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Middle Pleistocene to present-day crustal motion at the western border of the Roer graben and in Ardenne-Eifel: a geomorphic and geodetic perspective

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Investigating the Quaternary uplift of ancient massifs in the foreland of the alpine arc requires combining data which cover a spatial range from local to subcontinental and a temporal range from at least ~1 Ma to the present.

In the long-term of the Rhenish shield and the neighbouring upper and lower Rhine segments of the European Cenozoic Rift System, mean values of regional uplift and individual fault displacement rates are now available. In NE Ardenne for instance, river incision suggests regional uplift rates of 0.25-0.5 mm/yr during the middle Pleistocene, decreasing to <0.05 mm/yr since 0.4 Ma. Likewise, paleoseismological and geological observations at the fault scale point to individual displacement rates ≤0.15 mm/yr for the border faults of the Roer graben. However, further studies are strongly needed to increase the time and space resolution of this rate information. We thus have started recently a geomorphological study of river incision in Ardenne and Eifel, which aims to date terrace deposits of three representative rivers by means of the cosmic ray exposure method, using in-situ produced ^{10}Be in the quartz component of the fluvial sediments. This should provide a refined spatial and temporal pattern of the incision, reflecting to some extent the underlying uplift pattern.

In the short-term, until recently, most geodetically inferred vertical motion rates were up to one order of magnitude higher than the corresponding geological rates. It is now clear from a wealth of data collected in the area since 1993 that this discrepancy was primarily due the interference in the geodetic measurements between true tectonic motion and ground displacements induced by groundwater variations. This means that most previously published geodetic estimates of “tectonic” uplift in intraplate areas are

highly questionable. To get rid of the groundwater effect and to reliably quantify the tectonic component of motion, one needs to design measurement procedures adapted to the detection of extremely small and slow vertical displacements, to perform continuous monitoring or high-frequency surveys and to couple the geodetic data with groundwater data or an appropriate proxy of the latter. Using such a sophisticated approach at the local (fault) scale, a 3.7-year-long time series (4/2001-12/2004) obtained from 28 levelling surveys across the Feldbiss fault at Sittard (NL) has yielded a reliable fault displacement rate of 0.60 ± 0.11 mm/yr, confirmed by our latest surveys. This result could suggest a third way, between fault creep and earthquake, for slow-moving intraplate normal faults to accommodate the deformation. Regionally, 10 levelling surveys repeated from 1993 to 2002 caught a few aseismic fault motion events in NE Ardenne. They also provided some hints of a present-day uplift of the area at the rate of $\sim$0.4 mm/yr. But, at this spatial scale, the levelling technique is highly time-consuming and will have to be replaced by less precise but continuous GPS measurements. Provided the latter are collocated with groundwater monitoring, one may expect that the error on the estimated vertical displacement rates will come below the level of the tectonic signal ($\sim$0.1 mm/yr) after 5-6 years of measurement. To monitor the ground motion in the Ardenne and its surroundings, we currently install a permanent GPS station on top of the uplifting NE Ardenne, which will be processed simultaneously with the GPS permanent stations of the Belgian WALCORS and FLEPOS networks, in operation since 2003.