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New evidence for large earthquakes in mainland Portugal: paleoseismology of the Lower Tagus Valley fault

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Understanding the seismic behavior of major active intracontinental faults that remained quiescent over the time frame of the instrumental and historical seismic records is a fundamental goal for assessing the earthquake hazard of mainland Portugal. This work aims to provide the critical data required to quantify the seismic behavior of one of the major active faults in central Portugal, the Lower Tagus Valley Fault (LTVF), beyond the available seismic catalogs. The LTVF is mainly characterized by low rate of deformation and runs along a valley whose ground surface is partly obscured by vegetation cover and extensive agricultural activities. To overcome these limitations, the recently acquired airborne Light Detection and Ranging (LiDAR) data sets were processed and used to detect seismic fault traces and recent offset features. Using digital terrain models (DTMs) generated from the LiDAR "point cloud" data (grid resolution of 0.5 m) and high-resolution digital aerial orthophotos (pixel size of 10 cm), several well-preserved offset geomorphic features mostly ranging from several meters to several tens of meters have been recognized along the LTVF, confirming the occurrence of left-lateral strike-slip movements along the fault over late Quaternary timescales. The smallest preserved offsets along the East-LTVF (ELTVF) have been accurately measured both in the field and using LiDAR, drone-derived high-resolution topographic data, and photogrammetrically-derived digital surface model (DSM) that were acquired following a new aerial survey by a small unmanned aircraft system (sUAS). These small offsets are located along a single straight fault strand and their horizontal displacements are of the same order of magnitude (2–3 m) and can be associated with the most recent earthquake(s). Combining all the remotely sensed data and field observations leads to select a paleoseismic site (Santa Maria Creek site, south of Almeirim) along the ELTVF to uncover the record of past earthquakes over its late Pleistocene and Holocene history. At this site, a recently excavated paleoseismic trench in double-benched style across the fault records the evidence of at least four large earthquakes in the exposed stratigraphic sequence down to a depth of $\sim$6 m. Geochronological analyses, mainly using optically stimulated luminescence technique, are underway to bracket the ages of the identified earthquakes. Considering the smallest left-lateral displacements of 2–3 m preserved close to the trench site occurred during the most recent earthquake, the magnitude of this event should be on the order of Mw $\sim$7. The paleoseismic records may suggest a non-periodic seismic activity for strong earthquakes along the ELTVF. These findings highlight that high-resolution LiDAR data are essential for retrieving the cumulative component of the recent seismic deformations in regions whose landscapes are obscured by vegetation like the Lower Tagus Valley. Further, these results add to previous works performed in intracontinental areas that are characterized by low to moderate rates of deformation and indicate that paleoseismology is a robust tool to improve the seismic history in such seismotectonic settings. This is a crucial step towards a better assessment of seismic hazard within a region of low to moderate seismicity.