territorium

REVISTA DE GEOGRAFIA FÍSICA APLICADA NO ORDENAMENTO DO TERRITÓRIO E GESTÃO DE RISCOS NATURAIS

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Man's action and slope erosion. A case study in Tâmega Basin (1981) *

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Resumo:
No mês de Dezembro de 1981 ocorreu em Cavez, na margem esquerda do vale do Tâmega um movimento de terras que provocou uma grande perda de vidas humanas. Depois de formular algumas hipóteses, os autores observaram atentamente o local da ocorrência de modo a determinar as causas que originaram este tipo de fenómeno. As características topográficas e litológicas e as condições climáticas por si só não justificam a ocorrência deste tipo de fenómeno. De facto, os autores demonstram que, para além das condições naturais favoráveis, a actuação antrópica acentuou o impacto do fenómeno. A falta de uma correcta compreensão da dinâmica geomorfológica é, muitas vezes, responsável pelo aumento da frequência deste tipo de fenómenos.
Palavras chave:
Nordeste de Portugal, Geomorfologia, movimentos de terras, risco, impacto da actividade humana.

Résumé:
Au mois de décembre 1981, à Cavez (Arosa), sur les versants de la rive gauche du Tamega (Nord-est du Portugal), un mouvement de terrain très grave s'est déclenché. Ce mouvement, rapide, a provoqué quinze morts. En recherchant les causes du phénomène, les auteurs ont étudié la topographie, la lithologie et les conditions météorologiques dans la région. Ils ont aussi faits des enquêtes et ils ont trouvée l'action humaine comme une des causes les plus importantes du mouvement.
Mots clés:
Nord-est du Portugal, Géomorphologie, mouvements de terrain, risques, impactes de l'action humaine.

Abstract:
When a catastrophic landslide occurred in a small river basin on the left bank of the Tamega valley, in the Northeast of Portugal, which involved the sudden sliding of several tons of arable land and rocks and caused the destruction of a house and the death of fifteen people, the authors decided to carry out a careful investigation of this geomorphological phenomenon. After having formulated a number of hypotheses, they did a lot of field work in the area and carried out measurements to determine, as accurately as possible, both the real extension and the causes of the occurence of such a phenomenon in that particular place and at that particular time of the year. A series of studies enabled the authors to come the conclusion that the natural and human-induced causes had been responsible for the disaster. Disasters like this don't unfortunately constitute isolated incidents. Therefore, the authors think it is very important to study the local geomorphology carefully before any houses or the setting up of any human activity within the territory it is responsible for.
Key Words:
Northeast of Portugal, Geomorphology, landslide, risk, human impact.

Introduction

The small river basin of the Arosa brook, whose whole area barely covers one square kilometer, was the scene of one of the deadliest natural catastrophes caused by movements of land which have occurred in Northern Portugal in recent years.

This basin is situated on the left bank slope of the river Tâmega, a fairly important stream which flows in a deep narrow valley between the Alvão and Barroso plateaux. The basin is elongated in shape with a North-South orientation and it is easily reached by the masses of maritime air coming from the West that go up the condensation barrier along the Tâmega valley.

The high areas that border the plateaux of Trás-os-Montes in the West form a mountainous line which runs parallel to the Atlantic coast and contributes strongly to the rising of the maritime air masses, thus causing heavy rainfall in the area. This is the reason why that particular line is commonly known as "barreira de condensação."

Though situated in quite different exposure conditions, the two meteorological stations located nearest to the Arosa basin - Cavez and Ribeira de Pena - register yearly values as high as 1400 mm

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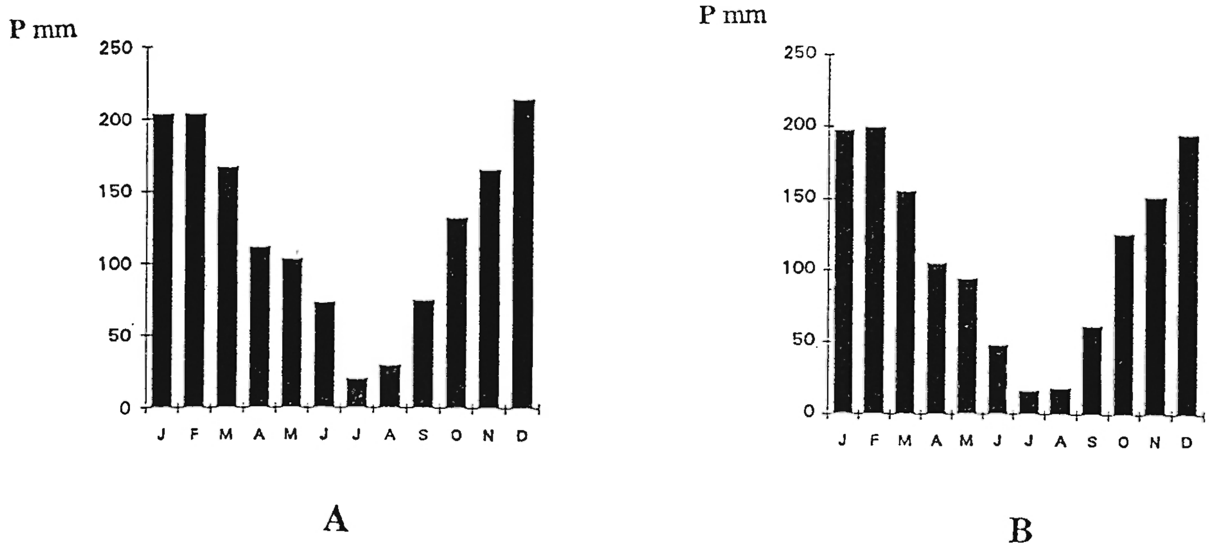

Fig. 1 - Rainfall graphs (A-Cavez; B - Ribeira de Pena). Source: INMG (National Institute of Meteorology and Geophysics).

(Fig. 1) while the number of days of rainfall is more than 100. The numbers show clearly that this is an area of heavy rainfall. Nevertheless, the distribution of the rainfall along the year is not regular; the wet months are followed by a hot dry summer with mediterranean characteristics.

The event

The mass movement, took place on the evening of the 27th December 1981. According to the Portuguese daily newspaper with the largest circulation in the country (Jornal de Notícias) the entire area overlooking the Tâmega was experiencing a heavy storm. Suddenly it was as if there was an earthquake. What might well be called an avalanche of water, mud, big and small rocks, shrubs and trees rolled down the hill in an overpowering maelstrom, destroying terraces painfully built over the years; it crashed into the wall of a coffee shop (Fot. 1), tore it apart as if it were made of paper, caused the concrete upper floor to collapse and went on its path of destruction to finally stop when it reached the river Tâmega in the valley below.

At the time there was a large number of

Fot. 1 - The building damaged by the landslide.

predominently young people in the coffee shop, drinking and talking, taking advantage of the presence of friends and relatives who had come from abroad to spend Christmas and New Year with their families. A significant portion of the male population of the small village of Arosa[1], situated at the edge of the basin, had gathered there. Trapped by the violence and speed of the phenomenon, they had no chance at all of escape. Fifteen people died and fourteen were badly hurt.

What had really happened? A considerable mass of land from the middle section of the valley began moving, at first as a rotational slide; this movement, however, soon changed into a more complex one, including solifluctions, until it finally became a typical debrisflow. In its rapid descent along the narrow talweg it destroyed every single man-made thing which opposed it, tearing away all sorts of materials which only served to make the moving mass even thicker.

There was no way this enormous mass of mud and rocks could pass through the narrow channel that was the normal course the brook water took to flow under the 211 Road. When it overflowed, it found in its way a building made of stone and brick which had very unwisely been built directly on the talweg. It simply broke down the walls, left part of the upper floor without support and added to the moving mass, not only the building materials it had snatched away but also all the furniture and the people inside the building. It only stopped, as said before, when it reached the foot of the slope, i.e., in the bed of the river Tâmega.

On the slope it left a longish scar in the direction of the maximum slope, with a length of 69 meters and a maximum width of 17 meters. In all, the landslide affected an area of 828 square meters (Fot. 2). The scarp had a median height of 1.5 meters which allows us to estimate the total volume of the materials removed at about 1,240 cubic meters.

As the talweg was interrupted by terraces and the stream had been diverted to feed small reservoirs which at the time were full, there was a further increase in the mass of soil constituted by the stones which formed the supporting walls of the terraces and the reservoirs.

The dislocation of all these materials exclusively according to the laws of gravity allowed the brook to regain violently its natural path in the old talweg which in the meantime had been transformed by man with a total ignorance and disregard for the principles that rule such phenomena as run off, evolution of the slopes and fluvial dynamics.

Fot. 2 - The small valley of the Arosa brook and the scar caused by the landslide.

Intervening Factors

For the occurence of this landslide there is no simple linear explanation as it is the outcome of various factors, involving nature and human intervention (F. Rebelo, 1977, 1983), which are now to be analysed.

The main cause, the one that was really decisive in the onset of the landslide at that precise moment and in that particular place was, no doubt, the heavy and continuous rainfall which had occurred in the days before and on the very day of the catastrophe.

[1] The village of Arosa, which belongs to the "freguesia" (parish) of Cavez and the "concelho" (municipality) of Cabeceiras de Basto, is situated near the bridge over the river Tâmega, on the road 206, which connects Guimarães and Vila Pouca de Aguiar.

The observation of the records of the daily rainfall registered in the nearest meteorological station (Fig. 2) show that in the days before the event it had rained very heavily for 20 days in Cavez and 18 in Ribeira de Pena. While in Cavez there had been nine days with rainfall less than 10 mm, in Ribeira de Pena it rained more than 10 mm every day. The mentioned records show that the total amount of rainfall in the twenty days preceding the disaster reached 397.6 mm in Cavez and 415.8 in Ribeira de Pena. Such values are uncommon for this area; the average rainfall for the month of December in both villages is less than 200 mm (Fig 3).

Another determining factor concerns the steepness of the slopes which characterize the whole basin (Fig. 4). The map shows that inclines between 8½ and 18½ are predominant in the basin but they alternate with areas where the slopes are gentler (Young, 1972). The landslide began in one of the places with the steeper incline.

A third cause is to be found in the fact that the whole basin is situated on granite bedrock. In the place where the landslide began this rock is covered by a thick layer of weathered granite. If, on the one hand, the altered granite makes it easier for the rain water to seep into the soil, on the other, the abundance of clay may prevent it from penetrating deeply into the ground and retain it in the superficial layers of the soil (B. Marques, 1990).

Besides, almost all the slope in which the small valley is situated is smoothed by slope deposits, resulting from solifluctions; they are fairly thick (2 m) and date back to a cold, humid period (A. Pedrosa, 1993). These deposits, which are heterometric and unconsolidated have a big fine clay matrix (65%) formed mainly by chlorite (75%), montemorillonite (18%), and 4% of kaolinite which contrasts with large-sized blocks -with a diameter superior to 40 cm. Consequently, there is in the area an important factor of instability, since the clay gains plasticity and thus creates the ideal conditions to enable the weight of the blocks to exert enough pressure to destroy the existing balance and set off a movement of land.

The topographic conditions played a part in the process as well. The small valley in which the landslide took place can be subdivided into two sections of different incline. Upstream from the place where this landslide occurred there is a small reception basin with a gentler incline, used for agriculture, which contrasts sharply with its lower section which has a much steeper incline.

The existence in the place where the movement began of a layer of vegetation mainly formed by herbaceous plants and small shrubs reinforces the scenario. By making the runoff more difficult, this vegetation cover increased the quantity of water retained in the soil and, consequently, the weight and

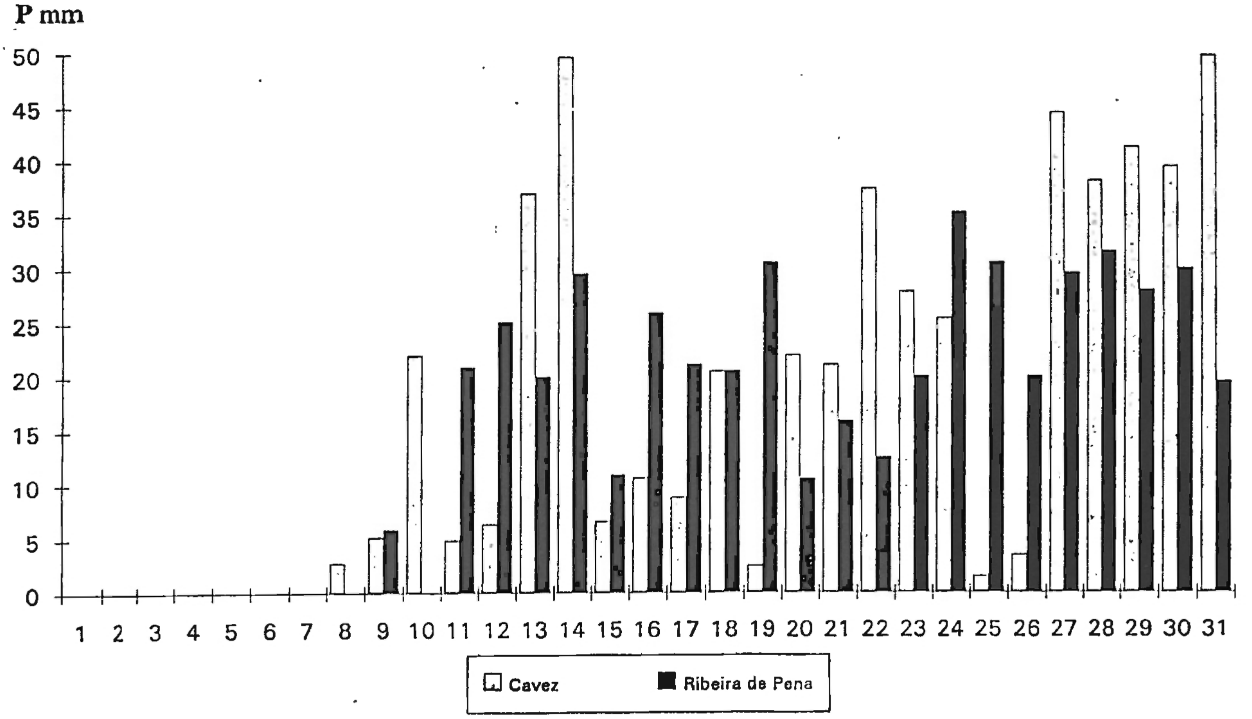

Fig. 2 - Daily rainfall records (mm)(December 1981). Source: INMG (National Institute of Meteorology and Geophysics).

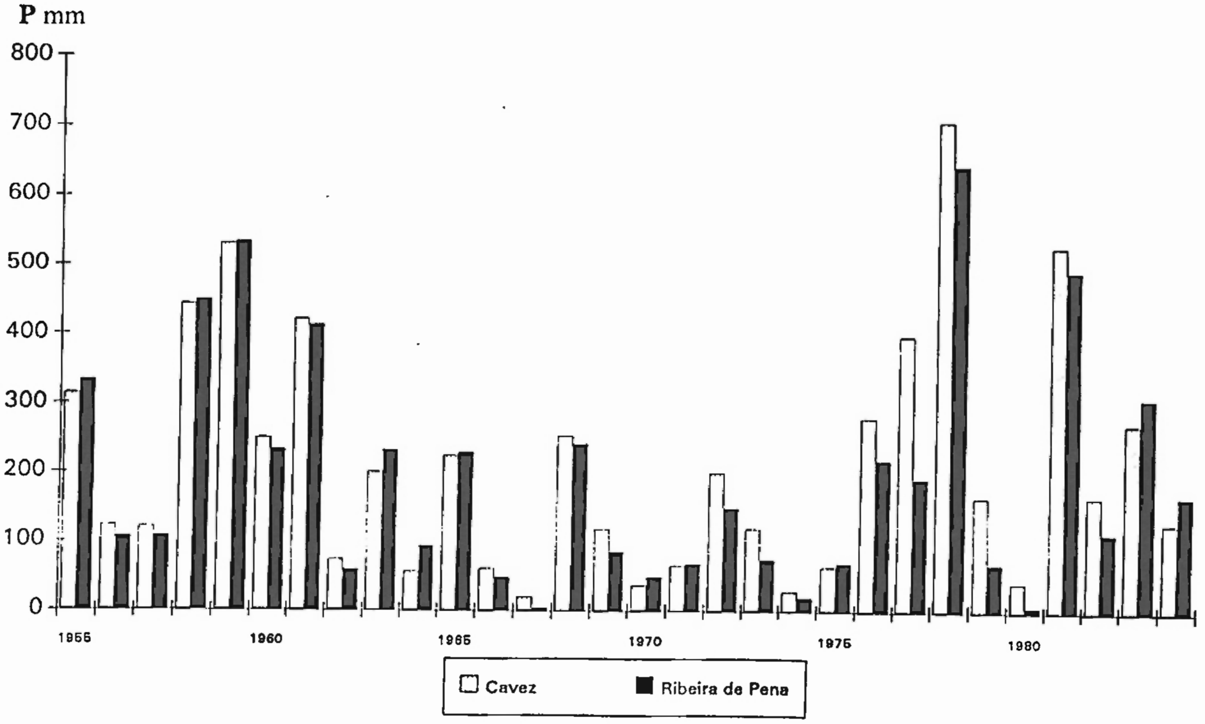

Fig. 3 - Amount of rainfall in the month of December in the area around the Arosa brook. Source: INMG (National Institute of Meteorology and Geophysics).

instability of the weathered materials.

All these factors helped to create a set of circumstances which were propitious to the setting off of a full-scale landslide: a series of very rainy days, a small reception basin in weathered granite, covered with vegetation and opening on to a narrow deep natural system of drainage with a steep slope. One can't forget that the movement began exactly in the place where the angle which separates the two mentioned sections changes, i.e., where a gentle slope becomes moderately steep (Young, 1972).

Apart from that, there is still the whole process of incorrect human intervention in the area which is responsible for the extent of damage and loss of life in a phenomenon which is fairly common in humid mountainous regions.

In our opinion the element that most contributed to increasing the intensity of this natural phenomenon has something to do with the alteration of the natural conditions of the runoff caused by a rural path (Fig. 4). It was built to enable the farmers to get to their fields and to the forest. It winds up the slope, disregarding the small streams it crosses and goes even into the next basin. Thus, besides concentrating all the runoff, the path itself has become an element of the drainage system, as if it were a river bed. A large part of the runoff, together with the water it collected on its way through the neighbouring river basin, was consequently channelled to a place immediately above the site where the movement of land originated.

This large quantity of water gushed into the main small valley through a water pipe 40 cm in diameter which allowed its way under the above-mentioned path and contributed decisively for the onset of the landslide.

Had the quantity of rain been normal, this temporary brook wouldn't have a large volume of water. Along the talweg a number of small reservoirs had been built which retained the water to be used later for the irrigation of the fields nearby. Owing to the steep angle of the slope, these fields were on terraces supported by small walls made of loosely piled stones. Much of this material was, as said before, incorporated in the original moving mass, contributing to its increase in weight and volume and causing the event to have more dramatic consequences.

Unlike what happens in bigger valleys in which the streams are permanent, in this case there were terraces across the river bed, which cut off the natural course of the talweg. However, what transformed a natural event, even if it was of greater magnitude than usual, into a catastrophe was the existence of a building right at the bottom of the valley[2]. It stood at

[2] The ruins of the building mentioned in the paper are still exactly as they were after the catastrophe and can be seen at kilometer 91,1 of the above mentioned road.

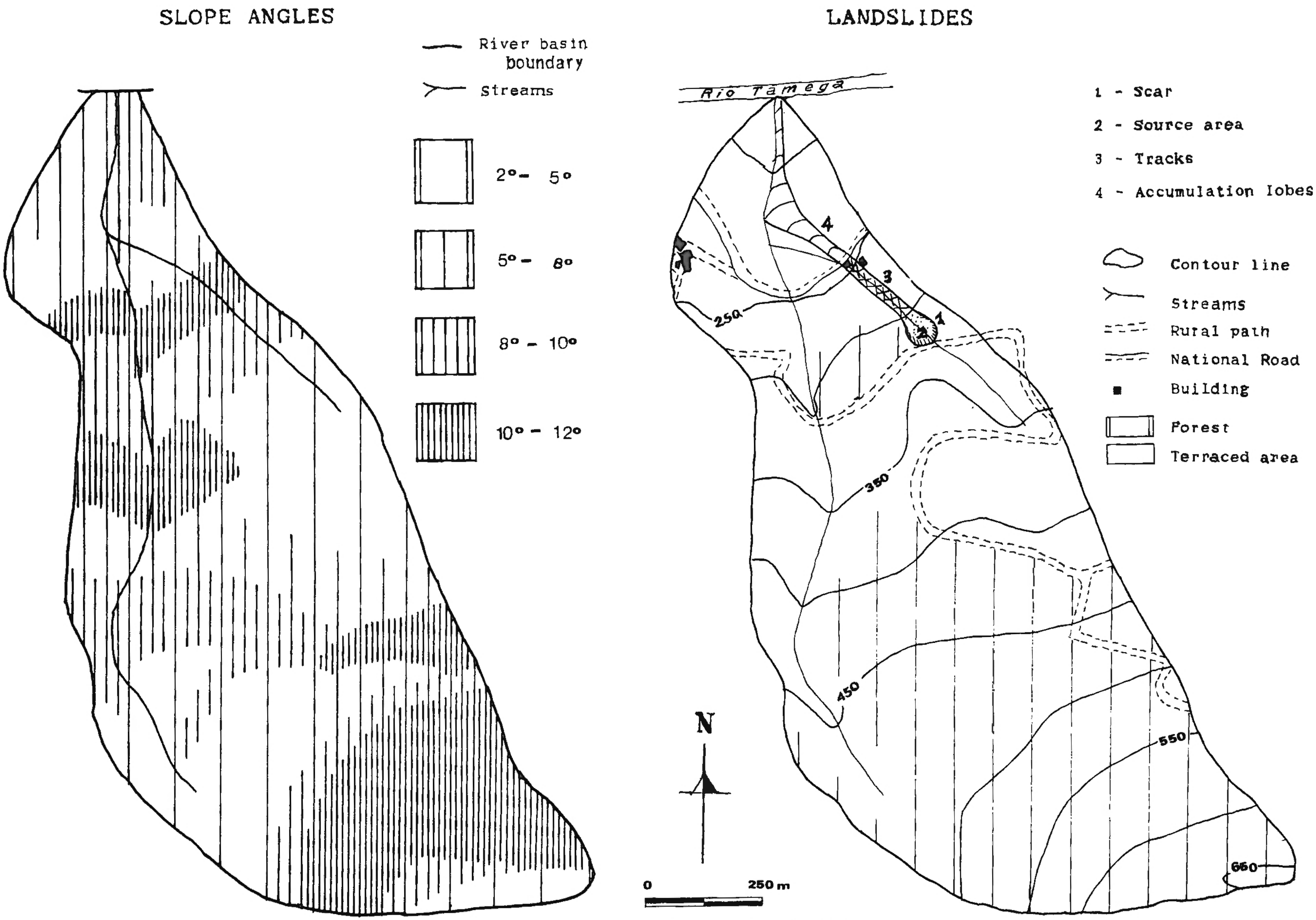

Fig. 4 - Slope angles and site of the landslides in the Arosa brook basin.

the side of the road in a recess which had resulted from the correction of one of the many curves of the road; the builder had erroneously taken for granted that the drainage pipe under the road would defend it from the effects of the brook water.

Conclusion

The emotional impact this phenomenon had on a local and even national scale was mainly due to the loss of human lives; it was that fact that transformed it into a catastrophe. However, such phenomena are much more usual than the few that make big headlines (L. Lourenço, 1988; A. Pedrosa, 1992). They are part of a geomorphological process that is permanently running its course and that man cannot or does not always know how to forecast.

Consequently, it is extremely important to bear in mind geomorphological factors whenever acting upon a geographical space. However, it cannot be understood as a mere topographic aspect. It is more and more critical not to disregard the dynamics of the morphogenetic processes (J. - C. Flageollet, 1989; F. Rebelo, 1991). The study and understanding of such matters can help to determine the probability of occurrence of natural hazards mankind is subjected to. In this way, man's intervention in the land will be more conscientious; he will avoid conflicts with the environment and will not settle in places which are unsuitable or do not offer a minimum of safety.

This problem has more than scientific and techinal aspects. There is also the pressing need to make the people involved and the public in general aware of it because they either ignore it or simply do not give it the attention it deserves. Quite often people even show a great disrespect for such matters. Clear proof of this is the fact that the present owner of the building severely damaged in Arosa in 1981 has been insistently trying to get official permission to rebuild the house and only the stubborn opposition of the local authorities has stopped him so far.

Forecasts carried out by experts of the possible occurence of natural phenomena must be borne in mind whenever man decides to do anything that transforms even a tiny part of the surface of our planet. This is in our opinion the right way to achieve a correct land planning.

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