m south of the fault. It may be concluded that the inversion of the Schin op Geul Fault started during the deposition of the Vaals Formation, continued during the deposition of the Gulpen Formation and ceased during the deposition of the Maastricht Formation. The presence of black flint in a poorly recovered section of

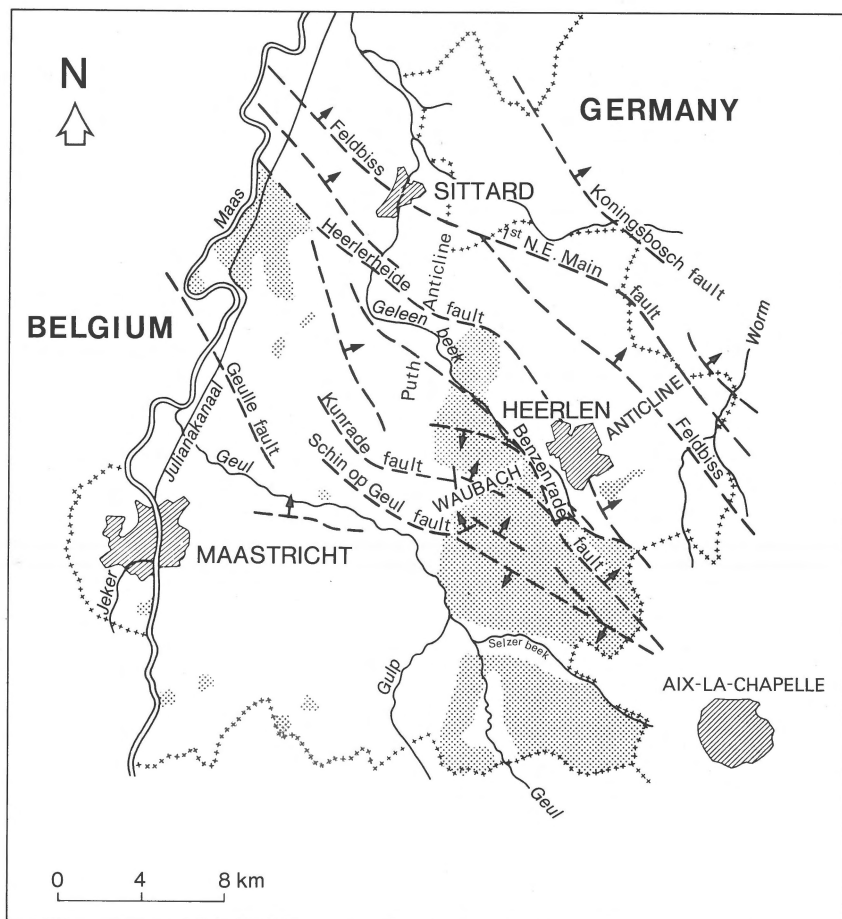


Fig. 2.
Distribution of the Aken Formation in South Limburg.

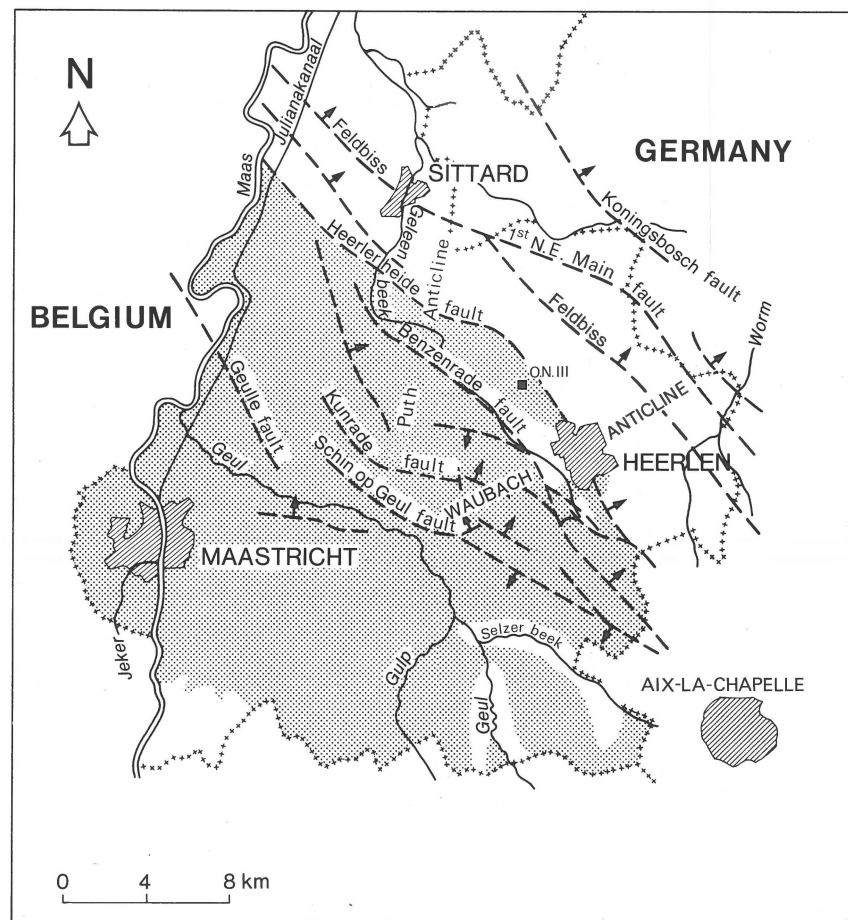


Fig. 3.
Distribution of the Vaals Formation in South Limburg.

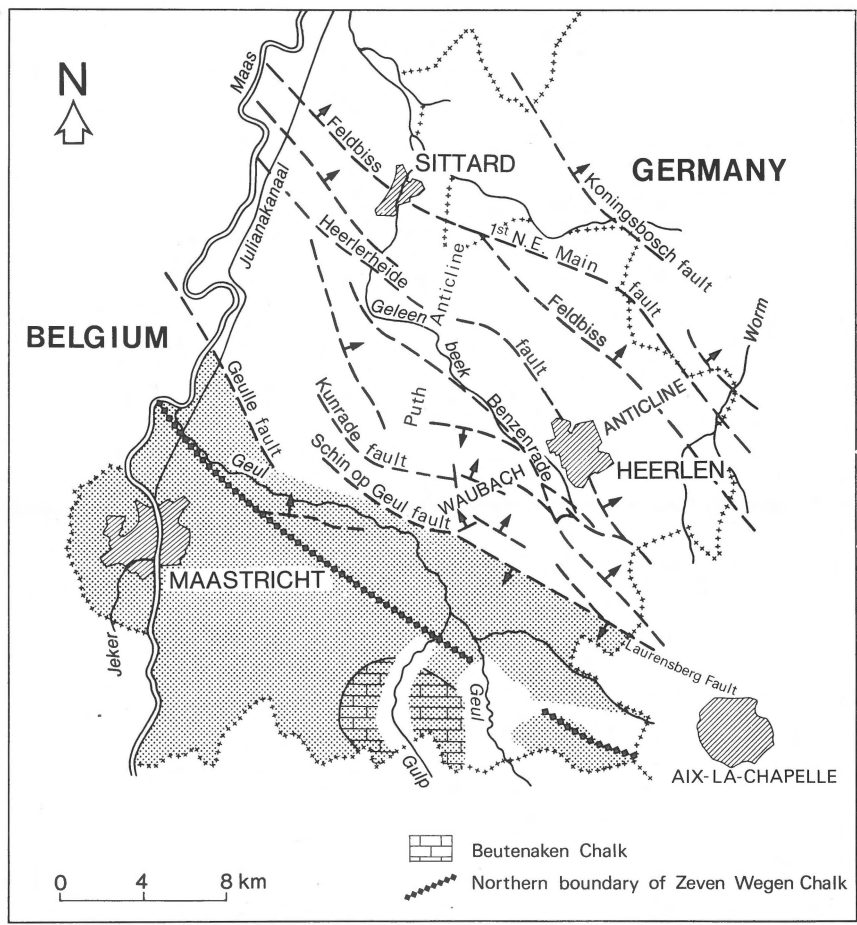


Fig. 4. Distribution of the Gulpen Formation in South Limburg.

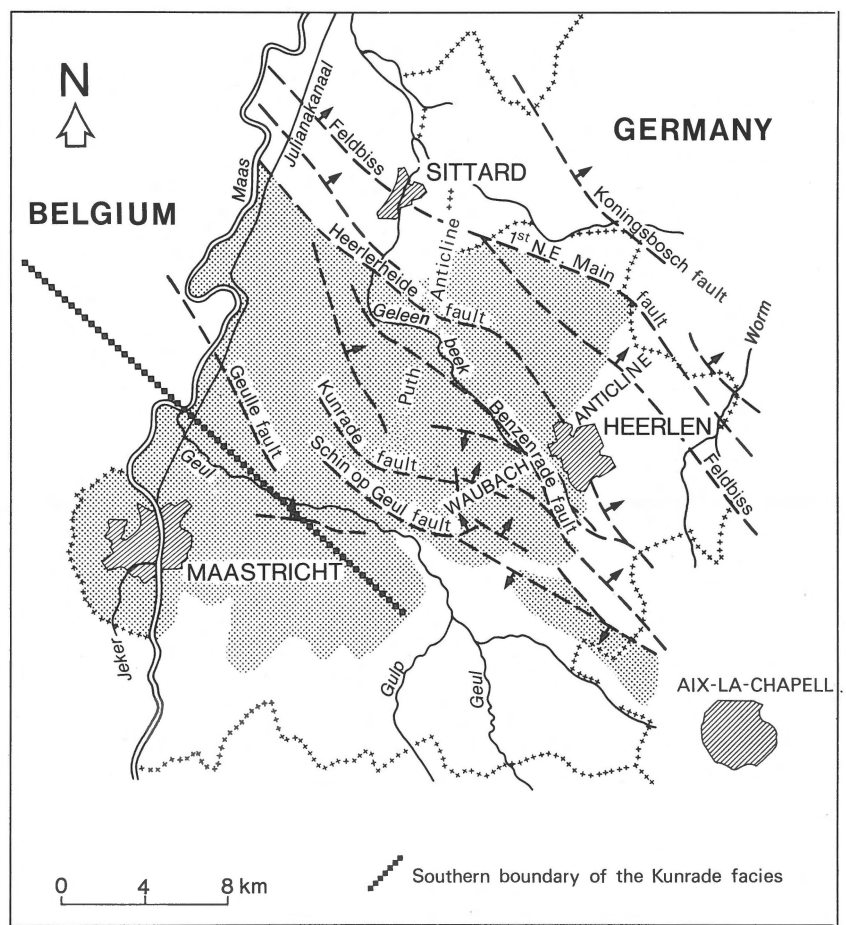


Fig. 5. Distribution of the Maastricht Formation in South Limburg.

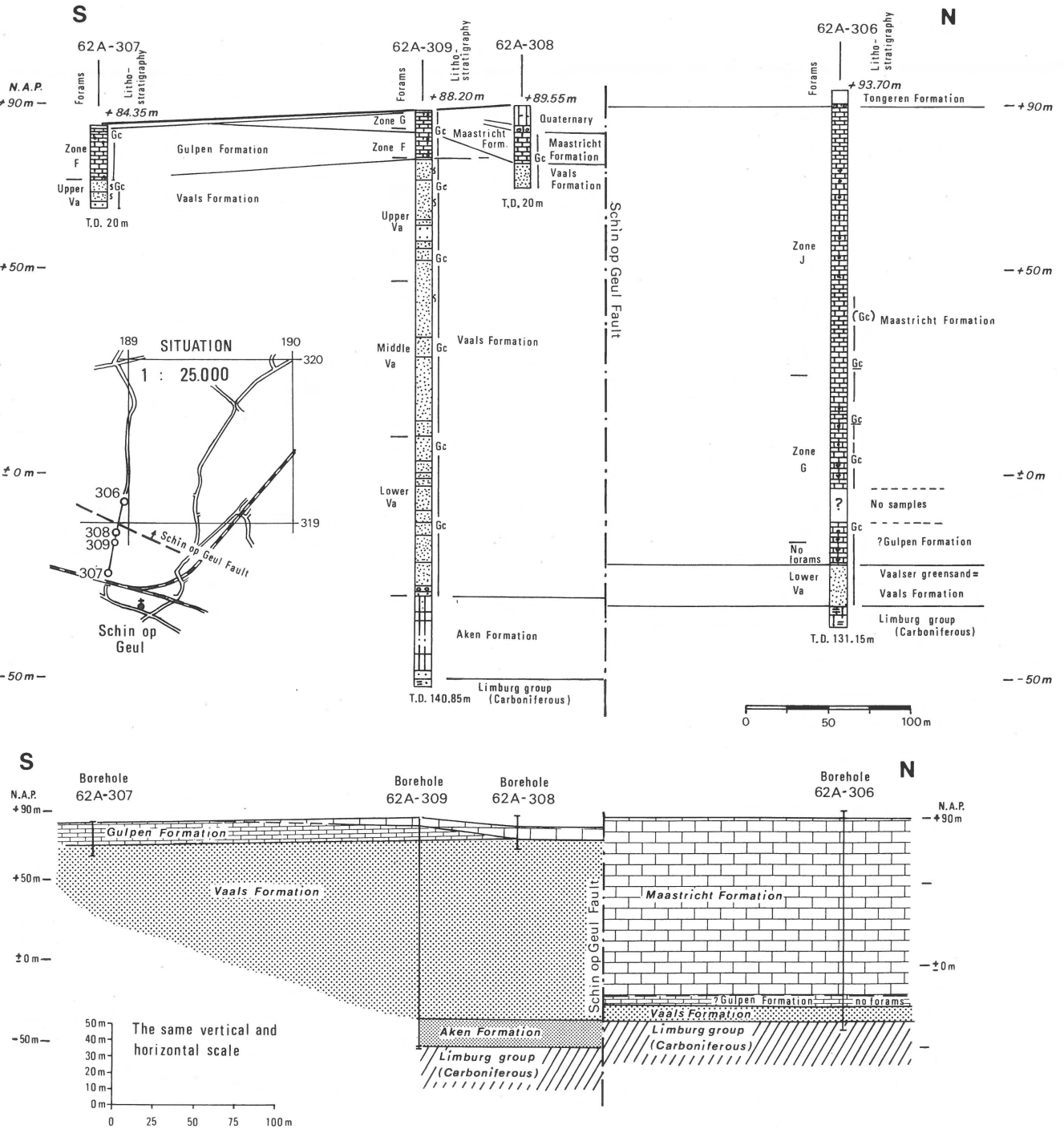


Fig. 6. Section across the Schin op Geul Fault near Schin op Geul A) 1/2 x exaggerated vertically, B) not exaggerated.

borehole 62A-306 on top of the Gulpen Formation may hint to reworking and represent a basal conglomerate of the Maastricht Formation, pointing to renewed deposition of Cretaceous sediments in the Central Graben.

MEESSEN (1980) established zone G of HOFKER (1966) in the

upper part of the Gulpen Formation which means that it certainly belongs to the Maastricht Formation.

The presence of nearly a hundred metres of Maastricht Formation north of the fault clearly indicates a renewed sedimentation and a stop of the inverse movement.

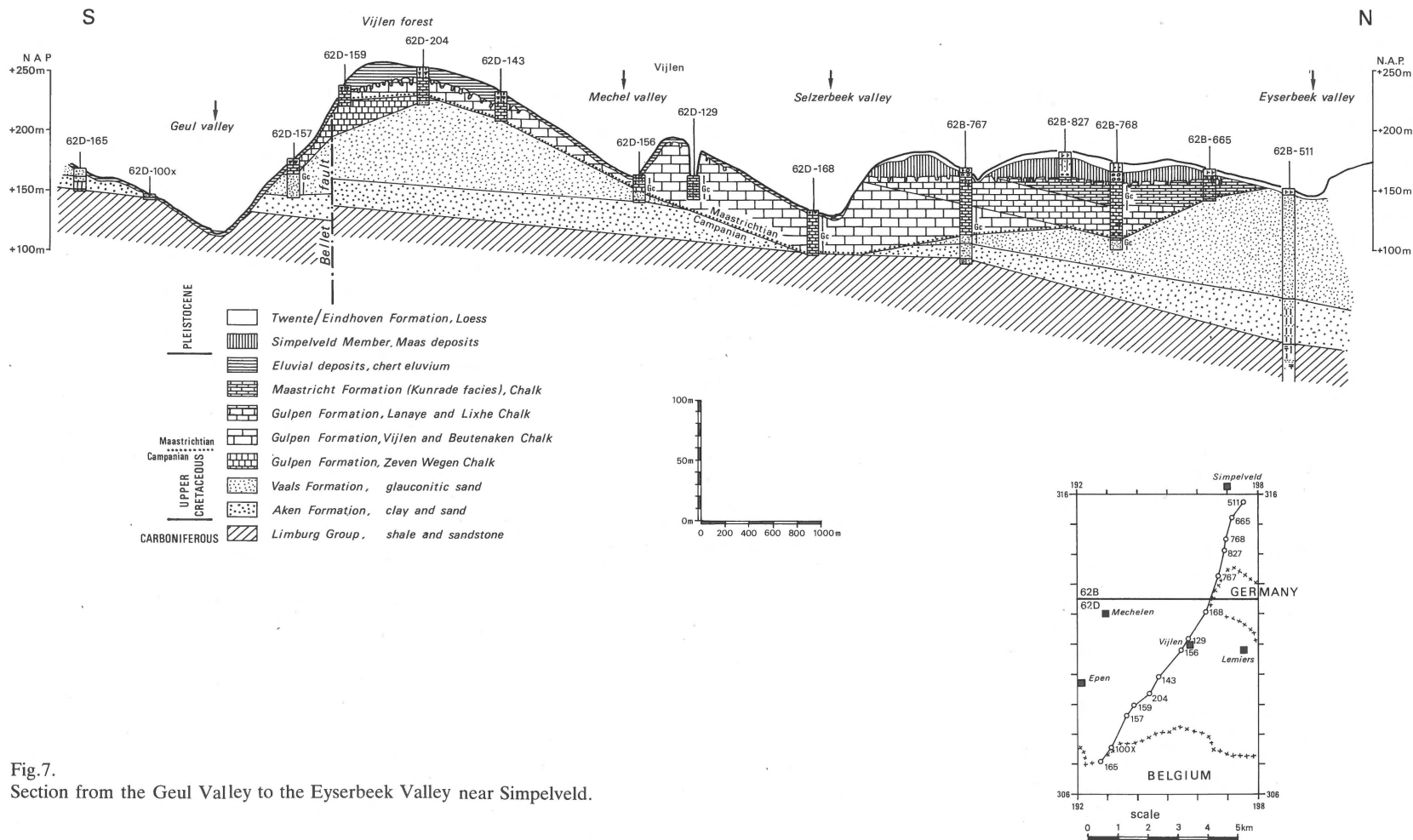


Fig.7. Section from the Geul Valley to the Eyserbeek Valley near Simpelveld.

SECTION FROM THE GEUL VALLEY TO THE EYSERBEEK VALLEY NEAR SIMPELVELD

This section (Fig. 7) shows the overlap of the Cretaceous formations due to the reversals in movement along the faultplanes (KUYL, 1980). A transgression of the Gulpen Formation from the south covers older formations of the Cretaceous. In the Selzerbeek area the Gulpen Formation rests on Carboniferous which indicates a structural high in that location during the Late Cretaceous. The reversal of movement has been discontinued during the deposition of the Maastricht Formation (Fig. 6) and caused the thick sequence of that formation north of the Schin op Geul Fault.

DISCUSSION OF THE RESULTS

Thoughts about the stratigraphical position of tectonic movements in the investigated area have changed (KUYL, 1980). The Sub-Hercynian phase was placed in the middle of the Santonian and the Laramic phase at the boundary between Cretaceous and Paleocene, which means that Cretaceous sedimentation started after the Sub-Hercynian phase on top of the Carboniferous and inversion was due to the Laramic phase (AHORNER, 1962). It is now thought that the Sub-Hercynian phase was prolonged during the Late Cretaceous (VAN STAALDUINEN ET AL., 1979). There are indications for a renewed positive movement during the Paleocene (BISSCHOPS, 1973). The Laramic phase caused deposition of Paleocene Chalk between the Feldbiss and the Benzenrade Fault (Fig. 1). These sediments are not present, perhaps removed by erosion, in the southern part of the investigated area.

The section across the Schin op Geul Fault (Fig. 6) clearly demonstrates a reversal of movements. This movement probably started during the deposition of the Vaals Formation (Campanian), and reached a maximum during the deposition of the Gulpen Formation (Campanian and Maastrichtian). The normal position, in which the Central Graben is no longer an upthrown part, was re-established during the deposition of the Maastricht Formation. It is a clear case of local block-faulting as no lateral change of facies has ever been observed in the sediments of the Vaals and Gulpen Formation. The geometry of the Vaals Formation (VAN DER WEYDEN, 1943; ROMEIN, 1963) suggests a progression of reversals in movement from north of the Heerlerheide Fault southwards up to the Schin op Geul Fault. The absence or thin sequence of the Vaals Formation directly north of the Benzenrade Fault and the Schin op Geul Fault is an indication for tilt. This would also explain the great thickness of the Vaals Formation, over 100 m, just south of the Schin op Geul Fault.

The section Geul Valley – Eyserbeek Valley (Fig. 7) clearly shows a gradual transgression of the Gulpen Formation to the north. This overstep of the Gulpen Formation was ended by the inversion of movement along the Schin op Geul Fault and its southeastern extension the Laurensberg Fault.

CONCLUSIONS

During the deposition of the Upper Cretaceous sediments in South Limburg, during the Sub-Hercynic tectonic phase, the movement along the Schin op Geul Fault was reversed. In the Central Graben the downthrown part became the upthrown part.

The inversion first occurred north of the Feldbiss and the Heerlerheide Fault during the deposition of the Vaals Formation (Campanian) and progressively extended southwards during the deposition of the Vaals and Gulpen Formation (Campanian to Maastrichtian).

The inversion affected successively the fault-blocks between the Heerlerheide and Benzenrade Fault, Benzenrade Fault and Kunrade Fault and the region between the Kunrade Fault and the Schin op Geul Fault with its southeastern extension the Laurensberg Fault.

The supposition of ROMEIN (1963) that the Central Graben and its bordering blocks never had a Gulpen Formation cover has considerably been strengthened. The section across the Schin op Geul Fault gives a thickness of over 100 m of the Vaals Formation south of the fault and only 10 m north of it. The Maastricht Formation (Kunrade facies) has a thickness of more than 100 m north of the fault while there remains only 8 m south of the fault. Although there may have been a considerable erosion south of the fault, it means that the inversion has been discontinued at the beginning of the deposition of the Maastricht Formation (Maastrichtian). The Central Graben became an area with sedimentation once again.

The section from the Geul Valley to the Eyserbeek Valley (Fig. 7) demonstrates the transgression of the Gulpen Formation from south to north, and blocked by the temporary horst north of the Schin op Geul Fault.

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