Cumulative and coseismic displacements derived from tectonic geomorphology and geodesy on the ruptured Petrinja Fault (Mw 6.4, 2020, Croatia)

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Résumé

The Mw 6.4 Petrinja earthquake that hit Croatia in 2020 is one of the largest magnitude intracontinental earthquakes that occurred in Europe in recent decades. To better constrain the seismic cycle of intraplate fault systems we then use the Petrinja case by comparing the long-term along-strike offsets accumulated on the Petrinja-Pokupsko fault with the coseismic slip distribution from the 2020 rupture.

We analyze the fault zone geomorphology from field observations and high-resolution topographic data to provide constraints on the surface fault geometry and associated long-term cumulative along-strike offsets. Our mapping shows a clear NW-SE-trending 10-km-long strand between Cepeliš and Donja Budičina, and a 1-4-km-long right-stepping segment to the north which shows evidence of significant uplift. The fault appears highly discontinuous with the deformation accommodated by a series of small fault sections, rather than by a

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single simple fault strand. Offset geomorphic markers (incised streams and terrace risers) record along-strike cumulative displacements ranging from 5 to ~20 m, and potentially up to 200 m. Several sites on the southern strand are used to estimate fault slip-rates from precise quantification of cumulative displacements combined with cosmogenic nuclide exposure and radiocarbon dating of the corresponding displaced markers.

Based on fast-static geodetic measurements, continuous GNSS time-series, optical image correlation, and coseismic interferograms, we also refine the 2020 ruptured fault trace and evaluate the static slip distribution for the earthquake at depth. The elastic inversion of the coseismic slip indicates a shallow seismic source (< 7 km) with dextral surface ruptures (reaching > 1.2 m) along the northern portion of the fault, as well as a potential sub-parallel secondary fault along the foothill SW of Petrinja. Nevertheless, comparing the geodetic displacements with the coseismic offsets measured in the field indicates indicates that $> 70\%$ of the slip is likely distributed at the surface.

The comparisons of the long-term and coseismic strain localization also suggests a transpressive setting in which the deformation is not absorbed by a single fault strand. The segmented long-term fault trace and the discontinuous 2020 rupture are consistent with an immature fault system.

Mots-Clés: Active faults, Petrinja earthquake, surface rupture, geodesy, slip inversion, fault slip, rate