MONITORING OF GROTTA DEL GELO

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Abstract

What follow is a brief report of the first and only experiment in environmental monitoring, by means of automatic digital micro data loggers to collect data concerning temperature and humidity. It was carried out by speleologists of Catania Centro Speleologico Etneo, in collaboration with the Etna Park Organisation represented by the Volcanist. The data refers to July 1997- July 1998 biennium. Ten speleologists participated in this experiment in different roles. They voluntarily carried out the climatic survey and the data processing. This experiment cleared the general reasons for the reduction of ice volume inside the cavity and, above all, it let us verify that a wholesome and correct use of Grotta del Gelo does not modify meaningfully, hypogeous environment.

Introduction

Grotta del Gelo is probably the most well-known Etna volcanic cavity both locally and internationally. Its fame is consequence of the ice formation phenomenon, which started over three centuries ago and still lasts. In the past *Grotta del Gelo* was known by shepherds who drove their flocks of sheep to water; from the 1970s it became an obliged destination for many excursionists, who saw in it a goal to achieve at least once during their life.

The cave is located in the "A" [1] zone of Etna Park, which is integral reserve (Fig. 1), in the territory of Randazzo. Its access is located at an altitude of 2030 metres above sea level on the north-west face of *Etna*, in the area called *Sciara del Follone*. This is the result of *Dammusi* lava flow cooling, which is the product of the ten year eruption (1614-1624), on Etna north face, which started at an altitude of 2550 metres and reached *Collabasso* Mount, at about 1200

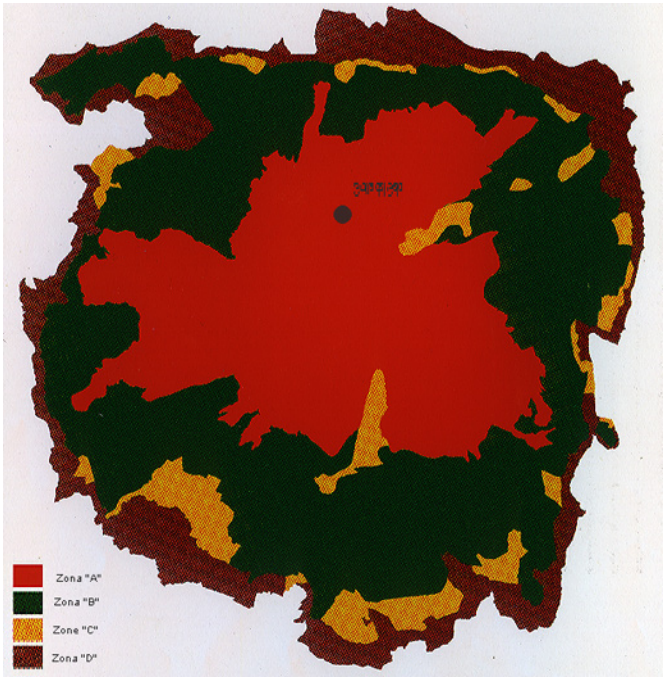
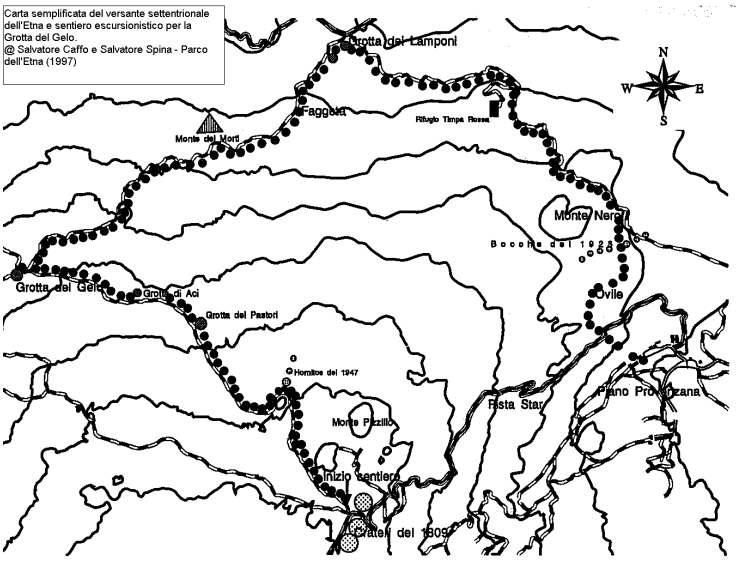


Fig. 1 – Map of Park zones

[1] The creation of the "A" zone has the purpose of integrally guaranteeing the preservation of volcano ecosystem difference, both to defend the general biological balance and to take care of natural environment of very high relevance both cultural and scientific. The intangibility of the "A" zone, whose size overcome the 19.000 ha, is fixed by the Law (art. 8, clauses I, II, III of the co-ordinated text of the law 98/81 and 14/88). It is an area where the naturalistic interest is prevalent and prior.



metres above sea level (Fig. 2). According to volcanospeleology, the cave is particularly important as an example of volcanic cavity of large dimension and for the presence of ice, which stuffs about the 40% of its volume, at a modest altitude if compared with the latitude.

Fig.2 – Simplified map of Etna north side and excursion track to reach Grotta del Gelo. © Salvatore Caffo and Salvatore Spina – Etna Park (1997)

Geological Framework

The radial eruption (Romano and Sturiale, 1982), which took place from 1614 to 1624 and was the longest among the Etna historical eruptions, during its activity, emitted an enormous quantity of lava, quantifiable in about 1050 x 10^6 m^3 (Romano and Sturiale, 1982), which flooded a considerable area of the volcanic edifice flowing from an altitude of 2550 metres for over 1400 metres of difference in height and enlarging for 21 km^2.

The complexity of the phenomenon that produced *pahoehoe* lava (Fig. 3), which are not frequent on our volcano, usually emitting *aa* lava, created a series of important morphologies as domes and mega-domes. They are located all over the surface of the immense lava flow. Furthermore, the streams of lava flow, during their evolution, were superimposed overlapping and obstructing one each other in their flowing towards lower altitudes. They produced cavities different in size and shape: superficial, deep or laminar, which were surmounted by rock slobs, few centimetres high resounding when somebody walks over them. This is why they were called *Dammuso*, in Arabic, which means ceiling, covering.

Fig. 3 – Pahoehoe lava field in "Dammusi" area inside "Sciara del Follone" (1614-24). Picture by Salvatore Caffo © 1997

The main streams created deeper canals, which were covered by crusts of different thickness and became the well-known cavities of this area. From the highest altitude we distinguish: Grotta del Diavolo (Devil Cave) at an altitude of 2400 m, Grotta del Lago (Lake Cave) at an altitude of 2200 m, Grotta di Aci (Aci Cave) and Grotta del Gelo (Ice Cave) at an altitude of 2000 m, Grotta dei Lamponi (Raspberry Cave) at an altitude of 1700 m. The secondary streams, which were more superficial, created, in natural lava flow terraces, other small cavities, which are not less interesting than the main ones. Some of them are well-known, thanks to their morphology, such as Grotta del Labirinto (Labyrinth Cave) at about an altitude of 1800 m and Grotta degli Inglesi (English People Cave), which, with other fifteen cavities constitutes a speleovolcanic complex of great importance.

The situation of the glacial phenomenon

Fig. 4 – Grotta del Gelo. detail of the canal which was formed by the decrease of ice thickness. Picture by Roberto Maugeri © 1998

The peculiarity of the glacial phenomenon inside Grotta del Gelo has drawn, during the time, the interest of naturalists and geologists who tried to explain the phenomenon and to describe its evolution. According to a series of observations, during the last thirty years, it was noticed that, from the 1980s, the glacial mass has transformed itself (Fig. 4), probably because of the 1981 eruption, which took place near the cave, or because of the frequent presence of excursionists. The difficult situation of the glacial mass induced some naturalistic associations to ask the competent organisations to help them start a campaign of research to define the size of the phenomenon better and to avoid a lost in the environmental resources.

Monitoring

Thanks to its peculiarity, *Grotta del Gelo* has a great environmental and scientific value. This is why naturalistic and speleological associations called the attention of Etna Park Service to a potential environmental alteration of the Cave, also because of uncontrolled presence of excursionists. On 12 January 1996, Etna Park organised, at the administrative office of Etna Park Service, the first technical meeting to discuss about *Grotta del Gelo.* At the meeting there were: Technical Managers of Catania Forest Inspectorate, competent for the territory, the Manager and speleologists of Cave Group of Club Alpino Italiano, Etna section, , the President and speleologists of Centro Speleologico Etneo, Head Manager and Managers of Etna Park Service.
During the meeting two goals to achieve were planned:
To regulate the fruition of the Cave to safeguard the hypogeous environment from potential situation of degradation.
To monitor the environment recording temperature and humidity by means of automatic micro data loggers.
The first goal, that is the regulation of the Cave fruition to safeguard the hypogeous environment from potential situation of degradation, was achieved thanks to the Presidential Measure n. 01/97 emitted on 10 January 1997. This action aims to regulate the fruition of the hypogeous cavity;
The second goal was achieved by means of the environmental monitoring of *Grotta del Gelo* from 9 July 1997 to 9 July 1999; that is one year longer than the term that was foreseen for the test: 9 July 1998.
Never before any institute of research, either Italian or foreigner, had constantly surveyed climatic-environmental data of the inside area of *Grotta del Gelo,* which could strengthen or deny the various hypotheses formulated by specialist and non specialist about the decrease of ice deposits thickness. So the administration of Etna Park Service decided to entrust the Volcanist , Co-ordinator Manager of “Nature Conservation” office, with the co-ordination of the scientific experiment.
On 22/4/97 the President empowered the Volcanist to start the necessary technical-administrative steps to carry out the experiment;

In order to cause the least environmental impact to the hypogeous ecosystem of *Grotta del Gelo*, even obtaining significant scientific data concerning the experiment, it was decided, after hearing the Technical-scientific Committee and the Executive Committee, to acquire the instruments: digital micro data loggers and software with relative licence whose total cost should not exceed £ 1.500.000;

On 26 June 1997 the President of Etna Park and the President of Centro Speleologico Etneo signed a specific agreement giving the micro data loggers, which had previously been bought, to the speleologists who would have recorded the measures inside the rheogenetic cavity;

On 9 July 1997 the Volcanist of Etna Park Service, Salvatore Caffo, in collaboration with an alpine guide of Park Service, Sebastiano Russo, and the speleologists of Centro Speleologico Etneo: Antonio Marino and Roberto Maugeri, installed the instruments, according to the technical project, which was planned by Roberto Maugeri with Park Service's approval (Fig. 5). The temperature and humidity loggers were programmed to acquire, automatically, data every hour for two months. Then, data was transferred to Personal Computer and processed by means of the proper software. Later the instruments were reprogrammed to record next data;

Fig. 5 - Installation of the automatic micro data loggers on the bottom of the hypogeous cavity. Picture by Roberto Maugeri © 1997

Temperature and humidity data concerning the first quarter, that is 9 July 1997 – 07 September 1997, regularly reached the Park Service on 24 September 1997;

The second group of data concerning the period 8 September 1997 – 9 November 1997 regularly reached the Park Service on 9 December 1997;

On 20 November 1997 the Italian *Glaciological Committee*, which is located in Turin, was informed about the kind of research which was taking place inside *Grotta del Gelo*;

The third group of data concerning the quarter from 9 November 1997 to 9 April 1998 regularly reached the Park Service on 24 April 1998;

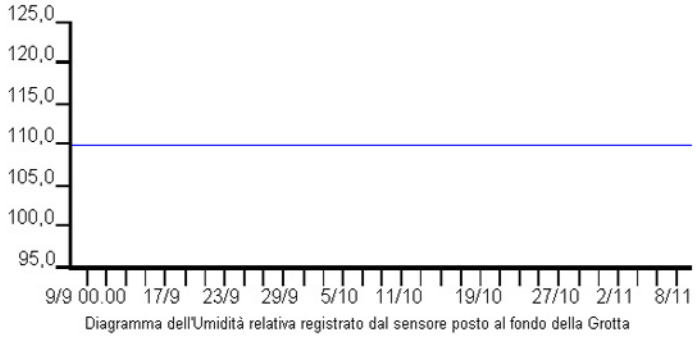
On 9 April 1998, in collaboration with the International Institute of Volcanology of Catania *CNR*, an automatic temperature micro data logger, placed on anemoscope, was placed at *Timpa Rossa*, on the north side of Etna, at an altitude of about 2000 m above sea level using as backing a present station of the institute. This data will be useful for a better reading and interpretation of surveyed data;

The fourth and fifth groups of data concerning, respectively, the period 9 April 1998 – 23 December 1998 and 18 January 1999 – 18 April 1999 were given, by the President of Centro Speleologico Etneo, the Volcanist who agreed with him on the extension of the experiment until 9 July 1999, so that to survey temperature and humidity concerning two seasons was possible. The sixth and last group of data was given the Park Service on August 1999. There is no need to highlight the high appreciation and esteem by Etna Park Service for the praiseworthy and free work, which so many geologists and speleologists of C.S.E. carried out.

All data concerning temperature and humidity were processed by qualified engineers of the Centro Speleologico Etneo using the proper software which Etna Park Service had supplied them. In order to interpret the surveyed data, the same were compared with the information relative to the number of people that were accompanied by the alpine guides of Etna Park during the follow excursions: 31/08/97; 14/09/97; 5/10/97; 02/11/97; 30/08/98; 27/09/98; 18/10/98; 08/11/98 which practically correspond to eight load tests. Furthermore a load test with 20 people inside *Grotta del Gelo* was made on 9 May 1998 by C.S.E.

Conclusive Results and Considerations

The survey conducted by the speleologists of Centro Speleologico Etneo under the technical-scientific co-ordination of the Volcanist let us get some conclusions:
Data concerning relative humidity has not shown any particular characteristic because the aria inside *Grotta del Gelo* is everlastingly saturated (Fig. 6).



Humidity variation are attributable to percolation water which, by chance, wetted the sensors (Fig. 7); As regards temperature inside *Grotta del Gelo*, there was a different situation in the middle area compared with the bottom one.

Fig. 6 – Diagram showing the relative humidity recorded by the sensor placed on the bottom of the Cave.

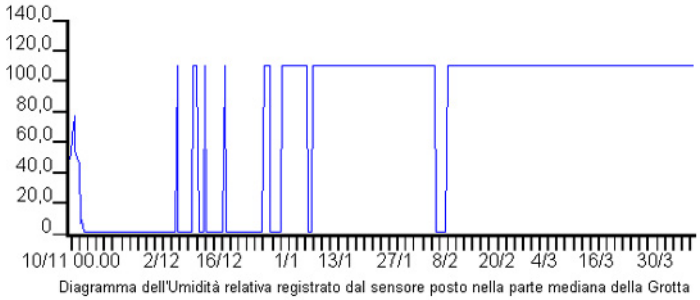


Fig. 7 – Diagram showing the relative humidity recorded by the sensor placed in the middle area of the Cave.

In fact the sensor located in the bottom area recorded temperature variations of few tenths of degree; on the contrary, the one in the middle showed variations of 0.5° C. However the most significant variations are attributable to atmospheric events such as long, abundant rains, quick decrease of temperature etc…(Fig. 8 and 9).

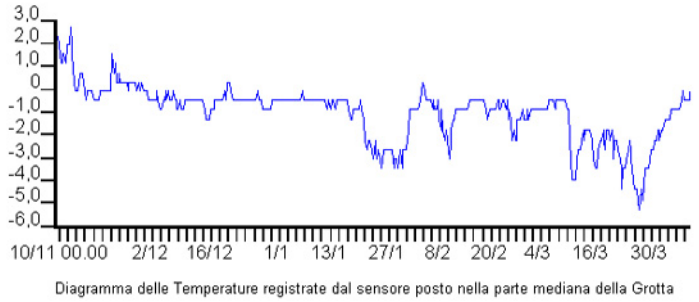


Fig. 8 - Diagram showing the temperature recorded by the sensor placed in the middle area of the Cave.

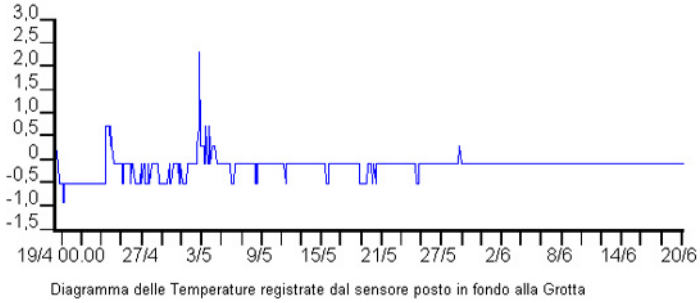


Fig. 9 - Diagram showing the temperature recorded by the sensor placed on the bottom of the Cave

It was noticed that human presence would appreciably not modify the internal environment (load test which took place on 09/05/98 (Fig.10) as well as the excursions of: 31/08/97; 14/09/97; 05/10/97; 02/11/97; 30/08/98; 18/10/98; 08/11/98 which practically correspond to eight load tests) as long as people do not stop there for a long time.
The temperature micro data logger, which was located at *Timpa Rossa*, on the north side of Etna, at an altitude of about 2000 m above sea level from 09/04/1998, allowed to verify that the sudden

Fig. 10 - Load test. Terminal area of lava duct inside Grotta del Gelo. Picture by Roberto Maugeri © 1998

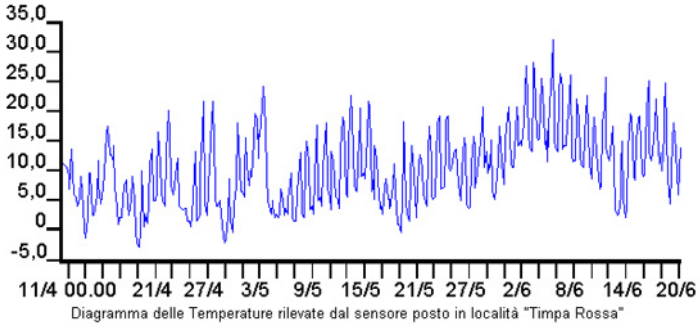


Fig. 11 - Diagram showing the temperature recorded by the sensor placed at “Timpa Rossa”

variations of temperature inside *Grotta del Gelo* correspond to external maximum values, according to the experiment (Fig. 11).
Not only does we consider valuable to highlight the importance of this project about the environmental monitoring of *Grotta del Gelo* for its intrinsic scientific value, but because it was also an excellent example of synergism between public institutions and associations of voluntary service demonstrating that what is required to act is only good will and professionalism.

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