The last pulse – dating the youngest deformation in the Alps with ESR thermochronometry (LUNAR)

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PhD: to be appointed at LIAG

Goals

To understand the underlying forces driving mountain building processes, it is vital to determine fault movement rates over time. However, a timescale gap exists between rates that can be determined on $<10^4$ yr timescales (e.g. seismology data, cosmogonic nuclides) and 10^6 yr timescales (e.g. existing thermochronometry). Bridging this gap between the scales is now possible with electron spin resonance (ESR) dating of quartz, which has an ultralow closure temperature of ~30-90°C and a dating range of 10^3-10^7 yr.

In this project, we will perform ultralow temperature thermochronometry using ESR dating on four major faults in the Alps (the Simplon, Brenner, Salzachtal, and Giudicaria Faults; Fig. 1) to estimate their Quaternary activity. Samples will be taken directly from fault cores, as well as indirectly across the fault, which will allow us to examine whether there is recent thermal overprint on the fault core. Indirect ESR ages, together with new apatite and zircon (U-Th)/He and existing fission track ages, will be used to model the exhumation of the footwalls through time. This will contribute significantly to fill the timescale gap between the present geophysical results and geological datasets spanning several million years, some of which have been produced in the 4D-MB SPP. Our study area covers the central-west, east, and southern parts the Alps and we will therefore be able to elucidate how the different parts of the orogen responded to the subduction polarity reversal.

Relevance for AlpArray Experiment, as well as for at least one of the four research themes of the 4D-MB's first phase

This project will benefit from comparison of our data with that of the seismological data collected from the AlpArray, DSEBRA and SWATH D seismic arrays. In particular, it will be of great value to compare present-day fault-motion information with Neogene fault kinematics. This project links to Themes 2, 3, and 4 of the first phase of the SPP. This research can be considered a bridge between Theme 4 (Motion and seismicity from the present backwards in time) and Theme 3 (Rock trajectories and deformation during mountain building). In particular, results of this project are expected to yield data on how well short and long-term rates of deformation compare, and whether present seismicity is representative of longer timescales. The results can then be used to provide a link to Theme 2 (Surface response to changes in deep structure on different time scales), where a combination of our data with previously-obtained thermochronological data may lead to better understanding of the influence of deep-seated processes on surface deformation.

New results and interpretations

We conducted provisional fieldwork at Visp, on an outcrop of a ductile/brittle fault zone on the edge of the Simplon Fault. Three major fault rocks can be identified, 1) high-grade, medium-grained mylonites, 2) 20 to 5 mm-thick quartz veins, probably caused by precipitation of fluids, and 3) fine-grained fault gouge. Quartz and feldspar minerals were separated from the gouge. Preliminary ESR measurements of the Al centre of the quartz revealed that the natural Al signal was only 16 % (~270 ka) of its saturation intensity, indicating that significant amounts of signal has been thermally reset by past earthquakes and/or exhumation (Fig. 2). Due to the young age, we also conducted feldspar luminescence dating of the same sample, and a fading corrected age of ~110 ka was obtained (Fig. 2).

These ages age are much younger than any other reported ages from the Alpine faults and show promising applicability of ultralow temperature thermochronology in the Alps.

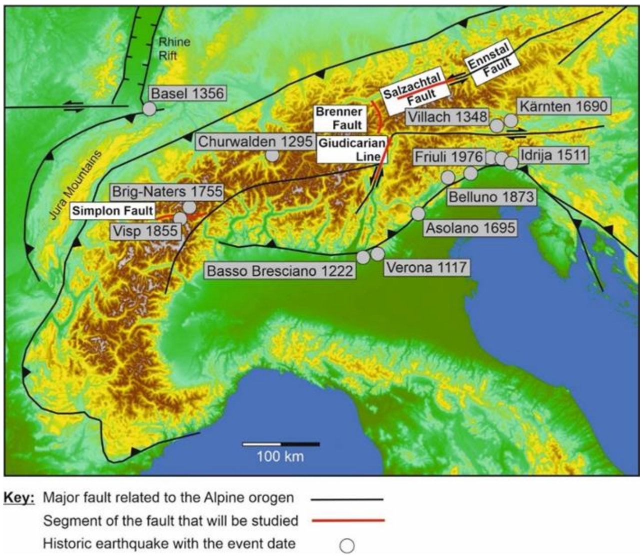

Fig. 1: Map showing the four faults that will be studied in this project.

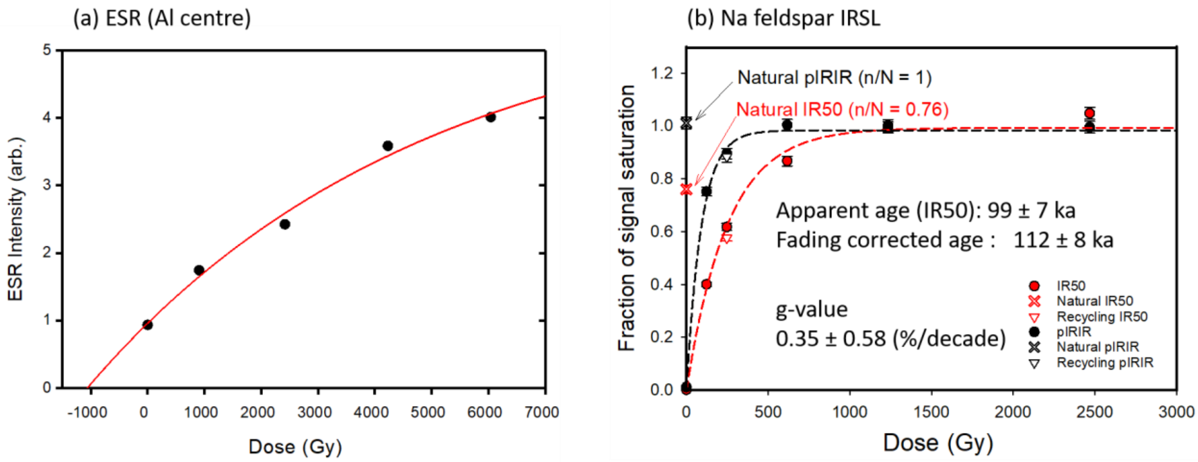

Fig. 2: Preliminary results of (a) quartz ESR dating and (b) feldspar luminescence dating from a gouge sample from the Simplon Fault.

Publication list

Tsukamoto, S., Guralnik, B., Oohashi, K., Otsubo, M., Tanner, D.C., Brandes, C., von Hagke, C. 2020. Testing direct dating of Alpine faults by luminescence and ESR. EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-7982, https://doi.org/10.5194/egusphere-egu2020-7982, 2020.

Tsukamoto, S., Tanner, D., Brandes, C., von Hagke, C. 2020. Direct dating of faults by luminescence and ESR: Case studies from Japan and Switzerland, JpGU-AGU Joint Meeting 2020, iPoster: https://jpgu-agu2020.ipostersessions.com/Default.aspx?s=15-CA-B6-52-7A-B2-72-CD-F9-45-80-62-FB-C4-97-37.