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FORMIGNANO MINE: A STUDY FOR THE RESEARCH PROJECT OF EMILIA-ROMAGNA REGIONAL SPELEOLOGICAL FEDERATION "EASTERN ROMAGNA GYPSUM AND SULPHUR"

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Abstract
The Emilia-Romagna Regional Speleological Federation for the 2014-2015 period has started an ambitious research project titled "Eastern Romagna Gypsum and Sulphur", which aims at surveying, recording and studying the natural and artificial cavities of Eastern Romagna. The area of interest covers the Savio valley (province of Forlì-Cesena) until the new regional border with Marche (following the inclusion of the seven municipalities of Valmarecchia, in the province of Rimini), also including the territory of San Marino Republic. The project includes two main study themes: on the one hand, the study of gypsiferous main features in the area, the survey and the localization of the cavities, their inclusion in the Regional Register, hydrological studies, microbiological analyses of sulphur springs and the study of bats; on the other hand, the related significant mining heritage that has impacted the area both in ancient times and in the modern era, especially from the late Nineteenth Century until the 60s when the last mines closed down. From the viewpoint of artificial cavities, the area has an important industrial archaeological value with an historical and social relevance due to the presence of many mining areas for the extraction of sulphur, belonging to the Formazione Gessoso-Solfifera (Messinian Evaporites). The numerous sulphur mines in this area were a major social and economic reality for many years, until their closure. The most historically interesting mine is that at Perticara (Novafeltria), which was the largest sulphur mine in Europe (currently, the site has become a very interesting museum called "Sulphur"). The same fate has not befallen at the second best preserved site, Formignano mine, discussed in this article, for which the project of developing a museum is still a dream to be realized.
Key words: Gypsum, Sulphur, Eastern Romagna, Formignano, Mines.

Riassunto
La Federazione Speleologica Regionale dell'Emilia-Romagna (FSRER) ha intrapreso per il biennio 2014-2015 un ambizioso progetto di ricerca dal titolo "Gessi e Solfi della Romagna orientale", che si prefigge di rilevare, documentare e studiare le cavità naturali e artificiali della Romagna orientale. Il territorio interessato si estende dalla valle del Savio (provincia di Forlì-Cesena) fino al nuovo confine regionale con le Marche, dopo l'annessione dei sette comuni dell'alta Valmarecchia nella provincia di Rimini, includendo inoltre anche il territorio della Repubblica di S. Marino. Il progetto prevede due principali ambiti di interesse; da un lato lo studio delle emergenze gessose presenti in zona, il rilievo e il posizionamento delle cavità, il loro inserimento nel Catasto Regionale, gli studi idrologici, le analisi microbiologiche delle sorgenti sulfuree e lo studio dei chirotteri. Dall'altro il notevole patrimonio minerario, frutto del fenomeno che ha interessato la zona sia in epoca antica sia in era moderna, nel periodo che va da fine ottocento fino agli anni '60 del secolo scorso, quando si è assistito al suo declino. La zona in esame ha, dal punto di vista delle cavità artificiali, un importante valore archeologico industriale, storico e sociale per la presenza di numerosissime zone minerarie di estrazione dello zolfo, appartenente alla Formazione Gessoso-Solfifera. Le numerose miniere di zolfo di questa zona hanno rappresentato una realtà economica e sociale importante per molti anni, fino alla loro chiusura. La miniera storicamente più interessante è sicuramente quella di Perticara (Novafeltria), che fu la miniera di zolfo più importante d'Europa. Attualmente il sito è diventato un museo, denominato "Sulphur". La stessa sorte non è toccata al secondo sito per importanza, le miniere di Formignano di cui si parla in questo articolo, per le quali il progetto di sviluppare un museo è ancora un sogno da realizzare.
Parole chiave: *Gesso, Solfi, Romagna Orientale, Formignano, Miniere.*

Sulphur deposits in Romagna

In Romagna (Northern Italy), sulphur deposits originated from the evaporation of sea water in the Tertiary Era (Messinian Age), when the Mediterranean Sea was temporarily isolated from the Atlantic Ocean. Sulphur was found in veins with widespread trend, low power, mostly interposed between deposits of bituminous clays that create layers of poor consistency and resistance that must be excavated and removed with caution during cultivation of the mines (Lipparini T., 1930).

Like other minerals, initially sulphur was found in outcrops: pure, and in small quantities near volcanoes. Soon, once that surface deposits exhausted, it was necessary to excavate tunnels.

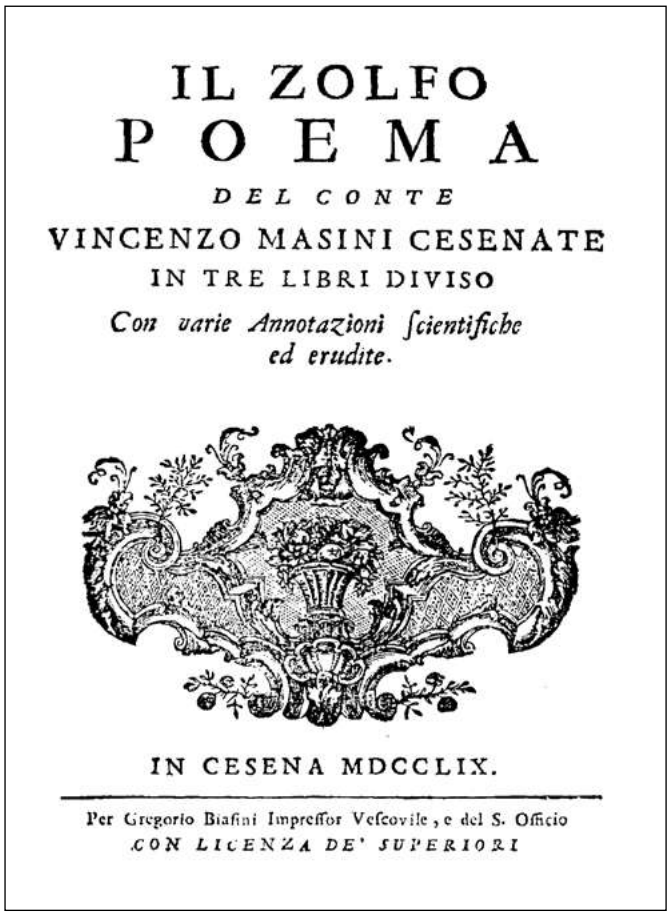

IL ZOLFO
POEMA
DEL CONTE
VINCENZO MASINI CESENATE
IN TRE LIBRI DIVISO
Con varie Annotazioni ſcientifiche ed erudite.
IN CESENA MDCCLIX.
Per Gregorio Biaſini Impreſſor Veſcovile, e del S. Officio
CON LICENZA DE' SUPERIORI

Fig. 1: cover of the poem "Il Zolfo" (Biblioteca Malatestiana di Cesena).
Fig. 1: copertina del poema "Il Zolfo" (Biblioteca Malatestiana di Cesena).

History of production of Sulphur in Romagna

Since ancient times sulphur, called the "burning rock", has been used for many different purposes. The Romans in particular used it pure in incendiary weapons, in medicine, to make adhesive, while his vapours (SO_2, SO_3) were used in textile bleaching and as disinfectants.

In Romagna, the first traces of mining activity date back to the Roman period and consist of toponyms apparently linked to sulphur (the existence of a mine called "Solfaranaccia" is documented, and a parish church, dedicated to St. Peter in Sulferino, localized where today the village of Borello stands). At that time, the mining activity was presumably of small relevance. Sulphur produced in the hills of the Apennines, following the Savio river, passed through Cesena and then arrived to the natural harbour of Cesenatico, an important site for the marketing of the product, effectively creating a "route for sulphur".

In the XIV Century the demand for sulphur in Europe grew rapidly as an essential constituent of gunpowder, widely used for civilian and military purposes. Several deposits of sulphur were exploited and many grinding mills were built next to the mines.

In 1759, Vincenzo Masini, born in Cesena, published a poem entitled "Il Zolfo" (Fig. 1), where the methods of extraction, the location of wells and production were described in verse, as usual in the Italian literature

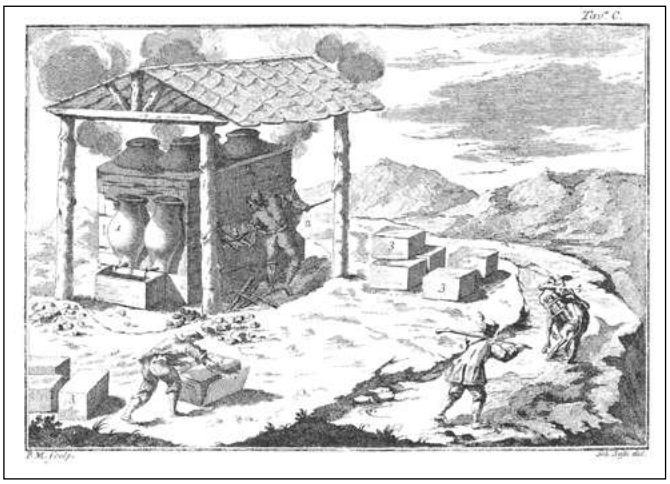


Fig. 2: mine tools, from an image taken after the poem by Vincenzo Masini (1759) (Biblioteca Malatestiana di Cesena).
Fig. 2: attrezzi da miniera in un'immagine tratta dal poema di Vincenzo Masini (1759) (Biblioteca Malatestiana di Cesena).

of the XVIII century, and with the help of detailed drawings (Fig. 2).

At the end of the XVIII century, sulphur began to be used to produce sulphuric acid, one of the most important basic elements of the industrial revolution. The level of consumption of sulphuric acid may in fact be regarded as an indicator of the commercial and industrial prosperity of a nation; in the second half of the XIX century sulphur was widely used in agriculture against a common disease of grapevines and other plants. As a result of the growing importance of the chemical industry, its production experienced a real boom and the frequent wars fought in Europe (especially in Italy, where the political reunification of the country led to many militar campaigns) required a constant supply of sulphur for the war industry.

Thus, the production of sulphur took off and Italy played a dominant role in the international markets; Sicily, with 75% of the world production, and the Romagna-Marche area, with 5%, were the two top producers in the world of the precious element.

The business had a strong impact on the economy of the area, mainly based on agriculture: at the beginning of the XIX century there were approximately 135 active extraction wells. The high demand for sulphur attracted many entrepreneurs and, in Sicily as in Romagna, the sulphur industry was regarded as the "new" industry in which to invest. There was a real "sulphur rush", which initially attracted local entrepreneurs and as a result, due to the necessary high investment, joint-stock companies with foreign investors, initially from France and, after 1870, from the United Kingdom.

The main problem of the mines of the Romagna-Marche area was the competition with the cheapest sicilian sulphur, in both the national and international markets: sicilian sulphur deposits were numerous, more extensive and their extraction was easier, often with the system "open air"; Sulphur was then exported raw so there were no refining costs and the cost of shipping was much lower than in Romagna, where the lack of communication infrastructures influenced the

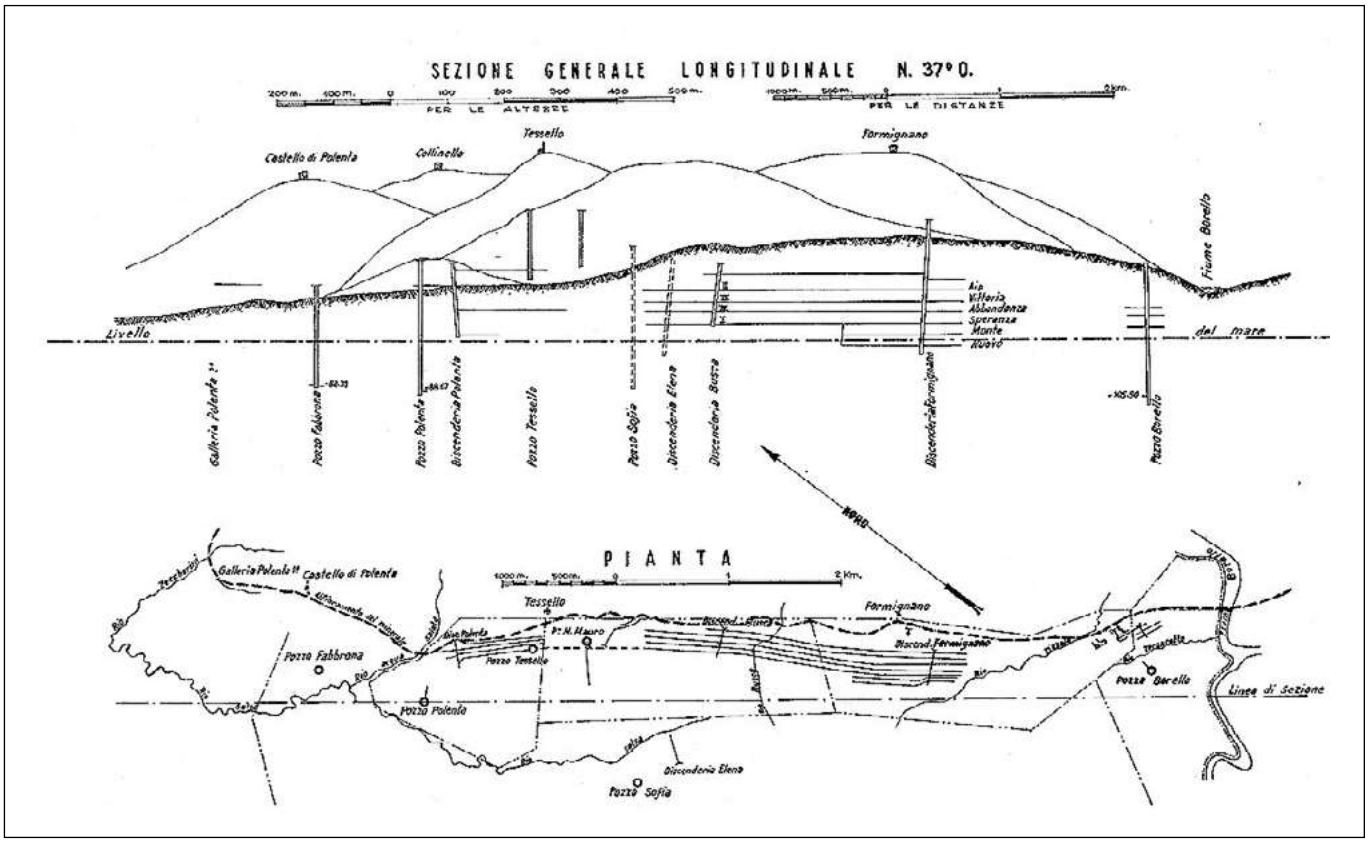
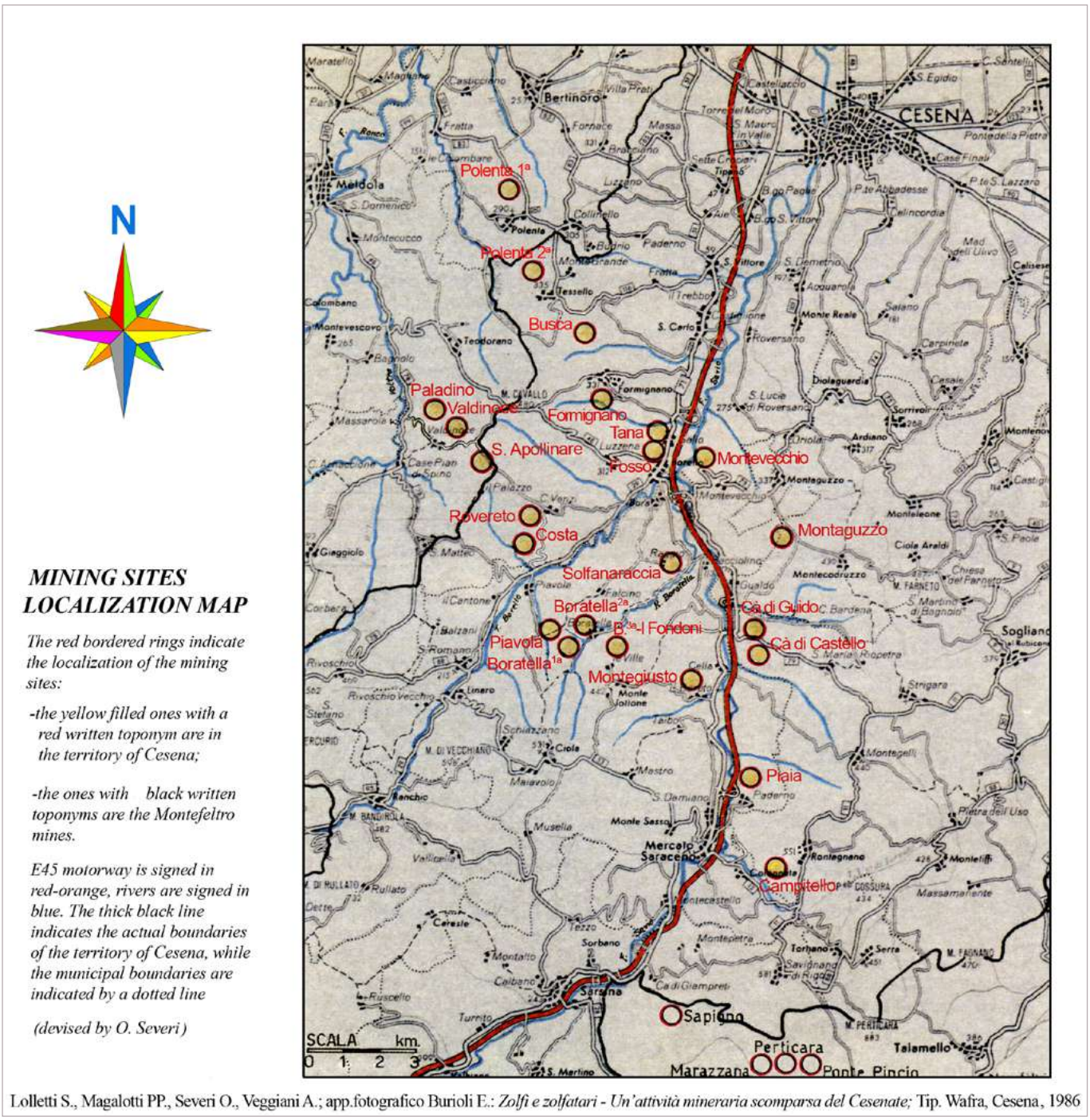


Fig. 3: section and plan of Formignano mining site (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 3: sezione e pianta del sito minerario di Formignano (Società di Ricerca e Studio della Romagna Mineraria).

sale price.
The producers in Romagna then decided to invest in the quality of the product, and to export it refined, in order to attract new markets and be able to compete with the sicilian sulphur.
In 1917, during the First World War, Montecatini, the biggest italian chemical company, decided to commit to sulphur, whose demand was steadily increasing due to the war; it acquired mines in the area and, as already mentioned, in a few years, closed all but the two most productive, Perticara and Formignano.
After the Second World War, the competition became unsustainable for italian producers due to the low cost of the American sulphur extracted almost pure with the modern Frasch process. The main mines remained open until 1962-64 in Romagna and until 1980 in Sicily, but with uneven results.
Technological development in the extraction of sulphur allowed the exploitation of new deposits and new sources for its production. Today, the sulphur story continues in other countries: United States, Canada, Japan, France, Poland, South America, Indonesia and the Philippines.

Formignano mining site

The Formignano mining site is part of the second largest basin of sulphur in Italy, after that of Sicily; it is located in Romagna, in the central-northern part of Italy.
Sulphur mining in the area has been going on since Roman times to the XX Century. The remains of this activity are now scattered throughout the territory and barely visible: the mine of Formignano, the last to close in Romagna, was the best preserved in the region before the annexation of the seven municipalities of Valmarecchia, province of Rimini (Scicli A. 1972).
The mining site is located approximately 1 km SE of Formignano, a small town near Borello, in the territory of Cesena (Forlì-Cesena province). The 2 km long and 500-600 meters deep vein is part of a formation 4-5 km wide and extended to 15-20 km (Fig. 3). Under the common name of Formignano it includes three fields of research and excavation; proceeding from NE to SW, they are "Polenta-Tessello", "Busca-Montemauro" and "Luzzena-Formignano", originally separated, and later interconnected by means of underground extensions of the galleries, and connected outside by a cableway (Fig. 4).
The first excavation certainly dates back to 1556. The exploitation of this mine was increased in the XIX century, during which the average production of sulphur went from a few dozen to 7,000 tons/year. During the XIX century the mine changed ownership several times. In 1843 it was run by the "Nuova Società delle Miniere Solfuree di Romagna", just formed in Bologna. In 1855, driven by the need to find new investors, this turned into a limited company with shares, the "Società Anonima delle Miniere Solfuree di Romagna". The company ran the Perticara mines (Montefeltro), and other mines including Formignano until 1896, when it was put into liquidation. After an attempt of self-management by a cooperative of workers and miners, in 1899 the mine was sold to a newly formed company, the "Miniere Solfuree Trezza-Albani Romagna", whose trade mark (the acronym



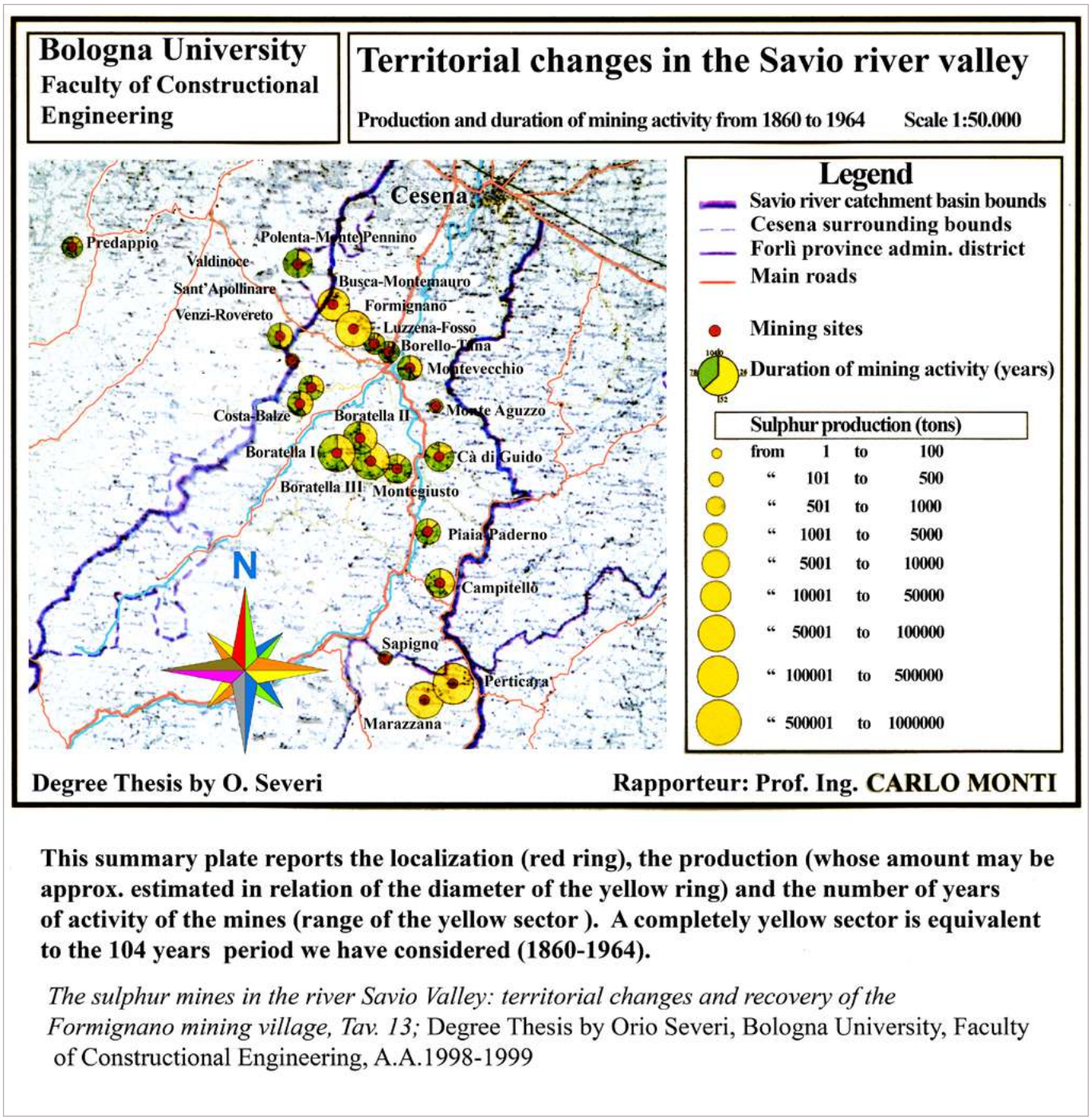
Lolletti S., Magalotti PP., Severi O., Veggiani A.; app.fotografico Burioli E.: *Zolfi e zolfatari - Un'attività mineraria scomparsa del Cesenate;* Tip. Wafra, Cesena, 1986

Fig. 4: location of sulphur mines in Romagna (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 4: ubicazione delle miniere di zolfo in Romagna (Società di Ricerca e Studio della Romagna Mineraria).

M.S.T.A.R.) was worldwide known (MONTI A., FAGIOLI D., 2005).

From 1917, in a short time the chemical company Montecatini acquired almost all the mines in the area and closed down several mines, keeping in activity only those in Perticara and Formignano where the Company invested in the modernization of machines and buildings. The difficulties in the extraction of the mineral, however, were always present: the veins were thin, the maximum power of two meters and in depth, thus requiring expensive digs, long and deep tunnels and a continuous drainage of great amounts of water. With the exception of a temporary closure in 1923, and during the Second World War, in 1945-46, mining activity in Formignano continued until 1962 (SEVERI O., 1998-1999), the year of closure: veins were not exhausted, but it was not more economically worthwile to keep it in business (Fig. 5).

In 1962 the excavation proceeded over 21 levels, to a depth of over 600 meters and covering an area of 3 squared kms; there were nine sloping adit downward (including the main one, 560 meters long, and that reached the eleventh level). The total production of the mine from 1861 to 1962 was of 409,000 tons of sulphur (reaching the peak in 1912, with 8,344 tons); on average there were 250 miners employed (with a maximum of 441 in 1910).



This summary plate reports the localization (red ring), the production (whose amount may be approx. estimated in relation of the diameter of the yellow ring) and the number of years of activity of the mines (range of the yellow sector). A completely yellow sector is equivalent to the 104 years period we have considered (1860-1964).

The sulphur mines in the river Savio Valley: territorial changes and recovery of the Formignano mining village, Tav. 13; Degree Thesis by Orio Severi, Bologna University, Faculty of Constructional Engineering, A.A.1998-1999

Fig. 5: territorial transformations in the Savio valley (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 5: trasformazioni territoriali nella valle del Savio (Società di Ricerca e Studio della Romagna Mineraria).

Formignano mining village

The Formignano mining village is located in an area of 20 hectares and includes buildings with a functional characterization (both for mining and for residential use for the employees of the mines) and melting plants; it is therefore a complete productive entity (Fig. 6).
The main group of buildings is aligned in E-W direction (Fig. 7), along two parallel paths: on one, at the upper level there are residential buildings, offices and warehouses, on the other, at a lower level, there are offices, workshops and laboratories. At the center of the two paths there is a water tank. The two paths are rejoined at both ends, and are connected in the middle (near the water tank) by a red brick staircase.
Away from the village we find, near the main entrance, a farmhouse, and below this, almost to the valley bottom (where once stood few miner's houses), the remains of a guesthouse. Near the present parking lot (where the Montecatini company built a tennis court for mine managers that was later dismantled) there is a small chapel dedicated to St. Barbara, the patron saint of firefighters and miners, and a plaque, erected in 2006, in memory of those injured and dead in the mine (MAGALOTTI P.P., 1998). The surrounding landscape still bears visible traces of mining activity (mounds of "*rosticci*", the burnt residues of the melting; Fig. 8), modification of the geological profiles and eco-habitat: it is a territory shaped both by nature and by man.

Fig. 6: the village of Formignano at the beginnings of the '900 (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 6: il villaggio di Formignano ai primi del '900 (Società di Ricerca e Studio della Romagna Mineraria).

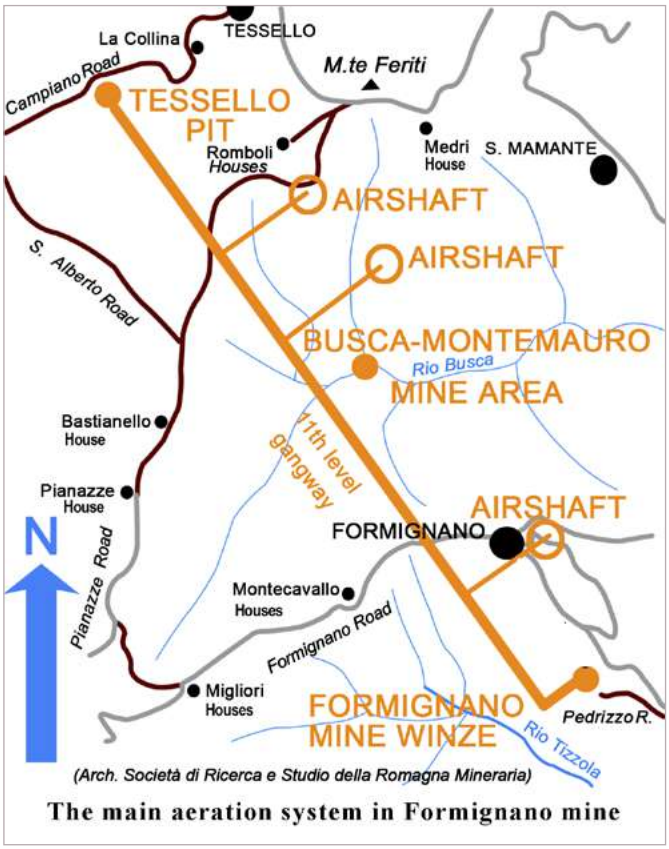


Fig. 7: the mining site map (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 7: la mappa del sito minerario (Società di Ricerca e Studio della Romagna Mineraria).

The life of a miner

Mining extraction in Romagna had a deep impact on its economy in the XIX century, still basically agricultural. Agriculture was going through a critical time, although it remained the main business until the XX century, alongside the work, often only temporary, in the mines. Sulphur mining changed the landscape (buildings, chimneys, excavations, gas fumes that destroy the vegetation, accumulation of residues from the melting and communication infrastructures) and, above all, the social texture of the area.

There was a previously unknown social mobility: workers of the mines were mainly farmers or laborers who, attracted by the possibility of a work with higher income, moved from the surrounding hills in the mining area along with their families.

But from a typical outdoor work, based on the rhythm of the seasons, they found themselves facing stiff shifts (8-12 hours) in a closed and hostile environment, with a strict hierarchy to adapt to, with new operational schemes to learn quickly, that had nothing to do with the traditional work of the fields, passed down from generation to generation (Figs. 9 and 10).

There was a dramatic change, from the traditional patriarchal family and a community with close ties to new work in a community of strangers. The family of "modern times" was quickly and brutally taking hold.

The working conditions were hazardous both for the frequency of collapses and the possibility of fires in the tunnels. In addition, sulphur trioxide which exhaled from smelting heavily polluted the air and caused severe lung disease in miners, as well as the dust of the excavations. The mortality was high and life expectancy was around 30 years old (Veggiani A., Lolletti S. Magalotti P.P., Severi O., Conti G., 1986).

The families lived in small shacks close to the mine, and contamination by sulphur trioxide, that burned all the vegetation, made it very difficult to grow any vegetable that could supplement the meager diet of the miners.

The essential food (meat, milk, oil, lard, wine, salt, etc) could be bought in small shops built near the mine (called "bettolino", i.e."canteen" or "box-office"), usually owned by the mining company itself, in a monopoly system. External controls on prices or checks on the quality of the food were rare; as a result, the miners and their families were subject to economic exploitation and to many severe diseases.

The purchases were made on credit scoring with notches carved on a wooden rod amounts and the distances between the notches were proportional to the debt that was withheld directly from the miner's wage. If this system met the needs of the miners in appearance, as they were almost all illiterate, it actually favoured the mining company, which imposed a heavy tax by way of additional charges for keeping the account. These shops were often the only meeting places of the miners and, quite often, they became the stage for arguments and fights that could degenerate and lead to revolver shots or stabbings.

From the second half of the XIX century the first attempts by the miners to improve the conditions of work and life took place. They formed associations of assistance for workers to help the miners in need: they were the first steps towards the creation of those cooperatives that later in the XX century would have profoundly marked the history of our region and of the whole country. And, even under the strict control of the authorities, many small circles, inspired by the new political ideas of an egalitarian society and human rights began to spread.

Fig. 8: an exemple of “rosticcio” (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 8: un esempio di "rosticcio" (Società di Ricerca e Studio della Romagna Mineraria).

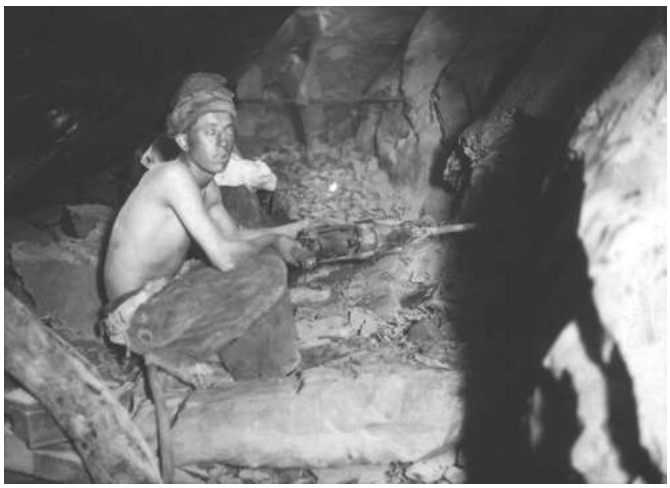


Fig. 10: gallery with miners at work (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 10: una galleria con i minatori al lavoro (Società di Ricerca e Studio della Romagna Mineraria).

The Società di Ricerca e Studio della Romagna Mineraria

After one hundred years since the establishment of the “Società di mutuo soccorso fra i liberi minatori del Borello” (which took place in 1872), on July 28, 1987, the *Società di Ricerca e Studio della Romagna Mineraria* was established with the purposes of interdisciplinary research, study and enhancement of the mining heritage in Romagna. It also aimed at promoting the recovery of the most significant aspects of mining archeology after the closure of the Formignano mine in June 1962.

In 1988, with the contribution of the *Cassa di Risparmio di Cesena*, a part of the archive of the company *“Società Anonima delle Miniere Solfuree di Romagna”*, which owned mines in Perticara, Formignano and Montefeltro in the XIX century until August 1895 was acquired and stored, and roughly catalogued in the Biblioteca Malatestiana di Cesena.

From the 1980s to the present day, various initiatives have been promoted by the Society, including the participation in 2006 in the cultural project of the European Community called MINEU for the enhancement of abandoned mining sites.

The museum that does not exist

The Formignano mine was used as a quarry of inert material for a long time after the closure; in the 1980s a first awareness of the importance of recording and telling its history raised. Oral histories, photographs and written records began to be collected by those who later formed the *Società di Ricerca e Studio della Romagna Mineraria*.

In addition to research, the cultural project of the Society has developed over time through the promotion of an annual *Sagra del Minatore* (Miner Fair), guided tours of the site, publications, seminars, exhibitions, creating the website *Paesi di Zolfo* (Sulphur lands), a

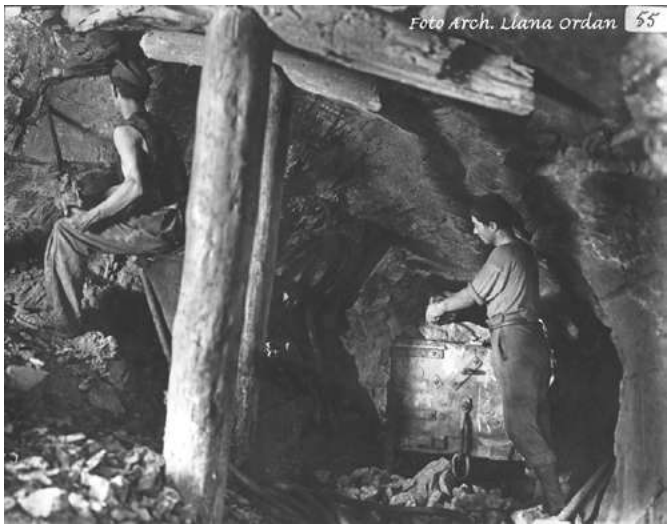


Fig. 9: shipyard inside the Formignano mine (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 9: un cantiere all'interno della miniera Formignano (Società di Ricerca e Studio della Romagna Mineraria).

Fig. 11: Formignano today (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 11: Formignano oggi (Società di Ricerca e Studio della Romagna Mineraria).

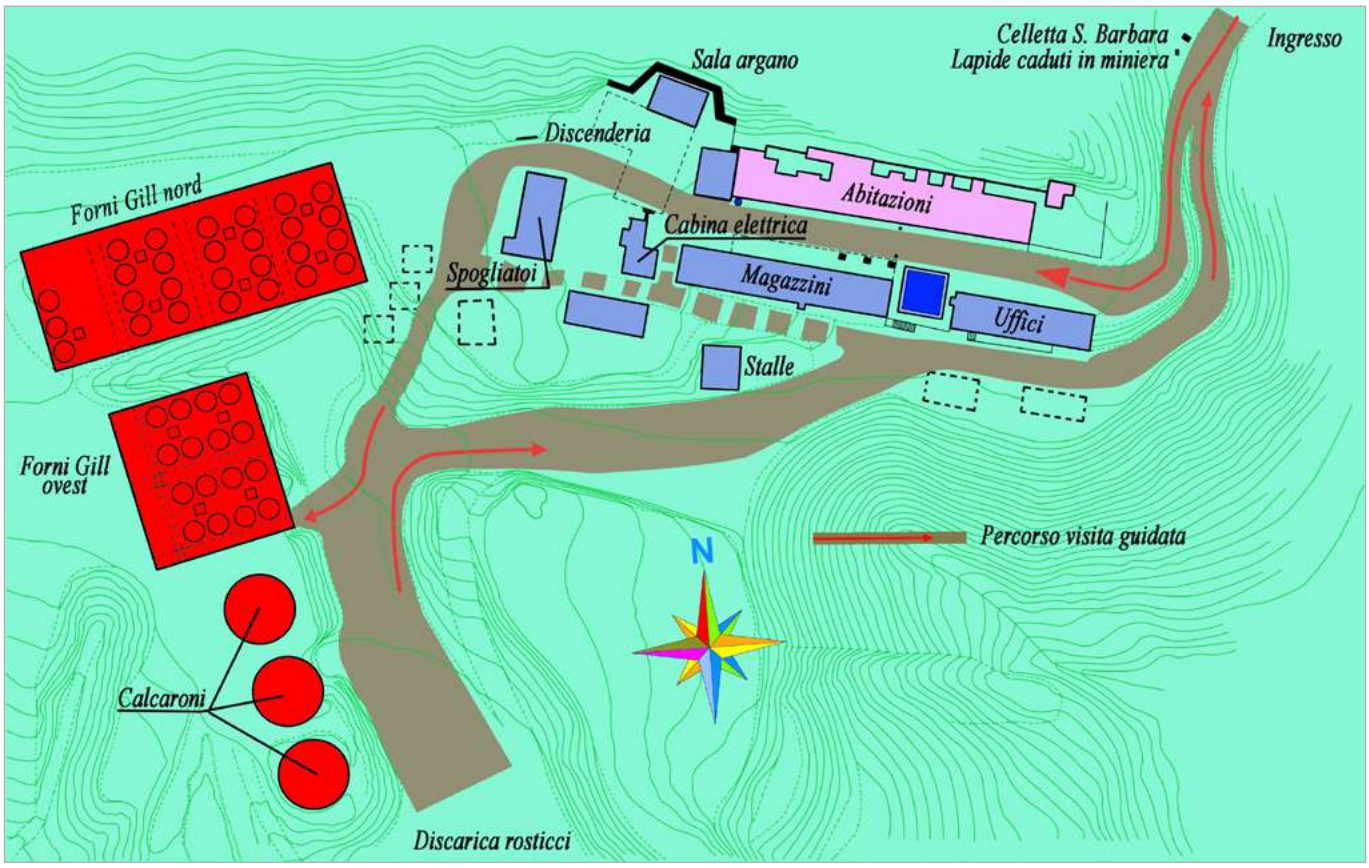


Fig. 12: the project for a museum (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 12: Il progetto per un museo (Società di Ricerca e Studio della Romagna Mineraria).

six-monthly newspaper.
In the 1990s, the focus of the activity was on the development of the area as a cultural heritage site, aiming at the restoration of the buildings and the acquisition of equipment from other mines (Fig. 11). A project for a mining museum-park with recreational and commercial activities in the name of sustainable development was developed in 1999; the area was purchased by the Town Council and it was declared of historical interest (Fig. 12).
Moreover, a documentation center with the headquarters of the *Società di Ricerca e Studio della Romagna Mineraria* would have been developed on the site in order to manage the cultural initiatives as permanent exhibit and temporary events to record and promote the long history of the mines and its workers. Unless the minimal safe stabilisation of a tunnel access to a battery of ovens Gill, the chronic lack of funds did not allow other interventions. Currently there is only a project to transform the site into a museum with ancillary commercial and hospitality activites that has been approved but the funds are not yet available.

Conclusion: do not forget!
Despite promises and expectations, the funds allocated and then cut due to the looming economic crisis, unfortunately, the site of Formignano has not become a mining museum of Romagna.
But the extensive work of the *Società di Ricerca e Studio della Romagna Mineraria*, through the recovery of materials, the study and promotion of initiatives aimed at leaving a trace in memory is an heritage to protect, and not to make us forget our origins (Figs. 13 and 14). We would like, in closing this paper, to remember the valuable contribution of a mining witness, Balilla Righini, who died recently at the age of one hundred years, knighted for his work merit by the President of the Italian Republic. and that told in his miner stories a past that does not emerge in historical documents, and that talks about the life in the sulphur mines in Formignano.

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References
Lipparini T. (a cura di), 1930, *Storia naturale de' gessi e solfi delle miniere di Romagna,* in: E. Lovarini e Comitato Marsiliano (a cura di), Scritti inediti di Luigi Ferdinando Marsili, Nicola Zanichelli, Bologna, pp. 189-211.
Magalotti P.P., 1998, *Paesi di Zolfo - Le miniere di zolfo nel Cesenate - Vicende storiche, economiche e sociali*, Società editrice Il Ponte Vecchio, Cesena.
Masini V., 1759, *Il Zolfo – Poema,* Biblioteca Malatestina, Cesena.
Monti A., Fagioli D., 2005, *Le antiche solfare del*

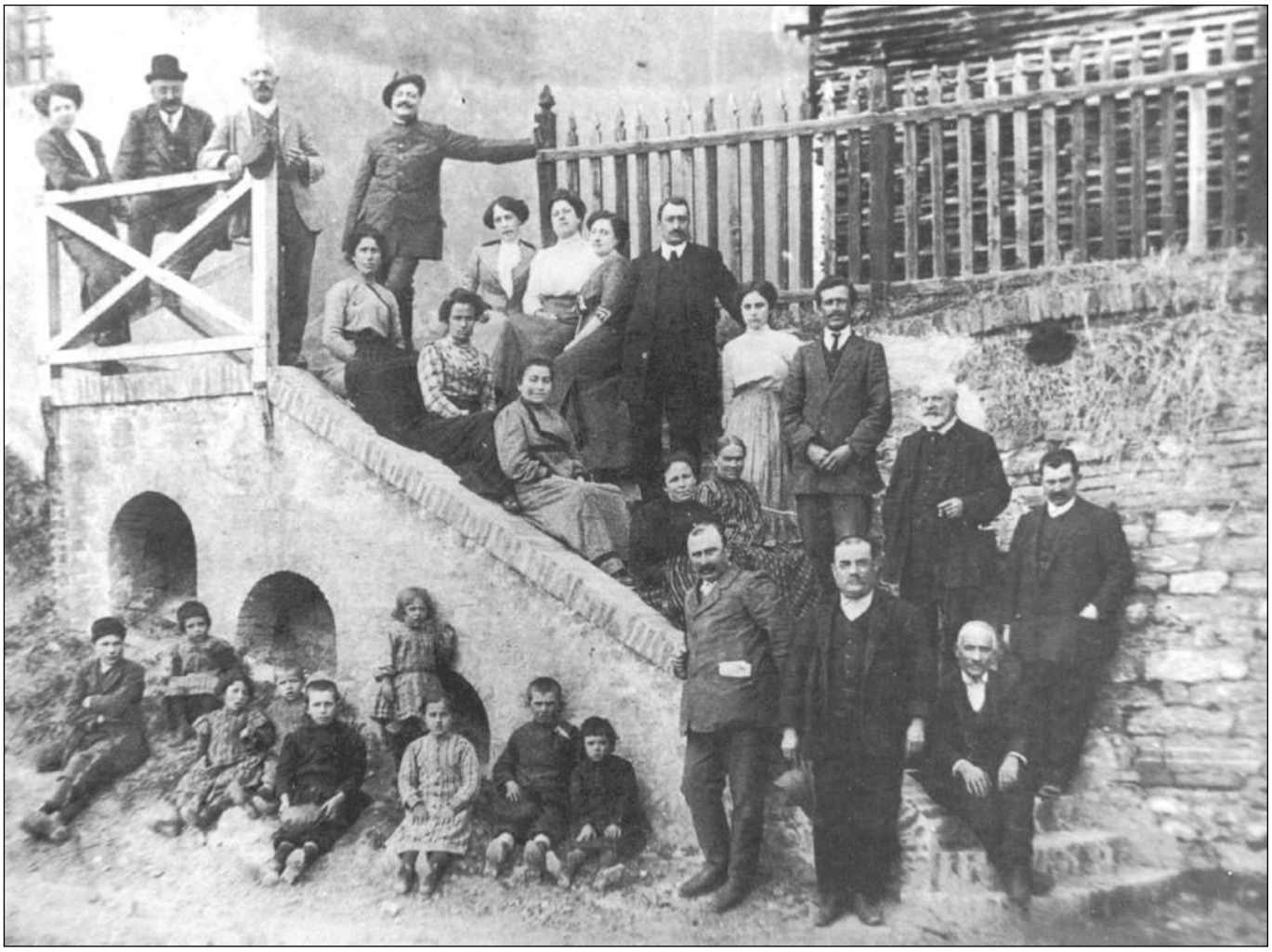

Fig. 13: Group photo at Formignano (1908) (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 13: Foto di gruppo a Formignano (1908) (Società di Ricerca e Studio della Romagna Mineraria).

Cesenate - Tre itinerari nel presente e nel passato delle minire di zolfo del Cesenate, Società editrice Il Ponte Vecchio, Cesena.
Scicli A. 1972, *L'attività estrattiva e le risorse minerarie della regione Emilia-Romagna*, Poligrafico Artioli, Modena, pp. 24-155.
Severi O., *The sulphur mines in the river Savio Valley: territorial changes and recovery of the Formignano mining village,* Degree Thesis, Bologna Univerity, Faculty of Constructional Engineering, A.A. 1998-1999.
Veggiani A., Lolletti S. Magalotti P.P., Severi O., Conti G., 1986, *Zolfi e zolfatari*, Tipografia Wafra, Cesena (Photographic collection edited by Eraldo Burioli).
Newsletter of the Società di Ricerca e Studio della Romagna Mineraria "Paesi di Zolfo".
Web site of the Società di Ricerca e Studio della Romagna Mineraria: www.miniereromagna.it.

Fig. 14: The same stair today (Società di Ricerca e Studio della Romagna Mineraria).
Fig. 14: La stessa scala oggi (Società di Ricerca e Studio della Romagna Mineraria).