Surface faulting during the 29 December 2020 Mw 6.4 Petrinja earthquake (Croatia)

Paolo Boncio¹, Sara Amoroso¹², Jure Atanackov³, Stéphane Baize⁴, Josip Barbača⁵, Miloš Bavec³, Nikola Belić⁵, Lucilla Benedetti⁶, Rok Brajković⁵, Vlatko Brčić⁶, Marko Budić⁵, Marco Caciagli², Bogomor Celarc³, Riccardo Civico², Francesca R. Cinti², Paolo Marco De Martini², Radovan Filjak⁵, Maxime Henriquet⁶, Branko Kordić⁵, Francesco Iezzi¹, Luca Minarelli², Adrien Moulin⁶, Rosa Nappi², Ana Novak⁵⁷, Matevž Novak³, Bruno Pace¹, Damir Palenik³, Daniela Pantosti², Stefano Pucci², Petra Jamšek Rupnik¹, Marko Špelić¹, Alessio Testa¹, Sotiris Valkaniotis⁸, and Martija Vukovski⁵

¹University of Chieti – Pescara, Italy
²Istituto Nazionale di Geofisica e Vulcanologia, Italy
³Geological Survey of Slovenia, Dimičeva 14, 1000 Ljubljana, Slovenia
⁴Institut de Radioprotection et Sûreté Nucléaire, Bureau des risques sismiques pour le Sûreté des Installations, 92260 Fontenay-aux-Roses, France
⁵Croatian Geological Survey (HGI-CGS), Zagreb, Croatia
⁶Aix Marseille Université, CNRS, IRO, Collège de France, CEREGE, Aix-en-Provence, France
⁷University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Geology, Aškerčeva 12, 1000 Ljubljana, Slovenia
⁸Consultant geologist, 42131 Trikala, Greece

The 29 December 2020, Mw 6.4 Petrinja earthquake nucleated at a depth of ~10 km in the Sisak-Moslavina County in northern Croatia, ~6 km WSW of the Petrinja town. Focal mechanisms, aftershocks distribution, and preliminary Sentinel-1 InSAR interferogram suggest that the NW-SE right-lateral strike-slip Pokupsko-Petrinja fault was the source of this event. The Croatian Geological Survey, joined by a European team of earthquake geologists from France, Slovenia and Italy, performed a prompt systematic survey of the area to map the surface effects of the earthquake. The field survey was guided by geological maps, preliminary morphotectonic mapping based on 1:5,000 topographical maps and InSAR interferogram. Locally, field mapping was aided by drone survey.

We mapped unambiguous evidence of surface faulting at several sites between Župić to the NW and Hrastovica to the SE, in the central part of the Pokupsko-Petrinja fault, for a total length of ~6.5 km. This is probably a minimum length since several portions of the fault have not been explored yet, and in part crossing forbidden uncleared minefields. Surface faulting was observed on anthropic features (roads, walls) and on Quaternary sediments (soft colluvium and alluvium) and Miocene bedrock (calcarenites). The observed ruptures strike mostly NW-SE, with evidences of strike-slip right-lateral displacement and zones of extension (opening) or contraction (small pressure ridges, moletracks) at local bends of the rupture trace. Those ruptures are interpreted as evidences of coseismic surface
faulting (primary effects) as they affect the morphology independently from the slope direction. Ground failures due to gravitational sliding and liquefaction occurrences were also observed, mapped and interpreted as secondary effects (see Amoroso et al., and Vukovski et al., this session). SE of Križ, the rupture broke a water pipeline with a right-lateral offset of several centimetres. Measured right-lateral net displacement varies from a few centimetres up to ~35 cm. A portion of the maximum measured displacement could be due to afterlisp, as it was mapped several days after the main shock. Hybrid surface ruptures (shear plus opening and liquefaction), striking SW-NE, with cm-size left-lateral strike-slip offsets were mapped on the northern side of the Petrinja town, ~3 km NE of the main fault.

Overall, the rupture zone appears discontinuous. Several factors might be inferred to explain this pattern such as incomplete mapping of the rupture, inherited structural discontinuities within the Pokupsko-Petrinja fault system, or specific mechanical properties of the Neogene-Quaternary strata.