

on Monday. No words could ever describe the hike back to camp in the dawn light, needless to say it was an unforgettable experience.

When we left the Picos on Friday 7th July, the underground campers that had planned to drop into the canyon at the top of the climb had not yet returned to the surface so we're still unsure as to which of our theories is correct. Further trips into 2/7 were done by Adam De Eyto, Patrick O'Donnell, Christian Staunton and Nancy Serrano, with Adam and Christian managing to spend 1 night underground on the big ledge campsite.

Caving in the Picos with OUCC taught us a great deal about the organisation required for the exploration of deep caves. Everything from the sterilisation of washing-up water to the need to have food prepared for returning cavers was considered. In the underground camps the need to be self-sufficient in all regards and the equipment to survive such a harsh environment became obvious. In all, the caving was spectacular, the scenery was amazing, the potential for further discovery was limitless but possibly best of all were the Boccadilla de Fillet (steak sandwiches available at the bar at Los Lagos), 100% Spanish Beef.

Details of the caving in Cantabria and other stories from the Picos will be included in the final expedition report.

Other members of the expedition: Kate King, SORCHA De Eyto and Ann Kennedy

John Sherry.

AZORES '98

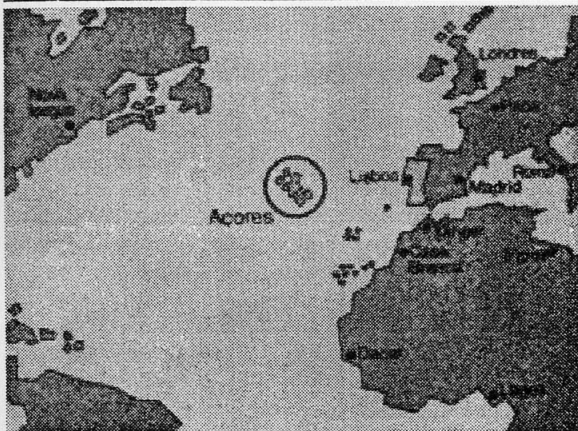
John & Angela Kelly

INTRODUCTION

Originally intended as a reconnaissance speleological visit with appended holiday, events conspired to expand the holiday component to the detriment of the speleological element. Significant research prior to the visit, together with contacts with locals and limited underground activity has allowed us to compile a short information report which will be deposited with the SUI library and should be of use to any group intending to visit these cavity riddled, fascinating and largely tourist free volcanic islands.

LOCATION, CLIMATE AND ACCESS

The Azores (Açores) are part of Portugal and are located approximately 27° E 37° N in the north central Atlantic. Climate is variable, late Autumn, Winter and early Spring characterized by high winds (average 65 mph). The climate the rest of the year is best described as "warm Irish", being very changeable but a few degrees warmer than Kerry. Good spells are very hot and wet spells (together with the dry stone walls and fields) are reminiscent of a warm wet week in north Tipperary.



Access is easy, through tickets with Air Portugal (Dublin – Heathrow – Lisbon) can be purchased, our flights were IR£379.00 return. Allow a full day to get there (8.30 am to 11.00 p.m.) and a stop over in Lisbon or London may be required on the way back. A number of the islands can be accessed directly from Lisbon, including Terceira, Pico and San Jorge. The longest and deepest caves, together with the highest peak in Portugal,

are on the islands of Pico and San Jorge and these would be a best bet for an initial flight.

Currency is the Portuguese Escudo (until the ECU) and food and drink are dirt cheap - ~35p for a bottle of beer, £2 - £3 for a bottle of half decent wine and about a fiver per person for a meal in a restaurant or bar. Camping is cheap as well.

Car hire costs unknown, had friends car on Terceira and used taxis on other islands - taxis quite expensive by Azores prices, but cheap compared to Dublin.

ISLANDS

Terceira

Big Island, quite a few caves. Large US airbase on the island means that the locals aren't too friendly if they think you're a yank (which they invariably do). US deported ~ 2000 Portuguese criminals to Portugal after they had served their sentences in the US and the Portuguese deported them all to the area around the airbase. Crime is pretty bad. Worth dropping in on for a while, but certain bits are best avoided. 1:50,000 map available if required.

Pico

Biggest and longest caves and pots. 3.8km long and 135m deep. Famous for Sperm whale hunting up to early '80's with rowing boats. Whale watching popular, also has highest mountain in Portugal (Pico) here.

San Jorge

Long thin island flanked by cliffs around most of coast. Good number of caves and locals very friendly indeed, especially English speaking taxi drivers. Well worth a visit for caves. Best diving/snorkelling experienced - superb visibility.

Other islands were left for the next generation.

CAVES

Passages vary from big tubes to low crawls. Basalts are very dark and the caves are very rough with lots of sharp projections. Fenian Terror Bypass writ large. Knee pads and gloves essential. Big flashes and fast films needed for photography. Caves generally only damp, muddy in places, definitely furry and oversuit country. Quite warm in summer. No evidence of active streams utilizing convenient lava conduits.

No vertical stuff needing rope attempted, but abrasive nature of rock and generally chossy nature of basalt would suggest ladder and lifeline may be safer, or use squillions of bolts.

MISCELLANY

BCRA RESEARCH FUND, 'HIDDEN EARTH 98' AND OTHER THINGS

As Irish correspondent for 'Caves and Caving', the British Cave Research Association quarterly journal, I have been asked to inform cavers that BCRA has a research fund which aims to issue grants of up to £1000 for small research projects. A common use for an award is the purchase of dye tracing materials but there is scope for a far wider range of projects.

If anyone is interested they can contact me for a copy of the BCRA Research Fund information sheet and application form.

The organisers of the BCRA annual conference have also asked me to publicise this year's event, Hidden Earth 98 which takes place 18th-20th September in Southport, a seaside resort just north of Liverpool. Its BCRACING and not far from Yorkshire so there's the opportunity to cave and to talk about caving; what more could a speleo desire?

This is also a good opportunity to remind you that I am always looking for items of news, discoveries etc for inclusion in the Irish section of 'Caves and Caving'. The items, which should be of interest to a wider audience, can be sent, faxed, e-mailed, phoned or whispered to me at any time during the year but preferably around the 20th of March, June, September and December.

For further details on any of the above contact: Pam Fogg at Newtate, Florencecourt, Co Fermanagh Tele (08) 01365348443 Fax (08) 01365348081
E-mail ropeaccessspecialists@compuserve.com

DIVE NORTH '98

For those into underwater bubbly activities, the NI Federation of sub-aqua clubs will be holding their annual conference, DIVE NORTH '98, in the Marine Court Hotel, Bangor, Co. Down. Further details from Randal Armstrong at Belfast 244832 ext 4239.

6th International Symposium on Vulcanospeleology



Hilo, Hawaii
August 1991

133/14

G. Thomas Rea
Editor



National
Speleological
Society

6th International Symposium on Vulcanospeleology

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1993

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August 1991

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Caves and Pits from the Azores With Some Comments on Their Geological Origin, Distribution, and Fauna

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Abstract

In 1989 Ogawa published an account of the distribution of volcanic caves and pits from the Azores. Further work in the last few years justifies an updating of the information. Ogawa listed 33 caves and 7 pits; now these numbers are 88 and 24. In this paper the caves and pits are listed according to their occurrence in the islands of the archipelago: Corvo (1;0), Flores (0;0), Faial (3;1), Pico (28;8), Graciosa (16;1), São Jorge (7;5), Terceira (20;6), São Miguel (10;3) and Santa Maria (3;0). Some data on the location, length, elevation, and fauna of each cave and pit are also given. During recent speleological expeditions by Os Montanheiros to the islands of Faial, Pico, Graciosa, São Jorge, Terceira, São Miguel, and Santa Maria over 10,000 meters of lava tubes and 400 meters of pits were surveyed and a total of 17 new maps are presented in this work. The longest lava tube, Torres Cave (Pico), is 3,350 meters long, 15 meters high, and 22 meters wide. The biggest pit, Algar do Montoso (São Jorge), is 137.5 meters deep. Presently 75% of the known caves have less than 300 meters. Some caves really belong to a single longitudinal lava tube broken into different sections. We also present some comments on the more relevant characteristics of each of the main caves and the distribution of lava tubes, pits, and related lava flows in each island. A short narrative of Azorean geology and some information for the preservation of the caves as well as some comments on the relict hypogean fauna are also provided.

Introduction

The Azorean archipelago is located in the North Atlantic, at the triple junction of the Eurasian, African, and North American plates. The distance between the Azores and the mainland is about 1,390 kilometers west of Cabo da Roca (the western most point of the European continent). It is formed by nine volcanic islands, aligned on a west-northwest to east-southeast trend, that are distributed in three groups: the western group with Corvo and Flores; the central group with Faial, Pico, Graciosa, São Jorge, and Ter-

ceira; the eastern group with São Miguel and Santa Maria (Figure 1).

The biggest island is São Miguel with 757 square kilometers and the smallest is Corvo with 17 square kilometers. Santa Maria is the most southern island (37°N, 25°W), and Flores is the most western one (31°W). The most northern one is Corvo (39.7°N) (see Table 1 and Figure 1).

The distance between Corvo and Santa Maria, the most widely separated islands, is about 615 kilometers. Corvo lies at approximately the same distance from the Iberian Peninsula and Newfoundland.

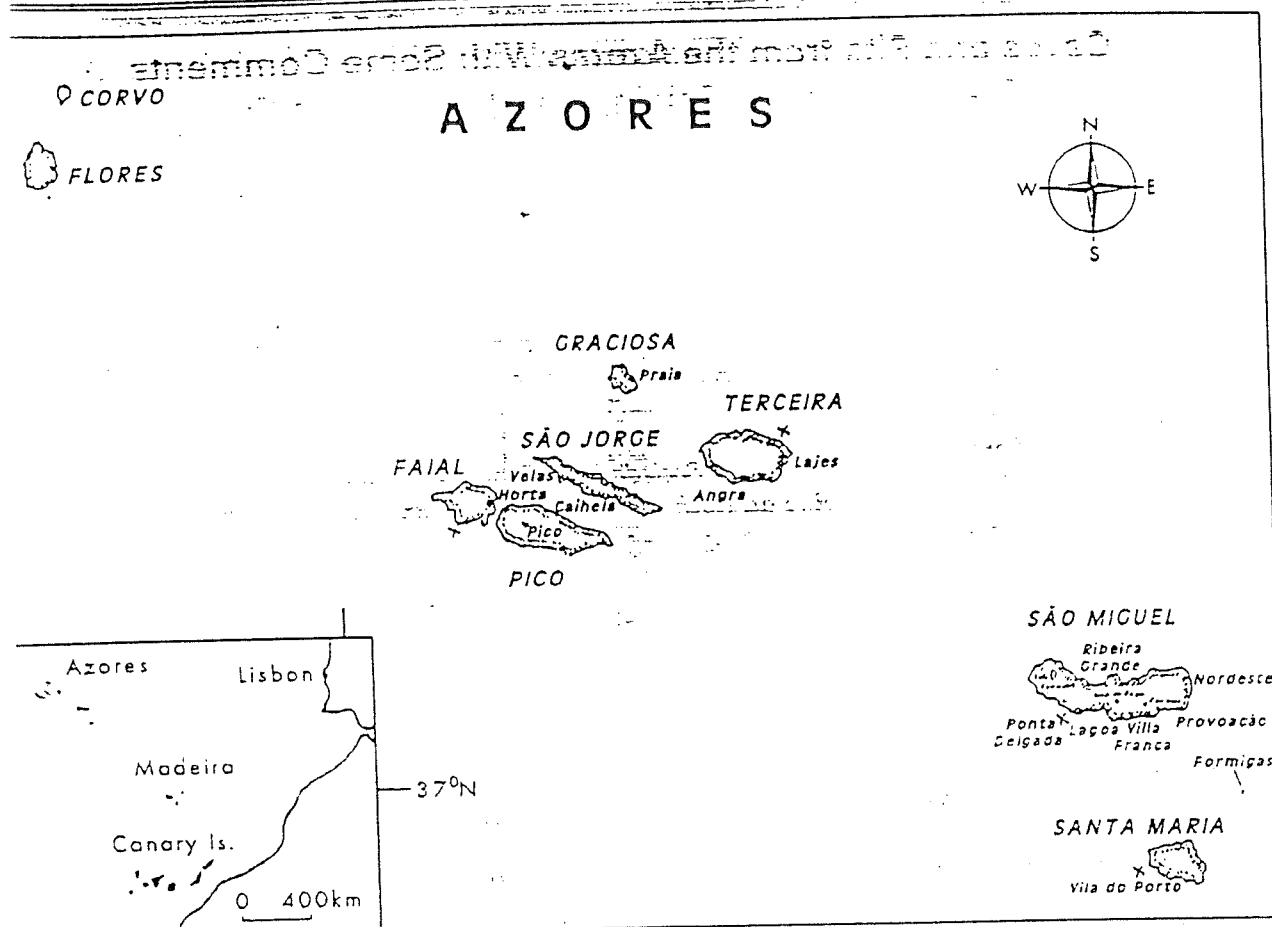


Figure 1 - Map of the studied area, Azores.

All the information concerning the longitude, latitude, area, maximum altitude, and geological age of each island are given in Table I.

Age and Origin of the Islands

All of the islands have a volcanic origin and there are many examples of historical volcanic eruptions

Island	Long.(W)	Lat.(N)	Area (km ²)	Altitude (m)	Age (million years)		
					A	B	C
Corvo	30.8	39.7	17	718	?	?	?
Flores	30.9	39.4	142	915	0.010	0.62(2.9)	1.8
Faial	28.5	38.6	172	1,043	2.6	0.73	0.73
Pico	28.2	38.5	433	2,351	1.1	0.037	0.037
Graciosa	27.8	39.1	62	402	0.62	0.62	2.5
São Jorge	27.9	38.7	246	1,053	2	0.55	0.55
Terceira	27.2	38.7	402	1,023	2	0.30	2
São Miguel	25.5	37.7	757	1,103	4	4.01	4.01
Santa Maria	25.1	36.9	97	587	8	8.12	8.12

Table I - Comparison of the physical characteristics of the nine Azorian islands.

A = Forjaz (pers. comm.); B = Abdel-Monem et al. (1975), Feraud et al. (1980); C = Queiroz (1990)

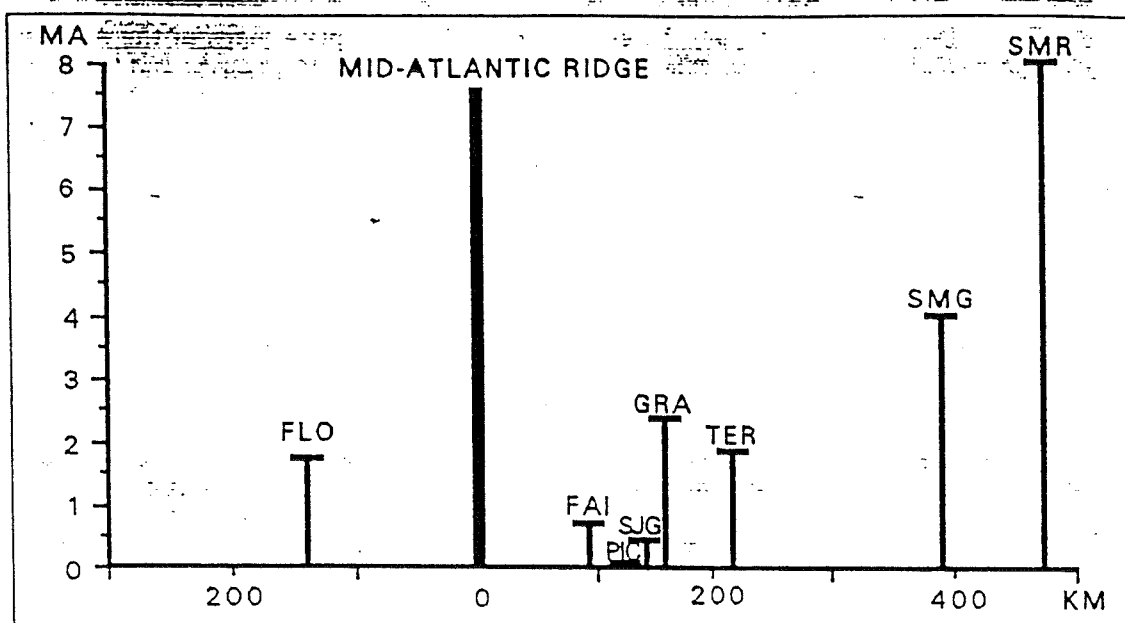


Figure 2—Relation between the age of each of the Azorean islands and the Middle Dorsal Atlantic. The geological ages are those proposed by Queiroz (1990) (Modified from Borges, 1991).

(see Weston, 1964). The geological age of the nine islands is very dissimilar. Since their formation took a long period of time, these islands present a recent volcanic morphology (e.g., Pico) or a more eroded, ancient formations (e.g., Flores and Santa Maria). There are several studies concerning the geological dating of the Azorean islands, but unfortunately there is no agreement on the age of some islands.

Three alternatives are proposed: one following Forjaz (pers. comm.) (column A), another with the results obtained by Abdel-Monem *et al.* (1975) and Feraud *et al.* (1980) (column B) with the K/Ar method, and finally one following Queiroz (1990) (column C). This last author follows, in part, Abdel-Monem *et al.* (*op. cit.*) and Feraud *et al.* (*op. cit.*) but also other recent studies (e.g., Forjaz, 1986b; White *et al.*, 1976; Azevedo *et al.*, 1986, all in Queiroz, *op. cit.*).

In Figure 2 we present the data of Queiroz (1990) in a graphical way. The age of the different islands of the archipelago is not positively correlated with their distance to the Middle Dorsal Atlantic (Feraud *et al.*, 1980). The same could be inferred from the ages proposed by Forjaz (pers. comm.) or Abdel-Monem *et al.*, (1975)/Feraud *et al.*, (1980).

As we can see from Table 1, different ages have been proposed for some islands, but nevertheless the eastern group is the older one, with 8.12 million

years (Santa Maria) (Abdel-Monem *et al.*, 1975), coming from the middle of the Miocene. Serughetti and Roche (1968) (in Ryall *et al.*, 1983) propose about 2.9 million years of age for Flores (Column B, Table 1), but Azevedo *et al.* (1986) (in Queiroz, *op. cit.*) estimates the age of this island at 1.8 million years. The central group is the youngest one.

We would also like to point out that the geological datings of the Azorean islands are far from being considered totally correct, mainly because the geological samples dated were probably not taken from the older stratigraphic layers (Nunes, pers. comm.).

The western part of each Azorean island is, geologically, the most recent one. This is connected with the seismo-volcanic mechanisms of this archipelago (Forjaz, pers. comm.), which is important because the occurrence and distribution of the Azorean lava tubes are somewhat related to recent lava flows (see below).

Speleological Studies in the Azores

The earliest reference concerning the occurrence of caves in the Azores is difficult to establish. Probably the work of Fouque (1873) — who briefly discussed lava tubes and pit caves on Terceira, Pico, and Graciosa — is one of the first. However, before his work, Webster (1821) mentioned caves

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in and near Ponta Delgada (São Miguel). Later, Pickering (1908) gave a follow-up on Fouqu e's exploration of the large pit Furna da Caldeira da Graciosa (Furna do Enxofre) on Graciosa Island.

The earliest speleological study recorded from the archipelago was made by Forjaz (1963) with a fine description and sketch of Furna de Henrique Maciel (Pico). Unfortunately the map of the cave is not presented. Recently (May 1990) two French speleologists (P. Brunet and C. Thomas) accompanied by one of us (A. Silva) made a map of this interesting cave (unpublished).

In 1966, a work of the Portuguese group Mocidade Portuguesa – Centro de Instru  o Especial de Espeleologia – describes the cave of Pau Velho (Gruta dos Balc es) (Terceira) with an incomplete map. This map was reproduced later by Halliday (1980). In 1967 Os Montanheiros made a fine map of this cave, later completed by Montserrat and Romero (1983) (see below).

Mottet (1970, 1972, 1974) presented some data on the geomorphology of some caves from Terceira (e.g., Gruta das Agulhas, Gruta do Natal, Gruta dos Balc es), but no maps are available.

Arruda (1972) studied and described some caves and pits from Pico: Furna Abrigo, Furna de Henrique Maciel II, Furna de Manuel Jos   Lima, and Algar do Alto do Morais. Although the maps of the Algar do Alto do Morais and Furna de Manuel Jos   Lima are probably incomplete, this author presents a fine map of Furna Abrigo.

The American speleologist, W. R. Halliday, (see Halliday, 1980 and also Anonymous, 1978) visited the Azores in April 1980 and worked out the first checklist of the Azorean caves and pits (Halliday, 1981). He listed the following caves and pits: Corvo (0;0), Flores (0;0), Faial (0;0), Pico (2;2), Graciosa (1;1), S  o Jorge (1;2), Terceira (11;2), S  o Miguel (3;0) and Santa Maria (0;0) (see also Table II). In these works we can find some sketches of the caves and pits but no impressive maps were presented. Some of these sketches (e. g., Algar do Carv  o, G. dos Montanheiros) were put at the disposal of W. Halliday by Os Montanheiros.

Authors	Caves	Pits	Total
Halliday (1981)	18	7	25
Ogawa (1989)	35	7	42
The Authors	88	24	112

Table II – Evolution of the knowledge of the number of caves and pits from the Azores.

The first complete maps of the Azorean caves were presented by Montserrat and Romero (1983). Three lava tubes (Balc es, Pau Velho, Natal) are described and mapped and one lava tube (Agulhas) and one pit (Algar do Carv  o) from Terceira are described by these authors. More recently Chinchon *et al.* (in press) presents further studies on Gruta dos Balc es, now the best studied lava tube in the whole archipelago.

Recently, Hayes and Braga (unpublished) presented at the 5th International Symposium on Vulcanospeleology (Japan, 1988) the first checklist of caves and pits from S  o Miguel.

Two biospeleological expeditions were carried out in the Azores directed by N.P. Ashmole (Edinburgh University) and P. Orom   (La Laguna University). These expeditions were supported by the National Geographic Society, USA, in July through August 1987 and 1989 (the latter also with the participation of one of us P. Borges) (see Orom   *et al.*, in press; Orom   and Borges, in press; Borges and Orom  , in press). Orom   *et al.* (op. cit.) presented the description of the biologically studied caves during the first of these expeditions (July through August 1987).

The most recent catalogue of the Azorean caves and pits was made by Ogawa (1989) (Table II), listing 35 caves and 7 pits. Since then, several speleological expeditions have been made in the Azorean islands by the Terceira (Azores) Os Montanheiros speleological group.

For a long period of time (1963 to 1987) the activity of Os Montanheiros had a recreation and tourist orientation, but also some speleological studies were made during several expeditions in the Azores:

1963 to 1976 – Several speleological visits were made to Graciosa, directed by A. Lu  s and R. Azevedo. The results of these visits are presented in Table III;

1967 – A speleological expedition directed by A. Lu  s to Pico. Two caves were visited (Gruta do Henrique Maciel and Furna Frei Matias);

1972 – A speleological expedition directed by A. Lu  s to S  o Jorge. As the main results of this visit, several sketches were made of the lava tubes Gruta da Beira and Gruta do Le  o and the pit Bocas do Fogo. All of them were revisited and completely mapped (see Plates 5, 6, and 7) in recent expeditions of Os Montanheiros (see below, S. Jorge-88 and Montoso-90);

1975 – A speleological expedition directed by A. Lu  s to Flores and Corvo. No caves were found on these islands;

1976 – A speleological expedition directed by R. Azevedo to Pico. The lava tube, Gruta dos Montanheiros was explored for the first time and an access ladder was built;

1978 – A speleological expedition directed by A. Silva to São Miguel. Several lava tubes and pits were explored (e.g., Gruta do Esqueleto, Gruta da Rua do Carvão, Algar da Batalha).

However, some of the works cited before (e.g., Mottet, 1974; Halliday, 1980, 1981; Montserrat and Romero, 1983; Chinchon *et al.*, in press; Ogawa, 1989; Oromí *et al.*, in press; Oromí and Borges, in press; Borges and Oromí, in press) were possible only thanks to the kind assistance of Os Montanheiros during part of the field work. Only recently a scientific goal was adopted by Os Montanheiros. The present work is done by three members of this group.

During the last years Os Montanheiros organized or took part in several expeditions to the islands of Flores, Faial, Pico, Graciosa, São Jorge, São Miguel, and Santa Maria (also the local island, Terceira). They have explored and mapped over 10,000 meters of caves and 400 meters of pits. The expeditions were:

1988 – October 31 to November 11, S. JORGE-88, Speleological Expedition to the island of São Jorge;

1989 – May 21 to 26, BIOSPEL-89, Biospeleological Expedition to the island of Pico (Azores);

1989 – July 4 to 11, FLORES-89, Zoological Expedition of the University of Azores (Dept. of Biology);

1989 – October 10 to 14, FAIAL-89, Biospeleological Expedition to the island of Faial (Azores);

1990 – March 3 to 11 and 17 to 21, BIOSPEL-90, Biospeleological Expedition to the island of Pico (Azores);

1990 – June 8 to 16, ST. MARIA-90, Zoological Expedition of the University of Azores (Dept. of Biology);

1990 – August 9 to 29, BIOSPEL-90-S. MIGUEL, Speleological Expedition to the island of São Miguel (Azores);

1990 – September 11 to 15, MONTOSO-90, Speleological Expedition to the island of São Jorge;

1991 – March 28 to April 3, TORRES-91, Speleological Expedition to the island of Pico (Azores);

1991 – June 6 to 11, ARCOSPEL-91, Speleological Expedition to the island of Pico (Azores).

The aim of the present contribution is to present a commented checklist of all the known Azorean caves and pits (see Table III, below). A total of 19 new maps or sketches of lava tube caves, littoral caves, and pits are presented. Some remarks on the conservation of the caves and on their fauna are also made.

Checklist of the Azorean Caves and Pits

Table III is a revised catalogue of the Azorean caves and pits (following four pages). Unfortunately in some cases the data presented is incomplete (e.g., caves from Graciosa). It includes the main name and other common names of each cave and pit, their location, the known length or depth in meters, and the minimum-maximum height and width also in meters. We also present data related to the altitude (elevation) of the main entrance of each cave and pit and the UTM coordinates. Finally, in each case we state whether there are maps and studies of the fauna available.

The data from Graciosa Island presented in Table III should be viewed with caution because it is based on incomplete notes taken by A. Luís, J.M. Fagundes, and R. Azevedo between 1963 and 1976 (speleological visits of Os Montanheiros to Graciosa).

The following abbreviations are used on the maps:

a = mapped by Arruda (1972)

b = mapped by Montserrat and Romero (1983)

c = mapped by the French speleologists, P. Brunet and C. Thomas accompanied by one of us (A. Silva) (unpublished)

d = mapped by Os Montanheiros speleological group and by the Amigos dos Açores ecologist group during the Biospel-90-S. Miguel, Speleological Expedition to the island of São Miguel (Azores)

Mont = mapped by Os Montanheiros speleological group

Ogawa = mapped by Ogawa (1989)

Sketch = only a sketch, made by Os Montanheiros, is available.

We also use in Table III the symbols: ? = information not available and ?? = not confirmed.

Seven maps are presented (Figures 3 to 7) with the location of the lava tubes, littoral caves, pits, and the main lava flows (information based on Anonymous, 1980 a, b, and c) in seven of the nine Azorean islands. The notation is the same as that used in the Checklist (Table III). For the caves we use the symbol "*" and for the pits the symbol "O."

Island and No.	Main Name	Other Names	Location	Length/ Depth (m)	Height (m)	Width (m)	Elev. (m)	UTM	Map	Fauna
1. Corvo										
Lava Tubes										
1	Gruta do Corvo		?	?	?					
2. Flores										
	No Caves Known									
3. Faial										
Lava Tubes										
1	Furna das Anelares	Lombega	Lombega	35.5	0.7-4.0	1.4-2.5	80	3482/42663	Mont	yes
2	Gruta do Cabeço do Canto	Concheiros	Cabeço do Canto	21.4	0.3-5.10	0.5-7.5	346	3420/42740	Mont	yes
3	G. do Parque do Capelo		Parque do Capelo	55.3	0.35-1.50	0.4-3.40	300	3452/42727		
Pits										
4	Furna Ruim		Cabeço Verde	-55		20.6-73.1	565	3467/42722	Mont	yes
4. Pico										
Lava Tubes										
1	Furna da Areia	F. do J. Maria	Caminho do cais Mourato	?	?	?	?	?		
2	F. da Laje	F. da Tr'Adelina;	Lajido	?	?	?	10	3755/42688		
3	F. da Miragaia	F. do Ranheira	Miragaia do Norte	50	?	?	140	3720/42661		
4	F. das Casas	F. do Chico	Lugar das Casas	?	?	?	20	3709/42685		
5	F. do Carregador	Algar do Barreira;	Algarves	20	2	7-6.0	330	3716/42641		
6	F. do Frei Matias	F. dos Algarves	Estrada Nova (Longit.)	666	7-7.2	7-14.2	680	3735/42609	Mont	
7	F. do Henrique Maciel	F. do Estácio	Santo António	812 > ??	7-4.5	7-4.0	140	3825/42649	c	yes
8	F. do Poço Novo	D. do Germano;	Poço Novo (Near the seaside)	?	?	?	?	?		
9	F. do Poço Velho	F. do Calote	Canal do Poço Velho	?	?	?	?	?		
10	F. do Tancaim	F. do Tanquinho;	Tanbor (Mistério de St Luzia)	?	?	?	275	3731/42655		
11	F. dos Bodes	F. do Ranheira	Cabeço-Chão	?	?	?	?	?		
12	F. dos Caldeirões		Canada dos Caldeirões, Bandeiras	?	?	?	110	3721/42668		
13	F. dos Mendonças		Canada da Traveasa	?	?	?	?	?		
14	F. dos Montanhinhos		Curral Queimado, Brejos	741	0.45-6.79	0.40-8.59	785	3831/42610	Mont	yes
15	F. D'Água	Bandeiras I; Bandeiras II	Bandeiras (Mistério de St Luzia)	250 + 100	7-2.0	7-5.0	100	3738/42670		
16	F. Manuel José Lima	F. dos Faustinos	Santo António, Miragaia	52	0.5-5.0	7-6.0	140	3773/42670	a	
17	F. Nova I		Farrobo (Mistério de St Luzia)	270.1	0.75-4.0	1-2.50	230	3741/42658	Sketch	
18	F. Nova II		Farrobo (Mistério de St Luzia)	?	?	?	210	3741/42659		
19	Gruta da Barca		Estrada Marginal, Barca	?	?	?	0	3675/42670		

Island and No.	Main Name	Other Names	Location	Length/ Depth (m)	Height (m)	Width (m)	Elev. (m)	UTM	Map	Fauna
4. Pico (cont)										
Lava Tubes										
20	G. da Capucha	Agostinha; João Serafim	Canada da Capucha, Bandeiras	310.78	0.43-5.10	1.8-10.95	75	3730/42675	Mont	yes
21	G. das Torres		Cabeço Bravo, Creação Velha	3,350	0.50-15.0	1.1-22.0	300	3681/42618	Mont	yes
22	G. do Capitão-Mor		Cais do Pico	300	?	?	30	3850/42649	c	
23	G. do Galeão I		Panha do Galeão, S. Caetano	255.9/-7.0	3.0-16.0	2.0-10.0	100	3749/42545	Mont	
24	G. do Galeão II		P. do Galeão (Ringue)	50	0.4-1.1	0.41-1.25	60	3748/42541	Sketch	
25	G. do Ruivo		Carregador	70	?	?	?	?		
26	G. do Soldado	Malha; Soldado; Moio; Terra Tapada	Mistério da Silveira	1,150	0.40-5.96	0.43-5.39	10	3868/42526	Mont	yes
27	G. dos Arcos		Arcos (Mistério de St Luzia)	216.5	0.30-2.10	1.0-1.60	50	3778/42686	Sketch	yes
28	G. dos Esqueletos		Igreja de St Luzia	91	0.80-1.60	1.0-2.10	130	3780/42674	Sketch	yes
Pits										
29	Algar da Furna Abrigo		Pico do Pico	-39		10.0-13.0	1,200	3750/42598	a	
30	A. do Alto do Morais		Canada do Mato (Frei Matias)	65/-10		12.0-30.0	1,015	3755/42605	a	
31	A. do Cabeço Bravo		Cabeço Bravo (Creação Velha)	323/-28.5	4.5-9.0	1.8-15.0	400	3698/42611	Sketch	
32	A. do Cabeço da Negra		Campo Raso, Candelária	7/-15.0	?	?	75	3695/42562		
33	A. do Capitão	Tambor III	Tambor (Mistério de St Luzia)	7/-5.5	?	?	200	3731/42658	c	
34	A. do Lanchão	A. do Cadete; A. do Ti Alfredo	Bandeiras (Mistério de St Luzia)	40.5/-5.5	0.40-5.0	0.50-2.0	110	3721/42667	Sketch	
35	A. do Tambor	Gratera do Cabeço	Tambor (Mistério de St Luzia)	97.4/-31.5	1.0-3.5	1.20-7.40	244	3733/42657	Sketch	
36	A. do Vale da Nogueira		Vale da Nogueira	?	?	?	?	?		
5. Graciosa										
Lava Tubes										
1	Furna da Labarda		?	7.4	?	2-4.40	?	?		
2	F. da Maria Encantada	F. do Castelo	Cume da Caldeira	56.5	2-2.80	2.5-5.7	200	4151/43207		
3	F. do Anel		?	50.4	?	2-3.50	?	?		
4	F. do Canto		?	11.3	?	2-10.80	?	?		
5	F. do Carro		?	15	?	2-2.20	?	?		
6	F. do Gato		?	11.0	?	2-6.60	?	?		
7	F. do Linheiro		?	8.2	?	2-10.0	?	?		
8	F. do Luis		?	12	?	2-9.0	?	?		
9	F. do Manuel de Ávila		?	14.7	?	2-8.10	?	?		
10	F. do Queimado		?	12.5	?	?	?	?		
11	F. dos Bolos		?	8	?	?	?	?		
12	F. D'Água		?	10.5	?	2-6.50	?	?		
13	F. Ferrada		?	3.4	2-6.20	2-8.10	260	4148/43211		

Island and No.	Main Name	Other Names	Location	Length/ Depth (m)	Height (m)	Width (m)	Elev. (m)	UTM	Map	Fauna
5. Graciosa (cont)										
Lava Tubes										
14	Galeria do Forninho		Luz	96	0.80-3.5	2-7.30	?	?		
15	Gruta da Canada das Furnas	Furna do Roque	Canada das Furnas	83	1.9-6.5	3.4-6.10	125	4148/43208		
16	G. do Bom Jesus		Bom Jesus	16	0.55-2.10	2.25-8.0	50	4115/43255	Mont	
Pits										
17	Furna do Enxofre		Caldeira da Graciosa	42		100	137	4159/43199	Ogawa	
6. São Jorge										
Lava Tubes										
1	Furna das Pombas	G. do Gais da Urzelina	Urzelina	?	?	?	0	4029/42782		
2	F. do Poio	F. da Lagoa de St Cristo	Fajã de St Cristo	?	?	?	25	4189/42758		
3	F. do Pombal	Mina D'Água	Pombal, Fenos, Manadas	?	?	?	510	4048/42769		
4	Gruta da Beira		Beira	183	2.50-10.0	2.50-15.0	275	3952/42839	Mont	yes
5	G. da Granja		Velas	?	?	?	?	3958/42817		
6	G. da Lomba do Gato		Guinada, Velas	?	?	?	250	3967/42816		
7	G. do Leão		Preso do Leão, Velas	177	0.5-6	0.8-3	250	3964/42818	Mont	
Pits										
8	Algar das Bocas do Fogo	Bocas de St Amaro	Lixeira de St Amaro	55.3/12.0		30.0-50.0	521	3982/42817	Mont	yes
9	A. do Montoso		Pico do Carvão	269/137.5	9.0-50.0	9.0-70.0	784	4048/42791	Mont	
10	A. do Pico da Maria Pires		Pico da Maria Pires	?	?	?	663	4000/42814		
11	A. do Pico dos Suspiros I		Pico dos Suspiros	?	?	?	920	4049/42792		
12	A. do Pico dos Suspiros II		Pico dos Suspiros	?	?	?	920	4049/42792		
7. Terceira										
Lava Tubes										
1	Forna de St Maria		Cabrito, Porto Judeu	320	?	?	450	4841/42852		
2	F. do Cabrito		Cabrito, Porto Judeu	200	?	?	400	4841/42849		
3	F. D'Água		Cabrito, Porto Judeu	250	?	?	450	4843/42845		
4	Galeria da Ribeira Seca		Ribeira Seca	60	?	?	175	4918/42813		
5	Galeria Queimada	Cafua Velha	Biscoitos, Pau Velho	639.9>??	0.3-2.5	0.26-10.9	473	4768/42895	Mont	
6	Gruta Branca Opala		Biscoitos, Pau Velho	87.3	0.9-3.1	1.1-2.8	280	4781/42923		
7	G. da Achada		Biscoito das Fontinhas	169	0.25-2.40	1.5-4.0	310	4868/42870		
8	G. da Madre de Deus		Porto Martins	244	0.5-10.8	0.5-21.0	210	4940/42816	Mont	yes
9	G. das Agulhas	G. da Salga	Porto Judeu	250.5	0.5-5.4	1.2-4.5	5	4909/42775	Mont	yes
10	G. das Feliceiras		Porto Judeu	?	?	?	600	4724/42854		
11	G. das Mercês		Onzeiro do Bogango	69	0.60-2.70	1.2-1.7	135	4869/42784		
12	G. de Santo António		Canada dos Marcos, Feteira	302.1	0.35-9.40	0.6-18.0	220	4936/42818		
13	G. do Caldeira		Biscoitos, Pau Velho	148	0.40-2.60	1.1-5.6	260	4774/42911		yes
14	G. do Canelo		Cabrito, Porto Judeu	255.87	0.30-3.80	1.7-11.3	465	4841/42850	Mont	

Island and No.	Main Name	Other Names	Location	Length/ Depth (m)	Height (m)	Width (m)	Elev. (m)	UTM	Map	Fauna
7. Terceira (cont.)										
Lava Tubes										
15	G. do Chocolate	Galerias Negras, G. do Cavalo G. dos Principiantes	Biscoitos, Pau Velho	109.7	0.50-6.20	0.4-3.6	250	4781/42924	Mont	yes
16	G. do Coelho		Lagoa do Negro	186.7 ??	1.0-2.1	1.2-3.5	540	4764/42879		
17	G. do Natal		Lagoda do Negro	389	0.50-7.0	0.8-12.0	540	4766/42878	b	
Pits										
18	G. do Pau Velho	G. dos Principiantes	Biscoitos, Pau Velho	245.5	1.0-4.0	0.4-12.0	350	4778/42908	b	
19	G. do Zé Grande		Serretinha	31.61	0.40-2.10	1.9-3.8	125	4867/42781	Mont	
20	G. dos Balcões		Biscoitos, Pau Velho	2,713	0.30-6.0	0.25-7.0	390	4778/42906	b	yes
Pits										
21	Algar do Carvão	G. dos Principiantes	Algar do Carvão, Porto Judeu	120/-90	1.6-40	2.10-20.0	629	4810/42865	Mont	yes
22	A. do Funil		Biscoitos	-22		11.0-20.0	500	4778/42879		
23	A. do Mistério		Biscoitos	151/-12	0.50-2.10	0.5-2.4	545	4763/42877		
24	A. do Negro		Lagoa do Negro, Biscoitos	16/-5.5		16	540	4762/42876		
25	A. do Pico das Dez		Pico das Dez, St Barbara	60/-20	0.30-3.50	1.0-4.5	350	4698/42849		
26	A. do Pico Gaspar		P. Gaspar, Lagoda do Negro, Bis	8.5/-18		2.35	540	4764/42873	Sketch	
8. São Miguel										
Lava Tubes										
1	Gruta da Canada da Giesta	Algar da Rua de Lisboa Algar da Rua do Paim; G. da Fábrica de Talaco	Pico da Pedra, Ribeira Grande	?	?	?	145	6228/41831		
2	G. da Quinta-Irene		Ribeirinha, Ribeira Grande	30	?	7-20.0	105	6329/41879		
3	G. da Rua do Carvão		Domingos Rebelo, P. Delgada	694.9	0.3-5.1	1.0-12.7	38	6159/41779	d	
4	G. da Rua do Paim		Rua do Paim, P. Delgada	285.4	0.5-5.1	1.2-10.5	71	6158/41785	d	
Pits										
5	G. das Arribanas	Furno do Pico da Cruz	Arrifes, Serra Gorda	?	?	?	275	6153/41828		
6	G. das Escadinhas		Ribeirinha, Ribeira Grande	31.2	0.44-1.6	0.75-5.1	140	6331/41868	d	
7	Gruta de Água de Pau		Água de Pau	323.1	0.2-2.6	0.8-6.6	2	6295/41752	d	yes
8	G. do Esqueleto		Lagoa do Fogo, R. Grande	188.2	0.3-9.5	1-12.5	250	6311/41843	d	yes
9	G. do Pico da Cruz	Furno do Pico da Cruz	Pico da Cruz, Pico da Pedra	98.5	0.6-2.9	0.85-5.4	273	6217/41830	d	yes
10	G. do Pico do Enforcado		Capelas, Ponta Delgada	184.8	0.45-3.20	0.7-6.0	245	6160/41868	d	yes
Pits										
11	Algar da Batalha	Gruta da Batalha Gruta da Ribeirinha	Fajã de Cima, Ponta Delgada	51.9/-9.5	0.4-3.3	0.5-5.7	240	6198/41837	d	
12	A. da Merla		Ribeirinha, Ribeira Grande	54.5/-5	0.9-2.5	7-3.7	150	6331/41870	d	
13	A. do Pico Queimado		Pico Queimado/Tico do Sapaleiro	10/-37.3	12	1.6	250	6283/41830	d	yes
9. Santa Maria										
Littoral Caves										
1	Furna das Pombas	Furna Velha	Vila do Porto	337	0.5-14.5	0.4-12.5	0	6663/40900	Mont	yes
2	Furna dos Anjos		Anjos	117.85	0.65-8.6	0.44-11.2	10	6639/40969	Mont	yes
3	Gruta do Romeiro		Ilhéu do Romeiro de S Lourenço	?	?	?	40	6745/40947		

New Maps and Sketches of Some Azorean Caves and Pits

Herewith we present 13 new maps and 4 sketches of 12 lava tube caves, 2 littoral caves and 3 pits. A short characterization of each is presented. The four sketches (Gruta das Torres, Algar da Bocas do Fogo, Galeria Queimada and Gruta das Agulhas) will soon be published as maps.

Faial

1. Gruta Das Anelares (Gruta da Lombega) (Plate 1; Figure 3, lava tube 1)

Location: Lombega (Faial); Elev: 80 m; UTM: 3482/42663; Length: 35.5 m; Height: 0.70-4.00 m; Width: 1.40-2.50 m.

During the Torres 91 Expedition to the island of Pico Os Montanheiros had the opportunity to study and map a small lava tube at Lombega, Faial. Later named by us Furna das Anelares, because of the ring-like (*anel* in Portuguese) stalactites commonly dispersed all over the ceiling. This is a small lava tube with only one entrance, a skylight situated 3.40 meters above the ground.

The floor is of aa lava and the ceiling is completely covered with thin brown stalactites (blade like) and ring stalactites.

Fauna: During the visit to this cave we had the opportunity to collect some specimens of one interesting hypogean species. The species is probably the troglobitic *Cixius cavazoricus* Hoch (Homoptera, Fulgoroidea) described from Gruta do Cabeço do Canto (see below). They were collected on roots situated at the north part of the cave (see points 3 and 3' of the map, plate 1).

2. Gruta do Cabeço do Canto (Gruta dos Concheiros) (Plate 2; Figure 3, lava tube 2)

Location: Cabeço do Canto, Capelinhos (Faial); Elev: 346 m; UTM: 3425/42740. Length: 21.4 m; Height: 0.30-5.10 m; Width: 0.50-7.50 m.

During the Faial-89 Biospeleological Expedition to the island of Faial we had the opportunity to visit the Capelinhos area. On information from a local person we went to the Cabeço do Canto and found a small lava tube there. The entrance is covered with ashes of the Capelinhos eruption (1957-58) and the floor of the cave is covered with many collapsed rocks.

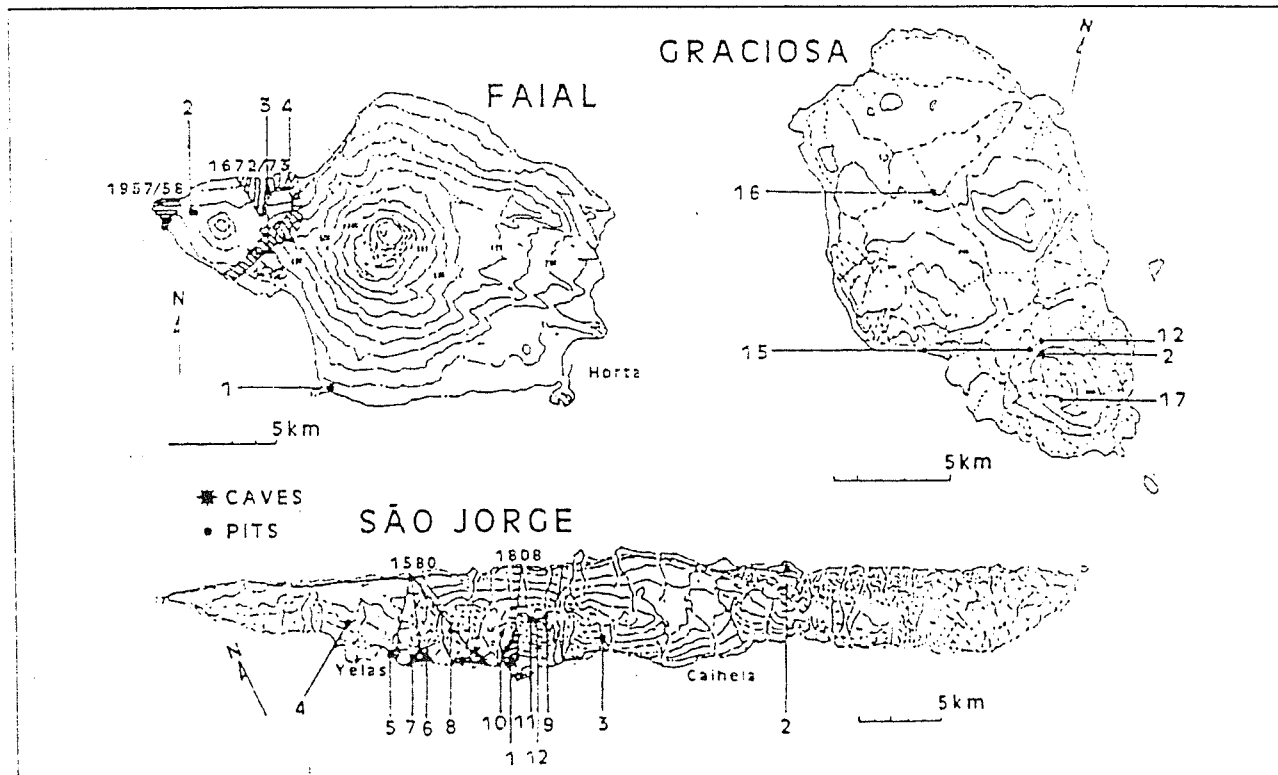


Figure 3—Maps of three central Azorean islands, Faial, Graciosa, and São Jorge, showing the location of the lava tubes and pits (see also Table 3).

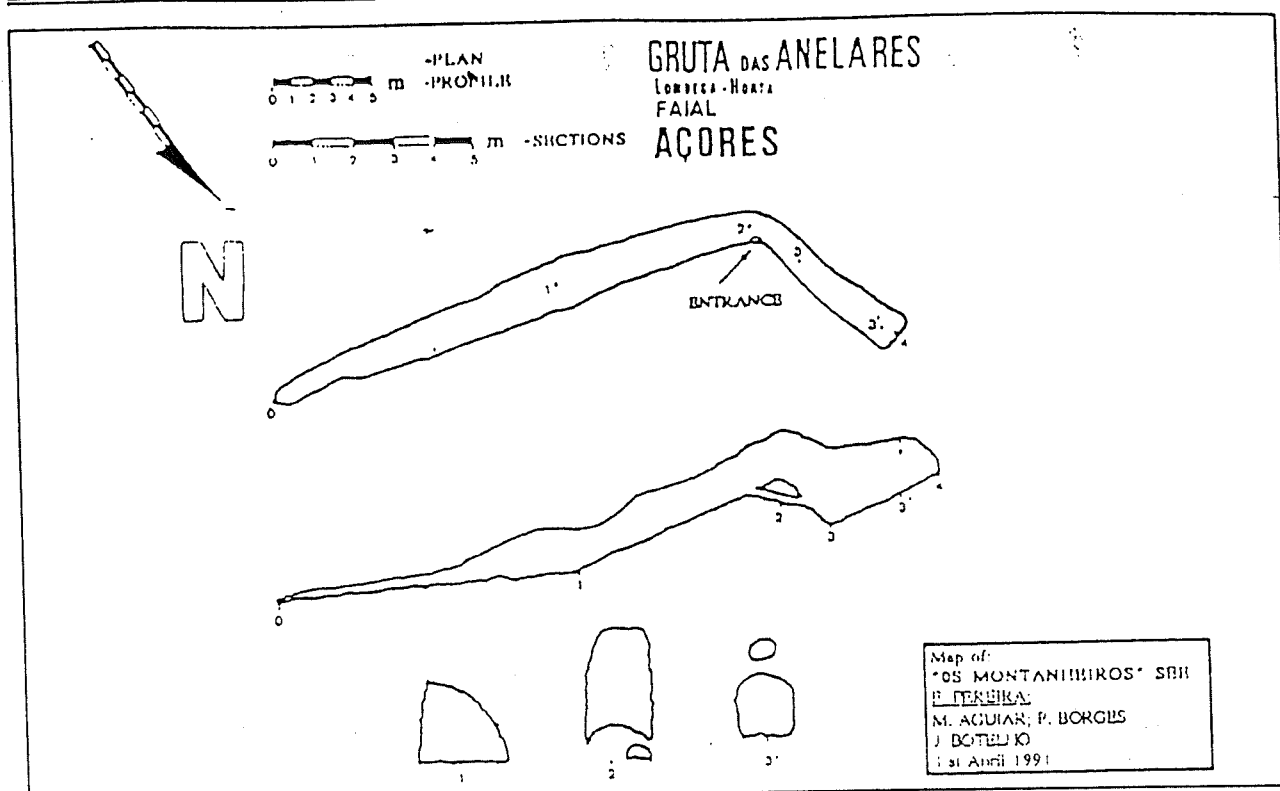


Plate 1 – Gruta das Anelares.

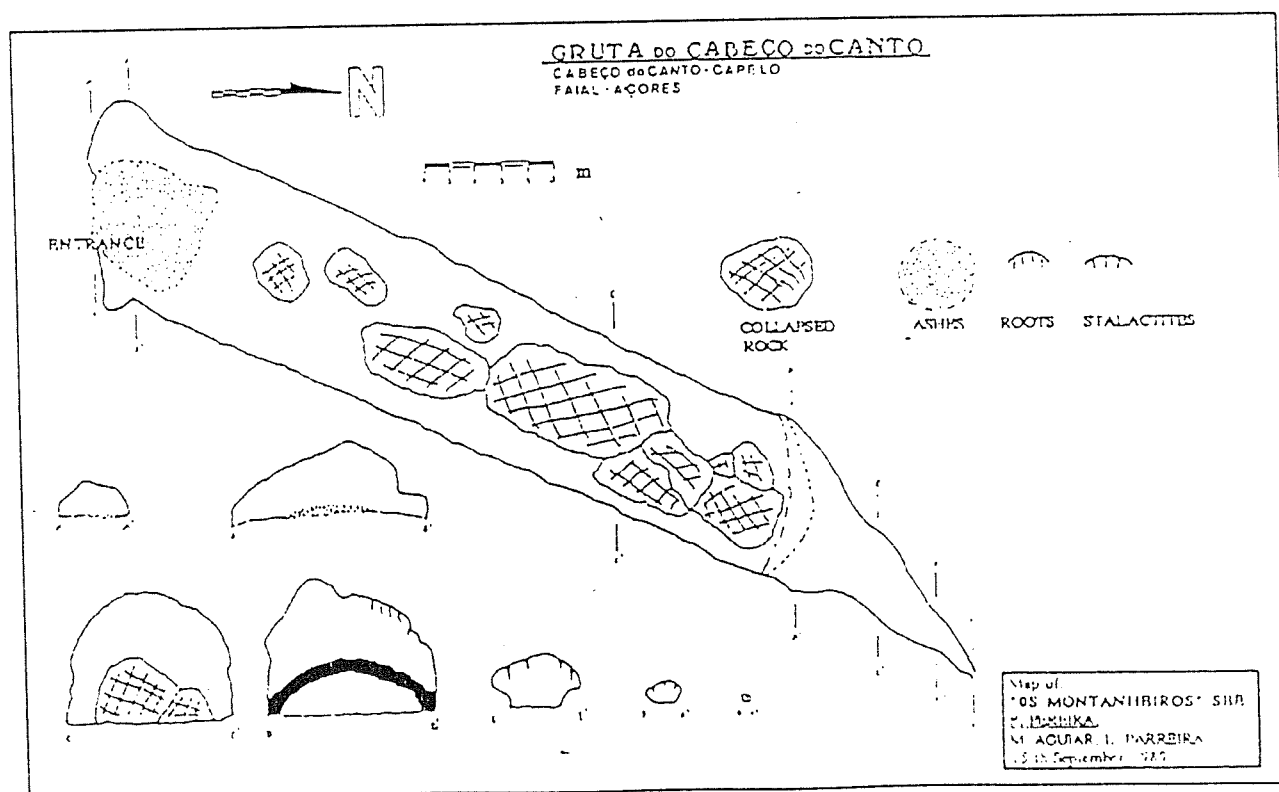


Plate 2 – Gruta do Cabeço do Canto.

There are two obvious levels of drainage shown on the double gallery at the end of the cave. In this part the upper level forms an arch (double ceiling) and the walls are reddish. Some small lava stalactites are present.

The Cabeço do Canto volcano is part of a recent complex of volcanoes aligned over a fracture line that connects the Caldeira do Faial and the Capelinhos Volcano.

Fauna: Recently Hoch (manuscript) described the troglobitic species *Cixius cavazoricus* Hoch (Homoptera, Fulgoroidea) with type specimens collected by us in this cave. The specimens were collected in roots situated in the north part of the cave (see sections D-D' and E-E' of the map). *Cixius cavazoricus* Hoch is a relict species, i.e., a cavernicolous species which has no close epigeal relatives on the same, or neighboring islands (Hoch, *op. cit.*). Mainly to ensure survival of this organism, this cave should be protected.

Pico

3. Furna dos Montanheiros (Plate 3; Figure 4, lava tube 14)

Location: Curral Queimado, Brejos, Regional Road nº 3, km 17 (Pico); Elev: 785 m; UTM: 3831/42610; Length: 741 m; Height: 0.45-6.79 m; Width: 0.40-8.59 m.

The cave is a typical lava tube and was mapped during the Biospel-90 Biospeleological Expedition of Os Montanheiros.

The main entrance is a skylight situated 400 meters from the west part of the tube where another skylight (hornito) occurs. The access is a wooden staircase constructed by Os Montanheiros.

It is a unitary "throughway" system, with remarkable formations that make it one of the most interesting lava tubes in the Azores.

The floor of this volcanic tunnel is of aa or pahoehoe type. There are several levels of drainage registered on the walls by lateral benches (*bancadas*). The same occurs in the impressive lava tubes Gruta dos Balcões (Terceira) and Gruta das Torres (Pico) (see below).

The west part of the cave is the most interesting one with some notable formations on the floor, like a model lava tube at reduced scale that shows how a large lava tube can be formed. In this part of the cave the lava flow was oxidized by the entrance of air (due to the compression of gases), and as a

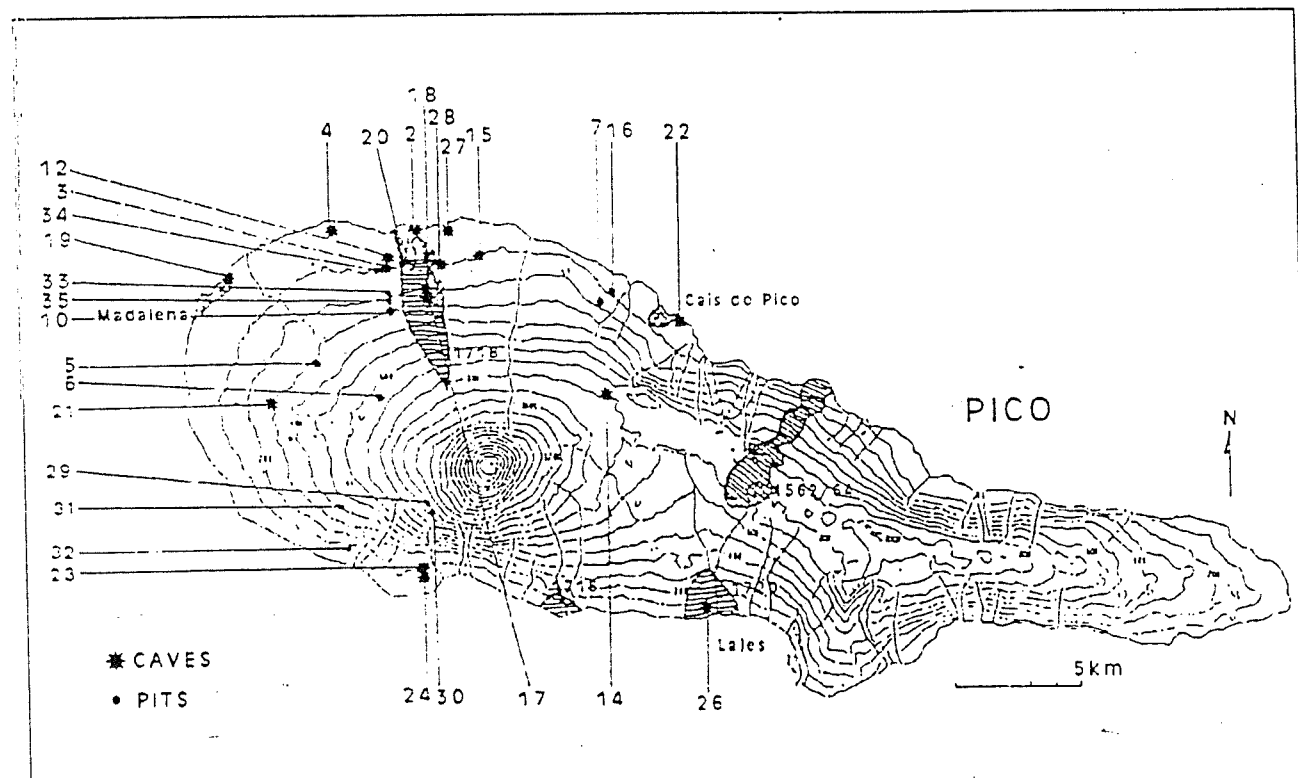


Figure 4 – Map of Pico Island showing the location of the lava tubes and pits (see also Table 3).

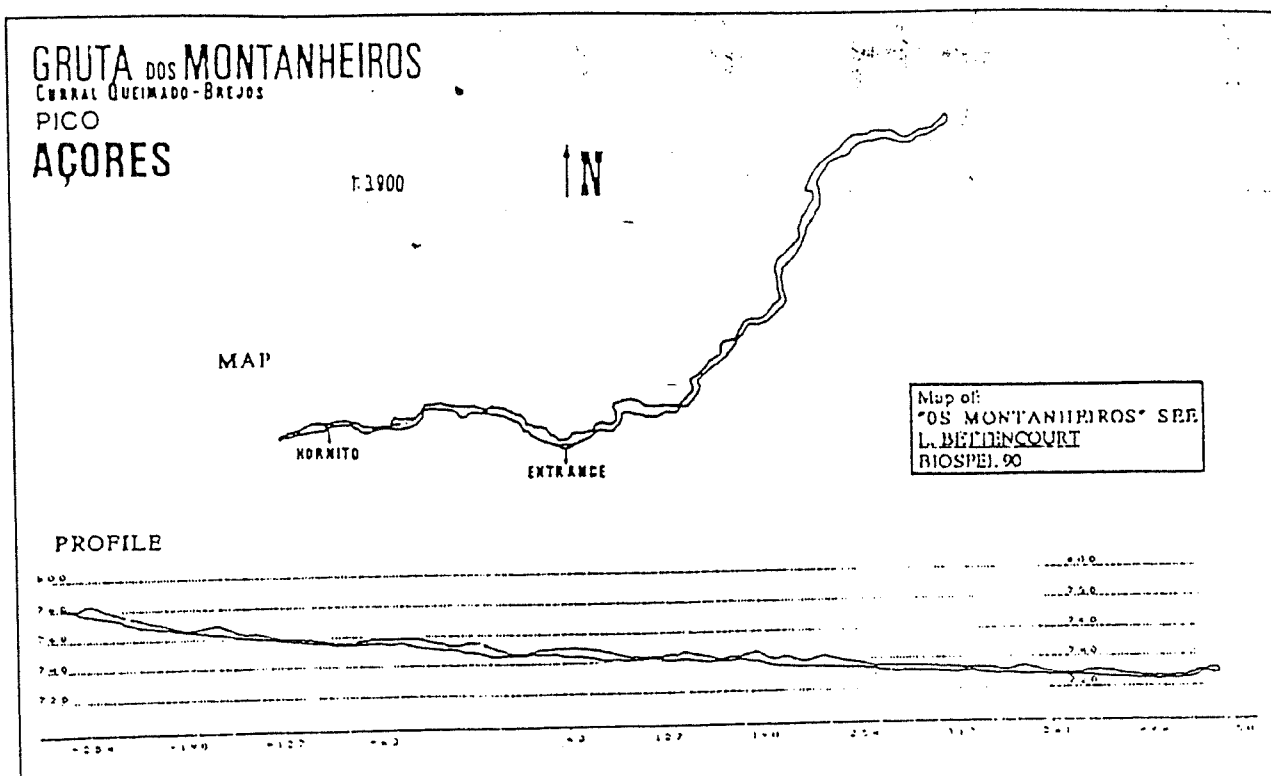


Plate 3 - Gruta dos Montanheiros.

consequence the rock is reddish. There are multiple levels. Fortunately the tube is well preserved with almost no collapsed rocks from the ceiling or walls.

In the north part of the tube there are some areas with collapsed rocks and in other parts we can find a collapsed rock covered by the lava flow. Several types of stalactites (lava-drops) cover the ceiling of all the cave.

Fauna: Biospeleologically this is one of the best studied caves in the Azores. As a consequence of the biospeleological expedition directed by N.P. Ashmole and P. Oromí (1987), a hypogean ground beetle was described, *Trechus picoensis* Machado (see Oromí et al., 1990).

Later, another carabid species (present only in the skylight area of the cave) was described, *Trechus montanheiorum* Oromí and Borges (see Oromí and Borges, in press). The type specimens were collected during the former expedition and during the Biospel-89 and Biospel-90 Biospeleological Expeditions of Os Montanheiros. The origin and speciation of these two interesting *Trechus* species are discussed in Borges and Oromí (in press).

In this cave we also found two new species of Collembola, *Onychiurus* sp. and *Pseudosinella azorica* Gama, both with obvious adaptations to cave life (Oromí et al., 1990).

Other species, common to other Pico caves (e.g., Soldão, Capucha, Arcos), could also be found in Gruta dos Montanheiros, like the undescribed *Cixus* sp. (see Hoch, in press) and the spider *The ridion pico* Merrett and Ashmole.

Speleologically and biologically Gruta dos Montanheiros is one of the most important caves of the Azores and should be protected.

4. Gruta das Torres (Plate 4; Figure 4, lava tube 21)

Location: Cabeço Bravo, Creação Velha (Pico); Elev: 200 m; UTM: 3681/42618; Length: 3,350 m; Height: 0.50-15.00 m; Width: 1.10-22.00 m.

This is now the most impressive volcanic lava tube in the Azores, with 3,350 meters mapped and more than 600 to 800 meters only visited for a total length of about 4,000 meters. In the list of the world's longest lava tubes revised (second revision) by Crawford (1979) the Gruta das Torres would occupy the seventh place. Gruta dos Balcões (Terceira) is now the second longest one in the Azores.

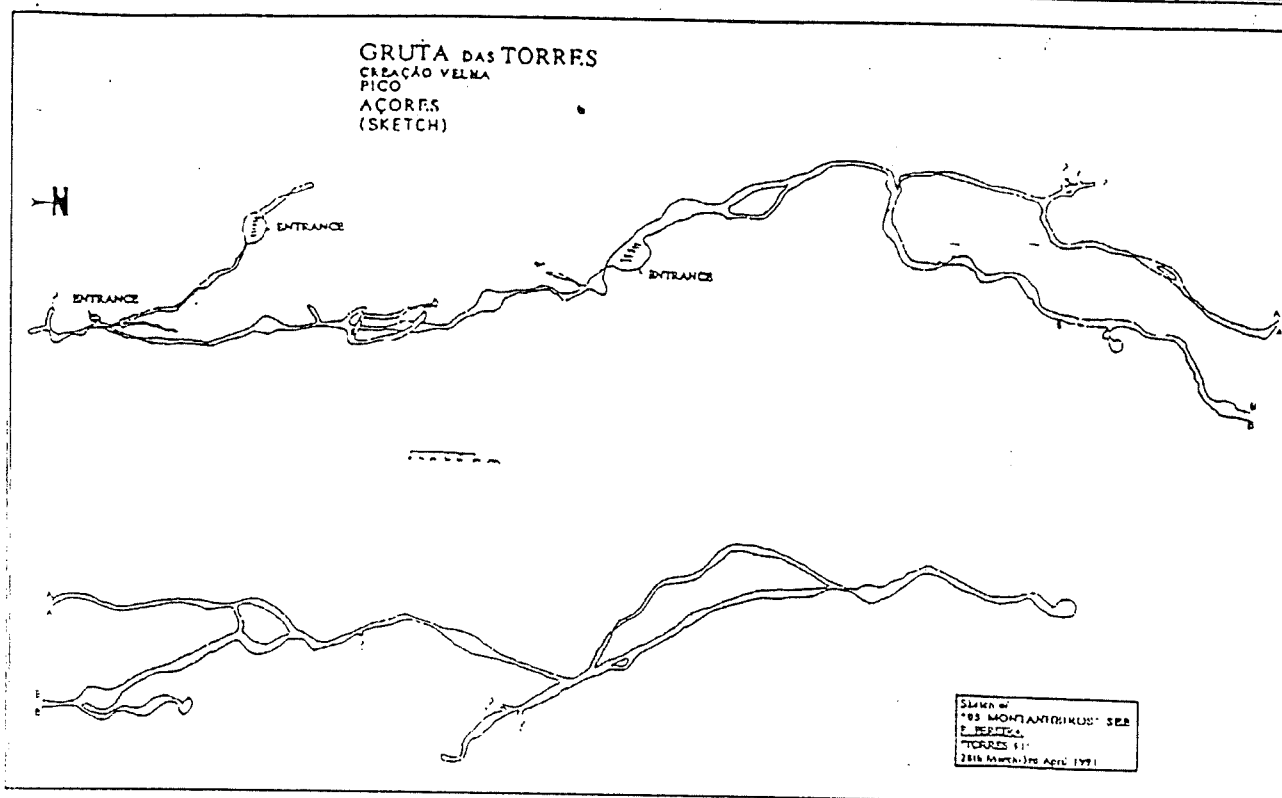


Plate 4—Gruta das Torres.

Between March 28 and April 3, 1991, a team of seven members of Os Montanheiros undertook a speleological expedition, Torres-91, to this magnificent cave, mapping and filming it.

The cave lies in lava fields of the northeast volcanic sector of Pico Mountain, southeast of Creação Velha.

It is a three-dimensional braided system with some remarkable formations. The floor is aa or pahoehoe type. There are at least 11 levels of drainage registered on the walls by lateral benches and three cornice levels. The height of 15 meters and the 11 drainage levels give an idea of the majesty of this lava tube cave.

This lava tube has two entrances, one, a skylight near one extremity, the other, 600 meters down, a large cone formed by the slumping of the roof. All over the main tube (about 2,500 meters in length) there are great blocks of lava collapsed from the roof making progress very difficult, but in some areas the floor is clean and of a beautiful pahoehoe lava or aa lava. In the main tunnel we can find some impressive lava gutters. The most interesting formations are in the secondary tunnels, some of them are unique. Sometimes there are very low crawlway passages.

Fauna: The undescribed *Cixius* sp. (see Hoch, *op. cit.*) was collected by us during the Torres-91 Speleological Expedition of Os Montanheiros to this cave. We have also put a set of pitfalls in the cave but the arthropods collected by these traps are still undetermined.

São Jorge

5. Gruta da Beira (Plates 5 and 6; Figure 3, lava tube 4)

Location: Beira (São Jorge); Elev: 275 m; UTM: 3952/42839; Length: 183 m; Height: 2.50-10.0 m; Width: 2.50-15.0 m.

This cave was mapped during the Speleological expedition of Os Montanheiros directed by A. Luís to São Jorge in 1972 and later revisited by the recent S. Jorge-88 Expedition of Os Montanheiros.

The cave is located in the Rosais Volcanic Complex, mainly with porphyric basalts. The lava tube has a north-northwest orientation, flowing to south-southwest at the sea direction.

The entrance, measuring ten by six meters, is a hollow in the collapsed roof of the cave. In the southern part of the tunnel there is a large room filled with earth. Several collapsed rocks from the

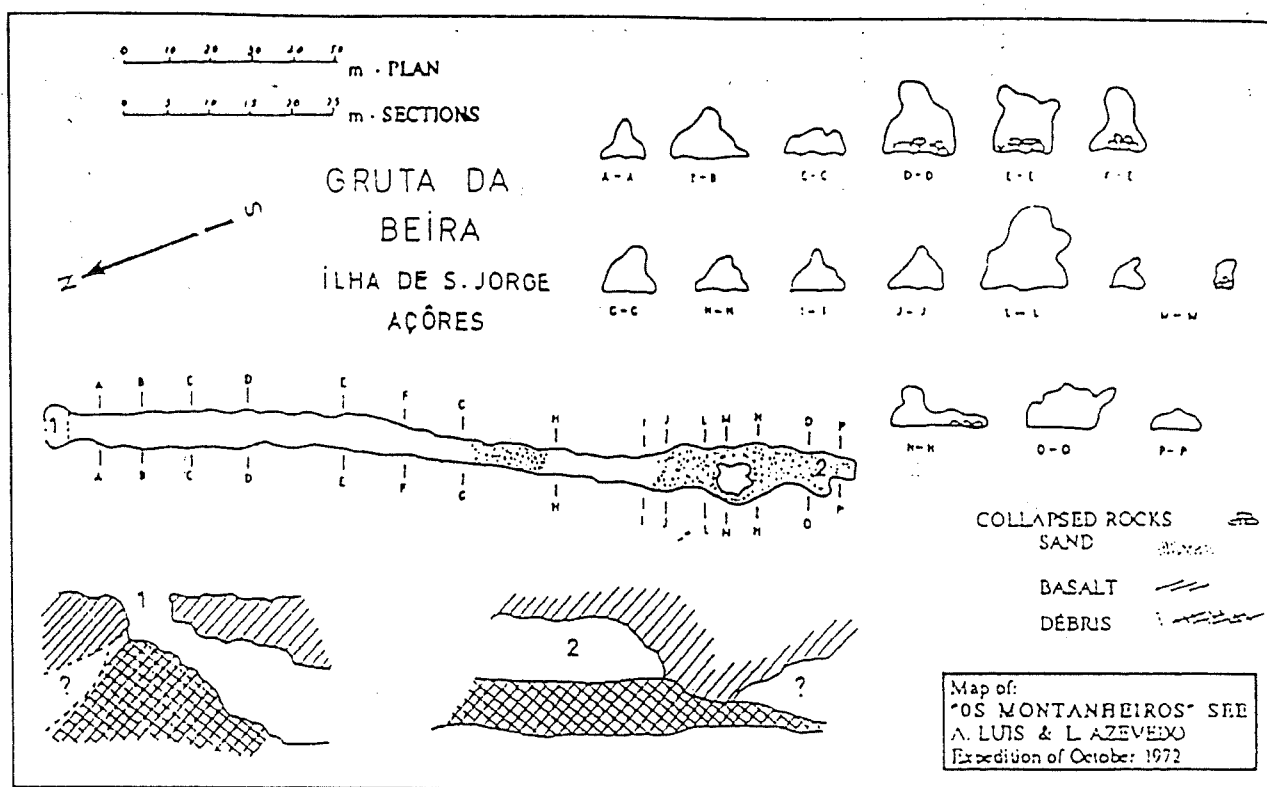


Plate 5 - Gruta da Beira (plan).

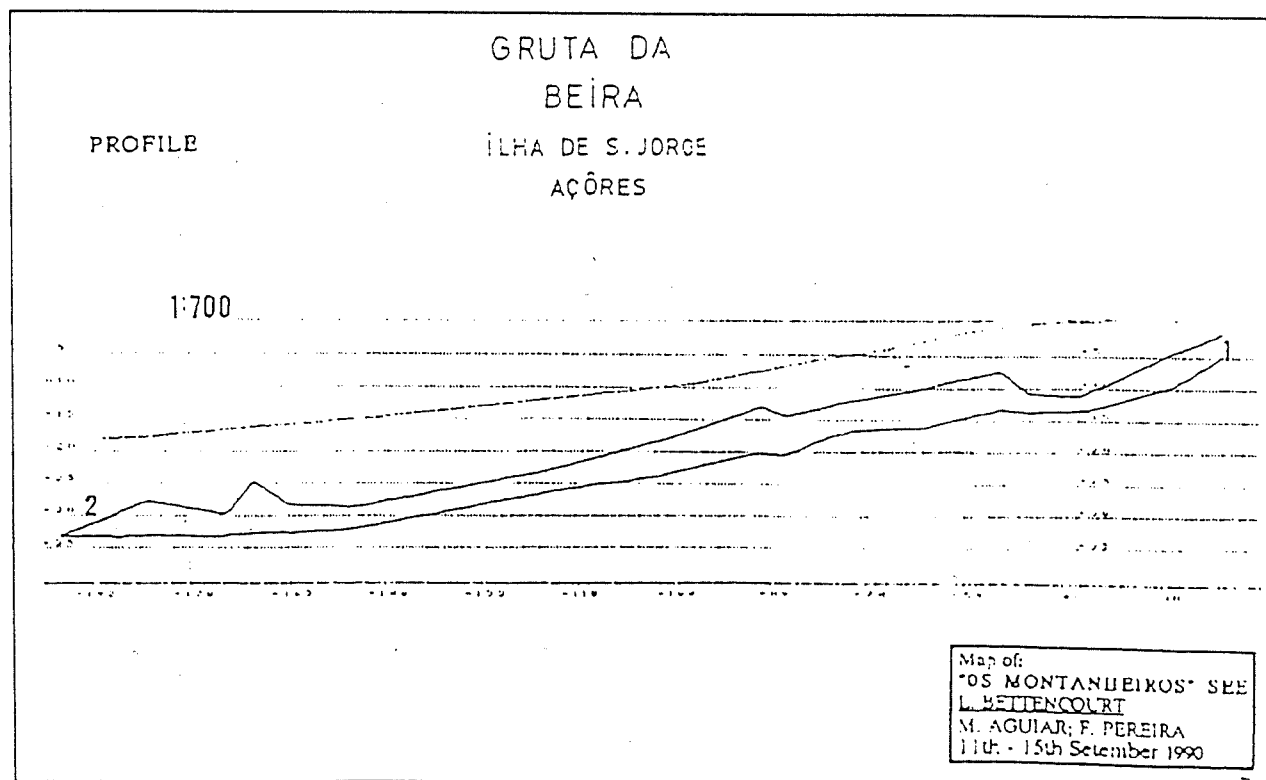


Plate 6 - Gruta da Beira (profile).

ceiling can be found all over the cave. The floor, and to some extent the lateral walls, are covered by earth, because of water infiltration from the roof and the entrance.

There are no lateral benches, but many stalactites can be found covered with a white substance similar to that found in Gruta das Agulhas (Terceira) (see below). Because of its dimensions and beauty, this lava tube should be protected.

Fauna: As a result of the biospeleological expedition directed by N.P. Ashmole and P. Oromí (1987), two troglobitic species were described from this lava tube, the pseudoscorpion *Pseudoblothrus oromii* Mahnert and an isopod (Trichoniscidae) Gen. sp. indet. that probably represents a new genus (see Oromí et al., 1990).

6. Gruta do Leão (Plate 7; Figure 3, lava tube 7)

Location: Presa do Leão (Queimada), Velas (São Jorge); Elev: 250 m; UTM: 3964/42818; Length: 177 m; Height: 0.50-6.00 m; Width: 0.80-3.00 m.

As with the previous cave, this lava tube was mapped during the speleological expedition to São Jorge of Os Montanheiros directed by A. Luís in

1972 and later revisited by the recent S. Jorge-88 Expedition of Os Montanheiros.

We think that this cave was formed by the lava flows of the eruption of 1808 (Bocas de St. Amaro). The entrance is a hollow, 0.6 by 0.4 meters, with a six-meter vertical drop. The gallery is narrow and high with a considerable slope. There are yellowish formations near the entrance, probably with the same composition as those present in the Algar das Bocas do Fogo (see below). Some collapsed rocks from the ceiling and walls are present.

Fauna: Unknown.

7. Algar das Bocas do Fogo (Bocas de St. Amaro) (Plate 8; Figure 3, pit 8)

Location: Lixeira de St. Amaro (São Jorge); Elev: 521 m; UTM: 3982/42817; Length: 55.3 m; Depth: 12.0 m; Width: 30.00-50.00 m.

This pit was mapped during the recent S. Jorge-88 Expedition of Os Montanheiros.

Algar das Bocas do Fogo is a volcanic crater in which the chimney has three openings that lead to a chamber of 30 by 50 meters. The best access is the larger opening with a drop of 40 meters. The 1808 eruption of St. Amaro originated at two openings with two lava flows.

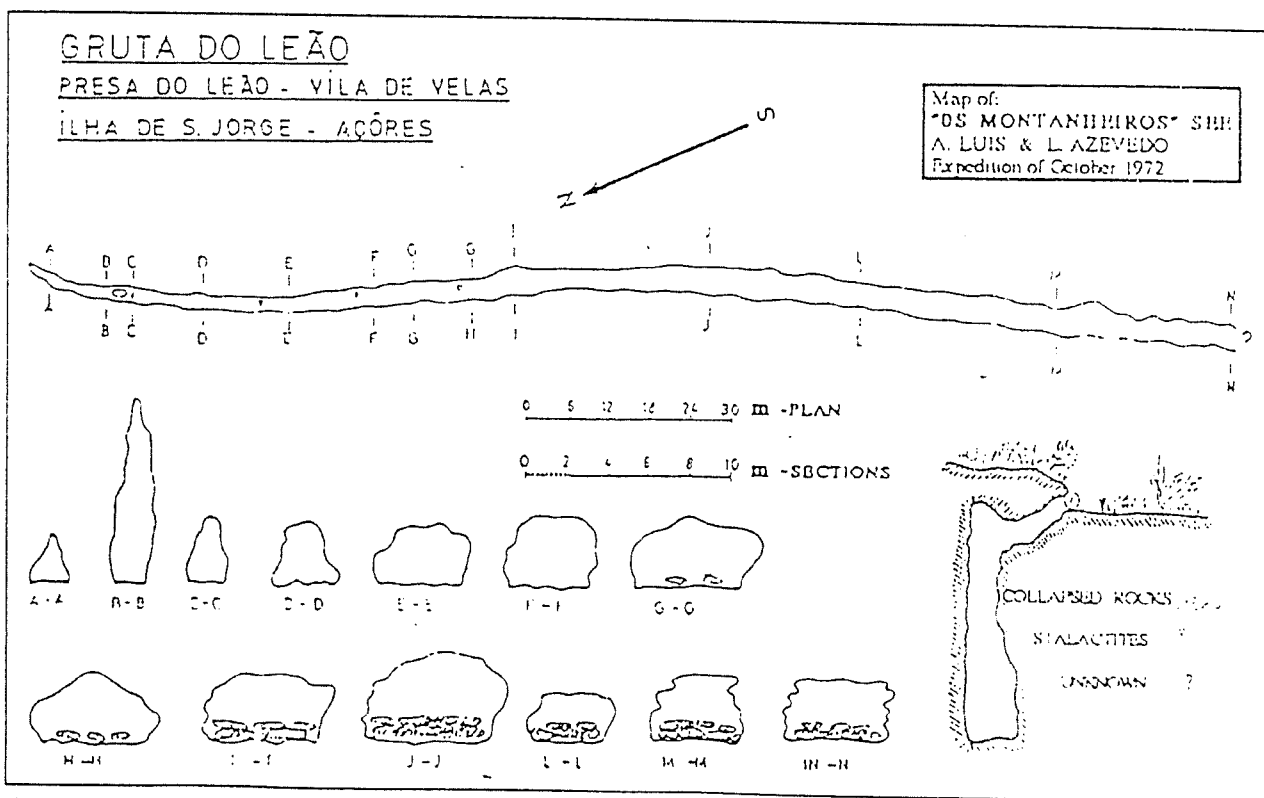


Plate 7 - Gruta do Leão.

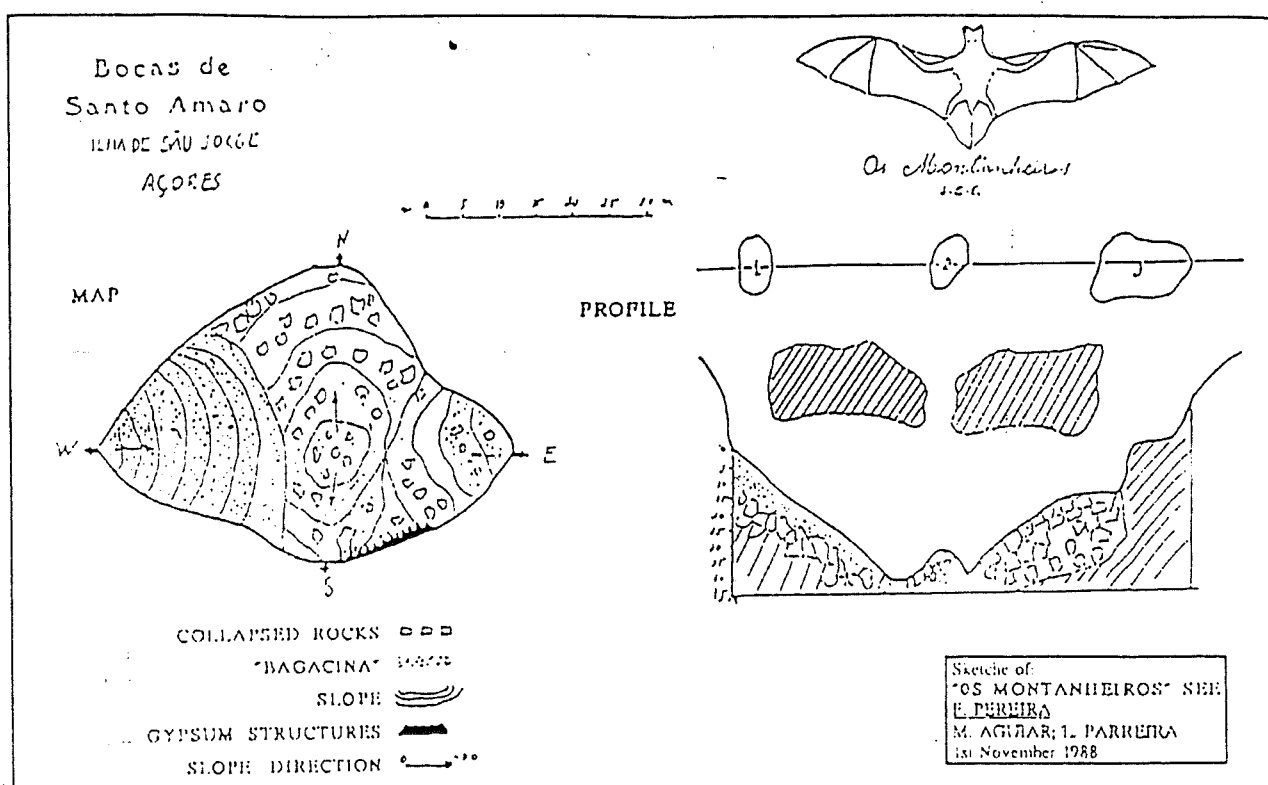


Plate 8—Algar das Bocas do Fogo.

Due to the materials accumulated under the lateral openings, the floor has a "V" cross section. A small cone of volcanic materials is present under the central opening. The two lateral ramps are 30 and 20 meters long with a drop of 15 and 10 meters. On the walls of the south part of the crater there are some deposits of white gypsum.

Fauna: During the biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989), a new species of a troglobitic ground beetle was found and described later, *Trechus jorgensis* Oromí and Borges. Unfortunately only a female is known.

8. Algar do Montoso (Plate 9; Figure 3, pit 9)

Location: Pico do Carvão (São Jorge); Elev: 1,019 m; UTM: 4048/42791; Length: 269 m; Depth: 137.5 m; Height: 9.00-50.00 m.; Width: 9.00-70.00 m.

This pit was mapped during the recent Montoso-90 Expedition of Os Montanheiros.

The Pico do Carvão is an extinct volcano with one crater and three openings—two of them closed and the third one open. This last volcanic chimney has three orifices (1, 2, and 3 from plate 8), the Algar do Montoso (named incorrectly by an error of toponymy, the correct name should be Algar do Carvão).

Of the three vertical pits, only the second and third (see plate 8) are used for vertical caving. Number 2 is more suitable, being formed by several terraces with a drop of 60 meters, ending in a large chamber of 150 by 70 meters (height 40 to 50 meters).

After reaching the bottom of pit number 2 the floor has a steep slope; a small lake covered by plant debris carried in by the rain water lies at one extremity. The ceiling and walls lost part of their cover because of the collapse of large basalt stones.

As in the Algar do Carvão (Terceira) (one of the most beautiful volcanic chimneys of the Azores), there are dripstone and flowstone formations on the walls, which are composed of obsidian or pitchstone, as well as locally profuse silicious (SiO_2) speleothems.

Pit Number 1 has a vertical drop of 80 meters ending in a circular chamber measuring 50 by 30 meters. The assemblage resembles very well an inverted funnel.

Pit Number 3 is a small well, 20 meters deep, all covered by a reddish stone, typical of the hornitos, that ends in a "throat" without any passage.

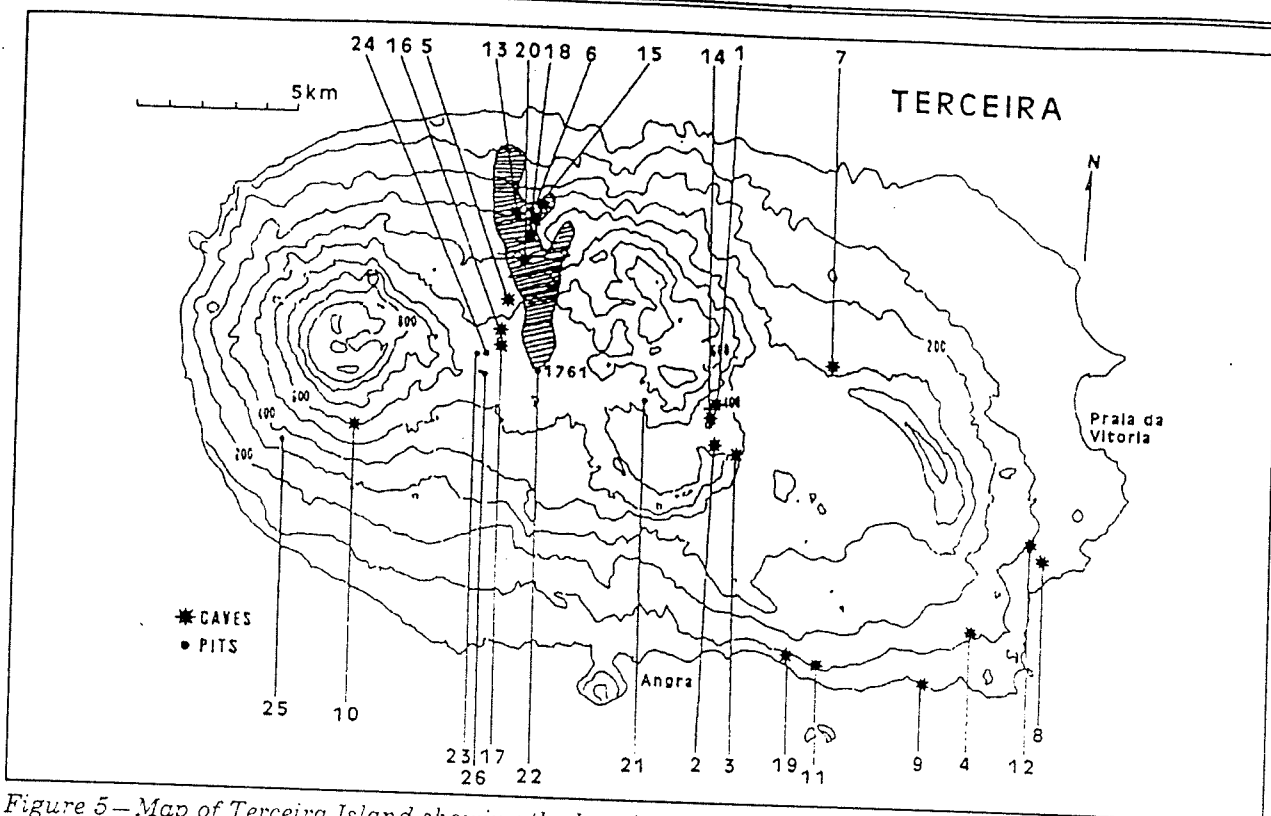


Figure 5—Map of Terceira Island showing the location of the lava tubes and pits (see also Table 3).

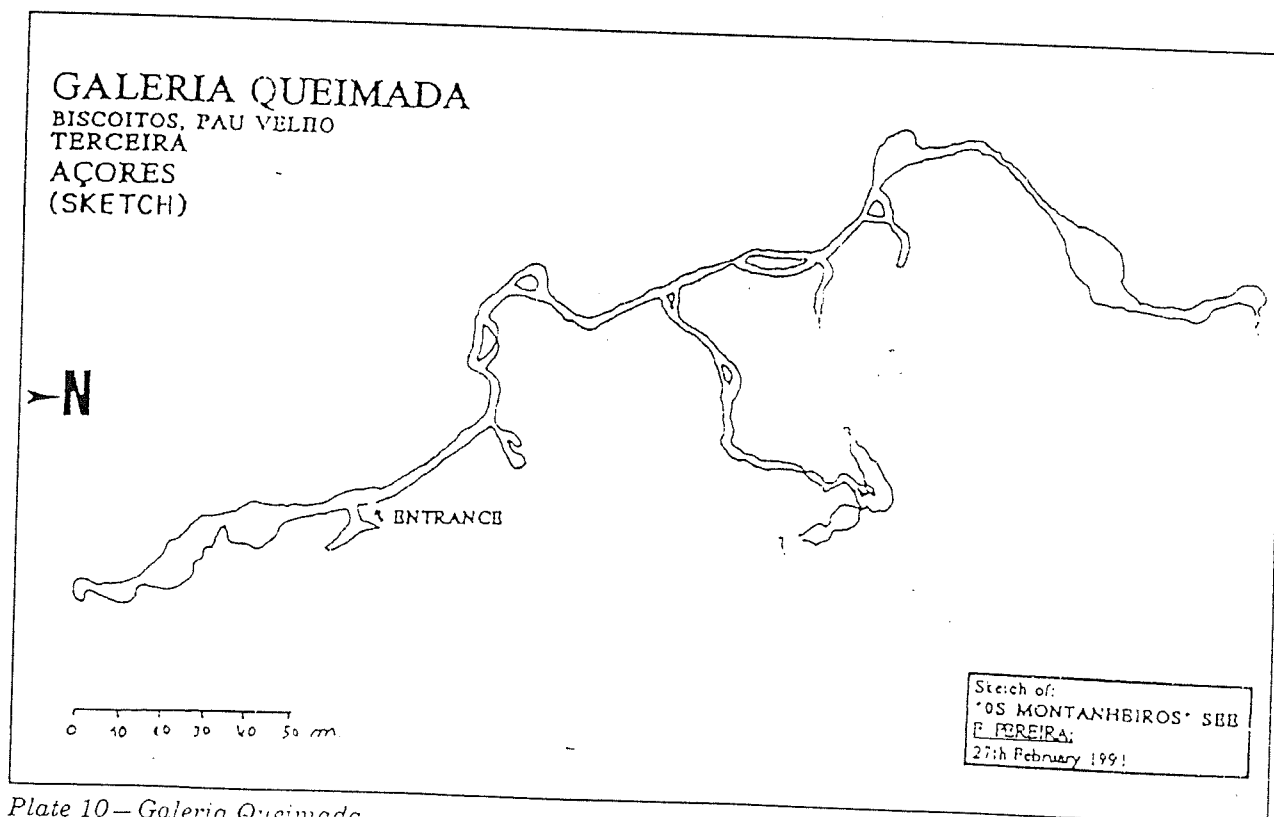


Plate 10—Galeria Queimada.

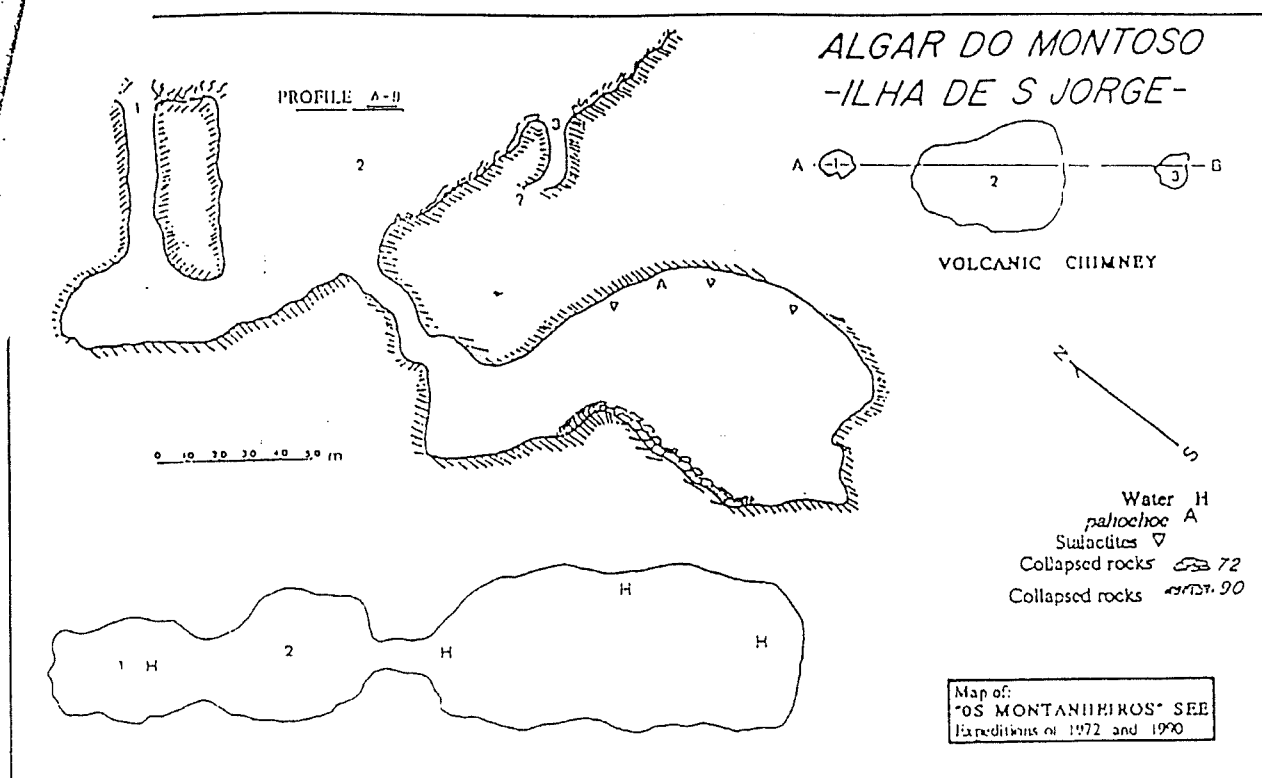


Plate 9—Algar do Montoso.

The Algar do Montoso is the Azores' deepest pit and could be developed as a show cave like Algar do Carvão (Terceira).

Fauna: Unknown.

Terceira

9. Galeria Queimada (Cafua Velha) (Plate 10; Figure 5, lava tube 5)

Location: Pau Velho, Biscoitos (Terceira); Elev: 473 m; UTM: 4768/42895; Length: 639.9 m; Height: 0.30-2.50 m; Width: 0.26-10.9 m.

The Galeria Queimada is located in the historical lava flow of Pau Velho (1761). Like the larger Gruta dos Balcões (situated in the same lava flow) it is a three-dimensionally braided system. It is a cave with some planimetric complexity and is not completely mapped (see ? in plate 10). It is the second biggest lava tube on Terceira and one of the most beautiful.

After the entrance, the broader part of the ceiling has a particular design, forming two large "teats" (*mamelones* from the Spanish). There are some unusually colorful limonite speleothems forming columns. Near the end of the main tube there is a beautiful structure of limonite forming a

"waterfall." In the main tube the floor is mostly of aa lava, but in the narrow, low secondary tubes the floor is pahoe-hoe type. In several parts of the lava tube the floor is covered with mud and water. Polymorphic stalactites (lava-drops) occur on the ceiling, some of them being very interesting.

Fauna: Unknown.

10. Gruta das Agulhas (Gruta da Salga) (Plate 11; Figure 5, lava tube 8)

Location: Porto Judeu (Terceira); Elev: 5 m; UTM: 4909/42775; Length: 250.5 m; Height: 0.50-5.40 m; Width: 1.20-4.50 m.

This is a mildly braided lava tube cavern (Halliday, 1981) formed by lavas from the eruption of Pico do Refugo. It was studied especially by Mottet (1974) because of its outstanding sequence of flow features. The cave was named "Agulhas" (needle) because of its needle-like lava formations of vitrified silica (opal) about 0.2 to 0.5 centimeters long.

The main entrance is at sea level. The floor is aa or pahoe-hoe. There are at least four levels of drainage registered on the walls by lateral benches.

In the middle of the cave there is evidence of a false floor which shows where the lava has drained away leaving a small tube (30 meters long and 0.5

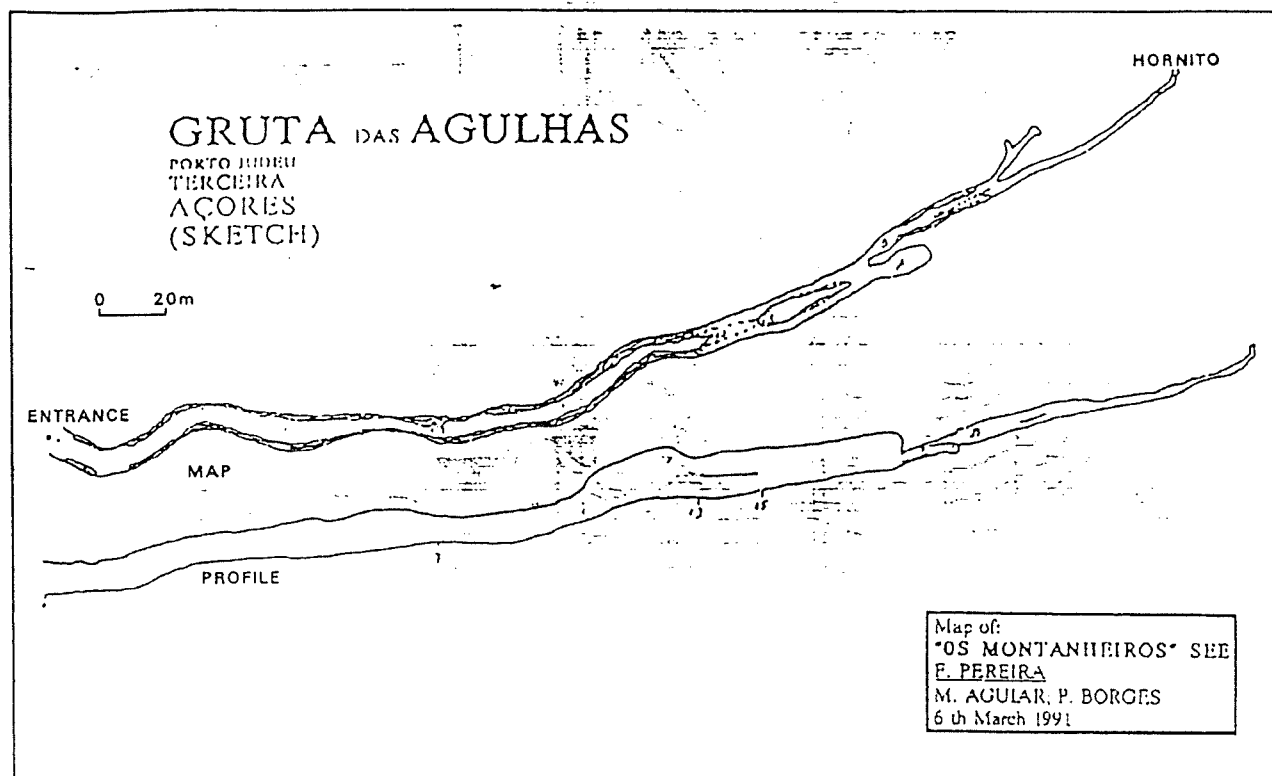


Plate 11 – Gruta das Agulhas.

to 1.2 meters high) inside the main lava tube. On the lateral walls there are oblique striated marks as a consequence of the accelerated escape of gases.

Fauna: As a consequence of the biospeleological expedition directed by N.P. Ashmole and P. Oromí (1987), several new interesting species were found and described from this cave: the hypogean Pseudoscorpion, *Pseudoblothrus vulcanus* Mahnert and the Amphipod (*Talitridae*), *Macarorchestia martini* Stock (*Macarorchestia* being a new genus) – its only cave adaptation is the small eyes (Stock, manuscript).

Three other hypogean species, not restricted to this cave, were also found: the collembola (*Entomobryidae*) *Pseudosinella ashmoleorum* Gama and *P. azorica* Gama (see Oromí *et al.*, 1990) and the centipede *Lithobius melanops orotavae* Latzel (see Eason and Ashmole, manuscript).

11. Gruta do Chocolate (Plate 12; Figure 5, lava tube 14)

Location: Pau Velho, Biscoitos (Terceira) Elev: 250 m; UTM: 4781/42924; Length: 109.7 m; Height: 0.50-6.20 m; Width: 0.40-3.60 m.

Gruta do Chocolate is a small but beautiful lava tube located in the Pau Velho lava flow (1761).

The entrance, a small aperture of 40 by 40 centimeters, is made through a secondary gallery which is partially obstructed by earth and roots. The first part of the cave has a reddish coloration up to one third of its height, probably as a consequence of oxidation.

We think that the occurrence of three superimposed tubes is a consequence of the bent tendency of the ground where the cave was formed. Therefore, the main gallery was subjected to several strangulations caused by materials that obstructed the flow of the lava. A new superimposed tube formed once the lava flowed again.

The first of the galleries is formed by a drainage tube through a hollow in the main "sink" type tube. It is a narrow, low tube with an aa type floor. The walls and ceiling are rich in remelt structures. There is also a formation (miniature of a lava tube) that shows how a lava tube can arise. Over the first gallery there is another, extending the main tube. A third gallery occurs over the second and reaches the cave entrance.

Forty meters upstream there is a large lava rock recovered by the lava flow. The passage at this site is difficult and has to be traversed by crawling over pahoe-hoe lava. Higher upstream there are yellow-

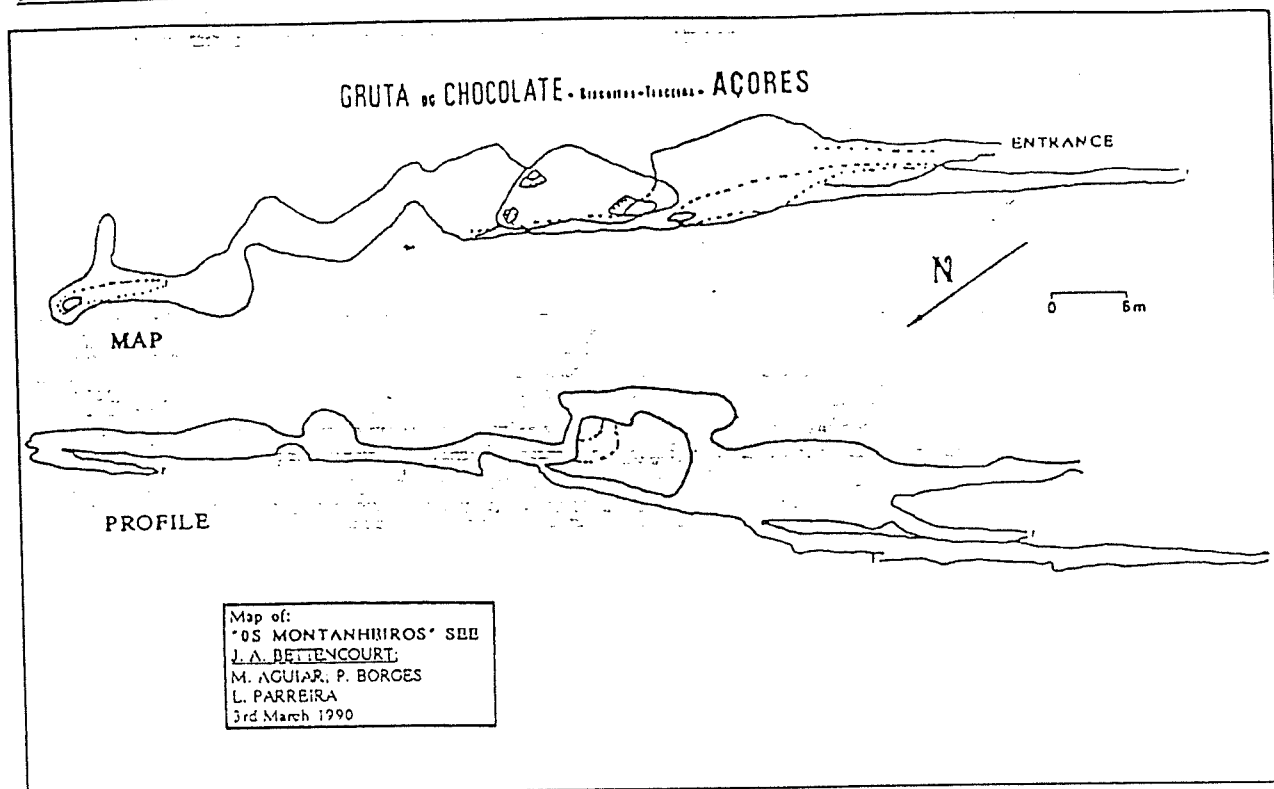


Plate 12 – Gruta do Chocolate.

ish formations, probably silica, covering the lava structures.

Fauna: Unknown.

São Miguel

12. Gruta de Água de Pau (Plate 13; Figure 6, lava tube 4)

Location: Água de Pau (São Miguel); Elev: 2 m; UTM: 6295/41752. Length: 323.1 m; Height: 0.20-2.60 m; Width: 0.80-6.60 m.

This lava tube was mapped during the recent Biospel-90-S. Miguel Expedition of Os Montanheiros.

This is a small, somewhat braided lava tube cave located only two meters above sea level and covered by some 70 meters of overburden (Oromí and Borges, in press). There are also two levels of galleries – a lateral entrance near the ceiling, 40 meters from the main entrance, being the access to the second gallery.

There are two main galleries that intercept each other. The main galleries have lateral benches in some parts, covered with rocks collapsed from the ceiling and walls. On the floor there are large blocks

of lava. On the walls there are rod stalactites and blisters (remelting stalactites). The secondary gallery has very low passages and some crawlways. The floor is pahoehoe and the ceiling is covered by stalactites (lava-drops).

The tube is interrupted by a collapse of the roof. Before reaching this point another large amount of collapsed rocks makes progress very difficult.

Fauna: The fauna of this cave was studied during the biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989). The general results of this study are still unpublished, but one troglotic species of ground beetle collected in this cave was recently described, *Thalassophilus azoricus* Oromí and Borges (see Oromí and Borges, in press). The type material consisted of 14 specimens (10 of them collected by Borges in 1990), but two more individuals were collected by one of us (F. Pereira) during the Biospel-90-S. Miguel Speleological Expedition of Os Montanheiros to the island of São Miguel.

So far it is the only eyeless ground beetle known from the Azores; it is a relict and paleoendemic species (Borges and Oromí, in press).

This cave should be protected.

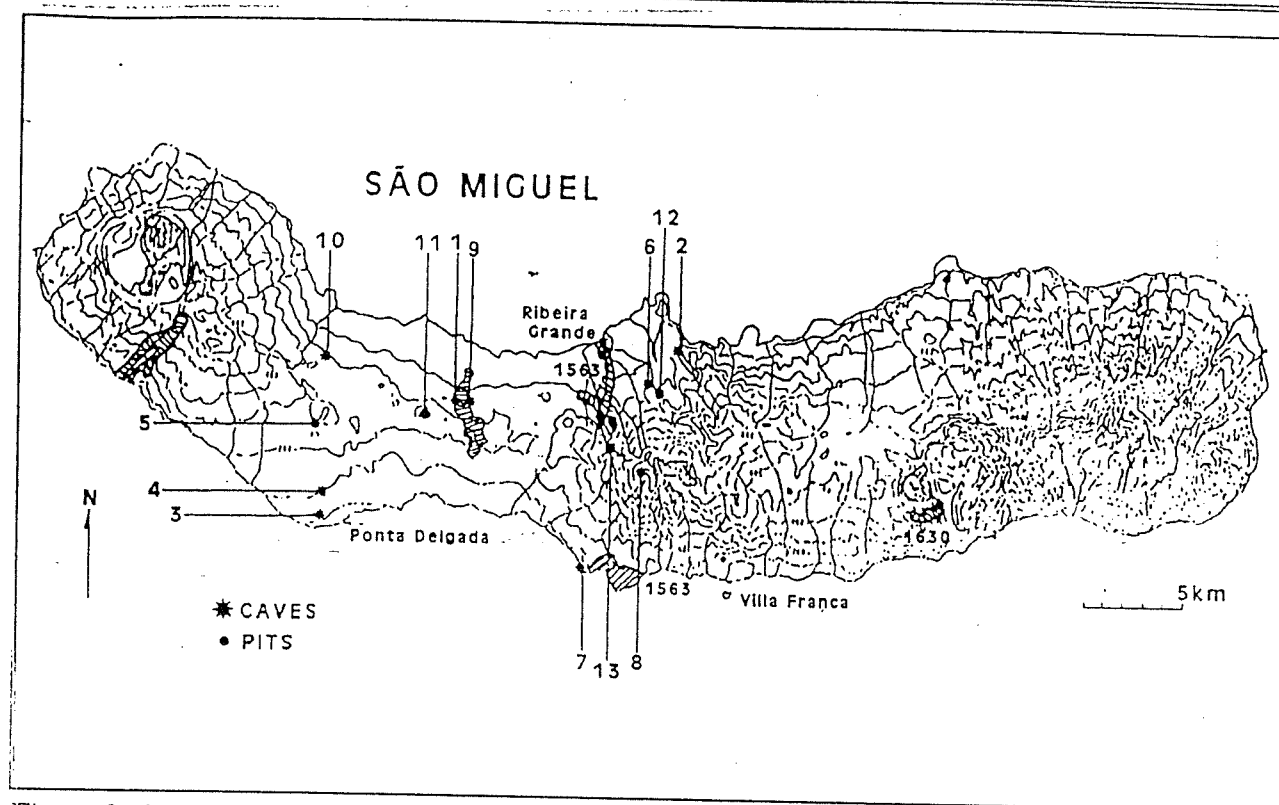


Figure 6—Map of São Miguel Island showing the location of the lava tubes and pits (see also Table 3)

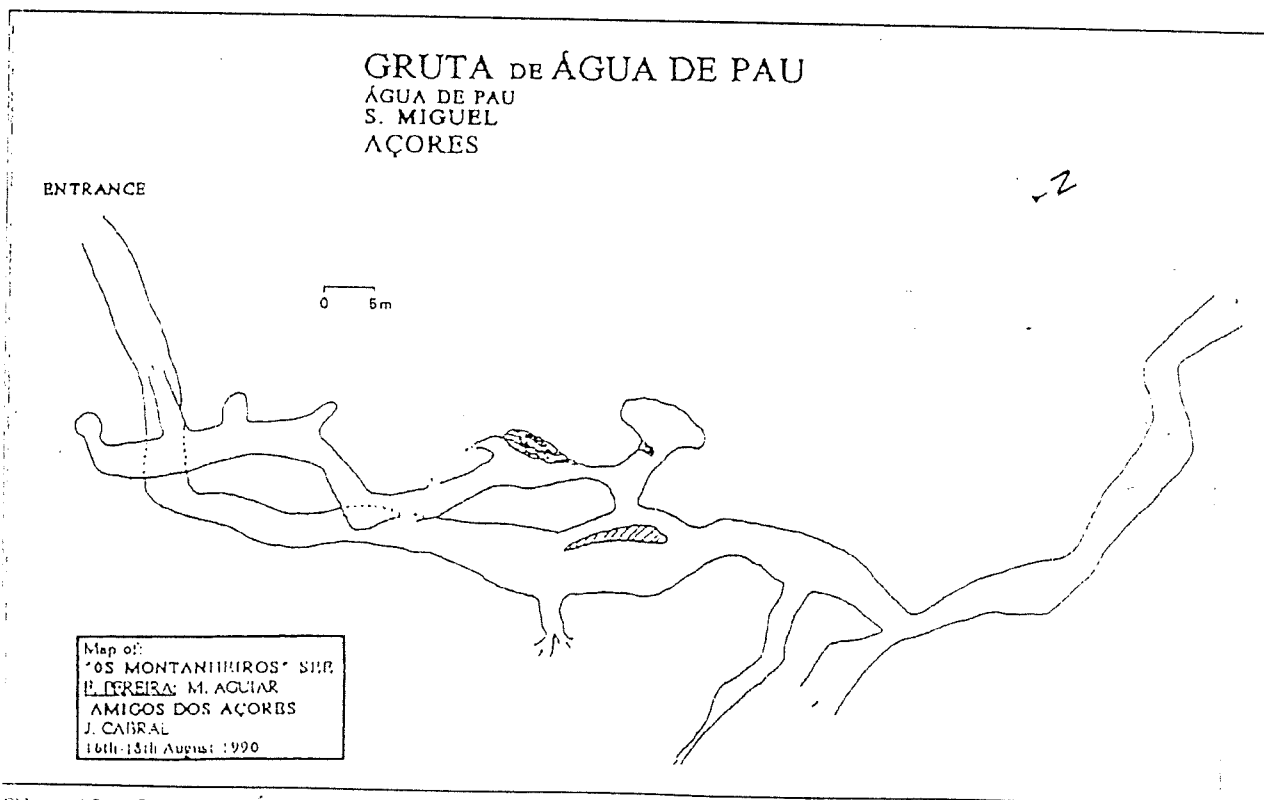


Plate 13—Gruta de Água de Pau.

13. Gruta do Esqueleto (Plate 14; Figure 6, lava tube 5)

Location: Lagoa do Fogo road, Ribeira Grande (São Miguel); Elev: 250 m; UTM: 6311/41843; Length: 188.2 m; Height: 0.30-9.50 m; Width: 1.00-12.50 m.

As with the previous one, this lava tube of large dimensions was mapped during the Biospel-90 S. Miguel Speleological Expedition of Os Montanheiros to the island of São Miguel.

It is located in the lava fields of the Serra de Água de Pau volcano. The entrance is a consequence of the collapse of a lateral part of the wall and roof at about 40 meters from the beginning of the lava tube.

The initial part of the cave, the largest one, is well preserved. There is a lid-type wall, probably the stopping point of a lava flow posterior to the tube formation. The walls have marks of several lava levels. In the ceiling there are many melt-stalactites.

Unfortunately the major part of the cave is very much spoiled. This is due to the collapse of great blocks of basalt from the ceiling and walls. Some vestiges of small stalactites and preliminary lava can still be seen. The tube ends with a collapse of

the roof. Probably this cave was destroyed by earthquakes and the land movements they caused.

Fauna: A biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989) visited this cave. The general results of this study are still unpublished.

14. Gruta do Pico da Cruz (Plate 15; Figure 6, lava tube 6)

Location: Pico da Cruz, Ponta Delgada (São Miguel); Elev: 273 m; UTM: 6217/41830; Length: 98.5 m; Height: 0.60-2.90 m; Width: 0.85-5.40 m.

This is a simple unitary or throughway lava tube (see Halliday and Larson, 1983) and was mapped during the Biospel-90 S. Miguel Speleological Expedition of Os Montanheiros to the island of São Miguel.

It is a narrow, low lava tube with an ovoid configuration in all its length. The entrance consists of two holes, quite near each other, that are a result of a collapsed vault. We think that the lava flow of the Pico da Cruz volcano is the origin of this lava tube.

Five meters before the end of the tube it becomes narrower and lower with a great slope. Fifteen meters after the main entrance there is a "sink"

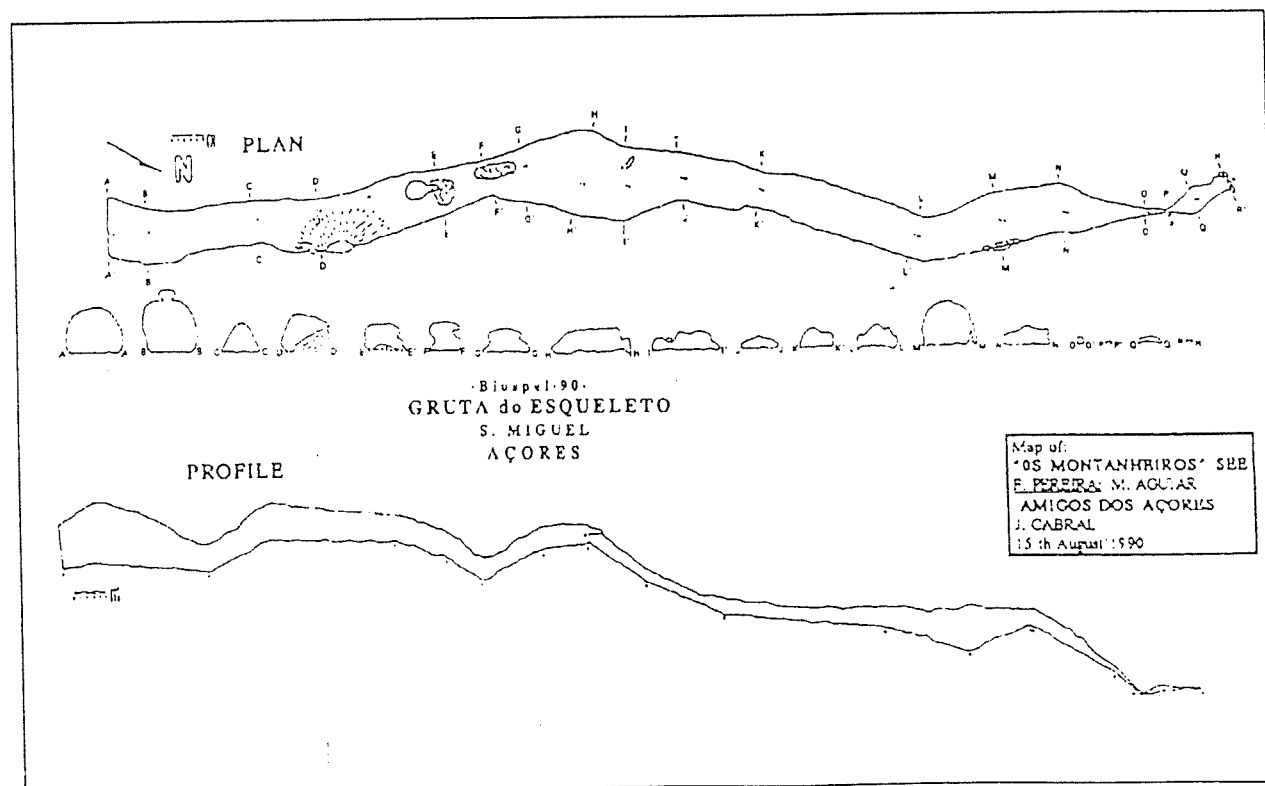


Plate 14 – Gruta do Esqueleto.

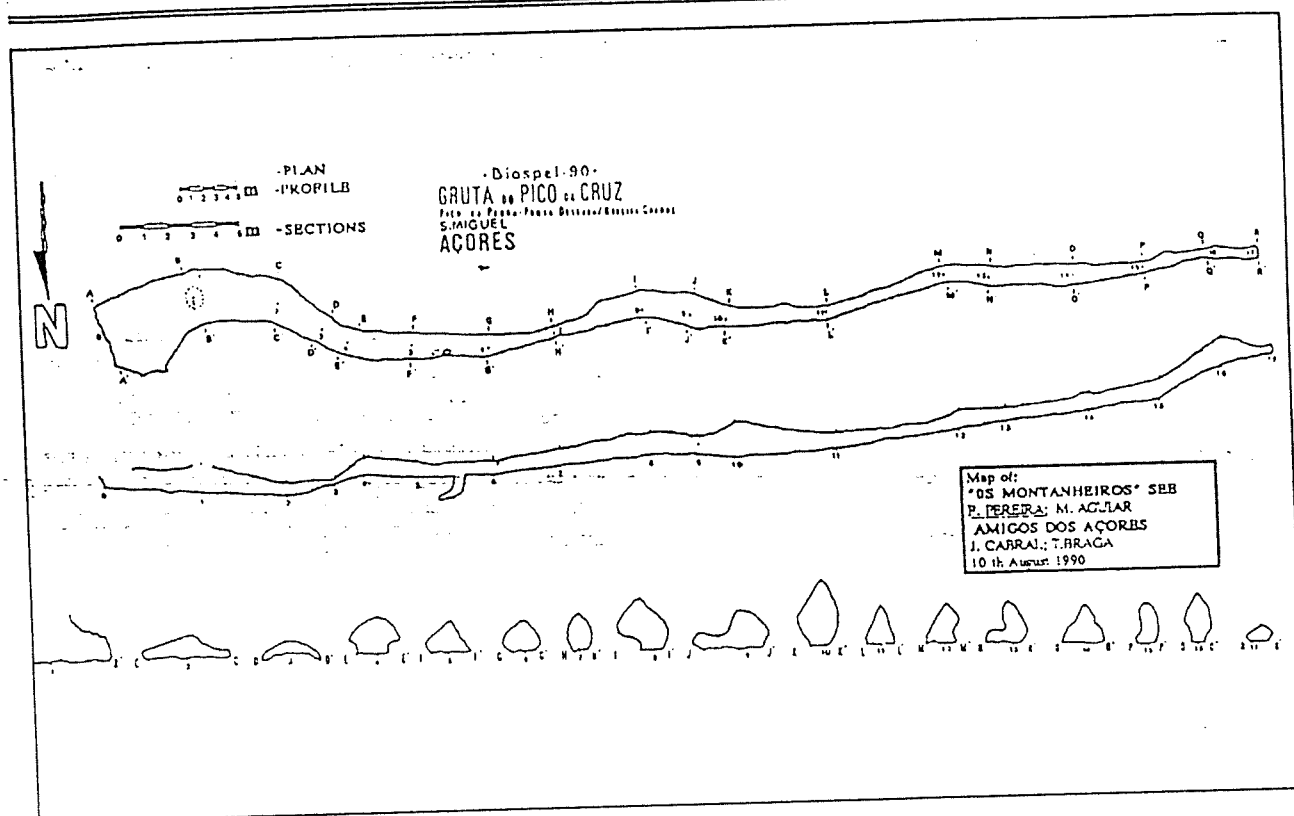


Plate 15— Gruta do Pico da Cruz.

that begins a secondary small tube under the main gallery. The levels of drainage are evident in the walls where we can also see signs of draining.

Due to its proximity to the high ground and the speleometric data, this cave must be a secondary lava tube originated by a small lava flow. This situation contrasts with other bigger lava flows originating from that volcano. Nearby there are several sinks showing the occurrence of other cavities that were destroyed by land movements.

Fauna: A biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989) visited this cave. The general results of this study are still unpublished.

15. Algar da Batalha (Plate 16 and 17; Figure 6, pit 8)

Location: Fajã de Cima, Ponta Delgada (São Miguel); Elev: 240 m; UTM: 6198/41837. Length: 51.9 m; Depth: 9.5 m; Height: 0.40-3.30 m; Width: 0.50-5.70 m.

Mapped during the recent Biospel-90-S-Miguel Expedition of Os Montanheiros, this pit is associated with a lava tube. The lava that flowed in the tube rose through the roof forming a pit and a

secondary tube that ended in a low, crawling gallery.

The upper level is 33.7 meters long, 0.50 to 3.20 meters wide, and 0.40 to 2.30 meters high. The lower level is 18.2 meters long, 2.90 to 5.70 meters wide, and 0.90-3.30 meters high. The entrance is a hole 1.40 by 0.90 meters and 9.5 meters deep.

Fauna: Unknown.

Santa Maria

16. Furna das Pombas (Furna Velha) (Plate 18; Figure 7, littoral cave 1)

Location: Vila do Porto (Santa Maria); Elev: 0 m; UTM: 6663/40900; Length: 337 m; Height: 0.50-14.50 m; Width: 0.40-12.50 m.

This cave was mapped during the recent St. Maria-90 Expedition, being a littoral cave of marine erosion located on the south cliff of Santa Maria near the aeolic park of Vila do Porto.

Inside the cave there are layers of fossiliferous sandstone and two basalt veins, with horizontal prismatic disjunction. Fifty meters after the main entrance, buried in the sand that covers the floor, we found a calcite speleothem. The wall in the

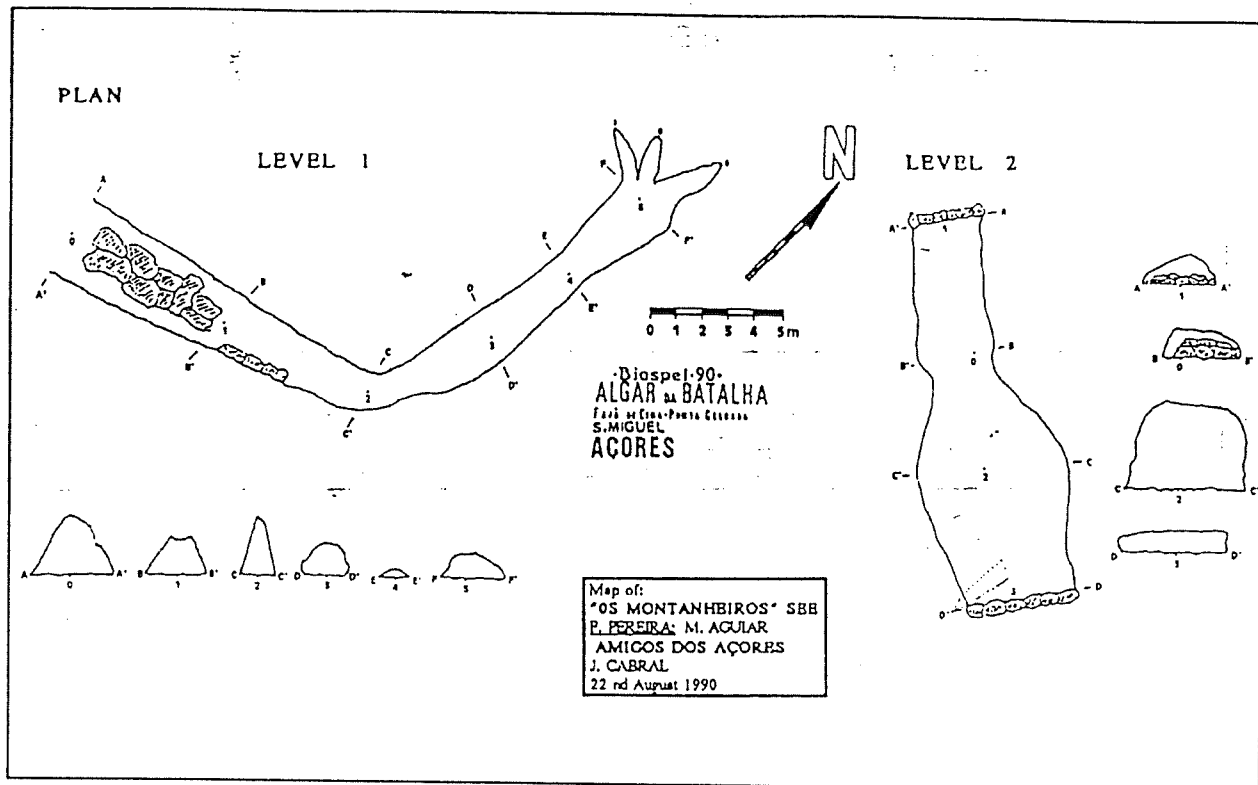


Plate 16—Algar da Batalha (Plan).

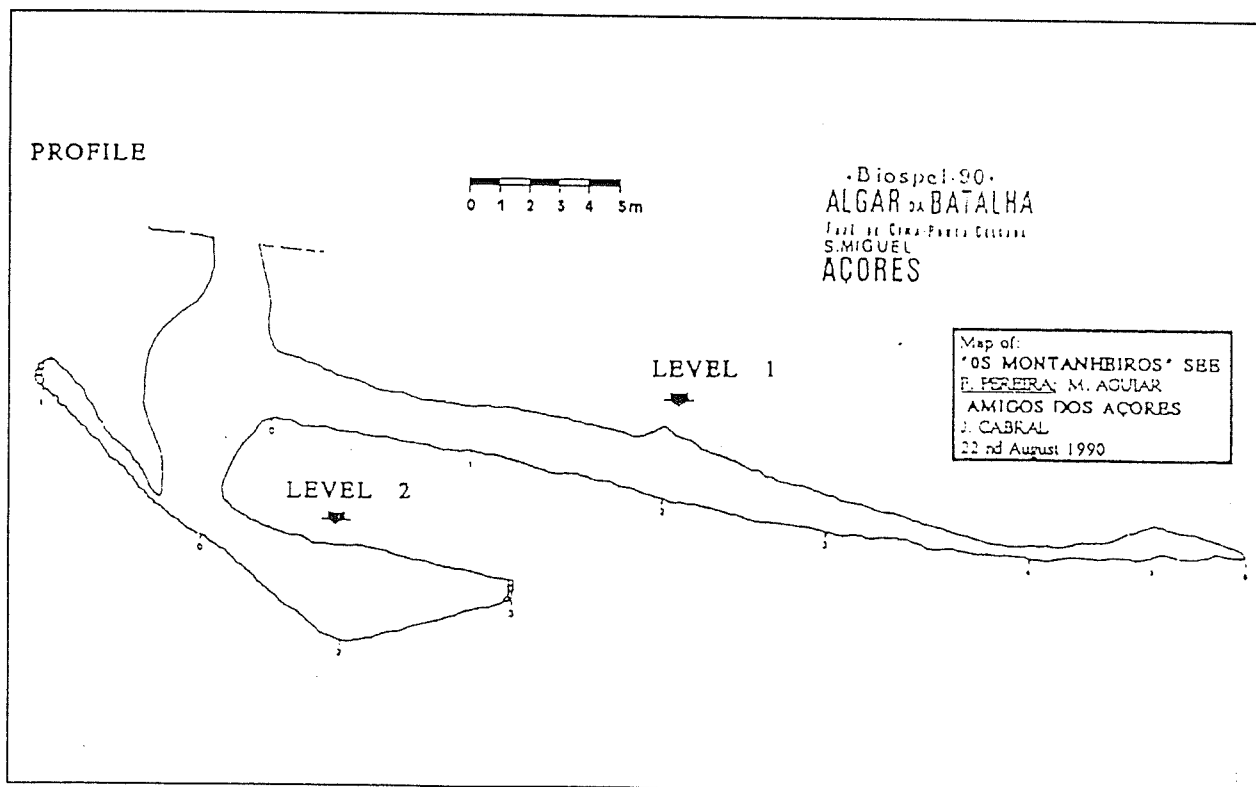


Plate 17—Algar da Batalha (Profile).

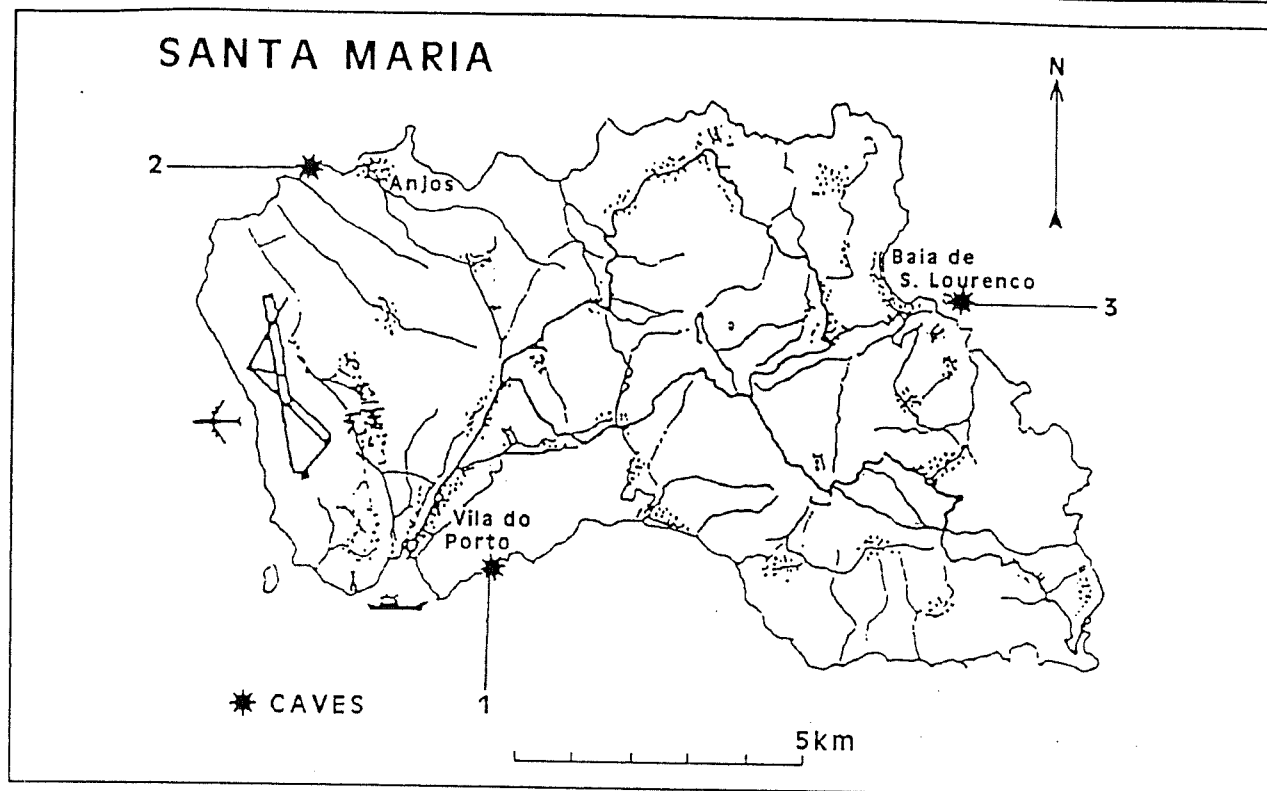


Figure 7—Map of Santa Maria Island showing the location of the littoral caves (see also Table 3).

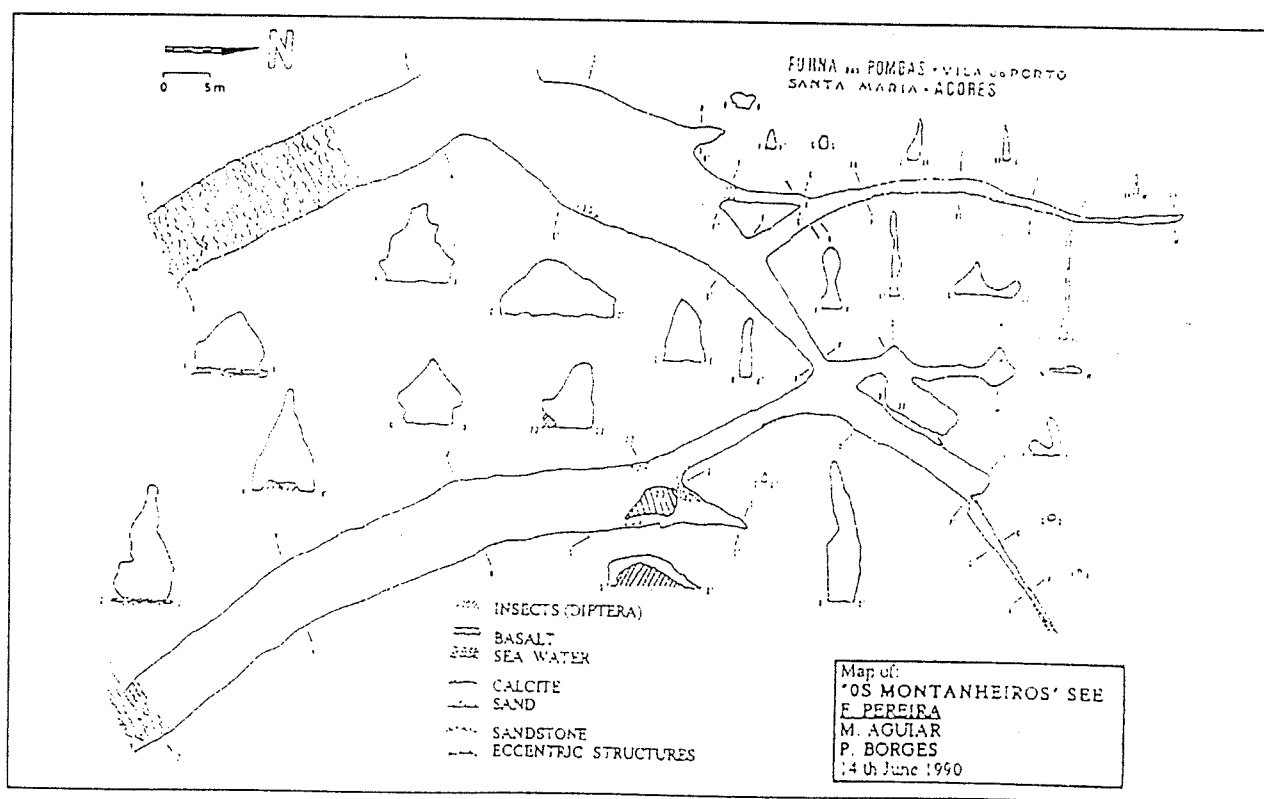


Plate 18—Furna das Pombas.

ality is covered by a layer of calcite from the ceiling to the floor.

Fauna: A biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989) visited this cave. The general results of this study are still unpublished.

17. Furna dos Anjos (Plate 19; Figure 7, littoral cave 2)

Location: Anjos (Santa Maria); **Elev:** 10 m; **UTM:** 6639/40969; **Length:** 117.85 m; **Height:** 0.65-8.60 m; **Width:** 0.44-11.20 m.

As with the previous one, this cave was mapped during the recent St. Maria-90 Expedition, being also a littoral cave of marine erosion located in a cliff to the west of Anjos. The cave is located in a basalt vein and we had the information that a rock exploration occurred on it. It has a relatively large chamber at the entrance that elongates itself into a tunnel which bifurcates just before the end.

Fauna: A biospeleological expedition directed by N.P. Ashmole and P. Oromí (1989) visited this cave. The general results of this study are still unpublished.

Conclusions

The most interesting Azorean island from the vulcanospeleological point of view is Pico. This island is dominated by the Pico volcano, a tall basaltic cone (2,351 meters high). The western two thirds of the island form a conspicuous lava field of recent age (Anonymous, 1980c).

All the main volcanic lava tubes on Pico are situated in pahoehoe basaltic lava flows (Forjaz, 1963). They are built by very fluid lavas under special conditions. Such a type of cave is very common, appearing in other Azorean islands also (e.g. Terceira).

On Pico there are several historical lava flows (see Figure 4), areas with a great concentration of lava tube caves and pits. The Mistério of S. Luzia (1718) is the Pico lava flow with a larger number of lava tubes (see Figure 4 and also Table III). Probably some of them are remains of a single longitudinal tube. In the Mistério of Silveira (1720) there is a remarkable lava tube, Gruta do Soldão (1,150 meters long), a simple unitary or throughway type lava tube (see Halliday and Larson, 1983) that is very well preserved.

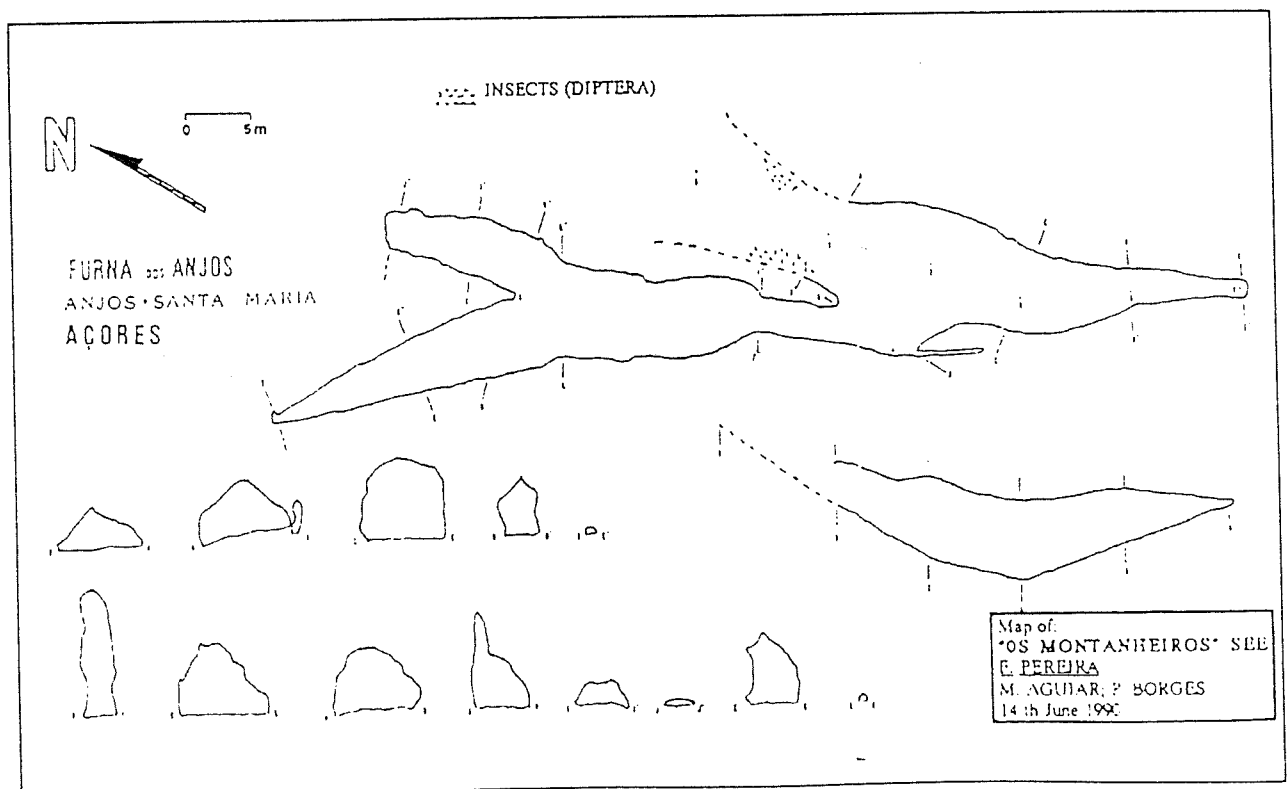


Plate 19 – Furna dos Anjos.

Several levels of drainage registered on the walls by lateral benches (*bancadas*) are commonly found in many caves from Pico and also Terceira and São Miguel. However the best example of this is in Gruta das Torres (Pico), with approximately 11 different levels of drainage.

Up to now 28 lava tubes and eight pits are known from Pico, but as a consequence of the laborious work of the amateur speleologist A. Garcia (Pico, Madalena) more will probably be discovered soon.

The cavernicolous fauna of Pico is very rich and diversified. Much work on ecology and evolutionary ecology can be done here in the future.

With respect to the caves and pits that occur on it, Terceira is without any doubt the second most interesting Azorean Island, after Pico. On this island there are several areas with caves of great interest (see Figure 5). The Pau Velho lava flow (1761) is probably the area with the most interesting caves from this island (see lava tubes 5, 6, 13, 15, 18, and 20).

Until now, three speleological sites have been identified in the Pau Velho lava flow (1761) on Terceira Island: Balcões (20), Galeria Queimada (5), and Caldeira (13). One of them, Balcões, is made up of more than one cave (Balcões, Pau Velho, Branco Opala, Chocolate), located between altitudes of 240 and 400 meters. It is quite probable that other caves, still unknown, will be found in the area.

Montserrat and Romero (1983) mapped Balcões and Pau Velho. During the field surveys (helped by Os Montanheiros) most of the other lava tubes situated in the lava flow mentioned above were visited and mapped in the last few years.

Balcões is the second longest lava tube in the Azores, 2,713 meters long. The caves cited before vary from 87 to 640 meters, with several galleries, rooms, and halls as beautiful as in Balcões.

Two of the caves already explored and mapped, the Galeria Queimada and Gruta do Chocolate (see Plates 10 and 12 respectively) have very diversified formations and may illustrate the importance of the speleological sites of the Pau Velho lava flow.

These caves have a moderate importance from the entomological point of view, because most of them are covered by pastures and there is some mud infiltration. Nevertheless, the relict cave carabid *Trechus terceiranus* Machado could be found in Balcões and Caldeira lava tubes (Borges and Oromí, in press).

On Terceira there is also Algar do Carvão, a remarkable volcanic chimney developed as a show cave since 1988.

As a consequence of the constant effort of Os Montanheiros, most of the main lava tube caves and pits from Terceira are already listed, however this speleological group has not yet been able to find the "magnific" pit described by Fouque (1873) (300 meters deep).

The hypogean fauna of Terceira is not so diversified as that of Pico, even though some remarkable troglobitic species occur in Terceira's lava tubes and pits.

On São Jorge there are two lava tubes (Beira and Leão) and two pits (Bocas do Fogo and Montoso) of great interest, not only because of their speleological structures but also because of their unique fauna. Algar do Montoso is a remarkable volcanic chimney (see plate 9) still poorly studied.

Faial has small and unimpressive lava tubes but with striking endemic hypogean arthropods on it. Furna Ruim is an exception with the third biggest vertical drop of the Azorean pits (55 meters).

On São Miguel all of the main caves are located in the recent part of the island, the center plateau. Most of them are small and very much destroyed. In spite of that, their fauna is worth noticing, probably because of the ancient age of the island (four million years) (Abdel-Monem *et al.*, 1975).

Santa Maria is the oldest island of the archipelago (eight million years) (Abdel-Monem *et al.*, *op. cit.*) without recent lava flows. It has only littoral caves of sea erosion (e.g., Anjos and Pombas).

Graciosa is still poorly studied, but on this island the beautiful Furna do Enxofre occurs, with a large lake at the bottom and *solfataras*.

On the smallest of the two eastern islands, Corvo, there is the record of one cave, presently closed.

Beautiful stalactites (lava-drops) and some stalagmites of many types and forms cover the ceiling and floor of the Azorean caves making them excellent objects of admiration and study.

After this work the number of known caves and pits from the Azorean Islands are: Corvo (1;0), Flores (0;0), Faial (3;1), Pico (28;8), Graciosa (16;1), São Jorge (7;5), Terceira (20;6), São Miguel (10;3) and Santa Maria (3;0).

Islands like Faial, Graciosa, and Santa Maria need a lot of field work for a better inventory. Others like Pico, Terceira, and São Miguel are in an advanced stage of knowledge but in spite of that there is still much speleological work to be done.

Pico is doubtless the Azorean island where more speleological surprises may show up. The Gruta das Torres is a good example of it. Presently the biggest lava tube known from this archipelago, it was only discovered very recently (1990).

Conservation Aspects

Cave ecosystems provide a unique habitat for evolutionary and ecological research. Because of that, all the caves where there is fauna adapted to the subterranean environment should be protected from all types of injuries (see Table III; and also Oromí et al., 1990, Oromí et al., in press, Borges and Oromí in press). These Azorean caves with biological interest are: Anelares, Cabeço do Canto, and Furna Ruim from Faial; Montanheiros, Soldão, Henrique Maciel, Capucha, Arcos, Gruta dos Esqueletos from Pico; Beira and Algar das Bocas do Fogo from São Jorge; Balcões, Coelho, Caldeira, Agulhas, Madre de Deus, Algar do Carvão from Terceira; Água de Pau and Esqueleto from São Miguel.

But the Azorean caves have other values, and we should preserve them for their geological or educational interest. In protecting them we are protecting much scientific and recreational patrimony.

Unfortunately some Azorean caves (e.g., Furna do Cabrito, Furna D'Água-Terceira) were closed and modified by construction by the government for protection of water resources. Others, like the once beautiful Gruta do Camelo (Terceira) is now completely destroyed, for the same purpose.

On the other hand, many of the Terceira lava tubes are visited by tourists and the population in general which is good. However a great amount of trash can be found on the floors of these caves (e.g., Natal, Balcões, Agulhas). Os Montanheiros has recently cleaned up Grutas do Natal and Agulhas. On Pico and São Miguel the entrances of some lava tubes and pits are currently used to dispose of domestic animals (e.g., Gruta do Galeão) or as garbage and offal dumps (e.g., Gruta do Galeão, Gruta da Rua do Carvão, Gruta da Merda, and so on).

Some lava tubes (e.g., Natal and Agulhas) and pits (Algar do Carvão) from Terceira are under the management of Os Montanheiros speleological group from Terceira (Azores). The peculiar features and dimensions of these caves and the remarkable scenic aspects of the Algar do Carvão make Terceira Island unique in the Azores. Some support for carefully supervised tourism is being

implanted by Os Montanheiros with the help of Secretaria Regional de Turismo e Ambiente (Environmental and Tourism Regional Secretary).

We recently found the hypogean relict beetle from Terceira, *Trechus terceiranus* Machado in the Algar do Carvão, showing that a rational tourist exploration won't harm the fauna of caves (pit in this case).

Nevertheless we should like to point out that, in some cases, if the habitat of a peculiar species is changed, the species is doomed to disappear. For example, the *Trechus montanheirorum* Oromí and Borges lives only at the entrance of the Gruta dos Montanheiros (Pico) (see Borges and Oromí, in press). In this case we think that its habitat must not be changed, and in consequence, no cement or other related products should be used for the construction of a better access than the existing wooden staircase.

As already noted by Halliday (1981) the Azores are islands of unusual speleological interest. They have some remarkable volcanic chimney caves (e.g., Algar do Carvão, Algar do Cabeço Bravo, Algar do Tambor, Furna Ruim, and Algar do Montoso) and lava tube caves (e.g., Balcões, Chocolate, Queimada, Agulhas, Torres, Montanheiros, Frei Matias, Soldão, and perhaps still others). Therefore all the lava tubes and pits of these islands should be protected.

There are several solutions for this. The top priority for the conservation of the caves and their fauna is to conduct accurate speleological and biological inventories on all islands in order to establish conservation priorities. Simultaneously it is also urgent to learn more about the ecology of the Azorean cave species so the protection measures will be effective.

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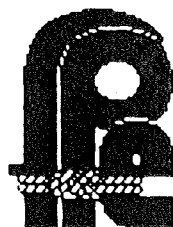
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OS MONTANHEIROS

SOCIEDADE DE EXPLORAÇÃO ESPELEOLÓGICA



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NACIONAL
DE ESPELEOLOGIA**

**I ENCONTRO INTERNACIONAL
DE VULCANOESPELEOLOGIA
DAS ILHAS ATLÂNTICAS**

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VULCANOESPELEOLOGIA DOS AÇORES

VULCANOSPELEOLOGY IN THE AZORES

GRUTAS E ALGARES DOS AÇORES.

I - SEIS NOVAS TOPOGRAFIAS DE TUBOS DE LAVA DA ILHA TERCEIRA

Por

P. A. V. Borges ¹, F. Pereira ² & A. Silva ².

ABSTRACT. In 1991, we presented a paper in the 6th International Symposium on Volcanospeleology about the distribution of volcanic caves and pits from the Azores. In the present paper we present a complete and updated list of the lava tubes and pits from Terceira and also six new maps and descriptions of lava tubes from this island. Data on the location, length, elevation and fauna of each cave are also given. Two of the lava tubes belong to the Pau Velho complex of caves (Gruta do Caldeira and Branca Opala) being located in the Pau Velho lava flow (1761). The other four lava tubes are located in older parts of the island. The known length of each of the six studied caves are the following: Caldeira= 148 m; Branca Opala= 99 m; Coelho= 171,5 m; Achada= 169,8 m; Mercês II= 65 m; Madre de Deus= 244,8 m. With these new six maps the Terceira has now 14 lava tubes mapped (45% of the known occurring lava tubes).

RESUMO. Em 1991, no "6th International Symposium on Volcanospeleology", apresentámos um estudo sobre a distribuição das grutas e algares dos Açores. No presente trabalho apresenta-se uma lista revista e actualizada das grutas e algares da ilha Terceira, sendo igualmente apresentadas seis novas topografias de tubos de lava desta ilha. São igualmente fornecidas informações sobre a localização, comprimento, altitude e fauna de cada gruta. Duas das grutas pertencem ao complexo Pau Velho (Gruta do Caldeira e Branca Opala) estando localizadas na corrente de lava do Pau Velho (1761). As outras quatro grutas estão localizadas em partes mais antigas da ilha. O comprimento conhecido de cada um dos tubos de lava estudados é o seguinte: Caldeira= 148 m; Branca Opala= 99 m; Coelho= 171,5 m; Achada= 169,8 m; Mercês II= 65 m; Madre de Deus= 244,8 m. Com estas seis novas topografias a ilha Terceira fica com 14 tubos de lava completamente mapeados, o que representa 45% do seu património conhecido.

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I. INTRODUÇÃO

A ilha Terceira é uma das nove ilhas que constitui o arquipélago dos Açores. Forma com outras quatro ilhas (Faial, Pico, S. Jorge e Graciosa) o grupo Central deste arquipélago, sendo estas cinco ilhas as geologicamente mais recentes dos Açores (*vide* ABDEL-MONEM *et al.*, 1975, FERAUD *et al.*, 1980).

Tal como as outras ilhas dos Açores, a ilha Terceira (27.2° Long. W; 38.7° Lat. N) possui uma origem vulcânica, não havendo, no entanto, acordo quanto à sua datação geológica. Assim, enquanto que FERAUD *et al.* (1980) referem a idade de 620 000 anos, FORJAZ (com. pess.) e QUEIROZ (1990) estimam em 2 milhões a idade da parte mais antiga desta ilha (a sua parte oriental).

Apesar dessas discordâncias, os factos apontam para a existência nesta ilha de complexos vulcânicos de diferentes idades geológicas, ocorrendo igualmente correntes de lava históricas (*vide* WESTON, 1964) e uma grande diversidade de cavidades vulcânicas.

Após os trabalhos pioneiros de FORJAZ (1963) (onde descreve a "Furna de Henrique Maciel" - Pico), de MOTTET (1970, 1972, 1974) (com a descrição geomorfológica das Grutas das Agulhas, do Natal e dos Balcões - Terceira), de ARRUDA (1972) (descrevendo e topografando a Furna Abrigo, Furna de Henrique Maciel II, Furna de Manuel José Lima e Algar do Alto do Morais - Pico) e de MONTSERRAT & ROMERO (1983) (com a descrição e topografia dos tubos de lava dos Balcões, Pau Velho e Natal - Terceira), tem-se assistido nos últimos anos a um incremento nos estudos espeleológicos nos Açores da autoria de grupos espeleólogos autóctones.

De facto, após as visitas recentes aos Açores de eminentes vulcanoespeleólogos como W. Halliday (*vide* HALLIDAY, 1980 e 1981) e T. Ogawa (*vide* OGAWA, 1989), que aproveitaram para realizar inventários das cavidades deste arquipélago (nessa altura já com o apoio de "OS MONTANHEIROS" - Terceira), são agora "OS MONTANHEIROS" da Terceira e os "AMIGOS DOS AÇORES" de S. Miguel a publicar activamente trabalhos sobre as cavidades vulcânicas dos Açores (*vide* BORGES *et al.*, em impressão e em preparação; HAYES & BRAGA, manuscrito; NUNES & BRAGA, 1992; NUNES *et al.*, em impressão; PEREIRA *et al.*, em preparação; e o presente trabalho).

BORGES *et al.* (em impressão) apresentaram no "6th International Symposium on Volcanospeleology" (Hilo, Hawaii, 1991) uma lista actualizada dos tubos de lava e algares dos Açores. Na presente contribuição pretendemos realizar a actualização dos dados referentes aos tubos de lava, algares, grutas de erosão marinha e ainda outros tipos de cavidades da ilha Terceira, apresentando-se igualmente seis (6) novas topografias de tubos de lava desta ilha.

II. LISTA DOS TUBOS DE LAVA, ALGARES, GRUTAS DE EROSÃO MARINHA E OUTRAS CAVIDADES DA ILHA TERCEIRA

Esta é uma lista revista dos tubos de lava, algares, grutas de erosão marinha e outros tipos de cavidades da ilha Terceira (Tabela I). Para a sua elaboração utilizou-se a mesma metodologia de BORGES *et al.* (em impressão e em preparação).

São usadas as seguintes abreviaturas para as autorias das Topografias:

a- por MONTSERRAT & ROMERO (1983); b- BORGES *et al.* (em impressão) - Croqui ou Topografia de "Os Montanheiros"; c- "Os Montanheiros", Topografia apresentada no presente trabalho; d- "Os Montanheiros", trabalho de campo realizado e Topografia em elaboração; e - Topografia dos espeleólogos franceses, P. BRUNET e C. THOMAS e de um de nós (A. SILVA).

Nas Figs. 1, 2, 3 e 4 apresenta-se a localização dos Tubos de Lava (Fig. 1), Algares (Fig. 2), Grutas de Erosão Marinha (Fig. 3) e Outros Tipos de Cavidades (Fig. 4) na ilha Terceira. A anotação utilizada é a mesma da Tabela I.

III. NOVAS TOPOGRAFIAS DE TUBOS DE LAVA DA ILHA TERCEIRA

1- GRUTA DO CALDEIRA (Figura 5; Foto 1)

Localização= Biscoitos, Pau Velho (Terceira) - (Fig. 1: Tubo de Lava 14)

Altitude = 260 m; U.T.M.= 4774/42911.

Comprimento= 148 m; Altura= 0,40-2,60 m; Largura= 1,10-5,60 m.

A Gruta do Caldeira encontra-se localizada no complexo lávico da erupção de 1761 do Pau Velho. Trata-se de um tubo de lava de pequenas dimensões (148 m) cujo desenvolvimento conhecido se faz por debaixo de pastagens.

Foi pela primeira vez assinalado em dois artigos da imprensa local (ANÓNIMO, 1986a e 1986b). A condensação de ar saído da gruta provocou preocupação nos habitantes locais, tendo então uma equipa de "Os Montanheiros" explorado essa nova cavidade vulcânica dos Biscoitos.

A descrição então apresentada deste tubo de lava foi a seguinte: "*A média de altura e largura varia entre os 7 e 1 metro e as larguras de 3 a 8 metros, terminando num grande desabamento impossível de ser transposto em virtude das diminutas aberturas existentes entre as pedras caídas, mas tudo indica que a gruta continua. Este troço tem uma extensão visitável da ordem dos 100 metros. A uma distância de 30 metros da entrada existe uma galeria secundária que se estende perpendicularmente à galeria principal, cuja altura e largura varia entre 30 centímetros/metros e 1 e 5 metros, terminando também num desabamento de momento intransponível. A gruta no seu todo tem muito interesse devido à quantidade de formações que possui: Estalactites; escorrimentos, bancadas, pavimentos de lava cordada, tudo indicando ser um possível ramal da gruta dos Balcões, devido à semelhança das formações.*" (vide ANÓNIMO, 1986a e 1986b).

Cavidades	Nome principal	Outros nomes	Localização	Comprim./Altura	Altura	Largura	ELEV.	U.T.M.	Topogr.	Fauna
TUBOS DE LAVA										
1	Furna de St. Maria	-	Cabrito, Porto Judeu	320 m	?	?	450 m	4841/42852	-	-
2	F. do Cabrito	-	Cabrito, Porto Judeu	200 m	?	?	400 m	4841/42849	-	-
3	F. D'Água	-	Cabrito, Porto Judeu	250 m	?	?	450 m	4843/42845	-	-
4	Galeria da Ribeira Seca	-	Ribeira Seca	60 m	?	?	175 m	4918/42813	-	-
5	Galeria Queimada	Cafua Velha	Biscoitos, Pau Velho	639,9 m >??	0,3-2,5	0,26-10,9	473 m	4768/42895	b	-
6	Gruta Branca Opala	G. do Rabão	Biscoitos, Pau Velho	99 m	0,7-5,0	1,6-10,0	280 m	4781/42923	c	-
7	G. da Achada	-	Biscoito das Fontinhas	169,8 m	0,25-1,70	1,2-8,7	310 m	4868/42870	c	-
8	G. da Madre de Deus	-	Porto Martins	244,8 m	0,4-13,5	0,4-11,5	210 m	4940/42816	c	Conhecida
9	G. das Agulhas	G. da Salga	Porto Judeu	250,5 m	0,5-5,4	1,2-4,5	5 m	4909/42775	b	Conhecida
10	Furna das Feiticeiras	-	Outeiro do Bogango	?	?	?	600 m	4724/42854	-	-
11	Gruta das Mercês I	-	Canada das Mercês, Feteira	?	?	?	135 m	4869/42784	-	-
12	G. das Mercês II	-	Canada das Mercês, Feteira	65 m	0,90-4,70	0,5-3,9	135 m	4869/42784	c	-
13	G. de Santo António	G. do Recanto	Porto Martins	302,1 m	0,35-9,40	0,6-18,0	220 m	4936/42818	-	-
14	G. do Caldeira	-	Biscoitos, Pau Velho	148 m	0,40-2,60	1,1-5,6	260 m	4774/42911	c	Conhecida
15	G. do Camelo	-	Cabrito, Porto Judeu	255,87 m	0,30-3,80	1,7-11,3	465 m	4841/42850	d	-
16	G. do Chocolate	-	Biscoitos, Pau Velho	109,7 m	0,50-6,20	0,4-3,6	250 m	4781/42924	b	Conhecida
17	G. do Coelho	-	Lagoa do Negro	171,5 m	0,45-5,0	1,0-7,2	540 m	4764/42879	c	Conhecida
18	G. do Natal	Galerias Negras; G. do Cavalo	Lagoa do Negro	389 m	0,50-7,0	0,8-12,0	540 m	4766/42878	a	-
19	G. do Pau Velho	G. dos Principiantes G. dos Carvociros	Biscoitos, Pau Velho	245,5 m	1,0-4,0	0,4-12,0	350 m	4778/42908	a	-
20	G. do Zé Grande	-	Serretinha	31,61 m	0,40-2,10	1,9-3,8	125 m	4867/42781	d	-
21	G. dos Balcões	G. do Bastião	Biscoitos, Pau Velho	2713 m	0,30-6,0	0,25-7,0	390 m	4778/42906	a	Conhecida
22	G. da Canada do Laranja	-	Altars	30 m	?	?	25 m	4761/42948	-	-
23	G. da Cascata	-	Biscoitos, Pau Velho	198 m	?	?	340 m	4777/42913	-	-
24	G. da Terra Mole	-	Biscoitos, Pau Velho	120 m	?	?	375 m	4773/42909	-	-
25	G. da Malha	-	Biscoitos, Pau Velho	450 m	?	?	490 m	4779/42892	-	-
26	G. da Santinha	-	Estrada da Doze Ribeiras	15 m ?	?	?	490 m	4768/42860	-	-
27	G. Santa Catarina	-	Cabo da Praia	28 m	?	?	40 m	4955/42838	-	-
28	G. do Pico do Funil	-	Pico do Funil, Porto Judeu	60 m	?	?	580 m	4815/42868	-	-
29	G. Pequena	-	Lagoa do Negro	29 m	?	?	540 m	4768/42876	-	-
30	Tubo 1	-	Monte Brasil	40 m ?	?	?		4808/42783	c	-
31	Tubo 2	-	Monte Brasil	87 m ?	?	?		4809/42783	c	-

Tabela I.- Cavidades subterrâneas da ilha Terceira (Tubos de Lava).

Cavidades	Nome principal	Outros nomes	Localização	Comprim./Altura	Altura	Largura	ELEV.	U.T.M.	Topogr.	Fauna
ALGARES										
1	Algar do Carvão	-	Algar do Carvão, Porto Judeu	120 m/ - 90 m	1,6-40	2,10-20,0	629 m	4810/42865	MONT.	Conhecida
2	A. do Funil	-	Biscoitos	-22 m	-	11,0-20,0	500 m	4778/42879	-	-
3	A. do Mistério	-	Biscoitos	151 m/ -12 m	0,50-2,10	0,5-2,4	545 m	4763/42877	-	-
4	A. do Negro	-	Lagoa do Negro, Biscoitos	16 m/ -5,5 m	-	16	540 m	4762/42876	-	-
5	A. do Pico das Dez	-	Pico das Dez, St. Barbara	60 m/ -20 m	0,30-3,50	1,0-4,5	350 m	4698/42849	d	-
6	A. do Pico Gaspar	-	Pico Gaspar, Lagoa do Negro	8,5 m/ -18 m	-	2,35	540 m	4764/42873	d	-
7	A. da Canada do Laranjo	-	Altares	7 m/ -5 m	?	?	40 m	4759/42945	-	-
8	A. do Pico do Funil	-	Pico do Funil, Porto Judeu	8 m/ -15 m	?	?	580 m	4815/42868	-	-
GRUTAS DE EROSÃO MARINHA										
1	Furna das Pombas	-	Quatro Ribeiras	?	?	?	0 m	4829/42943	d	-
2	F. dos Ninhos	-	Quatro Ribeiras	?	?	?	0 m	4829/42943	d	-
3	F. da Nascente	-	Quatro Ribeiras	?	?	?	0 m	4829/42943	d	-
4	Brisa Azul	-	Ilhéus das Cabras	80 m	?	?	0 m	4869/42876	-	-
OUTRAS CAV.										
1	Furna da Bugia	-	Bujia, Lajes	?	?	?	90 m	4928/42905	-	-
2	F. do Poço Negro	-	Serreta	?	?	?	0 m	4683/42924	-	-
3	Algar do Canadão	-	Raminho	-5 m	?	?	890 m	4721/42891	-	-
4	A. do Pico Alto	-	Pico Alto, Aqualva	-25 m	?	?	800 m	4818/42897	-	-
5	A. do Biscoitinho	-	Serreta	-8 m	?	?	510 m	4695/42893	-	-
6	A. do Chambre	-	Rocha do Chambre	-17 m ?	?	?	680 m	4795/42895	-	-
7	A. Adérito de Freitas	-	Pico Matias Simão	?	?	?	150 m	4747/42947	-	-
8	Gruta das Laranjas	-	Ribeira dos Pães, Lajes	20 m	?	?	20 m	4890/42925	-	-
9	Fenda do Pico Zimbreiro	-	Monte Brasil	-100 m ?	?	?	180 m	4799/42772	-	-
10	Gruta do Camarão	-	Cinco Ribeiras	?	?	?	?	4712/42801	-	-

Tabela I.- Cavidades subterrâneas da ilha Terceira (Algares, Grutas de Erosão Marinha e outros tipos de cavidades).

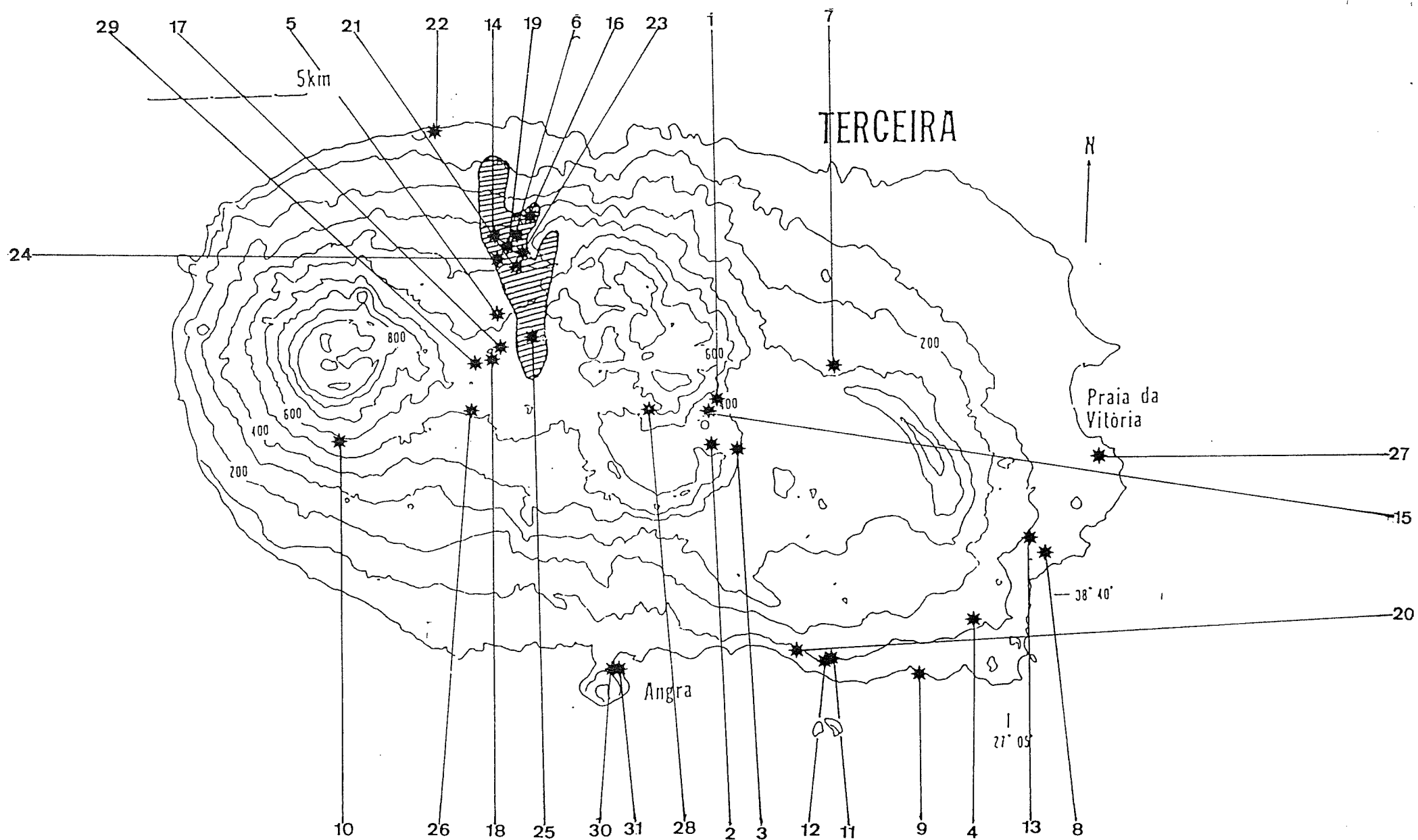


Figura 1.- Localização na ilha Terceira (Açores) dos Tubos de Lava conhecidos (*).

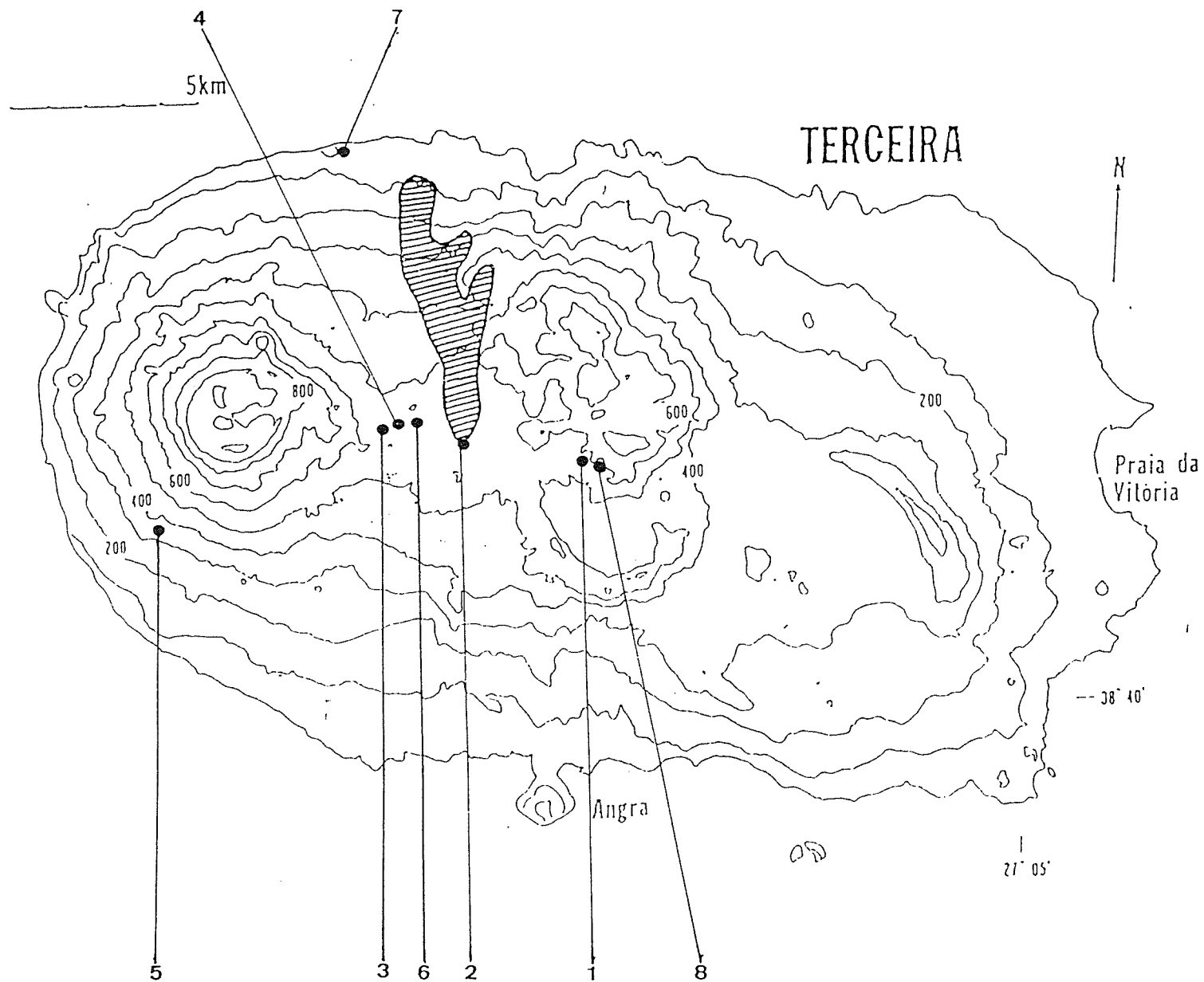


Figura 2.- Localização na ilha Terceira (Açores) dos Algaes conhecidos (•).

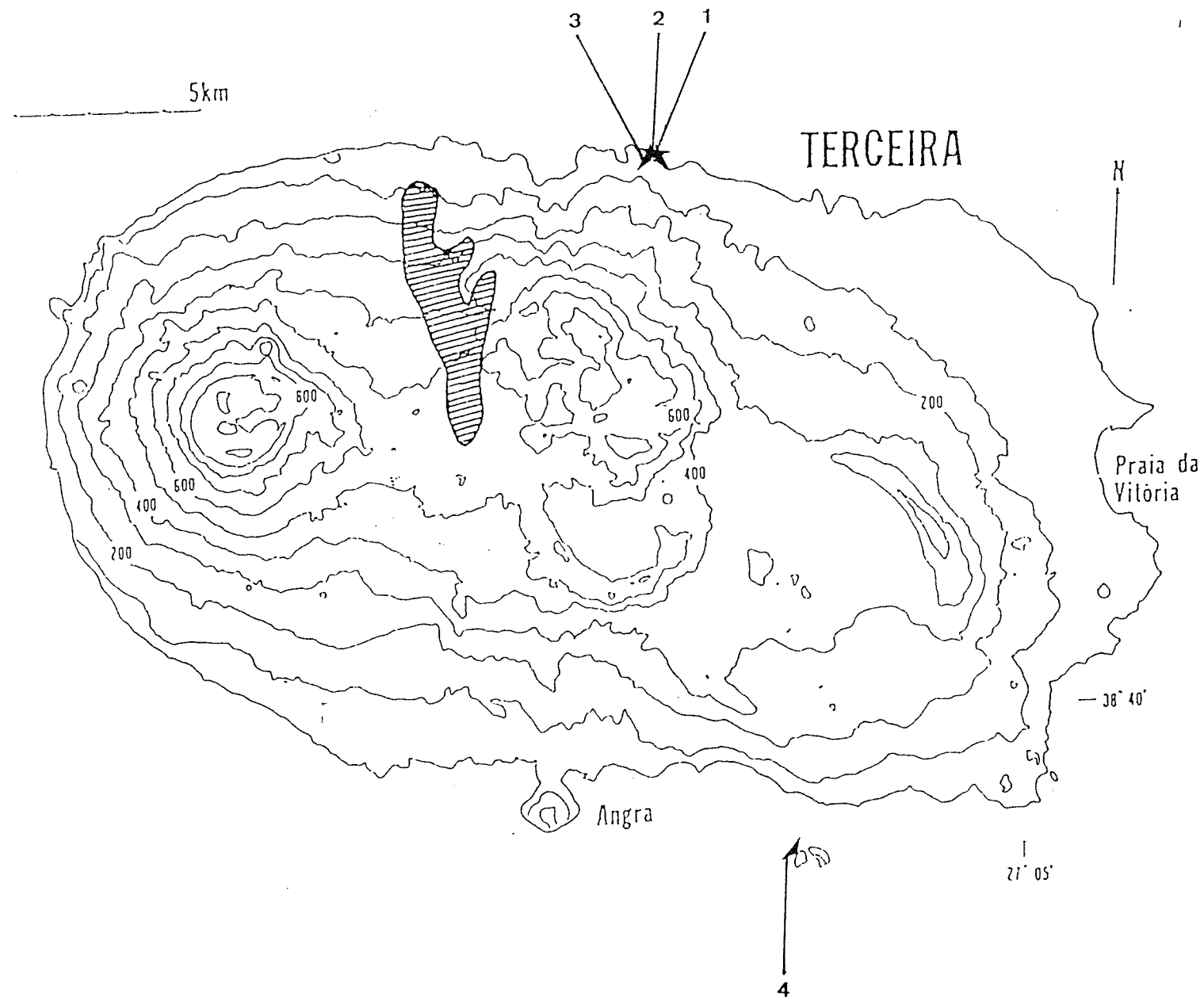


Figura 3.- Localização na ilha Terceira (Açores) das Grutas de Erosão Marinha conhecidas (▲).

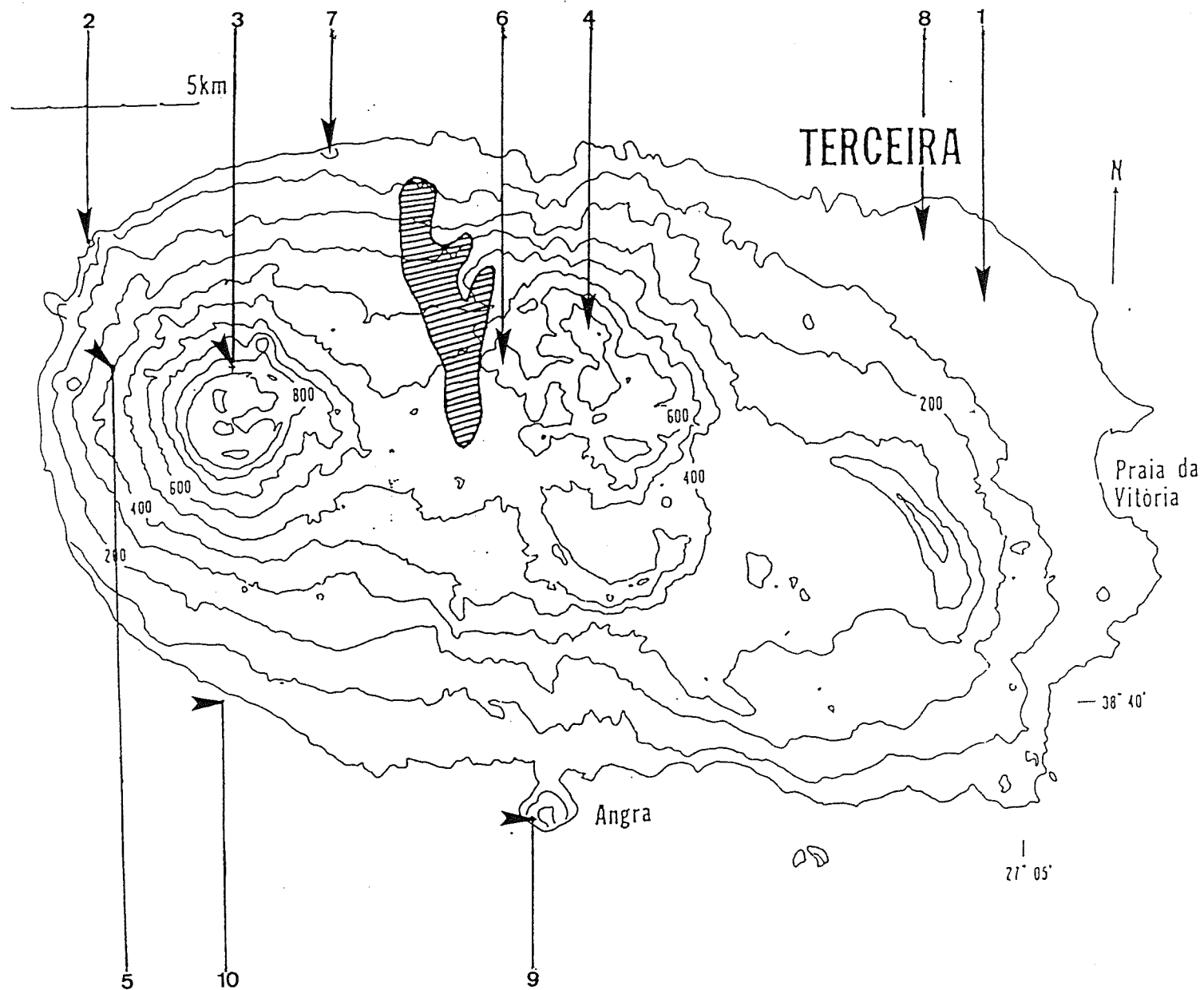


Figura 4.- Localização na ilha Terceira (Açores) de "outros tipos de cavidades" conhecidas (▲).

O tubo de lava por nós topografado condiz perfeitamente com a descrição acima apresentada. A entrada faz-se por uma rampa de entulho que obstrui a progressão no sentido S-N

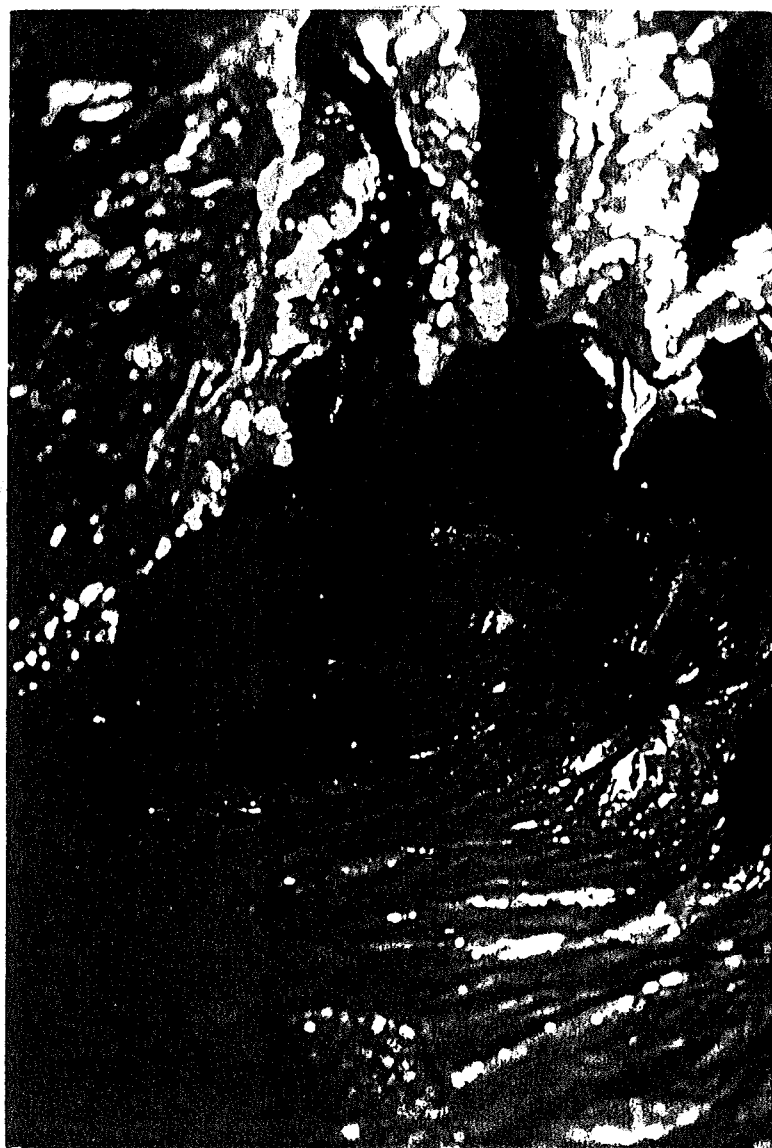


Foto 1.- Gruta do Caldeira: aspecto de uma corrente de lava secundária, podendo ver-se o nível superior que a lava atingiu antes de se escoar.

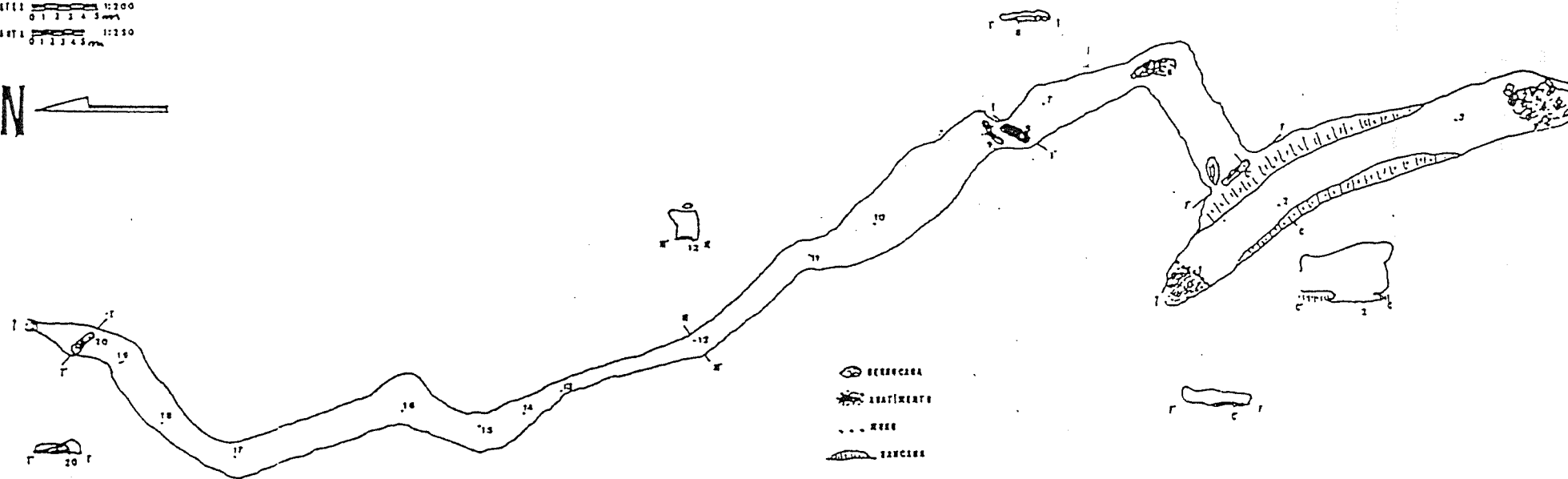
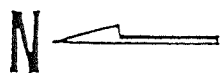
da galeria principal. Esta possui cerca de 30 m (e não os 100 m acima referidos) e encontra-se obstruída nas extremidades Sul (desabamento natural ?) e Norte (entulhada). O desenvolvimento desta galeria para Norte (jusante) poderá vir a ser explorado futuramente após remoção do entulho. A 30 m da Galeria Principal existem lateralmente bancadas com cerca de 50 cm de altura. A uma distância de 10 m (e não 30 m) da entrada existe uma Galeria Secundária que se desenvolve inicialmente no sentido W-E (10 m) e que inflete novamente no sentido N-S acompanhando a galeria principal paralelamente.

GRUTA DO CALDEIRA

BISCOITOS

TERCEIRA AÇORES

CRISTAL 0 1 2 3 4 5 m
PLANTA 0 1 2 3 4 5 m



Topografia de:
"OS MONTANHEIROS" SEE
E. PEREIRA
P. BORGES
R. GABRIEL
2 de Fevereiro de 1992

Figura 5.- Topografia da Gruta do Caldeira (Biscoitos, Terceira, Açores).

Ao longo do troço secundário ocorrem também bancadas laterais testemunhando as superfícies de escoamento. O pavimento que é do tipo *pahoehoe* na galeria principal (ocorrendo também lava cordada) é majoritariamente do tipo "aa" na galeria secundária.

Ainda na galeria secundária, existem grandes quantidades de escorrências ("Lava dripstone trails") nas paredes e estalactites de fusão ("Lava-drops") no tecto. No extremo Norte desta galeria há um estrangulamento com rastejo que se torna demasiado estreito para a progressão. Pensamos que o desabamento referido na descrição anterior ("*...terminando também num desabamento de momento intransponível*") coincide não com o extremo da galeria, mas sim com o ponto 20 da nossa topografia (Fig. 5). Entre os pontos 17 e 20 as paredes possuem um tom vermelho-acastanhado e esmaltado (Foto 1), podendo ver-se o nível superior que a lava atingiu antes de se escoar. Os trabalhos realizados pelos "Montanheiros" neste tubo de lava incluíram a sua topografia, filmagem video e levantamento fotográfico.

FAUNA: Durante uma experiência com pitfall que realizámos neste tubo de lava capturámos dois exemplares do Carabídeo troglóbio *Trechus terceiranus* Machado e ainda o Collembola (Entomobryidae) *Pseudosinella ashmoleorum* Gama (GAMA, comunicação pessoal).

2- BRANCA OPALA (Figura 6; Foto 2)

Localização= Biscoitos, Pau Velho - (Fig. 1: Tubo de Lava 6)

Altitude= 280 m; U.T.M.= 4781/42923.

Comprimento= 99 m; Altura= 0,70 - 5,00 m; Largura= 1,60 - 10,00 m.

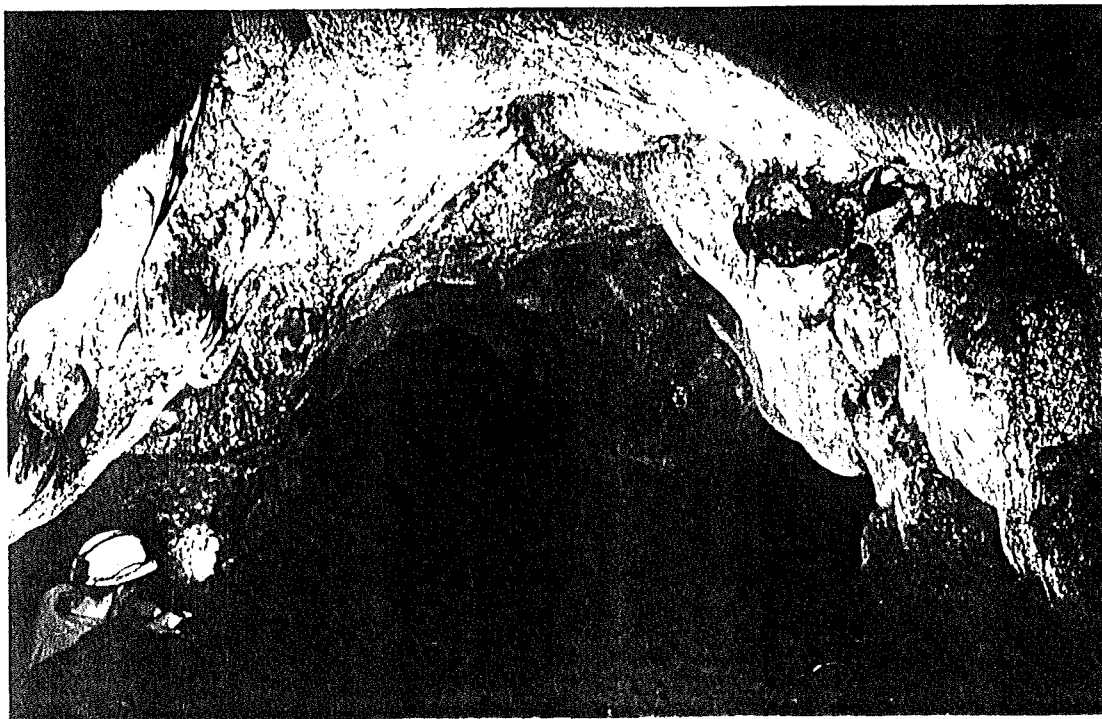


Foto 2.- Gruta da Branca Opala: formações ovais do tecto e paredes, formadas por materiais de características Siliciosas ("Opala").

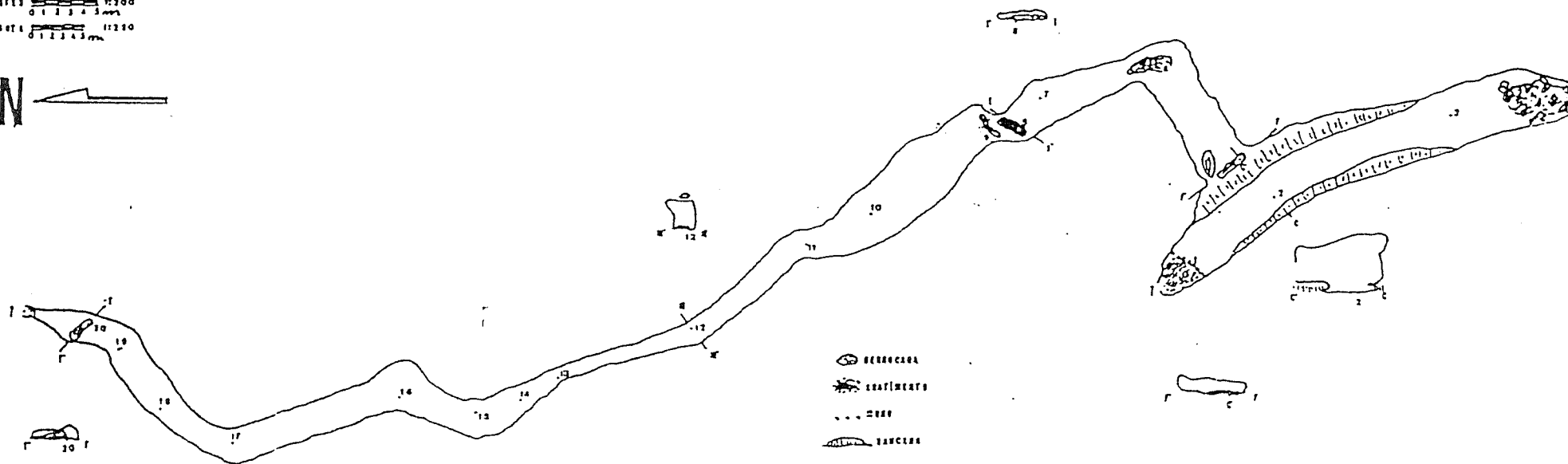
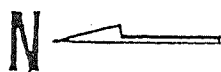
GRUTA DO CALDEIRA

BISCOITOS

TERCEIRA AÇORES

ESCALA 1:300
0 1 2 3 4 5 m

PLANTA 1:250
0 1 2 3 4 5 m



Topografia de:
"OS MONTANHEIROS" SEE
F. PEREIRA
P. BORGES
R. GABRIEL
2 de Fevereiro de 1992

Figura 5.- Topografia da Gruta do Caldeira (Biscoitos, Terceira, Açores).

Tal como o anterior tubo de lava, a Gruta Branca Opala parece pertencer ao complexo Pau Velho. Este tubo terá sido descoberto por um particular quando procurava localizar alguns patos fugidis. Trata-se de um tubo de lava linear de pequenas dimensões (99 m), com características únicas nos Açores (e talvez a nível mundial). Existem três entradas: a primeira a montante é um "Skylight"; a segunda e terceira formaram-se como consequência de desabamentos mais recentes.

Devido à topografia do terreno que antecede a entrada a montante, este tubo de lava funciona como colector das águas torrenciais que transportam todo o tipo de detritos orgânicos, pedras e lamas. Como consequência deste processo, na parte final da gruta existe um talude de materiais acumulados que formam um "dique".

Nos dias de grandes chuvadas, entre o ponto 8 e 11 (Fig. 6) toda a gruta fica ocupada por água sendo impossível qualquer tipo de progressão nesse troço.

Entre os pontos 6 e 13 as paredes laterais e o tecto estão completamente recobertos com materiais de características Siliciosas ("Opala") de formas variadas. Muito comuns são formações ovais (Foto 2). Julgamos que esses depósitos tiveram origem no seguinte processo: os materiais orgânicos arrastados pelas águas misturaram-se com a sílica existente nos terrenos limítrofes, depositando-se nas paredes durante os períodos em que a água preencheu o espaço entre os pontos 6 e 13.

FAUNA: Desconhecida.

3- GRUTA DO COELHO (Figura 7; Foto 3)

Localização= Lagoa do Negro - (Fig. 1: Tubo de Lava 17)

Altitude = 540 m; U.T.M.= 4764/42879.

Comprimento= 171,5 m; Altura= 0,45 - 5,00 m; Largura= 1,00 - 7,20 m.

Trata-se de um tubo de lava assinalado muito recentemente na bibliografia (*vide* OROMÍ *et al.*, 1991), mas que possivelmente era já conhecido pelos antigos "Montanheiros". No entanto, não existem registos antigos da existência desta cavidade, podendo a sua denominação antiga ser bem diferente daquela pela qual este tubo de lava foi baptizado recentemente. O nome actual deve-se à configuração da entrada principal, que se assemelha muito a uma toca de coelho.

Localiza-se na zona da Lagoa do Negro, pertencendo possivelmente ao mesmo complexo da Gruta do Natal (Fig. 1: Tubo de Lava 18) e do Algar do Negro (Fig. 2: Algar 4).

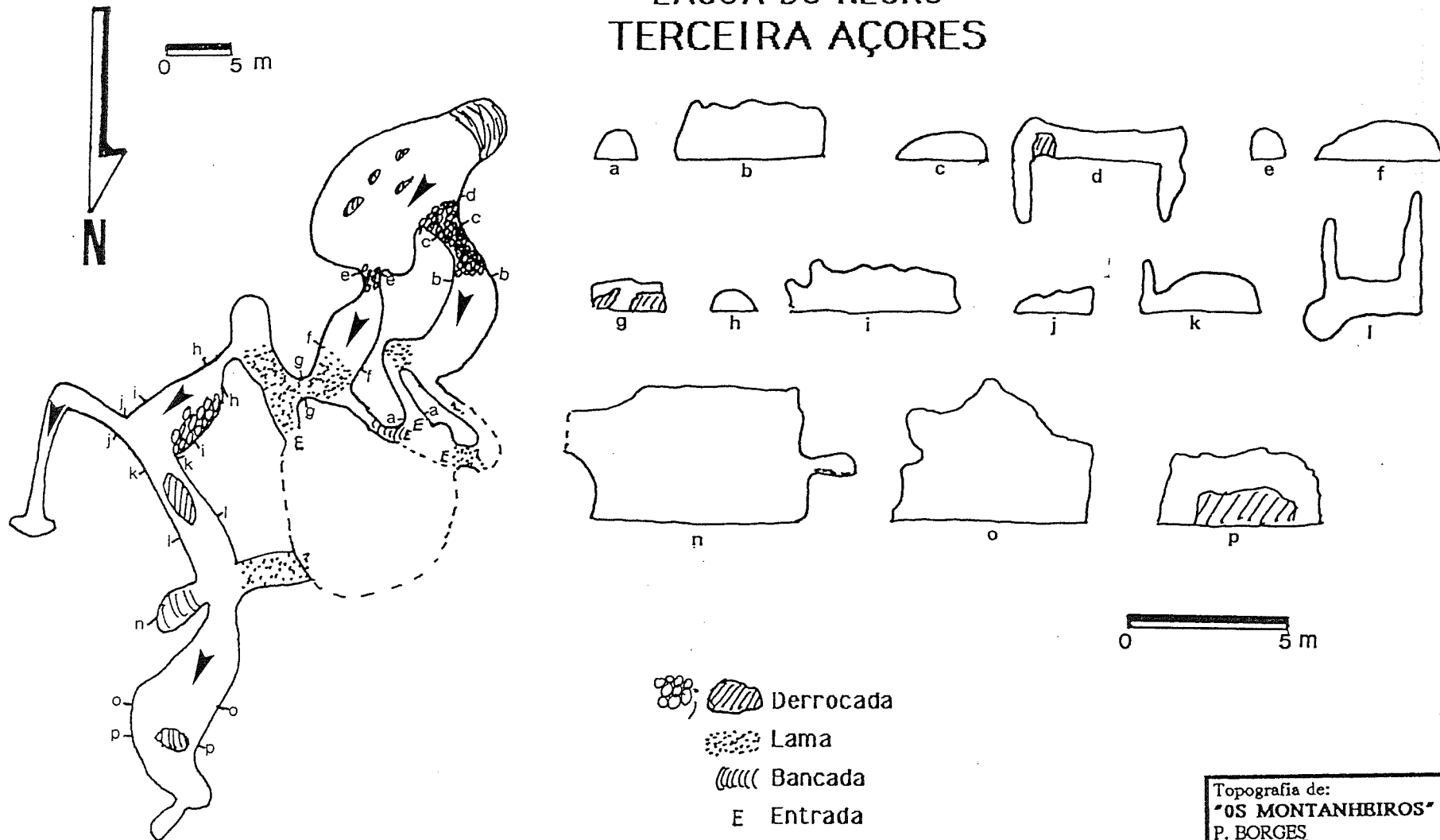
Apesar de se tratar de um tubo de lava de reduzidas dimensões (conhecidas !) possui um desenvolvimento algo labiríntico. O sentido principal de desenvolvimento é SW-NE.

Existem três possíveis zonas de entrada, assim como várias zonas com desabamentos de grandes dimensões. No seu extremo montante existe uma grande sala com 6-4 metros. Esta encontra-se a uma cota superior em relação às duas galerias que dela se ramificam.

A galeria que se inicia em e-e (Fig. 7) possui um pavimento tipo *pahoehoe* no seu início seguindo-se uma extensa zona de lamas que passa por duas entradas. A galeria que se inicia em d-d (Fig. 7) possui grande quantidade de desabamentos no seu início, seguindo-se uma zona de

GRUTA DO COELHO

LAGOA DO NEGRO
TERCEIRA AÇORES



Topografia de:
"OS MONTANHIROS" SBB
P. BORGES
F. PEREIRA
O. TEIXEIRA
27 de Março de 1992

Figura 7.- Topografia da Gruta do Coelho (Lagoa do Negro, Terceira, Açores).

pavimento tipo *pahoehoe* e finalmente bifurca-se numa entrada lamacenta (a-a) e numa outra galeria interrompida por uma derrocada.

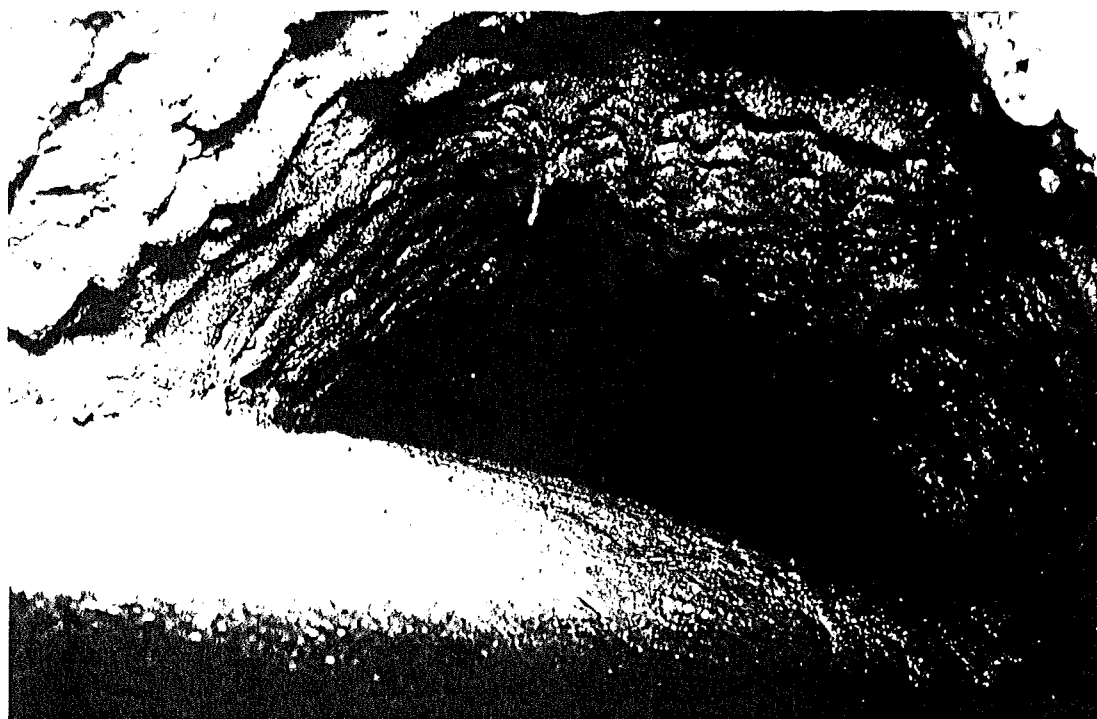


Foto 3.- Gruta do Coelho: modelo de tubo de lava em miniatura incrustado numa parede. Notar a presença de estalactites lávicas de forma cônica.

A jusante ocorrem algumas formações de grande interesse didático, com sejam vários modelos de tubos de lava em miniatura incrustados nas paredes (ver Foto 3). Também a jusante a gruta termina num pequeno rastejo cujo pavimento é de lava "aa".

FAUNA: Como consequência da expedição Bioespeleológica Internacional aos Açores foram capturadas as seguintes espécies (OROMÍ *et al.*, 1990):

-o Collembola (Onychiuridae) *Onychiurus* sp. e o Collembola (Entomobryidae) *Pseudosinella ashmoleorum* Gama;

-o Carabídeo troglóbio *Trechus terceiranus* Machado foi capturado em grande quantidade. Recentemente nós próprios capturámos grande quantidade de exemplares desta espécie nesta cavidade;

4- GRUTA DA ACHADA (Figura 8; Foto 4)

Localização= Achada, Biscoito das Fontinhas (Golfe) - (Fig. 1: Tubo de Lava 7)

Altitude= 310 m; U.T.M.= 4868/42870.

Comprimento= 169,8 m; Altura= 0,60 - 1,70 m; Largura= 1,20 - 8,70 m.

Conhecida dos "Montanheiros" desde dos anos 70, nunca tinha sido alvo de qualquer tipo de estudo espeleológico.

GRUTA DA ACHADA

ACHADA
TERCEIRA AÇORES

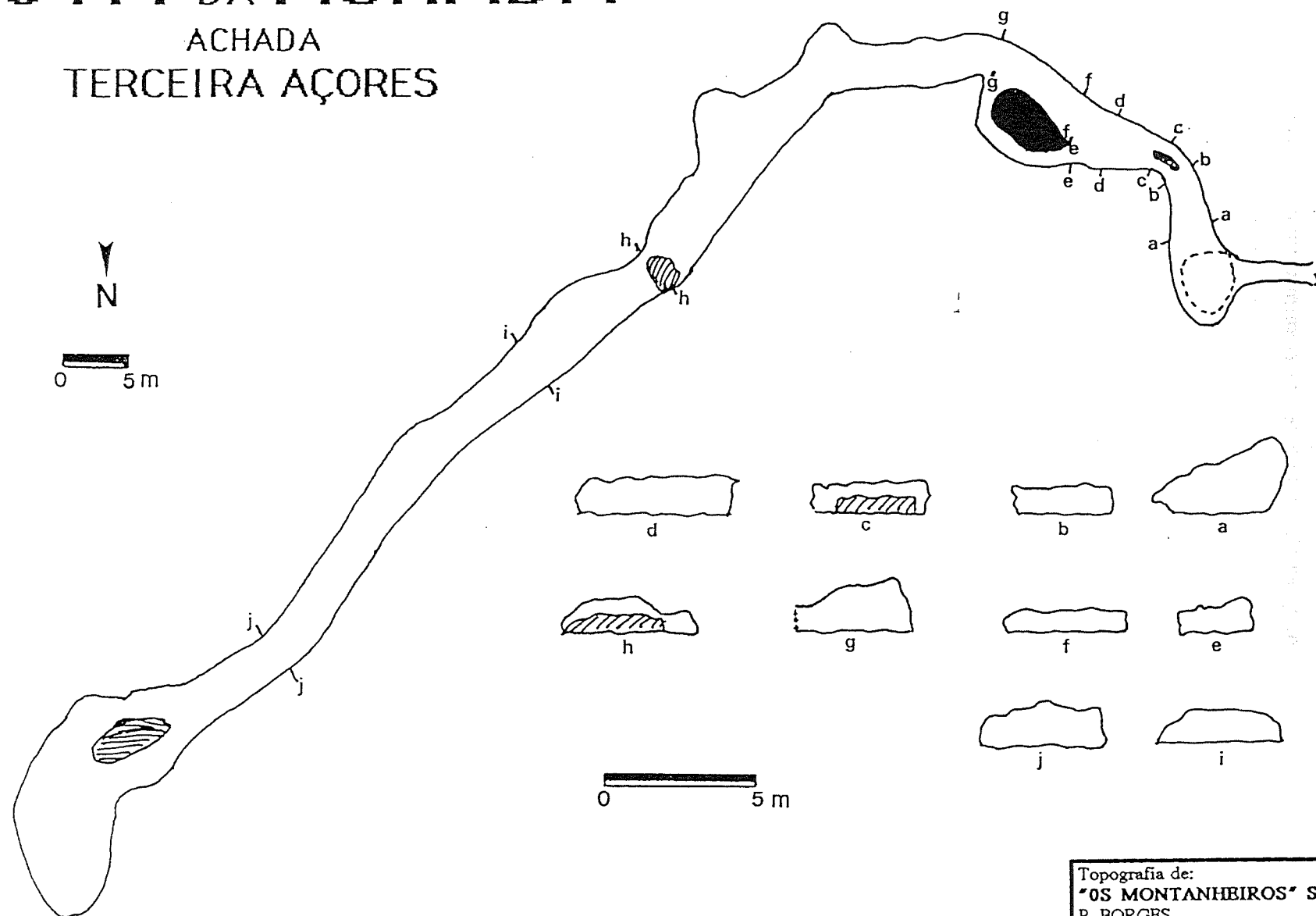


Figura 8.- Topografia da Gruta da Achada (Achada, Terceira, Açores).

Topografia de:
"OS MONTANHEIROS" SBE
P. BORGES
F. PEREIRA
O. TEIXEIRA
8 de Maio de 1992

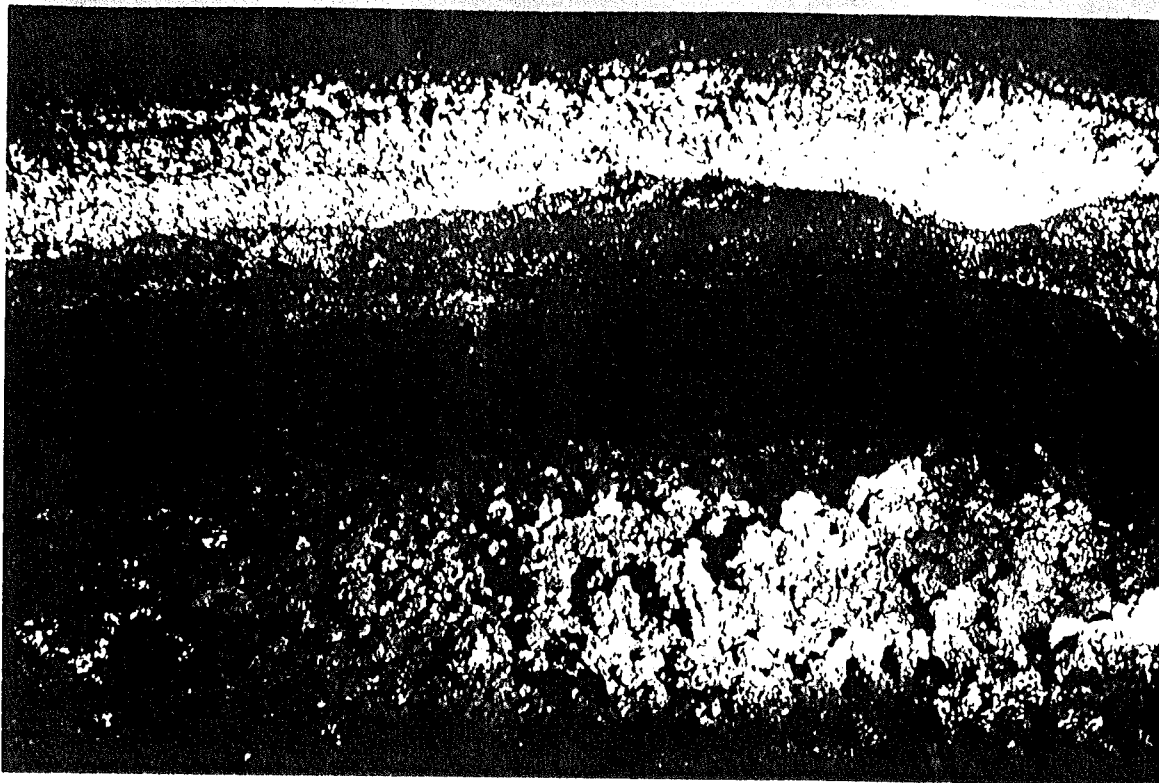


Foto 4.- Gruta da Achada: aspecto do pavimento do tipo "aa", podendo observar-se ainda a baixa altura desta cavidade vulcânica.

Trata-se de um tubo de lava "unitário" com 169,8 m de desenvolvimento conhecido. O pavimento é em grande parte do tipo "aa" (Foto 4), o que aliado ao facto de as alturas serem sempre pequenas do tipo "semi-rastejante", dificulta bastante a progressão.

O desenvolvimento da corrente de lava faz-se no sentido N-S com inflexão para W-E e finalmente SW-NE. Faz parte do complexo de lavas que transbordando da Caldeira do Guilherme Moniz e contornando o Pico de Gualpanal, correram para NE até ao Picão a SE das Lajes percorrendo uma distância de 7 km. A este complexo pertencem ainda os tubos de lava de Santa Maria (Fig. 1: Tubo de Lava 1), do Cabrito (Fig. 1: Tubo de Lava 2), da Água (Fig. 1: Tubo de Lava 3), do Camelo (Fig. 1: Tubo de Lava 15), entre outros.

A entrada é um desabamento do tecto, estando o pavimento coberto de fetos (p.ex. *Selaginella kraussiana*).

FAUNA: Desconhecida.

5- GRUTA DAS MERCÊS II (Figura 9; Foto 5)

Localização= Canada dos Marcos, Feteira - (Fig. 1: Tubo de Lava 12)

Altitude= 135 m; U.T.M.= 4869/42784.

Comprimento= 65 m; Altura= 0,90 - 4,70 m; Largura= 0,50 - 3,90 m.

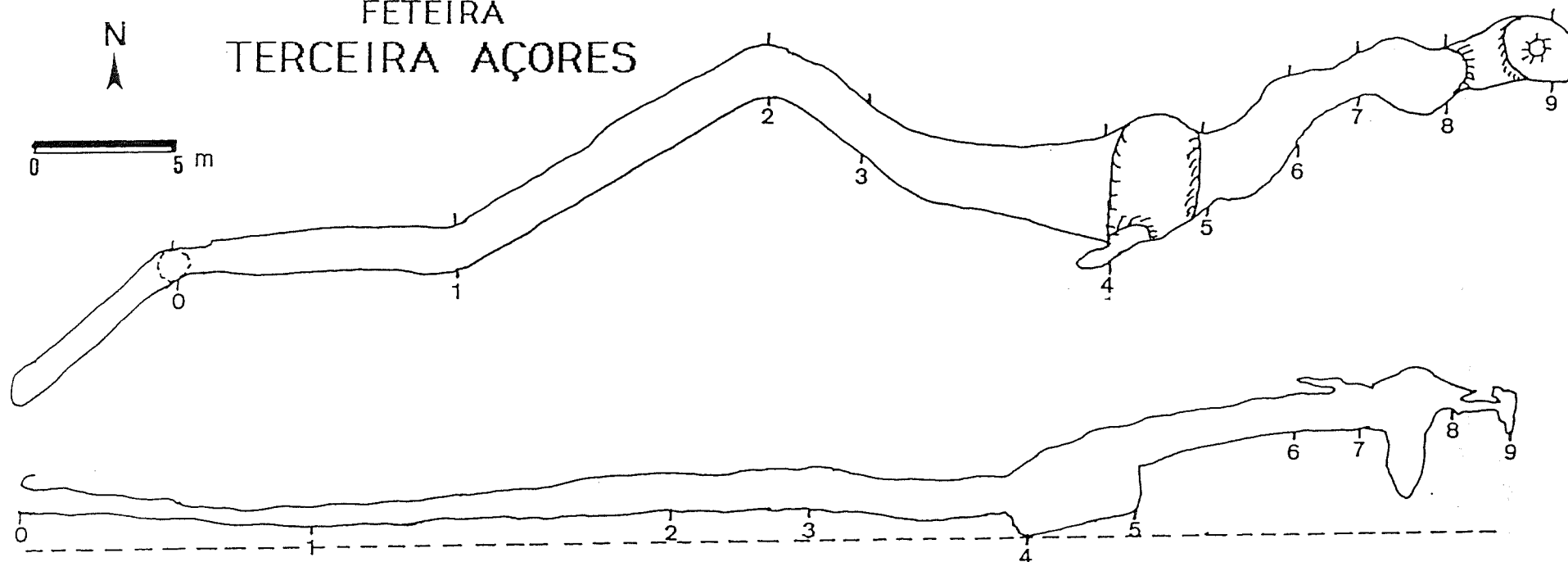
Descoberta pelos "Montanheiros" nos anos 80, está localizada em terrenos particulares.

GRUTA DAS MERCÊS II

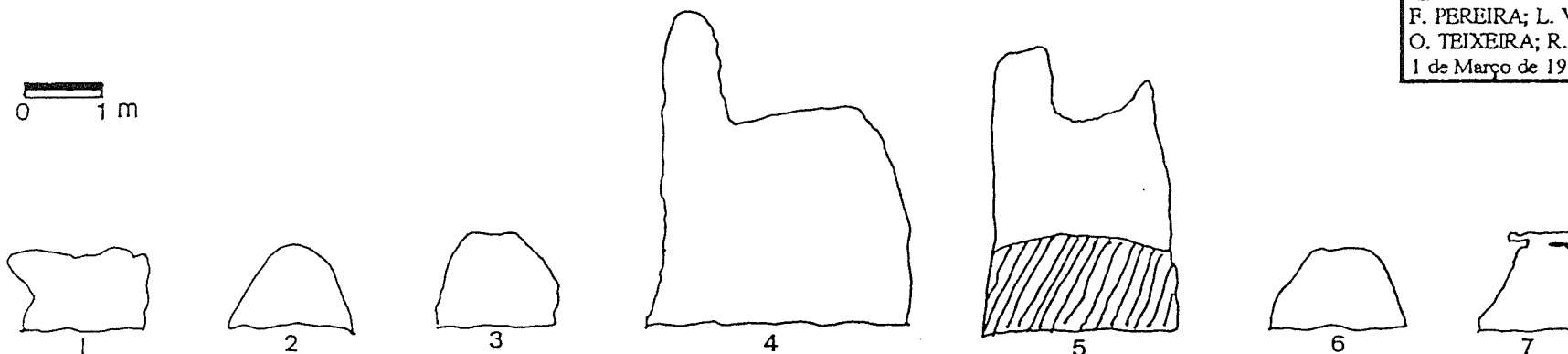
FETEIRA
TERCEIRA AÇORES



0 5 m



0 1 m



Topografia de:
"OS MONTANHEIROS" SEE
P. BORGES
F. PEREIRA; L. VASCONCELOS
O. TEIXEIRA; R. GABRIEL
1 de Março de 1992

Figura 9.- Topografia da Gruta das Mercês II (Feteira, Terceira, Açores).

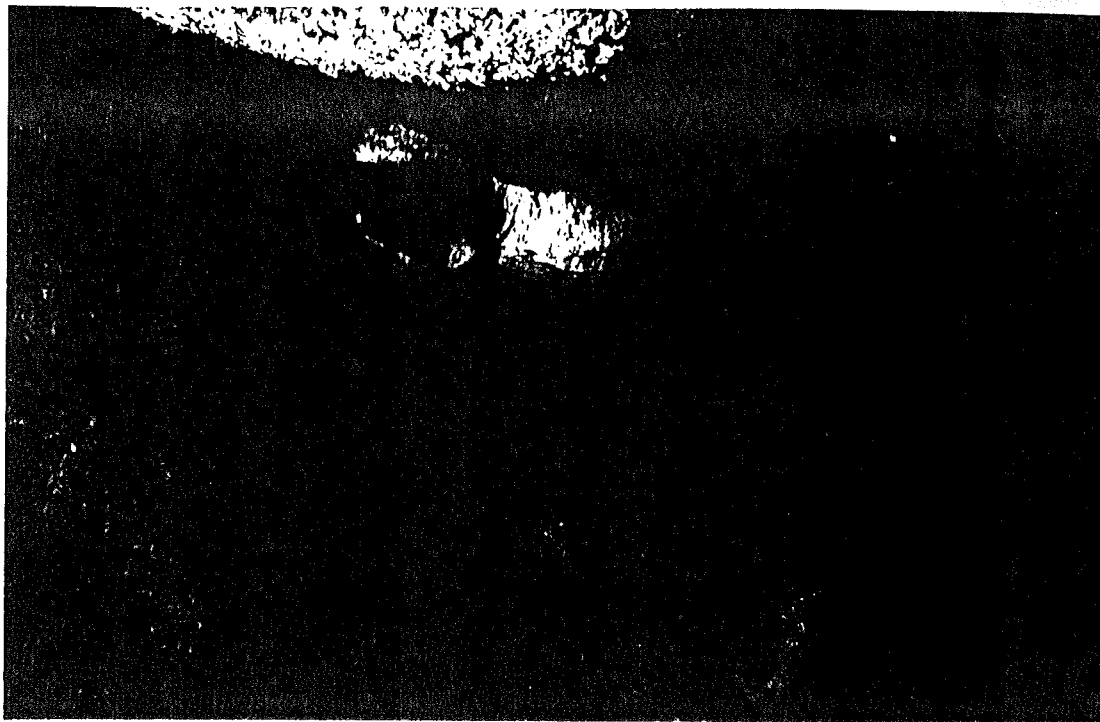


Foto 5.- Gruta das Mercês II: aspecto do desnivelamento do pavimento na zona 4-5 (Fig. 9).

Faz parte do mesmo complexo da Gruta da Achada, embora a um derrame diferente que correndo para Sul atingiu a costa da freguesia da Feteira, depois de percorrer cerca de 9 km. Tal como a Gruta da Achada é também um tubo de lava do tipo "unitário".

Desenvolve-se no sentido E-W. Possivelmente poderá ter ligação com a Gruta das Mercês I, conhecida desde os tempos da Fundação de "Os Montanheiros".

Nas zonas 4-5, 7-8 (Fig. 9) há um desnivelamento do pavimento que é do tipo *pahoehoe*.

FAUNA: Desconhecida.

6- GRUTA DA MADRE DE DEUS (Figura 10; Foto 6)

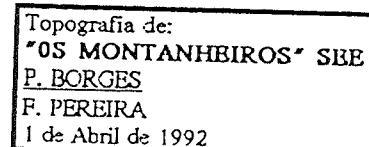
Localização=Porto Martins, Canada da Madre de Deus - (Fig. 1: Tubo de Lava 8)

Altitude = 210 m; U.T.M.= 4940/42816.

Comprimento= 244,8 m; Altura= 0,40 - 13,50 m; Largura= 0,40 - 11,50 m.

A primeira referência a esta Gruta é bastante antiga (*vide* ORMONDE, 1936), onde se fazem algumas descrições mais de carácter poético do que científico. Assim contrariamente ao que este autor refere (ORMONDE, *op. cit.*) não há a possibilidade (também expressa pela tradição) de haver uma ligação deste tubo e da quase contígua Gruta de Santo António (Fig. 1: Tubo de Lava 13) com a caldeira das Lages, distante deste local mais de uma dezena de quilómetros e com acidentes orográficos de diversa índole nesse percurso.

PORTO MARTINS
TERCEIRA AÇORES



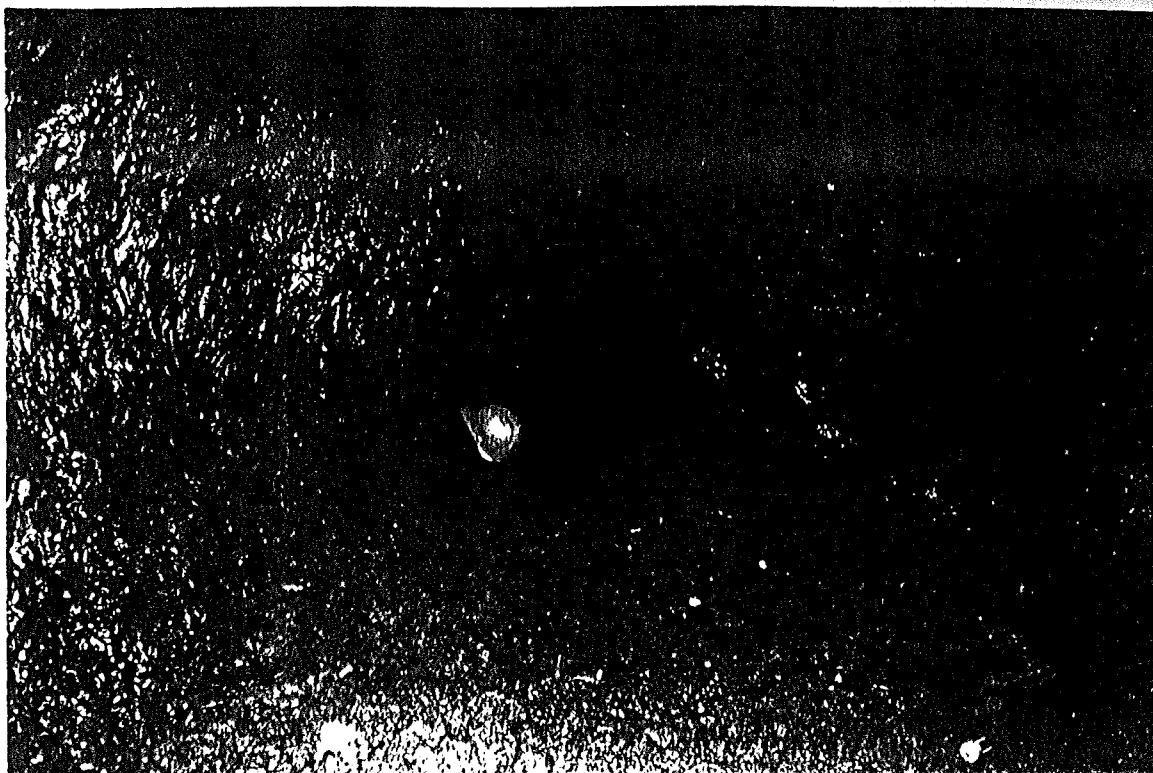


Foto 6.- Gruta da Madre de Deus: aspecto da entrada de um rastejo em que se pode ainda observar o padrão esmaltado das paredes.

Uma outra referência (ANÓNIMO, 1966) refere-se à existência de uma Algar do Porto Martins com uma vertical de 14 metros. Trata-se da entrada a montante (ponto 24, Fig. 10), proveniente do desabamento do tecto e que constitui o ponto mais alto da gruta (13,50 metros).

Essa abertura ilumina uma grande sala preenchida por grandes rochas e pedras. Apesar de não haver provas, pensa-se que para Norte a progressão levaria a uma ligação com a Gruta de Santo António, situada a algumas centenas de metros a montante. Aliás estes dois Tubos de lava deverão ter sido constituídos por um mesmo e único derramamento de lava.

Trata-se de parte de um tubo lávico de apreciáveis dimensões, um dos de maior amplitude da ilha Terceira. E dizemos "parte", já que a gruta, para jusante, continua, ao que consta por muitas centenas de metros [aliás MERELIM (1982) refere que a extensão deste tubo é de 650 m, praticamente o triplo do que é hoje conhecido (244,8 m)]; todavia, a passagem está obstruída por um grande abatimento do tecto da gruta, que aliás originou a entrada do tubo lávico a que agora nos referimos (ponto 0, Fig. 10), e onde existiria uma vasta sala, a avaliar pelas características daquele desmoronamento. Dos relatos de ORMONDE (1936) parece-nos que este desmoronamento ter-se-á dado durante o terramoto de 1841.

Como características principais deste tubo lávico, podemos apontar (adaptado de ANÓNIMO, 1991):

- a existência de 5 salas bastante amplas (Fig. 10, pontos 0, 4-5, 7, 10-12, 24);
- a ocorrência de imponentes bancadas nas salas 4-5 e 10-12 (Fig. 10);
- a ocorrência de grandes abatimentos nas salas 0, 7 e entre os pontos 18 e 24 (Fig. 10);

- a sala 7 está repleta de raízes de árvores, dispostas em curiosa configuração (Fig. 10);
- o estrangulamento desnivelado existente entre os pontos 12 e 15 (Fig. 10), obrigando a passagem rastejante de alguma dificuldade;
- a célebre "Língua de Sogra", ou seja, uma grande lage que se desprende duma das paredes laterais, ficando presa numa das extremidades, apresentando a forma de uma língua;
- a existência de duas entradas com diferentes características, uma sala de grande amplitude (ponto 0) e um algar com 13,50 m de vertical (ponto 24);
- nos tectos é possível observar vários tipos de estalactites lávicas.

FAUNA: Durante uma experiência com pitfall que realizámos neste tubo de lava capturámos nas partes escuras a centopeia *Lithobius obscurus azoreae* Eason & Ashmole (EASON & ASHMOLE, 1992). A mesma espécie foi por nós capturada junto com o Carabídeo *Trechus terceiranus* Machado em MSS (Meio Subterrâneo Superficial) no Pico Rachado (BORGES, em impressão).

IV. DISCUSSÃO E CONCLUSÕES

As cavidades vulcânicas da ilha Terceira constituem um património natural de inegável valor. Além do seu valor geológico intrínseco, não podemos deixar de referir o seu valor hidrológico e biológico.

O estado de conservação das grutas e algares desta ilha merece alguma preocupação, já que em alguns casos se assiste a uma poluição orgânica assinalável, consequência das visitas de turistas mais ou menos selvagens.

Hoje já existe um conhecimento suficiente da fauna de algumas dessas cavidades, de tal modo que qualquer projecto de aproveitamento turístico terá que obedecer a um estudo prévio de impacte ambiental. Assim, cavidades como a Gruta das Agulhas, Coelho, Madre de Deus, Caldeira e o Algar do Carvão possuem um património autóctone de artrópodes adaptados à vida cavernícola, que estando já inventariados urge agora proteger.

No entanto, não será de excluir a existência de outra fauna nestas ou noutras cavidades, pelo que como princípio se deve ter a preocupação de provocar o mínimo de disturbio no ambiente cavernícola.

Pelas suas características geomorfológicas particulares alguns dos tubos de lava estudados no presente trabalho merecem uma protecção e conservação cuidada. Estão nesse grupo a Gruta da Branca Opala (99 m), a Gruta do Coelho (171,5 m) e a Gruta da Madre de Deus (244,8 m). Estamos no entanto cientes de que não existe qualquer tipo de legislação nos Açores que proteja estas cavidades, pelo que urge a realização de um esforço nesse sentido.

Para concluir, poderemos afirmar que neste momento o número de tubos de lava, algares vulcânicos, grutas de erosão marinha e outras cavidades de acordo com a sua distribuição pelas nove ilhas do arquipélago é a seguinte (ver BORGES *et al.*, em preparação): Corvo (1;-;-;-),

Flores (-;-;-), Faial (3;1;-;-), Pico (28;8;-;-), Graciosa (18;2;-;-), S. Jorge (7;5;-;-), Terceira (31;8;4;10), S. Miguel (15;3;-;-6) and S. Maria (-;-;2;1).

V. AGRADECIMENTOS

A realização deste trabalho não teria sido possível sem o apoio nos trabalhos de topografia de campo dos nossos colegas de "Os Montanheiros", O. TEIXEIRA, R. GABRIEL, J. MARIA e L. VASCONCELOS. A todos eles expressamos o nosso profundo agradecimento.

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CAVES AND PITS FROM THE AZORES.

II - AN ANNOTATED CHECKLIST ¹

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RESUMO

Em 1989 Ogawa publicou um estudo com a listagem e distribuição das grutas e algares dos Açores. O incremento que se deu nos últimos anos na descoberta e estudo de novos tubos de lava e algares nos Açores justifica que se faça agora uma actualização dessa listagem. Ogawa listou 33 grutas e 7 algares sendo estes números agora de 101 e 27, respectivamente. A estas juntam-se ainda seis (6) grutas de erosão marinha e dezasseis (16) outras cavidades subterrâneas. Neste trabalho faz-se uma listagem dos tubos de lava, algares vulcânicos, grutas de erosão marinha e outras cavidades de acordo com a sua distribuição pelas nove ilhas do arquipélago: Corvo (1;-;-), Flores (-;-;-), Faial (3;1; -;-), Pico (28;8;-;-), Graciosa (18;2;-;-), São Jorge (7;5;-;-), Terceira (29;8;4;9), São Miguel (15;3;-;6) and Santa Maria (-;-;2;1). São fornecidas informações sobre a localização, espeleometria, altitude e ocorrência de fauna para cada gruta e algar. Apresentam-se igualmente uma curta narrativa da espeleologia Açoreana e alguns comentários sobre a preservação das grutas dos Açores.

ABSTRACT

In 1989, Ogawa published an account of the distribution of caves and pits from the Azores. Further work along the last years justifies an updating of the information. Ogawa listed 33 caves and 7 pits; now these numbers are 101 and 27. There are also additional six (6) littoral caves and sixteen (16) other type of cavities. In this paper the lava tubes, volcanic pits, littoral caves and other caves are listed according to their occurrence in the islands of the archipelago: Corvo (1;-;-), Flores (-;-;-), Faial (3; 1; -;-), Pico (28;8;-;-), Graciosa (18;2;-;-), São Jorge (7;5;-;-), Terceira (29;8;4;9), São Miguel (15;3;-;6) and Santa Maria (-;-;2;1). Some data about the location, speleometric measures, elevation and occurrence of fauna for each cave and pit are also given. A short narrative of Azorean speleology and some information for the preservation of the caves are also provided.

¹Text partially presented at the 6th International Symposium on Vulcano-speleology, Hilo, Hawaii (August, 1991)

INTRODUCTION

The Azorean archipelago is located on the North-Atlantic, at the triple junction of the Eurasian, African and North American plates. The distance between the Azores and the mainland is about 1390 km, from west of Cabo da Roca (the most occidental point of the European continent). It is formed by nine volcanic islands aligned on WNW-ESE trend, that are distributed in three groups: the occidental group with Corvo and Flores; the central group with Faial, Pico, Graciosa, São Jorge and Terceira; the oriental group with São Miguel and Santa Maria (Fig. 1).

All the islands have a volcanic origin, and there are many examples of historical volcanic eruptions (*vide* Weston, 1964).

The geological age of the nine islands is very dissimilar. Once their formation took a large period of time, these islands present a recent volcanic morphology (e.g., Pico) or more eroded, ancient formations (e.g., Flores and Santa Maria).

SPELEOLOGICAL STUDIES IN THE AZORES

The earliest reference concerning the occurrence of caves in the Azores is difficult to establish. Probably the work of Fouque (1873), who briefly discussed lava tubes and pit caves on Terceira, Pico and Graciosa is one of the first. However, before his work, Webster (1821) mentioned caves on and near Ponta Delgada (São Miguel). Later, Pickering (1908)

gave a follow up on Fouque's exploration of the large pit Furna da Caldeira da Graciosa (Furna do Enxofre) on Graciosa island.

The earliest speleological study recorded from the archipelago was made by Forjaz (1963) with a fine description and sketch of "Furna de Henrique Maciel" (Pico). Unfortunately the map of the cave is not presented. Recently (May of 1990) two French speleologists (P. Brunet and C. Thomas) accompanied by one of us (A. Silva) made the topography of this interesting cave (Brunet & Thomas, unpublished).

In 1966, a work of the Portuguese group "Mocidade Portuguesa" — Centro de Instrução Especial de Espeleologia — described the caves of Pau Velho (=Gruta dos Balcões) (Terceira) with an incomplete map. This map was reproduced later by Halliday (1980). In 1967 "Os Montanheiros" made a fine map of this cave, later completed by Montserrat & Romero (1983) (see below).

Mottet (1970, 1972, 1974) presented some data on the geomorphology of some caves from Terceira (e.g., Gruta das Agulhas, Gruta do Natal, Gruta dos Balcões), but no maps are available.

Arruda (1972) studied and described some caves and pits from Pico: Furna Abrigo, Furna de Henrique Maciel II, Furna de Manuel José Lima and Algar do Alto do Morais. Although the maps of the Algar do Alto do Morais and Furna de Manuel José Lima are probably incomplete, this author presents a fine map of Furna

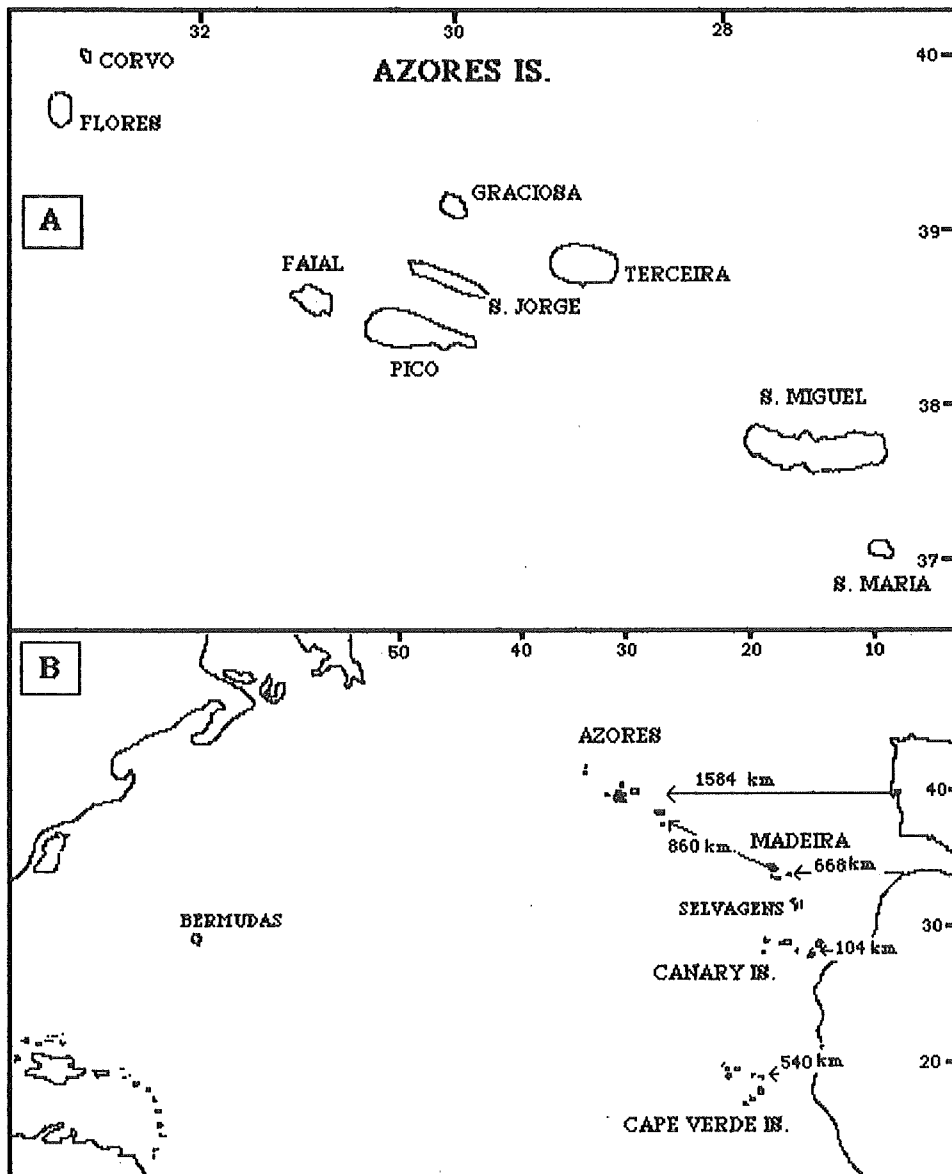


FIG. 1. A: The Azores Islands; B: Atlantic islands with the Macaronesian Archipelagoes and Cape Verde Islands.

Abrigo.

The american vulcanospeleologist W. R. Halliday (see Halliday, 1980 and also Anonymous, 1978) visited the Azores in April 1980 and worked out the first checklist of the Azorean caves and pits (Halliday, 1981). He listed the following caves and pits: Corvo (-;-), Flores (-;-), Faial (-;-), Pico (2;2), Graciosa (1;1), São Jorge (1;2), Terceira (11;2), São Miguel (3;-) and Santa Maria (-;-) (see also Table 1). In these works we can find some sketches of the caves and pits but no impressive maps were presented. Some of these sketches (e.g., Algar do Carvão, G. dos Montanheiros) were put at disposal of W. Halliday by "Os Montanheiros".

The first complete maps of the Azorean caves were presented by Montserrat & Romero (1983). Three lava tubes (Balcões; Pau Velho; Natal) are described and mapped and one lava tube (Agulhas) and one pit (Algar do Carvão) from Terceira are described by these authors. More recently Chinchon *et al.* (in press) presented further studies on "Gruta dos Balcões", now the best studied lava tube from the whole archipelago.

Recently, Hayes & Braga (unpub.) presented at the 5th International

Symposium on Vulcanospeleology (Japan, 1988) the first checklist of caves and pits from São Miguel.

Two Biospeleological Expeditions were carried out on the Azores directed by N.P. Ashmole (Edinburgh University) and P. Oromí (La Laguna University). They were supported by the National Geographic Society, U.S.A: July-August 1987 and 1989 (the latter also with the participation of one of us, P. Borges) (see Oromí *et al.*, 1990, 1991; Borges & Oromí, 1991; Oromí & Borges, 1991). Oromí *et al.* (1991) presented the description of the biologically studied caves during the first of these expeditions (July-August 1987).

The most recent catalogue of the Azorean caves and pits was made by Ogawa (1989) (Table 1), listing 35 caves and 7 pits.

Since then, several speleological expeditions have been made to the Azorean islands by the Terceira (Azores) speleological group "Os Montanheiros".

For a long period of time (1963-1987) the activity of "Os Montanheiros" had a recreative and tourist orientation, but also some speleological studies were made during several expeditions to islands of the Azores.

- (1963-1976) Several speleological visits were made to Graciosa, directed by A. Luís and R. Azevedo;

- (1967) Speleological expedition directed by A. Luís to Pico. Two caves were visited (Gruta do Henrique Maciel, Furna Frei Matias);

TABLE 1. Evolution of the knowledge of the number of lava tubes and pits from the Azores

AUTHORS	LAVA TUBES	PITS	TOTAL
HALLIDAY (1981)	18	7	25
OGAWA (1989)	35	7	42
THIS PAPER	101	27	128

- (1972) Speleological expedition directed by A. Luís to São Jorge. As main results of this visit, several sketches were made from the lava tubes Gruta da Beira, Gruta do Leão, and the pit Bocas do Fogo. All of them were revisited and completely mapped in recent expeditions of "Os Montanheiros" (see below, S.JORGE-88 and MONTOSO-90);

- (1975) Speleological expedition directed by A. Luís to Flores and Corvo. No caves were found in these islands;

- (1976) Speleological expedition directed by R. Azevedo to Pico. The lava tube, Gruta dos Montanheiros, was explored for the first time and an access was built;

- (1978) Speleological expedition directed by A. Silva to São Miguel. Several lava tubes and pits were explored (e.g., G. do Esqueleto, G. da Rua do Carvão, Algar da Batalha).

However, some of the works cited before (e.g., Mottet, 1974; Halliday, 1980, 1981; Montserrat & Romero, 1983; Chinchon *et al.*, in press; Ogawa, 1989; Oromí *et al.*, 1990, 1991; Oromí & Borges, 1991; Borges & Oromí, 1991) were possible only thanks to the kind assistance of "Os Montanheiros" during part of the field work.

In the last years "Os Montanheiros" organized or took part in several expeditions to the islands of Flores, Faial, Pico, Graciosa, São Jorge, São Miguel and Santa Maria (and, also the local island, Terceira). They have explored and mapped over 10 000 meters of caves and 400 me-

ters of pits. The expeditions were:

- (1988) 31st October-11th November, S.JORGE-88, Speleological Expedition to the island of São Jorge;

- (1989) 21st-26th May, BIOSPEL-89, Biospeleological Expedition to the island of Pico (Azores);

- (1989) 4th-11th July, FLORES-89, Zoological Expedition of the University of Azores (Dep. of Biology);

- (1989) 10th-14th October, FAIAL-89, Biospeleological Expedition to the island of Faial (Azores);

- (1990) 3rd-11th and 17th-21st March, BIOSPEL-90, Biospeleological Expedition to the island of Pico (Azores);

- (1990) 8th-16th June, ST. MARIA AND FORMIGAS-90, Zoological Expedition of the University of Azores (Dep. of Biology);

- (1990) 9th-29th August, BIOSPEL-90-S.MIGUEL. Speleological Expedition to the island of São Miguel (Azores);

- (1990) 11th-15th September, MONTOSO-90, Speleological Expedition to the island of São Jorge;

- (1991) 28th March-3rd April, TORRES-91, Speleological Expedition to the island of Pico (Azores);

- (1991) 6th-11th June, ARCO-SPEL-91, Speleological Expedition to the island of Pico (Azores).

- (1991) 19th-27th July, ALVO MORENO-91, Speleological Expedition to the island of Graciosa (Azores).

The aim of the present contribution is to present a commented checklist of all the Azorean known caves and pits (see Table 2).

TABLE 2. Checklist of the Azorean caves and pits. Measurements in meters. For

ISLAND and No.	MAIN NAME	OTHER NAMES	LOCATION
1. CORVO			
LAVA TUBES			
1	G. do Corvo	-	?
2. FLORES			
NO CAVES KNOWN			
3. FAIAL			
LAVA TUBES			
1	F. das Anelares	Lombega	Lombega
2	G. do Cabeço do Canto	Concheiros	Cabeço do Canto
3	G. do Parque do Capelo	-	Parque do Capelo
PITS			
1	F. Ruim	-	Cabeço Verde
4. PICO			
LAVA TUBES			
1	F. da Arcia	F. do J. Maria	Caminho do Cais Mourato
2	F. da Laje	F. da Ti Adelina; F. do Ranheta	Lagedo
3	F. da Miragaia	F. do Chico	Miragaia do Norte
4	F. das Casas	-	Lugar das Casas
5	F. do Carregador	Algar do Barrela; F. dos Algares	Algares
6	F. do Frei Matias	-	Estrada Nova (Long.)
7	F. do Henrique Maciel	F. do Estácio	Santo António
8	F. do Poço Novo	F. do Ti Germano; F. do Calote	Poço Novo (near the seaside)
9	F. do Poço Velho	-	Canada do Poço Velho
10	F. do Tancaim	F. do Tanquinho F. do Ranheta	Tambor (Mistério de St. Luzia)
11	F. dos Bodes	-	Cabeço do Chão
12	F. dos Caldeirões	-	Canada dos Caldeirões, Bandeiras
13	F. dos Mendonças	-	Canada da Travessa
14	F. dos Montanheiros	-	Curral Queimado, Brejos
15	F. d'Água	Bandeiras I; Bandeiras II F. dos Faustinos	Bandeiras (Mistério de St. Luzia)
16	F. Manuel José Lima	-	S. António, Miragaia
17	F. Nova I	-	Farrobo (Mistério de St. Luzia)
18	F. Nova II	-	Farrobo (Mistério de St. Luzia)
19	G. da Barca	-	Estrada Marginal, Barca
20	G. da Capucha	Agostinha João Serafim	Canada da Capucha, Bandeiras
21	G. das Torres	-	Cabeço Bravo,, Creação Velha
22	G. do Capitão-Mor	-	Cais do Pico
23	G. do Galeão I	-	P. do Galeão, S. Cactano
24	G. do Galeão II	-	P. do Galeão (Ringue)
25	G. do Ruivo	-	Carregador
26	G. do Soldão	Malha; Soldado; Moio; Terra Tapada	Mistério da Silveira

abbreviations see text, p. 568.

No.	LENGTH/DEPTH	HEIGHT	WIDTH	ELEV.	UTM	MAPPED	FAUNA
1	?		?	?	?	-	-
1	35,5 m	0,7-4,0	1,4-2,5	80	3482/42663	MONT	yes
2	21,4	0,3-5,10	0,5-7,5	346	3420/4270	MONT	yes
3	55,3	0,35-1,50	0,4-3-40	300	3452/42727	-	-
1	-55	-	20,6-73,1	565	3467/42722	MONT	-
1	?	?	?	?	?	-	-
2	?	?	?	10	3755/42688	-	-
3	50	?	?	140	3720/42661	-	-
4	?	?	?	20	3709/42685	-	-
5	20	2	?-6,0	330	3716/42641	-	-
6	666	?-7,2	?-14,2	680	3735/42609	MONT	-
7	812 > ??	?-4,5	?-4,0	140	3825/42649	c	yes
8	?	?	?	?	?	-	-
9	?	?	?	?	?	-	-
10	?	?	?	275	3731/42655	-	-
11	?	?	?	?	?	-	-
12	?	?	?	110	3721/42668	-	-
13	?	?	?	?	?	-	-
14	741	0,45-6,79	0,40-8,59	785	3831/42610	MONT	yes
15	250+100	?-2,0	?-5,0	100	3738/42670	-	-
16	52	0,5-5,0	?-6,0	140	3773/42670	a	-
17	270,1	0,75-4,0	1-2,50	230	3741/42658	SKETCH	-
18	?	?	?	210	3741/42659	-	-
19	?	?	?	0	3675/42670	-	-
20	310,78	0,43-5,10	1,8-10,95	75	3730/42675	MONT	yes
21	3350	0,50-15,0	1,1-22,0	300	3681/42618	MONT	yes
22	300	?	?	30	3850/42649	c	-
23	255,9/-7,0	3,0-16,0	2,0-10,0	100	3749/42545	MONT	-
24	50	0,4-1,1	0,41-1,25	60	3748/42541	SKETCH	-
25	70	?	?	?	?	-	-
26	1150	0,40-5,96	0,43-5,39	10	3868/42526	MONT	yes

TABLE 2. Checklist of the Azorean caves and pits. (Continuation)

ISLAND and No.	MAIN NAME	OTHER NAMES	LOCATION
4. PICO			
LAVA TUBES			
27	G. dos Arcos	-	Arcos (Mistério de Santa Luzia)
28	G. dos Esqueletos	-	Igreja de S. Luzia
PITS			
1	A. da Furna Abrigo	-	Pico do Pico
2	A. do Alto do Morais	-	Canada do Mato (Frei Matias)
3	A. do Cabeço Bravo	-	Cabeço Bravo (Creação Velha)
4	A. do Cabeço da Negra	-	Campo Raso, Candelária
5	A. do Capitão	Tambor III	Tambor (Mistério de St. Luzia)
6	A. do Lanchão	A. do Cadete; A. do Ti Alfredo	Bandeiras (Mistério de St. Luzia)
7	A. do Tambor	Cratera do Cabeço	Tambor (Mistério de St. Luzia)
8	A. do Vale da Nogueira	-	Vale da Nogueira
5. GRACIOSA			
LAVA TUBES			
1	F. da Labarda	-	Caldeira da Graciosa
2	F. da Maria Encantada	F. do Castelo	Cume da Caldeira
3	F. do Anel	-	Ponta da Barca
4	F. do Canto	-	Caldeira da Graciosa
5	F. do Cardo	-	Caldeira da Graciosa
6	F. do Gato	-	Caldeira da Graciosa
7	F. do Linheiro	-	Caldeira da Graciosa
8	F. do Luíz	-	Caldeira da Graciosa
9	F. do Manuel de Avila	-	Caldeira da Graciosa
10	F. do Queimado	-	Caldeira da Graciosa
11	F. dos Bolos	-	Caldeira da Graciosa
12	F. D'Água	F. do Beber	Praia
13	F. Furada	-	Caldeira da Graciosa
14	Galeria do Forninho	-	Luz
15	G. da Canada das Furnas	F. do Roque; F. de Lavar	Canada das Furnas
16	G. do Bom Jesus	-	Bom Jesus
17	G. do Manhengo	G. da Moura	Canada da Moura
18	G. do João Moreno	-	Bom Jesus
PITS			
1	F. do Enxofre	-	Caldeira da Graciosa
2	Caldeirinha do Pero Botelho	-	Serra Branca
6. S. JORGE			
LAVA TUBES			
1	F. das Pombas	G. do Cais da Urzelina	Urzelina
2	F. do Poio	F. da Lagoa de S. Cristo	Fajã de St. Cristo
3	F. do Pombal	Mina D'Água	Pombal, Fenos, Manadas
4	G. da Beira	-	Beira
5	G. da Granja	-	Velas
6	G. da Lomba do Gato	-	Queimada, Velas
7	G. do Leão	-	Presa do Leão, Velas

No.	LENGTH/DEPTH	HEIGHT	WIDTH	ELEV.	UTM	MAPPED	FAUNA
27	216,5	0,30-2,10	1,0-1,60	50	3778/42686	SKETCH	yes
28	91	0,80-1,60	1,0-2,10	130	3780/42674	SKETCH	yes
1	-39	-	10,0-13,0	1200	3750/42598	a	-
2	65 -10	-	12,0-30,0	1015	3755/42605	a	-
3	323 -28,5	4,5-9,0	1,8-15,0	400	3698/42611	SKETCH	-
4	? -15,0	?	?	75	3695/42562	-	-
5	? -5,5	?	?	200	3731/42658	c	-
6	40,5 -5,5	0,40-5,0	0,50-2,0	110	3721/42667	SKETCH	-
7	97,4 -31,5	1,0-3,5	1,20-7,40	244	3733/42657	SKETCH	-
8	?	?	?	?	?	-	-
1	7,4	?	?-4,40	?	?	-	-
2	56,5	?-2,80	2,5-5,7	200	4151/43207	-	-
3	50,4	?	?-3,50	?	?	-	-
4	11,3	?	?-10,80	?	?	-	-
5	15	?	?-2,20	?	?	-	-
6	11,0	?	?-6,60	?	?	-	-
7	8,2	?	?-10,0	?	?	-	-
8	12	?	?-9,0	?	?	-	-
9	14,7	?	?-8,10	?	?	-	-
10	12,5	?	?	?	?	-	-
11	8	?	?-6,50	?	?	-	-
12	10,5	?	?	260	4148/43211	-	-
13	3,4	?-6,20	?-8,10	?	?	-	-
14	180	0,80-3,5	?-7,30	?	?	-	-
15	83	1,9-6,5	3,4-6,10	125	4148/43208	-	-
16	16	0,55-2,10	2,25-8,0	50	4115/43255	MONI	-
17	?	?	?	?	?	-	-
18	?	?	?	?	?	-	-
1	-42	-	100	137	4159/43199	OGAWA	-
2	38 -35	10	15-33	?	?	SKETCH	-
1	?	?	?	0	4029/42782	-	-
2	?	?	?	25	4189/42758	-	-
3	?	?	?	510	4048/42769	-	-
4	183	2,50-10,0	2,50-15,0	275	3952/42839	MONI	yes
5	?	?	?	?	3958/42817	-	-
6	?	?	?	250	3967/42816	-	-
7	177	0,5-6	0,8-3	250	3964/42818	MONI	-

TABLE 2. Checklist of the Azorean caves and pits. (Continuation)

ISLAND and No.	MAIN NAME	OTHER NAMES	LOCATION
6. S. JORGE			
	PITS		
1	A. das Bocas do Fogo	Bocas de St. Amaro	Lixeira de St. Amaro
2	A. do Montoso	-	Pico do Carvão
3	A. do Pico da Maria Pires	-	Pico da Maria Pires
4	A. do Pico dos Suspiros I	-	Pico do Suspiros
5	A. do Pico dos Suspiros II	-	Pico dos Suspiros
7. TERCEIRA			
	LAVA TUBES		
1	F. de St. Maria	-	Cabrito, Porto Judeu
2	F. do Cabrito	-	Cabrito, Porto Judeu
3	F. D'Água	-	Cabrito, Porto Judeu
4	Galeria da Ribeira Seca	-	Ribeira Seca
5	Galeria Queimada	Cafua Velha	Biscoitos Pau Velho
6	G. Branca Opala	G. do Rabão	Biscoitos, Pau Velho
7	G. da Achada	-	Biscoitos da Fontinhas
8	G. da Madre de Deus	-	Porto Martins
9	G. das Agulhas	G. da Salga	Porto Judeu
10	F. das Feiticeiras	-	Outeiro do Bogango
11	G. das Mercês I	-	Canada das Mercês, Feteira
12	G. das Mercês II	-	Canada das Mercês, Feteira
13	G. de Santo António	G. do Recanto	Porto Martins
14	G. do Caldeira	-	Biscoitos, Pau Velho
15	G. do Camelo	-	Cabrito, Porto Judeu
16	G. do Chocolate	-	Biscoitos, Pau Velho
17	G. do Coelho	-	Lagoa do Negro
18	G. do Natal	Galerias Negras; G. do Cavalo	Lagoa do Negro
19	G. do Pau Velho	G. dos Principiantes; G. dos Carvoeiros	Biscoitos, Pau Velho
20	G. do Zé Grande	-	Serretinha
21	G. dos Balcões	G. do Bastião	Biscoitos, Pau Velho
22	G. da Canada do Laranjo	-	Altars
23	G. da Cascata	-	Biscoitos, Pau Velho
24	G. da Terra Mole	-	Biscoitos, Pau Velho
25	G. da Malha	-	Biscoitos, Pau Velho
26	G. da Santinha	-	Estrada da Doze Ribeiras
27	G. Santa Catarina	-	Cabo da Praia
28	G. do Pico do Funil	-	Pico do Funil, Porto Judeu
29	G. Pequena	-	Lagoa do Negro
	PITS		
1	A. do Carvão	-	Algar do Carvão, Porto Judeu
2	A. do Funil	-	Biscoitos
3	A. do Mistério	-	Biscoitos
4	A. do Negro	-	Lagoa do Negro, Biscoitos
5	A. do Pico das Dez	-	Pico das Dez, St. Barbara
6	A. do Pico Gaspar	-	Pico Gaspar, Lagoa do Negro
7	A. da Canada do Laranjo	-	Altars
8	A. do Pico do Funil	-	Pico do Funil, Porto Judeu
LITTORAL CAVES			
1	F. das Pombas	-	Quatro Ribeiras
2	F. dos Ninhos	-	Quatro Ribeiras

No.	LENGTH/DEPTH	HEIGHT	WIDTH	ELEV.	UTM	MAPPED	FAUNA
1	55,3 - 12,0	-	30,0-50,0	521	3982/42817	MONT	yes
2	269 -137,5	9,0-50,0	9,0-70,0	784	4048/42791	MONT	-
3	?	?	?	663	4000/42814	-	-
4	?	?	?	920	4049/42792	-	-
5	?	?	?	920	4049/42792	-	-
1	320	?	?	450	4841/42852	-	-
2	200	?	?	400	4841/42849	-	-
3	250	?	?	450	4843/42845	-	-
4	60	?	?	175	4918/42813	-	-
5	639,9>??	0,3-2,5	0,26-10,9	473	4768/42895	MONT	-
6	99	0,7-5,0	1,6-10,0	280	4781/42923	MONT	-
7	169,8	0,25-1,70	1,2-8,7	310	4868/42870	MONT	-
8	244,8	0,4-13,5	0,4-11,5	210	4940/42816	MONT	yes
9	250,5	0,5-5,4	1,2-4,5	5	4909/42775	MONT	yes
10	?	?	?	600	4724/42854	-	-
11	?	?	?	135	4869/42784	-	-
12	65	0,90-4,70	0,5-3,9	135	4869/42784	MONT	-
13	302,1	0,35-9,40	0,6-18,0	220	4936/42818	-	-
14	148	0,40-2,60	1,1-5,6	260	4774/42911	MONT	yes
15	255,87	0,30-3,80	1,7-11,3	465	4841/42850	MONT	-
16	109,7	0,50-6,20	0,4-3,6	250	4781/42924	MONT	yes
17	171,5	0,45-5,0	1,0-7,2	540	4764/42879	MONT	yes
18	389	0,50-7,0	0,8-12,0	540	4766/42878	b	-
19	245,5	1,0-4,0	0,4-12,0	350	4778/42908	b	-
20	31,61	0,40-2,10	1,9-3,8	125	4867/42781	MONT	-
21	2713	0,30-6,0	0,25-7,0	390	4778/42906	b	yes
22	30	?	?	25	4761/42948	-	-
23	198	?	?	375 ?	?	-	-
24	120	?	?	375 ?	?	-	-
25	450	?	?	490	4779/42892	-	-
26	15	?	?	490	4768/42860	-	-
27	28	?	?	40	4955/42838	-	-
28	60	?	?	580	4815/42868	-	-
29	29	?	?	540	4768/42876	-	-
1	120 -90	1,6-4,0	2,10-20,0	629	4810/42865	MONT	yes
2	-22	-	11,0-20,0	500	4778/42879	-	-
3	151 -12	0,50-2,10	0,5-2,4	545	4763/42877	-	-
4	16 -5,5	-	16	540	4762/42876	-	-
5	60 -20	0,30-3,50	1,0-4,5	350	4698/42849	-	-
6	8,5 -18	-	2,35	540	4764/42873	SKETCH	-
7	7 -5	?	?	40	4759/42945	-	-
8	8 -15	?	?	580	4815/42868	-	-
1	?	?	?	0	4829/42943	-	-
2	?	?	?	0	4829/42943	-	-

TABLE 2. Checklist of the Azorean caves and pits. (Continuation)

ISLAND and No.	MAIN NAME	OTHER NAMES	LOCATION
7. TERCEIRA			
LITTORAL CAVES			
3	F. da Nascente	-	Quatro Ribeiras
4	Brisa Azul	-	Ilhéus das Cabras
OTHER CAVES			
1	F. da Bugia	-	Bugia, Lajes
2	F. do Poço Negro	-	Serreta
3	A. do Canadão	-	Raminho
4	A. do Pico Alto	-	Pico Alto, Agualva
5	A. do Biscoitinho	-	Serreta
6	A. do Chambre	-	Rocha do Chambre
7	A. Adérito de Freitas	-	Pico Matias Simão
8	G. das Laranjas	-	Ribeira dos Pães, Lajes
9	Fenda do Pico Zimbreiro	-	Monte Brasil
8. S. MIGUEL			
LAVA TUBES			
1	G. da Canada da Giesta	-	Pico da Pedra, Ribeira Grande
2	G. da Quinta-Irene	-	Ribeirinha, Ribeira Grande
3	G. da Rua do Carvão	A. da Rua de Lisboa; A. da Rua do Paim; G. da Fábrica de Tabaco	Domingos Rebelo, P. Delgada
4	G. das Arribanas	-	Arrifes, Serra Gorda
5	G. das Escadinhas	-	Ribeirinha, Ribeira Grande
6	G. de Água de Pau	-	Água de Pau
7	G. do Esqueleto	-	Lagoa do Fogo, R. Grande
8	G. do Pico da Cruz	F. do Pico da Cruz	Pico da Cruz, Pico da Pedra
9	G. do Pico do Enforcado	-	Capelas, Ponta Delgada
10	G. das Feteiras	-	Feteiras
11	G. do Caldeirão	-	Caldeirão, Ribeira Grande
12	G. do Livramento	-	Livramento
13	G. do Pico do Funcho	-	Pico do Funcho
14	G. Queimada	-	Queimada, Arrifes
15	A. Bem Saúde	-	Rua Bem Saúde, P. Delgada
PITS			
1	A. da Batalha	G. da Batalha	Fajã de Cima, Ponta Delgada
2	A. da Ribeirinha	G. da Merda	Ribeirinha, Ribeira Grande
3	A. do Pico Queimada	-	Pico Queimado/Pico do Sapateiro
OTHER CAVES			
1	G. António Borges	-	Jardim A. Borges, P. Delgada
2	G. da Candelária	-	Candelária
3	G. da Lagoa	-	Santa Cruz da Lagoa
4	G. de Rabo de Peixe	-	Rabo de Peixe
5	G. da Soledade	-	Soledade, Fajã de Cima
6	G. de Vila Franca	-	Praia da Vinha da Areia
9. S. MARIA			
LITTORAL CAVES			
1	F. das Pombas	F. Velha	Vila do Porto
2	F. dos Anjos	-	Anjos
OTHER CAVES			
1	G. do Romeiro	-	Ilhéu do Romeiro de S. Lourenço

No.	LENGTH/DEPTH	HEIGHT	WIDTH	ELEV.	UTM	MAPPED	FAUNA
3	?	?	?	0	4829/42943	-	-
4	80	?	?	0	4869/42876	-	-
1	?	?	?	60	?	-	-
2	?	?	?	0	4683/42924	-	-
3	-5	?	?	890	4721/42891	-	-
4	-25	?	?	800	4818/42897	-	-
5	-8	?	?	510	4695/42893	-	-
6	-17 ?	?	?	680	4795/42895	-	-
7	?	?	?	150	4747/42947	-	-
8	20	?	?	20	?	-	-
9	400	?	?	180	4799/42772	-	-
1	45	?	?	170	6229/41835	c	-
2	>>62	?	?-20,0	90	6324/41873	c	-
3	980	0,3-5,1	1,0-12,7	20	6162/41775	d	-
4	?	?	?	280	6152/41829	-	-
5	31,2	0,44-1,6	0,75-5,1	135	6335/41867	d	-
6	323,1	0,2-2,6	0,8-6,6	5	6295/41753	d	yes
7	188,2	0,3-9,5	1-12,5	210	6314/41836	d	yes
8	98,5	0,6-2,9	0,85-5,4	260	6212/41829	d	yes
9	184,8	0,45-3,20	0,7-6,0	235	6151/41859	d	yes
10	22	?	?	35	6058/41845	-	-
11	>>1000 ?	?	?	235	6218/41824	-	-
12	10	?	?	45	6225/41797	-	-
13	60 ?	?	?	75	6179/41769	-	-
14	?	?	?	255	6144/41829	-	-
15	32	5	?	?	?	-	-
1	51,9-9,5	0,4-3,3	0,5-5,7	245	6197/41836	d	-
2	54,5-5	0,9-2,5	?-3,7	150	6334/41871	d	-
3	10-37,3	12	1,6	285	6281/41831	d	yes
1	200 !	?	?	35	6166/41781	-	-
2	14	?	?	130	6044/41865	-	-
3	27	?	?	5	6277/41771	c	-
4	55	?	?	20	6258/41861	-	-
5	19	?	?	150	6197/41816	-	-
6	?	?	?	10	6388/41756	-	-
1	337	0,5-14,5	0,4-12,5	0	6663/40900	MONI	yes
2	117,85	0,65-8,6	0,44-11,2	10	6630/40969	MONI	yes
1	?	?	?	40	6745/40947	-	-

CHECKLIST OF THE AZOREAN CAVES AND PITS

This is a revised catalogue of the Azorean Caves and Pits (Table 2). It includes the data presented by Borges *et al.* (1992) in the "VI International Symposium on Vulcanospeleology, Hilo, Hawaii (August 1991)" and also new data from: Santa Maria (Borges *et al.*, 1991); São Miguel (Nunes & Braga, 1992; Nunes *et al.*, in press); Terceira (Borges *et al.*, in press); Graciosa (Expedition of "Os Montanheiros" ALVO MORE-NO-91).

It includes the main name and other common names of each cave and pit, their location, the known length or depth in meters and the minimum-maximum height and width also in meters. We also present data related with the altitude (Elev.) of the main entrance of each cave and pit and the U.T.M. coordinates. Finally, in each case we refer if there are maps and faunistic studies available.

The list is also organized by four types of cavities; lava tubes, volcanic pits, littoral caves (mainly caves formed by the sea erosion) and other caves (fissures, cracks, artificial caves, etc.).

The following abbreviations are used in what concerns the map information:

a- mapped by Arruda (1972); b- mapped by Montserrat & Romero (1983); c- mapped by the French speleologists, P. Brunet and C. Thomas accompanied by one of us (A. Silva); d- mapped by the speleological group "Os Montanheiros" and by

the ecologist group "Amigos dos Açores" during the BIOSPEL-90-São Miguel, Speleological Expedition to the island of São Miguel (Azores); e- mapped by Nunes *et al.* (in press); MONT.- mapped by the speleological group "Os Montanheiros"; OGAWA - mapped by Ogawa (1989); SKETCH - only a sketch, made by "Os Montanheiros", is available;

We also use in Table 2 the symbols: ?- information not available; ??- not confirmed.

DISCUSSION AND CONCLUSIONS

The most interesting Azorean island from the vulcanospeleological point of view is Pico. This island is dominated by the Pico volcano, that is a tall basaltic cone (2351 m high). The western two thirds of the island form a conspicuous lava field of recent age (Anonymous, 1980). All the main volcanic lava tubes in Pico are situated in *pahoehoe* basaltic lava flows (Forjaz, 1963). They are built by very fluid lavas under special conditions. Such a type of caves is very common, appearing also in other Azorean islands (e.g., Terceira).

In Pico there are several historical lava flows, areas with a great concentration of lava tube caves and pits. The Mistério of Santa Luzia (1718) is the Pico lava flow with larger number of lava tubes. Probably some of them are remains of a unique longitudinal tube. In the Mistério of Silveira (1720) there is a remarkable lava tube, Gruta do Sol-dão (1150 m length), a simple "uni-

tary" or "throughway" type lava tube (*sensu* Halliday & Larson, 1983) excellently preserved.

Several levels of drainage registered on the walls by lateral benches ("bancadas") are commonly found in many caves from Pico and also Terceira and São Miguel. However the best example of this is on Gruta das Torres (Pico), with approximately 11 different levels of drainage.

Up to now 28 lava tubes and 8 pits are known from Pico, but as a consequence of the laborious work of the amateur speleologist A. Garcia (Pico, Madalena) more will probably be discovered soon.

With respect to the caves and pits that occur on it, Terceira is without any doubt the second most interesting Azorean island, after Pico. In this island there are several areas with caves of great interest.

The Pau Velho lava flow (1761) is probably the area with the most interesting caves from this island. Until now, about 3 speleological sites have been identified in the Pau Velho lava flow (1761), in Terceira island: "Balcões", "Galeria Queimada", and "Caldeira". One of them, "Balcões", is formed by more than one cave (Balcões, Pau Velho, Branco Opala, Chocolate), inserted between altitudes of 240 and 400 meters. Recently three other lava tubes were found (Cascata, Terra Mole and Malha) and it is quite probable that other caves, still unknown, will be found in the area. Balcões, 2713 meters long, is the second longest lava tube from the Azores.

In Terceira there is also Algar do Carvão, a remarkable volcanic chimney developed as show cave since 1988.

In São Jorge there are two lava tubes (Beira and Leão) and two pits (Bocas do Fogo and Montoso) of great interest, not only because of their speleological structures but also because of their unique fauna. Algar do Montoso is a remarkable volcanic chimney still poorly studied.

Faial has small and not impressive lava tubes but with striking endemic hypogean arthropods on it. Furna Ruim is an exception with the third bigger vertical of the Azorean pits (55 meters). In São Miguel all of the main caves are located in the recent part of the island, the center plateau. Most of them are small and very much destroyed. In spite of that, their fauna is worth noticing, probably because of the ancient age of the island (4 MA) (Abdel-Monem *et al.*, 1975).

Santa Maria is the oldest island of the archipelago (8 MA) (Abdel-Monem *et al.*, 1975) without recent lava flows. It has only littoral caves of sea erosion (e.g., Anjos and Pombas).

Graciosa is still poorly studied, but in this island occurs the beautiful Furna do Enxofre, with a large lake at the bottom and *solfataras*.

In the smallest of the two occidental islands, Corvo, there is the record of one cave, presently closed.

Beautiful stalactites ("lava-drops") and some stalagmites of many types and forms cover the ceiling and floor the Azorean caves making

them excellent objects of admiration and study.

After this work the number of lava tubes, volcanic pits, littoral caves and other caves known from the Azores are: Corvo (1;-;-), Flores (-;-;-), Faial (3;1;-;-), Pico (28;8;-;-), Graciosa (18;2;-;-), São Jorge (7;5;-;-), Terceira (29;8;4;9), São Miguel (15;3;-;6) and Santa Maria (-;-;2;1).

Islands like Faial, Graciosa and Santa Maria need a lot of field work for a better inventariation. Others like Pico, Terceira and São Miguel are in an advanced stage of knowledge but in spite of that there is still much speleological work to be done.

Pico is doubtless the Azorean island where more speleological surprises may show up. The Gruta das Torres is a good example of it. Presently the biggest lava tube known from this archipelago, was only discovered very recently (1990).

CONSERVATION ASPECTS

Cave ecosystems provide a unique habitat for evolutionary and ecological research. Because of that, all the caves where there is fauna adapted to subterranean environment should be protected from all types of anthropic perturbations (see Table 2; and also Oromí *et al*, 1990, 1991; Borges & Oromí, 1991). The Azorean caves with biological interest are: Anelares, Cabeço do Canto and Furna Ruim from Faial; Montanheiros, Soldão, Henrique Maciel, Capucha, Arcos, Gruta dos Esqueletos from Pico; Beira and Algar das Bocas do Fogo

from São Jorge; Balcões, Coelho, Caldeira, Agulhas, Madre de Deus, Algar do Carvão from Terceira; Água de Pau and Esqueleto from S. Miguel.

But the Azorean caves have other values, and we should preserve them for their geological or educational interest. Protecting them we are protecting many scientific and recreational patrimony.

Unfortunately some Azorean caves (e.g., Furna do Cabrito, Furna d'Água - Terceira) were closed and modified with constructions by the government for protection of water resources. Others, like the once beautiful Gruta do Camelo (Terceira), are now completely destroyed, for the same purpose.

On the other hand, lots of the Terceira lava tubes are visited by tourists and the population in general, which is good. However a great amount of trash can be found on the pavements of these caves (e.g., Natal, Balcões, Agulhas). "Os Montanheiros" have recently made a cleaning operation of grutas do Natal and Agulhas. In Pico and São Miguel the entrances of some lava tubes and pits are currently used as cemetery for domestic animals (e.g., Gruta do Galeão) or as garbage offal dumps (e.g., Gruta dos Galeão, Gruta da Rua do Carvão, Algar da Ribeirinha, etc).

Some lava tubes (e.g., Natal and Agulhas) and pits (Algar do Carvão) from Terceira are under the management of the speleological group from Terceira (Azores) "Os Montanheiros". The peculiar features and dimensions of these caves and the re-

markable scenic aspects of the Algar do Carvão make Terceira Island unique in the Azores. Some support for carefully supervised tourism is being implanted by "Os Montanheiros" with the help of Secretaria Regional de Turismo e Ambiente (Environmental and Tourism Regional Secretariat).

We found recently the hypogean relict beetle from Terceira, *Trechus terceiranus* Machado on the Algar do Carvão, showing that a rational touristic exploration will not harm the fauna of caves (pit in this case).

Nevertheless we should like to point out that, in some cases, if the habitat of a peculiar species changes, the species is doomed to disappear. For example, *Trechus montanheiorum* Oromí & Borges lives only at the entrance of the Gruta dos Montanheiros (Pico) (see Borges & Oromí, 1991). In this case we think that its habitat must not be changed, and in consequence, no cement or other related products should be used for the construction of better access than the existent, an wood staircase.

As already noted by Halliday (1981) the Azores are islands of unusual speleological interest. They have some remarkable volcanic chimney caves (e.g., Algar do Carvão, Algar do Cabeço Bravo, Algar do Tambor, Furna Ruim and Algar do Montoso) and lava tube caves (e.g., Balcões, Chocolate, Queimada, Agulhas, Torres, Montanheiros, Frei Matias, Soldão and perhaps still others). Therefore all the lava tubes and pits of these islands should be protected.

The solutions for this are several. The top priority for the conservation of the caves and their fauna is to conduct accurate speleological and biological inventories in all islands in order of establish priorities of conservation. Simultaneously it is also urgent to learn more about the ecology of the Azorean cave species so protective measures will be effective.

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ENCYCLOPAEDIA BIOSPEOLOGICA

TOME I

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AZORES

by

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I - THE AREA

The Azorean archipelago is located in the North Atlantic, at the triple junction of the Eurasian, African and North American plates. The distance between the Azores and the mainland is about 1390 km, calculated from Cabo da Roca (the most westerly point of the European continent). It is formed by nine volcanic islands, aligned on a WNW-ESE trend, which are distributed in three groups: the occidental group of Corvo and Flores; the central group of Faial, Pico, Graciosa, São Jorge and Terceira; and the oriental group of São Miguel and Santa Maria (Fig. 1).

The largest island is São Miguel (757 km²), and the smallest is Corvo (17 km²). Santa Maria is the most southerly island (37° N, 25° W), and Flores is the most westerly one (31° W). The most northerly one is Corvo (39,7° N) (see Tabl. 1 and Fig. 1). All the information concerning the longitude (long.), latitude (lat.), area, maximum altitude and geological age of each island are given in Tabl. 1.

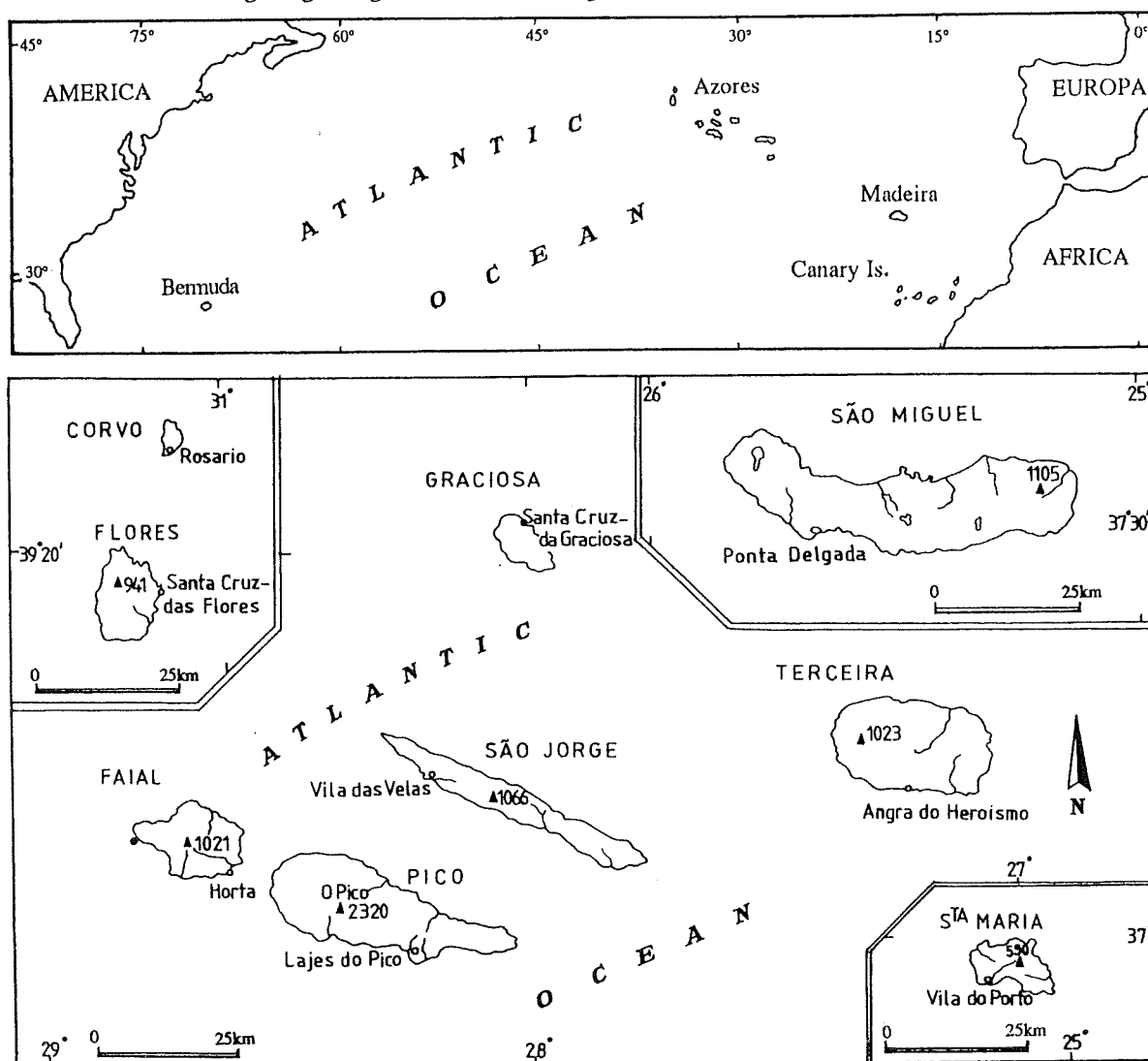


Fig. 1 - The Azorean archipelago.

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There are many examples of historical volcanic eruptions (vide WESTON, 1964). The geostructural environment of the Azores Plateau, defined by the 2000 meters bathymetric curve, is dominated by the confluence of the American, Eurasian and African lithospheric plates. This tectonic feature is responsible for a remarkable seismovolcanic activity from which the Capelinhos eruption (Faial island - 1957/58) and the 1st January 1980 earthquake (epicentral location 30 km W of Terceira island - Magnitude 7.2) are the most recent catastrophic events (GASPAR *et al.*, in press).

The geological age of the nine islands is very dissimilar. Because their formation took a long period of time, these islands present a recent volcanic morphology (e.g. Pico) or more eroded, ancient formations (e.g. Flores and S. Maria). There are several studies concerning the geological dating of the Azorean islands, but unfortunately there is no agreement concerning the age of some islands. Three alternatives are proposed (see Tabl. 1).

The acceptance of the Plate Tectonic mechanisms and the confirmed volcanic origin of the Azores, made the Azores a totally oceanic archipelago. The eastern part of every Azorean island is, geologically, the oldest one. This is connected with the seismovolcanic mechanisms of this archipelago (FORJAZ, pers. comm.).

Tabl. 1. - Comparisons of the physical characteristics of the nine Azorean islands. A : FORJAZ (pers. comm.); B : ABDELMONEM *et al.* (1975) and FERAUD *et al.* (1980); C : QUEIROZ (1990).

Islands	Long. (W)	Lat. (N)	Area (km ²)	Alt. (m)	Age (MA)		
					A	B	C
Corvo	30.8	39.7	17	718	?	?	?
Flores	30.9	39.4	142	915	0.01	0.62 (2.9)	1.80
Faial	28.5	38.6	172	1043	2.60	0.73	0.73
Pico	28.2	38.5	433	2351	1.10	0.037	0.037
Graciosa	27.8	39.1	62	402	0.62	0.62	2.50
S. Jorge	27.9	38.7	246	1053	2	0.55	0.55
Terceira	27.2	38.7	402	1023	2	0.30	2
S. Miguel	25.5	37.7	757	1103	4	4.01	4.01
S. Maria	25.1	36.9	97	587	8	8.12	8.12

Located at a mean latitude of 38° 30' and surrounded by the Atlantic Ocean, the Azores enjoy the benefits of a mild and agreeable climate. The influence of the warm Gulf Stream is important, allowing temperatures at sea level to be quite similar in the southeastern and in the northwestern islands; the same can be said of the humidity (AGOSTINHO, 1966). Low thermal amplitude, high precipitation and humidity are properties of this archipelago, with its marked oceanic climate.

In spite of the three groups of Azorean islands being separated from each other by sea channels 1000 to 2000 m deep, the channel between Faial and Pico has zones only 20 m and 50 m deep (BERTHOIS, 1953). It is therefore possible that at the height of the glaciation about 18,000 years ago, the lowering of the sea level could have permitted a terrestrial passage between these islands (EASON and ASHMOLE, 1992). Estimates of the glacial sea level range from less than 80 to over 130 m below the present level (BLOOM, 1971).

It seems probable, simply by virtue of the fact that the Azores is the most septentrional archipelago of Macaronesia, that it should have suffered in part the influence of the glaciations (ISRAELSON, 1990). However, COOPE (1986) affirmed that the fauna and flora of the Azores (and of the other southern Macaronesian archipelagoes) have not been subjected to the repeated exterminations and recolonizations that were imposed upon those of more northerly Atlantic islands (e.g. the Shetlands, the Faeroes, Iceland and Greenland) by the comings and goings of the polar front (see also BORGES, 1992).

II - THE ENVIRONMENT

The Azorean archipelago is a region with several very recent historical lava flows with a great concentration of lava tube caves and pits. All the main volcanic lava tubes are situated in *pahoehoe* basaltic lava flows (FORJAZ, 1963). They are built by very fluid lavas under special conditions, appearing in most of the Azorean islands, namely Pico, Faial, Terceira, Graciosa, S. Jorge and S. Miguel.

In fact, these islands are formed mainly by volcanic rocks with a dominance of basaltic lavas of the basic type, forming *pahoehoe* lava fields. It is also common to find lava flows of *aa* type which are very rough and known locally as "mistérios" or "biscoito". The mechanism of formation of the lava tubes mainly consists in rapid cooling and solidification of the upper surface, developing a porous and hard crust while lava is drained under it, leaving a lava tube (FORJAZ, *op. cit.*).

As already pointed out, in the Azores there are several historical lava flows. For instance, in Pico there are areas with a great concentration of lava tubes and pits. The Mistério of S. Luzia (1718) is the Pico lava flow with a larger number of lava tubes. Probably some of them are remain of a unique longitudinal tube (BORGES *et al.*, in press). In Mistério of Silveira (1720) there is a remarkable lava tube, Gruta do Saldão (1150 m length), a simple "unitary" or "throughway" type lava tube (*sensu* HALLIDAY and LARSON, 1983) excellently

preserved. Up to now 28 lava tubes and 8 pits are known from Pico, occurring the longest lava tube from the Azores in this island, Torres' Cave, with 3350 meters long (BORGES *et al.*, in press).

Terceira is doubtless the second most important Azorean island, after Pico, regarding to the occurrence of lava tubes and pits, with several areas with caves of great interest. The Pau Velho lava flow (1761) is probably the area with most interesting caves from this island, where is found Gruta dos Balcões, the second longest lava tube from the archipelago, with 2713 meters long (BORGES *et al.*, *op. cit.*). These caves have a moderate importance from the entomological point of view, because most of them are covered by pasturage and there is some mud impermeabilization. Nevertheless, the relict cave carabid *Trechus terceiranus* Machado can be found in Balcões and Caldeira lava tubes (BORGES and OROMÍ, 1991). Probably the most impressive cave in this island is Algar do Carvão, a remarkable volcanic chimney developed as show cave since 1988.

In São Jorge there are two lava tubes (Gruta da Beira and Gruta do Leão) and two pits (Bocas do Fogo and Algar do Montoso) of great interest, not only because their speleological structures but also because of their unique fauna. Gruta da Beira is a lava tube also affected by impermeabilization and thus with a poor fauna, but the endemic cavernicolous pseudoscorpion *Pseudoblothrus oromii* Mahnert and an undescribed cave isopod can be found there (OROMÍ *et al.*, 1990). Algar do Montoso is a huge volcanic pit situated at 900 m a.s.l., in a wet peat bog zone of this steep island. It is still poorly studied, mainly due to the hard weather and the difficult access to the hole.

Faial has the remarkable volcanic chimney Furna Ruim, the third bigger vertical of the Azorean pits (55 meters) but with hardly any completely dark place; anyway, the penumbra and high humidity are enough to hold a few troglobites. Besides there are a few small lava tubes but with some striking hypogean endemic arthropods.

In S. Miguel all the main caves are located in the recent part of the island, the central plateau geologically known as "Picos Volcanic Complex" (see NUNES and BRAGA, in press). Most of them are small and very spoiled, mainly because of the above commented soil erosion under pasture lands. In spite of that, some caves like Gruta de Água de Pau have a worth noticing fauna, probably because of the ancient age of island (4.01 Ma according to ABDEL-MONEM *et al.*, 1975).

S. Maria is the oldest island of the archipelago (8.12 Ma) (ABDEL-MONEM *et al.*, *op. cit.*) without recent lava flows. It has only littoral caves of sea erosion (e.g. Anjos and Pombas) and no adapted fauna has been found there.

Graciosa is still poorly studied, but in this island occurs the beautiful Furna do Enxofre, an enormous volcanic pit with a large lake at the bottom and solfataras that periodically become more active, creating bad air conditions (see also GÁSPAR *et al.*, in press).

In the smallest of two occidental islands, Corvo, there is the record of one cave, presently closed. Flores is a middle aged island with no very recent eruptions, therefore lacking lava flows and tubes.

After BORGES *et al.* (in press) the number of known caves and pits from the Azorean islands are: Corvo (1 : -), Flores (- : -), Faial (3 : 1), Pico (28 : 8), Graciosa (16 : 1), S. Jorge (7 : 5), Terceira (20 : 6), S. Miguel (10 : 3) and S. Maria (3 : -).

Besides the proper caves, another type of subterranean habitat can be found in more ancient areas (several million years old) where lava tubes have already been destroyed. Indeed in the island of S. Maria one can find troglobites adapted to live in the M.S.S. ("Milieu souterrain superficiel") (BORGES, 1993). A similar type of habitat occurs in more recent areas, what OROMÍ *et al.* (1986) have called "volcanic M.S.S."; on the slopes of Serra de Santa Bárbara (only 10,000 years old) in Terceira, BORGES and OROMÍ (1991) made the first record of a troglotitic species (*Trechus terceiranus* Machado) for the M.S.S. in the archipelago. Since then, we have collected other species in this habitat on the same island; most of them have not been yet studied, but the hypogean centipede *Lithobius obscurus azoreae* was recently recorded for the M.S.S. of Terceira by EASON and ASHMOLE (1992) (see also BORGES, 1993).

Like in other volcanic areas (e.g. Hawaii, Canaries) also it can be found on the Azores a particular habitat formed by recent lava flows, where there is a complex network of cracks and holes. This habitat is occupied by communities of lavicolous animals supported by the fallout of aerial plankton on the surface (ASHMOLE and ASHMOLE, 1987). While in the Canaries some relationships between this fauna and that of neighbouring lava tubes has been demonstrated (ASHMOLE *et al.*, in press), this is not the case for the Azores.

III - THE FAUNA

Cave arthropod collections from the Azores have been made only recently, being the first hypogean species described a few years ago (MACHADO, 1988). The biospeleological campaigns can be resumed as the following ones: two directed by N. P. ASHMOLE (Edinburgh University) and one of the authors (P. OROMÍ) and supported by the National Geographic Society, USA (July - August 1987 and 1989, the latter also with the participation of the junior author, P. BORGES); two expeditions of the Speleological group "Os Montanheiros" to the island of Pico in May 1989 and March 1990 with the participation of one of the authors (P. BORGES); an expedition carried out by one of us (P. BORGES) in April 1990 to S. Miguel.

Many of the cave species known to occur in the Azores belong to genera that have representatives in the troglotitic fauna of the Canaries (OROMÍ *et al.*, 1990), also an archipelago of volcanic origin and situated in the same biogeographic area (Macaronesia). This is so in the case of the ground beetles *Thalassophilus azoricus*

Oromí and Borges with some epigeal and cavernicolous relatives in the Canaries and Madeira; the *Trechus* spp. belong to the *T. tingitanus* species group (OROMÍ and BORGES, 1991) with some related species in the Canaries like *T. benaharitus* Machado and *T. minioculatus* Machado (BORGES and OROMÍ, 1991). Also the centipede *Lithobius* and the planthopper *Cixius* are genera represented in the Canaries by several related species, and the same is true to the collembolan genus *Pseudosinella* that has cavernicolous species in the Canaries (GAMA, 1988) but these species seem to be just troglaphiles.

The family Trichoniscidae (Isopoda) is represented in the hypogean environment of the archipelagoes, although by species belonging to distinct genera and showing different degrees of adaptation (see OROMÍ *et al.*, 1990). The Azorean cave-dwelling trichoniscid is found in S. Jorge and belongs to a new genus not yet described. The other terrestrial cave crustacean is *Macarorchestia martini* Stock, which occurs near the entrance of a cave where sea water arrives when the waves are big. Their adaptations to the underground are not very remarkable (STOCK, 1989).

Contrasting with the Canaries is the fact that most of the Azorean troglobites belong to genera without related epigeal species now living in the archipelago (see Tabl. 2). As a consequence of the absence of surviving epigeal close ancestors in the same island, we can say that these troglobites are local relicts. In some cases like *Thalassophilus azoricus* and the two cave-dwelling *Pseudoblothrus*, no congeneric epigeal species are known at all on the Azores, being then considered as regional relicts. Although similar situations can be found in the Canarian cave fauna, the proportion of relictic species is considerably smaller, many of the troglobitic species having closely related species living on the same island, often enclosed in endemic genera (OROMÍ and IZQUIERDO, in press).

There are however some exceptions to this rule in the Azores, being the case of the centipede genus *Lithobius* and of the homopteran *Cixius* spp., with some related epigeal species living in the same island. However, the only hypogean centipede *Lithobius obscurus azoreae* is not an advanced troglobite, just showing evident but moderate eye reduction and lengthening of appendages, and occurring mostly in the underground but sometimes on the surface. This phenomenon is not rare on these islands, where several troglobiomorphic species like *Thalassophilus azoricus* and *Trechus terceiranus* have been collected at the entrance of caves even during the day. But the climate is very humid and with mild temperatures, what probably explains this particular behaviour.

A cave-dwelling diplura is known from a lava tube in São Miguel, but their identity as *Campodea taurica* Silvestri has to be confirmed, since this is a species only known from caves of Crimea (SENDRA, pers. comm.)

Tabl. 2 - Cave-adapted terrestrial arthropods from the Azores. The islands in which they occur and the existence of epigeal congeners in the same or in other islands are indicated (*= endemic genera).

Species	Islands	Congeneric spp.	
		same	other
Pseudoscorpiones			
<i>Pseudoblothrus oromii</i> Mahnert	S. Jorge	no	no
<i>Pseudoblothrus vulcanus</i> Mahnert	Terceira	no	no
Araneae			
<i>Rugathodes pico</i> (Merrett and Ashmole)	Pico/Faial	no	yes
Amphipoda			
* <i>Macarorchestia martini</i> Stock	Terceira	no	no
Isopoda			
Trichoniscidae *n. gen. n. sp	S. Jorge	no	no
Chilopoda			
<i>Lithobius obscurus azoreae</i> Eason and Ashmole	Terc./Pico/Faial	yes	yes
Collembola			
<i>Onychiurus</i> sp.	Terceira/Pico	no	no
<i>Pseudosinella ashmoleorum</i> Gama	Terceira/Pico	no	no
Diplura			
<i>Campodea</i> aff. <i>taurica</i> Silvestri	S. Miguel	?	?
Homoptera			
<i>Cixius azopicavus</i> Hoch	Pico	yes	yes
<i>Cixius cavazoricus</i> Hoch	Faial	yes	yes
Coleoptera			
<i>Thalassophilus azoricus</i> Oromí and Borges	S. Miguel	no	no
<i>Trechus terceiranus</i> Machado	Terceira	no	yes
<i>Trechus picoensis</i> Machado	Pico	no	yes
<i>Trechus jorgensis</i> Oromí and Borges	S. Jorge	no	yes
<i>Trechus montanheirorum</i> Oromí and Borges	Pico	no	yes

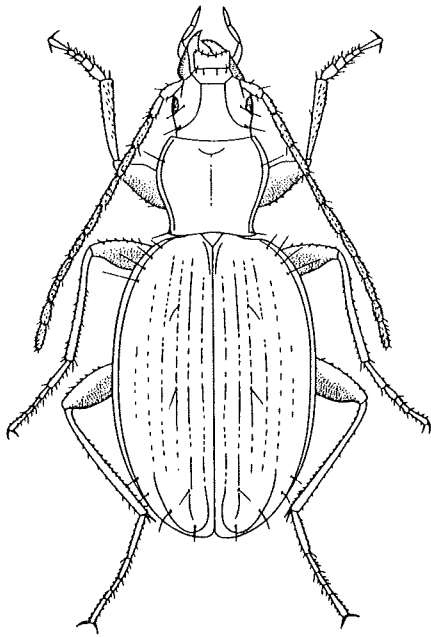


Fig. 2 - *Trechus picoensis* Machado (reprinted from Machado, 1988). Long. = 5,3 mm.

One notable case is the peculiar distribution of the two closely related ground beetles *Trechus picoensis* and *T. montanheirorum*. These species live in Pico in the same lava tube "Gruta dos Montanheiros", occurring in sympatry only near the entrance to the cave, and show different degrees of troglomorphy (integument depigmentation and reduction of eyes). Recently HOCH and HOWARTH (1989) presented a similar case in two new cave dwelling species of a new Australian cixiid genus (Homoptera: Fulgoroidea). *T. picoensis* (fig. 2) is regarded as being troglotic (obligatory cavernicole), and *T. montanheirorum* as being troglophilic (facultative cavernicole). As OROMÍ and BORGES (1991) pointed out, some of the most obvious differences between the two species are those relating to adaptation to cave life which are more marked in *picoensis*; some their differences like those of the male genitalia and chaetotaxy have probably evolved without relation to the hypogean environment. It is considered likely to be the result of a single invasion into the cave environment, being sister-species (BORGES and OROMÍ, 1991).

Concluding, we can say that the Azorean cave fauna is still in a poor stage of knowledge and probably some more hypogean species will be discovered soon. Also the following list of Azorean caves with biological interest should be protected and better studied: Anelares, Cabeço do Canto and Furna Ruim from Faial; Torres, Montanheiros, Soldão, Henrique Maciel, Capucha, Arcos, Gruta dos Esqueletos from Pico; Gruta da Beira, Algar do Montoso and Algar das Bocas do Fogo from S. Jorge;

Balcões, Coelho, Caldeira, Queimada, Agulhas, Madre de Deus, Santo António, Algar do Carvão from Terceira; Água de Pau and Esqueleto from S. Miguel.

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