VOLCANISM AND CAVES OF MT. ETNA: A BRIEF REPORT

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INTRODUCTION

Mt. Etna towers in the middle of the Mediterranean area. It is the greatest active volcano in Europe; it is well known throughout the world for its activity since ancient times. Many scientific and popular papers about it have been produced in past centuries. It is rich in volcanic caves of different types and represents the only volcanic cave area on continental Europe. But the region as a whole is scarcely known in the world of international vulcanospeleology.

Notwithstanding the difficulties of presenting an exhaustive picture of Mt. Etna's volcanism from a speleological angle, this paper aims to outline a vulcanospeleological portrait of the area through a summary of geographical, geological and historical notes on the region, and a brief description of some of its most significant caves. Some considerations on cave formation theories are added as well.

GEOGRAPHICAL AND HISTORICAL NOTES

Mt. Etna rises to a height of 3,350 m asl on the eastern coast of Sicily, isolated from other mountain systems. It is primarily of Tertiary age. In the north, the Alcantara Valley segregates Etna from the Peloritani Range, and the high Simeto Valley marks the western limit between Etna and the Nebrodi Mountains. South of the volcano lies the Catania Plain, formed by recent alluvial deposits of the Simeto, Dittaino and Gornalunga Rivers. Mt. Etna slopes down to the east into the Ionian Sea, through a series of still active NNE/SSW and NNW/SSE faults, which cause recurrent seismicity in the area.

The surface of Mt. Etna is more than 1,250 square km wide, and its average diameter is about 45 km. Built-up centers of population form a continuous belt around the volcano, at its feet and on its flanks, up to a height of almost 1,000 m. The region is intensely populated (more than one million inhabitants). Catania, which lies at the seaside between the plain and the southernmost limit of Mt. Etna, is the main town.

The origins of Catania are uncertain: many archaeological findings show that a village existed in this area in prehistoric ages, and the town was already an important trade center and port in Greek and Roman times, some centuries B.C.

The town suffered many destructions caused by eruptions and earthquakes. In recent historic times, it was partially flooded by lava during the great 1669 A.D. eruption, and completely razed by the 1693 A.D. earthquake. Nevertheless, Catania was rebuilt by the Duke of Camastra, and from then onwards, it has been growing larger and larger, to the size and importance of today.

VOLCANIC CAVE FORMATION: WHERE AND WHY

Though volcanic areas and rocks are very common on the Earth's surface, volcanic caves are formed only in zones where a distension type of volcanism occurs and basic lavas are the final volcanic products. Compression volcanism results from remelting of more or less deep batches of crustal rocks with a high silica percentage, and therefore, generating acid high viscosity lavas, incapable of fluxion. Distension volcanism in contrast, is fed through distension fissures, directly from the subcrustal mantle, thus producing very fluid lavas, capable of flowing and forming caves. This is the situation at Mt. Etna, though some complexities exist in its case.

Mount Etna: Structure and Evolution: The structure of Mt. Etna is very complex, since it is a multiple stratovolcano built up by intercrossing products of several volcanic units, active in different times and places.

Today's Etna is "a distension fissure-fed volcanic region with centralized structure" (Romano, 1979), rather than a single volcano; therefore, it is advisable to have a glimpse of its evolutional history for a better understanding of the subject. Different subsequent stages can be distinguished in the volcanic activity of the area:

A. First eruptive events: These date back to about 7/500,000 years ago, and occurred in the form of a submarine fissure eruption in the northern side of a shallow gulf closed to the north and the west by the Peloritani/Nebrodi sliding nappes, and to the south by the tectonic block uplift of Mts. Iblei. The submarine lavas were erupted on an underlying horizon of bluish clays of the "Sicilian" age (mid-Quaternary). Gradually they filled the gulf. Also, subaerial fissure eruptions occurred to the west at this stage.

The evidence of these ancient volcanic events can be traced in the pillow-lava and hyaloclastite horizons of Aci Castello and Aci Trezza, and in subaerial lava outcrops in the SW area (Paterno, Biancavilla and S.M. di Licodia).

B. Basal volcanism: An irregular tectonic uplift marked the beginning of this stage, which pushed the sea south, and eastward and resulted in a sloping basement whose height ranges from sea level (south) to about 700 m (NE) and 1,000 m asl (NW). Evidence of this stage is identified in several volcanic centers of Mt. Etna, such as the Calanna and Trifoglietto I Volcanoes to the east (Zafferana and Milo area), and the Paterno Volcano to the west. Also in the NW area, a high terrace of basal lava outcrops on the Alcantara River, east of Randazzo (Romano and Guest, 1979).

According to Cristofolini, et al (1977) and Romano and Sturiale (1981), at least two additional centers were active in this period: the Monte Po Volcano to the south (Pedara/Tardaria) and the Pernicana Volcano to the north.

C. Trifoglietto unit: The diffuse fissural activity of previous stages was gradually transformed to a central type of activity. After the cessation and eventual calderic collapse of the previously mentioned volcanic centers, a new and gigantic edifice gradually built up, the Trifoglietto unit. Not less than five volcanic centers were more or less contemporarily active in this unit: the Trifoglietto I, the Serra Giannicola Piccola, the Vavalaci, the Belvedere and the Zoccolaro Volcanoes. Evidence of these centers is found in the intercrossing lava and cinder beds and massive vertical dikes outcropping from the steep walls of Valle del Bove.

In fact, the activity and subsequent description of these volcanoes resulted in the impressive calderic collapse of Valle del Bove, a complex of coalescent calderas open eastward some 8 km wide (N/S axis) per 6 km long (E/W axis), incised for more than 1,000 m (at its deepest point) on the eastern bank of Etna.

Though the origin of this gigantic scar is still controversial (somebody even proposed a glacial origin! . . .), the presence of extensive lahar outcrops downslope eastward could be interpreted as the evidence of multiple phreatic explosions which eventually created and gradually enlarged and deepened the depression.

D. Mongibello unit: "Mongibello" is Etna's name in Sicilian speech. It is a Latin/Arab composite word, which sounds somewhat like "the pre-eminent Mountain" or "the Mountain itself." This unit was formed on the western flank of the pre-existing Trifoglietto unit, when the main volcanic axes shifted to NW from Trifoglietto to Mongibello.

The Mongibello unit surrounds the present central volcanic conduit and is featured by a strato-volcanic conical edifice rising from 1,800 to 2,900 m asl. The summit of this cone was truncated by two subsequent calderic collapses: the Ellittico caldera (filled by subsequent Leone eruptions), and the Leone caldera (unfilled and open on the NW Valle del Bove rim).

A further calderic collapse, termed the Piano caldera, marks the transition to Modern Mongibello. Some consideration on C14 dating led volcanologists to date the last collapse back to 2,000/2,500 years ago. The filled Piano caldera is today towered by the steep summit cone, consisting of thin lavas and pyroclastic rocks.

It can easily be seen that during the evolution of Etnean volcanism, the main activity center has gradually migrated from SE to NW. The remnants of the diverse volcanic centers are roughly ranked along a directrix which links the first submarine effusions with the summit apparatus of today's Etna.

Also, the chemical composition of lava changed somewhat during the volcanic axis shifting. The former transitional basalts and basalts of tholeiitic affinity of the first eruptive events changed through the alkaline basaltic series of the basal lavas up to the supersaturated elements (mugearites and benmoreites) of some centers in the Trifoglietto unit; and back again toward undersaturated terms, up to hawaiites, basic mugearites and alkalic basalts of modern Mongibello (Romano, 1979).

This led scholars to the conviction that Mt. Etna has not an actual magma reservoir, but is fed by different distension fissures. Furthermore, it is supposed (Romano, 1970) that some tilting occurred in the cracked crustal blocks floating on the underlying mantle, thus segregating portions of basal magma in the interstices, which in turn resulted in a gravitary differentiation of evolution of the erupted lava.

PRESENT VOLCANIC ACTIVITY

Mt. Etna performs an almost continuous activity of a mixed kind, with prevailing effusive events. Its summit complex apparatus (the Chasm, the NE crater, the Western Chasm or Bocca Nuova, and the SE crater) maintains a permanent fumarolic activity with recurrent explosive events. The last effusive eruption from the Chasm was in 1964. Effusive activity is very intense and recurrent on the flanks of the mountain and is performed through abundant effusions of aa lava which is fluid and rather degassed, and flows for remarkable distances.

The last eruption occurred in March 1981: a very fluid lava flow, emerging from NNW/SSE fissures gradually elongating from 2,550 m to 1,100 m asl on the northern side of the volcano. The lava moved downslope NNW for some 7.5 km, and reached the bed of the Alcantara River at about 600 m asl after crossing woods, orchards and vineyards. The flow severely threatened the town of Randazzo and buried large segments of the Etna ring-road and ring-railway, the state road from Fiumefreddo to Randazzo and the state railway from Giardini to Randazzo.

DIFFERENT ERUPTION TYPES OF MT. ETNA

According to mainly phenomenologic considerations, Etna eruptions can be distinguished into four main classes (Rittmann, 1963):

i. Terminal eruptions: All explosive and/or effusive phenomena, characterizing the eruption, are performed through the terminal apparatus.

ii. Subterminal eruptions: All explosive phenomena (emission of ash clouds, cinders, bombs and molten lava spatters) are performed through the summit apparatus, while outpourings of lava occur through one or more "bocca di forno" (arched boccas resembling oven mouths — Cucuzza-Silvestri, 1967) on the banks or at the base of the summit cone (between 3,300 and 3,000 m asl).

Nevertheless, in some subterminal eruptions, the outpouring of lava occurs at a really lower height, when fluid lava flows for some distance downslope beneath a thin crust of pre-existing solid lava, before coming onto the external surface through a rootless vent. This singular type of subterminal eruption can be easily recognized because of the absence of explosive activity in the vent; the lava outflow is only coupled with launching to a short distance of molten lava spatters, which, when falling to the ground, build up the typical welded spatter cones termed "hornitos."

iii. Lateral (or radial) eruptions: These eruptions are preceded by explosive activity in the summit apparatus, with violent emission of ashes and solid material. Magma coming from the main volcanic conduit becomes laterally wedged towards the surface through weakness trends, and the eruption is performed through an eruptive fissure in the flank of the volcano; this fissure is almost always radially oriented as to the main volcanic axis.

The explosive activity is performed in situ through the upper end of the fissure, where one or more ranked cinder cones (regular or crescentic or broken) are built up, while lava flows from the downslope end.

The activity of the summit apparatus in this stage is restricted to emission of fumes and ashes, due to internal collapses, and the end of the eruption is generally followed by a quiescent period, the duration of which is somewhat related to the violence, duration and discharge of the previous eruption.

iv. Eccentric eruptions: All explosive and/or effusive phenomena occur through adventive eruptive systems, which open onto the flanks of the volcano. Since accompanying activity in the summit apparatus is missing, magma is supposed to come onto the surface through a feeding fissure or dike independent of the main volcanic conduit. Most of Etna eruptions in historical times can be classed as subterminal or lateral ones.

CAVE FORMATION ON MOUNT ETNA

Factors contributing to cave formation on Mt. Etna are its distension fissure-fed volcanism, the chemical composition of its lava (alkalic basalts, hawaiites and mugearites) and the relevant temperature and fluidity, and the favorable topographical and environmental conditions (slopes ranging everywhere from 10° to 20° gradient and lack of natural obstacles or large water masses). In comparison to the caves of some other volcanic areas, the caves of Etna are small and of moderate extent.

It is remarkable that the great majority of Etna's lava flows consist of true aa lava, the pahoehoe being restricted to persistent subterminal "leaking" activity (such as the 1614/1624 A.D. eruption). In spite of this, thanks to the average slope gradient, lava can maintain a significant flowage capacity even below 1,000° C, when other lavas elsewhere, in normal conditions, have already started the final general congealing. Therefore, most lava tube caves on Mt. Etna are actually in aa lava rather than pahoehoe.

In addition to the rheogenetic surface caves (lava tube caves; Licitra, 1978/b, 1982/b), several rheogenetic fissure caves (eruptive fissure caves) and pneumatogenetic explosive caves (hollow welded spatter cones and hornitos) can be found on Mt. Etna. The writer did not succeed in identifying pneumatogenetic expansion caves (lava blisters), probably because the chemical composition of lava and/or the environmental conditions do not permit such caves to be formed. Nevertheless, some scholars reported caves of this kind along the coastline, between Capo Mulini and Pozzillo, probably generated by expanding seawater steam after the incandescent lava entered the sea.

VULCANOSPELEOLOGICAL RESEARCH AND STUDIES

Man's interest have been excited by volcanic phenomena of Etna since ancient times, either for superstitious purposes or for scientific ones. Ancient Greeks believed that Vulcan's smithy was located inside Etna, and that the God of Fire there prepared his father, Jupiter's thunderbolts. A legend also tells that the naturalistic philosopher Empedocles (5th century B.C.) spread the rumor that he had been called by the Gods, and then he hurled himself into Etna's crater. But Vulcan, offended by this lie, shot forth from the crater one of Empedocles' bronze boots, thus letting people know the truth. Today, a hillock just below the summit crater is named "philosopher's tower," in memory of this legend.

As early as 1359, Giovanni Boccaccio cited the Etnean cave Grotta di Talia (untraced by us) with these words: ". . . and a pelting was heard of subterranean waters, coming from the melting of Etna's snow reservoirs . . ." But the scholar who first positively took an interest in the caves of Etna was Anton Giulio de' Amodeo, nicknamed Filoteo. In his work "Topographia" (1591), he quoted many caves visited by himself, and described some of them. Nevertheless, only one of these caves has been identified by the GGC, and recorded in the Catalog files as "Riconco di Monte Dolce" (Si/CT/1110).

Many more or less definite citations of the caves of Etna can be found in the literature of the subsequent centuries, though the descriptions are often exaggerated and defiled by a good amount of folk beliefs and superstitions. The Dutchman Athananasius Kircher asserted (in Mundus Subterraneus, 1678) that he had visited a cave on Mt. Etna, capable of lodging 30,000 "homines."

The scholar Wolfgang Sartorius von Waltershausen described (1880), among others, the Grotta delle Palombe and published a sketch of it. It is remarkable that this cave, which shows a sheer 8 m vertical entrance pit, was already descended and explored some 100 years ago.

In the first decades of the present century, some volcanologists produced contributions concerned with Etnean caves, and formulated hypotheses on their genesis, but a methodical plan of speleological research was launched only about 50 years ago by Dr. Fracesco Miceli, a CAI Etna member, and founder of the G.G.C. In fact, Miceli found and described some fifty caves and laid down the foundations of the Mt. Etna Caves Catalog or Cadastre in the course of his more than thirty years of speleological activity. The G.G.C. carries on Micheli's work. It owns the topographical data of almost 200 caves. Descriptions and maps of many of these caves also have been compiled.

In 1975, to celebrate the CAI Etna centenary, the G.G.C. published a volume by Fabio Brunelli and Blaco Scammacca, Volcanic Caves of Sicily," containing the description and survey of the first 25 caves recorded in the Oadaster files, in addition to general information on vulcanospeleology.Also organized was a successful International Seminar on Lava Caves (August 27-29). The relevant Proceedings, published by

G.G.C. in 1977, represent a milestone in vulcanospeleological literature.

In addition to the G.G.C. of CAI Etna, the Speleological Group of CAI Giarre (founded in 1976) and the Group for Archaeological and Speleological Research of Acireale (founded in 1979) are today carrying out successful research on Etna caves. Although "official" science is not actually interested in volcanic caves, these groups can count on some supporting scientific organizations: the Volcanology and Geology Department of the Institute of Earth Sciences (State University of Catania) and the International Institute of Volcanology of Catania (National Research Council).

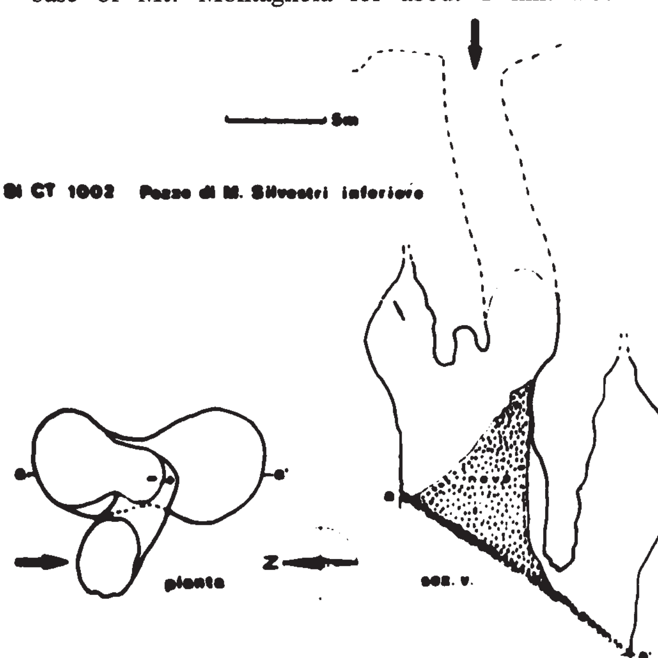
SOME VOLCANIC CAVES OF MOUNT ETNA

Etna caves are numerous and extremely varied, and many of them are located in true aa lava flows. Therefore, it is thought convenient to report brief descriptive, historical and morphogenetic quotations of only five significant rheogenetic caves, to give a general idea of the role of Etnean caves in the classification and study of volcanic cave formation.

I.1. Rheogenetic Fissure Caves (group 1.2)

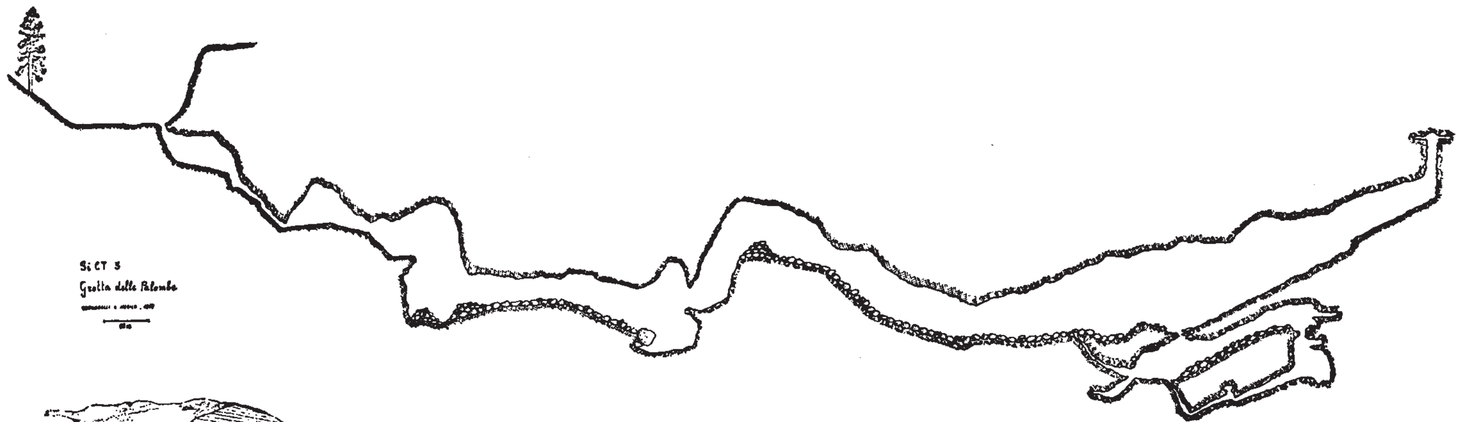
i. Pozzo di Monte Silvestri Inferiore (Lower Mount Silvestri Pit — Si/CT/1002): This is a vertical cave 31 m deep. It is shared by two subsequent pits with only 12 m planimetric range. The cave is in the eastern eruptive apparatus of the 1892 lateral eruption. The cave is deservedly well known, though its size is modest. In fact, in recent times, the Pozzo di M. Silvestri Inferiore has been quoted by scholars as a model to define the "eruptive conduit" type in some descriptive classifications. In addition to this, it is well known to non-experts because of its easy access; it is located a short distance from the road through an easy 100 m path.

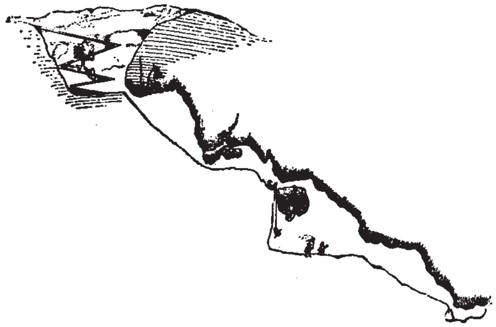
The 1892 eastern eruptive apparatus is formed by an eruptive fissure cracked out at about 2,000 m asl southward from the base of Mt. Montagnola for about 1 km. Four main explosive centers were here formed on the fissure, from its upper end downwards: Upper Mt. Silvestri, Lower Mt. Silvestri, Mt. Silvestri III and Mt. Silvestri IV. The first two are regular cinder cones, the third is a crescentic, while the fourth is a regular welded spatter cone with an explosive pit some 20 m in diameter and 40 m deep. Lava flowed southward from a large bocca situated between the third and the fourth cone on the western side of the fissure, and eastward from two pseudo-boccas situated some 200 m away ESE from Mt. Silvestri IV.



The cave entrance is located in the center of the bowl-shaped crater of lower Mount Silvestri, and consists of a cylindrical subvertical conduit about 2 m in diameter, which sinks down through unconsolidated materials (cinders, ashes, loose lava spatters) accumulated during the explosive activity of the crater. The inner part of the entrance pit is coated with a lava plaster 5 to 10 cm thick, and leads to a 12 m vertical bell-shaped inner pit, contained in the eruptive fissure itself. Its vertical walls, 5 m apart, are coated with a skimmed lava plaster also.

A complete report, including the description, topographical





Querschnitt der Grotta delle Palombe bei Nicolosi.

survey, morphology and genetic considerations of this cave, was submitted by G. Licitra and F. Cavallaro to the XIII National Speleological Congress held in Perugia in 1978.

ii. Grotta delle Palombe (Si/CT/1003): In 1669, the southern flank of Etna was the scene of its largest eruption in historical times; the eruption "of the Monti Rossi," lasted 122 days. After a strong local earthquake which destroyed the small village of Nicolosi, immediately west of the village itself, at 850 m asl, the ground cracked on March 11 with formation of a large explosive/effusive fissure more than 1 km long, trending N/S, from which flowed a large lava flow which reached and entered the sea at a distance of about 15 km, after having flooded the villages of Mompilieri, Belpasso and Misterbianco and the western part of the town of Catania. The medieval Ursino Castle (XII century A.D.), built up on the cliffs at the seaside, today is almost 1 km from the sea itself. The quantity of emitted lava is estimated to be about 1.0 cubic km (Romano and Cristofolini, 1980), and the pyroclastic materials ejected around the fissure vent formed a broken cinder cone whose twin tops, more than 200 m high, were named Monti Rossi (Red Hills), because of their color.

In addition to numerous lava tube caves formed in this flow (not specifically mentioned in this paper), a pit-cave named Grotta delle Palombe, was left in the bottom of a small bowl-shaped crater, at the northern end of the fissure vent. It is a mixed type cave, with a 35 m depth and a planimetric range of about 150 m.

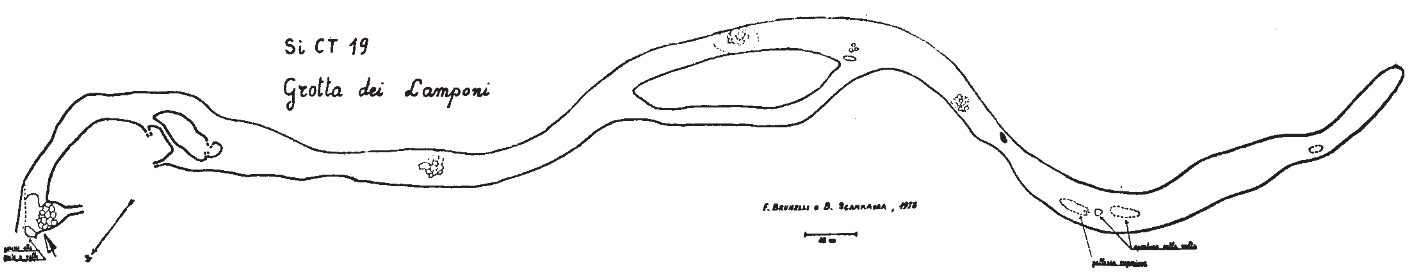
The Grotta delle Palombe is undoubtedly the most studied and best known cave by Etna scholars. It was mentioned in 1773 by Patric Brydone, and was visited at the end of the same century by the naturalist Giuseppe Recupero. A report of the exploration carried out by Mario Gemmellaro was published in 1858 by his brother Carlo. Even Sartorius visited this cave up to the same point as M. Gemmellaro did (the edge of the 17 m pit), and left an accurate description and a longitudinal cross-section of the cave in his work "Der Etna" (1880); this represents perhaps the first attempt to topographic survey in a volcanic cave anywhere in the world. The cave was completely mapped in 1969 by Domenico Condarelli and Pietro Nobile, and this map (cross-section), with the cave description, was published in the volume Volcanic Caves of Sicily, by Brunelli and Scammacca (1975).

The entrance of Grotta delle Palombe is formed by a bell-shaped pit 8 m deep, at the head of which a cavern 5 m wide per 13 m long is located. From the southern end of the cavern, a sloping 40 m passage leads to the edge of a 17 m vertical pit. The cave lengthens southward from the head of this pit between the walls of the eruptive fissure, about 3 m wide, through several collapse zones.

1.2— Genetic Considerations on Eruptive Fissure Caves

These two caves are both of the rheogenetic fissure type, namely they were generated by lava flowing inside and through an eruptive fissure.

This kind of genesis operates in two subsequent steps. In the first step, molten lava, pushed onward by endogenetic forces, opens a way to the surface through weakness trends, thus generating eruptive phenomena. In the second step, when the



endogenetic push shifts to lower heights or diminishes and eventually ceases, a lowering of lava level occurs inside the fissure.

In case the fissure walls are well cemented and large collapses do not close the fissure, after the lava sinks down, an elongated narrow hollow is left, with parallel walls, which is termed rheogenetic fissure cave (Licitra, 1978/c —1981/b).

II.1 — Rheogenetic Surface Caves (group 1.1)

Lava tube caves are widespread on Etna, thanks to its basic lava and to its mainly effusive activity. Yet the moderate fluidity of Etna lava (in comparison with the Hawaiian and Icelandic lavas) manages to form caves with modest planimetric range; the Grotta dei Lamponi, the longest known lava tube cave on Etna, has a planimetric range of only 700 m.

Notwithstanding this, a wide range of different morphological features can be observed in Etna lava tube caves: circular, elliptical, triangular or irregular traverse cross-sections; round or gothic arched and flat roofed passages; loose or welded cinder floors and pahoehoe or slab floors; multi-storied, braided and coalescent tubes; lateral benches and shelves, detachment laminae, glassy linings, etc. It is, therefore, possible to carry out a wide set of systematic comparative studies of lava tube caves on this volcano.

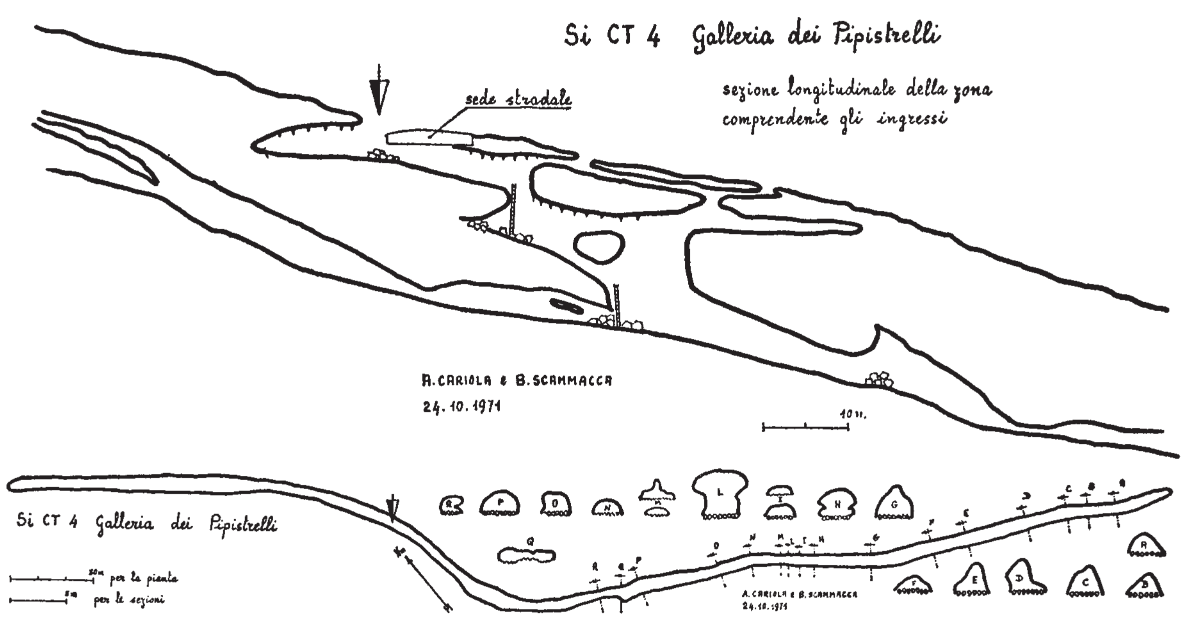
i. Grotta dei Lamponi — (Si/CT/1019): This cave is situated at 1,750 m asl on the northern flank of etna, in the lava flow of the eruption which lasted from 1614 until 1624. This large lava flow, named "Lava dei Dammusi," was made by an enormous number of small pahoehoe flows rather than a single significant flow (as the 1669 flow), and is supposed to have been due to a persistent subterminal "leaking" activity (Romano and Guest, 1979). The Grotta dei Lamponi was explored for the first time in 1965 by some members of CAI Linguaglossa. It is a long, almost unbraided lava tube, which can be entered through a collapse hole in the roof, situated two-thirds of the way downslope from the upper end. The entrance divides the gallery into two different segments. In the upper segment, the gallery shows a moderate gradient, an almost regular elliptical cross section, and is separated from the surface by a rocky cover ranging from 2 to 4 m average thickness. The floor is made of welded cinders, but in some places, it is hidden by lava blocks collapsed from the ceiling. A large skylight looks into the lava tube at its upper end, and a minor collapse hole affects the tube roof some 40 m downslope from the skylight. A minor branch diverges to the left (looking downslope) from the main tube into a narrow and spiny crawlway, which rejoins the main tube after some 5 m; one small tributary tube a few meters long can be seen on the left wall of the gallery just at the main entrance.

In the segment downslope from the entrance (not yet mapped by G.G.C.), some 120 m long, the gradient increases considerably and the gallery plunges into the body of the lava flow. The lower end of the cave is segregated from the surface by a rocky cover about 70 m thick.

Some large lateral horizontal shelves can be noted in this section of the lava tube. In the writer's opinion, a large mass of lava ponded (see Romano and Guest, 1979) and started congealing inside the tube during the active flow, but the increasing hydrostatic pressure exerted by additional lava arriving from the source vent succeeded in clearing some passage downslope, thus abruptly emptying the molten lava reservoir. The horizontal shelves could be the remnants of the supposed underground lava reservoir. The grotta dei Lamponi and other caves in the "Lava dei Dammusi," were carefully surveyed in 1976 by a joint team (SMCC and Leicester University, U.K.), headed by Dr. Chris Wood, with G.G.C. cooperation.

ii. Grotta dei Tre Livelli —(Si/CT/1004): This cave is located on the SSE flank of Mt. Etna, at 1,725 m asl in the 1972 A.D. lava flow. It was discovered in 1964 during the construction of the road from Zafferana to Cassa Cantoniera dell 'Etna. It is probably the best example of a lava tube cave on Mt. Etna.

The Grotta dei Tre Livelli shows three superimposed flow galleries, connected by two pits 5 m each; there is a vertical range of about 8 between the upper and lower end of the lowest gallery. The total length of the cave is almost 500 m. It is possible to trace back the steps that featured the operation and



evolution of the active flow, through a skilled study of the surface features and of the three galleries of the cave. In fact, while the flow front gradually proceeded downslope, the flow level stabilized at a lower height inside the lava tube, and then started being covered by a solid crust, thus forming the subsequent level.

The lowest gallery of the cave contains interesting features: the floor is formed by welded cinders (uplifted welded slabs in the vicinity of the upper end), and very long lateral shelves and curled detachment laminae can be observed along the walls. Furthermore, the gallery is almost unaffected by collapse.

iii. Grotta dell'Intraleo Cave —(Si/CT/1007): Like the preceding ones, this cave shows special features that can involve interesting studies. The Grotta dell'Intraleo is located at 1,325 m asl on the western flank of Etna, at the foot of Mt. Intraleo. The parent flow is thought to have been formed by the 1595 A.D. eruption but the date is uncertain for lack of documentation on this eruption; the local parish archives (main sources of news about ancient eruptions) were almost completely destroyed by the 1693 A.D. earthquake.

This lave tube cave is elongated downslope westward from the base of Mt. Intraleo. It has two segments separated by a large collapse hole some 12 m wide by 3 m long. Many morphological features induce the belief that the collapse occurred just at the end of the active flow. In the first segment of the cave, up slope just before entering the collapse hole, the floor is lifted in the middle and a 20 m crawlway passage runs beneath it. It is thought that the discharge of lava increased after a solid crust had formed on the flow surface inside the lava tube, and it caused the crust to be cracked and lifted up and the small inner passage to be formed.

The cave segment downslope from the collapse hole displays evidence of the evolving and final stages of the flow. It is a braided tube, divided into three divergent (in space) and subsequent (in time) branches, with gradually lowering flow levels from the left to the right. Furthermore, another large gallery a few meters long is situated beneath the floor of this second cave segment. This gallery, featured by very large detachment laminae, marks the last stage of the active flow, before the final congealing of lava and collapse of the tube roof upstream.

A complete report concerning the Mt. Intraleo and Gallobianco lava flows and their caves will be submitted by Dr. C. Pandolfo, G. Puglisi and the writer to the forthcoming National Speleological Congress of Italy in Bologna at the beginning of September 1983.

II.2 — Genetic Considerations on Lava Tube Caves

The study of the previously outlined rheogenetic surface caves, of many other lava tube caves of Etna, and some observations in the Raufarholshellir lava tube, Iceland (visited in August 1980), induced the writer to the conviction that some misunderstandings and an essential equivocation do affect theories concerning lava tube cave formation, since almost all authors dealing with this topic enunciated their general genetic theories based on the study of a single cave or lava field. Therefore, although the concerned theories are generally valid in the observed cases, they often conflict with other theories based on observation of other caves and/or lava fields.

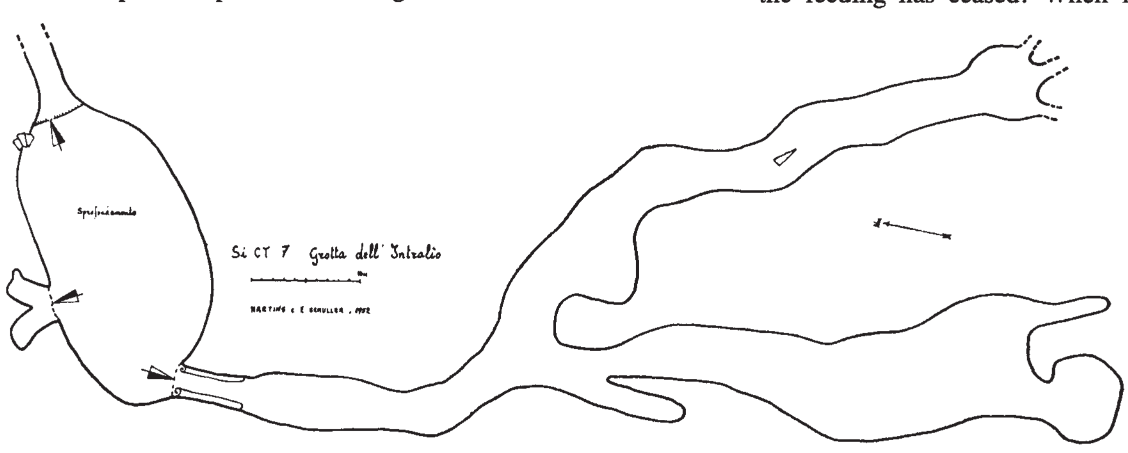
In the writer's opinion, the problem must be examined from a theoretical angle, to gain widespread applicability, as it was already indicated by Poli (1959), Ollier and Brown (1965), and Rittman (1977).

In fact, the first flow of lava on the surface is always by gravity. But owing to the thermal loss to the air and to the ground, the molten lava becomes restricted to a channel and then chilled, forming a solid crust, beneath which the flow continues under hydrostatic pressure (exerted by additional lava arriving from the vent) with hardly any further thermal loss.

Yet the flowage level inside any active lava tube always tends to lower, both through diversion into new flow units at the flow front and/or remelting and erosion of the flow bed, thus restoring gravitative flowage conditions inside the tube with further thermal losses in the gaseous space. This causes the cycle to be repeated over and over.

Thermal compensation is the factor permitting the flow motion, either by gravity or by hydrostatic pressure, while the flow is fed. The active lava flow preserves its heat because any thermal loss is continuously balanced by the incoming of new molten lava at a higher temperature, and thus the flow mobility is maintained.

As a consequence, lava tube caves are actually generated DURING the active flow operations, through the gradual lowering of flowage level/bed inside the tubes, instead of being caused by drainage of still molten lava from the tubes AFTER the feeding has ceased. When feeding from the source vent ceases, the thermal compensation mechanism ceases its operation, and damping down of the flow is almost immediate. Only minor segments of tubes in very fluid lava flows can be actually formed by final drainage of still molten lava, and for a really short extent.



CONCLUSIONS

These notes on the present situation of vulcanospeleological studies on Etna are necessarily concise and full of gaps, as it is impossible to condense in a few pages a wealth of studies and research involving many scholars and many decades of theoretical and observational studies.

In any event, the writer hopes he has succeeded in outlining a comprehensive view of present local knowledge. This is continuously increasing, thanks to the numerous and different caves which can be found and studied on Mt. Etna, and thanks to the eruptions which occur with a certain frequency, thus making possible the observation and study of the actual operation of active lava flows.

The International Symposium on Vulcanospeleology and the Round Table of Lava Tube Cave Formation, which will be held in Catania in September 1983, celebrating the 50th anniversary of the Etna Caves Cadaster, will provide a significant opportunity for comparison and review of the previous studies, of achieved knowledge, and future programs of research and study.

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