

CAVES AND PITS FROM THE AZORES.  
II - AN ANNOTATED CHECKLIST <sup>1</sup>

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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.

<sup>1</sup>Text 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

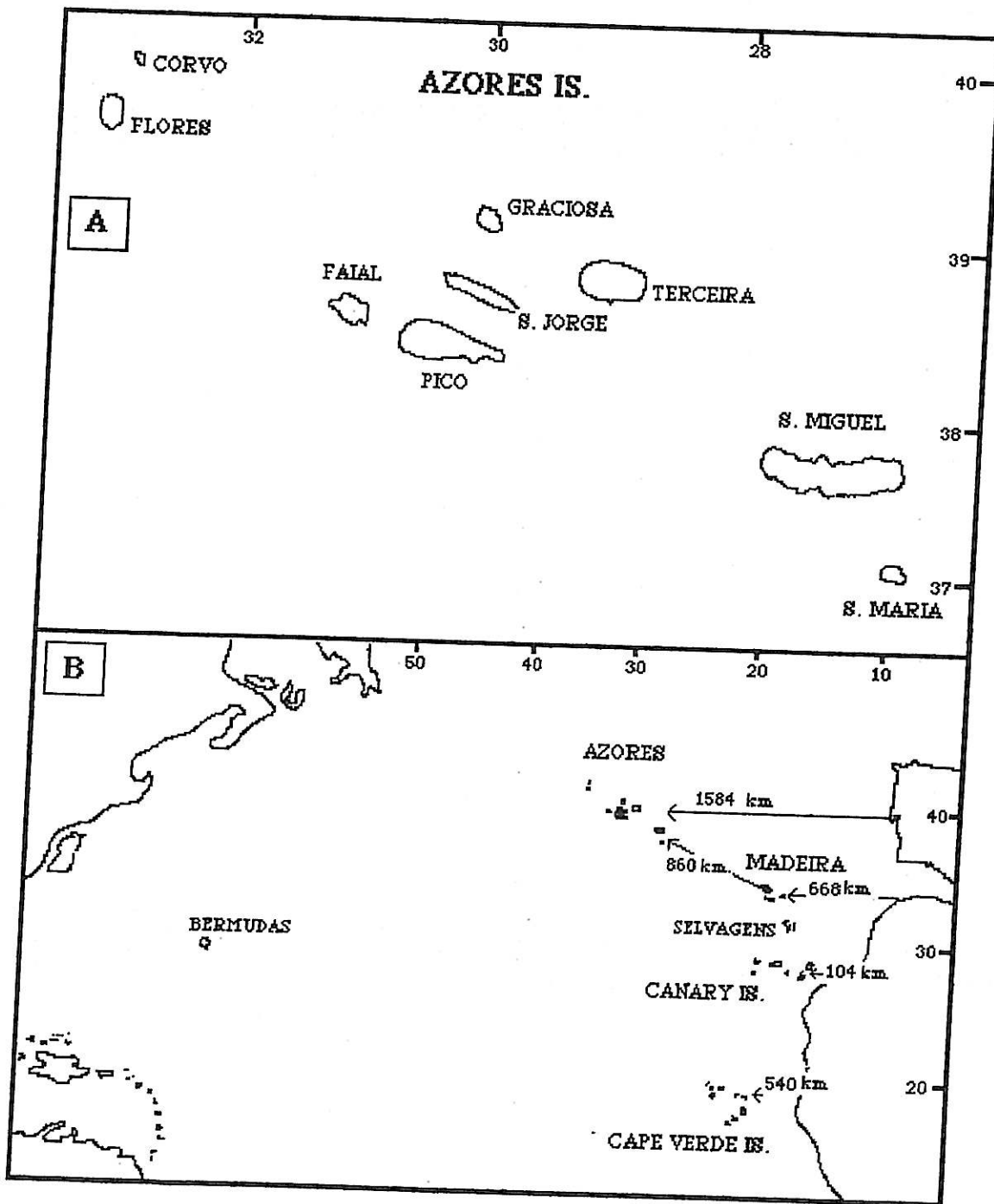


FIG. 1. A: The Azores Islands; B: Atlantic islands with the Macaronesian Archipelagoes and Cape Verde Islands.

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

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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
<b>4. PICO</b>			
<b>LAVA TUBES</b>			
27	G. dos Arcos	-	Arcos (Mistério de Santa Luzia)
28	G. dos Esqueletos	-	Igreja de S. Luzia
<b>PITS</b>			
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
<b>5. GRACIOSA</b>			
<b>LAVA TUBES</b>			
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
<b>PITS</b>			
1	F. do Enxofre	-	Caldeira da Graciosa
2	Caldeirinha do Pero Botelho	-	Serra Branca
<b>6. S. JORGE</b>			
<b>LAVA TUBES</b>			
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

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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	?	?	?	?	-	-
13	3,4	?-6,20	?-8,10	260	4148/43211	-	-
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	MONT	-
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	MONT	yes
5	?	?	?	?	3958/42817	-	-
6	?	?	?	250	3967/42816	-	-
7	177	0,5-6	0,8-3	250	3964/42818	MONT	-

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

ISLAND and No.	MAIN NAME	OTHER NAMES	LOCATION
<b>6. S. JORGE</b>			
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 dos Suspiros
5	A. do Pico dos Suspiros II	-	Pico dos Suspiros
<b>7. TERCEIRA</b>			
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 Feilicças	-	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
<b>7. TERCEIRA</b>			
<b>LITTORAL CAVES</b>			
3	F. da Nascente	-	Quatro Ribeiras
4	Brisa Azul	-	Ilhéus das Cabras
<b>OTHER CAVES</b>			
1	F. da Bugia	-	Bugia, Lajes
2	F. do Poço Negro	-	Serreta
3	A. do Canadá	-	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
<b>8. S. MIGUEL</b>			
<b>LAVA TUBES</b>			
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
<b>PITS</b>			
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
<b>OTHER CAVES</b>			
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
<b>9. S. MARIA</b>			
<b>LITTORAL CAVES</b>			
1	F. das Pombas	F. Velha	Vila do Porto
2	F. dos Anjos	-	Anjos
<b>OTHER CAVES</b>			
1	G. do Romeiro	-	Ilhéu do Romeiro de S. Lourenço

## AÇOREANA

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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	e	-
2	>>62	?	?-20,0	90	6324/41873	e	-
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 Soldão (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 ("lavadrrops") 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 Esquelestos 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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