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Zebra stripes in the Atacama revisited – seismicity-induced granular fingering as a mechanism for zebra stripe formation?

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The hyperarid parts of the Atacama Desert, N Chile, are among the driest places on Earth, and a number of studies have emphasized the remarkable slowness of earth surface processes since the late Tertiary. Nevertheless, geomorphic processes such as overland flow or flash flood activity, salt-driven shrink-swell processes, dust deposition, or seismic shaking have significantly contributed to the landscape formation in the Atacama. Hitherto, the study of Owen et al. (2013) represents the only study with detailed investigations on the enigmatic and Atacama-specific zebra stripes, which are contour-parallel, thin lateral bands of rather angular gravels on hillslopes, characterized by grain sorting and a specific wavelength. While these authors suggest that zebra stripes represent fossil evidence of overland flow, recent investigations on the formation of the Atacama boulder fields emphasized the significance of seismicity in shaping Atacama landscapes, thereby challenging the water-related evolution of zebra stripes.
Based on UAV-derived high-resolution aerial photos, geomorphological surveys and sediment sampling, this contribution adds important new and contrary data on zebra stripe patterns, which may be conducive in their better understanding. We document a wider distribution of zebra-type stone stripes than previously published, and a rather high variability of zebra stripe characteristics with regard to stripe orientation, sorting-patterns and bedding properties. Stripes are poorly to well sorted, and surface gravel units may be multi-grained and up to 10 cm thick, loosely bedded, and entirely uncemented. At most locations, stripe orientation seems to be oblique rather than parallel to contour lines. In addition, stripe fronts at numerous locations consist of multiple bulges of 0.5-2 m width showing lateral and downslope coarsening patterns. Based on the form-concordance between these zebra stripes and experiments on segregation-induced granular fingering, we propose a combination of seismic shaking and dry granular free surface flows as the most likely mechanism for the formation of zebra stripes, rather than (palaeo-) overland flow. As such, our findings may complicate the geomorphic interpretation of zebra stripes and the inference of related geomorphic processes.