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The Cave-Complex "A Touba do Brión – Cobreiras" cavernous weathering related to mass wasting downward sheeting planes.

La alteración del complejo de cuevas A Touba do Brión-Cobreiras relacionado con movimientos de masas según planos de exfoliación.

VAQUEIRO RODRÍGUEZ, M.[1]

Abstract

The studied area is located in Vincios, Gondomar council, in the western side of the Serra do Galiñeiro Mountains, in the southwestern part of the Pontevedra province (Spain). The present paper studies the genesis and evolution of the Touba do Brión cave, a granitic structure developed by a mass wasting - sheeting slide in the upper part of a deeply incised, water-carrying gorge, named Cobreiras, a tributary gorge of the Estocas - Zamáns river, falling down between the paleo-levels A6 and B1. This complex is a multi-stage cave that encloses several important weathering caves structured into sheeting - wasting planes. Non-mylonitic or breccia infillings were found among sheets but local cavernous weathering may be related to shearing structures.

Key words: Mass wasting, cavernous weathering, weathering caves, fissure cave, granitic karst.

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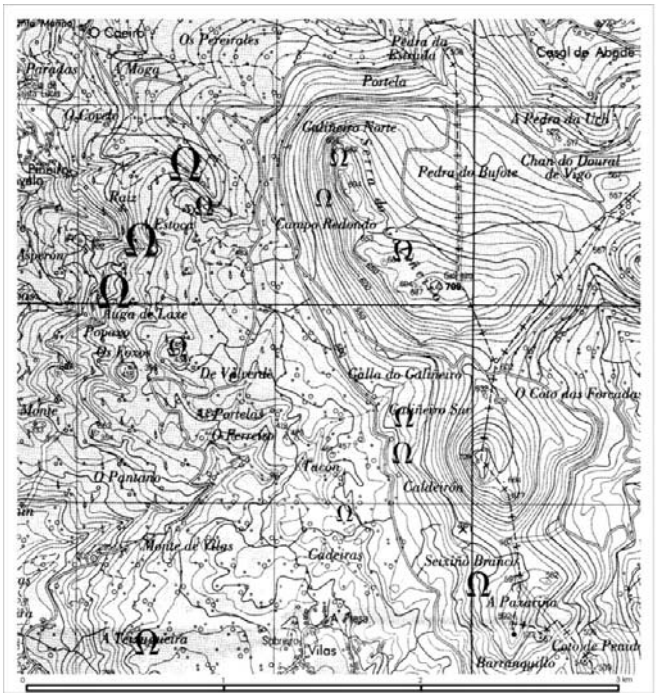
INTRODUCTION

The studied area is located in Vincios, Gondomar council, in the western of the Serra do Galiñeiro Mountains, in the south-west part of the Pontevedra province. (Fig.1).

The *Touba do Bríon* cave, UTM (X,Y) = (523289, 4665343) a granitic structure developed helped by a big rock displacement (a sheet slide), and it is located in the upper part of a deeply incised, water-carrying gorge, named *Cobreiras*, a tributary gorge of the *Estocas-Zamáns* river, falling down between the paleo-surfaces A6 and B1. Several caves in the western part of the Galiñeiro Mountains are located between 450 and 350 m.a.s.l. (levels A6 and B1) (see Figs1 and 2).



GRANITICAL CAVES AND SYSTEMS
IN THE WESTERN SIDE OF
SERRA DO GALIÑEIRO MOUNTAINS
GALIÑEIRO PEAK: UTM(X,Y,Z): (524845,4665088,705)

Fig.1. Location

REFERENCES AND TERMINOLOGY

From 1998 CEM is using the genetic classification criteria of some non-karstic caves (STRIEBEL, 1996). This criterion has been adapted to the features observed at the Galician pseudokarstic granitic areas (CEM, 1998). Terms proposed by VIDAL ROMANI (1989) are included too.

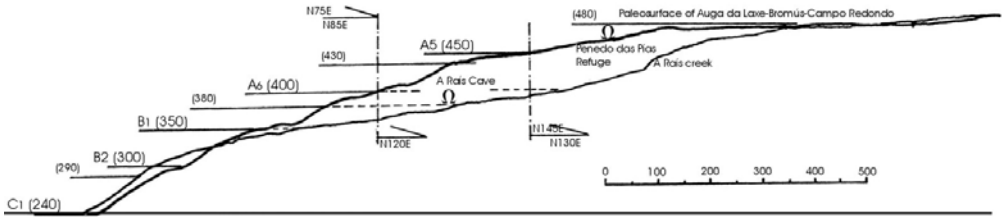
The karst terminology (FIELD, 1999) is used in accordance with similar morphologies and structures. Similar form does not imply similar genesis.

The designation for the different paleo-surface and levels is used in accordance with previous works (PAGÉS & VIDAL ROMANÍ, 1997).

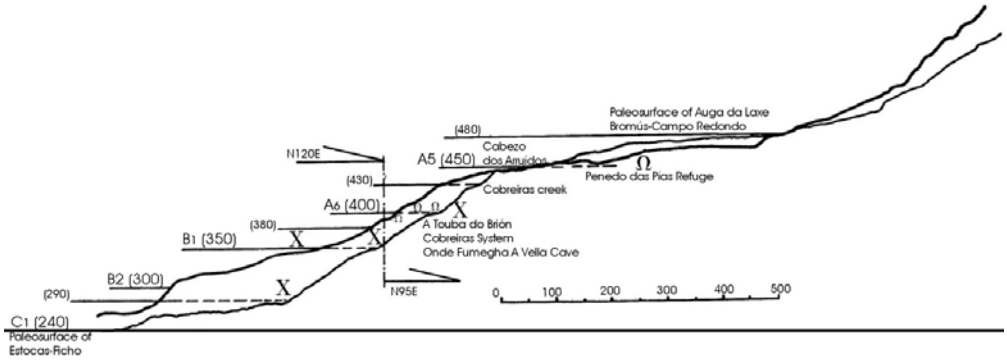
GEOLOGICAL SETTINGS

The *Zamáns* riversides, in the western part of the *Serra do Galiñeiro* Mountain, is a two-mica granite (FLOOR, 1966).

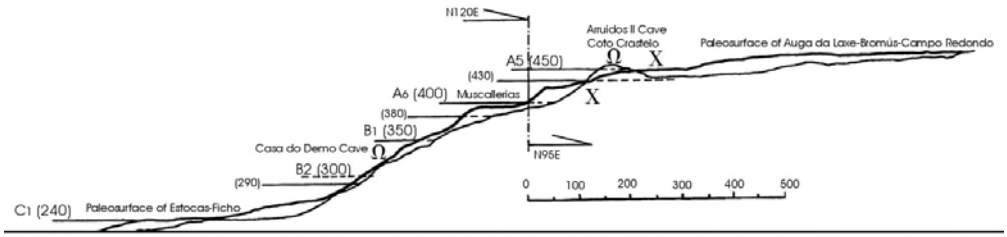
Even though this paper describes the genesis and evolution of *Touba do Brion* Cave, we considered useful to describe the main morphological



A. Profiles in *A Raís* creek



B. Profiles in *Cobreiras* creek



C. Profiles in *Muscallerias* creek

Fig.2. Sequence of stepped paleo-surfaces in the tributaries creeks where main caves are located. W: Cave or refuge. C: Quarry.

Fig. 3. Level A5: Campo Redondo-Auga da Laxe-Bromús.

Fig. 4. Transition zone between level A5 and A6: Seasonal lacustrine wells feed the Cobreiras Creek. Image made around the Touba do Bríon-Cobreiras head creek.

exokarstic features, which therefore are correlated with the western riverside evolution of the *Zamáns* river.

The western area of these mountains is a stepped area, developed from an old surface which has a mean altitude of 420 m.a.s.l. This surface can be correlated with the *Fundamental Surface of Galicia*.

Several steps and plains related to the incision of the middle part of the *Zamáns* river have been located and correlated with the levels defined in the western extent of the *Fundamental Surface of Galicia* (PAGÉS & VIDAL, 1997) (Fig.2 a-c).

The *Serra do Galiñeiro* Mountain is a riebeckite gneiss residual located on the Fundamental Surface of Galicia.

The main geomorphological elements in the *Fundamental Surface* (FS) are the residual reliefs: domes and tors between levels A6-A5 and A5-B1, and the lateral stepped creeks cutting across the several flats of the sequence of paleo-surfaces that form the FS.

There are several levels/flats derived from the degradation of the FS (B1, B2 and C1) being A6 and B1 the less developed.

In general, residual reliefs are dome or castle-kopje forms, which correspond to the remains of a previous surface.

Several caves are related to this residual relief. Generally, they are structural caves, tafoni caves, and other small endokarstic forms.

The best preserved paleosurfaces are A5 and C1 locally covered by sedimentary sequences and water

accumulates over them temporarily. The stratigraphic sequences on A5 (Fig.5) are as follows:

O (A00) solum: Ash-grey colour.

A solum: Humic level. Many quartz fragments. *Bronze Age* ceramic beds have been located in this solum.

B soil: Colluvial beds, mainly heterometric quartz pebbles (polished but not eroded) cemented with residual clay and quartz sand. Colluvial solums are bedding directly over a granitic grus facie. Many Paleolithic beds from *Achelense Age* have been located in solum Bu1.

C soil: Granitic grus facies.

The caves located on these surfaces are related to the residual reliefs. They are of two types: tafoni and block caves.

The caves located on C1 level are tafoni forms (there exists a possible relation between the development of these caves and the mylonitic infillings of the sheet structure in the domes) .

The caves located on A5 level are block caves produced by tor or dome removal (block dislocation). Other minor weathering forms are gnamma type.

Neolithic and Bronze Age activities are related to the two types of caves.

CAVES RELATED TO ROCK MASS WASTING

There are three caves related to a rock mass movement in the eastern side of Zamáns river. From North to South they are:

A Raís Cave. (Figs 15 C and D). UTM(X,Y) = (523558, 4665658)

A Touba do Brión - Cobreiras Complex: In these mass-wasting there are three well differentiated structures: *Onde Fumegha A Vella* Cave; *A Touba do Brión* Cave UTM(X,Y) = (523289, 4665343); and *Cobreiras* System, UTM(X,Y) = (523299, 4665290).

A Casa do Demo Cave. (Figs.15 A and B) . UTM(X,Y) = (523260, 4665040)

The caves of *A Raís*, *Cobreiras* System and *A Casa do Demo* are *Boulder fragment caves or Erosion Boulder Caves*.

They are an important combinational type of boulder cave and erosion cave: "If a rock slide occurs within a narrow, water-carrying gorge, the creek is first blocked by boulders. It erodes these boulders by finding a new way and forms water-carrying cavities and caves. Later there may occur further rock slides caused by continued erosion." (STRIEBEL, 1996).

Onde Fumegha A Vella Cave is a small cavity developed by blocks dislocation during a rockslide, in the middle part of a steep seasonal waterfall. This cave consists in several blocks hanging down over the scarp on a middle step. It only has an etnographic value.

The biggest rockslide is in *Cobreiras* creek (Figs 6 and 7.A). Here, there are two sets of fractures: N120ºE-N140ºE, aligned with the tributaries creek, and N45ºE-N50ºE aligned with the main river. Transition steps between levels are N45ºE-N50ºE steps.

The rockslide is a displacement started out from N140ºE-N150ºE fault (fault scarp: See Figs 6 and 7) in which a mass of rock breaks away along a pre-existing surface and rotates more or less downslope. Here, the pre-existing plane is the curved surface of the local anticlinal sheet structure.

Cave surveys and local ortho-images indicate a rotation where tors were fanned out to the west. There were two slides directions downslope: to the tributary creek and to the steps that defines the paleo-surface succession.

Note that mass wasting is not homogeneous. There are many castle-kopje wasted relatively intact downslope, and there is debris and block slides, falls and topples. These differences may be caused by N45ºE-N50ºE fault set.

A TOUBA DO BRION COMPLEX

Cave description

The cave is located at the north side of the *Cobreiras* creek, (south of *Cabezo dos Arruidos*). It is a well defined anticlinal sheet structure with pseudo-foliation vertically dipping on the sides of the dome.

The cave is a multi-stage (polyphasic) cave. The present structure is a combination of several features developed in the different stages.

A Touba do Brión complex encloses two fans of fissures with west rotation.: *A Ghrencha do Brión* or Western trench, and the Eastern trench. The first one is 18 m deep.

Fig.5. Stratigraphic profiles on A5 surface

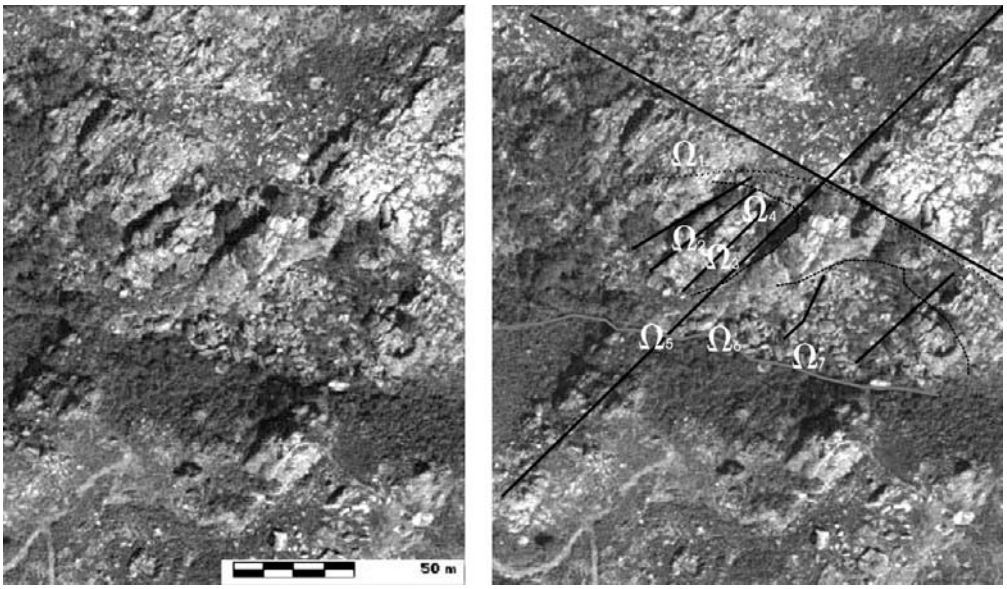


Fig. 6. Unprocessed and processed orthoimages of Cobreiras creek. Main fractures and displacement directions are marked. Cave locations are indicated: W1: Onde Fumegha a Vella Cave; A Touba do Bríon Complex: W2: A Ghrencha do Bríon - Western trench, W3: Eastern Trench, and W4: A Mina do Bríon - Main Shinkhole down fault scarp; W5: Cobreiras III; W6: Cobreiras II - Down the talus; W7: Cobreiras I

A Touba do Bríon is a castle-kopje between the trenches. Many caves have been developed around this castle, but the complex of caves encloses other minor geomorphological features:

The landslide structures: Head and main sinkhole, named *A Mina do Bríon*, main escarpment and fault scarp. The main sinkhole is like a circus dip, defined by main fault scarp and by fissures and tor scarps. An important part of the local surface water is drained into this structure.

The fissure cave named *A Ghrencha do Brion*, produced by the castle-kopje movements during slide.

Tafoni caves related to rock disintegration in the sheet boundaries during the displacement. Locally, these weathering forms are named "lapas".

Several types of boulder and block-crack caves. These structures are related to the different stages of evolution of each subtype of cave.

There have been surveyed about 152 m of "galleries" and structures around the castle-kopje.

Each trench has a particular morphology. So, western trench has several well-developed lapas located in the central tor dipping 50º S. Polygonal cracking is located at the first half of the wall at the top of these lapas and is directly related to the sheet surfaces (Fig.9-D). Moreover, at the top of the fissure there are hanging boulders and blocks. Climbing this boulder structure the main sinkhole is reached.

The eastern trench is more open than the western one and it is not considered as a fissure cave. The main geomorphological features are block and boulder caves, and a subhorizontal lapa. Many block caves may be produced by old collapsed lapas dipping 50º S.

The bottom of subvertical lapas is filled with soil, biogenic detritus and clastic infillings from cavernous weathering composed by granitic heterometric fragments without apparent order.

Organic complex speleothemes, caolinite speleothemes and opal-A stalactites (fractal stalactites) have been found.

The *Mina do Bríon* is the main exokarstic drainage area, formed by collapsed blocks and boulders covering the narrow part of the western

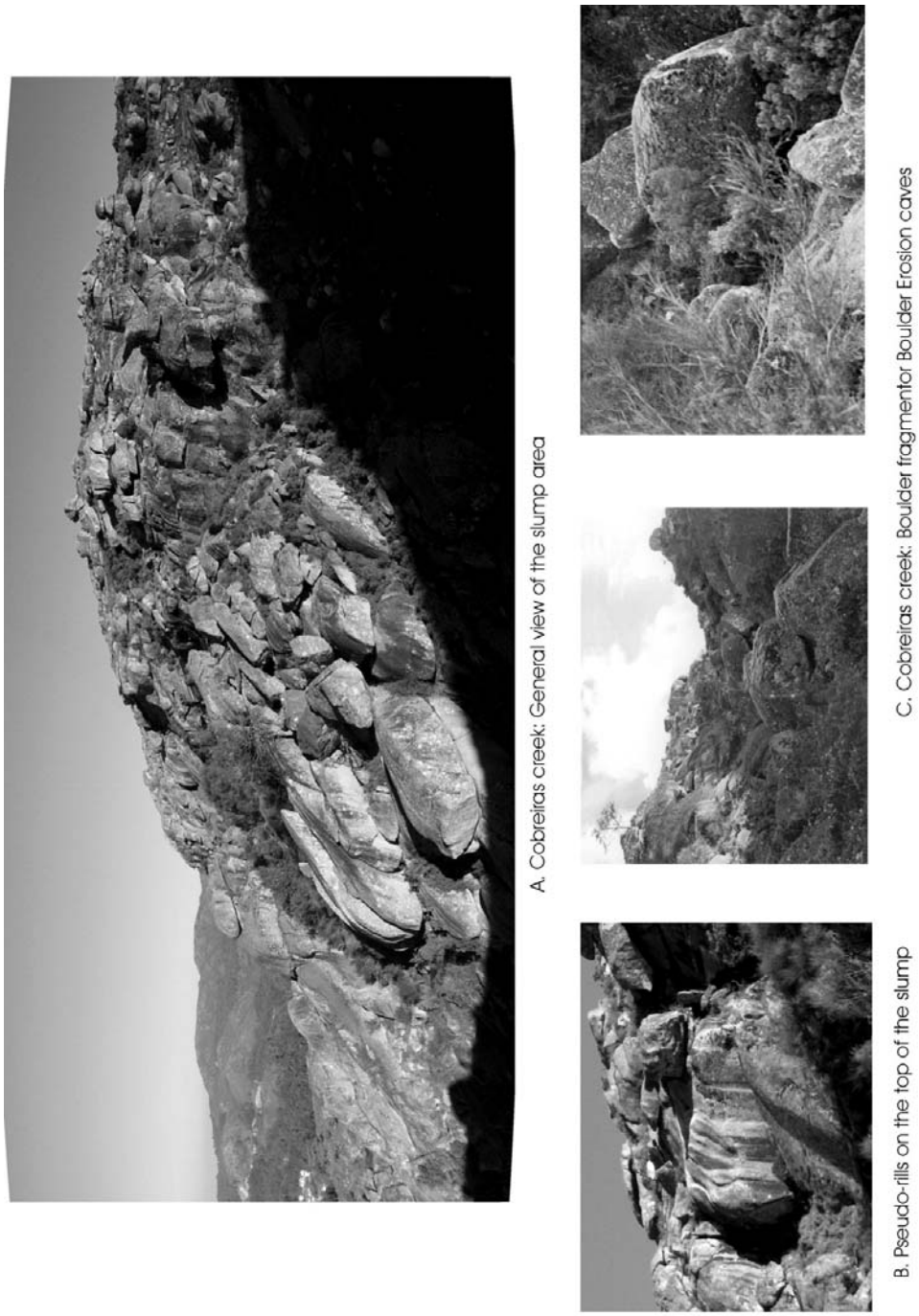


Fig.7. The head of the *Cobreiras* Creek. At the left it can be observed the fault scarp in which rock slide may have come from.

trench. The trench is collapsed too in the upper area, and filled with rounded blocks.

Cave genesis and evolution

A Touba do Brion complex is a multi-stage structure. The proposed genesis is described below with different stages:

1. Rock-slide: The first stage:

The basic complex structure is produced by downward rock displacement, a slide of the anticli-

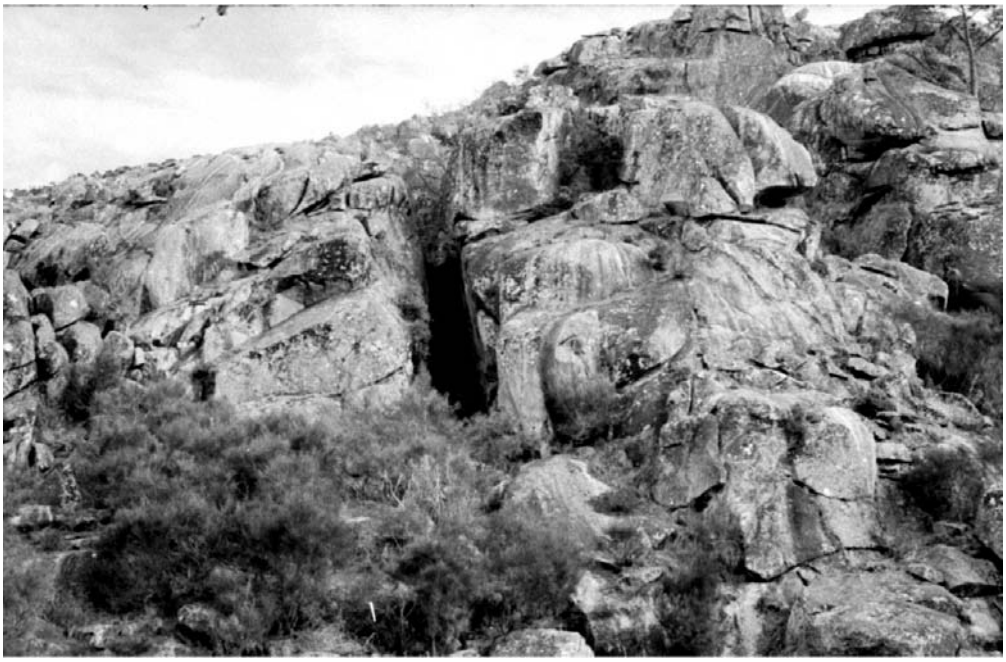


Fig. 8. The western trench, named "A Ghrencha do Bríon" is an open fissure 18 m of height.

nal sheet structure according to one or more sheet planes turned to the west. Some sheets are preserved intact after movement.

The rock slide is a deep slide from the N140ºE-N150ºE normal fault, cutting the sheet structure of *Cabezo dos Arruidos*, and is aligned with the *Cobreiras* creek.

The movement is roughly parallel to the dipping of sheet structure planes.

2. Consequent morphologies: The second stage:

Consequently, the rock slide produces:

Removal of castle-kopje, opening wide fissures and trenches like *A Ghrencha do Brion*.

Blocks falling down on the creek cover the front of the slide defining the different types of caves.

Toppling affects the blocks on slope face (N140ºE-N150ºE set).

Mass displacement only produces block caves in the talus and fissure caves in the scarp.

2. Residual morphologies: The present stage:

This stage corresponds to the generation of the last morphologies: block and boulder caves caused by collapses and rock falling from the steep slope.

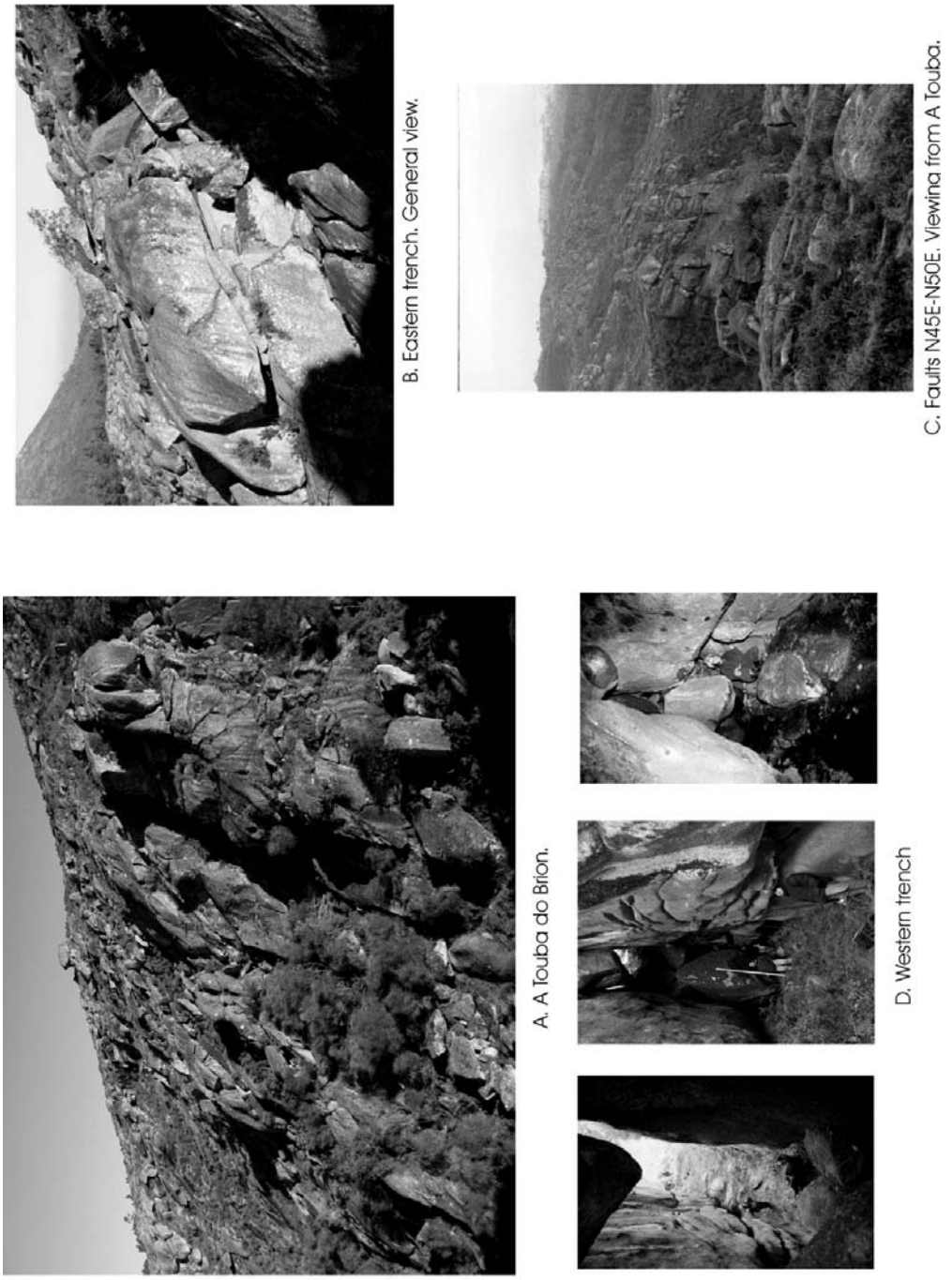


Fig.9. *A Touba do Brión.*

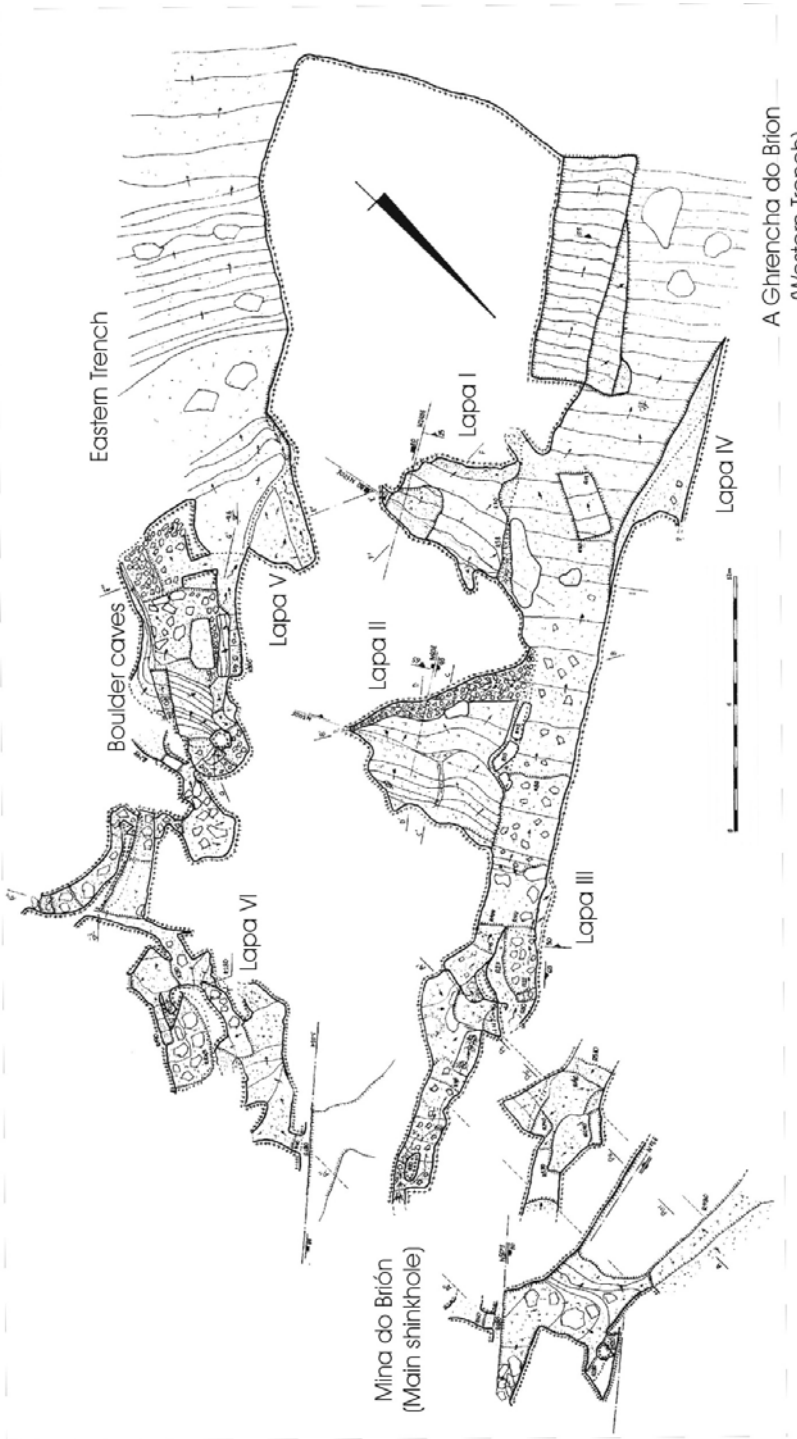


Fig.10. ***A Touba do Brión*** **– Pant view.**

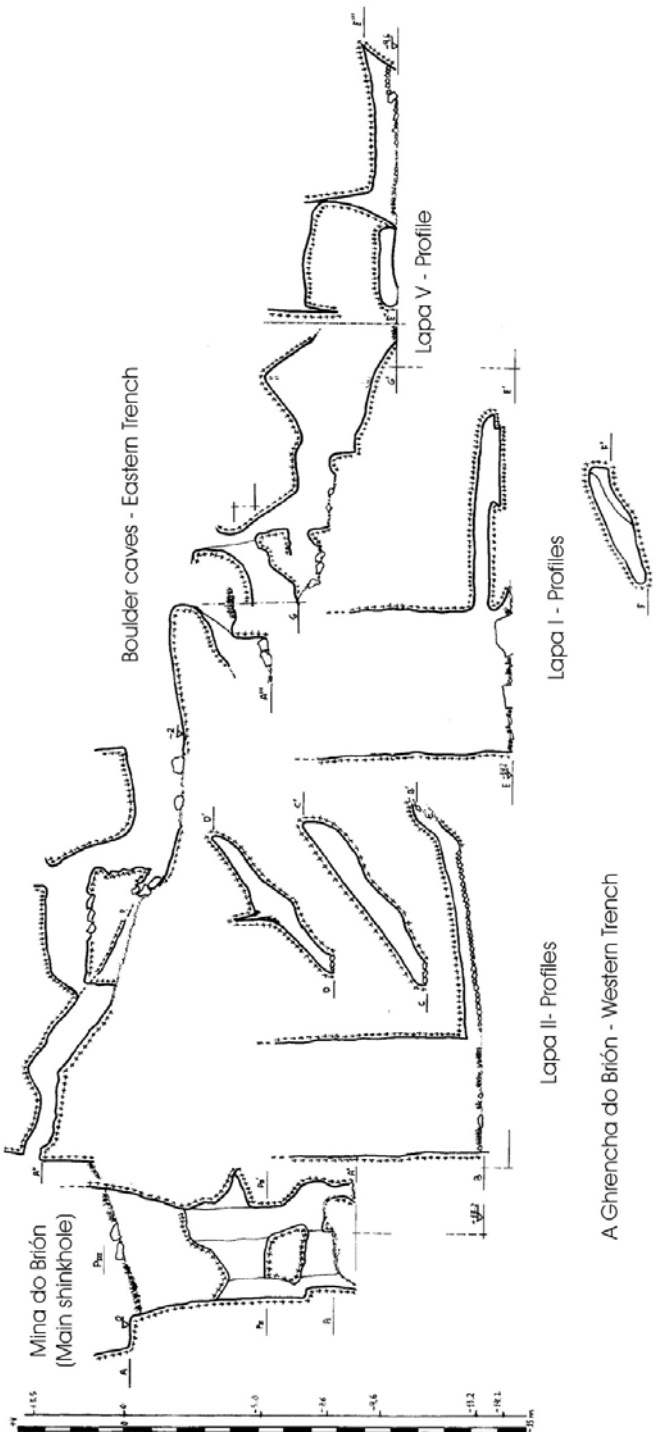


Fig.11. ***A Touba do Brión*** **– Profiles , sections and auxiliary views.**

Fig. 12. Western trench. The lapas start in the sheet boundaries and progress into the sides of the trenches.

Cavernous weathering in the Touba-Cobreiras complex

The lapas formation starts in the sheet boundaries and progress into the sides of the trenches. These caves develop parallel to the anticlinal sheet structure and are considered as consequent endokarstic forms derived from rock slide.

There are very dipping planes. Mean dip angle is about 50º S (fig.13, and surveys in Figs 10 and 11).

Rockslides generate relatively thin sheets of rock that are broken into smaller blocks as they migrate downslope. No mylonitic or breccia bands have been found.

All weathering forms are developed parallel to the slide planes due to the differential movement among sheets where the rock rock is probably weakened by shearing.

Lapa I contains the only endokarstic gnamma of the area. It is a pan developed parallel to the sheet structure. (Fig. 13.B).

Down the talus, it can be observed many imbricated sheets.

Endokarst drainage (coming down from *Touba do Brión*) is running into the sheet boundaries. Contact surface becomes open fissures, and cavernous weathering is developed going up the drainage conduit. Note that water is running off over the intermediate sheet. (Fig.14).

Speleothemes are related to the water dripping points from upper sheets.

CONCLUSIONS

Flats and surfaces described above are correlated with the paleo-surfaces developed by degradation of the *Fundamental Surface* (PAGÉS & VIDAL ROMANÍ, 1997).

The caves developed in these surfaces are associated with domes and tors, the residuals of older paleo-surfaces. These caves are mainly block structure types.

The best developed surfaces are A5 and C1.

A5 is colluvial quartzose deposit derived from the alteration solum, fossilized by levels containing pieces dated as *Achelense* and *Bronze ages*.

The colluvial deposits are partially dismantled but never as infillings of the caves.

The mass wasting caves are generated by slide-slump movements. All morphologies result from the combination of the anticlinal sheet structure with the orthogonal fracture set. Structural features were vital in delimiting the mass wasting and the cave structure.

Although all mass wasting caves are located among the Eocene-Miocene paleo-surfaces, the structure of these caves is directly related to late-Hercynian fractures as the orientation of creeks and gorges development. The age of the studied caves is Quaternary.

The most special forms are the tafoni-structures, locally termed *lapas*. They are a special cavernous weathering related to the developed sheet structure. It is a very common kind of form in the area.

Down the talus, the endokarstic tributary drainage is located into the sheet plane structure where lapas have been developed. It occurs in *Cobreiras II Cave* (Fig.14), and in *Lapa da Moura* Cave (Fig.16).

Tafoni caves are related to the points where mylonitic infillings among sheets are preserved. These tafoni are not related to mass wasting, and

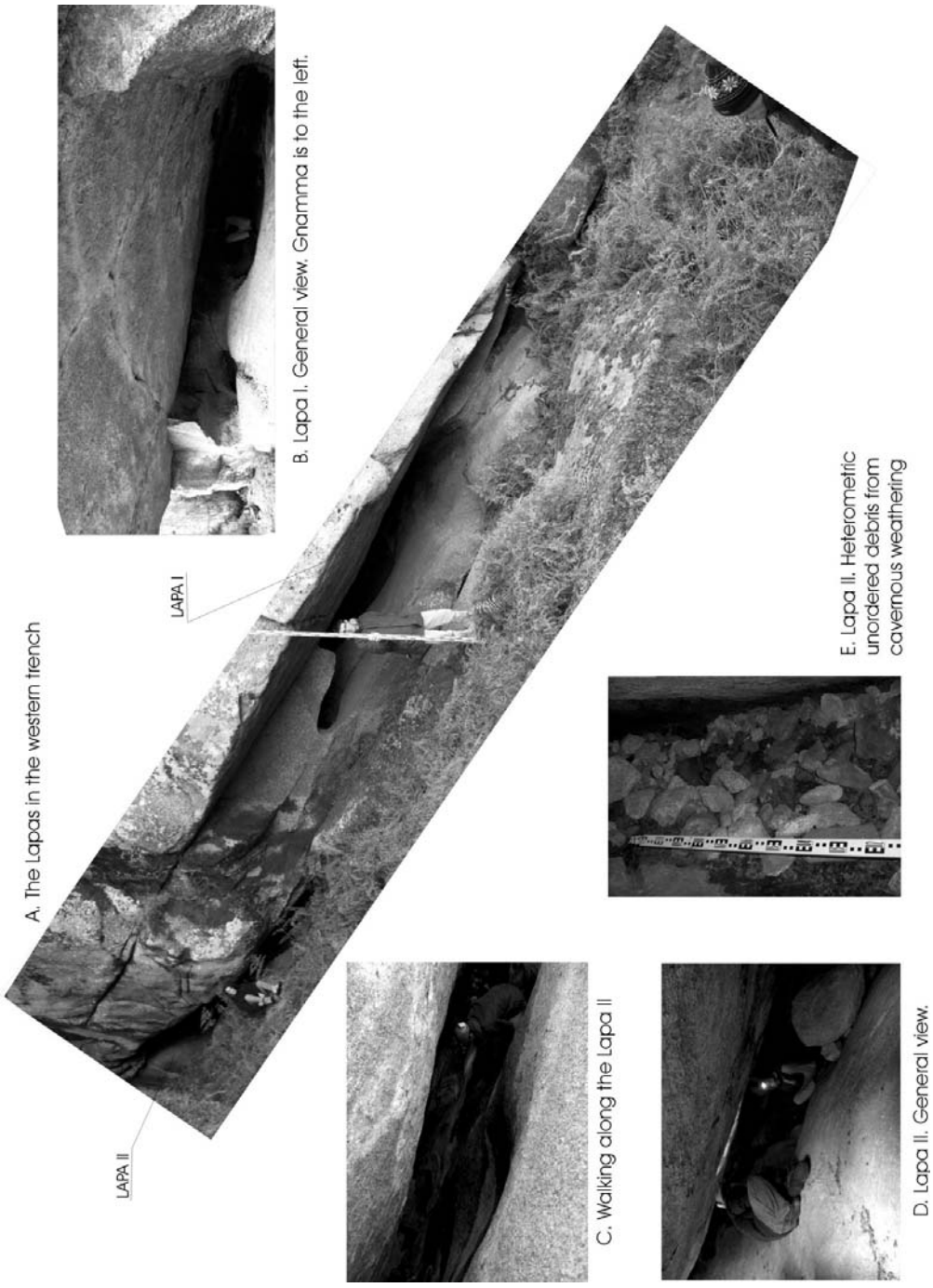


Fig.13. Cavernous weathering in the western trench: Lapa I (to the center and right) and Lapa II (to the left).

movements of tafoni are postgenetic, and caused when mylonite is weathered and eroded.

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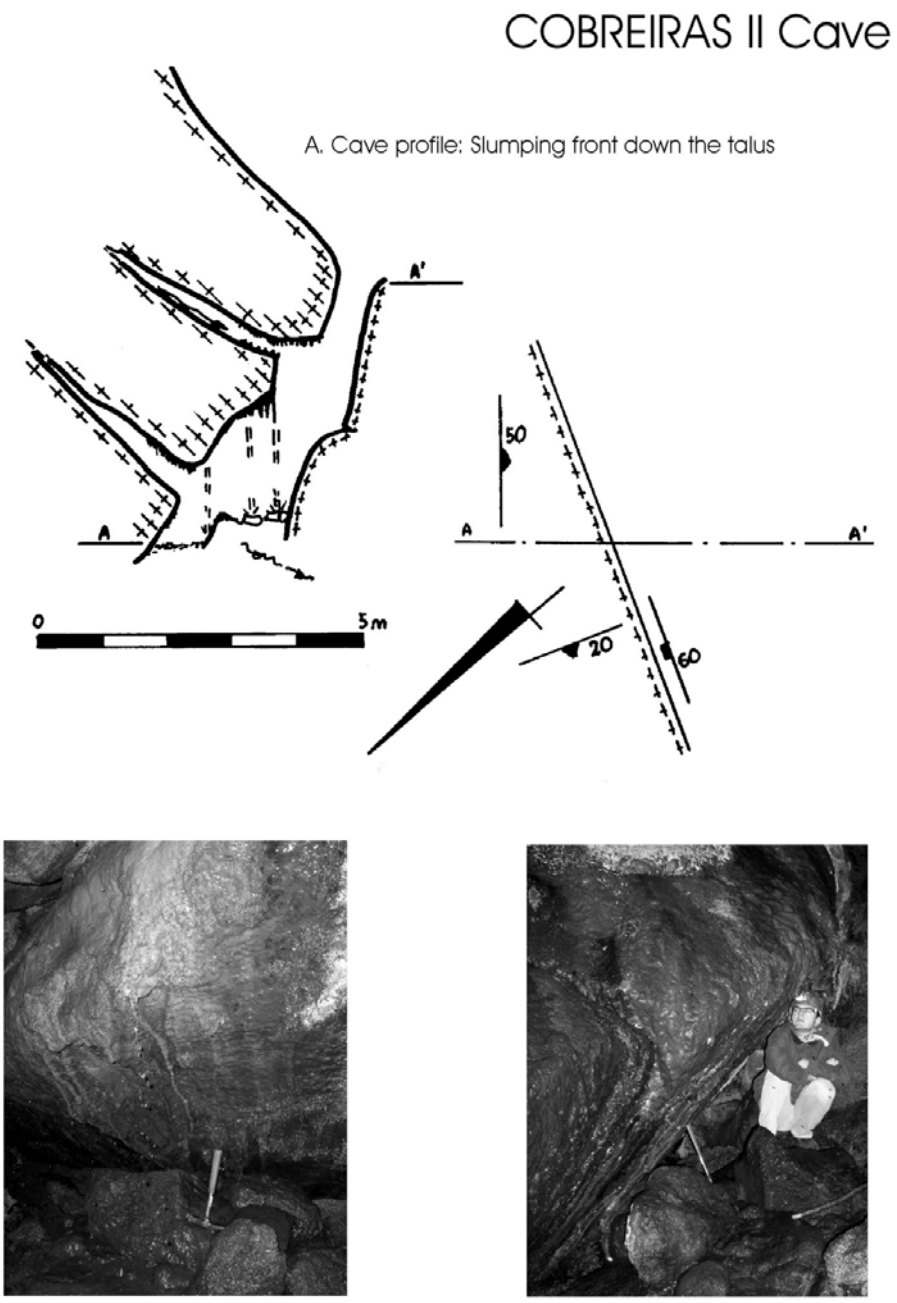
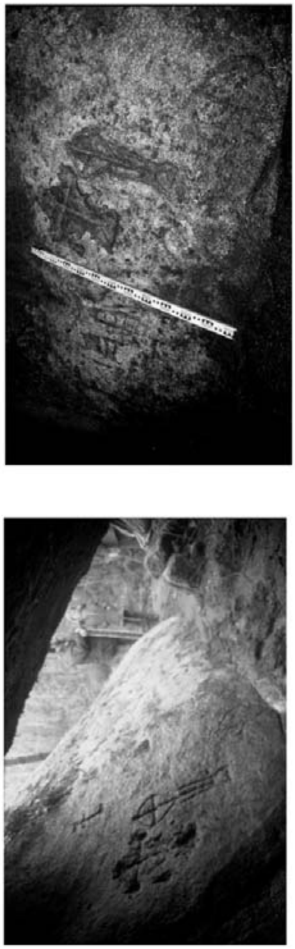


Fig.14. Cobreiras II: Down the talus

A.A Casa do Demo. General view of the primigeneous rock slide

B.A Casa do Demo.
A view of the stoneworker forge



C.A Raís Cave. Subterranean Meival engraving.

D.A Raís Cave. A little root-stalagmite

Fig.15. A Casa do Demo Cave and A Raís Cave

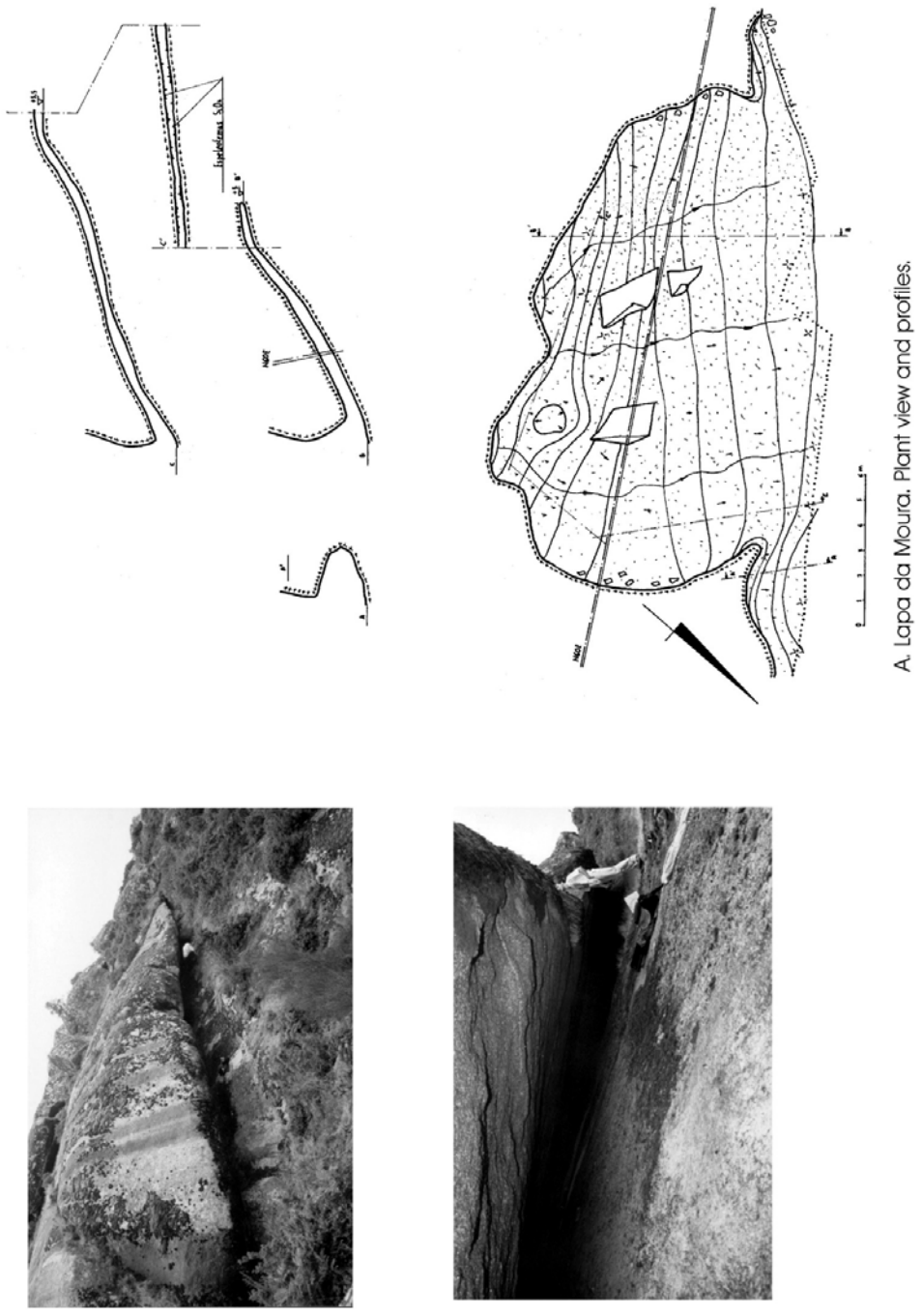


Fig.16. Lapa da Moura Cave.

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