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Unveil the traces of ancient mining

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ABSTRACT
The Archaeological Mines Park of San Silvestro is part of the Campiglia mining area. It represents its most important historical core. The Park covers a surface of around 450 hectares on the mountains Calvi, Rombolo, Poggio all'Aione and along the valleys Temperino, Lanzi and Manienti. The main characteristic of the Park is the richness of mining activity traces towards copper, lead and silver. The mining activity started during the 7th century BC with the Etruscan civilization and continued until 1979, when the last mine was closed. Many karst cavities of the Campiglia are "cave-mines': they are the result of a natural event and the action of ancient miners, who searched metalliferous minerals. In Campiglia there are traces of hundreds of Etruscan, medieval and modern mining operations, tunnels from the 19th and 20th centuries. The aim of the Archaeological and Mining park of San Silvestro is to highlight historical landscape, the result of centuries of mining activities. Some of the buildings, originally used for productive and administrative purposes, have been restored to house exhibitions and services for visitors. The impressive ruins of the medieval village of San Silvestro and two of the modern mining tunnels, have been equipped for guided tours. The accessibility of ancient mining works is however still difficult and this represents a limit in the enhancement and protection of these sites. Speleologists, archaeologists and geologists will be involved in making a project to let everyone discover the most ancient underground mines. We have three main targets: (1) produce high quality pictures of the most interesting and impressive mining traces; (2) create 3D models useful for scientific and cultural purposes; (3) equip some of the ancient shafts with light structures to allow small groups to visit them. We will describe the morphological characteristics of one of these ancient mines, giving some advice for the production of high quality picture in this contest. We will also describe the technique used for the production of a 3D model and how to equip the mine for the visit of small groups of people.

Keywords: mines, Etruscans, Middle Age, research, tourism, accessibility

INTRODUCTION

The Archaeological Mines Park of San Silvestro is located in the southern part of Tuscany, in front of Elba Island. It represents the most important historical core of the Campiglia mining area. The Park covers a surface of around 450 hectares on the mountains Calvi, Rombolo, Poggio all'Aione and along the valleys Temperino, Lanzi and Manienti (Fig. 1). The main characteristic of the Park is the richness of mining activity traces towards copper, lead and silver. The mining activity started during the 7th century BC with the Etruscan civilization and continued until 1979, when the last mine was closed.

During the Etruscan period and the Middle Age, ores were mined by the simple method of "following the veins". Miners started searching from the surface, then followed the vein widening the excavation when they met interesting concentrations of metals.

Rocca San Silvestro, where miners and smiths lived during the Middle age, was

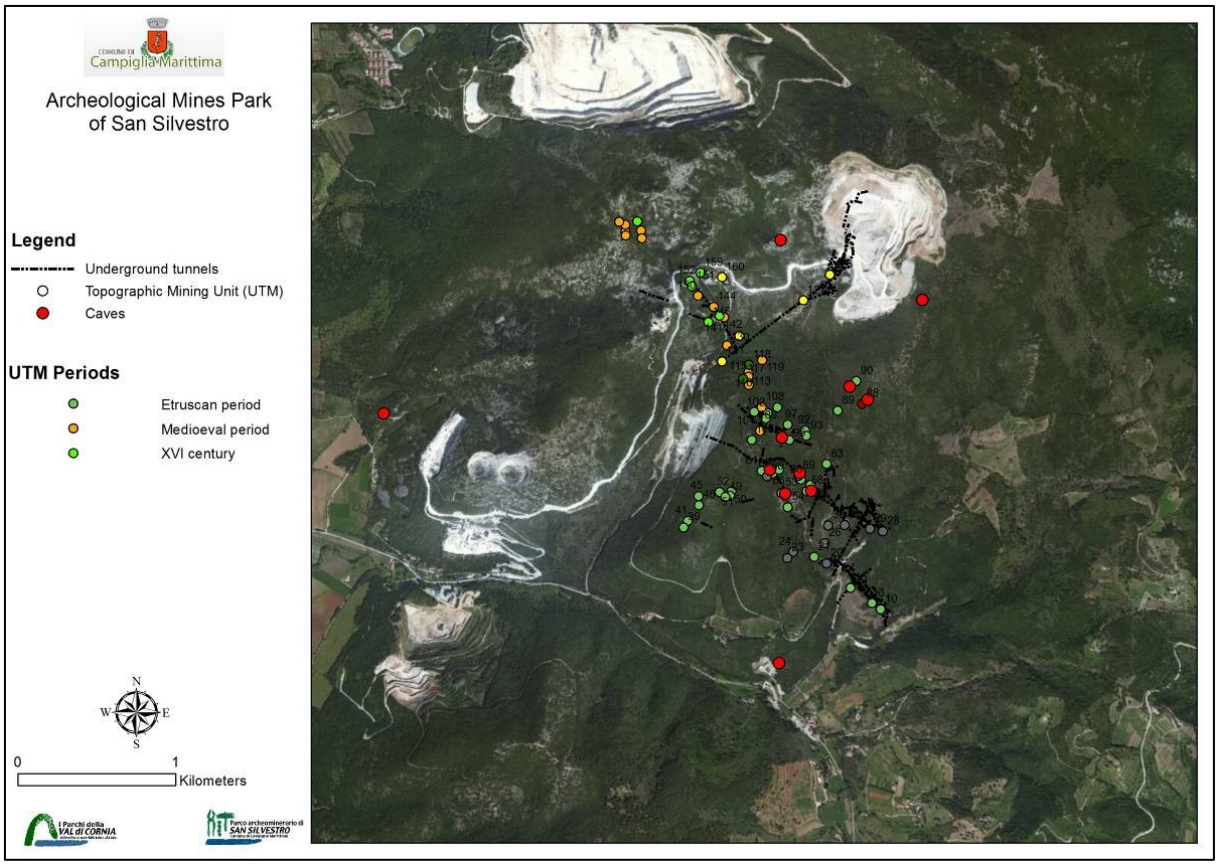

Fig. 1 The San Silvestro Park area. Colored points indicate the location of the ancient Topographic Mining Units (UTM)

abandoned in the second half of the 14th century. Mining activity started again, for a short time, between 1549 and 1559. Skilled workers coming from Carinthia and from Tyrol were called by Cosimo I de' Medici for their renowned experience. The 16th century mining technique was to dig out opencast mines that frequently cut across the workings of the previous age. During the 17th and 18th century, mining activities were sporadics. In the first half of the 19th century scientific interest in the Campiglia area was sharpened. French companies first and then English societies achieved mining claims. Tunnels were excavated on several levels connected by shafts due to upgraded skills and more advanced tools. They were used for the transport of miners and minerals. New excavations were always restarted from the previous ones; this gave privileged access to deeper ores or to finish the exploitation of metal bearing rocks identified in earlier times (Semplici, 2011).

In the Park, it is possible to visit two mining tunnels excavated between the middle of the 19th century and the 60's of the 20th century. The Temperino tunnel was excavated to check out ancient diggings. During the visit, you can see some of them. In the Lanzi-Temperino tunnel, you can observe mining works and equipment of the 20th century. The paths of the Park allow a view of the main curiosities of mining archaeology in the area, from the openings of the ancient and medieval mines to the 16th century quarries, from the remains of old extraction shafts to modern tunnels. Nevertheless ancient diggings had not yet been enhanced enough. It's important to work on the accessibility of these diggings and to equip them for the visit, real or virtual. This work represents a first rating about the ancient diggings that could be restored and the methods to improve their cultural and physical accessibility. Buca della Faina, an ancient mine of the Park, is one of the easiest to be equipped for the visit, due to its small dimension and shape.

GEOLOGICAL SETTING

The Campiglia area is characterized by a N-S trending horst of Mesozoic carbonate rocks (Tuscan units), with the massive limestone outcropping widely. Its borders are high-angle faults that connect sediment of the Tuscan Nappe with the Jurassic Eocene Ligurian sediment (Fig. 2). In the Miocene, the southern part of Tuscany was interested by a widespread magmatism, with the emplacement of plutons, dikes and effusive products. The Campiglia carbonate horst was intruded by a monzogranite pluton (5.7 Ma; Borsi et al., 1967) cropping out at Botro ai Marmi and intercepted by borings till a depth of about 1000 mt below Monte Valerio. Circulation of hydrothermal fluids coming out from the granitic body is at the base of the formation of the distal Zn-Pb-Ag skarn deposits. Later a mafic porphyry was emplaced in the Temperino area; hydrothermal fluids released by this magma were responsible of the genesis of Zn-Pb-Cu-Ag skarn deposits of the Temperino mine (Dini et al., 2013; Vezzoni et al., 2016). A second felsic porphyry dike (Coquand dike) cross cutted the other magmatic and metasomatic rocks (Vezzoni, 2014).Magmatic activity ended with the effusion of rhyolitic products, outcropping to the west area of the carbonate horst (sanidine ^{40}Ar-^{39}Ar date of 4.38±0.04 Ma; Feldstein et al., 1994).

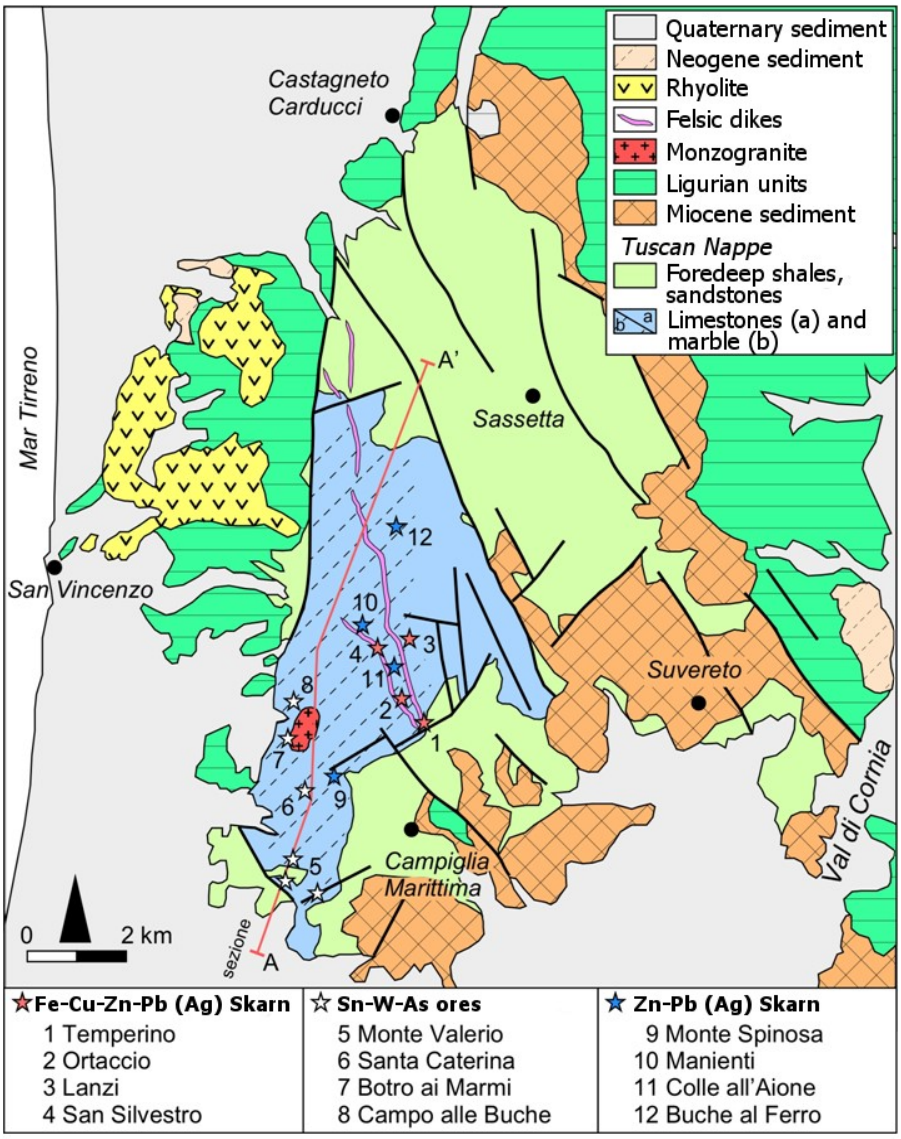

Fig. 2 Schematic geological map of the Campigliese area. (modified from Dini et al., 2013)

Skarn indicates a rock composed of calcium, magnesium and iron silicates. We refer to "skarn deposits" when they contain economically attractive concentrations of metal ores, such as magnetite or copper, lead, silver, zinc and iron sulphides. The skarn in the Temperino area is essentially composed of hedenbergite and ilvaite, in addition to quartz, calcite, epidote and johannsenite. It contains copper, lead and zinc sulphide, such as chalcopyrite, galena and sphalerite

In the Campiglia Hills there are lots of karst cavities, some of them surveyed in the "Catasto delle Cavità Naturali" of the "Federazione Speleologica Toscana". The cavities are mostly vertical due to the tectonic that conditioned the trend (Cascone, 1993). Karst cavities were used by ancient miners for underground explorations in the searching of ores. Some of them were enlarged, lengthened and cut by mining works during the Etruscan and Medieval period, using the technique of "following the veins" (Casini, 2001). For this reason these cavities, partly natural, partly artificial, are defined as cave-mines (Cascone, 1993). The entrance of several ancient mines was found in the Campiglia hills (Cascone & Casini, 1997; Cascone & Casini, 2001) (Fig. 1). The largest ancient mining complex inside the Park of San Silvestro is the one of Poggio all'Aione. This complex dates back to the 1st century B.C., owing to the finding of a piece of a DRESSEL 1 type amphora.

METHODOLOGY

The relief and the representation of natural or artificial underground cavities is difficult, owing to the complexity of the access, the darkness and the high humidity level. Production of a photographic documentation valuable from a scientific, archaeological and cultural point of view, needs to be well finished and meaningful as attestation.

In the preparation of the photographic set of an underground cavity, it could be useful to locate one or two people in different positions, in order to let the scale and the structure of the cavity. The right light positioning is an important aspect, essential to underline mining and archaeological features. The radiant light, for example, could emphasize shapes and colours, typical of the mining complex, as far as the ancient mining traces, artificial niches, galleries and tunnels.

A photographic documentation is moreover essential for the creation of 3D detailed models. These models could allow a virtual visit of the mining cavity, an efficient means in touristic, educational and didactic field.

The photogrammetry technique, used also in panoramic and architecture field, allow to rebuild a 3D model of an object, taking stereometric frames, in particular digital pictures.

Photogrammetry is the totality of all the analytic, graphic and optic processes with which we can reproduce an object or different projections of it. Stereographic pictures of the object should be taken from various positions, in order to have detailed documents of it and a base for the three-dimensional metric relief for 3D models.

This technique is particularly useful for the relief of narrow underground cavities, since the basic tools are a camera with flashlight and few lights. The modern laser scanner are not always suitable for the relief of narrow cavities, due to their size and weight.

THE BUCA DELLA FAINA, AN EXAMPLE OF AN ANCIENT CAVE-MINE

The *Buca della Faina* is one of the most ancient cave-mine of the Park. Its entrance is on the Via delle Ferruzze, one of the paths of the Park and can easily be reached by foot or by an off-road vehicle.

During the Etruscan period and the Middle Age, mineral prospecting in the

Campiglia area was carried out through the location and identification of outcrops of the oxidized part of the skarn deposits, usually made up of iron oxides and hydroxides and copper sulphate and carbonate.

Even the mafic and felsic porphyry, some of which strictly connected with the formation of the metalliferous ores, could be a useful clue to define the area from which to dig mining wells. The *Buca dell'Aquila,* another ancient mine located a few meters away from the *Buca della Faina,* was dug at the contact between porphyry and limestone.

Ancient miners sought iron ore, copper, lead, silver and tin. Excavation techniques were rather crude, since the available tools were picks, awls (with pyramidal and conical tips) and sledge hammers for manual use. Etruscan and Middle Age mines usually consist of a shaft, no more than one meter in diameter, and tiny tunnels, which followed an irregular winding course. The most highly oxidised mineralisation masses were crushed and sorted; the undesired material was accumulated at the bottom of the mine and only the material rich in metal was transported to the surface. Where mineralisation was more substantial, larger hollows were created.

At *Buca della Faina* ancient miners started their activity from a karst cavity, located near a small outcrop of oxidised skarn. They followed the vein underground through an artificial tunnel around 20 meters long and 1.60 meters wide. The cave-mine has an easy entrance, with a natural side, where stand beautiful flows of calcite. All along the irregular tunnel there are small excavation chambers and shafts, that connect the first level with other two lower levels.

Seven meters from the entrance it opens a small mineral search of 1 x 1 meter, which ends after four meters. A three meter deep well opens nine meters from the entrance, and continues in a 10-meter-long, one-meter-high tunnel, which in turn overlooks a well that connects the first and the second level tunnels with a tunnel at the third level, the lowest of the mine.

At 11 meters from the entrance a further deep well opens, continuing in the third level tunnel, five meters long and 0.80 meters high. The tunnel continues with a four meter jump and ends in an elongated excavation chamber of 2 x 2 x 9 meters. On the opposite side, the three meter well ends in another five meters high and four meters wide excavation chambers, from which two filled galleries leave. The last well opens 16 meters from the entrance, it is about seven meters deep and ends in an elongated shaped excavation chamber. This well is the only that allow to reach all levels.

The ancient mine was mainly dug in iron oxides and hydroxides, while copper minerals are visible only in limited areas. Gypsum is widespread in concretions and small crystals, and this could attest to the original presence of sulphides. On the walls of the artificial excavation, traces left by four different types of tips are still visible: conic big and small, pyramidal big and small. The tools used for the extraction were pickaxes, mallets and awls.

There are no traces of the use of fire, black powder, or explosives, a sign that the mine has not been used in the 19th and 20th century. Outside the mine there is a dump of ores, that begins at the entrance of the shaft, goes straight down the valley and is crossed by the path.

RESULTS

The protection and the valorisation of a cultural site depend from its physical and cultural accessibility. The visitors cannot understand and appreciate the cultural site without evidences and documents. Where the physical access is complicated, photography can be used as a first enhancing tool. A picture can explain and communicate if it represents of the context.

A picture truly represents the context if the photographer has technical competence

and scientific knowledge of it.

The Fig. 3 and the Fig. 4 are pictures taken for this purpouse. The first was taken at the entrance of Buca della Faina and allows to evaluate physical accessibility and dimension of the entrance.

The second picture was taken inside the mine, at the cross point of two shafts. It allows describing dimensions, structure and geological nature of this part of the mine. The picture emphasizes the colours typical of the iron oxides present in the most superficial part of skarn deposits.

3D models created by means of photogrammetry technique, could allow to have a detailed view of the excavated area, and highlight the volumes, the shapes and excavation technical features.

Three-dimensional model and detailed reliefs are extremely important for the protection of the underground mining sites and useful from a scientific point of view, for example to calculate the different volumes of the ores extracted. The three-dimensional relief could also be used for virtual 3D guided tour. Two of the ancient mines of the Park have been selected for the realization of a 3D model: Buca della Faina and the Manienti medieval mine.

One example of the enhancement of underground cavities is the 3D virtual tour realized inside the Grotta di Gianninoni, in the Parco della Maremma. Inside this cave were found the remains of an Ursus Spelaeus. This is the link to see the video http://youtu.be/PA42RvlYxCI.

It could be very important, where possible, making ancient mines accessible. The Buca della Faina, is the easiest mine in the Park of San Silvestro to be equipped for the visit with small groups of people, followed by specialized guides.

The personal equipment necessary is a light suit, a helmet with front light and a light harness. Securing the site could be easy: steel ropes and cables anchored to the walls with pressure nails, few lights in the lower levels that let every part of the mine to be visible.

In the section part of the Buca della Faina there is the detail of the lights, the ladder and the denial of access (Fig. 5). Visitors will be assisted in the short downwards on the steel stepladder, with a security rope.

These few low environmental impact arrangements, could let the site of Buca

Fig. 3 The entrance of Buca della Faina (Photo by G. Dellavalle)

Fig. 4 The inside of Buca della Faina mine (Photo by G. Dellavalle)

della Faina visible, and allow tourists to appreciate the mining technique of the Etruscan and Medieval time.

CONCLUSIONS AND FUTURE PLANS

The Campiglia area is characterized by the traces of hundreds of Etruscan, medieval and modern mining operations, a medieval castle, 16th, 19th and 20th century buildings and mining infrastructures.

The aim of the Archaeological and Mining park of San Silvestro is the protection and the valorisation of this cultural site that results from centuries of mining activities. Some of the buildings, originally used for productive and administrative purposes, have been restored to house exhibitions and services for visitors. The impressive ruins of the medieval village of San Silvestro and two of the modern mining tunnels have been restored and equipped for guided tours.

The accessibility of ancient mining works is however still difficult and this represents a limit in the enhancement and protection of these sites. The Buca della Faina, an ancient cave-mine of the park, is one of the easiest site to be equipped for the visit of few people groups, thanks to the fact that it is quite easy to reach and small in size. The artificial ancient excavation, small galleries, niches, linking shafts between the three level of the mine are limited in length and not so steep. Securing the site could be easy and of minimum impact: steel ropes and cables anchored to the walls with pressure nails, few lights in the lower levels, that let every part of the mine to be visible. The personal equipment necessary for the visit is a light suit, a helmet with front light and a light harness.

A first guided tour test at the Buca della Faina was conducted on May 28, during the IX National Day of Mines. The test, attended by about fifteen people, proved that the visit is feasible up to the second level of the mine with the simple support of staff with speleological preparation. We got into the mine groups of four people, and in this way each group took about 30 minutes to do the visit.

The introduction of simple safety measures, such as those mentioned in the article, will allow not only to get to the

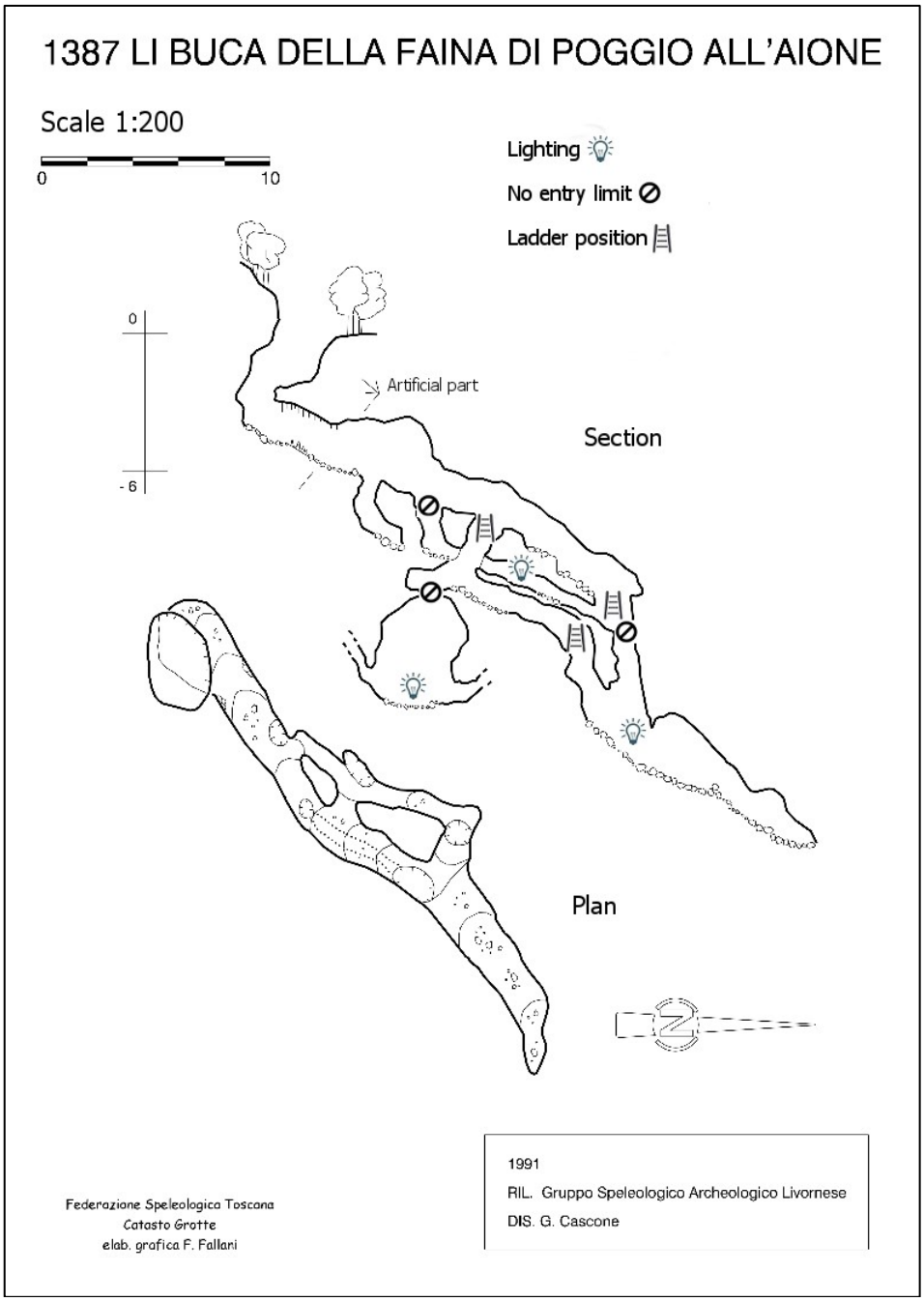

Fig. 5 Buca della Faina relief (Gruppo Spelelogico Archeologico Livornese). The detail of the lights, ladders and denial of access positions are indicated.

third level of the mine but to speed up the visit, although we believe that for the understanding of the site and its articulation it is necessary to spent at least 20 minutes into the mine. Starting from the entrance tothe Park, the time to walk to Faina's Buca entrance is about an hour. At least two guides are needed, one that follows the visit inside the mine and the other one that remains outside and deepens the archaeological-mining issues with the people who are waiting to enter.

We have evaluated that such visits, which can be organized by reservation, can be opened to groups of not more than 15 people, due to the necessary waiting time spent outside of the Buca della Faina. During the same day, more visit time frames may be scheduled, at least one hour and a half away from each other. The feedback we had on the visitors who took part in the tour on May 28 was definitely

positive. The experience has been considered to be of a cultural and emotional point of view, involving the visitors in the discovery of such a complex and articulated mining context as the one that can be visited in the San Silvestro Park.

The other ancient mining works of the park, quite impossible to reach, could be enhanced with the production of detailed photographic material, 3D models, virtual guided tours, thematic guides and video. These material could be part of the visit of the Park and could be shared on the web.

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