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Major Historical Earthquakes of the Rhine Graben

Interplate - Intraplate Continental Deformation

From archives to comparative seismotectonics

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Faults and earthquake activity in northwestern Europe

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The relationship between geologic faults and seismic activity within stable continental regions is not as evident as at plate boundaries where the accumulated strain during the seismic cycle is mostly released along identified active faults. In the stable plate interior of Europe the Lower Rhine Embayment (LRE) is the only region where slow active faults have been unambiguously identified and related to earthquake activity. Geologically active faults have not yet been identified in the region around the LRE, despite the fact that the three strongest known earthquakes, with estimated magnitude around 6.0, occurred there.

To better characterize the relationship between earthquake activity and faults in this region, it is necessary to improve our identification and knowledge of both the geological structures and the seismic activity. In this presentation, we discuss: (1) the importance to evaluate the long-term persistence of the tectonic activity at the fault zones which are supposed to have generated large and moderate historical earthquakes, and (2) the mechanical conditions supporting the fact that old geological faults can be the source of large earthquakes.

By studying in the geomorphology and the geological records the recent tectonic activity of the Sangatte and Hockay fault zones which generated the large (M~6.0) 1580 - Strait of Dover and 1692 - northern Belgian Ardenne earthquakes, we evidenced that the Quaternary activity of these faults is very elusive if it exists and that such large earthquakes are very infrequent on these faults. These results support the episodic, clustered and migrating character of the seismicity in this stable continental region which is already suggested by the observation that during the last 700 years moderate and large earthquakes always occurred at different locations.

By investigating the relationship between the current seismicity and Caledonian and Variscan structures crossing the Belgian territory, we discuss the ability of these old fault zones to generate large earthquakes. In our conclusions, we emphasize the importance of considering the fundamental mechanical and structural homogeneity differences between active faults in a presently deformed crust, as in plate boundary or active intraplate regions, versus possibly reactivated parts of old structures that survived several tectonic and erosional cycles in a crust where the tectonic stress is mainly related to the differences in gravitational potential energy.