Geomorphic and geophysical reconnaissance of the Reppel and Bocholt faults, NE Belgium

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ABSTRACT

Results of an investigation of the activity of the Reppel and Bocholt Faults at the southwestern border of the Roer Valley Graben are presented. These show clearly that the small geomorphic scarps (± 2 m high) coincide with a shallow geological contrast and with a geophysical anomaly on GPR, electrical, electrical tomography and shallow seismic reflection profiles. We thus found evidence for recent surface faulting that most probably was caused by large earthquakes.

KEYWORDS

Active fault, fault scarp, Roer Valley Graben, paleoseismology.

Introduction

To the NW of the town of Bree, the Neeroeteren Fault which is part of the Feldbiss Fault Zone at the southwestern border of the Roer Valley Graben separates into three branches. From west to east these are the Grote Brogel, Reppel and Bocholt Faults (fig. 1). The latter two were studied in more detail. These faults have been recognised on intermediate resolution seismic reflection profiles performed by the Belgian Geologic Survey on land (Demyttenaere and Laga, 1988) and on those done by the Renard Centre of Marine Geology on the Campine Canals (De Batist & Versteeg, 1999). The long term slip rates from the upper Miocene onwards (table 1) were derived from these seismic lines.

	Neeroeteren	Gr. Brogel	Reppel	Bocholt
slip rate mm/yr	**0.06**	0.02	0.01	0.033
height m	**20**	9	2	2

Table 1 - Average slip rates since Upper Miocene and average scarp heights for the different faults (Béatse, 1999)

This table shows how the slip of the single Neeroeteren Fault is distributed between the different fault branches. When extended to the surface, the faults on the seismic profiles correspond with subtle morphologic scarps (fig. 1) that are described in Paulissen, 1997.

Geomorphology

The fault scarps of the Reppel and Bocholt Faults are much smaller than that of the Neeroeteren Fault (table 1) probably due to the distribution of fault slip. On the field the scarps are expressed as low angle linear slopes of ± 2 m height in the more or less flat Bocholt Plain. At many places however anthropic action or river erosion modified the scarp. This could clearly be seen on detailed DEM's of the sites REP-1 and BOCH-2. Several sites where the scarps were better preserved where selected for further investigation in order to confirm the tectonic nature of the scarps and to find favourable sites for trenching. Theodolite profiles were made perpendicular to the scarp. With one of these we modelled the scarp degradation back in time (Camelbeeck et al., this volume). The result indicates that the last tectonic event at the Reppel Fault likely occurred during the last 20 kyr and produced a surface offset of ± 0.5 m.
Geomorphic arguments for a shallow surface rupturing faults were also found in differences in meander sinuosity and incision of small rivers that cross the faults. To the NW the scarps gradually become less evident and eventually they disappear.
The larger height of the Grote Brogel Scarp is probably partly due to differential erosion because it forms the edge of the outcrop of Main Terrace Gravel on the Campine Plateau. The Grote Brogel Fault is not one sharp plane but a zone of fault branches as can be seen on seismic profiles. As a consequence the total fault scarp is much broader. Due to these difficulties the Grote Brogel Fault was excluded from this study.

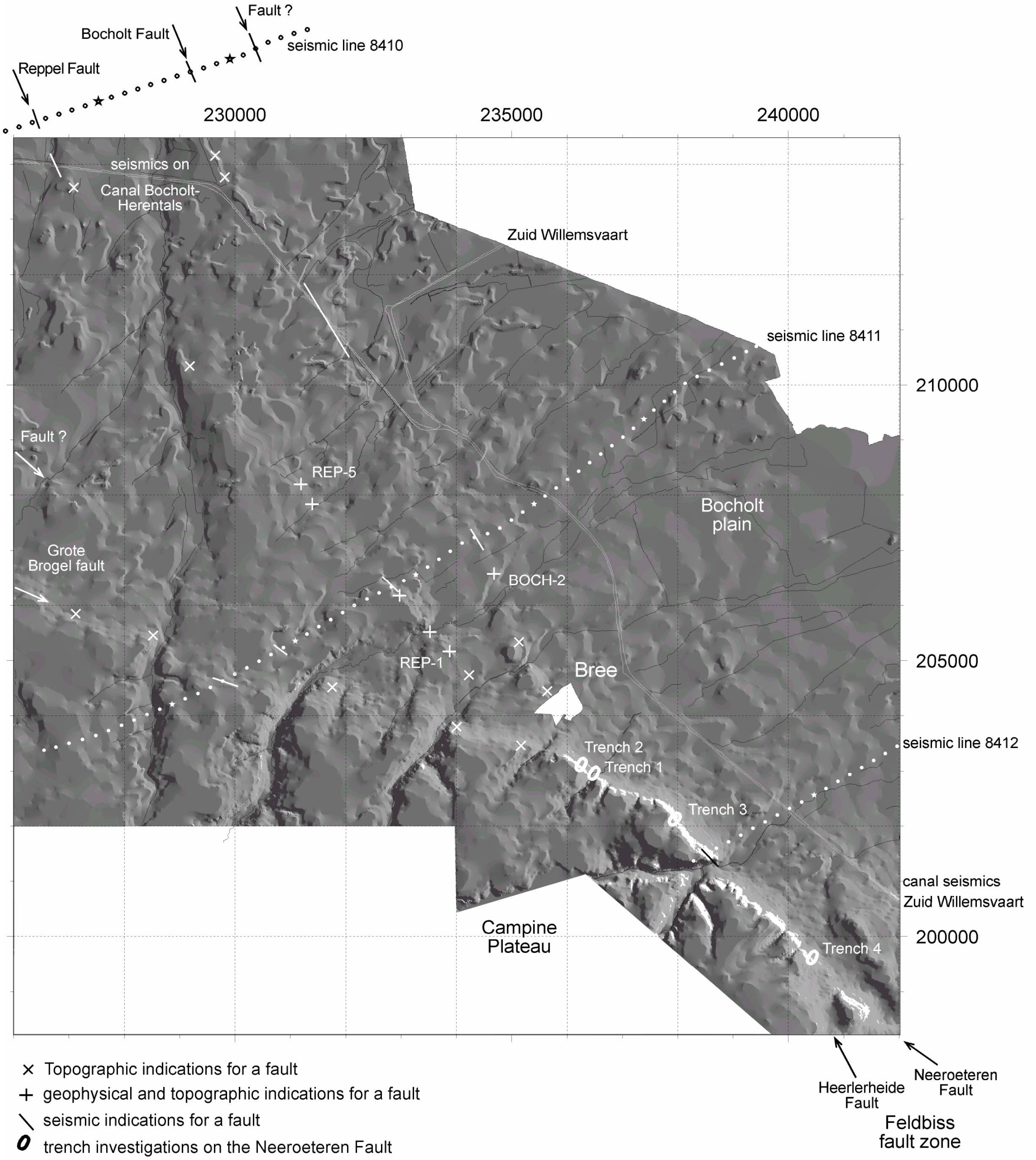

Figure 1 - Relief gradient map with investigated sites, digitised from 1/10000 topographic map

Hand core profiles

At the sites where the morphological scarp was best preserved, hand core profiles where done to see whether the scarp corresponds with a geologic contrast in the Weichselian coversands or the Middle Pleistocene Bocholt Sands of the Bocholt Plain. At all investigated sites we were able to find offset layers and a sudden change in depth of the watertable at the position of the scarp (fig. 2). Sometimes it was difficult to distinguish fault-displaced layers from other lateral lithology changes. In most cases the displacement of the layers could be measured but we had no precise age control because the local Holocene and Late Pleistocene stratigraphy is not well established. The hand core profiles also served as a control for the geophysical measurements that were done at the same sites.

Geophysics

To get a better view of the fault at depth and of the exact location of the fault we used a combination of different geophysical measurements perpendicular to the supposed fault at the most promising sites. These measurements were

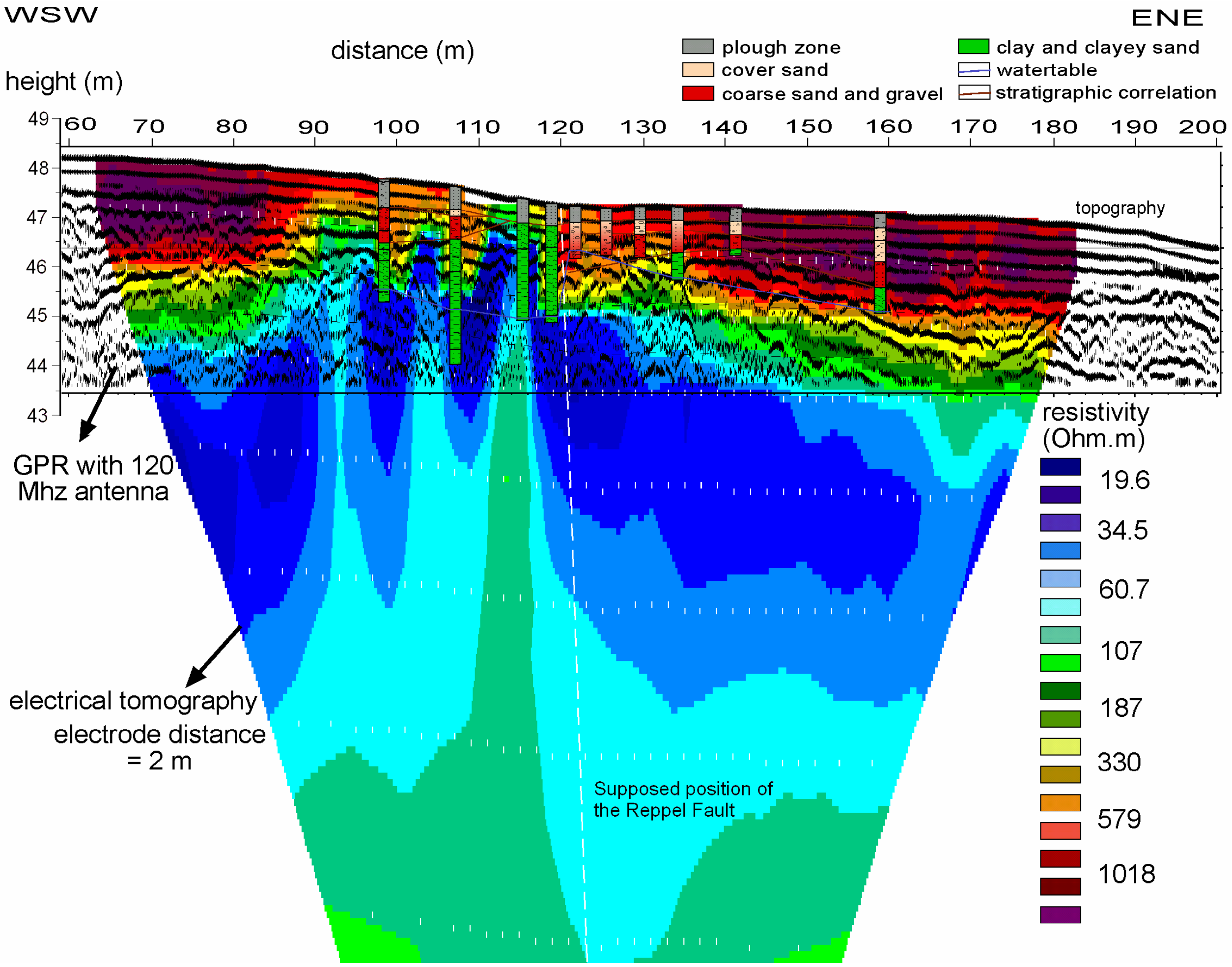

Figure 2 - Combined profile of site REP-1a with topography, hand cores, electrical tomography and GPR

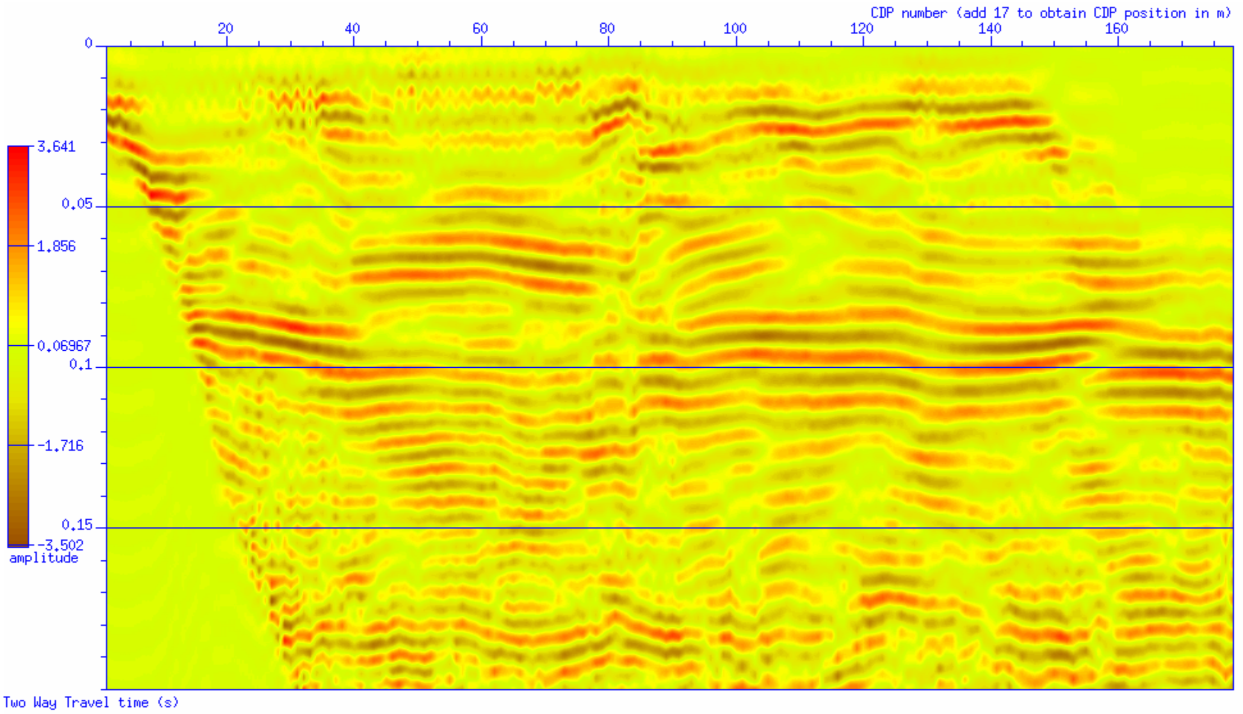

Figure 3 - High resolution seismic reflection profile at site REP-1b, using a small weight drop seismic source

done by the L.G.I.H and a full description of the applied methods can be found in Demanet et al. (in press). For a fast and simple preliminary prospection we performed electric profiles using a Schlumberger configuration with a 10 m electrode spacing. The 1D results of these measurements are difficult to interpret but generally we found a resistivity contrast that corresponded with the position of the scarp and the lithological anomalies.

The second method that we applied at two sites on the Reppel Fault is electrical tomography which gives a 2D view of the resistivity at depth. At both sites the largest anomaly coincided with the anomalies found with the other methods (fig. 2).

Ground Penetrating Radar (GPR) profiles were made at four sites on the Reppel Fault and at one site on the Bocholt Fault. They provide high resolution profiles of the structures near the surface. GPR profiles gave good results at some sites but remain however difficult to interpret.

Case study: site REP-1

At site REP-1a (fig. 2) we found a thick clayey layer which was dipping away from the fault in both directions and was overlain by coarse gravely sand and some coversand. The displacement was about 1 m and on the footwall near the fault the coarse sands and coversands where eroded away. At the position of the fault the watertable makes an opposite jump of about 1.5 m. On the radar profile a dome structure can be observed below which no clear reflectors appear and only minor disturbances can be seen around 120m, the supposed fault position. The dome probably represents the top of the clayey layer in the footwall and the top of the watertable in the hanging wall because both clay and water block the radar signal. The electrical tomography shows the dipping and offset low resistive clay layer and a clear anomaly from bottom to top of the profile at the fault position.

Finally a high resolution seismic reflection profile at a farm road at 100 m distance from site REP-1a was made in co-operation with the Universities of Utrecht and Gent. This profile was made twice, respectively with a small weight drop (fig. 3) and a vibrator sweep as seismic source. On these profiles three faults can be observed. The one at ± CDP 85 corresponds to the scarp while the other at ± CDP 30 and a minor fault at ± CDP 125 have no apparent morphology. The depth penetration was 10 to 100 m. This method fills the gap between the existing intermediate resolution seismic lines and the shallow geophysical methods that we applied in this study.

Conclusions

The coincidence at all investigated sites of a morphologic scarp with offset geologic layers in boreholes and with anomalies in shallow geophysical measurements indicates recent surface rupturing. According to Paulissen (1973) the coversands at surface in the Bocholt Plain are of Weichselian age. The rupture also affects these deposits and thus the age of the last surface rupture is Weichselian or younger. The modelling of the scarp at site REP1 gave an age younger than 20 kyr but this is only a rough value.

Trenching will be required to establish if this faulting is either a-seismic or caused by large earthquakes as along the Bree Fault Scarp (Camelbeeck & Meghraoui, 1998) and in the latter case to establish the seismic cycles of the two faults.

To identify and precisely locate active faults with such a low slip rate as the Reppel and Bocholt fault a combination of different methods is required.

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