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MEASUREMENT OF SURFICIAL DYNAMICS IN BESIBERRIS ACTIVE ROCK GLACIER

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RESUMEN.- Control de la dinámica superficial en el glaciar rocoso activo de Besiberris.- Con esta breve nota pretendemos dar a conocer los estudios que, desde la Iª campaña realizada en el verano de 1991, están llevando a cabo varios miembros del Departamento de Geografía de la Universidad de Zaragoza en el glaciar rocoso de Besiberris (Pirineo leridano) de cara a controlar sus pautas de movimiento superficial.

Palabras clave.- Campaña de control, glaciar rocoso, dinámica superficial, Pirineo Central.

ABSTRACT.- Measurement of surficial dynamics in Besiberris active rock glacier.- With this note we want to make known the studies that, from the first campaign developed in 1991 summer, several members from the Department of Geography (Zaragoza University) are carrying out on the Besiberris rock glacier (Leridan Pyrenees) in order to control its surficial movement patterns.

Key words.- Monitorizing campaign, rock glacier, surficial dynamics, Central Pyrenees.

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1. INTRODUCTION

The aim of this brief note is to make known the studies that, from the past 1991 summer, several members of our Department of Geography (Zaragoza University) are carrying out on the Besiberris rock glacier - morphology located in the Spanish Central Pyrenees, at about 2650-2800 m a.s.l. - in order to control its surficial dynamics and movement rates. These include the establishment of a net-transect of control-points, from which accurate triangulation measurements had been obtained in August 1991, that will serve as reference in successive campaigns; the beginning of a lichenometric analysis of the rock glacier surface and its neighbourhood, to quantify anomalies in the colonization and development patterns related to the presence of differential flow and, finally, the detailed photographical observation of a small section on the rock glacier's frontal slope and its subsequent photogrammetrical analysis.

2. CHARACTERISTICS AND LOCATION OF BESIBERRIS ROCK GLACIER

The study of Pyrenean rock glacier morphologies have recently adquired an important development in Spanish scientific literature. Starting from the pioneer work of SERRAT, D. (1979), several works have been later produced [GUTIERREZ, M. & PEÑA, J.L. , 1981; HAMILTON, G.S. , 1988; AGUDO, C. *et al.* , 1989; CHUECA, J. , 1989, 1990, 1991; SERRANO, E. & RUBIO, V. , 1989; MARTI, M. & SERRAT, D. , 1990; CHUECA, J. & JULIAN, A. , 1991; SERRANO, E. *et al.* , 1991 (this one dedicated to the analysis of Besiberris glacier)]. Besiberris rock glacier is located in the southern central sector of the Pyrenean Range (Fig. 1), in the granitic Besiberris massif, near the limits between Huesca and Lérida provinces (Sheet 181; Mapa Topográfico Nacional 1:50000). The massif is aligned in a N-S direction, reaching heights over 3000 m (Besiberri N, 3014 m; Besiberri del Mig, 3008 m; Besiberri S, 3030 m; Comaloforno, 3033 m) and acting as a watershed between Noguera Ribagorzana and Noguera de Tor rivers. The rock glacier is ubicated at the foot of the Besiberri del Mig-Sur-Avellaners (2990 m) crest, facing north, and inside a shady and narrow cirque in which a small residual snow-patch is preserved. It begins at the 2800 m level and extends to the 2650 m, with a length of around 700 m and mean slope values close to 20°-30° (over 50° in the frontal talus). Its maximum width exceeds the 400 m in the mid-section even though, in general, does not surpass the 250 m value.

Morphologically, the rock glacier could be included in the tongue-shaped type, showing an atypical surficial topography, with signs of both extending - longitudinal furrows and ridges lined up along the central axis - and compressing flow - in a lateral apex with marked and well developed transverse furrows -. We think that its origin and/or preservation may be linked to the presence of an important periglacial activity, whose effects are visibly widespread throughout this high-altitude alpine area. The permanent snow-patch that surrounds the whole root sector and a portion of the rock glacier lateral talus confirms the existence of, at least, discontinuous permafrost. The feeding by seasonal avalanche processes must contribute to the apparition and development of intersticial ice, although the absence of visible outcrops makes difficult its direct observation. High slope values would have aid fluidal mechanisms by reducing basal shear stress and strain rates. Among the indirect indicative elements that let infer the existence of a present-day flow (creep) in Besiberris rock glacier we may mention: non-presence of vegetal colonization; extreme dynamism in the frontal talus, with abundant micro debris-flows and rock slides; presence of an apron of fresh coarse boulders at the foot of the fronto-lateral slopes; instability of blocks and existence of preferential-structured orientation of surface boulders in particular areas. The rock glacier's chronology has been estimated with approximation taking into

account its ubication inside morainic arcs belonging to the Little Ice Age, dated by lichenometrical techniques from the *Rhizocarpon geographicum s.l.* growth curve established in the nearby Benasque valley (CHUECA, J. & JULIAN, A. , 1992). Similar chronologies have been proposed for the few Spanish Pyrenean active rock glaciers so far studied (HAMILTON, G.S. , 1988; AGUDO, C. *et al.* , 1989; SERRANO, E. & RUBIO, V. , 1989).

3. CONTROL OF SURFICIAL DYNAMICS IN BESIBERRIS ROCK GLACIER

To carry out the control of surficial dynamics in Besiberris rock glacier we combined three different techniques usually mentioned in literature (*v.* HAEBERLI, W. , 1985): a) Installation of a net of control-points by placing nails in the fissures of several very large boulders; b) lichenometrical analysis of the rock glacier's surface and its surroundings, and c) photogrammetrical observation of the frontal-talus evolution. Repeated monitorizing in following years will lead us to a better understanding of its movement patterns improved, *a posteriori,* with the adoption of new control-points and the use of more sophisticated measurement techniques.

3. 1. Net-transect of control-points

Up to 11 control-points were established along a transect which crosses Besiberris rock glacier medium-part, with a NE-SW direction (transversally to the major flowline) and in an area with mean slope values around 15°-20° (Fig. 1). An spike nail especially designed to make easy the insertion in rock fissures was placed in each control-point, taking precise reference of its spatial location to facilitate successive readings. All boulders chosen as nail emplacements were of large dimensions, metric, and supposedly well fixed, in order to avoid the danger of measuring erratic movements not representative of the flow of the rock glacier. Accurate measurements between each control-point and its closest neighbours were carried out using a precision-tape, trying to set a triangulation array as dense as possible. The magnitude of the distances this way obtained (in no case over 30 m) and the realization of repeated measures, allow us to estimate an error margin in the whole survey process of around ± 1 cm.

The absence of solid bedrock in the western rock glacier margin - due to its hanging up ubication in the edge of a steep glacial threshold - made necessary to reference individual control-markers to a fixed survey station placed on the rock wall that frames the rock glacier in its eastern sector, at the foot of Besiberri del Mig peak. As the limitations in surveying accuracy of the tape measurer restricted its use to distances no over 30 m long, only the three more oriental control-points were directly related to this fixed station, while the position of the rest of them was determined by triangulation and foresight techniques. In next campaigns we will try to solve this problem using an electro-optical distance measurer, instrument much more precise and manageable that will facilitate an appropriate survey of the slow rock glacier movement. We intend as well to increase the net of control-markers, making it denser and homogeneous, and pursuing the total covering of all rock glacier's sections.

3. 2. Lichenometrical analysis

The lichenometrical analysis that we have started will help in the characterization of different facies with chronological value identifiable in the deposits

(talus, moraines, rock glacier) ubicated inside Besiberris cirque, trying to determine, particularly, the spatial location of differential-movement areas present in the rock glacier's surface. As the sampling process was designed to be global and exhaustive, a long period of time will be necessary to finish it. In a first stage, we have proceeded to inspect the distal stretch of the rock glacier and a wide section of the moraines that surround it, leaving for next campaigns the analysis of the rest of our work area. The guide-species used belongs to the *Rhizocarpon geographicum* (*s.l.*) subgenus, lichen abundantly present in the granitic lithologies of this sector. We have based the study in the application of three complementary techniques (for methodological aspects see INNES, J.L. , 1985): a) determination of the ten largest diameters found in each sample-point; b) analysis of the lichen degree cover existing on 20 blocks of each locality, and c) study of the size-frequency distributions of lichen tali.

3. 3. Photogrammetrical analysis of the frontal-talus

As we have mentioned before, the frontal-talus of Besiberris rock glacier shows notable signs of activity. To quantify in an accurate manner these displacements, we are carrying out detailed observations on this area using several photogrammetrical techniques. In this first campaign we have got overview and close-up pictures and stereopairs of the eastern fronto-lateral talus from a fixed station ubicated in its nearness. Its comparison in the future with new photographs, and the measure of the displacements in this way detected, will let us confirm and assess graphically the dynamism of the rock glacier's front.

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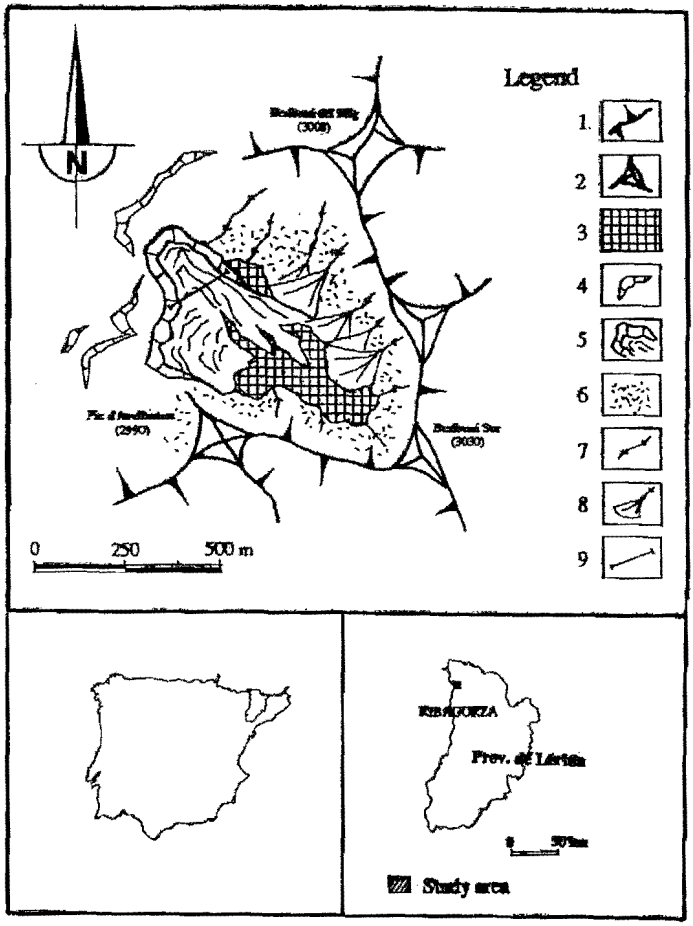

Fig. 1.- Location and geomorphological map of the study area. Legend: 1) Crests in granites; 2) Hörner; 3) Snow-patches; 4) Little Ice Age moraines; 5) Rock glacier; 6) Taluses; 7) Avalanche-chutes; 8) Talus-cones; 9) Control-transect.