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Geomorphic consequences of two large glacier and rock glacier destabilizations in the Central and northern Chilean Andes

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Mountain areas are occasionaly affected by complex mass movements of high magnitude and large extent, which generally involve water, snow, rock and ice in variable proportions. Those events can take the form of rock avalanche, landslide, debris flow, glacier collapse or a combination of these phenomenons. In the Central Andes of Chile, they affect hardly accessible regions with low population, explaining the scarcity of previous studies. Nevertheless, during the last 30 years, some documented examples of such events in this region have shown that the volume of material involved is in the order of several millions of m^3, the areas affected can reach several tenth of km^2 and the velocity of the movement can exceed several tenths of m/s.

In this context, this study intends i) to inventory and to describe the main characteristics of events previously documented in the Central Andes of Chile, and ii) analyse in detail two recent events (2005-2007) never described before which have affected in one case a glacier and in another case a rock glacier.

With the objectives of determining the possible chain of triggering factors and interpreting the event's significance in terms of geomorphic, cryogenic and climatic dynamics, we used air photographs, satellite imagery (Landsat TM & ETM+; Quick Bird when available in Google Earth 5.0), data from the closest meteorological stations, glacier mass balance data and seismic records to investigate the collapse of a rock glacier occurred in 2006 on the west-facing flank of the Cerro Las Tórtolas (6160 m asl; 29º58' S. - 69º55' W.), in the arid North of Chile, and the collapse of a glacier that occurred during austral summer 2006-2007 on the South side of the Tinguiririca Volcano (4075 m asl; 34°48' S. - 70°21' W.).

The rock glacier collapse of the Cerro Las Tórtolas West flank occurred during the spring of 2006, but signs of destabilization were already observable since the end of 2005. The deposit of the collapsed mass of the glacier covered $0.12km^2$, nevertheless part of the material mobilized was channelised in a 200m-wide ravine generating an hyper-concentrated flow of snow, ice, water and debris, which traveled for 3 km downslope.

The event of the Tinguiririca Volcano South flank occurred between the 29th of December 2006 and the 14th of January 2007 and affected a mountain glacier of 0.46 km^2. The destabilization of this later led to a quasi complete detachment of the glacier mass, which flowed to the bottom of the valley and, incorporating rock debris, snow and water, traveled downslope for more than 7 km.

The destabilization and collapse of both studied landforms occurred during exceptionnaly warm periods of spring and summer and the climatic conditions produced intense glacier downwasting in Chile. This situation might have favoured the destabilization, either by reducing the basal friction of the glacier or by saturating the detritic sole of the rock glacier, both mechanisms being related to large quantity of melt water in the system. Although further research is needed, this temporal concordance suggests that those extreme geomorphologic phenomenons could be partly related to warming air temperatures.