

## **Deglaciation phases and derived geomorphologic processes on the Coropuna stratovolcano (southern Peru)**

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Our study area was located on Nevado Coropuna (15° 31' S; 72° 39' W), a stratovolcano located in the western range of the Peruvian Andes with a maximum altitude of 6.377m. The research objectives were: map the geomorphologic remnants of the maximum glacier advance and the subsequent process of deglaciation that developed on Coropuna, establish relative time sequencing of the morainic formations observed, and analyze the association of glacial processes and volcanic activity. The study of deglaciation on Nevado Coropuna is of great interest not only for geomorphologic research, but also with regard to hydrovolcanic hazard prevention.

The phases of deglaciation and surges that alternate throughout the late Pleistocene and Holocene in this sector of the Andes have not been studied and constitute a future research goal that encompasses an array of multidisciplinary interests. Coropuna is a tropical stratovolcano topped by glaciers of various types that often are dozens of meters thick and cover a surface area of 120 km<sup>2</sup>. With the aid of satellite imagery processing and photointerpretation, we were able to detect relatively recent phases of volcanic activity and establish a time sequence that revealed a general tendency toward glacial recession.

Sudden ablation of some of the glaciers on Coropuna caused by volcanic and/or climatic events are apt to trigger mudflows that could affect dozens of communities located on the southern slope near Pampacolca, Chuquibamba and Yanaquihua. The flows may originate at different altitudes which, in some cases, could mean as much as a 3000 m elevation difference over a distance of 15-30 km from the summit to the towns. This high risk scenario clearly demands the development of hazard prevention studies.

In our study we used Landsat 2000 satellite images in MrSid format in combination with 1-2-3 bands in false color, and the aerial photographs from a 1955 (U.S. Army), in black and white. Both sets of images were georeferenced and rectified using ArcMap. The base topography was obtained by digitizing maps 2339-I-Pampacolca and 2340-II-Capilla (U.S. Army 1967) from the Instituto Geografico de Peru, with a scale of 1:50,000 and U.T.M. projection with provisional horizontal datum for South America, 1956. These sources were integrated in a GIS by combining ArcView, ArcGIS and ERDAS to georeference geomorphologic cartography and to perform analysis, data overlay, measurements, correlations, and statistical calculations.

The results produced a relative chronology of morainic formations generated during the most recent advance of the Last Glacial Maximum and during the events that occurred in the subsequent deglaciation process. The geomorphologic units of volcanic origin were significant in terms of their relationship to the glacial processes. The conclusions propose aspects that should be considered in programming fieldwork that will assist in verifying our hypothesis and advancing the research.

In the abstract we present the case of the northern glacier systems of valleys of Mapa Mayo and Chaqui Ullullo (figure 1, 2 and 3), based on partial geomorphologic mapping of this sector and two Digital Elevation Models (DEMs)

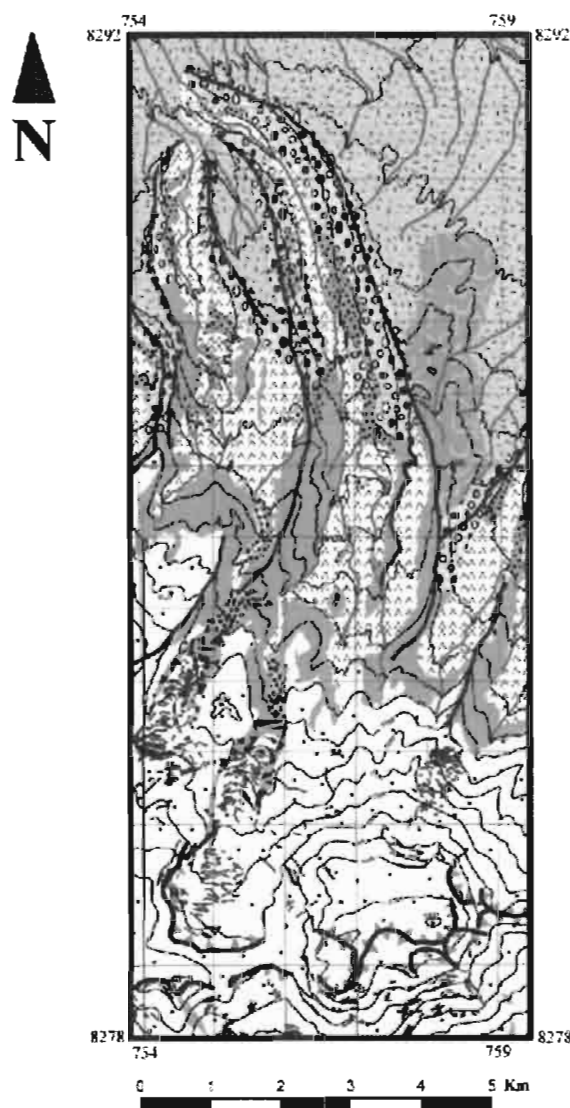
in which we identified control points to overlay the Landsat image and the georeferenced photographs from the U.S. Army reconnaissance flight.

The finished work provides maps and DEMs with different scales that show the spatial distribution of past processes and analyzes the risks associated with possible sudden episodes of deglaciation. The system used to generate this information will serve as the basis for future modeling verification tests as part of the Lahar Project ([www.ucm.es/info/agr/lahar.html](http://www.ucm.es/info/agr/lahar.html)).

## THE GLACIER COMPLEX OF CHAQUI ULLULLO AND MAPA MAYO










(North side of the Coropuna stratovolcano · Andes Range · Perú)

**FIG. 1: GEOMORPHOLOGIC CARTOGRAPHY**









### LEGEND OF FIG. 1

**GLACIAR LANDFORMS**

-  Glacial cirques
-  Maximum glacial advance limits
-  Glaciers and snow areas
-  Crevasses
-  Maximum advance moraines
-  Intermediate phase moraines
-  Recent moraine complex
-  Present push moraines
-  Bottom of the glacial valleys

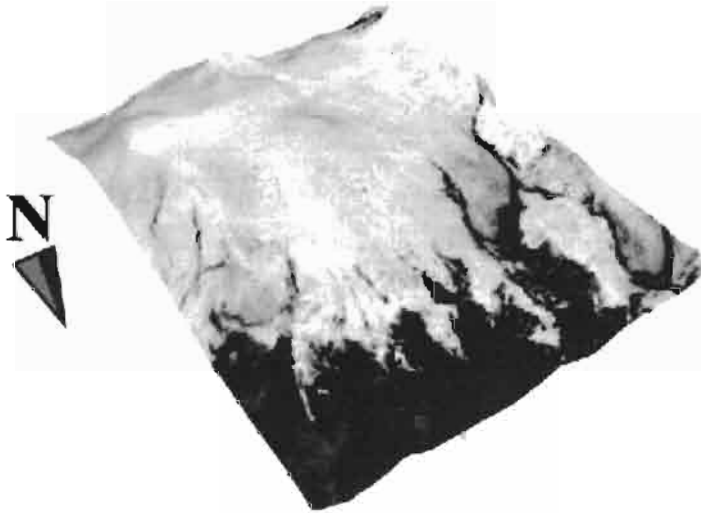
**COMPLEMENT INFORMATION**

-  Rock Steps
-  Preglacial lava flows
-  Proglacial ash ramps
-  Drainage streams
-  Chaqui Ullullo lake
-  Isoline 100 m. equidistance

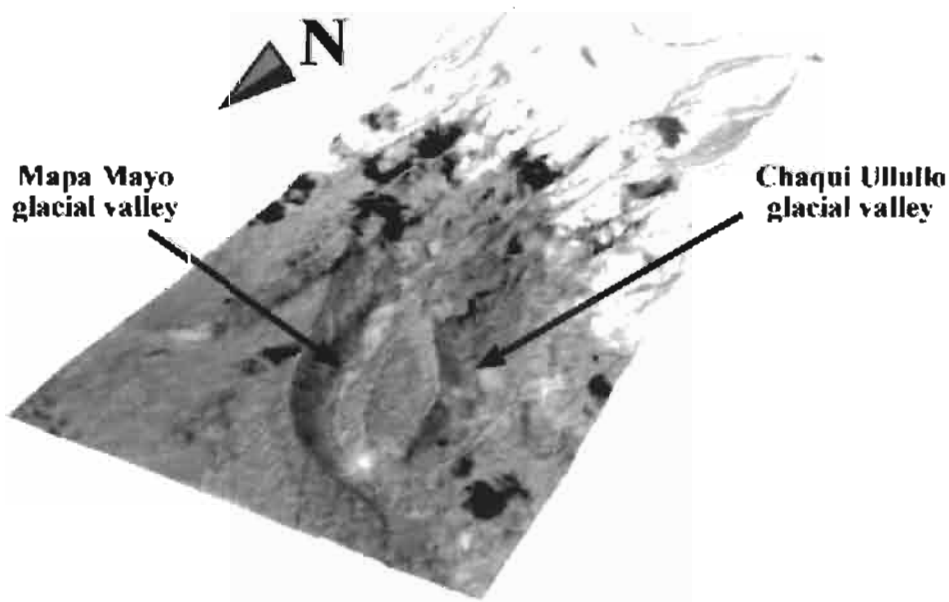
Base maps: 2239 I - Puno/centra (1:40 000 - Castilla) e 1:50 000  
 Instituto Geográfico de Perú (based on U. S. ARMY 1967)  
 U. S. M. PROJECTION - (Horizontal datum: 1959 datum South America 1956  
 Aerial photos of: 14495 y 15177 (U. S. ARMY 1955)

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**DIGITAL ELEVATION MODEL (D.E.M.)**



**FIG. 2:** The summit area of the glacial complex of Mapa Mayo and Chaqui Ullullo, aerial photo number 15177 over DEM (view from NE)



**FIG. 3:** The moraine complex of Chaqui Ullullo and Mapa Mayo, (Landsat image 2000) over DEM, view from NW)