Earth surface response to Quaternary faulting and shallow crustal structure in the eastern Adria-Alpine collision zone and the Friulian plain

PIs: Christoph Grützner (Friedrich-Schiller-Universität Jena), Klaus Reicherter (RWTH Aachen University), Friedhelm von Blanckenburg (GFZ Helmholtz-Zentrum Potsdam)

Research questions

- Which faults in Friuli and W Slovenia area actively accommodate the present-day convergence of Adria and Eurasia and is active tectonic deformation confined to a few major structures or is it widely distributed?
- How much does catchment-averaged erosion change in vicinity to seismically active faults (relative to an endmember scenario not affected by faulting) and what are the differences in erosion rates, for a given rock erodibility, for different fault types?

In addition to remote sensing analyses of surface deformation structures, we visited more than one hundred sites in several field campaigns to W Slovenia and NE Italy. We mapped active faults, took structural measurements, and collected aerial imagery with drones to produce high-resolution digital elevation models of faults. Near-surface geophysics were applied to more than 20 sites and several kilometres of geophysical profiles were collected in total. In late 2018, we excavated one paleoseismological trench across the Idrija Fault and two across the Predjama Fault. Radiocarbon dating of deformed sediment layers found in the trenches revealed that both faults had at least one surface-rupturing earthquake in the Holocene, although no strong earthquakes were known from the instrumental and historical records (Figure 1).
We found that all Dinaric faults (NW-SE striking, right-lateral strike-slip faults) that we visited show geomorphological evidence for Late Quaternary deformation. Several sites have experienced surface-rupturing earthquakes in the Holocene.
Catchment-averaged erosion rates calculated based on cosmogenic ^{10}Be have been obtained from 14 samples during the 1st half of the one year funding period of the project. The obtained rates range between 60 and 430 m/Ma and are thus as high as rates from glaciated regions of the Alps and higher than the rates obtained from the tectonic inactive area of the Koralpe region NE of the study area (Figure 2). The erosion rates obtained during this study are derived from catchments not being affected by glaciation indicating that tectonic activity along the different strike-slip faults characterizing the study area must be responsible for these high rates.
Taking all our observations together, we conclude that in the Dinarides-Alps transition zone crustal deformation due to the northward motion of Adria is accommodated in a wide right-lateral shear zone that encompasses numerous active faults. These faults are distributed between the Adriatic coast and the Periadriatic Line. Although the Idrija and Sava Faults have taken up more total displacement than the other faults, all of them must be considered active and capable of producing surface-rupturing earthquakes. In turn this means that all of the faults in the study area must have rather low slip-rates and long earthquake recurrence intervals. The latter constitutes an immense problem because usually seismic hazard assessments and also studies of regional tectonics rely on instrumental and historical earthquake data as input values.
Our results are relevant for Theme 2 of the SPP2017: “Surface response to changes in mountain structure on different time scales”. We can show that erosion rates are directly linked to fault activity. Post-glacial erosion is nowadays largely controlled by the active tectonics, even in the case of faults with predominant strike-slip motion that do not cause much surface uplift. With respect to Theme 4 of the SPP2017: “Motion patterns & seismicity” we can show that the observation time span of instrumental and historical seismicity is too short to capture the strongest earthquakes that the faults are capable of. Even worse, faults may be characterized as inactive due to their lack of recent earthquake activity, although they hosted morphogenic events in the past. Our study thus fills an important gap in the seismicity data set and helps to better understand the overall picture of crustal deformation.

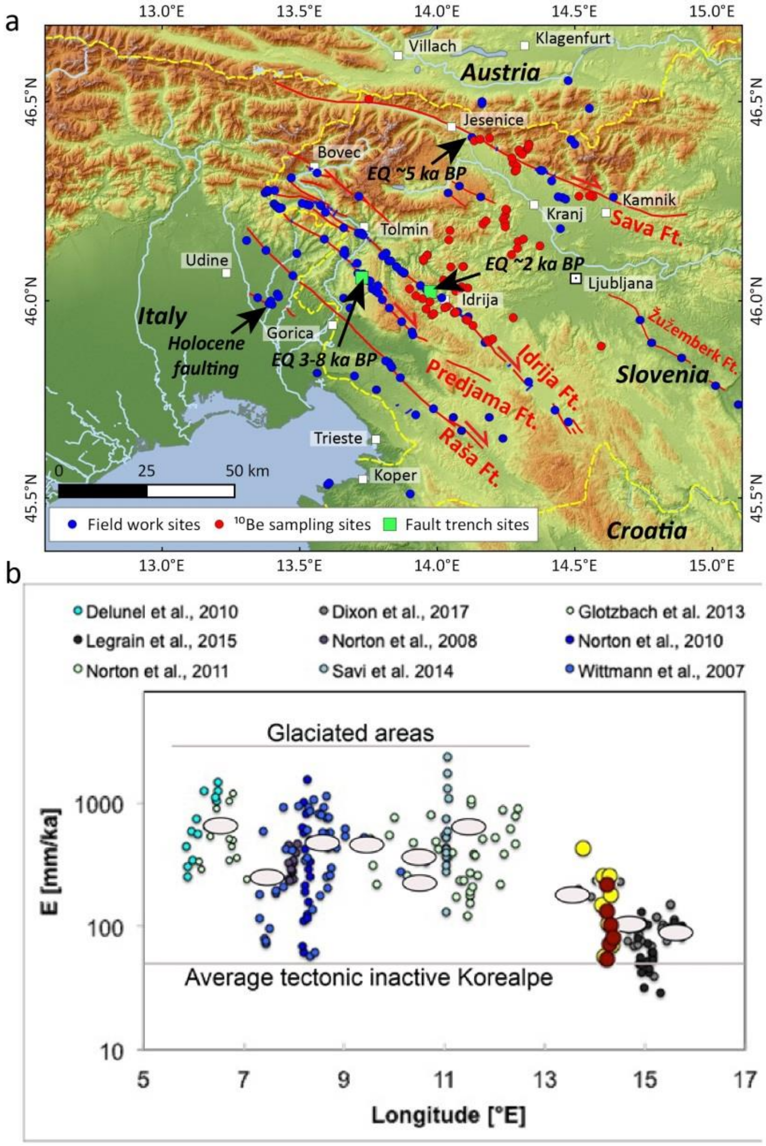

Figure 1: (a) Overview of the field work conducted in the first two years of the project. Black arrows point to sites at which Holocene surface ruptures have been documented. The relative motion between Adria and Europe is taken up by a large number of right-lateral active strike-slip faults. (b) Erosion rates in Slovenia (red and yellow) compared to rates from other parts of the Alps.

Publications

- Grützner, 2018. Active faulting in NW Slovenia and NE Italy – first results from field studies and tectonic geomorphology. In: Koukousioura, O., & Chatzipetros, A. (Eds.) PATA Days Thessaloniki, 25-27 June, 2018, 91-94.
- Grützner, 2018. Active faulting in the eastern Southern Alps-Dinarides – insights from field studies, geophysics, and high-resolution topography data. GeoBonn, 2-6 September, 2018, Bonn Germany.
- Grützner et al., 2019. Active tectonics of the Dinarides in Slovenia - new data from remote sensing, field studies, geophysics, and palaeoseismology. Geophysical Research Abstracts Vol. 21, EGU2019-11300, 2019.
- Grützner et al., 2019. Active tectonics of the Dinarides in Slovenia - new insights from palaeoseismology. INQUA Congress 2019, 25-31 July, Dublin, Ireland.

Outreach

- RTV4 Documentary on our trenching project (in Slovenian), 22. 11. 2018
- Lichtgedanken (FSU Jena research magazine), January 2018
- Ostthüringer Zeitung, 13. 07. 2017