RECENT COLLAPSE OF ROCK GLACIERS

TWO STUDY CASES IN THE ALPS AND IN THE ANDES

Xavier Bodin[1], Jean-Michel Krysiecki[2] and Pablo Iribarren Anacona[3]

INTRODUCTION

In mountain areas, the consequences of ice-rich permafrost degradation constitute a crucial yet poorly understood question. Indeed, in the Alps, numerous acceleration and destabilization of rock glaciers have been reported (Roer et al., 2008) and raise questions on the possibly rapid evolution of mountain permafrost under warmer conditions.

Recently, the collapse of two rock glaciers occurred in the French Alps and the Chilean Andes, with an important mass movement affecting the rock glacier body and a mud flow originating from the collapsed mass. After describing these two cases (Fig. 1) in terms of their morphological specificities (based on field work and photo analysis) and the chronology of the phenomenon (inferred from oral witnesses, photos and satellite imagery), we discuss here the potential respective roles of i) the site-specific characteristics, like the bedrock topography, the geological context or the meteorological conditions, and of ii) the long-term climatic evolution, like increasing air temperature or snow cover trend on the change of rock glacier dynamics.

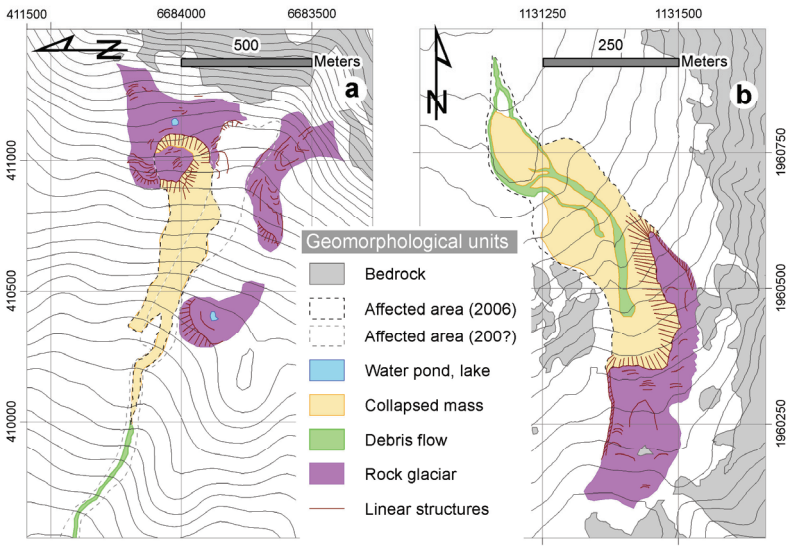

Fig. 1 Geomorphological context of the collapse of Las Tórtolas (a) and Le Bérard (b) rock glaciers. DEM from ASTER data and IGN map, coordinates in meter

DESCRIPTION OF THE EVENTS

At the end of boreal summer 2006 (Krysiecki et al., 2008), the Bérard rock glacier (Fig. 1a, N44°26'37" – E6°40'59", 2850 – 2650 m asl.), located in the upper part of a North facing valley, has experienced a collapse of its frontal part.

Signs of destabilization were already visible in summer 2004 with the formation of a 80 m-long transverse crack.

A volume of 1.5 million m^3 of ice and debris was deposited 150 m lower on a flat part of the slope and was subsequently affected by a mud flow.

[1] Dr. Xavier Bodin. Laboratoire EDYTEM, CNRS – Université de Savoie, Le Bourget du Lac, France (e-mail : xavier.bodin@univ-savoie.fr)
[2] MSc Jean-Michel Krysiecki, Institut de Géographie Alpine, Université Joseph Fourier, Grenoble, France
[3] Pablo Iribarren Anacona, Unidad de Glaciología y Nieves, Dirección General de Aguas, Santiago, Chile

The rock glacier collapse on the Cerro Las Tórtolas West flank (Fig. 1b, S29°58'17" – W69°55'21", 4700 – 4300 m asl.) occurred during austral spring 2006 (Iribarren & Bodin, 2010), but signs of destabilization were already observable since the end of 2005. The deposit of the collapsed mass of the glacier covered 0.12 km², nevertheless part of the material mobilized was channelized in a 200 m-wide ravine generating a hyper-concentrated flow of snow, ice, water and debris, which travelled for 3 km downslope.

DISCUSSION

Several site specific-characteristics, which could have favoured the triggering of these events, can be identified:

- the bedrock topography: for both cases, the collapsed part of the rock glacier was lying on a ~20° slope and directly hanging over steeper slope (30-35°);
- the geological context: for both cases, no marked seismic activity was recorded (Servicio Sismológico de Chile and Sismalp networks) at the considered places and periods; no detailed geological mapping is available for Las Tórtolas whereas for Bérard the litho-structural settings don't seem to be favourable to deep-seated mass movements;
- the meteorological conditions: the air temperature and the water discharge data recorded at La Laguna station (located 28 km further South from the Las Tórtolas rock glacier) suggest that a strong snow melting event was occurring between end of October 2006 and mid November 2006 (Fig. 2a); in the Bérard rock glacier area, warm air temperature and heavy raining storms have been recorded in July 2006 at Les Orres station (Fig. 2b).

At a larger time-scale, the regional climatic analysis point out toward a warming of surface temperature, amounting to ~ 0.2-0.4°C/decade between 1979 and 2006 around 2000-3000 m asl. in the Northern Chilean Andes (Falvey & Garreaud, 2009) and to 0.9°C during the 20th century (Casty et al., 2009) in the Alps. Similarly, the longest series of ground temperature on mountain permafrost, in the Swiss Alps (Haeberli & Gruber, 2008), show an increase of 0.4°C/decade between 1987 and 2007, whereas no such data are available in the Andes.

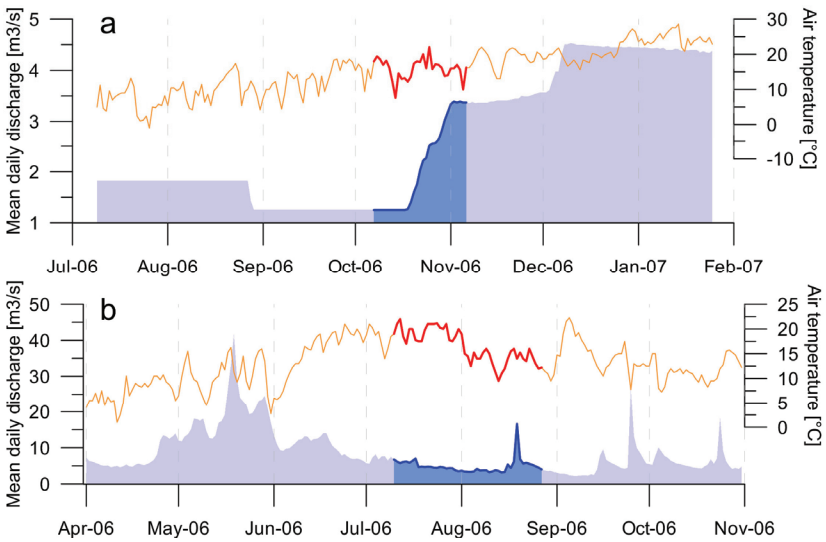

Fig. 2 Air temperature and water discharge at the closest stations from Las Tórtolas (a) and Le Bérard (b) rock glaciers (in darker colours the period during which the collapse occurred). Source: Meteo France and DGA-MOP.

For the two studied cases, the topographical convexity of the terrain might have favoured a progressive destabilization of the rock glacier, whereas the initiation of the movement could coincide with large inflows of melt-water and precipitation. In addition, the permafrost warming during the last decades (Haeberli & Gruber, 2009) might cause higher deformation rates (Kääb et al., 2007) and increased basal sliding due to higher water content (Ikeda et al., 2008).

Keywords: mountain permafrost, rock glacier, mass movement, hazard