Estudos do Quaternário, 4, APEQ, Lisboa, 2001, p. 61-68

VESTIGES OF THE QUATERNARY GLACIATION IN CABREIRA MOUNTAIN (NORTH-WEST PORTUGAL)

P. PEREIRA * & A. BENTO GONÇALVES **

Abstract

In the north-west of Portugal, the quaternary glaciation hadn't only reached the mountains of Gerês and Peneda. Also in Cabreira mountain, southward and with low altitude, forms and deposits with origin in the quaternary cold are remarked, even than in a smaller number and of a smaller dimension. This article tries to point out the sheltered character of the glaciation in the culminant massif of Cabreira mountain, as well as to distinguish the two kinds of landscapes present there, derived from an intense gelifraction (slopes with cryoclastic debris) and from glacial morphogenesis.

Key-words: Cabreira mountain, cold vestiges, Quaternary, sheltered character of the glaciation.

Resumo

Vestígios da glaciação quaternária na Serra da Cabreira (Noroeste de Portugal – No Noroeste português, a glaciação quaternária não terá atingido apenas as Serras do Gerês e da Peneda. Também na Serra da Cabreira, mais a Sul e a menor altitude se observam formas e depósitos com origem no frio quaternário, ainda que em menor número e de menor dimensão. No presente artigo, procede-se a uma abordagem sobre o tema e sobre a região, procurando-se salientar as condições excepcionais para a ocorrência do episódio de glaciação no maciço culminante da Serra da Cabreira, assim como distinguir os dois tipos de paisagem aí presentes, derivados de uma intensa gelifracção (vertentes cobertas de crioclastos) e da morfogénese glaciar.

Palavras-Chave: Serra da Cabreira, vestígios do frio, Quaternário, carácter abrigado da glaciação.

1. THE WÜRMIAN GLACIATION IN THE NORTH-WEST OF PORTUGAL

The study of the Pleistocene glaciation in the north-west of Portugal has interested the scientific community since the end of the 19th century. In fact, CHOFFAT (1895) had already referred to the possibility of a quaternary glaciation in Gerês mountain, although without presenting vestiges and concrete proves.

The vestiges of the glaciation in Gerês mountain have been searched since then and granted as possible by several researchers (FLEURY, 1916; RIBEIRO, 1955), but only with GIRÃO (1958) they begin to be presented, such as erratic blocks, "roches moutonnées", moraines and above all the lakes of glacial origin (CARVALHO & NUNES, 1981).

Only with the end of the decade of 70 some studies appeared deepened in glacial vestiges, not only in Gerês mountain but also in Peneda mountain, in which typically glacial forms and deposits are identified, as striate rocks, erratic blocks, moraines, fluvioglacial deposits or glacial cirques (COUDÉ-GAUSSEN, 1978; SCHMIDT-THOMÉ, 1978).

However, the result of these studies weren't commonly accepted by the scientific community, there were even authors defending the non-existence of a Pleistocene glaciation in the Portuguese north-west, considering that the forms and deposits identified there would have a torrential origin (TEIXEIRA & CARDOSO, 1979). Previously, the possibility of a quaternary glaciation in the northern mountains was renounced by LAUTENSACH (1932) during the study of these manifestations in Estrela mountain.

Recent studies established a consent as for the evidence of these vestiges in the Peneda and Gerês mountains (COUDÉ-GAUSSEN, 1981; MOREIRA & RAMOS, 1981; CARVALHO E NUNES, 1981; COUDÉ *et al.*, 1983; VIDAL ROMANI *et al.*, 1990; FERREIRA *et al.*, 1992, 1999), at the same time when the 1150 meters high were established as the snow line while the last glaciation of the north-west mountains. In the same way, forms and deposits were there cartographed, giving indications of a glaciation essentially of the cirque type and valley, with "glacial tongues" that wouldn't exceed the 150 meters thick, of a morphology that shows the weak efficacy of the glaciers, that essentially mobilized mantles of the pre-glacial changing and of a structural (in the guidance of the glacial valleys) and climatic (in the bigger heaping of the snows in the sheltered snows, either of sunstroke, or of the dominating winds of the west) conditioning of the glaciation (FERREIRA *et al.*, 1992, 1999).

The date of these episode has never been the main issue of the studies fulfilled recently, which considered above all the morphologic aspects. As a matter of fact, to the reconstruction of the glacial dynamics in the north-west of Portugal, it is considered essentially the association of the forms and deposits that better indicate that dynamics (moraines and sub-glacial tills) and its insertion in the regional geomorphology

* Geography and Planning, Ph. D. Student paolo@det.uminho.pt
** Secção de Geografia, Universidade do Minho, Campus de Azurém, 4810 Guimarães, bento@eng.uminho.pt

(FERREIRA *et al.*, 1992). However, those deposits are often confused with soils or with regolith itself, in the case of tills, or with slope deposits, in the case of moraines, when they aren't totally in the surface (VIDAL ROMANI & MOSQUERA, 1999; VIDAL ROMANI *et al.*, 1999).

In the several studies, absolute datation wasn't accomplished and it's being implicit that the glacial episodes described fit to würm (between 80 000 and 10 000 BP). As a matter of fact, it is consensual to temporise the glaciation of the north-west mountains in the terminal würm, and more precisely there are 18 000 BP, considering the moment when the temperatures reached the lower values and the sea its lower level, about 100 meters lower than the actual level (grimaldian regression). By Galicia latitude, in the winter, the surface temperature of the sea water would be about 2° C (13° C actually) and by Oporto about 7° C (14° C actually) finding to the latitudes of 40-42° N the preferential currency of the hollowed depressions to which strong winds from the west were associated to, that deviated into high rainfalls (even more abundant than nowadays) which feeded the glaciers in the north-west mountains (DAVEAU, 1979, 1980).

However, it is known that, due to the granitic substrate above which the glaciation has developed its datation becomes difficult. On the one hand, the geomorphological analysis is rather unwise, since the succession of phases of the glacial advancement, related to the alternation with warmer periods, made the vestiges of the last glaciations disappear and on the other hand the absolute datation was until now impossible due to predominance of the detrital component of the deposits. This absolute dating, by cosmogenic isotopes in quartz crystal, that allows to establish the age of exposure to the cosmic radiation of a glacied rock surface, has pointed to samples collected in Gerês, very different ages, settling that the current vestiges correspond to several phases of glaciation and not to only one (VIDAL ROMANI & MOSQUERA, 1999; VIDAL ROMANI *et al.*, 1999).

2. THE VESTIGES OF THE GLACIATION IN CABREIRA MOUNTAIN

As we have referred, of the north-west mountains of Portugal, only Peneda and Gerês are considered by the scientific community as mountainous areas affected by the quaternary glaciations, although altitudes above 1200 meters are marked in other mountains of the region. The Larouco mountain even displays similar altitudes to Gerês (1525 meters), Marão reaches 1415 meters, as well as Alvão (1329 meters), Barroso (1279 meters) and Cabreira (1262 meters) go beyond that level. The last would have been the only, besides the firsts, where implications of the quaternary cold while glaciation have been identified.

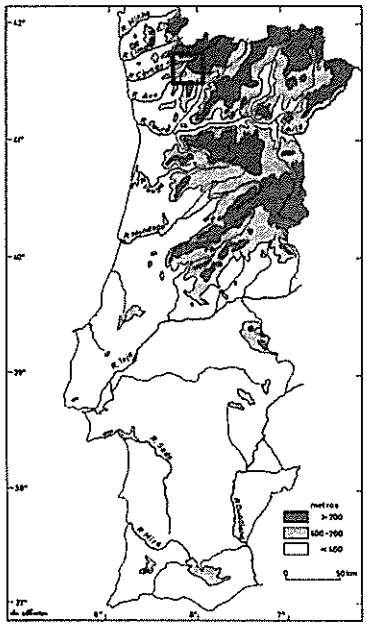

Figure 1 – Cabreira mountain location
Figura 1 – Localização da Serra da Cabreira

The quaternary glaciations in Cabreira mountain have been little studied until the present time. In his discourse about the municipality of Vieira do Minho written in 1923, VIEIRA referred to the «undeniable documents of the glacial era» (VIEIRA, 1923, p. 105). But it was DAVEAU that, after having raised the possibility of such glaciation (DAVEAU, 1977, 1980), presented in 1985 an important study with the collaboration of DEVY-VARETA (DAVEAU & DEVY-VARETA, 1985) and up to now, there weren't any other investigations on that matter in the area of Cabreira mountain.

According to DAVEAU & DEVY-VARETA (1985) in Cabreira mountain there would have been, in quaternary times, favourable conditions to the event of glacial erosion, more precisely in the culminant massif of the mountain, which can be considered as the meridional limit of those manifestations in the north-west of Iberian peninsula.

The conclusions presented by the authoresses about a quaternary glaciation southward Gerês mountain, considered as the meridional limit in the glacial episode of the north-west of the Iberian peninsula, and in altitudes between 1200 and 850 meters they can be seen as doubtful or at least unexpected. That study pretended, above all, to show how the quaternary cold had influence in the morphology of the Cabreira mountain northern slope, resulting of the favourable regional and local conditions verified there.

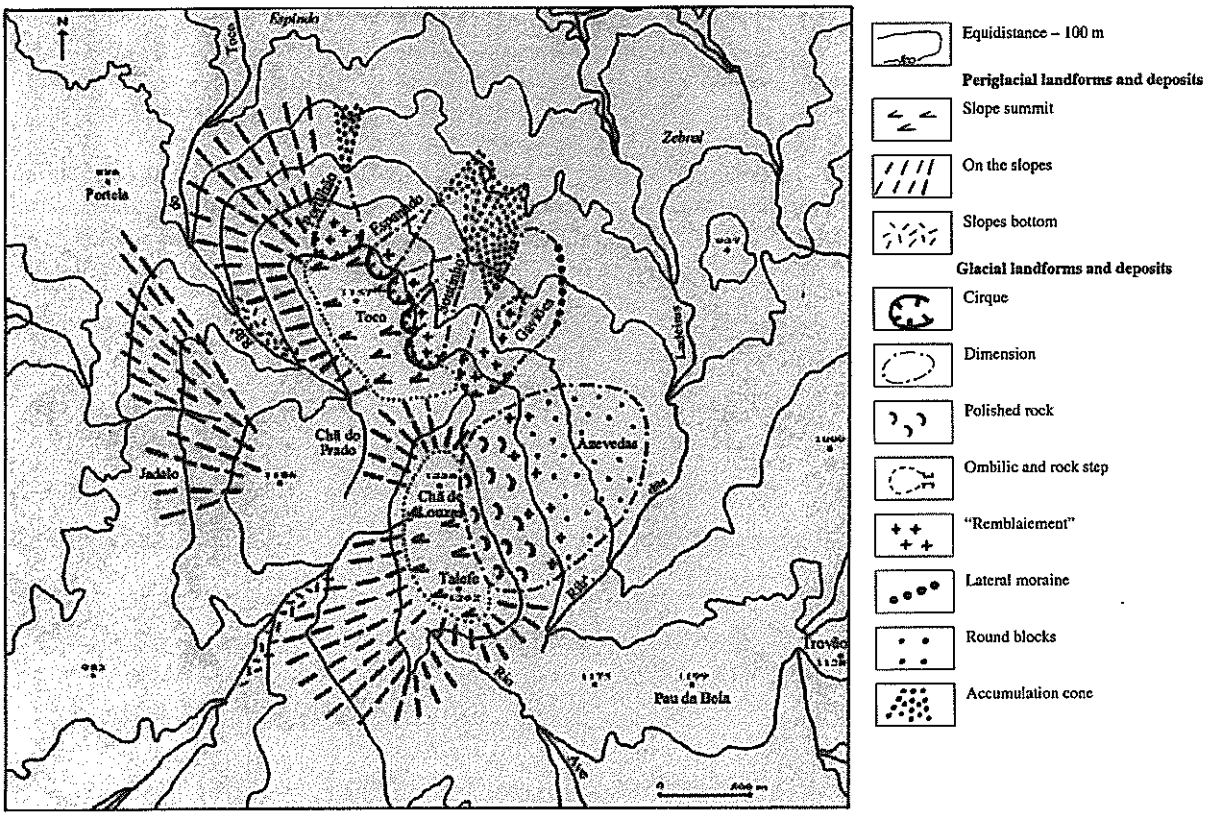

Figure 2 – Glacial and periglacial forms and deposits in culminant massif of Cabreira mountain
Figura 2 – Formas e depósitos glaciários e periglaciários no maciço culminante da serra da Cabreira.

On one hand, there is the presence of marks of the heaping and persistence of snow in the soil (firn and glacial tongues), as well as of glossy rock substrate, morenic deposits and heterometric deposits of angulous and round blocks, in the northern and eastern slopes of the culminant massif Talefe-Chã de Lousas-Toco and, on the other hand, the presence of a covering of granitic flagstones in those levelled tops and in their western slopes (figure 2).

2.1 The sheltered character of the glaciation

The vestiges observed in Cabreira mountain should however be seen as a result of a glaciation which occurred due to very favourable regional and local geographic conditions to its occurrence. This justifies why in other higher places of the region, similar manifestations aren't seen. In fact, the Cabreira mountain (1262 meters high) is part of the condensation barrier formed by the mountains of the inner north-west (figure 1). It is more affected by high rainfall (up to 3500 mm per year) than for instance the taller Larouco mountain, which reaches a height of 1525 meters, but east of Gerês mountain (DAVEAU *et al.*, 1977). This rainfall would have been even greater and predominantly in snow at the time of the north-west mountains glaciations. On the other hand the high slope angle, or the aspect of some slopes, may have created sheltered areas from the predominant westerly winds and the sun, leading to the development of firns and valley glaciers.

In the same way, it's important to refer that these vestiges can't be compared to those verified in Peneda and Gerês mountains, where glacial tongues showed densities in the order of the 150 meters and where those would be rather extensive, along valleys, and even less to those identified in other mountains of Galicia.

It's clear, though, that, even of a modest size, firns and glacial tongues have developed in some slopes of the Cabreira mountain. As we can see in figure 2, such would have happened in the small valleys of Pontilhão, Espanado and Soutinho, engraved in the north and north-west slope of Toco and mainly in the small valley of Gaviões and in the slope of Azevedas, NNE and E, respectively, of the levelled culminant top Talefe-Chã de Lousas.

The most developed glacial tongue (Gaviões) would have little more than a kilometre long and the maximum of 30 meters thick. Curiously, the small

valley where this one has installed doesn't seem to be occupied by a glacier, contrarily to the ribeira de Soutinho small valley, that seems much more engraved and with a bottom much more concavous, though in this one such an important glacial tongue hasn't developed (DAVEAU & DEVY-VARETA, 1985).

In figure 3, it's presented a simplified reconstitution of the probable glacial dynamics in Cabreira mountain, where it can be seen that the usual and icy west winds would blow the heaped snow in the occidental slope until the sheltered slopes of the sunstroke and of the winds, by its declivity and by its slope orientation. The result of this dynamics is the one of the referred morphological disparity, between the occidental and the oriental slopes.

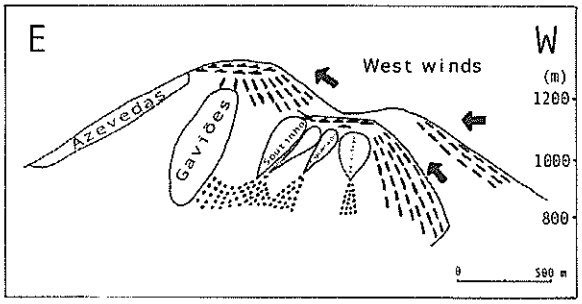

Figure 3 – Wind dynamics in culminant massif of Cabreira mountain (simplified reconstitution).

Figura 3 – Dinâmica simplificada dos ventos dominantes no maciço culminante da serra da Cabreira.

On the one hand, the high occidental slopes and the levelled summits, where the western winds didn't allow the snow and ice to heap, presented a modelled of intense gelifraction, with big granitic flagstones (macrogelifraction), while in the sheltered slopes it can be seen either erosion forms upstream, or heaping forms downstream (DAVEAU & DEVY-VARETA, 1985).

Focusing only these last two, we chose to divide the firn and glacial tongues related to the culminant massif of Cabreira (figure 4) into two groups: those which present clear marks of a glacier typical working and those which are constituted above all as glacial cirque but with little heaping of ice downstream (table 1).

	Location and slope aspect	Higher Alt. (m)	Lower Alt. (m)	Forms and Deposits
Clear Glacial marks	Gaviões (NE)	1200	850	Ombilic Rock step Lat. moraine Cirque
	Azevedas (E)	1220	950	Polished Rock Moraine blocks
Cirques and firns	Soutinho (NE) Espanado (NE) Pontilhão (N)	1100	800	Cirques Heterometric deposits

Table 1 – Glacial forms and deposits.

Quadro 1 – Formas e depósitos de origem glaciar.

In these are included the glacial cirque enclosed in small valleys of the northern and eastern slopes of Toco, namely those of Pontilhão, of Espanado and of Soutinho (a principal, to which the other two are associated). The present marks in these small valleys show that the snow coming from the levelled summit of

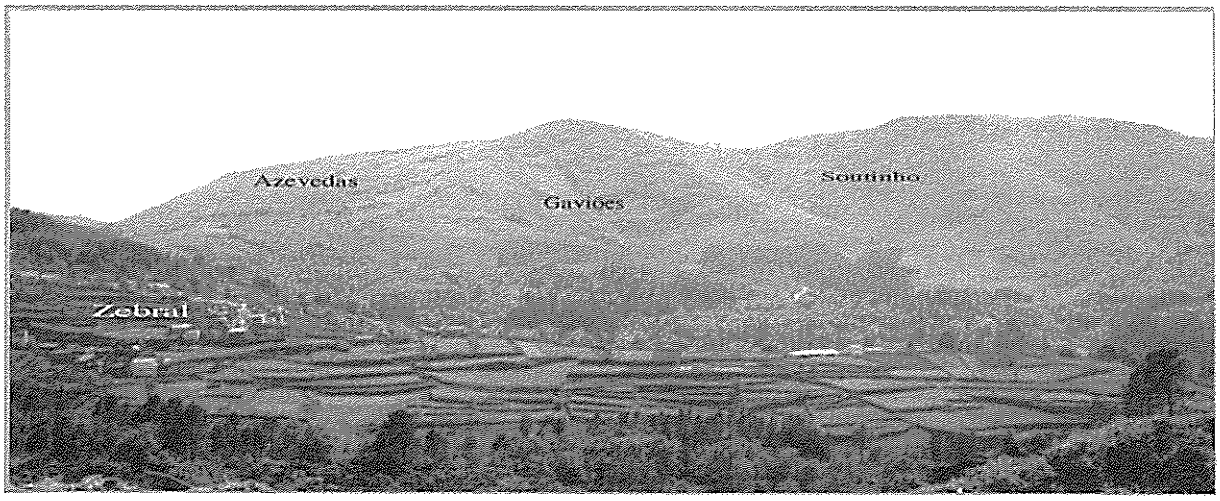

Figure 4 – North slope of the Cabreira mountain culminant massif.

Figura 4 – Vertente norte do maciço culminante da serra da Cabreira.

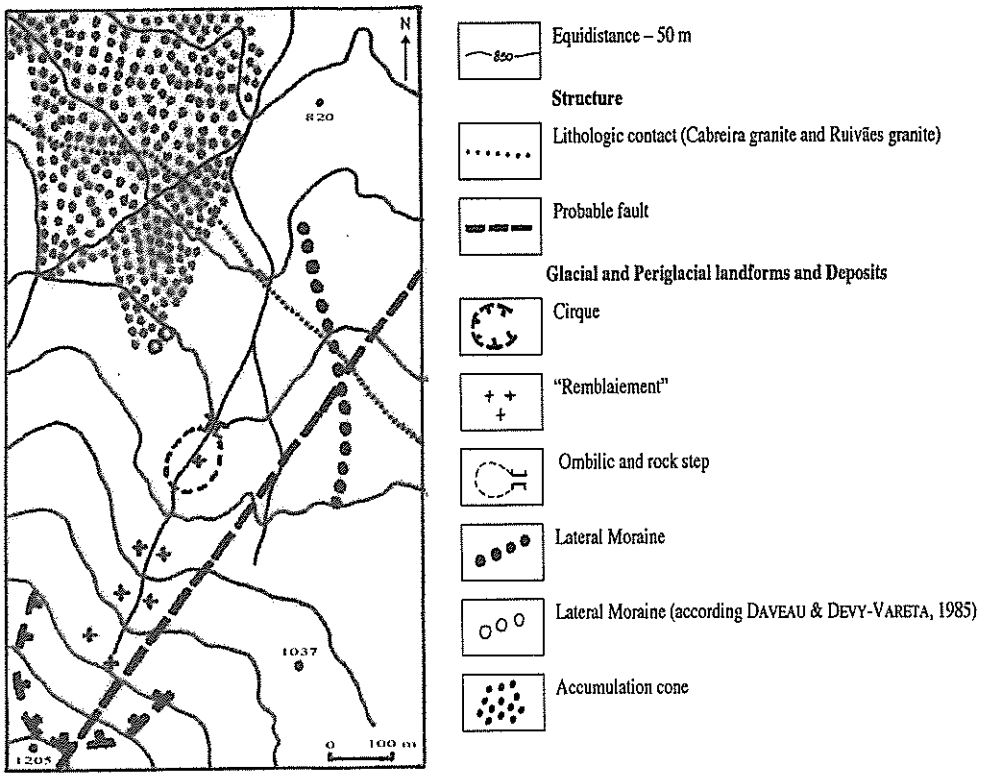

Figure 5 – Forms and deposits of Gaviões glacier
Figura 5 – Formas e depósitos do glaciar dos Gaviões

Toco (around 1150 meters high) wouldn't be enough to its feeding downstream, having heaped itself essencially in the higher part of the sheltered slopes forming there those little glacial cirque (DAVEAU & DEVY-VARETA, 1985). More downstream of those gullys, surely restored by the quaternary glacial action, it's seen above all the heaping of vast heterometric deposits, whose origin is questionable, that can be, or decurrent of that glacial dynamics or from the phase ending thaw and, therefore, of torrential fluvio-glacial origin. On these deposits, that present deep and mosty soils, there were the first pine (*Pinus sylvestris*) plantations in the mountain, in 1929. This settlement, as others that are situated in the bottom of the very entrenched valleys, escaped to the fire wave of the seventies, that devastated almost of the mountain (DAVEAU & DEVY-VARETA, 1985; DEVY-VARETA, 1993).

Those which present clear marks of having worked as firn and with glacial tongue are the ones of Azevedas and Gaviões, associated to the extensive levelled summit Talefe-Chã de Lousas (1236-1262 meters). It might be that one of the reasons of being there bigger glacial evidences than the ones in the slopes associated to Toco. In fact, the Gaviões glacier as well as the one of Azevedas have developed their upper ends in hights that rounded the 1200 meters, while in Toco, that upper limit would be about 100 meters lower, by 1100. The existence of snowfields by this altitude (confirmed by Soutinho, Espanado and Pontilhão glacial cirques) places the snow line even lower (DAVEAU & DEVY-VARETA, 1985).

The Azevedas glacier would have developed between 1200 and 900 meters high and in a vast area, between the levelled summit of Talefe and the bottom of ribeira de Ladeiras valley. In the higher slope, there are polished outcrop and the bottom of the slope is covered with small "round" blocks, quite clear in the wall that were built with them in the sloughs of Azevedas. According to DAVEAU & DEVY-VARETA (1985), the unity of the Azevedas seems to have been little active and little thick, comparingly to the one of Gaviões, since it doesn't present a real terminal moraine, and whose existence has only became possible thanks to its shelter position and to the abundant feeding of snow coming from the massif of Talefe.

However, between the Azevedas and Gaviões, near to the Tremonha toponym it is observed an extensive heaping of blocks of big dimensions. Our observation on the ground allowed us to verify that these are quite rounded and present, sometimes, grooved sight, fancying it as a possible lateral moraine of the Azevedas glacier.

The unit of Gaviões (figure 4), even of smaller dimensions than the one of Azevedas, would have been the only to inherit typical glacier forms. Although, as we referred, it has developed in a carving form of slope, between 1200 and 850 meters high, the vestiges observed there are characteristic of those present in valleys: glacial cirque with polished rock, rock step and lateral moraines, on the left and on the right, being the last one the most developed, between the 950 and 850 meters high (figure 6).

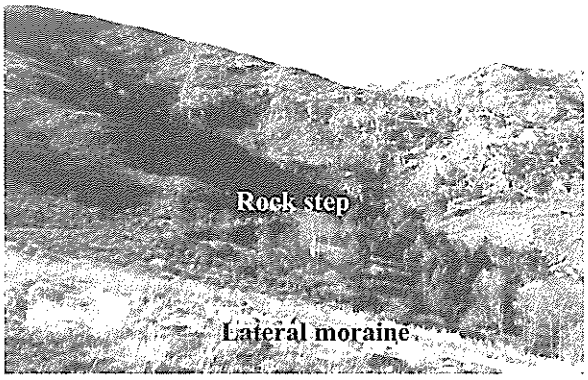

Figure 6 – Gaviões small valley
Figura 6 – Valeiro dos Gaviões

This moraine is easily identified on the ground, aligning it, visibly from south to north and around 500 meters. It is a heap of rounded blocks, some with more than a meter of diameter, presenting strias and, as it is confirmed in the cut provoked by the forest trail, wrapped up in a very thin and dark coloured matrix, as DAVEAU & DEVY-VARETA (1985) refer. The authores-ses still defend that matrix absorbs more humidity than the ranker soils of the closer slopes, fact that is confirmed by the development of a kind of fern (*Pteridium aquilinum*) common in moistened areas when in these prevail under shrub formations such as the furze (*Ulex parviflorus; Ulex minor*), the shrub (*Chamaespartium tridentatum*) or the heather (*Erica arborea; Erica australis; Erica umbelatta; Calluna vulgaris; Erica lusitanica*) (POLUNIN & SMYTHIES, 1991).

The terminal part of the main moraine, between 900 and 850 meters high, is situated on the Ruivães granite. In some places where it crops out, it is verified that its grain is quite more coarse than the one of the constituent granite of the moraine blocks, of a thinner grain, clearly Cabreira granite.

The ombilic and respective rock step are situated around 900 meters high, near a private terrain inserted in the forest perimeter, where it's located the biggest groove of the water course at the bottom of the small valley (figure 6).In the field survey, we didn't find vestiges of the other lateral moraine, located by DAVEAU & DEVY-VARETA (1985) around 100 meters north-west at the same altitude, already in contact with heterometric deposits decurrent, either from the Gaviões glacier, or from the Soutinho heaping, probably due to the recent opening of a forest trail in that place.

Figure 5 shows that the carving in the Gaviões slope would have processed according to the orientation of the fracture line that crosses the mountain, from NNE to SSW, in the surroundings of Zebral till its south-west slope, and that would have also conditioned the installation of the tops of the riverside of Vilar Chão. In that way, we can say that the carving of the Gaviões small valley would have been favoured by that fragility line. Thus, beside the morphological factors as the declivity and the slope aspect, we can considerate the tectonics as a favourable factor to the development of the Gaviões glacier.

It isn't imposed, in the case of Cabreira mountain, an attempt of interpretation of the very recent tectonic movements and that they had moved affected areas by glacial erosion. Contrarily to the Gerês mountain, where forms of erosion and moraine deposits were found in different altitudes, the vestiges observed in the N and E slopes of the culminant massif Talefe-Chã de Lousas-Toco, surely by the physical proximity of the glacierism episodes, they are found in the several cases, sensibly at the same altitude, between 1200 and 850 meters.

2.2. The periglacial action in the occidental slope

The action of the quaternary cold in Cabreira mountain didn't limit itself to the heaping of ice in the sheltered slopes, bring much more evident the vestiges of the periglacial action.

In the case of Cabreira mountain, we can presume as fundamental the periglacial processes that would have happened during the glaciation episodes, as well as in the final phase of its thaw. The actual aspect of the affected areas by this periglacial dynamics, with a vast covering of granite flagstones (as far as we can see, it is what determines the most, the culminant massif landscape), revels essentially gelifraction processes, in other words, the horizontal fractures and other fractures of the granite by action of the turn of the interstitial water in the liquid and solid states, in short periods of time.

Such as we have referred previously, the granite flagstones, with a thickness between 10 to 20 centimeters, some of which with more than a meter of diameter, are observed in the levelled summits of Talefe-Chã de Lousas and of Toco, as well as in its occidental slopes. It would be there where during the glacial period the cold western winds would be felt, not allowing the development of firns, but a granite outcrop macrogelifraction.

On the other hand, it seems to be, in the region of the north-west mountains, differential lithological behaviours facing the periglacial quaternary dynamics. Indeed, the Cabreira granite (of two mica and of medium grain) will be one of the prime factors to the event of a modelled in plaques since, before identical conditions, it doesn't manifest in the Peneda and Gerês mountains, in the domain of Gerês granite (of coarse grain and with porphyroid tendency), where a modelled in balls prevails (tors and block chaos) (DEVY-VARETA, 1993).

In figure 2, it's represented the cryoclastic debris in the summits, in the slopes and in its bases. In the levelled summits of Talefe-Chã de Lousas-Toco, they appear involved in a very thin and dark soil, of the rankers kind. The fields survey allowed us to verify some interesting aspects: on one hand, the "lousas" are stirred by human action, that, according to DAVEAU & DEVY-VARETA (1985), happened from the arborisation work of the mountain summits at the end of the decade of 1940; on the other hand, we verify, and mainly in Toco, the presence of some outcrop, presenting a clear horizontal fractures. Those horizontal fractures are confirmed in outcrops near the fire watch tower of Talefe, we can verify in decurrent trenches of the constructions present there, that the gelifraction effects are deeper than a meter depth.

What concerns our study area, such modelled of flagstone appears in the referred levelled summits and the occidental and northern slopes of Toco, in an area that would correspond to Montado do Toco (the oak-grove of the beginning of the 20th century). Near the Fragas do Toco, in the base of the occidental slope, it's verified the stressed accumulation of that material, involved in a thinner matrix as it is referred by DAVEAU & DEVY-VARETA (1985).

According to our observations, this flagstone covering happens, not only in the slopes referred by the authoresses, on the left bank of the tops of the riverside of Vilar Chão and in the right bank of the riverside of Toco, but also in the steep slope of Jadelo (figure 2), where we can observe, either the horizontal fracturation and in flagstone of big Cabreira granite blocks, or an extensive covering of cryoclastic debris, in the base on apparently periglacial thick deposits.

The gelifraction of the outcrops would have resulted from the slopes revetment and regularization with that angulous flintstones and in a "block slopes" (SUMMERFIELD, 1994) or "champs de blocks" (CAMPY & MACAIRE, 1989) landscape.

In Estrela mountain, some slopes were regularized like this, over 800 meters high and also in the Portuguese north-west mountains, but over 600-700 meters, during the times of the quaternary cold (DAVEAU, 1973). DAVEAU & DEVY-VARETA (1985) relate the modelled of gelifraction verified in the high places and in the occidental slopes of Talefe and Toco, with that verified in Estrela mountain, in Alto de Pedrice, around 1750 meters high, that is, above the snow line during the quaternary glaciations and above the actual periglacial manifestations limit, both rounding 1650 meters high.

The actual periglacial manifestations in Portugal come down essentially to these higher points of Estrela mountain, where the action ice/thaw keeps active, due to the rather rigorous winters and of the summers more or less dry verified there (DAVEAU, 1978). However, also in Gerês mountain, and at altitudes between 1250 and 1350 meters in the slope of the left bank of the riverside of Madorno were identified processes of very recent gelifraction, by means of the freshness of the broken blocks (COUDÉ.GAUSSEN, 1981). Recent studies, allowed to identify similar processes in other mountainous areas, as in Freita mountain (CORDEIRO, 1986) or in Marão mountain (PEDROSA, 1993). Before this situation of sub actual periglacier at low altitude, we have considered as probable that also in higher points and in the Cabreira culminant massif slopes could occur similar processes, fact that we'll try to investigate in the future. On the other hand, and mainly in the north faced slopes, like the majority of our study area, it was observed in December 1999 an ice action in the soil, even that very superficial, under the pipkrake form. In some cases such observation occurred even in altitudes under 800 meters, close to Espindo village or near the Gândara forest house. At higher altitudes, in the Gaviões and Azevedas area and above all in the summits they can last during several days, as well as they present themselves quite developed.

CONCLUSION

Even that could raise some hesitation, it's undeniable the great importance that the quaternary cold had had in the Cabreira mountain morphology, and specially in its culminant massif. On the one hand, the presence of a covering of granite flagstones in the levelled summits and in the occidental slopes, regularizing them. On the other hand, the marks of transport and heaping, iced masses, in the more sheltered slopes, in the north and east.

The superficiality of this paper, in which it is basically made a presentation of the forms and surface formations of Cabreira mountain related to the quaternary cold, associated to the few studies accomplished there until nowadays on that matter, leads, as it is obvious, to the incapacity to sketch clearly the morphogenetic processes that were in the origin of these formations.

The moraine deposits and the heterometric deposits will be related to the glaciation maximum.

Already the cryoclastic debris and the gravity talus, observed mainly in the declivous slopes of Toco, Talefe and Jadelo, besides being associated to the intense gelifraction in the glaciation maximum period, they could have been equally affected by the posterior times ice/thaw and even during the Holocene, as it is proposed to some slope formations, in similar altitudes, identified in Marão mountain (PEDROSA, 1993).

In what concerns the vestiges of the heaping of snows and ice in the quaternary at a low altitude, it's emphasized the fact of such glaciation only being possible in very privileged conditions, of shelter due to sunstroke and to the dominant winds, like were the ones of Cabreira mountain, and such as it would have happened in some points of Gerês (FERREIRA *et al.*, 1992, 1999).

The snow line proposed with the glaciation event of Serra da Cabreira (around 1050 meters high) lowers around 100 meters the one proposed to Gerês mountain by COUDÉ-GAUSSEN (1981). On the other hand, FERREIRA *et al.* (1999) defend also to some points of Gerês mountain, namely in its south-east slope, a snow line rounded 1000 meters high, that can indicate and value even more the importance of the local morphology, superior to the altitude and of the local thermic gradient.

REFERENCES:

CAMPY, M. & MACAIRE, J. J. (1989) – *Géologie des Formations Superficielles*. Géodynamique, Faciès, Utilisation, Masson, Paris, 433 p.

CARVALHO, G. S. & NUNES, J. L. (1981) – «A problemática dos índices glaciários quaternários nas serras do Gerês e Peneda» *Cuad. Lab. Xeol. de Laxe*, 5, A Coruña, p. 289-295.

CHOFFAT, P. (1895) – «Promenade au Gerêz. Souvenirs d'un Géologue», *Boletim da Sociedade de Geografia de Lisboa*, 14 série, n.º 1, p. 1-8.

CORDEIRO, A. M. R (1986) – «Nota preliminar sobre formas e formações periglaciares na Serra da Freita», *Cadernos de Geografia*, n.º 5, Coimbra, 1986, pp. 161-172.

COUDÉ, A.; COUDÉ-GAUSSEN, G.; DAVEAU, S. (1983) – «Nouvelles observations sur la glaciation des montagnes du Nord-Ouest du Portugal» *Cuadernos do Laboratório Xeológico de Laxe*, 5, Coruña, p. 381-393.

COUDÉ-GAUSSEN, G. (1978) – «Confirmation de l'existence d'une glaciation Wurmienne dans les montagnes du Nord-Ouest du Portugal» *Compt. Rend. Somm. Soc. Géol. de France*, 1, p. 34-37.

COUDÉ-GAUSSEN, G. (1981) – *Les Serras da Peneda et Gerês*, Memórias, CEG, n.º 5, Lisboa, 254 p.

DAVEAU, S. (1973) – «Quelques exemples d'évolution quaternaires des versants au Portugal», *Finisterra*, 8 (15), C.E.G., Lisboa, p. 5-47.

DAVEAU, S. (1977) – «Um exemplo de aplicação da teledetecção à investigação geográfica. A glaciação quaternária das montanhas do Noroeste de Portugal», *Finisterra*, 12 (23), Lisboa, p. 156-159.

DAVEAU, S. (1978) – «Le périglaciaire d'altitude au Portugal», *Colloque sur le périglaciaire d'altitude du domaine méditerranéen et abords*, Ass. Géogr. Alsace, Strasbourg, p. 63-78.

DAVEAU, S. (1979) – «Técnicas novas em paleogeografia. O Atlântico Norte há 18 000 anos», *Finisterra*, 14 (27), Centro de Estudos Geográficos, Lisboa, p. 82-86.

DAVEAU, S. (1980) – «Espaço e tempo. Evolução do ambiente geográfico de Portugal ao longo dos tempos pré-históricos», *Clio*, 2, Lisboa, p. 13-37.

DAVEAU, S.; COELHO, C.; COSTA, V.G.; CARVALHO, L. (1977) – *Répartition et rhytme des précipitations au Portugal*, Memórias do CEG, n.º 3, Lisboa, 192 p.

DAVEAU, S. & DEVY-VARETA, N. (1985) – «Gélifraction, Nivation et Glaciation d'Abri de la Serra da Cabreira», *Actas da 1.ª Reunião do Quaternário Ibérico*, Vol. 1, Lisboa, p. 75-84.

DEVY-VARETA, N. (1993) – *A Floresta no Espaço e no Tempo em Portugal: o caso da arborização da serra da Cabreira, 1919--1975*, Tese de Doutoramento, Faculdade de Letras da Universidade do Porto, 459 p.

FERREIRA, A. B.; VIDAL ROMANI, J. R.; VILAPLANA, J. M.; RODRIGUES, M. L.; ZÊZERE, J. L.; MONGE, C. (1992) – «Formas e depósitos glaciários e periglaciários da serra do Gerês-Xurês (Portugal; Galiza). Levantamento Cartográfico», *Cuad. Lab. Xeol. Laxe*, A Coruña, 17, p. 121-135.

FERREIRA, A. B.; VIDAL ROMANI, J. R.; ZÊZERE, J. L.; RODRIGUES, M. L. (1999) – *A Glaciação Plistocénica da Serra do Gerês. Vestígios geomorfológicos e sedimentológicos*, Relatório n.º 37, A.G.F.A., C. E. G., Lisboa, 1999, 150 p.

FLEURY, E. (1916) – «Sur les anciennes glaciations de la Serra de Estrela (Portugal)», *C. R. A. Sc.*, Paris, 162, p. 599-601.

GIRÃO, A. A. (1958) – «Glaciação Quaternária da Serra do Jurês», *Boletim do Centro de Estudos Geográficos*, Vol. II, 16 e 17, Coimbra, p. 13-22.

LAUTENSACH, H. (1932) – «Estudo dos glaciares da serra da Estrela» *Mem. Notic. Mus. Miner. Geol. Univ. Coimbra*, 6, Coimbra, p. 1-60.

MOREIRA, A. & RAMOS, J. F. (1981) – «Vestígios de glaciações na serra da Peneda (Noroeste de Portugal)», *Comunicações dos Serviços Geológicos de Portugal*, Tomo 67 (1), Lisboa, p. 95-98, Est. 4.

PEDROSA, A. S. (1993) – *Serra do Marão. Estudo de Geomorfologia*. Dissertação de Doutoramento em Geografia Física, Universidade do Porto, 479 p.

POLUNIN, O. & SMYTHIES B. E. (1991) – *Flowers of South-West Europe*. A field guide, Oxford University Press, 480 p.

RIBEIRO, O. (1955) – «Portugal», *in* M. TÉRAN (Coord.) *Geografia de Espanha e Portugal*, Barcelona, 290 p.

SCHMIDT-THOMÉ, P. (1978) – «Nuevos testigos de una glaciación wuermiense extensa y de altura muy baja en el Noroeste de la Peninsula Iberica (Orense, España y Minho/Trás-os-Montes, Portugal). Geologia de la parte norte del Macizo Ibérico», *Cuaderno del Seminario de Estudios Cerâmicos de Sargadelos*, 27, p. 219-243.

SUMMERFIELD, M. A. (1994) – *Global Geomorphology. An introduction to the study of landforms*, Longman, Scientific & Technical, Essex, 537 p.

TEIXEIRA, C. & CARDOSO, J. L. (1979) – «A não confirmação de fenómenos glaciários nas montanhas do Norte de Portugal (Peneda-Gerês)», *Boletim da Sociedade Geológica de Portugal*, Vol. XXI, Lisboa, p. 163-184.

VIDAL ROMANI, J. R.; VILAPLANA J. M.; FERREIRA, A. B.; ZÊZERE, J. L.; RODRIGUES, M. L. (1990) – «Estudio de los till subglaciares de la Serra de Gerês-Xurés (Minho – Portugal; Ourense – Galicia)», *Cuaternario y Geomorfologia*, 4, p. 13-25.

VIDAL ROMANI, J. R. & MOSQUERA, D. F. (1999). «Cronología glaciar pleistocena de la Serra de Gerês (norte de Portugal)», *Estudos do Quaternário*, 2, APEQ, Lisboa, p. 57-64.

VIDAL ROMANI, J. R.; MOSQUERA, D. F.; MARTI, K.; FERREIRA, A. B. (1999) – «Nuevos datos para la cronologia glaciar pleistocena en el NW de la Península Ibérica», *Cadernos Lab. Xeolóxico de Laxe*, 24, Coruña, p. 7-29.

VIEIRA, J. C. A. (1923) – *Vieira do Minho – Notícia Histórica e Descriptiva*, Edição do Hospital João da Torre, Vieira do Minho, 576 p.