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Coupled controls of climate, geology, and biota on late Pleistocene alluvial fan morphodynamics along the coast of the hyperarid Atacama Desert

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In the hyperarid environment of the Atacama Desert, alluvial fans are the principle fluvial geo-archive reflecting variations in climate and tectonics in their architecture. While they have been studied in the core of the desert to reconstruct long-term palaeoenvironmental changes from the Oligocene to the Quaternary and, in particular, to constrain the onset of hyperaridity, alluvial fans along the coast (20.5°S – 25.5°S) are younger and show a much higher activity; thus, they can serve as archives during the Pleistocene to Holocene evolution. However, past and recent morphodynamics of the coastal alluvial fans (CAF) are yet poorly reconstructed so that the understanding of an interplay between climatic, geologic, and biotic controls is still challenging.

We related climatic, lithologic, and tectonic source-area characteristics to geomorphometric parameters of the CAF and their catchments. Geomorphometric analyses were conducted based on the 12.5 m TanDEM□X WorldDEM™, lithological and tectonic data were extracted from regional geological maps, and the frequency of heavy rainfall events derived from a regional Weather Research and Forecasting (WRF) model was used as a climate parameter. We further combined luminescence dating, cosmogenic nuclide exposure dating, and existing chronological data to constrain the timing of Pleistocene alluvial fan deposition as well as the ages of interbedded marine terraces.

Results indicate a primary climatic control on CAF dynamics shown in the functional relationships with catchment hydromorphometrics that mirror a high susceptibility to debris-flows as well as in the temporal pattern of CAF activity. Distinct phases of CAF activity occurred during the late Pleistocene (95–80 ka, 60–45 ka, and 35-20 ka) and the Holocene – driven by atmospheric changes from the Pacific Ocean. The primary source of precipitation is reflected along the latitudinal gradient: frontal systems and cut-off lows mainly originating from the extratropics. Towards the south, an increasing density of Loma vegetation can be observed so that also possible feedback

mechanisms of biota on sediment supply need to be considered. While source-area lithology is of negligible relevance for CAF morphodynamics, an important long-term influence of tectonics can be seen in the regional uplift, which in turn controls the catchment shape and relief. From the numerical dating of the marine terraces, uplift rates ranging between ~0.06 and ~0.57 m/ka were derived for the late Pleistocene period.

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