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Italy, Rome, March 11/17 - 2015



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## THE COZZO DISI MINE (CASTELTERMINI, SICILY, ITALY) A MULTI-DISCIPLINARY APPROACH TO RECORD, STUDY, PRESERVE AND DEVELOP THE MINING HERITAGE IN SICILY

Giovanni Badino <sup>1</sup>, Claudia Chiappino <sup>2</sup>, Antonio D'Aquila <sup>3</sup>,  
Fiorenzo Fiorenza <sup>4</sup>, Giuseppe Spitaleri <sup>4</sup>, Marco Vattano <sup>4</sup>

<sup>1</sup> University of Turin, Department of Physics - La Venta Esplorazioni Geografiche

<sup>2</sup> Artificial Cavities Commission of SSI - National Mining Engineer Association, Turin

<sup>3</sup> National Mining Engineer Association, Caltanissetta

<sup>4</sup> Speleological Regional Federation of Sicily

Corresponding Author: Claudia Chiappino, claudiachiappino@rocketmail.com

### Abstract

Cozzo Disi was one of the main sulphur mines in Italy, but after the closure and more than 10 years of desertion, urgent works are now necessary to save it from vandalism and flooding. This big mine contains geological and mineralogical peculiarities, so uncommon to be sometimes unique: this is the case of the "Grandi Garbere" at 3<sup>rd</sup> level, majestic karst cavities, containing magnificent selenite crystals documented by old miners. The possibility to have a "Sicilian Naica" attracted a multi-disciplinary underground task-force, now exploring the mine underground, in order to inspect old works and their good-safety conditions, and to achieve the rooms/caves of "Grandi Garbere". This extraordinary discovery should be relevant for the future of this territory. In the past, the mine was characterized by huge safety problems: hydrogen sulfide, carbon dioxide and explosive atmospheres; so, the team involved in actual and future explorations has to move with caution, using adequate equipment and - if necessary - waiting for acceptable environmental conditions created by artificial tools (ventilation, pumping, etc.).

**Keywords:** mine, Grandi Garbere, Sicilian Naica, hydrogen sulfide, equipment.

### Riassunto

La miniera di Cozzo Disi fu fino al 1964 una delle più grandi a livello nazionale e, dopo la chiusura delle miniere di Perticara e Cabernardi, divenne in assoluto la principale. Chiuse i battenti definitivamente nel 1988, a seguito della Legge Regionale n. 34, che stabilì la chiusura di tutte le miniere di zolfo siciliane. Cozzo Disi fu oggetto di presidio e manutenzione fino al 1992, le operazioni principali comprendevano l'eduazione delle acque sotterranee. Nel novembre 1990 l'Ente Minerario Siciliano consegnò la miniera alla Regione Sicilia, cessò ogni tipo di gestione e la miniera fu condannata all'abbandono, ad atti di vandalismo e all'allagamento. La legge regionale nel 1991 costituì quattro musei minerari: Gessolungo, La Grasta, Trabia Tallarita e Ciavolotta; la miniera-museo di Cozzo Disi fu istituita nello stesso periodo. Una legge regionale nel 1996 destinò fondi per la "salvaguardia delle strutture sotterranee del Museo Minerario di Cozzo Disi": il finanziamento consentì il recupero delle due gallerie "Canalotto" e "Flottazione", collegate da una discenderia in grado di superare il dislivello esistente pari a 15 metri. Un percorso ad anello avrebbe dovuto rendere fruibile in sicurezza al pubblico il sotterraneo, vista l'insistente domanda di visitatori interessati al sito. Ma non fu abbastanza per salvare la miniera dopo un così lungo periodo di abbandono. Il sotterraneo della miniera si trova in buone condizioni fino all'ottavo livello, alla profondità di 230 m; vi si trovano conservate peculiarità geologiche, mineralogiche e naturalistiche come le "Grandi Garbere" del terzo livello, maestose cavità carsiche le cui pareti sono ricoperte da immensi cristalli di gesso di eccezionale purezza e limpidezza. Per rendere possibile la visione di queste meraviglie anche al pubblico sarà necessario recuperare alcune vecchie gallerie ed installare nuovi ascensori; la priorità assoluta è rimettere in funzione gli impianti di eduazione delle acque per salvare la miniera, che rischia di finire sommersa dopo oltre 10 anni di abbandono. Nel 2013 è stato istituito un Consiglio Tecnico-Scientifico, nell'ottica di redigere un nuovo Piano di Gestione a supporto del Comune di Casteltermini nel futuro progetto di sviluppo. Una squadra di lavoro minerario/speleologica sta ora esplorando i sotterranei della miniera, con il duplice obiettivo di: ispezionare i lavori minerari, con la finalità di identificare zone in buone condizioni di sicurezza da destinare alla fruizione turistica, dopo gli opportuni lavori di recupero; raggiungere le cavità naturali denominate "Grandi Garbere", per documentare a livello mondiale questa straordinaria scoperta, che potrebbe diventare la chiave di volta per la valorizzazione della cultura e dell'economia di questo territorio. A partire dal marzo 2013, una serie di esplorazioni sono state condotte da un team super-specializzato e multidisciplinare costituito da ingegneri minerari e speleologi, in stretto coordinamento con il Distretto Minerario di Caltanissetta. Nel passato, nel periodo di attività estrattiva, Cozzo Disi fu caratterizzata da notevoli problemi di sicurezza: presenza di idrogeno solforato, anidride carbonica ed atmosfere esplosive causarono molti incidenti mortali, documentati nelle cronache dell'epoca. Le squadre coinvolte nelle ricognizioni attuali e future devono necessariamente muoversi con particolari calma e prudenza, utilizzando equipaggiamenti adeguati e - se necessario - aspettando che si creino condizioni ambientali accettabili create da mezzi artificiali (ventilazione, pompaggio, etc.). Si è tentato di raggiungere la cosiddetta "zona grotte" sia percorrendo direttamente le gallerie del terzo livello dalla "Via Operai", sia cercando eventuali collegamenti con l'esterno con prospezioni in superficie, infine cercando il varco dai livelli sottostanti (quarto e quinto). Con progressioni successive, studiando le carte e superando man mano i problemi tecnici legati alla presenza di gas ed acqua, la punta del maggio 2014 ha consentito di arrivare vicino alle "Grandi Garbere".

**Parole chiave:** miniera, Grandi Garbere, Naica siciliana, idrogeno solforato, attrezzature.



Fig. 1: view of the outside structures of the Cozzo Disi mine, in the 2014 spring (photo F. Fiorenza).

Fig. 1: vista delle strutture esterne della Miniera di Cozzo Disi nella primavera del 2014 (foto F. Fiorenza).

### Mine history and development

The Cozzo Disi Mine was until 1964 one of the main sulphur extractive plants in Italy and, after the closing of Perticara and Cabernardi mines in Marche Region (today in the Emilia Romagna territory), it became the largest (Capitano et al., 2004 and references therein). Mining definitively closed in 1988, as a consequence of the Regional Law n. 34, which established the closure of all the sulphur mines in Sicily.

While the other mines were practically completely abandoned, Cozzo Disi was kept in maintenance since 1992, with groundwater exploitation.

In November 1990 the Sicilian Mining Administration – which had the property of the whole sulphur mining district – delivered the mine to the Sicilian Region; in this way, maintenance and pumping stopped and the mine was abandoned to plunder, vandalism and flooding (Fig. 1).

The 1991 Regional Law established four regional mining museums based, respectively, in the mines of Gessolungo and La Grasta at Caltanissetta, at Trabia Tallarita of Riesi, and at Sommatino and Ciavolotta mine of Favara; the Cozzo Disi Mine-Museum was established at the same time.



Fig. 2: the "Floatation" tunnel during inspections of May 2014 (photo G. Badino).

Fig. 2: fasi dell'ispezione del tunnel "Flottazione" nel maggio 2014 (foto G. Badino).

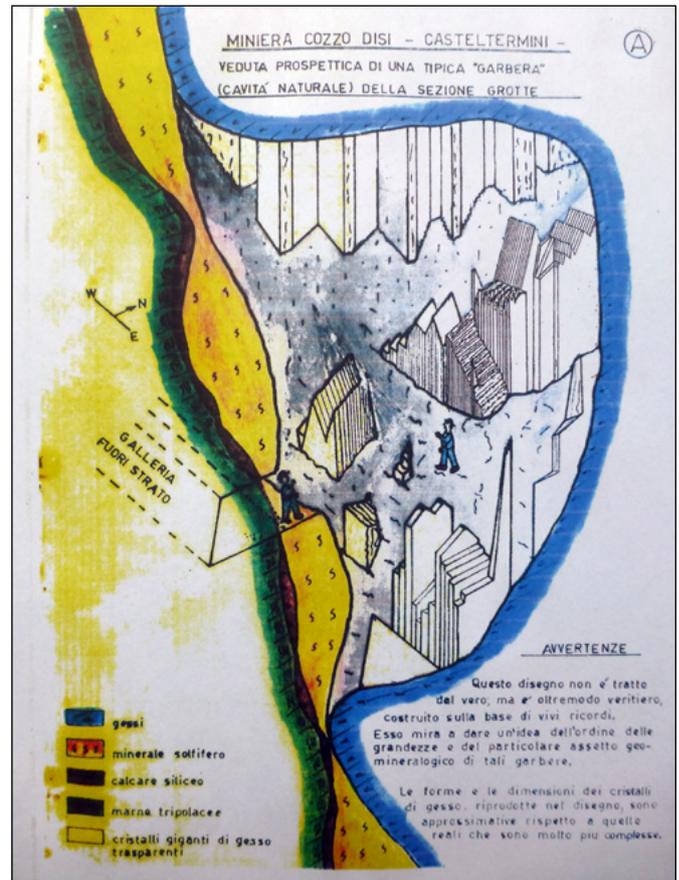


Fig. 3: draft of the "Garbera" chamber (after LA PORTA, 1992).

Fig. 3: schizzo di una "Garbera" (mod. da LA PORTA, 1992).

The Regione Sicilia, therefore, transposed the mining heritage as an important resource for the territory management.

Unfortunately, until 1996, nothing was actually done; then, a regional law allocated a billion of old "Lire" for the "safeguard of the underground infrastructures of the Cozzo Disi Mine-Museum". This funds allowed the restoration of the "Floatation" tunnel (Fig. 2), and of another gallery (Canalotto) located 15 metres below, connected to the first one with an underground circular track should be already accessible to the public, which demand insistently to visit the site.

In 2001 another billion was financed to restore plants and buildings, but it was not enough to save this big mine after a so long time of neglect, especially because after the end of these works, no maintenance was made; more funds are necessary now, to start urgent extra-ordinary maintenance works and to implement a new management. These operations could allow studies and explorations in safety conditions, to get all the information requested to save and promote this exceptional site.

Cozzo Disi, if opportunely exploited, should represent a strong tourist target, similar to other national and international successful mining museums.

The underground mine is well preserved until the 8<sup>th</sup> level, at a 230 m depth; it contains geologic, mineralogical and naturalistic peculiarities, so uncommon to be sometimes unique: this is the case of



Fig. 4: view of the Main shaft, form the 5th level gallery, in 2014 May (photo M. Vattano).

*Fig. 4; vista del pozzo principale dal 5 livello della miniera nel maggio 2014 (foto M. Vattano).*

the “Grandi Garbere” at 3<sup>rd</sup> level, huge karst cavities, which sides are covered by immense gypsum crystals of remarkable purity and limpidity (MEZZADRI P, 1989, La serie gessoso solfifera della Sicilia ed altre memorie geo-minerarie).

A witness, the mine topographer in the 50’s, Amedeo La Porta, reports in a written remark about crystals with metric dimensions (Fig. 3).

At the 12<sup>th</sup> level, the sulphur deposit is almost untouched.

Walking in these fabulous galleries excavated in the gypsum/sulphur ore, and to see glittering crystals in the artificial lights, is particularly evocative.

To show to visitors these natural wonders it is necessary to restore some old tunnels and realize new lifts; the main, urgent problem is now pumping waters to save the mine, after 10 years of abandonment (Fig. 4).

In 2013 a Technical Scientific Council (CTS) was established, composed by Cultural Associations and Public Administrations (ISPRA-Ministry, Mining District, Monuments and Fine Arts Department, etc.), to create a new Management Plan to support



Fig. 5: technical meeting with the Mining District Chief Engineer (photo G. Badino).

*Fig. 5: riunione tecnica con l’Ingegnere Capo al Distretto Minerario di Caltanissetta (foto G. Badino).*

the Casteltermini Municipality in the development of future projects.

Following the CTS guidelines, a mining and speleological task-force is now exploring underground spaces, with two targets:

a) inspect the mining works, to realize the technical measures necessary to visit the mine in safety conditions;

b) to reach the rooms/caves of “Grandi Garbere”, in order to document a worldwide, extraordinary discovery that should be relevant for the culture and economy of this territory.

In the past, in its industrial life, Cozzo Disi was characterized by huge safety problems: hydrogen sulfide, carbon dioxide and explosive atmospheres caused many deadly accidents.

The team involved in the surveys has therefore to move with calm and caution, using adequate equipment and - if necessary - waiting for acceptable environmental conditions created by artificial tools (ventilation, pumping, etc.).



Fig. 6: 3<sup>th</sup> level gallery partially flooded (photo G. Badino).

*Fig. 6: Galleria del terzo livello parzialmente invasa dall’acqua (foto G. Badino).*

### Underground explorations

In the last two years (2013-2014) a series of explorations were conducted, in order to reach the levels where the crystal caves have been documented by old miners.

In the modern practice of caving, contacts with the mining world are frequent. These contacts are sometimes local and fortuitous, whilst in other situations they characterize the caving approach of an entire regions (Tuscany and Sardinia in the first place).

The connection of these two underground worlds has earned a planetary resonance thanks to the discovery of the geode-cave of Naica, in Mexico (Badino et al., 2009, The Naica cave survey., and references therein), about a decade ago; since then, the image of the cave mines is changed. The extreme environmental conditions and the magnificent selenite crystals of this cave intercepted in the heart of a huge silver mine of the state of Chihuahua, have gained immense interest, well outside the cavers world, thanks to the worldwide popularization of these researches made by La Venta Geographical Association and Speleo Research & Films. The possibility to have a “Sicilian Naica” attracted



Fig. 7: view of the debris deposit, in the final sector of 3<sup>th</sup> level gallery. This landslide block the passage to “Garbere” (photo M. Vattano).

*Fig. 7: particolare della frana nella parte finale della galleria del 3° livello, che sbarrava la strada verso le “Garbere” (foto M. Vattano).*

the attention of many people: the Sicilian Regional Speleological Federation, the Association La Venta, the cultural associations in mining (ANIM) and in industrial archaeology (AIPAI) aimed to attain, explore and protect these caves, to avoid the risk of losing a priceless heritage and an unbelievable opportunity of development for the territory (CAPITANO et al., 2004).

In 2010, thanks to contacts with the Mining District of Caltanissetta (Fig. 5), there was the possibility of a joint survey in the mine of Casteltermini, that by the early 2000’s was part of an environmental project with the establishment of a Mining Park.

Cavers and miners tried to reach the 3<sup>rd</sup> level of Cozzo Disi; the environmental conditions were uncertain and potentially harmful, since these structures were abandoned around 40 years ago. Some first surveys were carried out in 2011, and soon emerged the problems related to the massive presence of hydrogen sulphide.

A first heavy exploration started in March 2013 with a descent at the 3<sup>rd</sup> level (Fig. 6) of the mine, trying to reach directly the “Grandi Garbere”.

The team entered the “Gallery Canalotto” and, along the “Via Operai”, reached the 3<sup>rd</sup> level. The gallery was flooded by about one meter of water, the air was of poor quality, whilst the high temperature and the pungent and persistent sulphur smell made the progression very difficult.

After advancing about two hundred meters, the hopes to achieve the Garbere crashed, a few meters from it, against a double barrier.

The main gallery is closed by a landslide (Fig. 7), particularly unstable and with breakdown deposits that touch the ceiling; to the right, a stone wall closes inexorably a possible by-pass. Exploration is planned for the next year, after partial demolition of the landslide deposit.

In the next months researches are scheduled at the surface, in an area estimated to be located above the “Grandi Garbere”, a few hundred meters higher. The purpose of such explorations is to identify some possible



Fig. 8: surficial explorations carried out by cavers of the Regional Speleological Federation (photo F. Fiorenza).

*Fig. 8: fase di ricerca esterna a cura del team della Federazione Speleologica Regionale Siciliana (foto F. Fiorenza).*

natural passages, like fractures, dolines or a sink point. These morphologies are in fact quite usual in evaporites as in the site of Cozzo Disi mine, located in the Messinian evaporitic series (DECIMA & WEZEL, 1971; MEZZADRI, 1989), about 7 million of years old. With natural entrances, many problems related to the mine galleries security would be overtaken, at least in this first phase of exploration surveys.

The FSRS engaged a large group of cavers from all over Sicily to perform these researches on 13 and 14 April 2013 (Fig. 8).

Initially a detailed research started in the area, dividing it into sub-areas assigned to different teams equipped with GPS.

In this large territory, roughly 50 hectares, only few points of moderate interest were found, concentrated in the area between the galleries of the old mine (characterized by the name “bursting areas”) and the Main Shaft: two small fractures and a collapse.

The first fracture explored, on a wall of a hill at an altitude of 330 m a.s.l., was reached with cave-climbing techniques, and a traverse of about ten meters was equipped. The horizontal fracture, however, closed after a few meters.

The second fracture was explored starting from two different points, at 316 and 322 m a.s.l. From the first point the fracture is accessible for 3 m in western direction and for other 3 m downward. Beyond this point we found a not practicable passage which however shows some prosecutions, very close to the topographic surface (roughly 312 m a.s.l.).

From the higher entrance, equipped with rope for vertical progression, it is possible to explore the narrow fracture for about ten meters in western direction, and just a few meters downward (Fig. 9), up to a narrow passage. The extreme instability of the multiple collapsed boulders around the fracture prevents any attempt to dig. There is a considerable cold airflow toward the entrance, probably due to local circulation. On the walls there are abundant gypsum speleothems in selenite shape, tabular and acicular, centimetres in

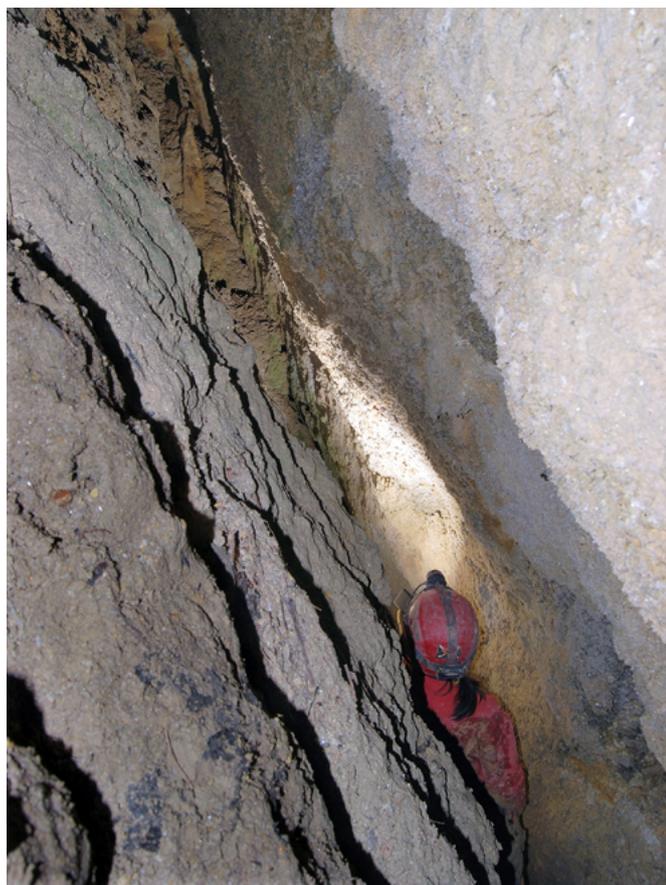


Fig. 9: speleological explorations inside one of the surficial fractures (photo F. Fiorenza).

*Fig. 9: esplorazione speleologica all'interno di una delle fratture superficiali (foto F. Fiorenza).*

size, often terminated with the typical germination of spearhead.

Finally it was quickly explored a cave 50 metres south of the fracture mentioned above.

The entrance, circular and about one metre wide, was formed as a consequence of a collapse of the ground level. The exploration requires progression techniques on rope. Few meters after the entrance the gallery widens and leads into a large room, roughly 10-15 m for 5-10 m in size.

The rock fall cluttering the floor would permit possible continuations but the absence of any significant airflow discourages further explorations.

This short and intense cave search ended without any hopes of finding natural alternative ways to the "Grandi Garbere".

In March 2014, we had a new chance to get into the mine. Before our descent a technical team of the mine went to open a series of doors to allow ventilation in the third level. This allowed us to find low concentrations of gas which was, in any way, continuously kept under control with a portable meter for harmful atmospheres. The "Via Operai" presented in the first part good conditions with well-defined steps, but in the lower parts the steps were damaged or completely destroyed. The gallery of the 3<sup>rd</sup> Level was flooded for most of its length, up to almost one metre of depth. The water



Fig. 10: the 3<sup>th</sup> level gallery which ends on the gypsum blocks man-made wall. Over this the passage is blocked by the debris deposit (photo M. Vattano).

*Fig. 10: porzione finale della galleria del 3° livello con il muro in blocchi di gesso, oltre il quale il passaggio è ostruito dalla frana in fig. 12 (foto M. Vattano).*

looked reddish, probably also due to the deterioration of some tracks now completely submerged. In its final parts, just before the wall beyond which there should be the Garbere, there was a small concrete dam (Fig. 10); the water behind it was deeper and white-gray in colour.

As described above, the conduit was closed at the front by a ceiling collapse and by a wall on the right.

We used gas detectors in some holes in this wall, finding low concentrations of hydrogen sulphide, and then began the removal of some elements of the wall itself. Behind this artefact, made by gypsum blocks aggregated by cement mortar, there was a further collapse made of brown clays soaked in water, which had broken the wood armours. It was impossible to pass through this point also because the water-saturated clays might also contain some harmful gas pockets.

The following day we found a temperature increase in this area, probably due to a circulation of air in a "horseshoe", with cooler air flowing on the water surface in circular pattern, to then stand on the roof. This mechanism cools air and water in the area closest to the first part of gallery.

During all the inspections we collected mineral and water samples at many different points. The topographic survey (Figs. 11-12) of the whole gallery



Fig. 11: air circulation analysis and topographic activities in the 3<sup>rd</sup> level gallery (photo M. Vattano).

Fig. 11: fasi di analisi della circolazione dell'aria e di rilievo topografico nella galleria del 3° livello (foto M. Vattano).

was also carried out, from this "Garbere wall" to the "Via Operai".

At the end of this operation a meeting was organized in the headquarters of the Mining District of Caltanissetta (Fig. 5), to study the old mine topographic surveys. We discovered that there is still a possible attempt to access "easily" to Garbere, by lower levels.

The maps showed that we could continue the descent in the "Via Operai", entering then on the 4<sup>th</sup> level until an inclined gallery, and along it to rise back to the level of Garbere.

The hopes of success seemed extremely small in that area abandoned for over 40 years, both for the likely presence of landslides, and the certain presence of hydrogen sulfide which was historically abundant in the 4<sup>th</sup> level. But this was the last attempt, potentially promising success, with caving techniques, and then it was decided to try it.

In May 2014, after many extreme bureaucratic difficulties, we go back underground, to reach the 4<sup>th</sup> level and also to measure accurately the level of the water table, a fundamental parameter for the survival of the whole mine, that had never been measured.

We went down quickly along the "Via Operai" (Fig. 13),

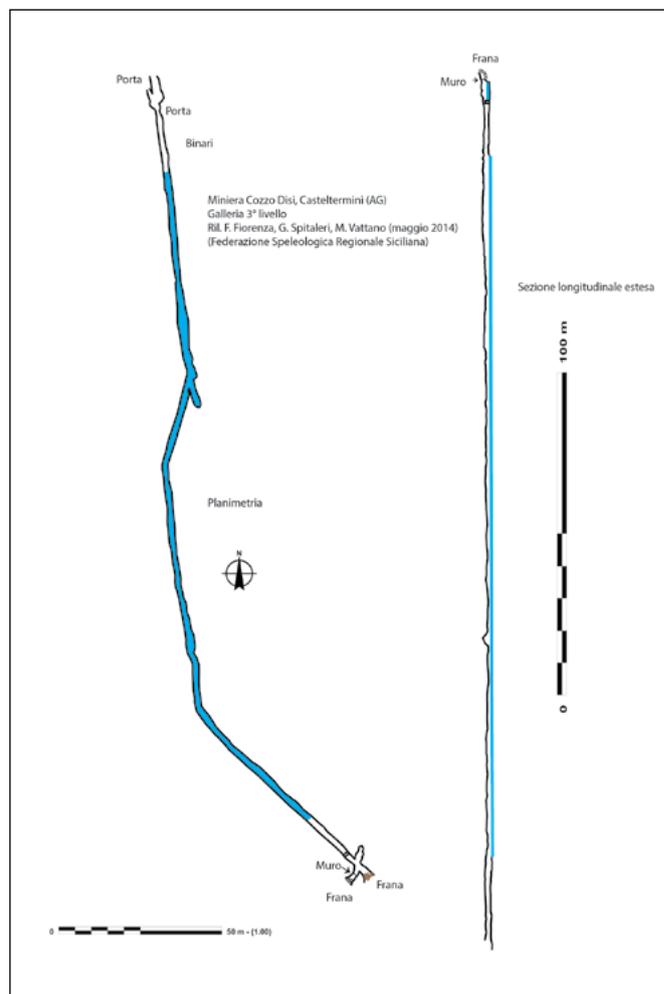


Fig. 12: topographic survey of the 3<sup>rd</sup> level gallery which lead to the "Garbere".

Fig. 12: rilievo topografico ipogeo della galleria del terzo livello che conduce verso le "Garbere".

reaching the 3<sup>rd</sup> level, finding the path well ventilated and not feeling at all the presence of H<sub>2</sub>S.

As a precautionary measure, from this level downwards, we went ahead with the gas meter turned on, and even wearing the gas masks.

Along the "Via Operai" below the 3<sup>rd</sup> level the hydrogen sulphide concentrations were higher.

In the 4<sup>th</sup> level, a dry gallery with a very strong airflow was found; the airflow was absorbed at the end of the tunnel, closed by two walls. The first is built in gypsum blocks covered with mortar, and has several holes, that absorb the airflow, whilst the second is made of cement. The gallery is in the direction of "Garbere".

We continued the descent along the "Via Operai" to the 5<sup>th</sup> level. This last gallery, where there are also telephone panels and other electrical controls, is very wide and in good conditions, closed with a wall that we did not analyse for lack of time and for the presence of a water pool apparently rich in H<sub>2</sub>S that we preferred not to touch.

There was an increase of H<sub>2</sub>S concentration, up to 1.1 ppm (Fig. 14), but this disappeared at the entrance to the gallery of this level, crossed by a strong air flow.

From this gallery it was possible to see the end of the



Fig. 13: climb-up on to the "via Operai" straicase (photo M. Vattano).

Fig. 13: risalita lungo la "Via Operai" (foto M. Vattano).



Fig. 14: check of level of dangerous gas before the access in the 5th level gallery (photo M. Vattano).

Fig. 14: fasi della misura del livello di gas pericolosi prima dell'ingresso al 5° livello (foto M. Vattano).



Fig. 15: the team satisfaction after the achievement of the 5<sup>th</sup> level of the Cozzo Disi mine (auto-shoot, photo M. Vattano).

Fig. 15: la soddisfazione del team, dopo il raggiungimento del 5° livello della miniera di Cozzo Disi (autoscatto, foto M. Vattano).

elevator shaft and to measure the height of the water table, just below. Its level is 7.09 m from the floor of the 5<sup>th</sup> level (Fig. 4).

### Conclusions

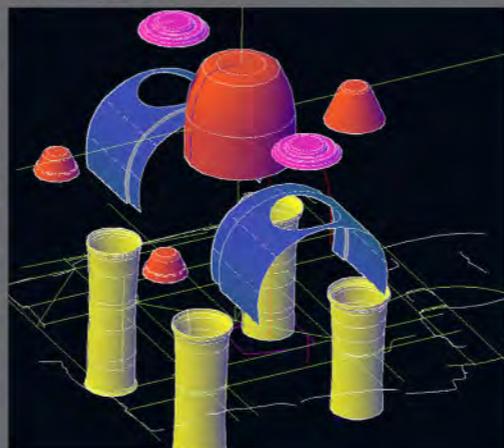
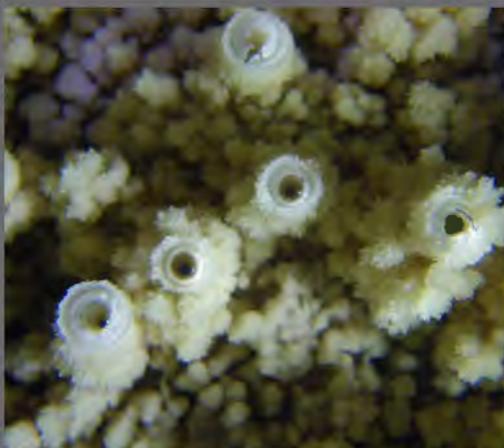
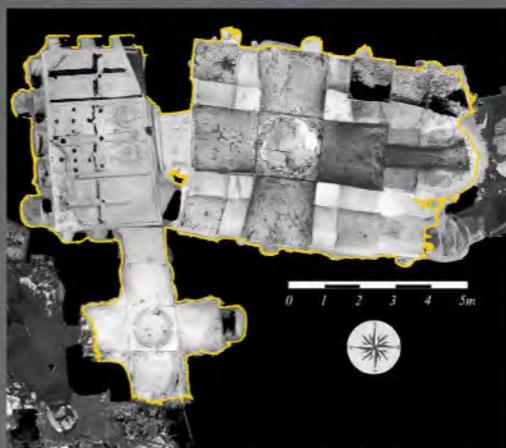
In the last decades, "Grandi Garbere" of the great mine of Cozzo Disi have been hidden in a kind of myth, inaccessible for the progressive deterioration of the mine structures and for a bureaucratic situation of incredible complexity.

After three years of efforts, they seem now finally reachable (Fig. 15), thanks to the combined efforts of many people who want to raise awareness of what appears to be a true geological treasure of our planet, with enormous potential impact on the development of the whole area and of its history.

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