Boletín de la Asociación de Geógrafos Españoles N.º 62 - 2013, págs. 463-465
I.S.S.N.: 0212-9426

GLACIAL GEOMORPHOLOGY AND DYNAMICS IN CARDAÑO VALLEY, PALENCIA (CANTABRIAN MOUNTAINS)

José María Redondo Vega
Javier Santos González
Departamento de Geografía y Geología. Universidad de León
jmredv@unileon.es, jsango@unileon.es

Extensive glaciation during the Quaternary in the Cantabrian Mountains created many glacial erosional forms (cirques, rock basins, lakes, U-shaped valleys...) which are widespread in the head of the main valleys. Moraines are less abundant due to the intensive postglacial erosion, especially in Cantabrian and Miño basins. In the last 10 years diverse authors have demonstrated that valley glaciers are more important than previous research has indicated (Pérez Alberti y Valcárcel Díaz, 1998; García de Celis y Martínez Fernández, 2002; González Gutiérrez, 2002; Redondo Vega, 2002; Alonso y Suárez Rodríguez, 2004; González Trueba, 2006; Jalut *et al*., 2010; Santos González, 2010).

Cardaño valley is, in the context of the Cantabrian Mountains, a very interesting place in the study of glacial geomorphology because of the well preserved erosional and depositional forms. Some works in the 19th century (Prado, 1852; Saint Saud, 1893) indicated the existence of permanent snow patches and, perhaps, a small glacier, in Cubil del Can and Espigüete, related with the Little Ice Age. Others studied the glacial geomorphology, especially the frontal moraine in Cardaño de Abajo, first mentioned by Nussbaum y Gigax (1953) and later included in Magna geological cartography (Rodríguez Fernández, 1984). Castañón Álvarez (1989) completed a thorough study of the valley and recognized the main glacial forms. According to the author, the Cardaño glacier was 10.8 km long and its front reached 1280 m. Recent work in the context of an inventory of Geological Heritage in Palencia province (Fernández Martínez *et al*., 2009) has demonstrated the existence of other glacial deposits that allow us to reconstruct in great detail the past ice extension.

An intensive fieldwork was carried out in order to recognize the glacial limits in Cardaño valley. The granodiorite outcrop located at the head of the valley (Agujas de Cardaño) was relevant in the investigation because there are many fragments of this rock in the entire valley, most of them on the top of sandstones and limestone rocks.

Then, we have reconstructed the paleoglacier and its hypsometry using a Geographical Information System (ArcGIS 9.2) in order to estimate the position of the Equilibrium Line Altitude (ELA) with the Area Altitude Balance Ratio (AABR) method. We have used the techniques defined by Benn and Gemmell (1997), Rea (2009) and the spreadsheet developed by Osmaston (2005). We then applied the AABR value for glaciers located in the Alpine and Atlantic zones (Rea, 2009), because we consider them the most adequate ones for the characteristics of Cardaño paleoglacier.

Cardaño valley is a short (15 kilometres long), south oriented and very steep valley in the north of Palencia province. The highest summits are around 2400 meters above sea level and the mouth into the Carrión river (now flooded by Camporredondo reservoir) is at 1260 m. Cardaño river is oriented North to South and crosses across the Paleozoicic structure, which is oriented West to East, (Rodríguez Fernández, 1984) and is intensively affected by the Alpine orogeny. Cardaño tributary streams are oriented East to West, following the structure. Cardaño river eroded its valley following the main geological discontinuities. Due to the high altitude of the valley and the favourable topographical conditions an important glacier system was developed during the last glaciation period.

Cirques are well defined, especially in the north face of the Espigüete summit and in the southern slope of the Agujas de Cardaño. In the last one, there are some lakes and ponds at 2120 m and 2055 m. The biggest one has approximately two hectares and is developed in the contact area between the Curavacas conglomerates and the granodiorites. Another pond is located in the Hoya Continua cirque, closed by a small moraine. A relevant small-scale erosional form is a polished and striated Carboniferous limestone outcrop close to the crossroad of Cardaño de Arriba, well preserved due to the till protection.

Depositional forms are widespread all along the valley, especially till and erratic boulders. At the head of the valley there are some lateral moraines, the biggest one located South of Pozo Lomas lake. In the Chico valley, where only very small glaciers developed in the South face of Espigüete peak, there are clay deposits, probably related to a paleolake at the end of this valley. Granodiorite erratic blocks (most of them 1 to 2 meters A-exe long) are essential in order to reconstruct the glacier thickness, which was 220 m at the mouth of Mazobres stream and 210 m at the crossroad to Cardaño de Arriba. Above this limit, the development of karren structures is notable, but poor below the erratic boulders.

In the road around Camporredondo reservoir, there are several till deposits integrated by all the different rock types of the valley, including big boulders of granodiorite, conglomerates and sandstones. The latest ones are frequently striated. The deposit is matrix-supported and boulders are sub-angular to sub-rounded, with the main exe preferably oriented North to South. Periglacial deposits are covering the till.

But the most important glacial deposits are three frontal moraines located to the south of Cardaño de Abajo at Camporredondo reservoir. The external one is a double arc with many boulders; some of them are striated. 250 m to the north there is another well preserved moraine. The latest one is a big moraine with many boulders; this is the only one recognized in previous research. The first and the second are normally flooded by Camporredondo reservoir. The last one is only partially flooded and emerged as an island. Lateral moraines in this part of the valley are well preserved only in some areas, due to intense erosion by landslides and human activity.

After the recognition of erosional and depositional glacial forms, we reconstructed the glacial limits and estimated the ELA position using the AABR method. Firstly, we calculated the hypsometry of the paleoglacier and the distribution of the glacial surface in each altitude range. With the data we estimated the ELA position at 1840±13 using the spreadsheet of Osmaston (2005). This is a high value compared with other Cantabrian valleys, but it is partially related with the south orientation of the valley and the location of the massif, south of Picos de Europa.

More effort is needed to reconstruct the paleoELAs in Cantabrian Mountains, but it is clear that there were great differences between valleys, with lowering values to the north, westernmost and easternmost. As an example, in Castro Valnera massif it was situated around 1100-1300 m (Serrano y Gutiérrez Morillo, 2002), similar to other ranges like Aralar (Ugarte, 1992), Cabezo Lloroso (Castañón Álvarez, 1990), Sierra del Palo (Alonso, 1998) or Caurel (Rodríguez Gutián *et al*., 1995). In Ancares range, Valcárcel Díaz and Pérez Alberti (1998) estimated 1350 m, the same value indicated by Alonso (1992) in the Ibias valley.

On the contrary, in Alto Campoo and Valdecebollas, Serrano and Gutiérrez Morillo (2002) calculated the ELA position at 1700-1900 m, even though, if the glacier deposits indicated by Fernández Martínez *et al*. (2009) are right, the value could be lower during the glacier maximum. In the central part of the Cantabrian Mountains, González Gutiérrez (2002) estimated 1500 to 1700 m south of the divide, and Jiménez Sánchez (1996) calculated 1550 m in the northern part. Santos González (2010) obtained a similar value in the Sil valley.

Recessional phases are difficult to reconstruct in detail because there are scarce moraines related with other phases, except some moraines above 2000 m in the cirques. There are small rock glaciers in some cirques, as in the Murcia peak (Redondo Vega *et al*., 2010), indicating permafrost conditions after the glaciation.

In conclusion, the ELA position in Cardaño glacier was situated at around 1840 m during its maximum advance, a high value compared with other Cantabrian valleys, but large surfaces over this altitude (and over 2000 m) favoured the development of the glacier system, 13.1 kilometres long and 3200 hectares in size.

But the importance of this glacier is not its extension (bigger glaciers were developed at many other Cantabrian valleys), but the good preservation and the high diversity of the erosional and depositional glacial forms, as cirques, moraines, striated outcrops or erratics. The glacial geomorphology of the valley has a relevant geomorphologic value and it is an important Geomorphosite that we must preserve.