Activity and stability of zebra stripes in the central Atacama Desert based on geomorphological and geochronological evidence

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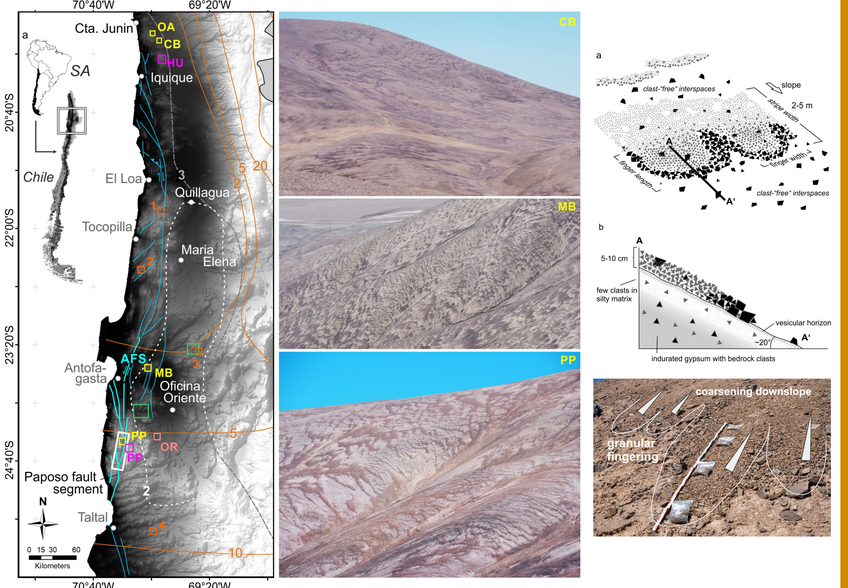
Research context

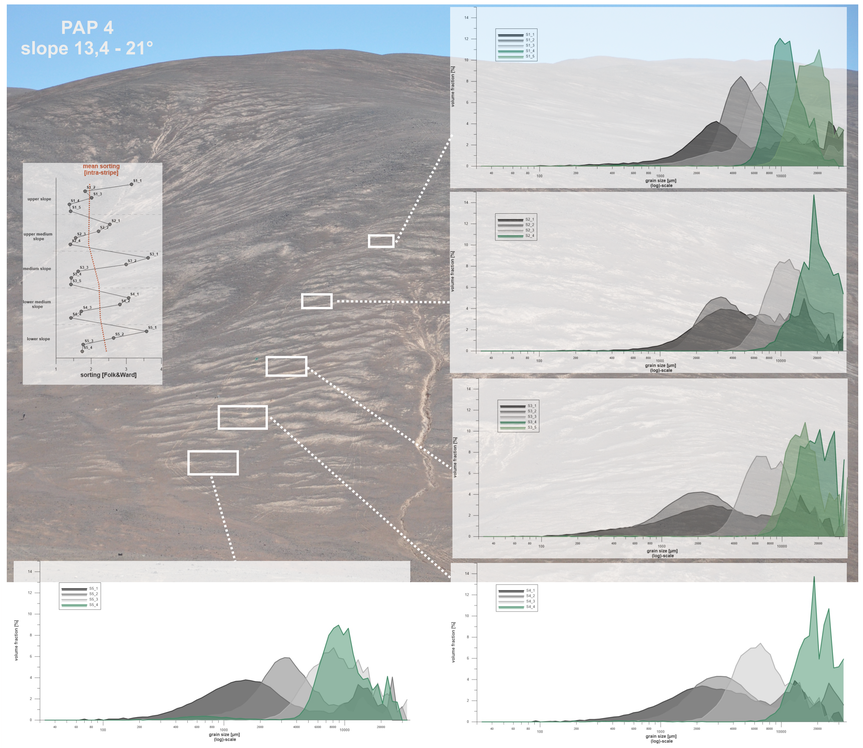
This work was conducted in the context of the **DFG-funded Collaborative Research Centre 1211 (CRC1211)** „Earth - Evolution at the dry limit“, particularly the subproject C03. The CRC pioneers the research on the **mutual evolutionary relationships between earth surface processes and biota in arid and hyper-arid areas** of the **Atacama Desert**, Northern Chile. Subproject C03 aims on understanding driving factors of **hillslope dynamics** in this driest part of the earth on recent and geological timescales.

Introduction

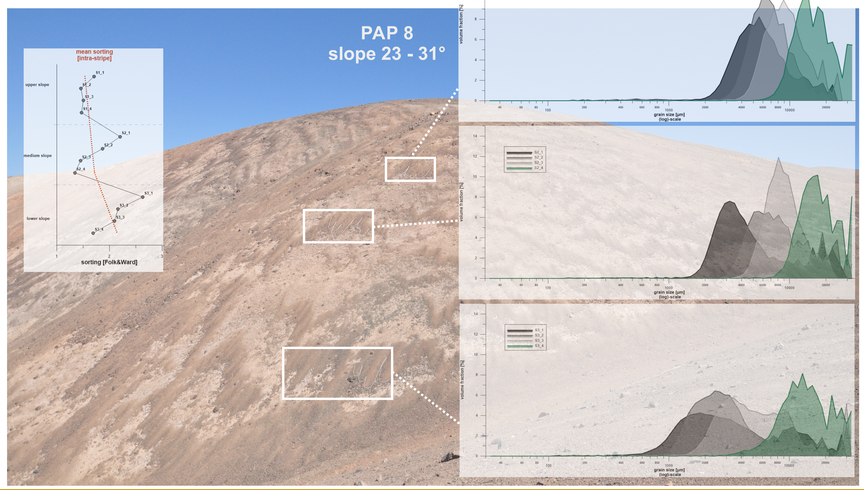
The Atacama-specific zebra stripes generally occur on hillslopes of varying inclination within areas of lowest rainfall and low fog frequency. As perhaps the most enigmatic landform in the Atacama, zebra stripes are made up by sequences of **contour-parallel**, lateral bands of **angular clasts** with **stripe-internal grain sorting** followed by rather **clast-free interspaces**. The lateral succession of 1-3m wide frontal lobes resembles **granular fingering** identified in experimental tests on granular flows of different particle mixtures (i.e. Pouliquen et al., 1997; Valderrama et al., 2018). In a region, where water, vegetation or soil formation processes are virtually absent, and their influence on surface geomorphology is limited, we emphasize the role of seismicity in the formation of zebra stripes and the Atacama landscape in general. Inter-site comparison points to considerable differences between individual zebra stripe appearances, potentially reflecting different timescales of seismic acitivity.



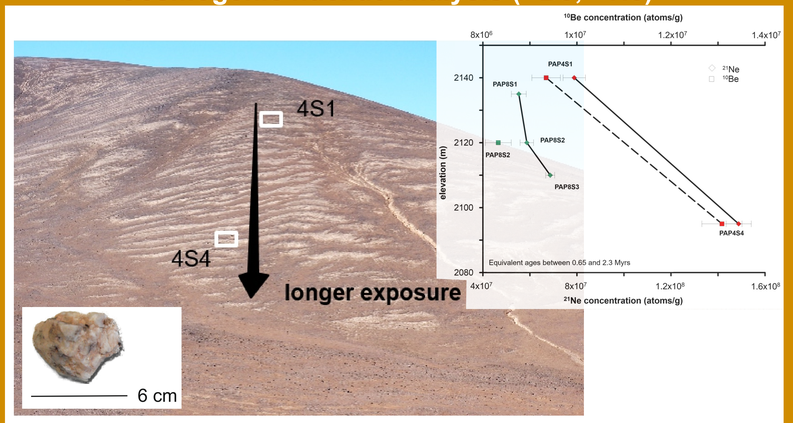
Geomorphological features indicating „activity“



Active forms of zebra stripes are indicated by **well-developed frontal lobes**, **reduced dust accumulation** in clast interstices, clearly developed **downslope sorting within individual stripes** and concurrent **slightly decreasing mean sorting** values of entire stripes towards lower slope sections. High proportions of surface cover are assumed to be related to free floating of particles. In contrast, presumed palaeo-activity of stripes is related to poorly visible to degraded frontal lobes, higher dust contents, indistinct sorting trends and high portions of clasts embedded into the underlying vesicular horizon.

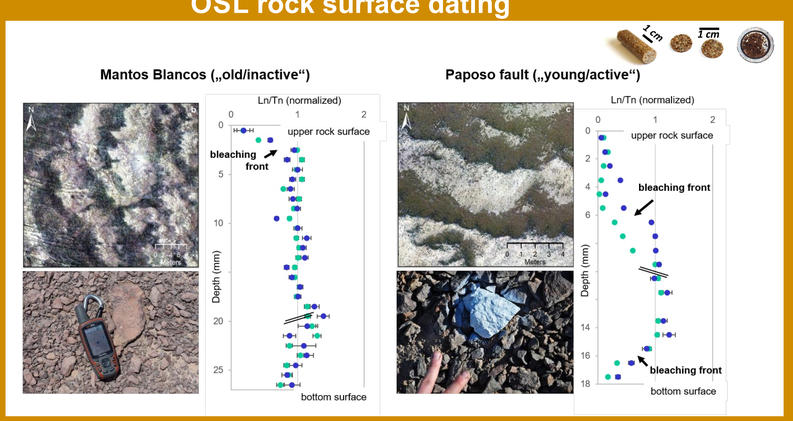


Cosmogenic nuclide analysis (^{10}Be; ^{21}Ne)



Preliminary chronological data of cosmogenic nuclide analyses (^{10}Be; ^{21}Ne) and OSL rock surface dating suggests the potential of these techniques as a tool for **deciphering relative intra- and inter-site chronologies** and constraining timescales of activity/stability patterns. A parallel **downslope increase of terrestrial cosmogenic nuclide concentrations** on PAP4 and PAP8 supports the assumption of succesive downslope transport of clasts, likely related to zebra stripe formation. Comparative OSL rock surface dating experiments suggest that **active stripes contain clasts with bleaching fronts on both surface and bottom sides**, pointing to late Pleistocene or Holocene clast overturning. Inactivity is indicated by similar IR50 and pIR225 bleaching curves (equilibrium of bleaching and dosing) in upper clast surfaces and the lack of a bleaching front at the bottom side, pointing to long exposures without clast overturning.

OSL rock surface dating



Future perspectives

Future investigations will concentrate on:

- The role of (sub-) surface gypsum dynamics and the significance of (rare) fog influence (shrink-swell dynamics?)
- Long term soil-moisture and temperature trends (freeze-thaw processes?)
- Measurements of local seismic activity
- Particle-based simulations of granular flows and stripe formation
- Constraining timescales of zebra stripe formation
- Focusing on intersite comparisons

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