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Active tectonics in the Upper Rhine Graben Integration of paleoseismology, geomorphology and geomechanical modeling

Gwendolyn Peters

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This thesis focuses on the tectonic activity of the northern Upper Rhine Graben (URG), Germany, from Quaternary to Present. The URG is presently characterized by high human modifications and low intra-plate seismicity. During the Quaternary, surface processes have been high. Therefore, records of the slow deformation are less well preserved and difficult to detect. Given this setting, an integration of several techniques is required to study the active tectonics, which is demonstrated in this thesis by the use of paleoseismological trenching, fluvial terrace mapping, quantitative tectonic geomorphology and tectonic modeling. Chapter 1 presents a review of the geodynamic setting of the URG. The results of paleoseismological trenching and shallow geophysical measurements are presented in chapter 2. Trenching focused on the Western Border Fault (WBF) of the northern URG and revealed indications for Late Pleistocene activity of that fault. Backstripping of the sequence of events at the trench site demonstrated the interplay of activity on the WBF and fluvial and erosional processes during the Quaternary. At a regional scale, the effects of fault activity on the landscape evolution are investigated using geomorphological techniques. Chapter 3 includes a fluvial terrace study of the northern URG and adjacent areas. The work includes morphological terrace mapping along the WBF. Correlation of these newly mapped terraces with previous terrace mapping in the region enables construction of a longitudinal profile. Based on this profile the effects of fault movements on the terraces are determined and displacement rates and patterns are evaluated. Chapter 4 presents an analysis of the tectonic geomorphology of the northern URG. Quantitative measurements of the landscape shape are used for characterizing lithological or tectonic controls on the morphology and drainage. This study enables determination of the balance between erosion and tectonic activity and identification of active fault segments. The fourth component of this thesis addresses the reactivation potential of faults under the present-day stress field using the finite element method (chapter 5). Existing fault data and new data obtained from trenchingand geomorphology are incorporated in a 3D slip tendency analysis. The analysisreveals a high reactivation potential for faults with documented faulting history. It is proposed that these faults are characterized by aseismic creep, whereas faults with a low reactivation potential are seismic faults since they are capable of loading sufficient stress. Integration of all new data results in an updated active fault map of the URG presented in the last chapter of the thesis.

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