Clustered activity of Intraplate Faults: The silent and slow active faults of southern Germany

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Silent and slow faults pose a particularly fascinating challenge in the field of active tectonic studies, especially in regions characterized as Stable Continental Regions (SCR) or Active Intraplate Regions (AIR), such as Central Europe. The term "silent faults" encompasses a broad spectrum of meanings, with "silent" denoting either the absence of seismic activity, the lack of faulting that generates earthquakes (though possibly involving creep), or the limited visibility of these faults in terms of their geomorphological and geological features.

Slow active faults, generally defined by slip rates of ≤ 0.1 mm per year, typically do not produce noticeable topographic features in regions with a humid or moderate climate. The slip rate of a fault is a critical parameter governing the occurrence of earthquakes and seismic hazard in a given area. Lower slip rates result in longer intervals between earthquakes of a specific magnitude. Owing to these prolonged recurrence intervals, earthquakes occurring on low slip-rate faults are often absent from historical records and standard processes for assessing seismic hazard.

In our study, we present new fault data obtained from the AIR region of the Rhine Graben rift within the German SCR region. Generally, Holocene surface rupturing events are exceedingly rare in these areas, with recurrence intervals spanning approximately 1,000-10,000 years. The associated slip rates are notably low, often below 0.5 mm per year, or even ≤ 0.1 mm per year. We also observe secondary earthquake effects in a broader context, extending beyond our study regions.

However, some faults exhibit distinct linear scarps and topographic variations, as revealed through high-resolution Digital Elevation Models (DEMs) and geophysical field surveys. It is indeed puzzling how these small-scale scarps, with heights of around 50 cm and formed during single events, have managed to persist for 1,000-10,000 years, particularly in agricultural areas. Nevertheless, recurring paleo-earthquakes are recorded in surface deposits, as demonstrated by our trench excavations in the Upper Rhine Graben.

Geodetic techniques, such as GPS and Differential Interferometric Synthetic Aperture Radar (DInSAR), offer valuable tools for detecting silent faults. However, their signals can be influenced by factors like groundwater extraction, seasonality, vegetation, and other obstacles. Additionally, in the Upper Rhine Graben, some normal faults display evidence of "Clustering and Quiescence" in terms of earthquake occurrences, potentially explaining the persistence of these scarps over time. This contrasts with the "One Shot" hypothesis sometimes applied to SCR faults.

To further our understanding of the history of silent and slow faults, we propose the integration of high-resolution geodetic techniques, like GPS and DInSAR, with traditional paleoseismological investigations. Despite potential signal distortions caused by groundwater and vegetation, this combined approach holds promise in unveiling the hidden history of these slow and silent faults.