Quaternary Seismic Slip in the Eastern Alps: Dating Fault Gouges from the Periadriatic Fault System Using Trapped Charge Dating Methods

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The Periadriatic Fault System (PAF) is among the largest post-collisional structures of the Alps. Recent studies using GPS velocities suggest that Adria-Europe convergence is still being accommodated in the Eastern Alps. However, according to instrumental and historical seismicity records, earthquake activity is mostly concentrated along structures in the adjacent Southern Alps and adjacent Dinarides. Apart from ambiguous historical events, the PAF has little to no earthquake record. Electron spin resonance (ESR) and Optically Stimulated Luminescence (OSL) are dating methods that can be applied as ultra-low temperature thermochronometers (closing temperature below 100 °C), with a Quaternary dating range of a few decades up to ~2 Ma. Both are potentially applicable to date shear heating during earthquakes in slowly deforming fault zones. Since the saturation dose of the quartz ESR signals is larger than that of quartz and feldspar OSL, ESR enables establishing a maximum age of the events (assuming the resetting during seismic events was at least partial), while OSL allows finding their minimum age when the signal is in saturation. We analyzed fault gouge samples from 4 localities along the easternmost segment of the PAF (east of the Giudicarie Fault), and 5 localities along the southernmost segment of the Lavanttal Fault.

For ESR, we measured the signals from the Al center in quartz, comparing the results from the single aliquot additive dose (SAAD) and single aliquot regenerative dose (SAR) protocols. Different grain size fractions were measured (SAR protocol) to establish a grain-size age plateau. For OSL, we measured the Infrared Stimulated Luminescence (IRSL) signal at 50 °C (IR50) and the post-IR IRSL signal at 225 °C (pIRIR225) on potassium feldspar. Additionally, experiments of thermal activation of the OSL signal in quartz were performed to observe the shear heating effect in different grain size fractions.

For the PAF, the OSL shear heating sensitivity experiments show that quartz has been thermally activated to temperatures below 300 °C, corroborating that shear heating was sufficient for at least a partial system reset. The ESR grain size plateaus suggest that the most effectively reset fraction is 100-150 µm. In general, our dating results indicate that the studied segment of the PAF system accommodated seismotectonic deformation within a maximum age ranging from 1075 ± 48 to 349 ± 17 ka (ESR SAR) and a minimum age in the range of 196 ± 12 to 281 ± 16 ka (pIRIR225). The obtained ages and the current configuration of the structure suggest that the studied segment of the PAF could be considered a potentially active fault at least. In the case of the Lavanttal fault, the ESR dose-response curves were either close to or in saturation, allowing to obtain only minimum ages of ca. 4 Ma for the last total reset of the system. This could be the result of insufficient shear heating by low magnitude earthquakes, or the fault has not seen significant activity since then. Altogether, our results show that large structures in the Eastern Alps such as the PAF have accommodated part of the Adria-Europe convergence during the Quaternary and can potentially host earthquakes in the future.