Eccentricity-driven fluvial fill terrace formation in the southern-central Andes, NW Argentina

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Introduction

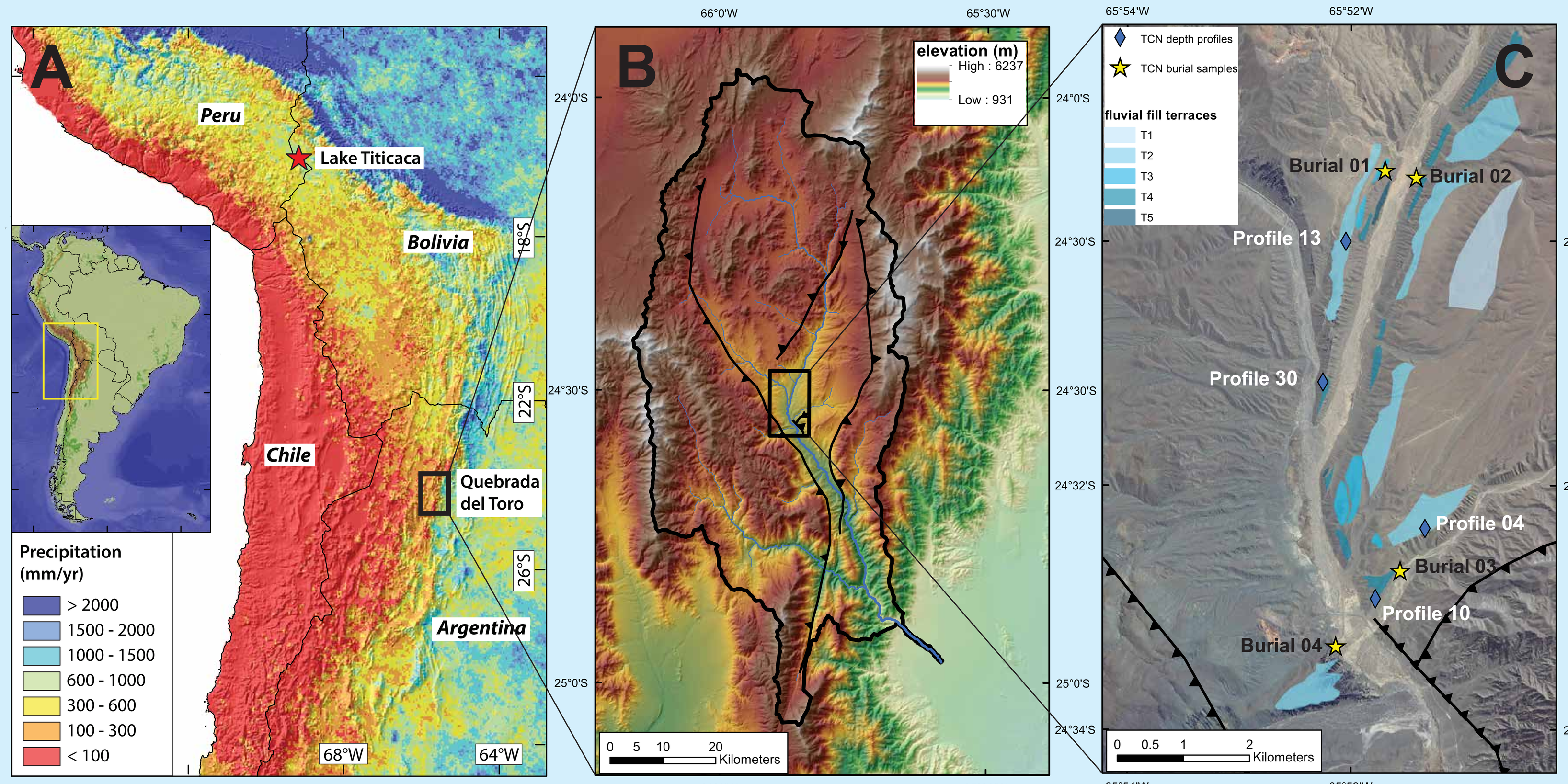


Fig. 1 A) Mean annual rainfall in the Central Andes based on TRMM satellite data and location of the study area Quebrada del Toro in NW Argentina. B) Topographic map of the Quebrada del Toro (SRTM 30m). C) Fluvial fill terraces in the upper part of the Quebrada del Toro. Within the fill, we observe a minimum of 5 terrace levels with pronounced differences in their extent and preservation.

Fluvial fill terraces record changes in past sediment to water discharge ratios. Across the world, fill terrace formation in glaciated catchments has been linked to variable sediment production and river discharge over glacial–interglacial cycles.
However, so far, little is known about how changes in global climate on multi-millennial timescales affected sediment dynamics in regions far from major glaciers and ice sheets. Several recent studies in the Central Andes, for example, have linked terrace formation to changes in precipitation associated with precessional climate forcing (e.g. Schildgen et al., 2016; Steffen et al., 2010). In this study, we investigate the timing of fluvial fill terrace formation in the Quebrada del Toro, an intermontane basin located in the Eastern Cordillera of the southern-central Andes in NW Argentina (Fig. 1).

Methods

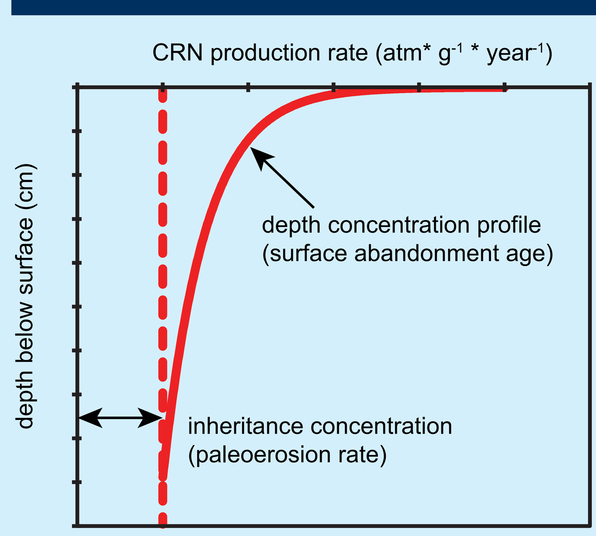


Fig. 2 CRN in-situ production decreases exponentially with depth. By fitting an exponential curve to the samples, the surface exposure age can be calculated.

- Dating of terrace surfaces with the cosmogenic radionuclide (TCN) ^{10}Be (Fig. 2)
- 4 depth profiles on different terraces (Fig. 3 A&B)
- Sampling of either exclusively sand (0.25 - 0.5 mm) or clasts (1 - 3 cm)

Inflationary surfaces

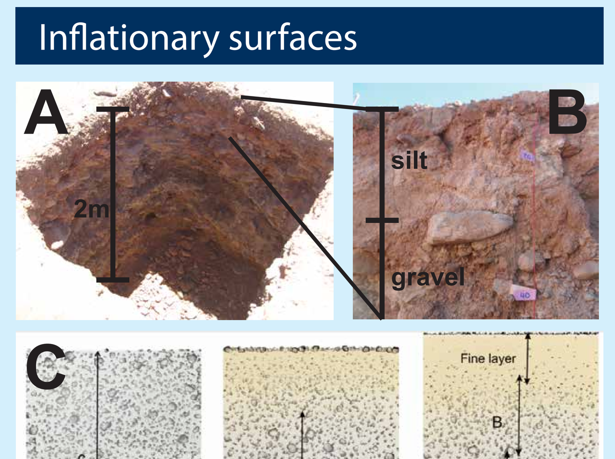
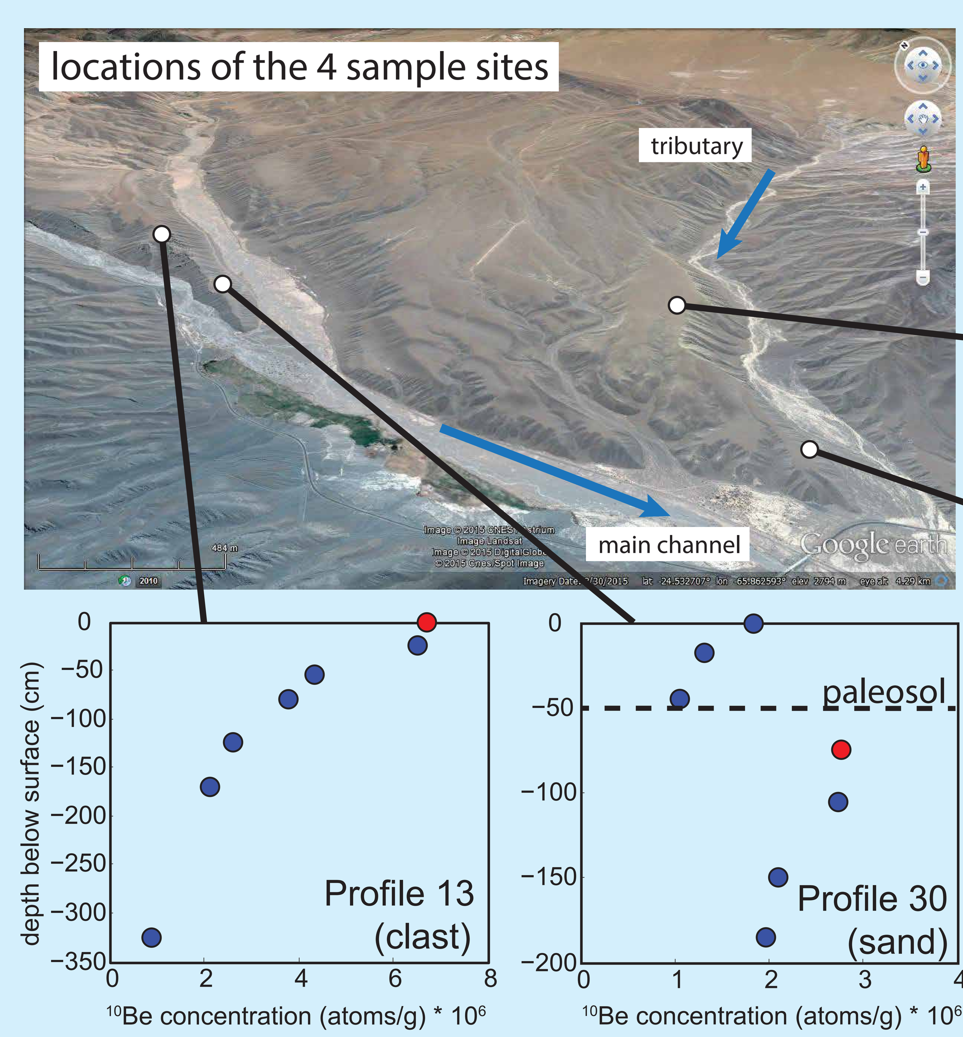


Fig. 3 A & B) Field pictures from a cosmo pit. C) Theoretical development of a desert pavement based on soil inflation. Aeolian imported sand/silt accumulates at the surface and has therefore a lower ^{10}Be concentration. Picture downloaded from *.

Analysis of terrace ages



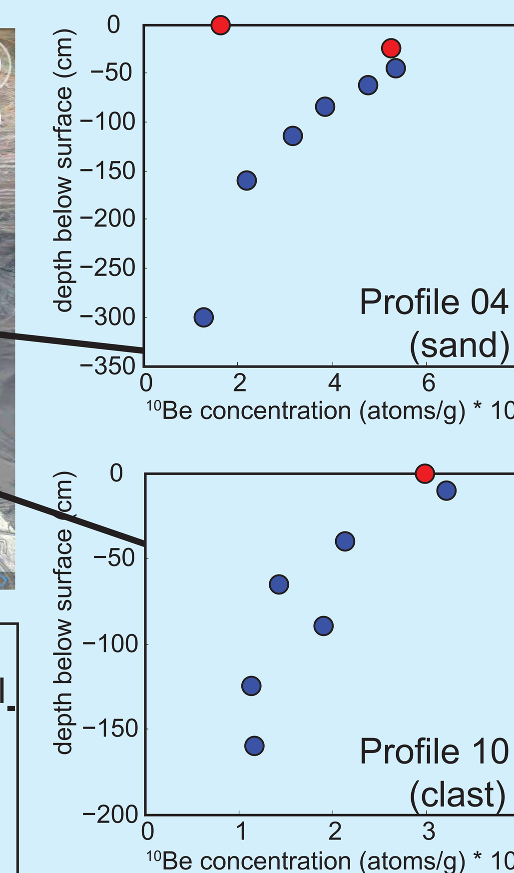
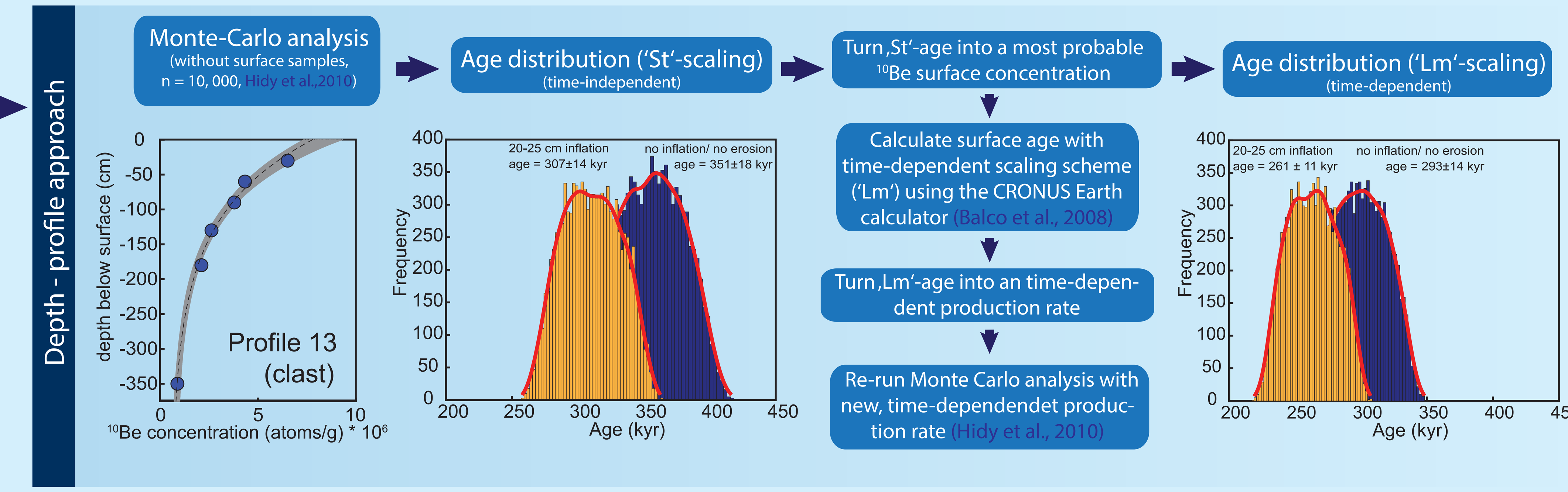
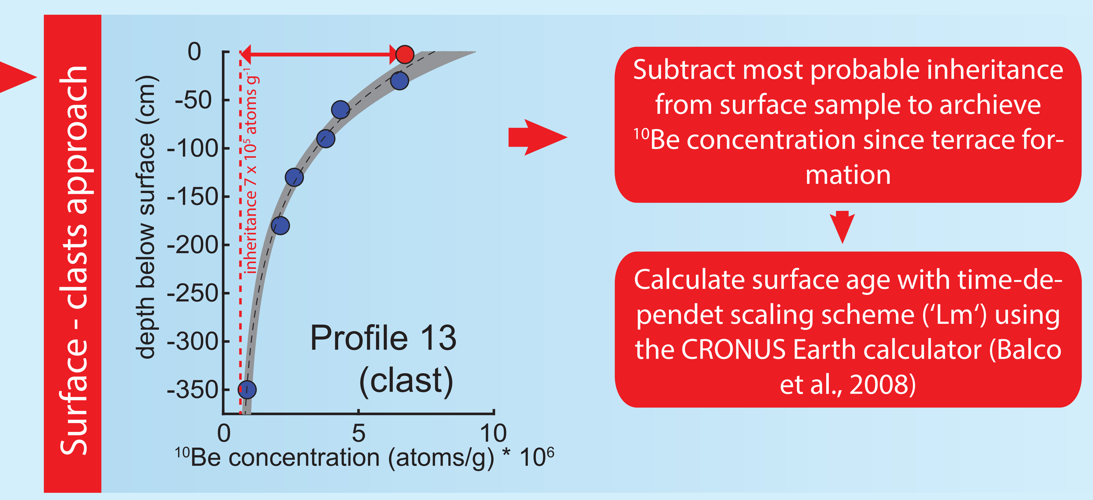


Fig. 4 ^{10}Be concentration depth profiles of the 4 terrace pits. 2 pits on E and W side of main channel, respectively. Please note that profile 30 records 2 events. Error bars are smaller than circle sizes.





- Surface samples have lower concentrations than expected ➡ we hypothesize due to inflation (see Fig. 3)
- We performed two terrace surface age calculations:

1) A Monte-Carlo depth-profile approach without the surface samples (with & without assuming inflation) (Hidy et al., 2010)

2) Surface sample age calculation with the CRONUS Earth calculator after subtracting inheritance (Balco et al., 2008)

Results

Table 1. Summary of calculated terraces surface abandonment ages.

'Lm'- age ± 1σ (kyr)	no erosion/ no inflation	inflation	age based on surface sample
Profile 04	298 ± 17	243 ± 14 (30-40 cm)	
Profile 13	293 ±14	261 ±12 (20-25 cm)	242 ± 18
Profile 10	100 ± 10	86 ± 8 (0-10 cm)	98 ± 7
Profile 30a (top)	70 ± 5		
(bottom)	75 ±12	55 ± 11 (40-45 cm)	
30b (bottom + top)	70 + 75 = 145	70 + 55 = 125	

- Final ages vary greatly with the amount of inflation and with the approach
- Surface-clast samples support the hypothesis of inflation (no-inflation scenarios give ages that are too old)

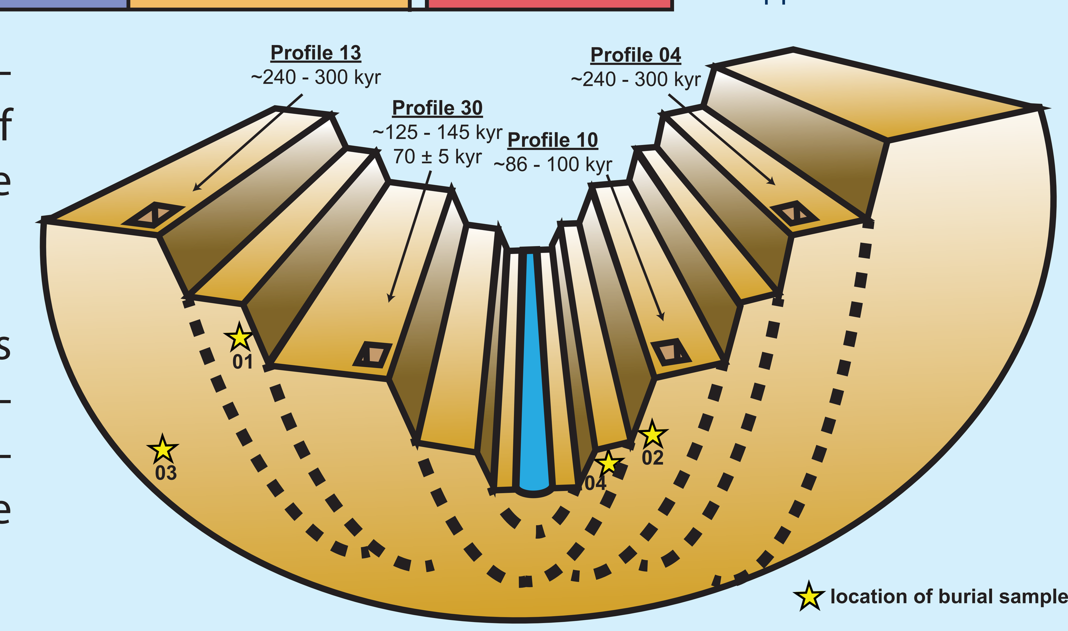


Fig. 5 Simplified model of fill terrace distribution and location of the pits. Ages show the resulting age range of all different calculation approaches.

Interpretation & Conclusion

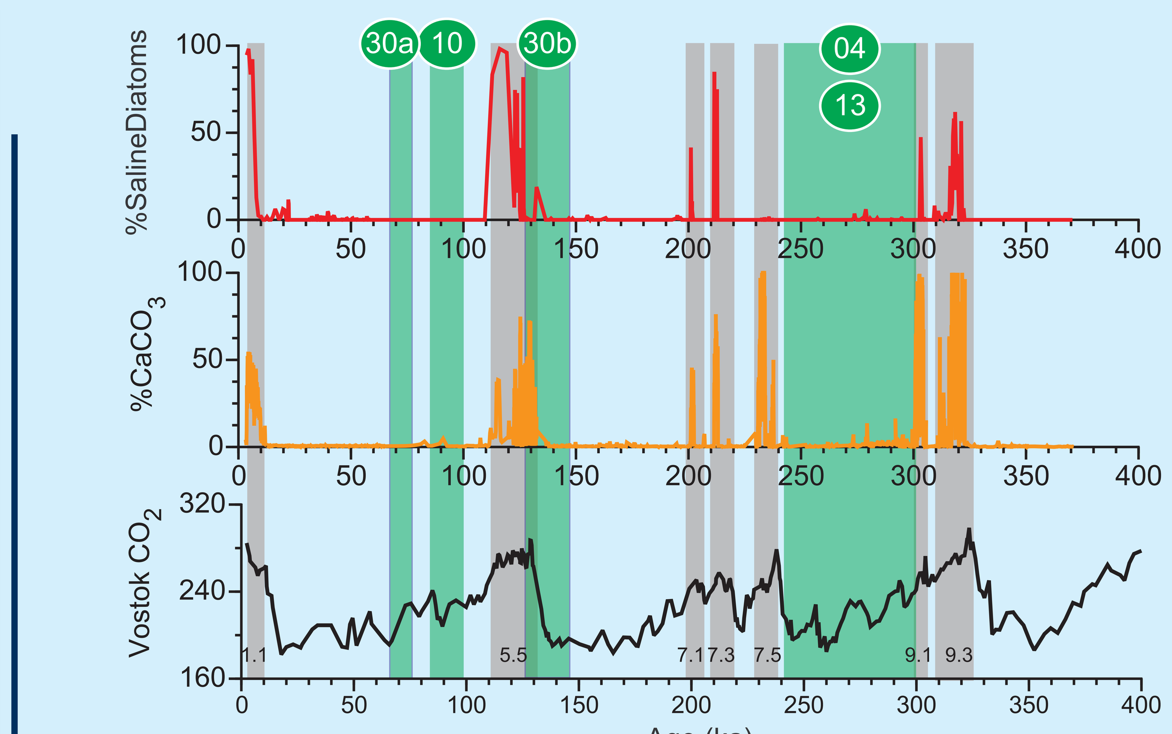


Fig. 6 Terrace surface age-ranges (shaded in green) compared to a paleoclimate record from Lake Titicaca (Baker & Fritz, 2015). The Lake Titicaca record shows increased salinity during major interglacial stages (shaded in grey). For the location of Lake Titicaca see Fig. 1. This figure is modified from Baker & Fritz (2015).

- Terrace surface ages based on ^{10}Be depth profile interpretations are up to 50 kyr younger when inflation is taken into account ➡ inflation hypothesis supported by surface clast ages and thus inflation should be considered when working in areas characterized by desert pavements
- Terrace surface ages fall in non- saline and thus wetter climate phases compared to the Lake Titicaca paleoclimate record from Baker & Fritz (2015) (Fig. 6)
- Remnants of further terraces between and above the dated ones additionally indicate the formation of terraces related to the 100-kyr climate cycle (eccentricity)

References

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