Holocene cryo-geomorphological dynamics in the upper Río Limarí basin (30-31°S), Subtropical Andes of Chile: paleoclimatic implications for the origin of rock glaciers

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In the Subtropical Andes of Chile, the cryosphere is highly sensitive to climate changes (Bodin et al. 2010). This mountainous landscape, abundant in debris, showcases landforms resulting from the interplay between glacial and periglacial dynamics that have shaped the landscape from the Last Glacial Maximum (LGM) to the present. These well-preserved landforms present an excellent opportunity for better understanding the intricate atmosphere-cryosphere interactions concerning climate shifts (Fernández et al. 2023; García et al. 2014; Knight and Harrison 2014; Lira et al. 2022).

The headwaters of the Río Limarí basin (30-31°S; ~3000-5000 m a.s.l) are part of the semiarid Andes of Chile, which are still influenced by the mid-latitude westerly winds and intersect the Arid Diagonal in the south. Precipitation occurs mainly in winter associated with a weakened South Pacific Anticyclone, with its interannual variability influenced by the El Niño Southern Oscillation (ENSO) (Garreaud 2009). The dry and cold conditions lead to the ubiquitous presence of landforms associated with ice-rich permafrost, such as rock glaciers. In fact, rock glaciers in the Río Limarí basin cover an area of ~25.6 km^2 (DGA 2022). However, the origin and processes of rock glaciers as well as the evolution of the cryosphere since the last Glacial Termination (~18-11 ka; Denton et al. 2010) is an unresolved issue (Knight et al. 2019), and of increasing relevance due to the potential of rock glaciers as water reserves in these areas experiencing drought conditions (Azócar and Brenning 2010; Fernández and Ferrando 2018).

A mosaic of glacial, periglacial, and paraglacial landforms is identified in the Andean portion of the Río Limarí basin, accounting for the interaction and succession between glacial, paraglacial, and periglacial dynamics occurring since the Late Pleistocene to the present (Carraha et al. in press). The retreat of glaciers likely triggered periglacial dynamics in this Andean environment. In this context, our focus lies on interpreting the cryo-geomorphology and its climatic implications in the Río Limarí basin, specifically considering potential variations in glacial and periglacial domains throughout the Holocene. Our objective involves analyzing the origins of rock glaciers and the factors influencing their spatial distribution. This is acknowledging that the diversity, frequency, and distribution of rock glaciers serve as crucial indicators of regional cryosphere evolution dynamics (Frauenfelder and Kääb 2000). Additionally, we aim to assess the presence and distribution of permafrost in the valley while exploring the role of ENSO in influencing the glacial-periglacial domains controlling the landscape.

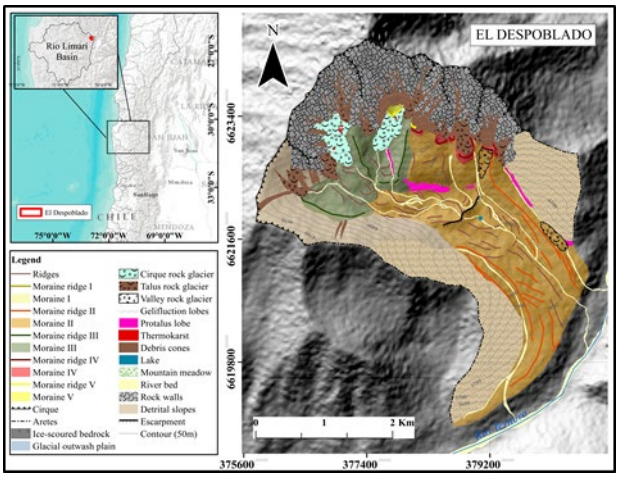

Figure 1. Geomorphological map of El Despoblado Valley.

Therefore, we present a detailed, field-based reconstruction of the geomorphology in the upper Río Limarí basin. Our methodology involves field work and remote sensing analysis to conduct detailed geomorphological mapping in El Despoblado valley (30°31'S; 3600-5400 m a.s.l) (Figure 1), a formerly glaciated valley situated in the head of the Río Limarí basin. Through the meticulous geomorphological mapping carried out in this valley, we have identified different types of rock glaciers, such as cirque, talus, and valley rock glaciers, as well as more complex

landforms including ‘debris rock glaciers’ (Barsch 1996) or moraine-derived rock glaciers (Lilleøren and Etzelmüller 2011), suggesting periglacial reworking of glacial deposits. We have also identified rock glaciers whose geomorphological features suggest different degrees of activity and which act as indicators for the occurrence of permafrost conditions in the valley (Barsch 1992; Buckel et al. 2021).

Our ongoing efforts aim to shed light on the causal relationship between glacial retreat and the formation of rock glaciers within this study area. Furthermore, surface exposure dating efforts have been made to establish temporal constraints for these geomorphic records. These findings from a barely explored region in the Andes, to be presented during the International Conference on Permafrost ICOP2024, provide valuable insights into understanding landscape transformations amidst regional climate changes and increasing aridity.

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