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Did the enhanced lateglacial monsoon trigger glacial advances south of the Arid Diagonal?

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The South American Summer Monsoon (SASM) causes the advection of moisture from the Atlantic and the Amazon Basin to the Altiplano and the Central Andes. The influence of the monsoon decreases rapidly in southern direction. Between 18˚S and 27˚S no glaciers exist due to the extreme aridity. South of this so-called Arid Diagonal, a steep precipitation gradient from 100 mm/yr at 26˚S to 400 mm/yr at 30˚S is attributed to the growing influence of the westerlies, which transport moisture from the Pacific. The Central Andes are obviously a key area for studying Late Quaternary changes in the tropical and extratropical circulation systems. Huge moraines, documenting at least one period of substantially increased precipitation, are indeed found north and south of the Arid Diagonal. Dating difficulties due to the lack of suitable material for radiocarbon dating, however, severely hindered the establishment of reliable glacial chronologies and thus the reconstruction of past climatic conditions.

In Bolivia, north of the Arid Diagonal, glacial advances have been confirmed to be synchronous with lateglacial lake transgression phases (Tauca, ∼15-12 ka BP). As expected, the glacial advances thus occurred at times of increased South American Summer Monsoon. Timing and precipitation source of the maximum glacier expansion south of the Arid Diagonal remains speculative. Glacier-climate models indicate different temperature and precipitation conditions for the prominent glacial advance than for those north of the Arid Diagonal. It was therefore suggested that the glacial advances occurred during the global temperature minimum of the Last Glacial Maximum (∼18-20 ka BP). The seasonality of the precipitation could not clearly be deduced from the glacier-climate model, but based on the present climate conditions, the westerlies were expected to contribute significantly to the moisture advection.

In order to establish a reliable glacial chronology for the Encierro Valley (29˚S), just south of the Arid Diagonal, we applied surface exposure dating using *in-situ* produced cosmogenic ^{10}Be. Our results indicate that the most prominent moraine was deposited by a glacial advance at ∼15 ka BP (six boulders with exposure ages of 14.9, 14.4, 13.8, 13.1, 11.6 and 9.7 ka BP). Furthermore, a recessional moraine could be dated to ∼12 ka BP (12.4, 12.1, 11.6 and 11.1 ka BP). The observed data scatter is mainly attributed to post-depositional geomorphological instability causing boulders to rotate and to be exhumed from the moraine matrix. Boulder ages can thus easily underestimate the deposition age of the moraine and the oldest sample should be the best estimate for the age of the glacial advance. When discussing the exposure ages in the paleoclimatic context, one should be aware of a systematic uncertainty of ∼10%. This is due to uncertainties concerning the reference production rate, as well as latitude and altitude scaling.

We conclude that the Late Quaternary glacial advances south of the Arid Diagonal probably occurred synchronously with those north of the Arid Diagonal and the lateglacial lake transgression phases on the Altiplano. Increased precipitation, rather than reduced temperature, played the dominant role for the glacial advances in the Encierro Valley. We tentatively suggest that the South American Summer Monsoon influenced regions south of the Arid Diagonal much more during the Lateglacial than today, triggering extensive glacial advances, which are documented by prominent moraines.