RWTH AACHEN UNIVERSITY

Neotektonik Georisiken

Paleoseismological studies in the Lower Rhine Embayment - The Rurrand fault responsible for the 1756 Düren earthquakes?

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1 The site:

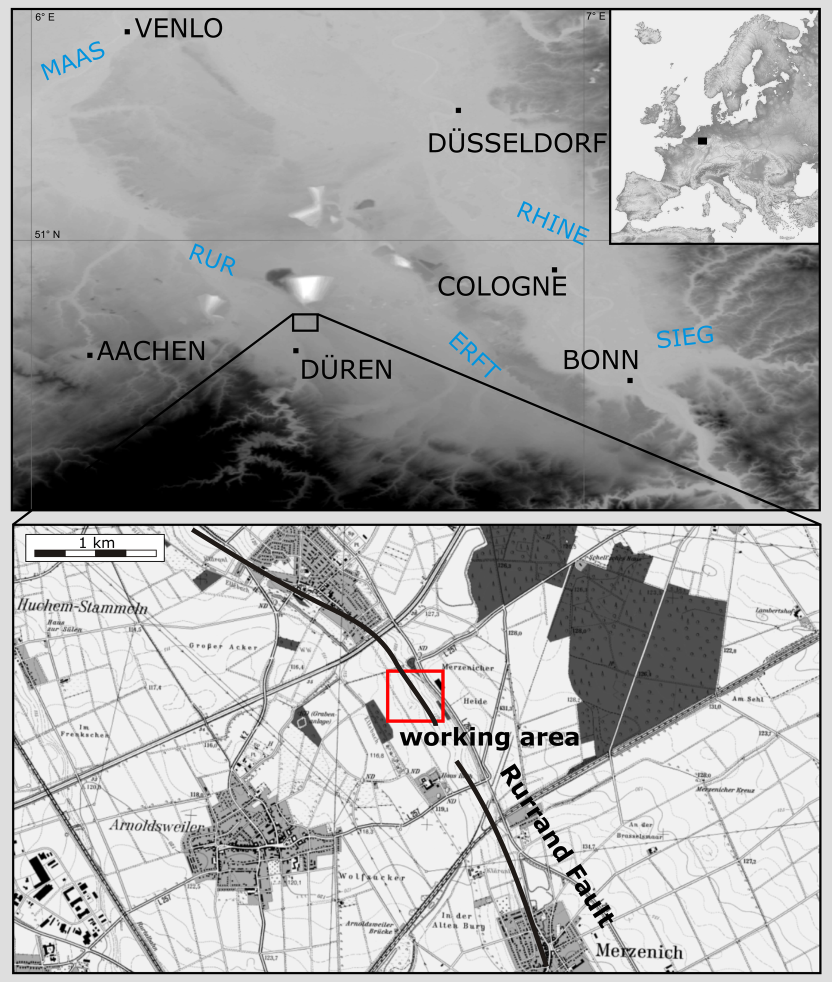

Figure 1: The working area in western Germany. The SE-NW striking Rurrand Fault is located between Aachen and Cologne, close to Düren at the Rur river.

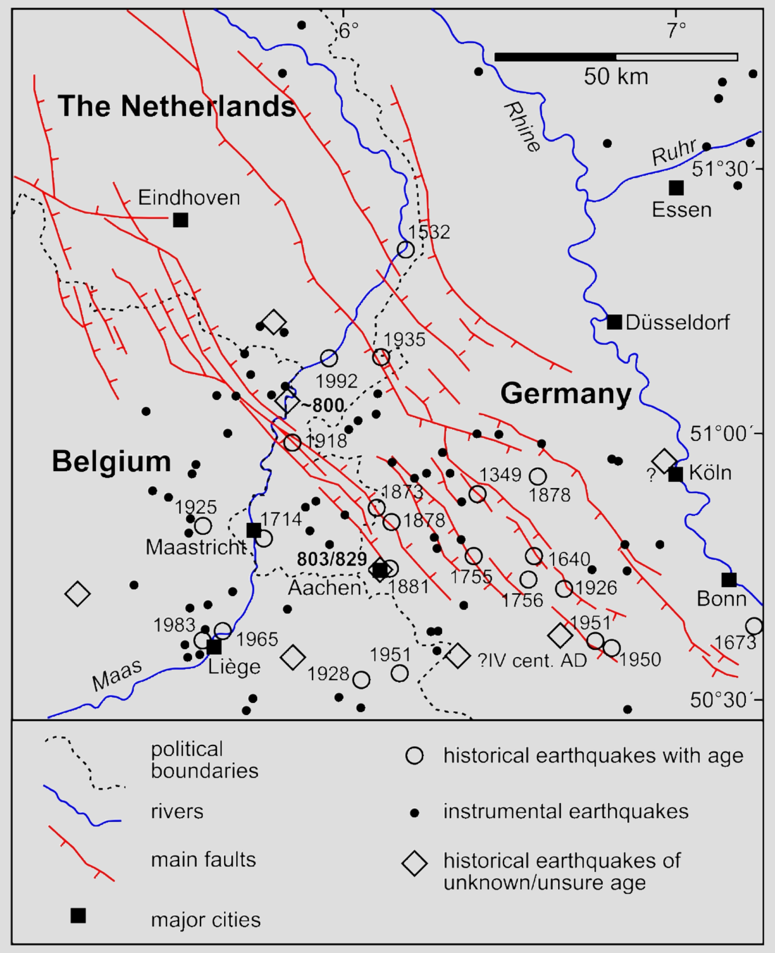

Figure 2: Neotectonics and historical earthquakes in the study area, the Lower Rhine Embayment.

In 1756, several strong earthquakes occurred close to Düren in western Germany (Figs. 1,2).

Historical sources claim that two people died and hundreds of houses were destroyed. The events were felt hundreds of kilometres away from the epicentre, therefore, a magnitude of at least 6 seems to be reasonable, despite the seismic source is still unclear.

The Rurrand Fault (Rurrandverwerfung, Fig. 3) in the Lower Rhine Embayment possibly indicates the Düren earthquake sequence.

Recent studies reported that active faults in the study area are characterized by recurrence periods in the order of tens of ka.

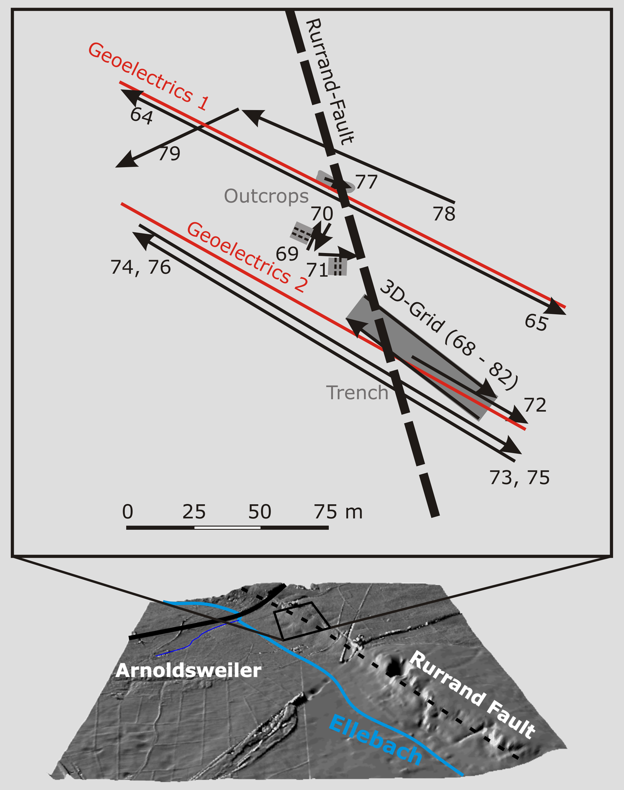

Figure 3: Location of trenches, outcrops and geophysical profiles at the study area (upper image). Map based on airborne laserscanning data (lower image).

Active faults in Germany are often not visible in the field due to relatively high erosion rates. Therefore, the seismic hazard might be under-estimated.

2 Methods:

Figure 4: GPR measurements (270 MHz).

Figure 5: Geoelectrics survey

Figure 6: Trenching and archeological sketching and analysis.

GPR (Fig. 4):
- GSSI 100, 400, 270 MHz antennas, SIR-3000, survey wheel

Geoelectrics (Fig. 5):
- 4-point-light classic geoelectrics system
- 80 electrodes, 1.5 m spacing

Trenching (Fig 6):
- archeological investigations due to highway construction
- several trenches parallel and perpendicular to the fault, archeological sketching

A high-resolution **DEM** was created based on airborne laserscanning data (Fig. 3)

3 Results: geophysics

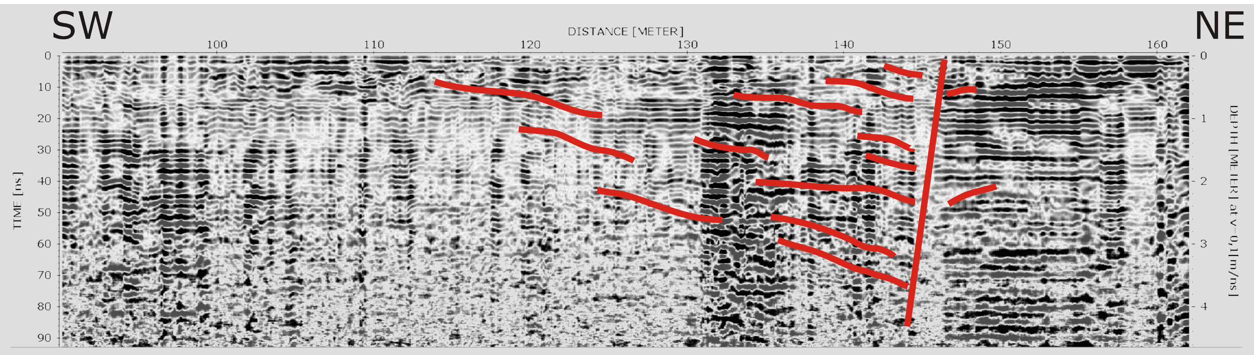

Figure 7: 270 Mhz GPR profile crossing the fault with an angle of 45°. The fault cropped out 2 m away from the GPR profile, allowing a direct comparison. Down to a depth of 4 m several reflectors dip towards the NW. A sharp contrast in reflection amplitudes marks the fault itself. On the footwall, only few layers appear to dip towards the Rurrand Fault. The results were confirmed with the 100 MHz and 400 MHz antennas as well and later also confirmed by the geoelectrics survey (Fig. 8).

Archaeological remains (Neolithic, Iron Age, Roman and Medieval) were found in the immediate vicinity of the Rurrand Fault during road construction works in 2010. Beside the Rhine Graben this fault is one of the most prominent NW-SE trending normal faults with a morphological expression in the area. Holocene surface-near sediments with significant offsets covered by thin colluvial sediments were found and a complex fault geometry was observed during the archaeological excavations (Figs. 10-12). Growing displacement of the major fault downsection suggest at least two major, surface-rupturing earthquakes along the Rurrand Fault in the Holocene/Late Pleistocene.

Shallow geophysical methods (Figs. 7, 8) were used to gather additional data. DC geoelectrics and georadar were applied in order to image the deeper parts of the fault zone.

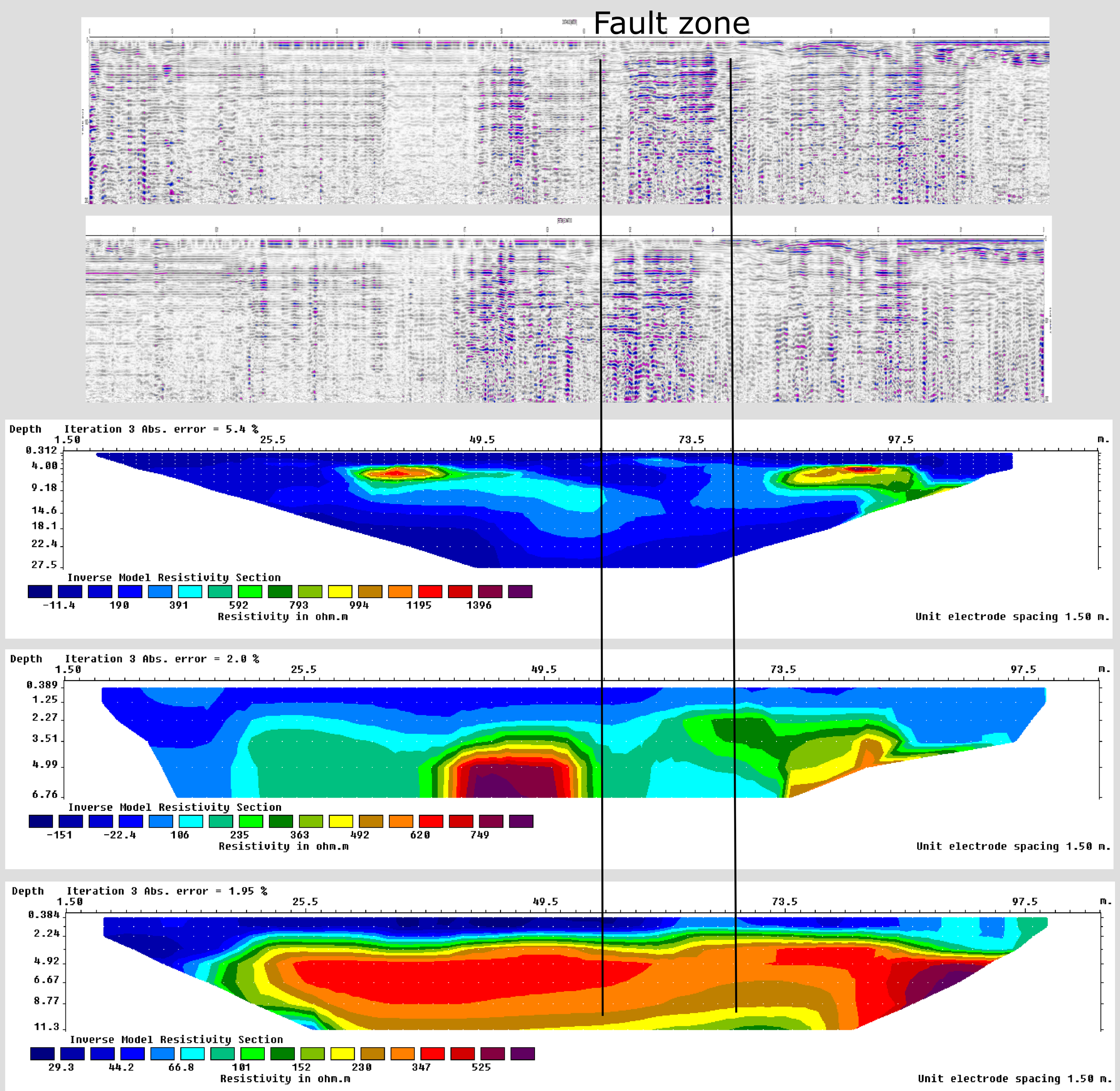

Figure 8: 270 MHz GPR profile (upper image) and Geoelectrics (dipole-dipole, schlumberger, wenner) data (lower image) from the Rurrand Fault. The fault zone is visible as a section of higher amplitudes in the radargramm, which are due to outcropping gravels with a low conductivity. An area of decreased resisitivities marks the fault in the Geoelectrics profile. This is most likely due to water circulating in the fault zone.

trenches

Radiocarbon and luminescence dating of sediment samples are still in progress, but the morphological expression of the fault, the shallow depths of the offset sediments, and geophysical data allow concluding on very recent seismicity along this active fault.

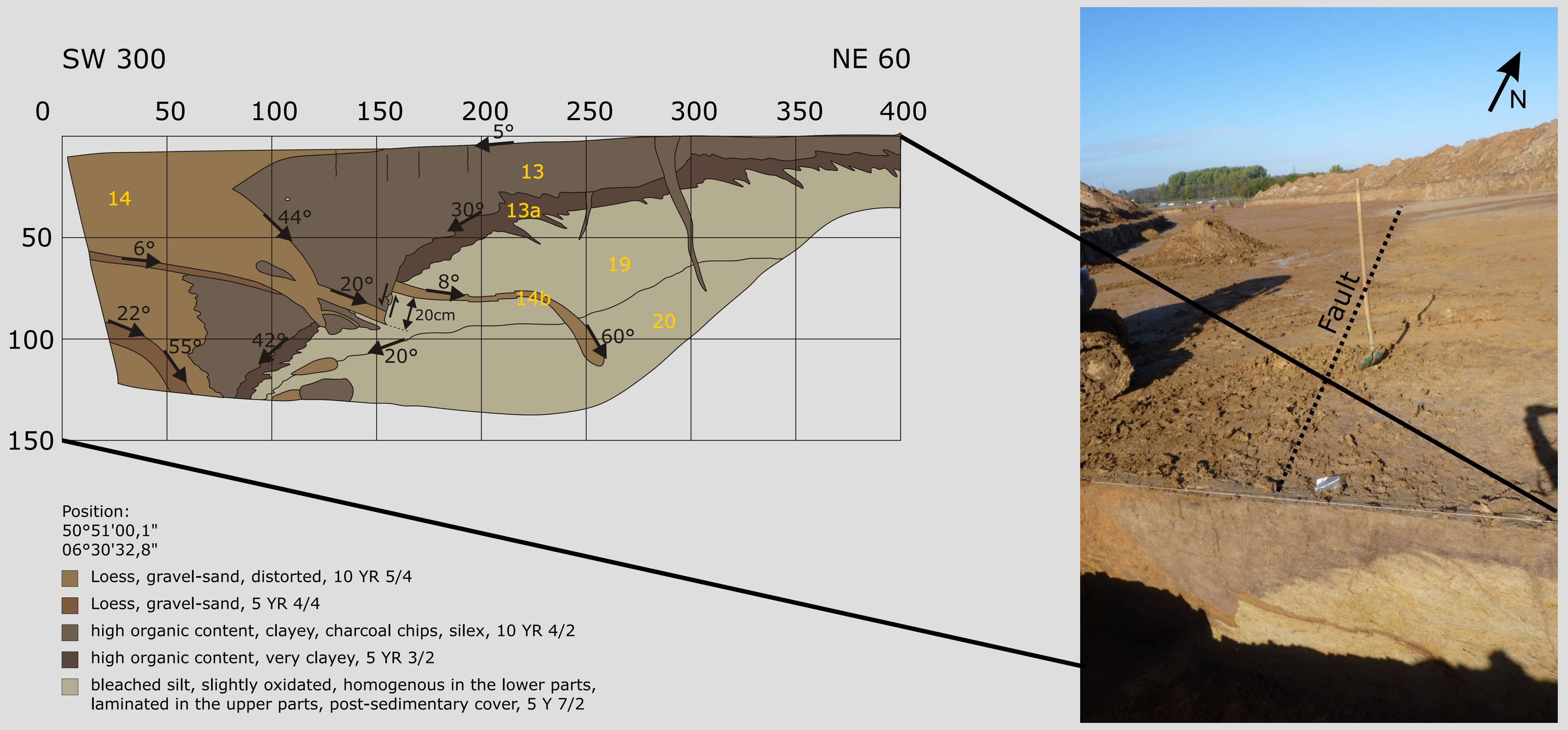

Figure 9: archeological sketch of the fault zone and image of the outcrop.

Figure 10: Offset surface-near layers have been found during the archeological excavations. Clayey sediments appear to be injected into upper layers. Fault offset is in the order of 20 cm in the youngest geological units.

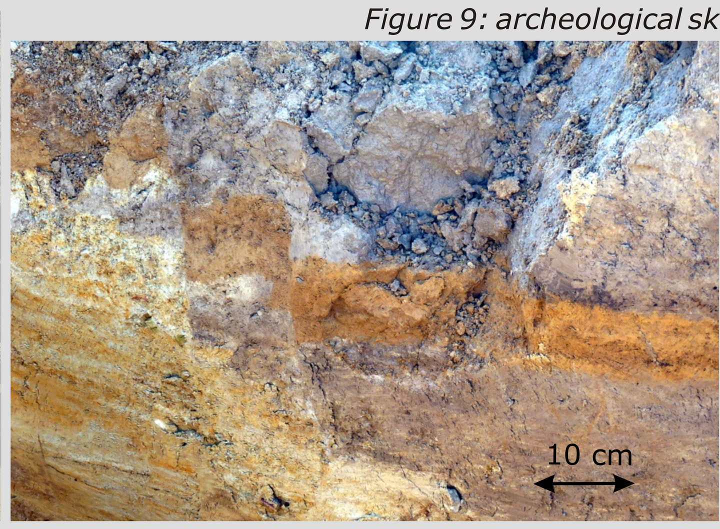

Figure 11: Step-like offset clearly points to seismic deformation instead of soil creep. Displacement is about 5 cm. The offset reddish layer is made up of clayey-silty, loess material, 50 cm below the surface.

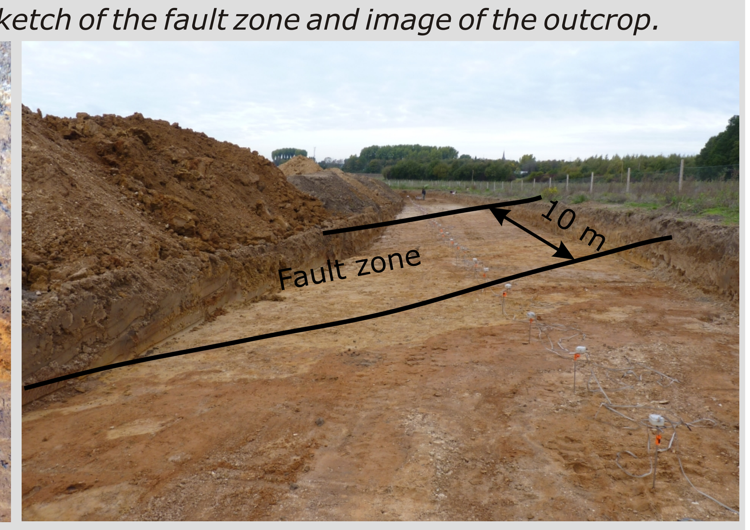

Figure 12: The fault zone is clearly visible in the trenches, not only at the walls, but also on the floor. This enabled a very good correlation with the geophysical data and a precise analysis of subsurface features.