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The seismotectonic significance of the 2008-2010 seismic swarm in the Brabant Massif (Belgium)

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Structural interpretations of the tectonic grain of orogenic mountain belts have often been based on the study of potential field data. The steep architecture of mountain belts can be highlighted by the inclination of the magnetic field and by the persistence of aeromagnetic lineaments with depth. With respect to seismology, matched filtering has proven to be very useful for linking seismicity with deep-seated tectonic structures by separating short-wavelength anomalies, that originate from shallow depths, from long-wavelength anomalies that generally originate at greater depths.

Between 2008 and 2010 more than 300 low-magnitude earthquakes occurred 20 km SE of Brussels (Belgium). Thanks to a locally deployed temporary seismic network covering the epicentral area, very small events could be detected (magnitude variation between M_L -0.7 and M_L 3.2). The spatial distribution of the hypocenter locations show a dense spatial cluster displaying a narrow, 1.5-km long, NW-SE oriented fault zone at a depth range between 5 and 7 km, located in the Cambrian basement rocks of the Lower Palaeozoic Anglo-Brabant Massif. Its NW-SE orientation is in agreement with the structural grain in this part of the Brabant Massif.

In order to find a relevant tectonic structure that could correspond to the 2008-2010 seismic swarm, we present a full seismotectonic analysis linking local geology to the seismic swarm. A systematic filtering approach was applied in which the magnetic field was carefully bandpass filtered to generate different aeromagnetic maps that highlight sources near the hypocenter depths. Filtering demonstrates that the structure responsible for the seismic swarm is limited in length as it is bordered at both ends by magnetic lineaments with different orientations than the seismic swarm. These observations explain the rather limited spatial distribution of the swarm, both in a vertical and horizontal direction.

Although few of the largest historical seismic events in Belgium occurred within the borders of the Brabant Massif, the limited fault length thus suggests that, given its favourable orientation to reactivation in the current stress configuration, it potentially could result in a reduced seismic hazard for this region.