Feasibility study of quartz ESR dating for sediments in northern Switzerland

Photo: Modern fluvial sediments at Grüt Altikon

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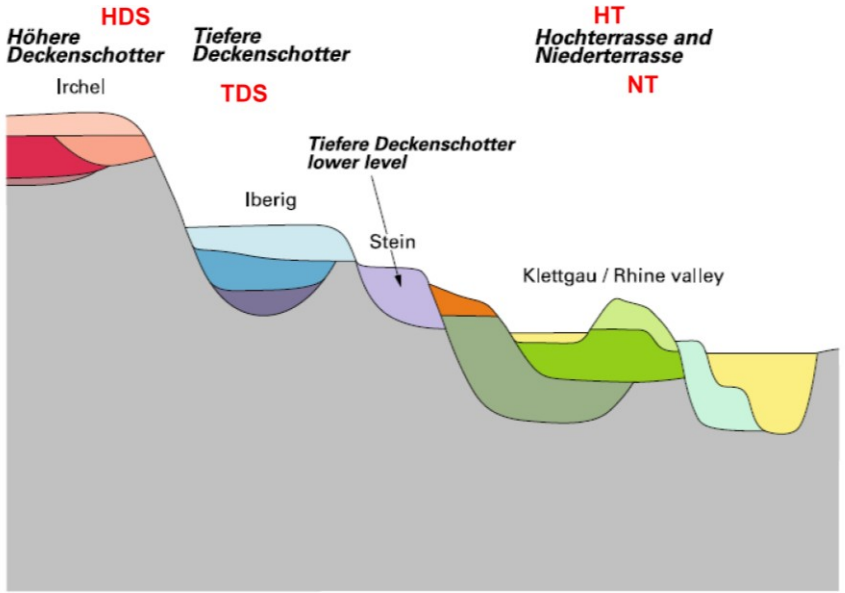
Introduction – Swiss Deckenschotter

- Glaciofluvial sediments in the Swiss Alpine Foreland are termed Höhere and Tiefere Deceknshotter (HDS, TDS), Hochterrasse (HT) and Niederterrase (NT) (e.g. Graf, 1993)
- Establishing a chronology for HDS and TDS has been difficult
- Biochronology based on Arvicoline teeth from Irchel Hasli suggested MN17 (ca. 1.8-2.5 Ma, Bollinger, 1996)
- Much efforts have been made in TCN dating, but the age discrepancy with the biochronology still exists; e.g. HDS from Irchel Hasli was dated to 1.3 ± 0.1 Ma (Dieleman et al., 2022)
- Beyond the age range of luminescence dating
- How about quartz ESR? (dating of >2Ma was possible, e.g. Rink et al., 2007)



Graf and Burkhalter (2016)

Study aims

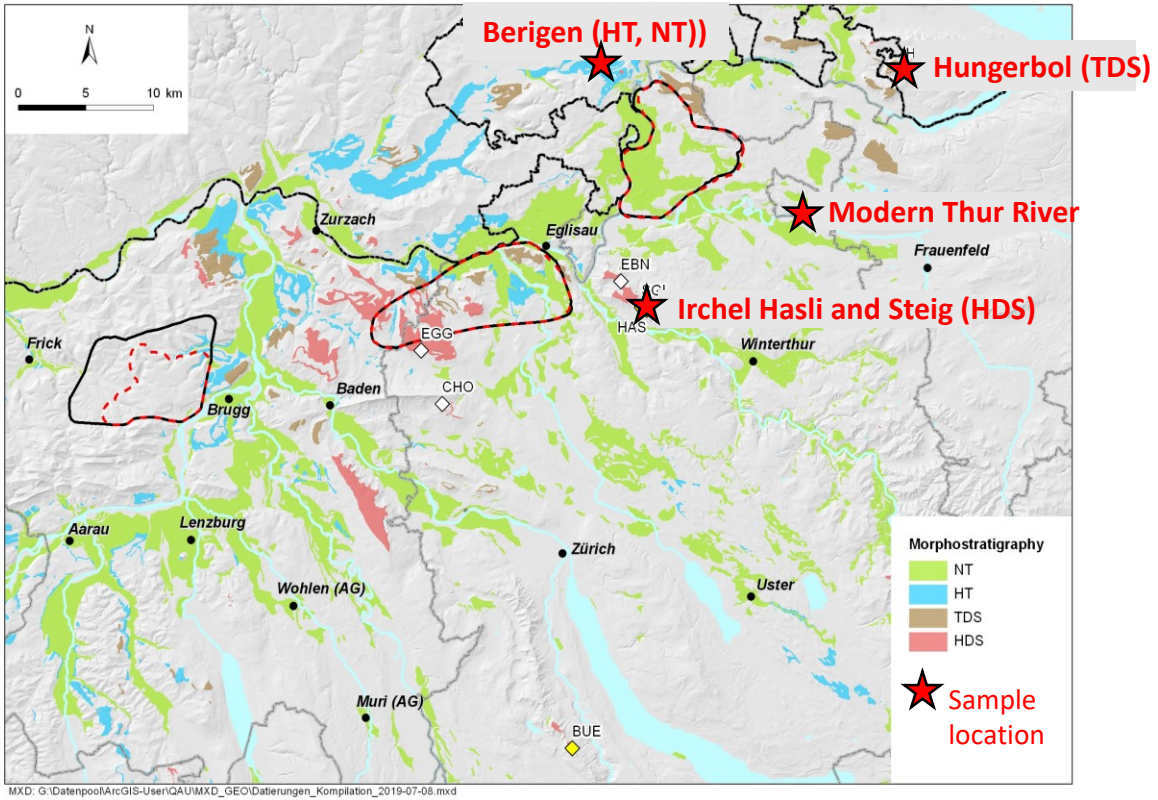
To assess the feasibility of quartz ESR dating using the Ti centre* for sediments in northern Switzerland;

- By testing samples of known ages (HT and LT samples from Berigen; Lowick et al., 2015, and modern fluvial sediments)
- By dating Höhrere and Tiefere Deckenschotter samples

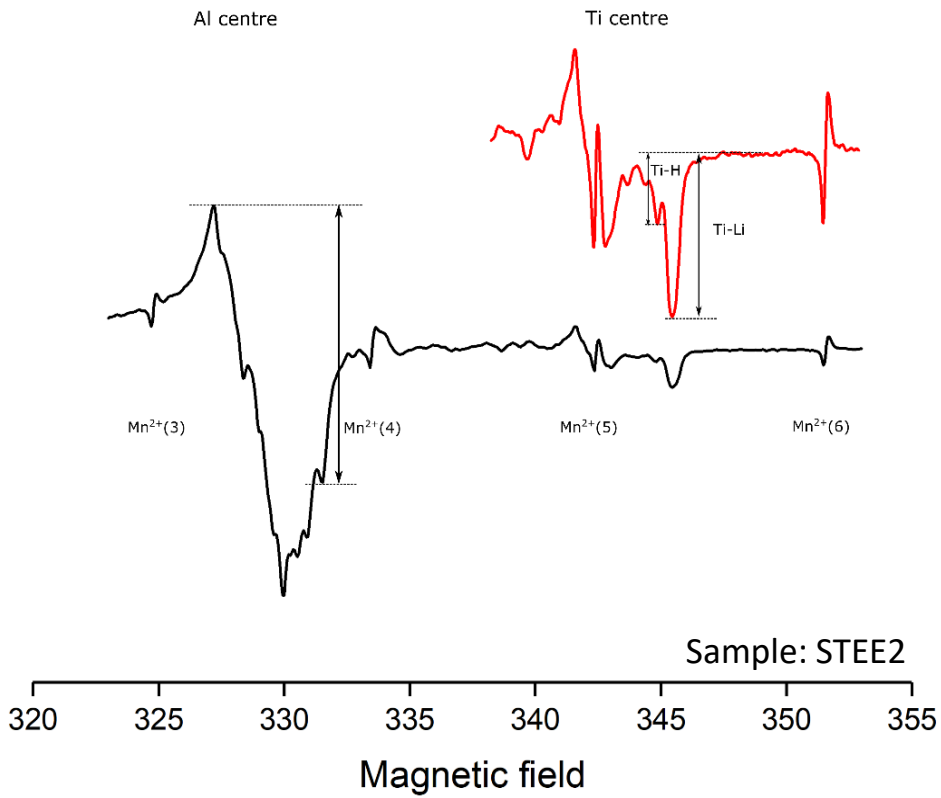
*Ti centre of quartz is known to be better bleachable than the Al centre (e.g. Toyoda et al., 2000)

Samples

- HDS from Irchel Hasli (HASE1, HASE2), Irchel Steig (STEE2)
- TDS from Hungerbol (HUNE2)
- HT and NT from Berigen (BER3: 150 ± 11 ka , BER6: 25 ± 3 ka; by OSL Lowick et al., 2015)
- Modern fluvial sediments from Thur (GRUE0, GRUE1)



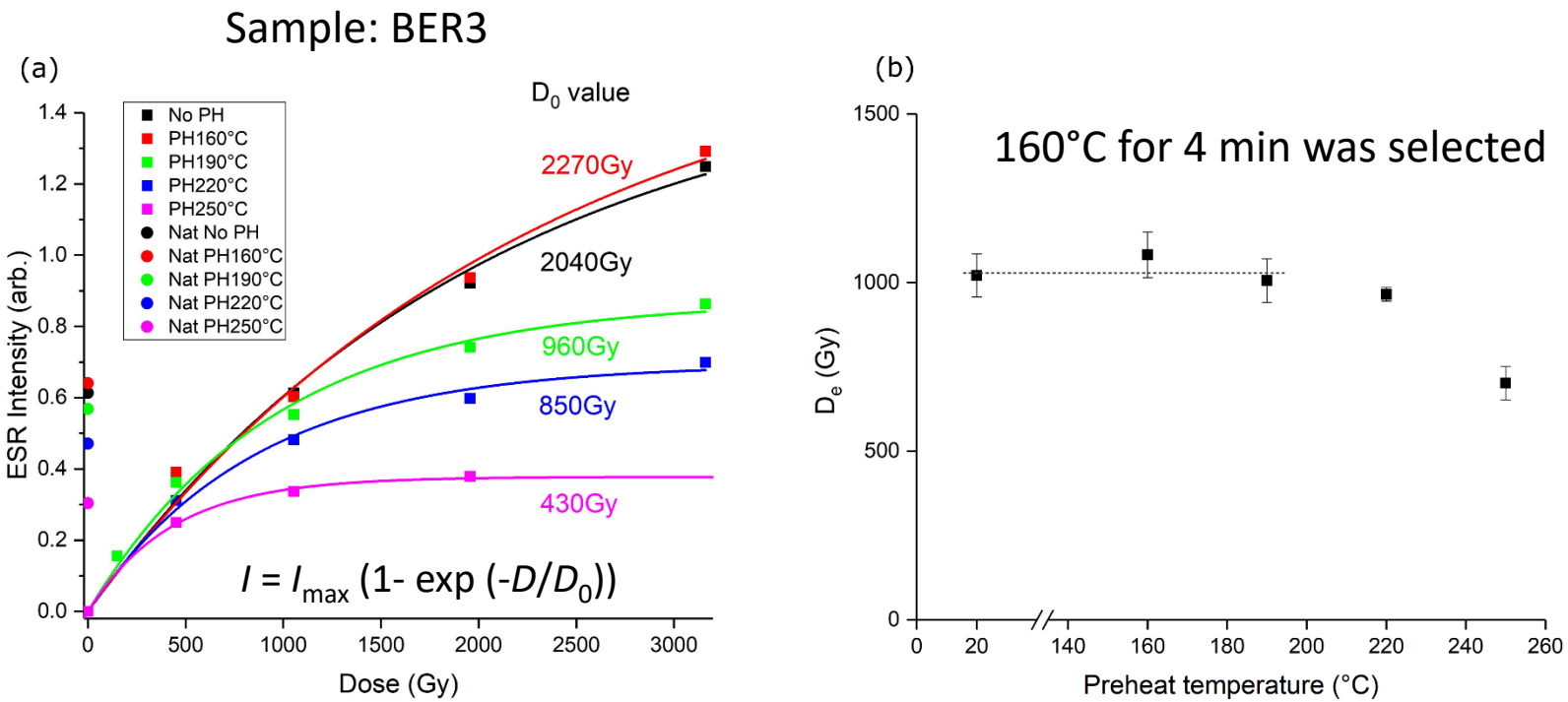
ESR spectra and protocol



ESR SAR protocol (Tsukamoto et al., 2015, 2017)

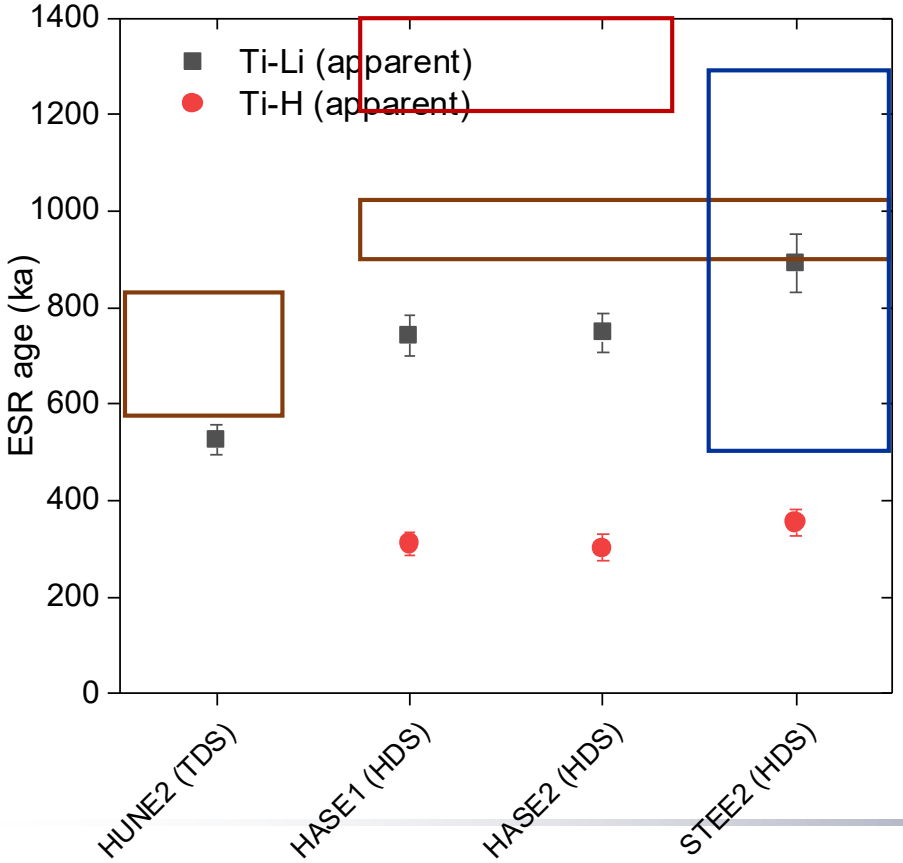
	Treatment
1	Preheat (T°C, 4 min)
2	Natural ESR
3	Anneal (400°C, 4 min)
4	Zero-dose ESR
5	Dose (X-ray, 0.3 Gy/s)
6	Preheat (T°C, 4 min)
7	Regenerated ESR
8	Repeat 5-7

Preheat test (Ti-Li centre)



D_0 decreased with preheat temperature (Tsukamoto et al., 2018)

Apparent ESR ages of HDS and TDS



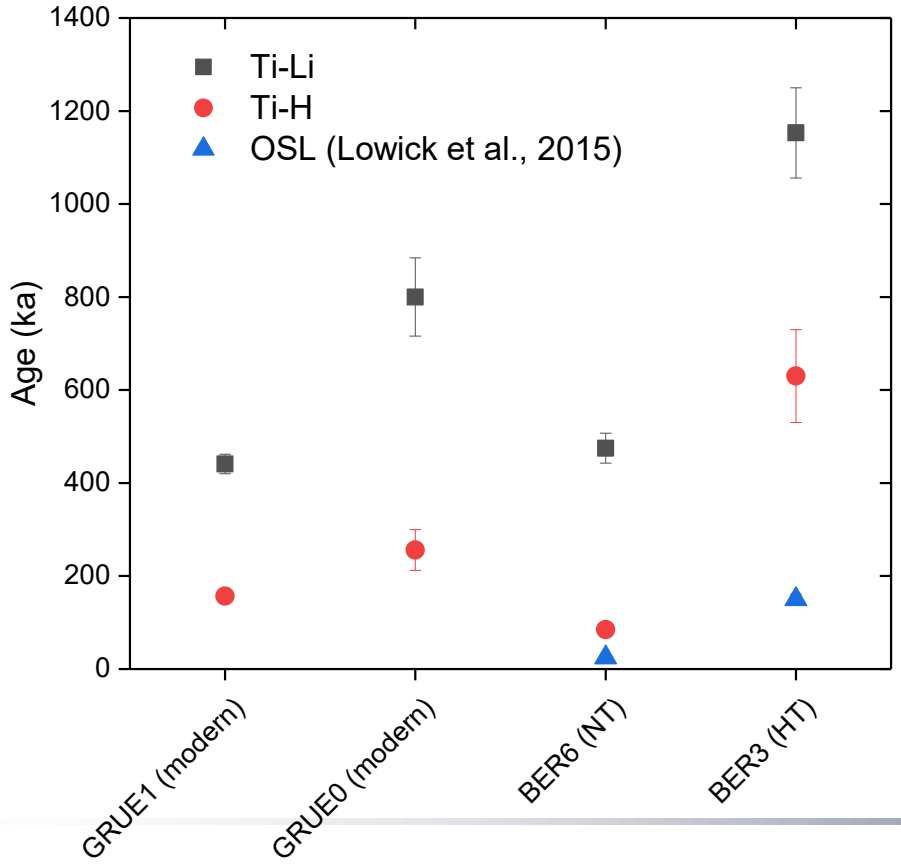
Comparison of the Ti-Li ages with the recent TCN results

Isochron age of HDS from Irchel Steig: 0.9 ± 0.4 Ma (Claude et al., 2019); from Irchel Hasli: 1.3 ± 0.1 Ma (Dieleman et al., 2022)

Bayesian P-PINI burial ages*
HDS: 0.95 ± 0.07 Ma
TDS: 0.69 ± 0.12 Ma
(Knudsen et al., 2020)

*particle pathway inversion of nuclide inventories

ESR ages of HT, NT and modern fluvial sediments

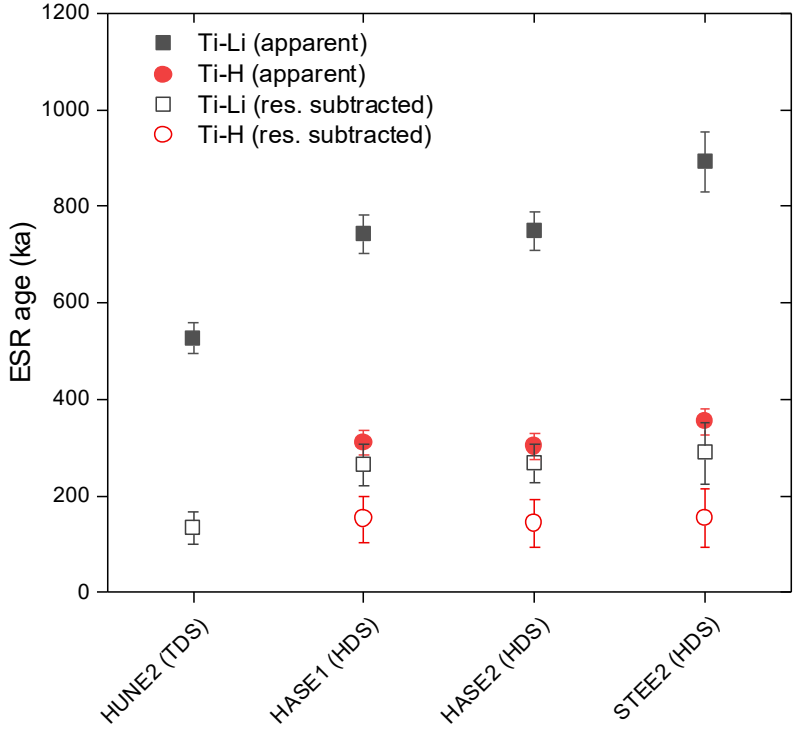


From the difference between the ESR and known ages, mean residual dose and age were calculated.

Ti-Li: 790 ± 60 Gy (700 ± 160 ka)

Ti-H: 260 ± 70 Gy (250 ± 100 ka)

Residual subtracted ages and short summary



- The apparent Ti-Li ages from HDS and TDS are close to P-PINI burial ages (Knudsen et al., 2020).
- However, if we subtract the mean residual dose, the ages become unreasonably young; ~320 ka for HDS, ~150 ka for TDS using the Ti-Li centre.
- Potential causes of ESR age underestimation would be a short thermal lifetime of the signals.