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Determination of recent stress directions and faults in the Leinetal-Graben; Germany – first experiences with the new NEMR-method

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Abstract: The Natural Electromagnetic Radiation (NEMR) method is a new method to determine recent stress directions and the location of active faults and landslides. We are testing the NEMR method in the Leinetal-Graben, Lower Saxony, Germany. Our results for the maximum horizontal stress direction are consistent with data published in the World Stress Map (WSM). Furthermore, the method showed its capability in detecting faults and landslides.

Keywords: NEMR method, stress directions, active faults.

The NEMR method is a new method to determine recent stress directions in the uppermost crust and for detecting faults and landslides. In our study we tested the applicability of this method in the Leinetal-Graben, Lower Saxony, Germany, for these three applications.

The Leinetal-Graben belongs to the intra-continental European rift system and is located in the North German Basin. The graben is characterised by NNE-SSW trending normal faults partly reactivated with strike-slip components and a distinct structural asymmetry between the western and eastern parts.

Methods

The emission of electromagnetic radiation (NEMR) is a result of the generation of dipoles at molecular scale due to the propagation and extension of micro cracks; thus NEMR is related to brittle deformation processes. Up to now NEMR has been known from metals (Jagasivamani and Iyer, 1988), ice (Fifolt *et al.*, 1993), glass (Bahat *et al.*, 2002), and different rock types (Nitsan, 1977; Warwick *et al.*, 1982; Ogawa *et al.*, 1985; Cress *et al.*, 1987; Yamada *et al.*, 1989; O'Keefe and Thiel, 1995). Hence, brittle behaviour of the material seems to be the only requirement for the generation of NEMR. Although NEMR is well known from laboratory studies, there is only minor experience with field work (Reuther *et al.*, 2002; Lauterbach, 2005; Lichtenberger, 2006; Mallik *et al.*, 2008; Reuther and Moser, 2009). In field studies, the measurement of the NEMR can be used to determine the direction of the recent principal stresses, provided that the direction of the micro crack formation/propagation is controlled by the local or regional stress field respectively. The NEMR is measured with the Cereskop. This measurement device is equipped with a beam antenna, and works in a range between 5 kHz and 50 kHz. It has several filters to avoid the influence of artificial emissions.

There are three different measuring methods that are mainly used to study the local/regional stress field. 1) Horizontal measurements, where the antenna is moved in a circle in the horizontal; 2) cross sectional measurement (only subsurface investigations), where the antenna is moved in a circle in the vertical; and 3) linear measurement along a linear profile to detect active faulting. In the Leinetal-Graben, we performed horizontal and linear measurements.

Results

We show that the proposed method is easily applicable to the detection of faults. It was possible to locate several faults on the Eastern Graben shoulder that were known from field studies and aerial photographs. In addition, high NEMR intensities occurred in the vicinity of unstable slopes and potential landslides.

The results of the horizontal measurements show orientations of the maximum horizontal stress in NE-SW and NW-SE directions, which agree with known data for Northern Germany (Fig. 1a). Repeated measurements yielded consistent data, though at some localities a switch between these two directions has been observed (Fig. 1b).

Discussion and conclusions

Our main aim was to determine horizontal stress directions and to test the applicability of the NEMR method in the field to detect active faults and potential landslides. Our results for the horizontal stress directions are largely consistent with the data published in the World Stress Map (Fig. 1a). The reason for the temporary switch between the two observed directions is still unknown and is part of future work. One hypothetical explanation discussed is the influence of tidal crustal undulations. To check this possibility, we are planning to perform measurements in diurnal and annual cycles. Stress data obtained with other methods, which could be used for comparison, are lacking for the study area.

Despite the open questions mentioned above, we conclude that the NEMR method is appropriate to detect active faults and their dip-directions as well as the geometric features of landslides and unstable slopes.

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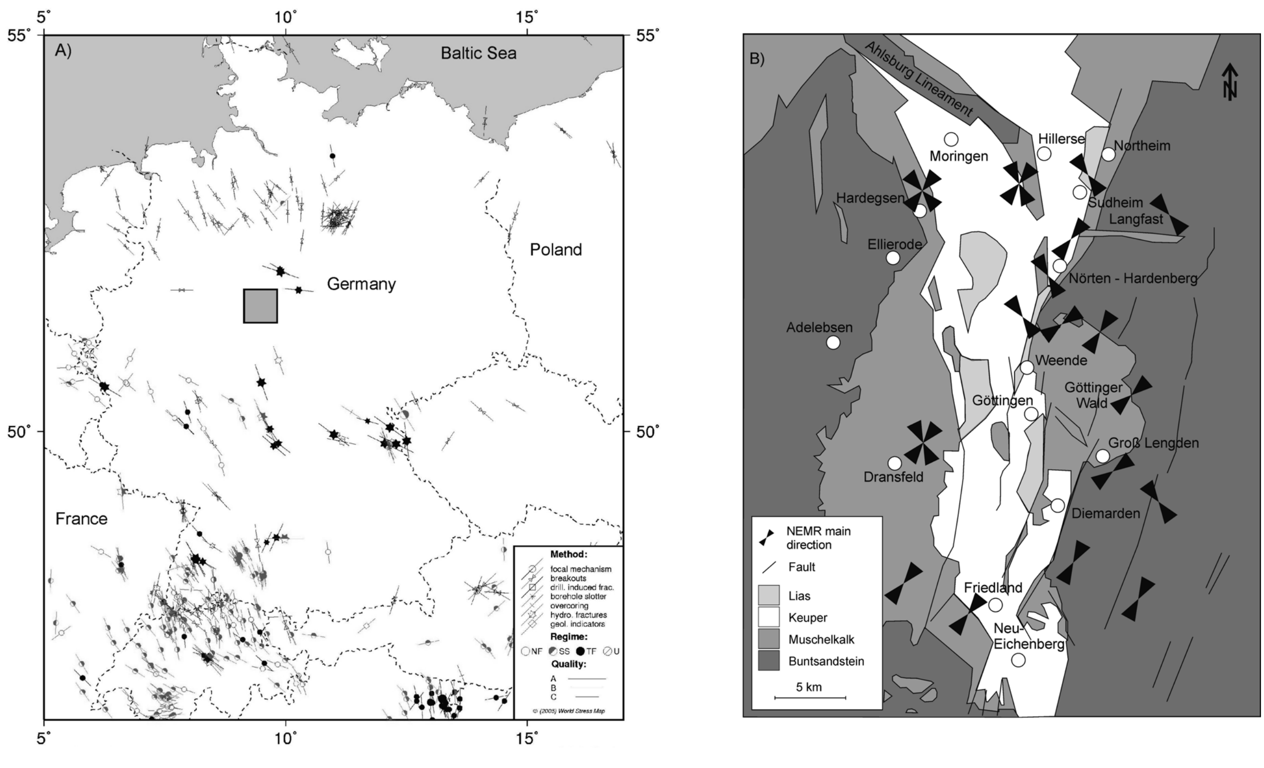

Figure 1. A) Stress data for Germany (modified after Reinecker, *et al.* 2005); gray box marks the location of the study area as shown in B). Stress regimes: NF: Normal Faulting; SS: Strike-Slip Faulting; TF: Thrust Faulting; U: Unknown. Quality A, B, C gives the accuracy of the orientation of the main horizontal stress (A = ±15º; B = ±20º; C = ±25º), B) NEMR main direction in the Leinetal-Graben corresponding to the maximum horizontal stress direction.

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