



Paleoseismological evidence for large past earthquakes on reverse and strike-slip faults in Slovenia: Examples from the Idrija and Vodice faults

Petra Jamšek Rupnik¹, Jure Atanackov², Miloš Bavec³

¹ Geological Survey of Slovenia, Ljubljana, Slovenia, petra.jamsek@geo-zs.si

² Geological Survey of Slovenia, Ljubljana, Slovenia, jure.atanackov@geo-zs.si

³ Geological Survey of Slovenia, Ljubljana, Slovenia, milos.bavec@geo-zs.si

Abstract

Paleoseismological techniques have been developed to investigate past seismic activity on faults and provide valuable data for estimating the seismic hazard of an area, especially when the historical earthquake record is much shorter than the average earthquake cycle. Paleoseismic evidence can include joints, discrete faults, folds, soft-sediment deformation and liquefaction, depending on the magnitude of the paleoseismic event, the type of causative fault, and the material disturbed.

Key words: paleoseismology, reverse fault, strike-slip fault, Vodice fault, Idrija fault

Paleoseismological techniques have been developed to investigate past seismic activity on faults and provide valuable data for estimating the seismic hazard of an area, especially when the historical earthquake record is much shorter than the average earthquake cycle. Paleoseismic evidence can include joints, discrete faults, folds, soft-sediment deformation and liquefaction, depending on the magnitude of the paleoseismic event, the type of causative fault, and the material disturbed [1]. In Slovenia, the first attempts of modern paleoseismological studies were made in the Krško Basin in the early 2000s and later successfully carried out to study the reverse Vodice fault in Ljubljana Basin and the major regional strike-slip Idrija fault in western Slovenia (Figure . 1).

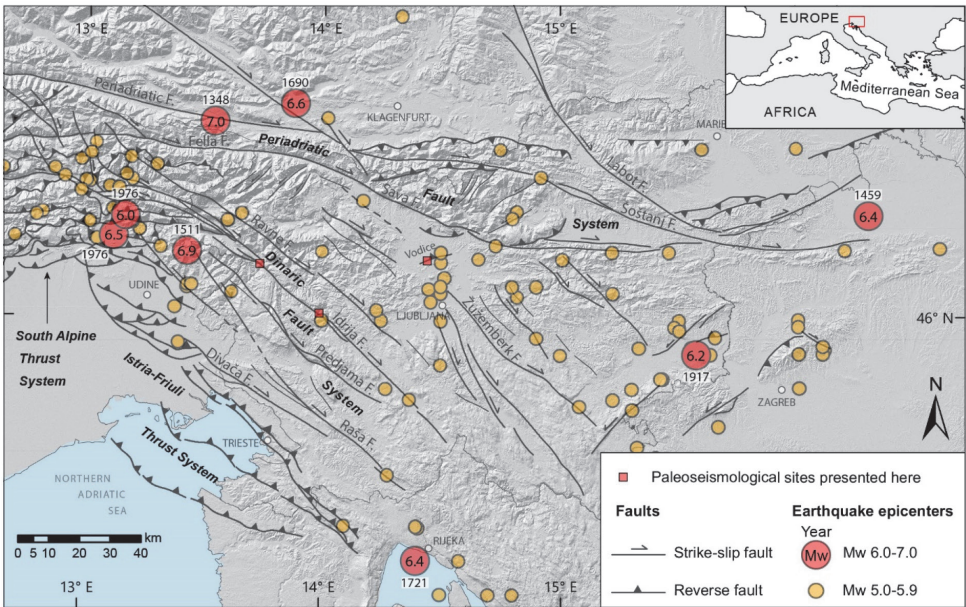


Figure 1. Seismotectonic map of Slovenia and its vicinity with locations of paleoseismological sites presented in this contribution. The faults are summarized from Poli and Zanferrari [2] and Atanackov et al. [3], the earthquakes are taken from the SHEEC catalogues 1000-1899 [4] and 1900-2006 [5]

This contribution presents the paleoseismological evidence for large past earthquakes on the Vodice and Idrija faults, obtained during several exploratory trenching campaigns in the last decade. Two exploratory trenches were made on the Vodice fault, which additionally confirmed the tectonic origin of the 10 km long fault scarp and provided evidence of the last major earthquake that disrupted the sediments within the trench about 9 thousand years ago [6]. The first paleoseismological trench on the Idrija fault was conducted at the Kanomlja site, which showed that the last major earthquake on this fault corresponds to the historical Idrija earthquake of 1511 Mw6.8 [7]. A recent study of the paleoseismic history of the Idrija fault near Most na Soči suggests that frequent large earthquakes occurred during the penultimate glaciation and revealed local

fault complexities due to geometric and kinematic changes of the fault at this location [8].

In addition to the scientific results, this contribution highlights the practical lessons and pitfalls to be considered in paleoseismic trenching we have encountered in the specific environmental conditions in the transition zone between the Alps, the Dinarides and the Pannonian Basin tectonic domains.

Acknowledgements

The findings summarized in this contribution are part of three individual paleoseismological studies that were carried out in past decade by many co-workers that are acknowledged here and in the references: B. Celarc, I. Hajdas, J. Jež, V. Kastelic, S. Lowick, B. Milanič, G. Monegato, M. Novak, F. Preusser, D. Skaberne, M. Zajc, M. Žebre, G. Žibret. These studies were financially supported by Slovenian Research Agency (Program P1-0011, Projects L1-2383 and J1-2479, Young Researcher Grants) and by the Slovenian Environment Agency (project Elaboration of Map of Active Faults).

References

- [1] McCalpin, J.P. ed. (2009): *Paleoseismology*. (Vol. 95). Academic press.
- [2] Poli, M.E., Zanferrari, A. (2018): The seismogenic sources of the 1976 Friuli earthquakes: a new seismotectonic model for the Friuli area. *Bollettino di Geofisica Teorica ed Applicata*, 59 (4), 463-480.
- [3] Atanackov, J., Jamšek Rupnik, P., Jež, J., Celarc, B., Novak, M., Milanič, B., Markelj, A., Bavec, M., Kastelic, V. (in revision): Database of active faults in Slovenia: compiling a new active fault database at the junction between the Alps, the Dinarides and the Pannonian Basin tectonic domains.
- [4] Stucchi, M., Rovida, A., Capera, A. A. G., Alexandre, P., Camelbeeck, T., Demircioglu, M. B., Gasperini, P., Kouskouna, V., Musson, R. M. W., Radulian, M., Sesetyan, K., Vilanova, S., Baumont, D., Bungum, H., Fah, D., Lenhardt, W., Makropoulos, K., Solares, J. M. M., Scotti, O., Živčić, M., Albini, P., Batllo, J., Papaioannou, C., Tatevossian, R., Locati, M., Meletti, C., Viganò, D., Giardini, D. (2013): The SHARE European Earthquake Catalogue (SHEEC) 1000-1899. *Journal of Seismology*, 17 (2), 523-544.
- [5] Grünthal, G., Wahlström, R. (2012): The European-Mediterranean Earthquake Catalogue (EMEC) for the last millennium. *Journal of Seismology*, 16 (3), 535-570.
- [6] Jamšek Rupnik, P., Atanackov, J., Skaberne, D., Jež, J., Milanič, B., Novak, M., Lowick, S., Bavec, M. (2015): Paleoseismic evidence of the Vodice fault capability (Ljubljana Basin, Slovenia), *6th International INQUA Meeting on Paleoseismology, Active Tectonics and Archaeoseismology*, Pescina, Italy (Miscellanea INGV, 27), 4 pages.
- [7] Bavec, M., Atanackov, J., Celarc, B., Hajdas, I., Jamšek Rupnik, P., Jež, J., Kastelic, V., Milanič, B., Novak, M., Skaberne, D., Žibret, G. (2013): Evidence of Idrija fault seismogenic activity during the Late Holocene including the 1511 Mm 6.8 earthquake, *4th International INQUA Meeting on Paleoseismology, Active Tectonics and Archeoseismology*, Aachen, Germany, 4 pages.
- [8] Jamšek Rupnik, P., Žebre, M., Jež, J., Preusser, F., Zajc, M., Monegato, G. (2019): Deformed Pleistocene deposits in Most na Soči, W Slovenia, *24th Meeting of Slovenian Geologists*, Ljubljana, Slovenia (Geološki zbornik, 25), 4 pages.