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# Tectonic geomorphology of the northern Upper Rhine Graben, Germany

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**Abstract**

This paper focuses on the northern Upper Rhine Graben (URG), which experienced low tectonic deformation and multiple climate changes during Quaternary times. Recently, human modifications have been high. The paper presents the results of a study into the effects of fault activity on the landscape evolution of the area. The study aims to detect active faults and to determine the last phase of tectonic activity. Information on the long-term tectonic activity is gained from the geological record (drainage system, sediment distributions, fluvial terraces, fault mapping). Previous studies are reviewed and supplemented with new data on tectonic activity. The compilation of all data is presented as a series of paleogeographic maps from Late Miocene to present. It is demonstrated that differential uplift of the western margin of the northern URG had significant impact on the drainage system, the formation of fluvial terraces and the landscape of the western graben shoulder. In a second part of the paper, the imprint of tectonics on the present-day landscape is investigated at the regional scale in order to determine the location of fault scarps and tectonically influenced parts of the drainage system. This study uses an integrated analysis of topography, drainage patterns and fault network. The comparison of features suggests a structural control by numerous NNE- and NNW-oriented intra-graben faults on the flow directions of streams in the Rhine Valley. Several scarps in the Rhine Valley are identified and interpreted to result from intra-graben faulting activity, which in turn controlled fluvial dissection. The third part of the paper presents quantitative measurements of the present-day landscape shape. Calculations of geomorphic indices are used to determine the balance between erosional and tectonic processes and to identify active fault segments. The mountain-front sinuosity and valley shape indices measured along the border faults and in the footwall area are used to determine the level of activity of the faults. Stream profiles of the western and eastern catchments of the River Rhine are investigated for gradient changes at the crossing of the border faults. The combined interpretation of geomorphic indices points to active border fault segments on both sides of the graben. Based on the integration of all results it is concluded that the tectonic morphology identified for the northern URG formed in response to long-term, low level tectonic processes. Due to a significant decrease in erosional and depositional activity during the last 15,000 years, the tectonic morphology has probably been preserved until present.


*Keywords:* geomorphic indices; paleogeographic maps; active tectonics; Quaternary; Upper Rhine Graben

## 1. Introduction

This paper investigates the effects of faulting activity on the landscape evolution of the northern Upper Rhine Graben (URG). The URG is a Tertiary graben and represents the central part of the European Cenozoic Rift

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System (ECRIS, Fig. 1). The main phase of rifting occurred during Oligocene and Miocene with subsidence in the individual graben structures continuing, at a reduced rate, until Quaternary. Currently, the URG and the Lower Rhine Graben are the most active graben segments of the ECRIS. In the URG, Quaternary deposits reach thicknesses from a few tens of meters to over 380 m (Bartz, 1974). The main Quaternary depocenter is the so-called Heidelberger Loch situated in the northern URG. In this part of the graben,

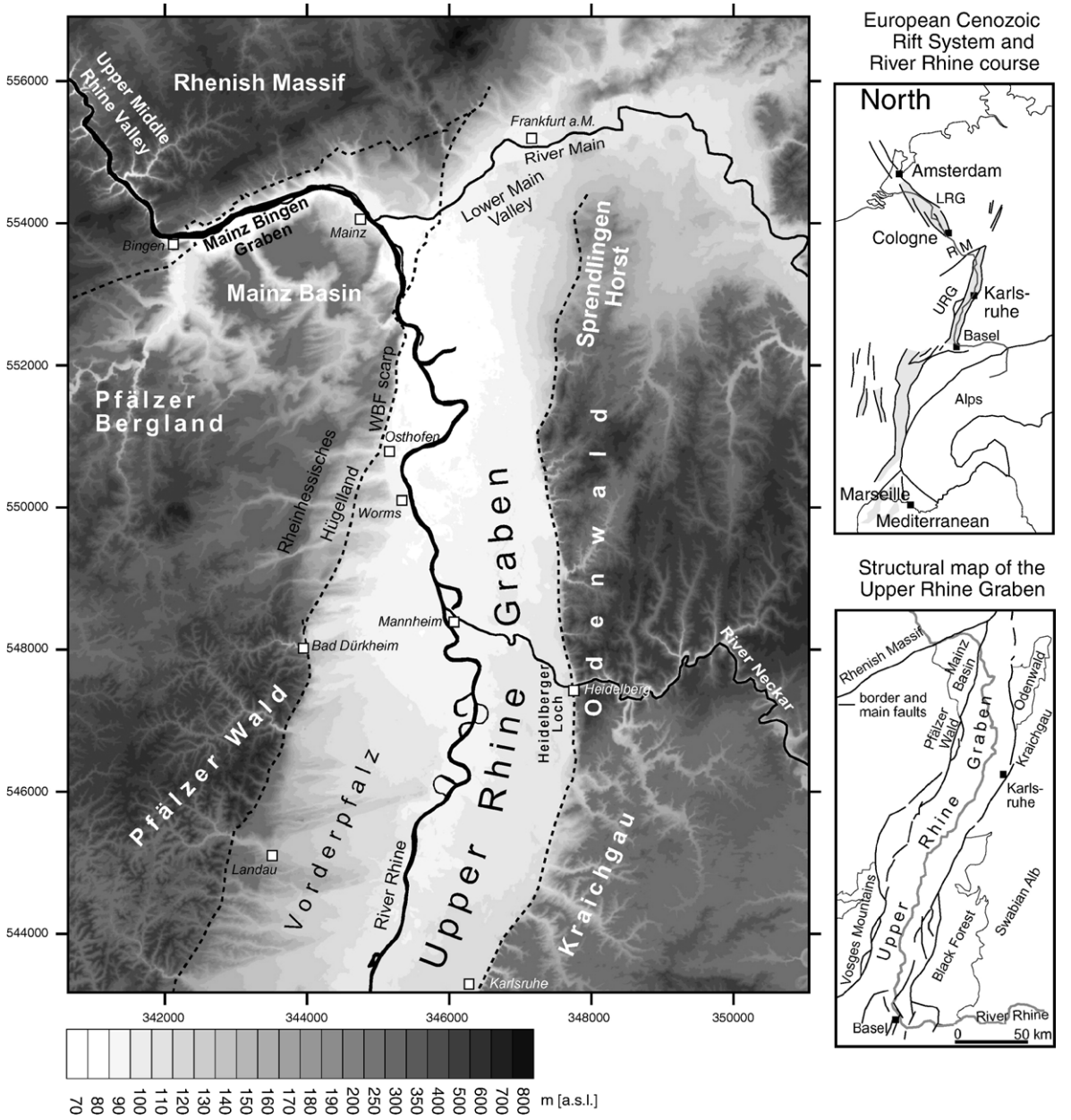


Fig. 1. Morphology of the study area. The eastern side of the graben in the northern URG is characterized by a low relief with elevations of 85–110 m a.s.l. whilst the western side has a landscape of valleys and ridges with elevations of 110–250 m a.s.l. The shoulder areas reach peak elevations of greater than 600 m a.s.l. in the Pfälzer Wald, the Odenwald and the Rhenish Massif. The Kraichgau, Sprendlingen Horst and the Mainz Basin are lower shoulder areas with elevations generally between 200–300 m high. The small maps show the European Cenozoic Rift System and the location of the URG. The structural map displays the border faults of the URG and the main structural units in the shoulder areas of the graben. The course of the River Rhine across the URG is indicated with the grey line. Digital data for the contour map and shaded relief maps in Figs. 1, 2, 6 and 11 from DGM50 M745 (2001). All maps are in German Gauss-Krüger coordinate system.