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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 (6;0), Faial (3;1), Pico (28;9), Graciosa (16;1), São Jorge (7;5), Terceira (26;6), São Miguel (19;3) and Santa Maria (8;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 tube 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 westernmost 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 Terceira; 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 515 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.

<table>
<thead>
<tr>
<th>Island</th>
<th>Long.(W)</th>
<th>Lat.(N)</th>
<th>Area (km²)</th>
<th>Altitude (m)</th>
<th>Age (million years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>corvo</td>
<td>30.8</td>
<td>39.7</td>
<td>17</td>
<td>718</td>
<td>A: ? B: ? C: ?</td>
</tr>
<tr>
<td>lapes</td>
<td>30.9</td>
<td>39.4</td>
<td>142</td>
<td>915</td>
<td>A: 0.010 B: 0.62(C.9) C: 1.8</td>
</tr>
<tr>
<td>aial</td>
<td>28.5</td>
<td>38.6</td>
<td>172</td>
<td>1,043</td>
<td>A: 2.6 B: 0.73 C: 0.73</td>
</tr>
<tr>
<td>icar</td>
<td>28.2</td>
<td>38.5</td>
<td>453</td>
<td>2,351</td>
<td>A: 1.1 B: 0.037 C: 0.037</td>
</tr>
<tr>
<td>graciosa</td>
<td>27.8</td>
<td>39.1</td>
<td>52</td>
<td>402</td>
<td>A: 0.62 B: 0.62 C: 2.5</td>
</tr>
<tr>
<td>lo Jorge</td>
<td>27.9</td>
<td>38.7</td>
<td>246</td>
<td>1,053</td>
<td>A: 2 B: 0.55 C: 0.55</td>
</tr>
<tr>
<td>erceira</td>
<td>27.2</td>
<td>38.7</td>
<td>402</td>
<td>1,023</td>
<td>A: 2 B: 0.30 C: 2</td>
</tr>
<tr>
<td>lo Miguel</td>
<td>25.5</td>
<td>37.7</td>
<td>757</td>
<td>1,103</td>
<td>A: 4 B: 4.01 C: 4.01</td>
</tr>
<tr>
<td>sao Maria</td>
<td>25.1</td>
<td>36.9</td>
<td>97</td>
<td>587</td>
<td>A: 8 B: 8.12 C: 8.12</td>
</tr>
</tbody>
</table>

*Table I—Comparison of the physical characteristics of the nine Azorian islands.*

Forjaz (pers. comm.); B = Abdel-Monem et al. (1975), Feraud et al. (1980); C = Queiroz (1990)
(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. Saruggetti 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.
in and near Ponta Delgada (São Miguel). Later, Pickering (1908) gave a follow-up on Fouqué'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 Instrução Especial de Espeleologia—describes the cave of Pau Velho (Gruta dos Balcoes) (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 Balcoes), but no maps are available.

Arruda (1972) studied and described some caves and pits from Pico: Furna Abrigo, Furna de Henrique Maciel I, 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 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 (18); Flores (19); Faial (20); Pico (21); Graciosa (22); São Jorge (23); Terceira (24). São Miguel (25); and Santa Maria (26) (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 Carvão, G. dos Montanheiros) were put at the disposal of W. Halliday by Os Montanheiros.

The first complete maps of the Azorean caves were presented by Montserrat and Romero (1983). Three lava tubes (Balcoes, Pau Velho, Natal) are described and mapped and one lava tube (Aguilas) and one pit (Algar do Carvao) from Terceira are described by these authors. More recently Chinchon et al. (in press) presents further studies on Gruta dos Balcoes, 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 São Miguel.

Two biospeleological expeditions were carried out in the Azores directed by N.J. Ashmole (Edinburgh University) and P. Oromi (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 Oromi et al., in press; Oromi and Borges, in press; Borges and Oromi, in press). Oromi et al. (op. cit.) presented the description of the biospeleologically 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. Luís and R. Azevedo. The results of these visits are presented in Table III;

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

1972—A speleological expedition directed by A. Luís to São Jorge. As the main results of this visit, several sketches were made of the lava tubes Gruta da Beira and Gruta do Leão, 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. Luís to Flores and Corvo. No caves were found on these islands.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Caves</th>
<th>Pits</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halliday (1981)</td>
<td>18</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>Ogawa (1989)</td>
<td>35</td>
<td>7</td>
<td>42</td>
</tr>
<tr>
<td>The Authors</td>
<td>55</td>
<td>24</td>
<td>112</td>
</tr>
</tbody>
</table>

Table II—Evolution of the knowledge of the number of caves and pits from the Azores.
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; Chiscom et al., in press; Ogawa, 1986; Oromi et al., in press; Oromi and Borges, in press; Borges and Oromi, 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 26 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 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."
<table>
<thead>
<tr>
<th>Island and No.</th>
<th>Main Name</th>
<th>Other Names</th>
<th>Location</th>
<th>Length/Depth (m)</th>
<th>Height (m)</th>
<th>Width (m)</th>
<th>Elev (m)</th>
<th>UTM</th>
<th>Map</th>
<th>Fauna</th>
</tr>
</thead>
<tbody>
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<td>1. Corvo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lava Tubes</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Gruta do Corvo</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Flores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Faial</td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Furna das Ançãres</td>
<td>Lombega</td>
<td>Lombega</td>
<td>35.6</td>
<td>0.7-4.0</td>
<td>1.4-2.5</td>
<td>80</td>
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<td>Mont</td>
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</tr>
<tr>
<td>2</td>
<td>Gruta do Cabeço do Canto</td>
<td>Conchileiros</td>
<td>Cabeço do Canto</td>
<td>21.4</td>
<td>0.3-5.10</td>
<td>0.5-7.6</td>
<td>346</td>
<td>3420/42740</td>
<td>Mont</td>
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<tr>
<td>3</td>
<td>G. do Parque do Cabelo</td>
<td>Parque do Cabelo</td>
<td></td>
<td>65.3</td>
<td>0.35-1.50</td>
<td>0.4-3.40</td>
<td>300</td>
<td>3452/42727</td>
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</tr>
<tr>
<td>Pits</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Gruta Ruim</td>
<td></td>
<td>Cabeço Verde</td>
<td>5198</td>
<td>20.6-73.1</td>
<td>665</td>
<td>3467/42722</td>
<td>Mont</td>
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<td></td>
</tr>
<tr>
<td>4. Pico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>F. da Miragaia</td>
<td>F. do Chico</td>
<td>Miragaia do Norte</td>
<td>50</td>
<td>?</td>
<td>?</td>
<td>149</td>
<td>3720/42661</td>
<td>Mont</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F. das Casas</td>
<td>F. do Chico</td>
<td>Lugar das Casas</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>29</td>
<td>3709/42665</td>
<td>Mont</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>F. do Carregador</td>
<td>Algo do Barreiro;</td>
<td>Algores</td>
<td>?</td>
<td>2.9</td>
<td>7.6-8.0</td>
<td>329</td>
<td>3716/42641</td>
<td>Mont</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>F. do Frei Matias</td>
<td>F. do Frei Matias</td>
<td>Estrada Novo (Longo)</td>
<td>666</td>
<td>7.2-7.4</td>
<td>7.1-7.4</td>
<td>684</td>
<td>3755/42655</td>
<td>Mont</td>
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<tr>
<td>7</td>
<td>F. do Henrique Maciel</td>
<td>F. do Estácio</td>
<td>Santo António</td>
<td>612-77</td>
<td>7.4-7.4</td>
<td>7.4-7.5</td>
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<td>8</td>
<td>F. do Poço Novo</td>
<td>D. do Germano;</td>
<td>Poço Novo (Near the seaside</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td></td>
<td></td>
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<td>10</td>
<td>F. do Tancain</td>
<td>F. do Tanquinhar;</td>
<td>Tambor (Mistério de St Luzia)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>275</td>
<td>3731/42655</td>
<td>Mont</td>
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<tr>
<td>11</td>
<td>F. dos Bodes</td>
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<td></td>
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<tr>
<td>12</td>
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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 Pego, Galeria Queimada and Gruta das Agulhas) will soon be published as maps.

Faial

1. Gruta Das Anelares (Gruta da Lombeja) (Plate 1; Figure 3, lava tube 1)
   Location: Lombeja (Faial); Elev: 80 m; UTM: 3462/42663; 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 Montaneiros had the opportunity to study and map a small lava tube at Lombeja, 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.

2. Gruta do Caboço do Canto (Gruta dos Concheiros) (Plate 2; Figure 3, lava tube 2)
   Location: Caboço do Canto, Capelinhos (Faial); Elev: 346 m; UTM: 3423/42740. 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 Caboço 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.

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 caucoricus Hoch (Homoptera, Fulgoroidea) described from Gruta do Caboço 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).

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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 Capelinhas Volcano.

Fauna: Recently Hoch (manuscript) described the troglobitic species Cixius cauzaorius 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 cauzaorius Hoch is a relict species, i.e., a cavernicolous species which has no close epigean 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 n° 3, km 17 (Pico); Elev: 785 m; UTM: 3631/42610; 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 (bonadotes). The same occurs in the impressive lava tubes Gruta dos Balcoes (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.](image-url)
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, *Treachus picoensis* Machado (see Oromí et al., 1990).

Later, another carabid species (present only in the skylight area of the cave) was described, *Treachus montanheirorum* 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 *Treachus* 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, Criação 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 600 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.
Between March 28 and April 3, 1991, a team of seven members of Os Montanheiros undertook a geoeological expedition, Torres-91, to this magnificent cave, mapping and filming it.

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

It is a three-dimensional braided system with some remarkable formations. The floor is ash or pahoehoe type. There are at least 11 levels of drainage registered on the walls by lateral benches and tree 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) are are great blocks of lava collapsed from the of making progress very difficult, but in some cases the floor is clean and of a beautiful pahoehoe type as lava. In the main tunnel we can find some pahoehoe gutters. The most interesting formations are in the secondary tunnels, some of them unique. Sometimes there are very low crawly 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 Rossiá 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 Pseudobothrus oromí 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 (Queimadas), Velas (São Jorge); Elev: 250 m; UTM: 2964/42818; 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.
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. Oromi (1989), a new species of a troglobitic ground beetle was found and described later, Trechus jorgensis Oromi 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 5), the Algar do Montoso (named incorrectly by an error of toponomy, 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 (SiO2) 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.
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 Balcoes (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 aa lava, but in the narrow, low secondary tubes the floor is pahoehoe 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: 0.30-5.40 m; Width: 1.20-4.50 m.

This is a mildly braided lava tube cavern (Hallingday, 1951) 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 pahoehoe. 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
Figure 5—Map of Terceira Island showing the location of the lava tubes and pits (see also Table 3).

GALERIA QUEIMADA
BISCOITOS, PAU VELHO
TERCEIRA
AÇORES
(SKETCH)

Plate 10—Galeria Queimada.
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. Oromi (1987), several new interesting species were found and described from this cave: the hypogean Pseudoscorion, Pseudobothrus vulcanus Mahnert and the Amphipod (Talitridae), Macarostegia martini Stock (Macarostegia 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 collombola (Entomobryidae) Pseudosinella ashmoleorum Gama and P. azorica Gama (see Oromi et al., 1990) and the centipede Lithobius melanops crotaeae Latzel (see Eason and Ashmole, manuscript).

11. Gruta do Chocolate (Plate 12; Figure 5, lava tube 14)
Location: Pau Velho, Biscotis (Terceira) Elev: 250 m; UTM: 4751.42824; 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 pahoehoe lava. Higher upstream there are yellow-
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: 6285/41752. Length: 323.1 m; Height: 0.20-
2.60 m; Width: 0.50-6.50 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 (Oromi 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. Ashmore and P. Oromi (1989). The general results of this study are still unpublished, but one troglobitic species of ground beetle collected in this cave was recently described, Thalassophilus azoricus Oromi and Borges (see Oromi 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 Oromi, 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)

Gruta de Água de Pau

Agua de Pau
S. Miguel
Acores

Map of "45 Montanheiros" Sheriffs
Estate M. A. A. A. C. O. R. E. S.
A. C. O. R. E. S
J. O. P. A. R.
16th-21st August 1990

Fig 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. Oró (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: 0.60-2.50 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"
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. Ashmore and P. Oroni (1989) visited this cave. The general results of this study are still unpublished.

15. Algar da Batalha (Plate 16 and 17; Figure 6, pit S)
   Location: Fajã de Cima, Ponta Delgada (São Miguel); Elev: 240 m; UTM: 61964/1837. Length: 51.9 m; Depth: 9.5 m; Height: 0.40-3.30 m; Width: 0.50-5.70 m.
   Mapped during the recent Bioapel-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: 66634/0900; 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 aeolian 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 this...
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 Pombos.
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 Silveria (1720) there is a remarkable lava tube, Gruta do Soldado (1,150 meters long), a simple unitary or throughway type lava tube (see Halliday and Larson, 1983) that is very well 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 in Gruta das Torras (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 carbide Trehus terceiranus Machado could be found in Balcões and Caldeira lava tubes (Borges and Oromi, 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 Fauque (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 highest 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-Moneim et al., 1975).

Santa Maria is the oldest island of the archipelago (eight million years) (Abdel-Moneim 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 solfatara.

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 (6;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.

148
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 Oromi et al., 1990, Oromi et al., in press, Borges and Oromi 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’Agua-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 Turism 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 Oromi and Borges lives only at the entrance of the Gruta dos Montanheiros (Pico) (see Borges and Oromi, 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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