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

Paolo Boncio1, Sara Amoroso1,2, Jure Atanackov3, Stéphane Baize4, Josip Barbača5, Miloš Bavec3, Nikola Belić5, Lucilla Benedetti6, Rok Brajkovič3, Vlatko Brčić5, Marko Budić5, Marco Caciagli2, Bogomor Celarc3, Riccardo Civico2, Francesca R. Cinti2, Paolo Marco De Martini2, Radovan Filjak5, Maxime Henriquet6, Branko Kordić5, Francesco Iezzi1, Luca Minarelli6, Adrien Moulin6, Rosa Nappi2, Ana Novak5,2, Matevž Novak3, Bruno Pace1, Damir Palenik3, Daniela Pantosti2, Stefano Pucci2, Petra Jamšek Rupnik1, Marko Špelić5, 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.