Strong earthquakes as main trigger mechanism for large prehistoric rock slope failures in Western Tyrol (Austria, Eastern Alps):

Constraints from lacustrine paleoseismology

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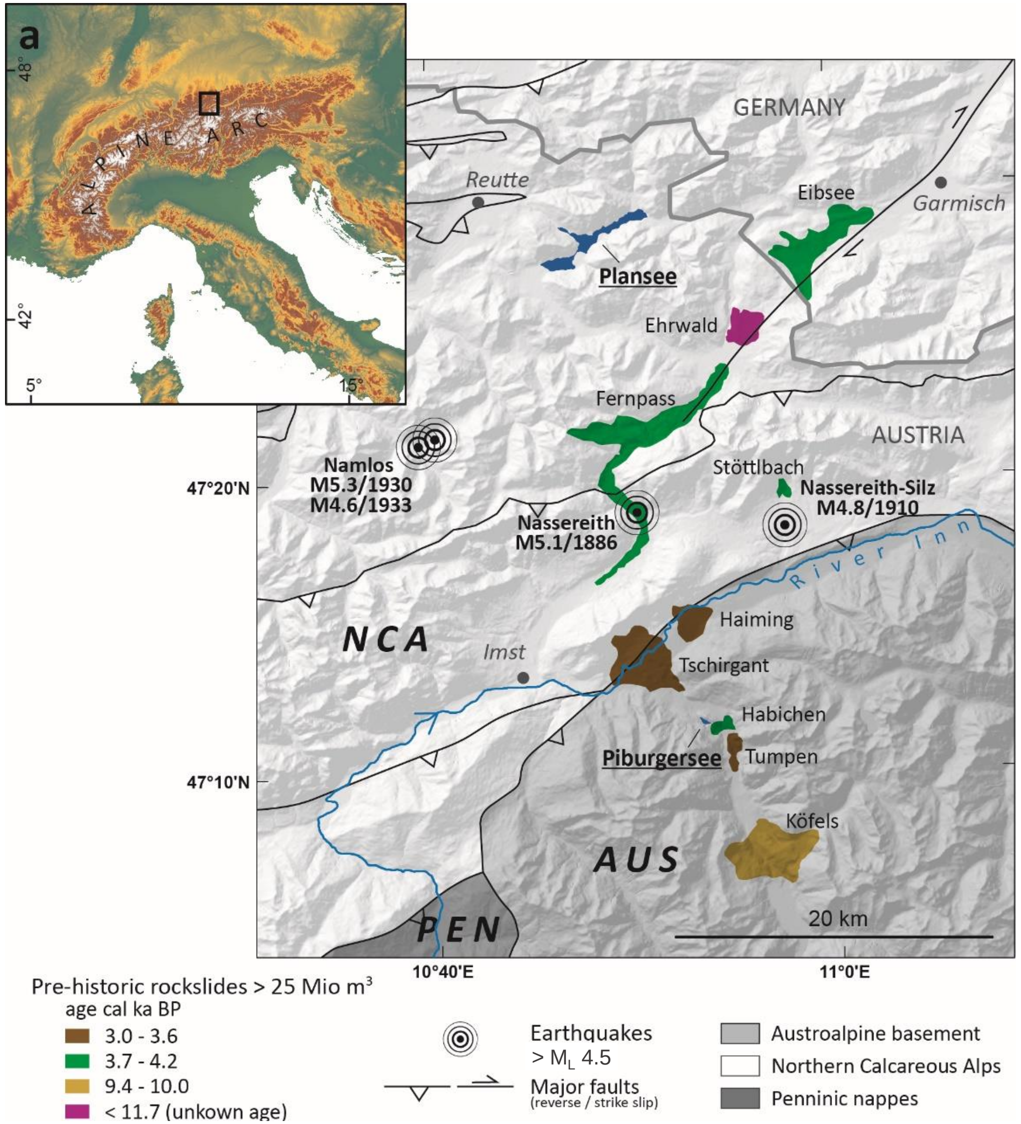
Geological setting



spatial and **temporal** (4.2-3.0 ka) **cluster** of pre-historic **rockslides** (> 25 Mio m³) within two tectonic units in the western Eastern Alps (Prager et al. 2008)

Study area is one of the **seismically most active regions** of the Eastern Alps (Lenhardt et al. 2007)

→ What is the role of earthquakes in triggering and preparing major rockslides?

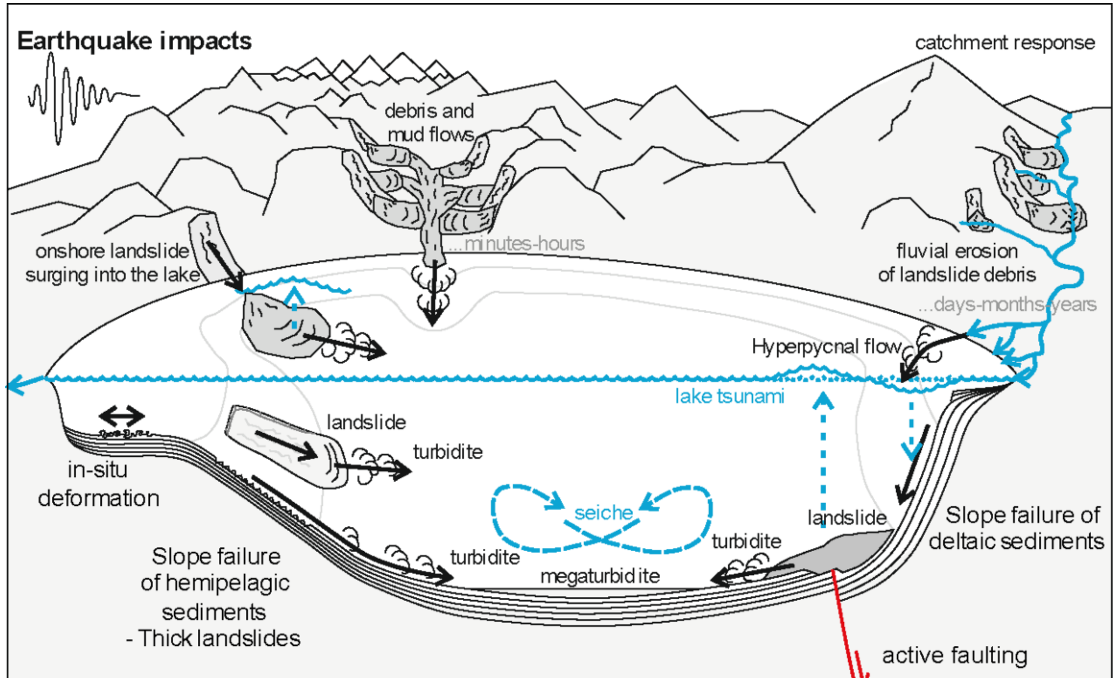
We established **paleoseismic data** from two rockslide-independent lake archives Piburgersee and Plansee

Figure: Geology simplified from Ortner (2003) Earthquake data from ZAMG (2018) Rockslide age references see last figure

Lake sediments as natural (paleo-)seismographs

Strong **earthquakes** generate **specific sedimentary** imprints in lakes, such as:

- In-situ deformation in shallow areas
- Multiple subaquatic landslides
- Post-seismic catchment response



after Van Daele et al. 2015

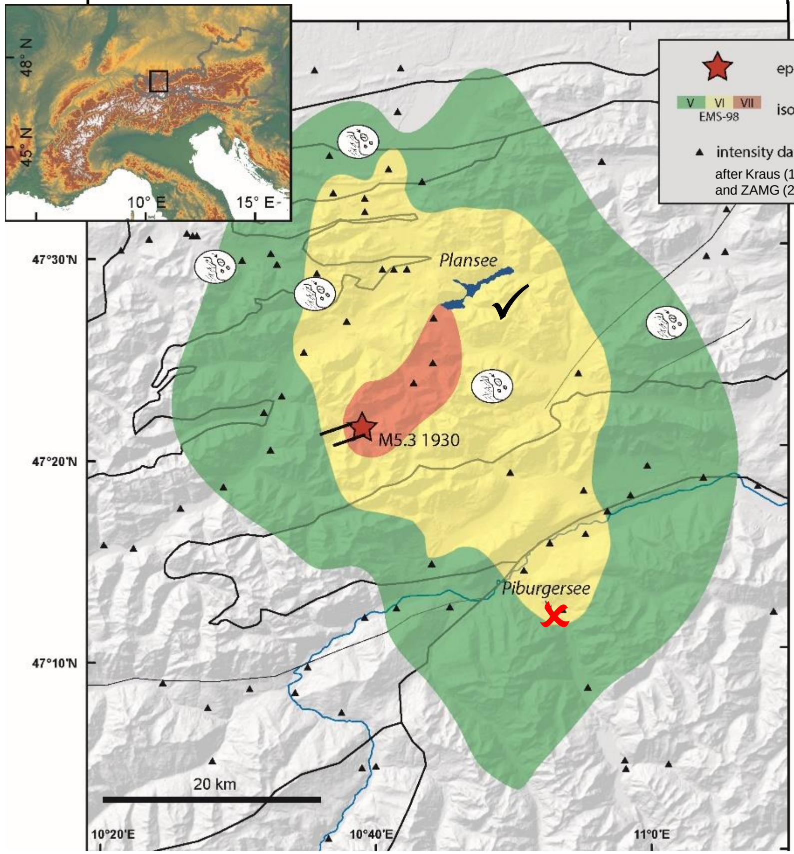
Field data acquisition

Single-channel seismics

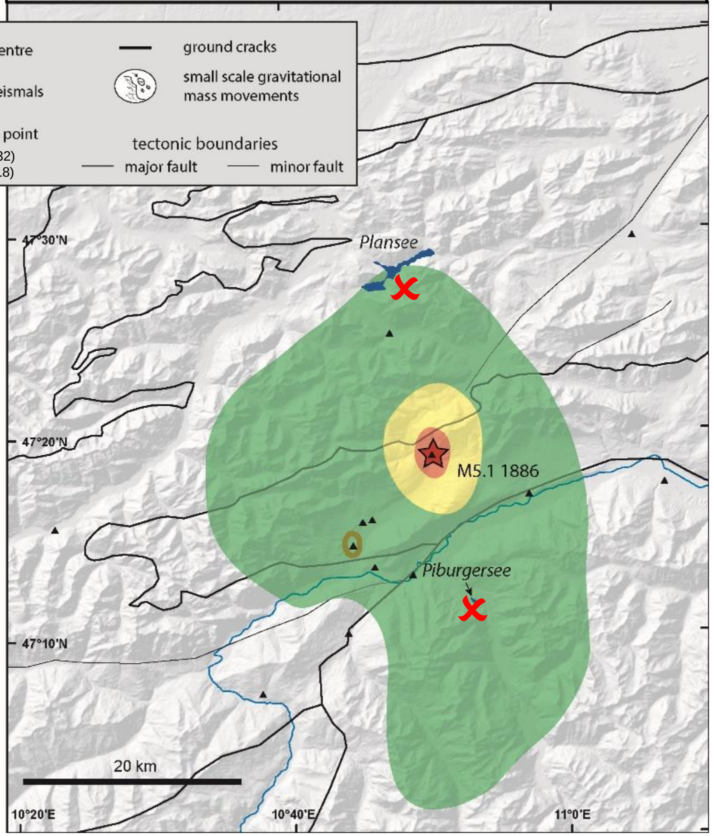
Sediment coring

Calibration of the natural seismograph

M5.3 Namlos earthquake in 1930
(strongest regional EQ historically known)



M5.1 Nassereith earthquake in 1886



✓ earthquake-induced sedimentary imprint **recorded**

✗ **No** earthquake-induced sedimentary imprint recorded

Earthquake-recording threshold in Plansee:

Seismic intensity ≥VI (EMS-98) at the lake site, because M5.3 1930 event recorded and M5.1 1886 event not recorded having seismic intensities of ≥ VI and V at Plansee, respectively.

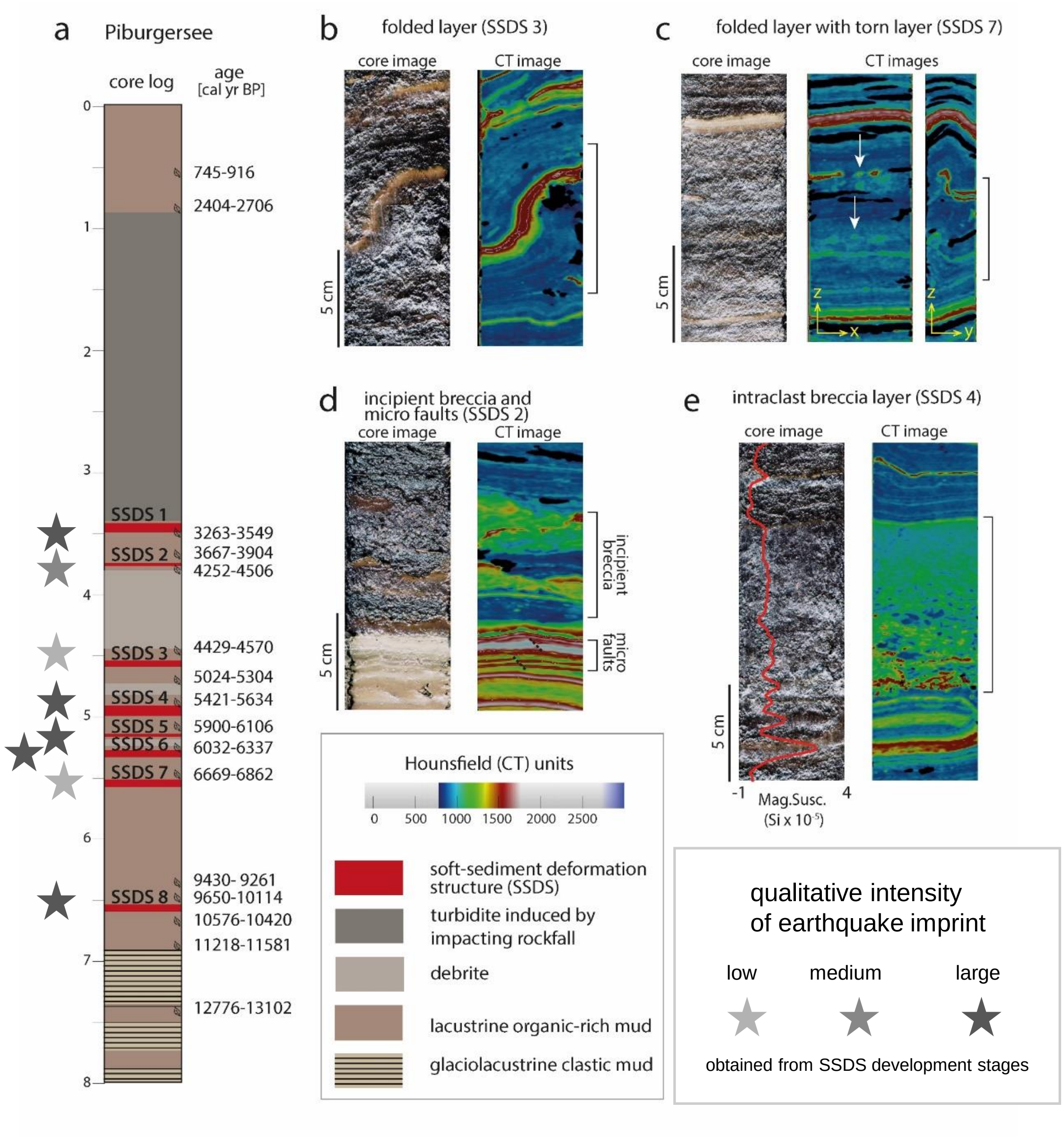
Earthquake-recording threshold in Piburgersee:

Seismic intensity >VI (EMS-98) at the lake site, because both M5.3 1930 and M5.1 1886 reaching seismic intensity VI and V, respectiviely, have negative evidence.

→ Paleo-earthquakes recorded in one of the lakes must have exceeded these intensity thresholds.

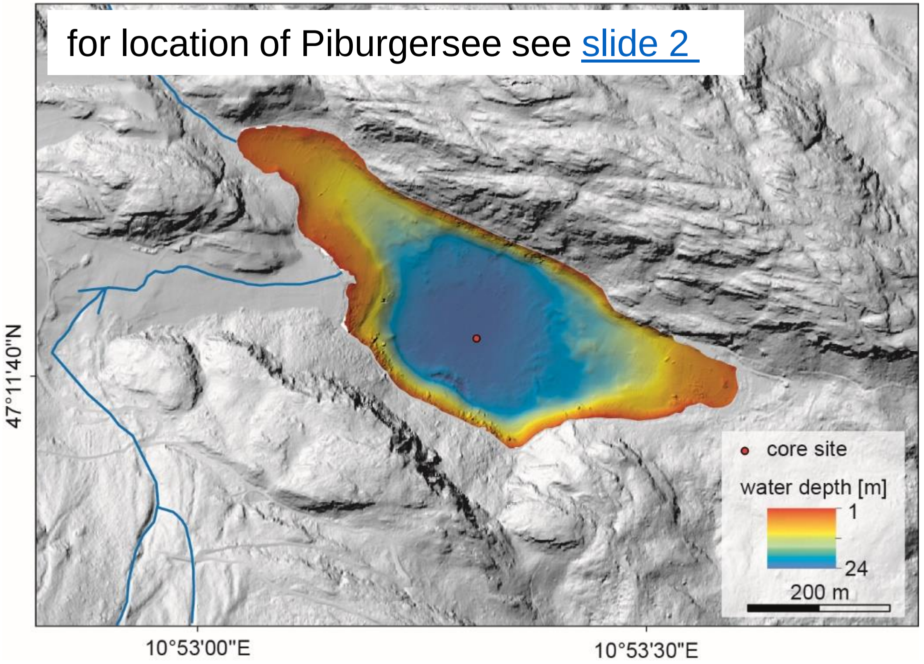
→ A paleo-earthquake recorded in both lakes is stronger than the historically known maximum magnitude (M5.3)

Piburgersee paleoseismic record



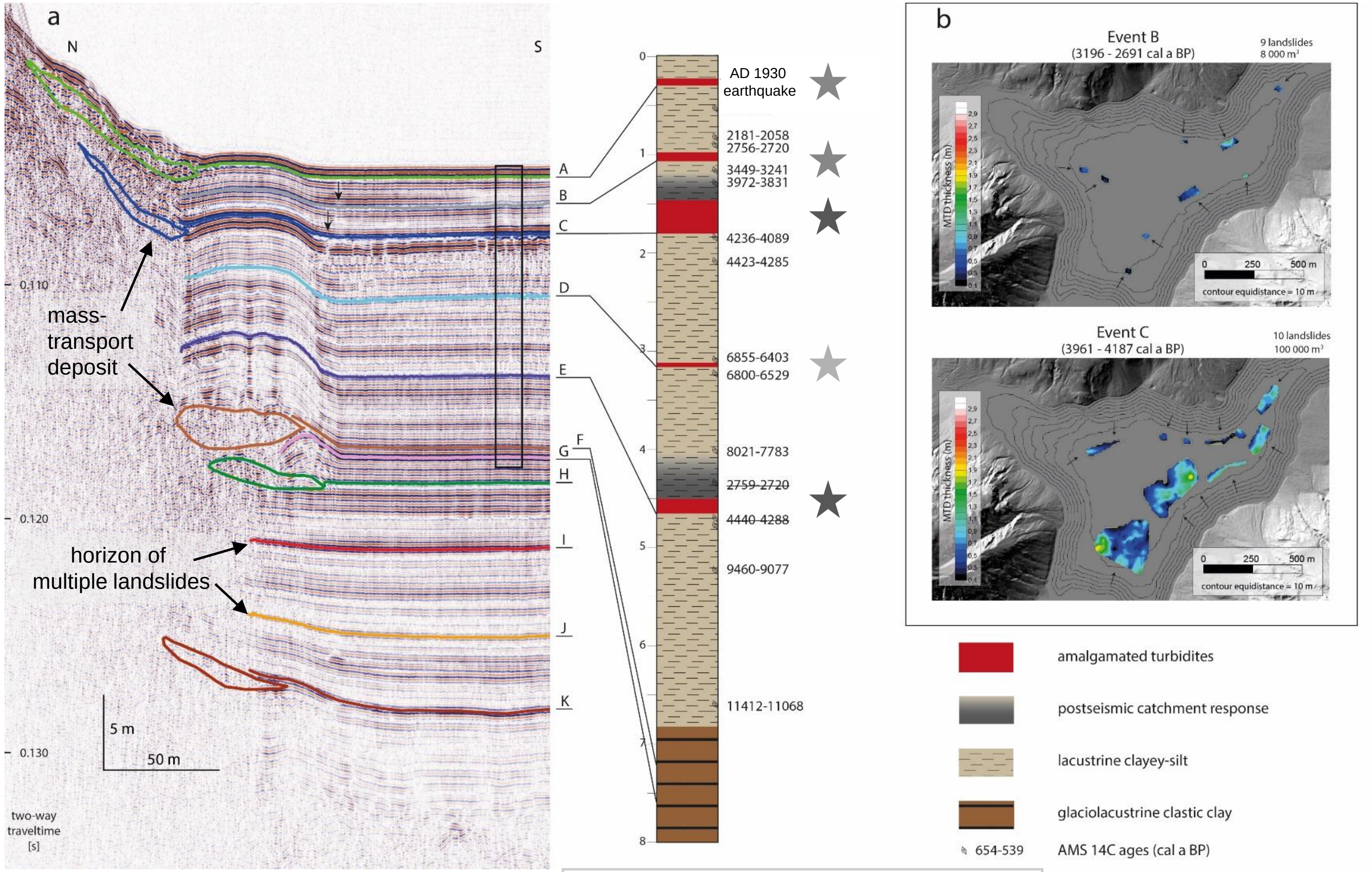
Strong earthquakes* are recorded as **soft-sediment deformation structures SSDS** (left Figure: b-e)

→ Eight strong paleo-earthquakes within the continuous and precisely dated lacustrine archive



*larger seismic intensity ≥VI (EMS-98) at the lake site.
See slide 4 for explanation

Plansee paleoseismic record



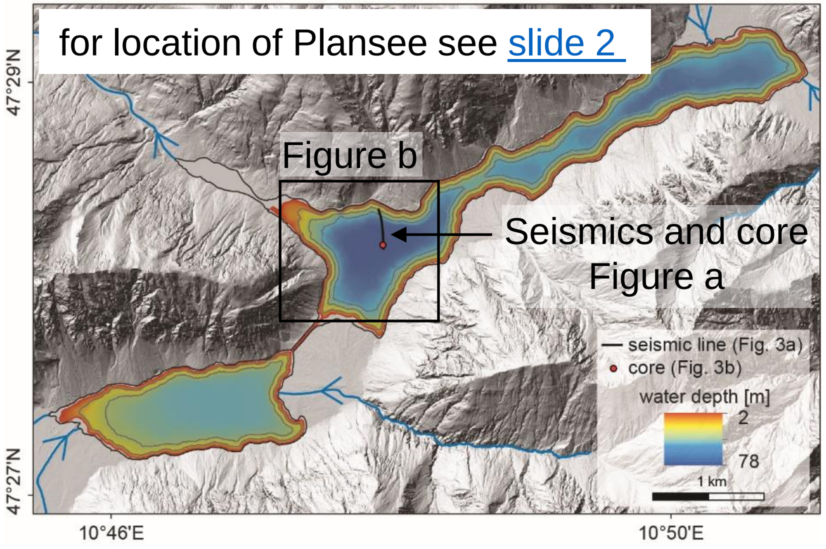
qualitative intensity
of earthquake imprint

low ★ medium ★ large ★

obtained from turbidite thickness (Moernaut et al. 2014)
and postseismic catchment response (Howarth et al. 2016)

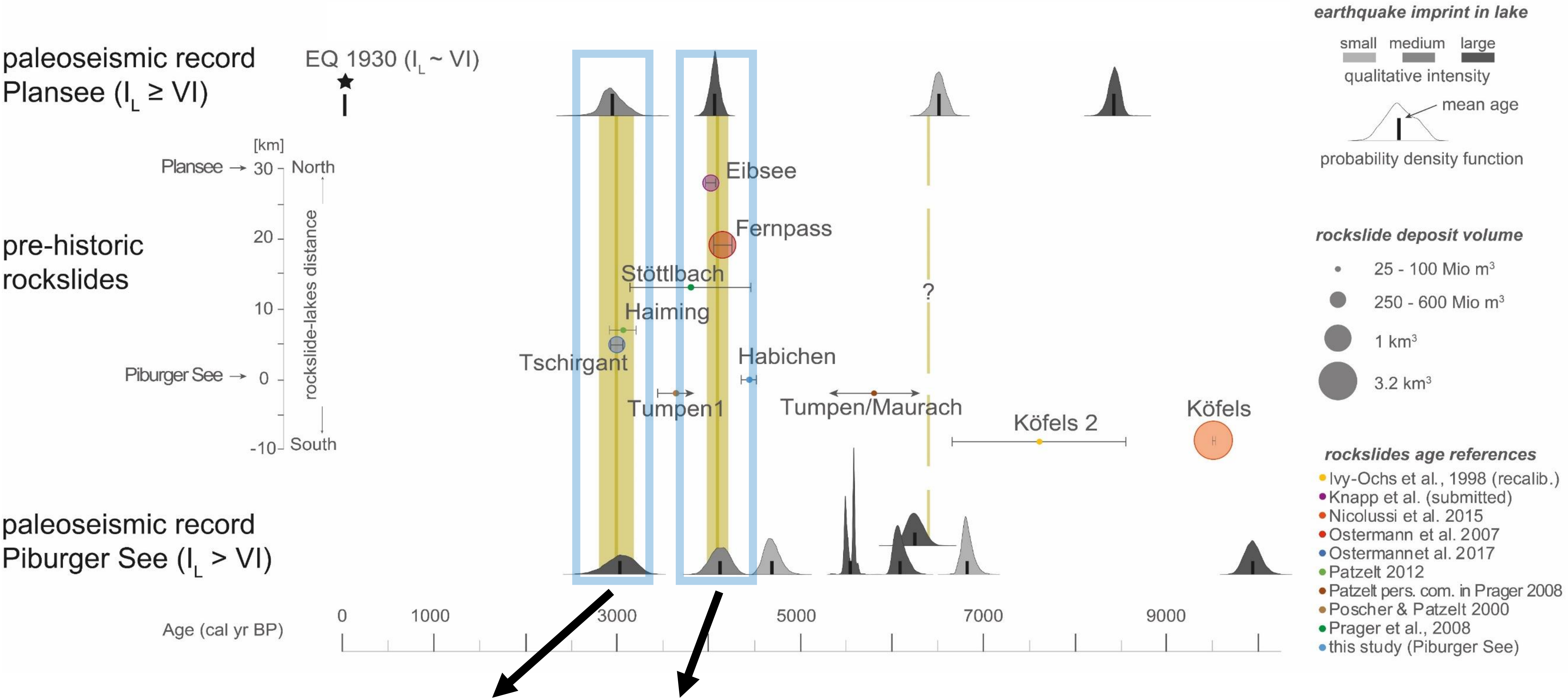
Strong earthquakes* are recorded as **coeval multiple subaquatic landslides** (Figure a and b)

→ Five strong paleo-earthquakes in the Holocene within the continuous and precisely dated lacustrine archive



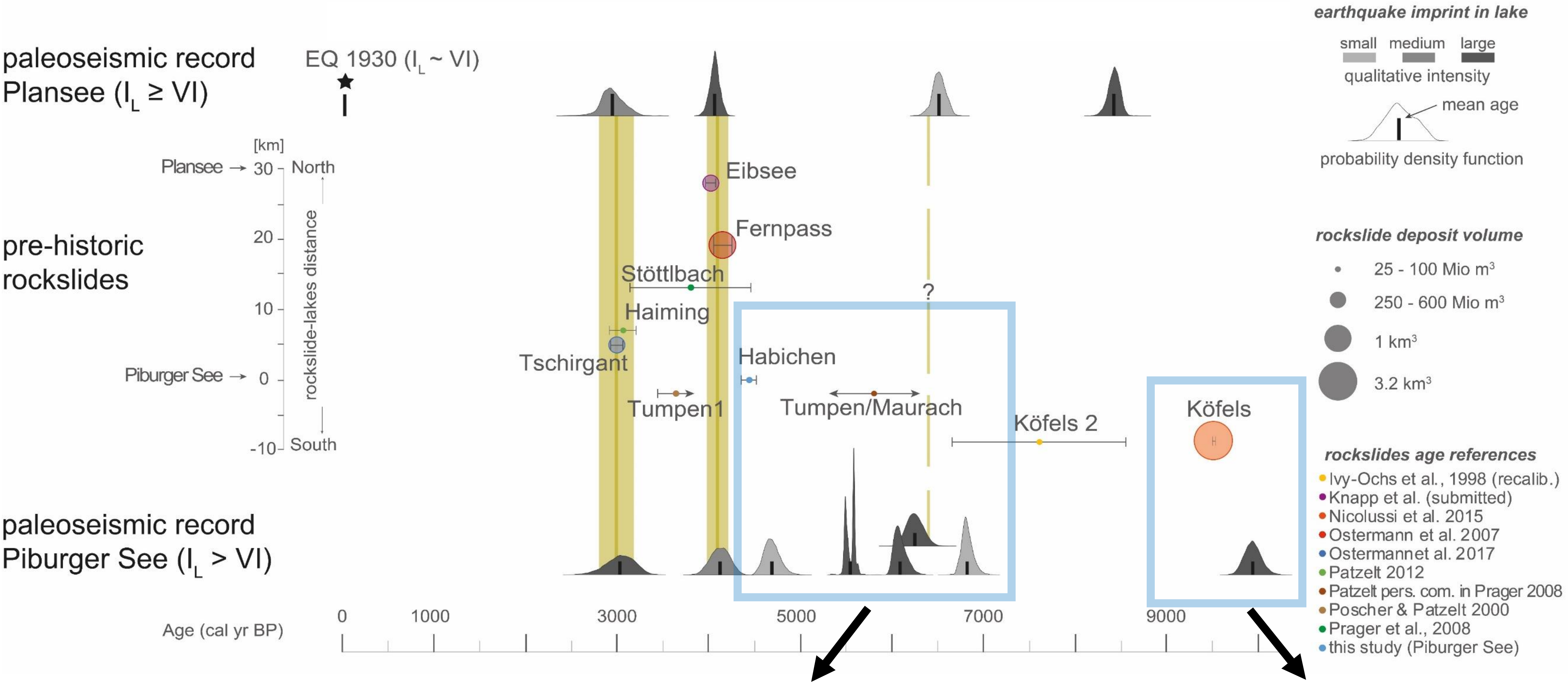
*larger seismic intensity >VI (EMS-98) at the lake site.
See slide 4 for explanation

Comparison of pre-historic rockslides to paleoseismic records (i)



Coincidence of strong earthquakes recorded in both lakes with multiple rockslides

Comparison of pre-historic rockslides to paleoseismic records (ii)



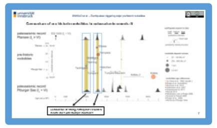
Phase of enhanced seismicity with little rockslide activity highlights the role of earthquakes as preparatory factor

A strong earthquake at 9.8 ka fundamentaly degraded and prepared the slope of Köfels to failure

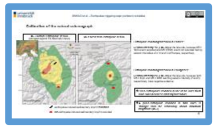
Conclusions

The elaborated rockslide-independent lacustrine paleoseismic archives reveal that:

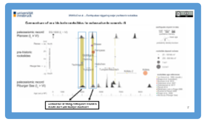
- An earthquake cluster coincides with the rockslide cluster (4.2 – 3.0 ka)



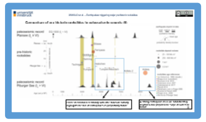
- Paleo-earthquakes at 4.1 an 3.0 ka are stronger than the historically known maximum magnitude



- Multiple rockslides are ultimately triggered by these strong earthquakes at 4.1 and 3.0 ka



- Earthquakes are important rockslide preparatory factors



use links to go back to corresponding data

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