Geophysical Research Abstracts
Vol. 19, EGU2017-15072, 2017
EGU General Assembly 2017

Late Quaternary activity of the Grote Brogel fault, NE Belgium

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The Grote Brogel fault (GBF) is a WNW-ESE striking normal fault that is part of the western border fault system of the Roer Valley Graben in NE Belgium. It is one of three faults branching NW-ward from the main border fault (Geleen fault) near Bree, but its orientation diverges ∼22° from the general NW-SE orientation of the graben, causing a wide left step. Unlike the Geleen fault, the surface expression of the GBF has not been investigated in detail so far. We studied the Quaternary activity of the GBF and its effects on the local hydrology based on a high-resolution LiDAR digital terrain model (DTM), and geophysical and geological surveying at two sites, combining Electrical Resistivity Tomography (ERT), Cone Penetration Tests (CPTs) and boreholes.

The GBF defines the northern edge of the Campine Plateau, an elevated area covered by the late Early to Middle Pleistocene Main Terrace of the Meuse River. Cumulative vertical offset since deposition of this terrace has resulted in a distinct ∼10-km-long fault scarp, the height of which decreases from ∼11 m near Bree in the east to less than 5 m near Grote Brogel in the west. The along-strike evolution of offset suggests that the GBF does not define an individual rupture segment, but is likely contiguous with the Geleen fault. DTM analysis indicates that scarps are only preserved in a few isolated places, and that the surface trace is rather complex, consisting of a series of short, relatively straight sections with strikes varying between ∼255° and ∼310°, arranged in a generally left-stepping pattern.

At both investigated sites, ERT profiles clearly demonstrate the presence of fault splays in the shallow subsurface (< 50 m) underneath the identified scarps evidenced by a sudden increase in depth and thickness of a high-resistivity unit on top of a lower-resistivity unit. Boreholes and CPTs allow correlating the high-resistivity unit with the medium to coarse gravel-bearing sands of the Meuse Group, and the lower-resistivity unit below with the finer sands of the Pliocene Mol Formation. From the ERT profiles, we estimate vertical offsets of the base of the Meuse deposits of ∼13 m at the eastern site, and ∼6 m in the west. These are only slightly larger than the topographic offsets, indicating that most of the offset post-dates deposition of the Meuse Group. Earlier fault activity is attested by a change in facies (and related resistivity values on the ERT-profiles) in the Mol Fm, but cannot be quantified.

Water level measurements in the boreholes and CPT holes indicate that the GBF acts as a hydrologic boundary that prevents groundwater flow from the elevated footwall towards the hanging wall, resulting in hydraulic heads of up to 12.7 m. At both investigated sites, the hydraulic head correlates with the topographic offset. At the eastern site, the shallow groundwater table in the footwall has given rise to a wet zone that is indicated on soil moisture maps and is also expressed by darker tones on aerial maps. The extent of this wet zone appears largely influenced by a local stepover that we could image in pseudo-3D using a series of closely spaced ERT profiles.