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MINERAL RESOURCES MAPPING IN THE 18TH CENTURY (TUSCANY, ITALY)

Cartografía de recursos minerales en el siglo XVIII (Toscana, Italia)

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ABSTRACT

The Miscellanea di Piante section of the State Archives of Florence (SAF) preserves eight mining maps, drawn up during the Lorraine regency period of the Grand Duchy of Tuscany (1737-1765). In this article, we have analysed four maps produced in 1766 by Carlo Mazzoni, a Tuscan engineer, in Northern Tuscany (Apuan Alps, near Massa) and four maps made probably in 1760-1765 by Francis Anton Eegat - a German speaking technician - in Southern Tuscany (surroundings of Volterra and Massa Marittima - "Metal-bearing Hills"). This paper aims to evaluate the maps beyond the simple representation of territory, through technical analysis of recorded symbols and data from a geological-mining point of view. Upon completion of this analysis, it will be possible to understand what practical knowledge of mineral resources was available in the 18th century, before the foundation of mining academies.

KEY WORDS: Apuan Alps, Metal-bearing Hills, mine maps, mineral resources, Tuscany.

RESUMEN

En la sección "Miscellanea di piante" del Archivo nacional de Florencia se conservan ocho mapas mineros realizados durante la época de la regencia de los Lorena en el Gran Ducado de Toscana (1737-1765). En este ensayo hemos analizado cuatro mapas realizados en 1776 por Carlo Mazzoni – un ingeniero toscano – en el norte de la Toscana (los Alpes Apuanos, cerca de Massa) y cuatro mapas producidos (probablemente en 1760-1765) por Francis Anton Eegat – un técnico que hablaba alemán – en el sur de la Toscana (los alrededores de Volterra y Massa Marittima – Colinas Metalíferas). Este ensayo quiere considerar los mapas, además de la simple representación del territorio, mediante un análisis técnico, desde el punto de vista geológico y minero, sobre símbolos y datos registrados. Al final de este análisis será posible comprender los conocimientos prácticos de los recursos minerales en el siglo XVIII, antes de la fundación de las academias mineras.

PALABRAS CLAVE: Alpes Apuanos, Colinas Metalíferas, mapas mineros, recursos minerales, Toscana.

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INTRODUCTION

In 1737, after the death of Gian Gastone de' Medici, the last ruler of the Medici dynasty, Duke Franz III von Lothringen left Lorraine and became the new Grand Duke of Tuscany, the first of the Lorraine dynasty. In 1736, he married Maria Theresia von Österreich but remained distant from his new dominion, ruling Tuscany by means of a regent, and preferring to stay at the imperial court in Vienna, where he became Kaiser Franz I in 1745. During the Lorraine regency period (1737-1765), the primary aim of the rulers was to determine the potential of the economic resources (agriculture, industry and raw materials) of the new grand duchy (Rombai, 1987; Riparbelli, 1989a). Therefore, the Lorraine introduced the "French model" of cartography (widespread in Europe) as a basic

tool for the rule and growth of territory (Guarducci and Rombai, 2011).

In 1737, Franz III appointed the Prince of Craon as regent in Tuscany, supported by Emmanuel Nay, Count of Richecourt, who became the following regent in 1749.

At this time, the renowned naturalist Giovanni Targioni Tozzetti (1712-1783) lived and worked in Florence. In 1743, he wrote to the Count of Richecourt describing the profit expected from Tuscan mines. Subsequently, between 1751-1754, Targioni Tozzetti published his greatest work in six volumes, which gave an account of his journeys to several places in Tuscany, and reported a great many observations on nature and history there (Targioni Tozzetti, 1751-1754). Probably due to such indications, a survey on all Tuscan mining sites, until then unproductive or abandoned, was started thanks to the contribution of expert technicians. The regency assigned the technicians Carlo Maria Mazzoni and Francis Anton Eegat to the task of conducting surveys and making maps of active or abandoned mines and their surroundings. The results of these surveys were reproduced in eight maps: four by Mazzoni (1766 a-d) in the Apuan Alps (Northern Tuscany), and four by Eegat (1760-1765 a-d) in the surroundings of Massa Marittima and Volterra (Southern Tuscany) (Fig. 1). These maps, among others, have already been studied, especially from a geographical point of view (Francovich and Rombai, 1990 and Rombai, 1991).

TUSCAN PRECURSORS AND TARGIONI TOZZETTI

Many famous technicians, scientists and naturalists were active in Tuscany from the Renaissance until the 18th century; in this study we mention only a few who are interesting because of their work on mineralogy or mines. In 1540, Vannoccio Biringuccio (1480 - 1539?) published posthumously *De la Pirotechnia* (Biringuccio, 1540), at least 10 years before the *De Re Metallica* by Georgius Agricola (1556), although unfortunately it was less known abroad as it was written not in Latin but in the Tuscan language. Biringuccio was a master craftsman in smelting ore and metallurgy: in his book he deals with mining engineering, describes and debates minerals and their uses, the veins of metal, the rules for exploiting a mine and mineral processing. For the first time, he applied his knowledge of geology and mineralogy to industrial and practical problems, by introducing applied and economic geology. He was a mining-metallurgy engineer skilled in artillery and artistic melting; he travelled a great deal and worked in Carnia, Friuli, Durrës, Venice, Saxony, Lombard valleys and Milan.

Grand Duke Ferdinando II de' Medici established the Sperimentale Accademia Medicea in 1642, and was also patron of the Accademia del Cimento, the first scientific society with an experimental nature, founded in 1657. In addition, Ferdinando was a generous patron of the most influential scientists of the time: Francesco Redi, Lorenzo Magalotti, Marcello Malpighi, Galileo Galilei, Evangelista Torricelli and Vincenzo Viviani.

Niels Stensen (1638-1676) was a Danish physician, naturalist and Catholic bishop, as well as a pioneer of geology and stratigraphy; in 1666 he moved to the court of Ferdinando II de' Medici in Florence. In addition to his anatomical studies, in 1669, Stensen (Latinized as Steno) published *De solido intra solidum naturaliter contento dissertationis prodromus*, where he discussed the origin of fossils, the natural laws controlling the appearance of crystals, the bodies included in crystals, and the geological structure of Tuscany (Morello, 2003). Steno formulated several opinions on tectonics, speculated about floods as the origin of sedimentary rocks and, after accurate observations on crystals, established Steno's law of constant angles, also known as the first law of crystallography.

During two centuries, the Targioni Tozzetti family were an influential reference point for the scientific and cultural life in Tuscany. The best-known naturalist of the family was surely Giovanni Targioni Tozzetti (1712-1783), a physician, botanist, mineralogist, cartographer, geographer and historian. He inherited a passion for sciences both from his uncle Cipriano Antonino Targioni (1672-1748) and from his teacher Pier Antonio Micheli (1679-1737), a botanist and mycologist.

Giovanni Arduino (1714-1795), a renowned Venetian geologist (Dal Piaz, 1922), became a friend of Targioni Tozzetti while he was active in Tuscany as a mining engineer appointed from 1753-1757 at the Carbonaie copper deposit (Merse Valley), following which the two kept in touch by mail (Vaccari, 2008). In the autumn of 1742 and 1743 and the spring of 1745, Giovanni Targioni Tozzetti made several journeys of scientific discovery in Tuscany. In 1743, he wrote two letters to the Count of Richecourt to arouse the Regency's interest in the wealth lying in Tuscan mines. Relying on his examination and experience, he wrote the *Breve relazione delle osservazioni fatte sopra le miniere del Contado di Pisa, Volterra, Siena e Massa Marittima nell'autunno dell'anno 1742* (Observations on the Tuscan mines - Targioni Tozzetti 1743a) dated March 5, 1743, and then the *Dissertazione del Dott. Giovanni Targioni sopra l'utilità che si può sperare dalle miniere della Toscana* (On the benefit expected from Tuscan mines – Targioni Tozzetti 1743b) dated April 24, 1743. We do not have any information on Richecourt's answer, but we know that, after these letters, Targioni Tozzetti published (1751-1754) the first edition in six volumes of his renowned work *Relazioni d'alcuni viaggi fatti in diverse parti della Toscana per osservare le produzioni naturali e gli antichi monumenti di essa* (Reports on journeys in Tuscany). In this work, together with an account of his journeys, he also described a great many observations on Tuscan mines. In the fourth volume, he included a long and detailed report on the Apuan Alps mines, written by the Swedish metallurgist, Reinhold Angerstein (1718-1760). This report, with the attached map of the Bottino silver mine, is dated September 19, 1751: *Relazione delle miniere che sono nella Montagna di Seravezza, Capitanato di Pietrasanta* (Angerstein, 1751; Targioni Tozzetti, 1754; Seccaroni and Haldi, 2016). Probably thanks to these indications and to the strong stimulus by Targioni Tozzetti, in 1760 the expert technicians Carlo Maria Mazzoni and Francis Anton Eegat were entrusted with the task of conducting surveys

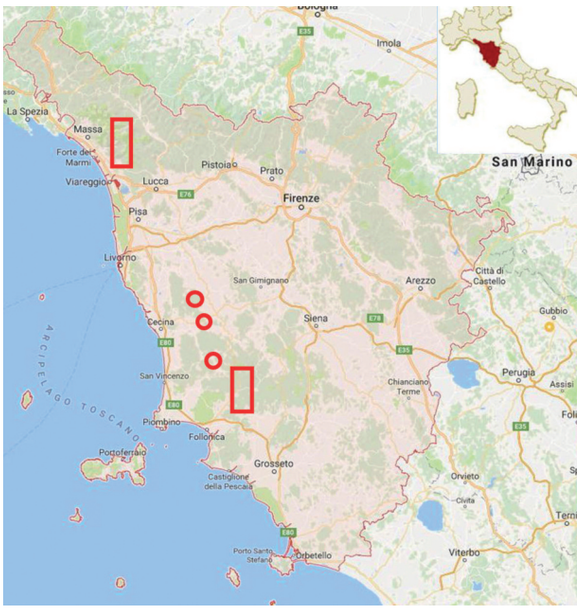

Figure 1. Location of maps by Mazzoni and Eegat in Tuscany.
Figura 1. Mapa de localización de los mapas de Mazzoni y en la Toscana.

and making maps of active or abandoned mines and their surroundings for the Real Estate Register.

PREVIOUS INFORMATION ON THE MAPPED MINES

For more ancient times, there are no books providing information on Tuscan mines; but in *De la Pirotechnia* (1540) Biringuccio wrote of the iron foundry and mine at Boccheggiano (Della minera del ferro, et sua natura – cap.VI, libro I, 46), and the alum rock mine of Monterotondo (Dell'alume di rocca , et sua minera – cap. VI, libro II, 76), near Siena. Afterwards in *Relazioni d'alcuni Viaggi*, Giovanni Targioni Tozzetti illustrated various mines with accurate details. He wrote about the Caporciano copper mine near Montecatini Val di Cècina (Osservazioni intorno alla Miniera di Rame di Caporciano - Tomo 2, 289-300): in 1742, the mine was abandoned; in the hill towards east there were four shaft openings (almost completely filled) and another two closed shafts towards the north. From the dump, he collected and accurately described six samples of host rock and mineralization and reported information on the history of this mine. Caporciano mine was exploited from the 15th century until 1630, when it was abandoned due to a plague and, later, to an accident that occurred during an unlucky attempt to reopen. Finally, Targioni Tozzetti spoke about the economic benefit of reopening this rich mine and suggested open-pit mining, suitable to avoid high costs and underground water problems. He spoke about the presence of coal near Querceto (Carboni fossili del Comune di Querceto, e luoghi adiacenti - Tomo 2, 364-367), and located large pieces of coal in creeks that had been mined and used in the past for the forges in Leghorn. Afterwards, Targioni Tozzetti visited the Montieri silver mine (Osservazioni intorno alla Miniera d'argento di Montieri - Tomo 3, 52-59), which he believed was much older than the first written records (from the 12th century) and, from the huge amount of slag, he dated mining activity back to the Etruscan age. He recognized 30 old shafts, named Bottini, very near to each other but almost all buried and not possible to explore. However, Targioni Tozzetti searched in the mine dumps and residues of metallurgical operations and took samples for later examination by an assayer. Later, in August 1751 in Florence, he met the two Swedish mining experts, Alexander Funck and Reinhold Angerstein (Francovich and Rombai, 1990), from whom he learned a great deal and received other useful information on Tuscan mines. In the slag heaps of Montieri, as well as in those of Caporciano, Funck and Angerstein noticed that there was still a very large quantity of silver and a fair amount of copper, left by unskilled ancient metallurgists, and underlined the ease with which these metals could be recovered to provide a significant profit. The Swedish experts were astonished by the wealth remaining in these abandoned mines, but understood that this inactivity was justified by the high earnings from Tuscan farming. Near Montieri, Targioni Tozzetti observed the Carbonaie mines (Descrizione delle Miniere delle Carbonaie - Tomo 3, 59-63) on a steep southern knoll brushed by the Merse River. The slopes were entirely dug over and full of holes or filled up shafts. Towards the west was the Cagniano ditch, where he saw a big vein of marcasite (pyrite), and other similar, but smaller veins downhill. There were no previous records of these ancient mines, but Targioni Tozzetti did not believe that they were used only to mine green vitriol (ferrous sulphate), but also to extract silver. Next, he travelled towards Massa Marittima and reported the presence of several ancient abandoned mines near Boccheggiano and Prata. He was unable to examine personally the surroundings of Massa Marittima because of the heavy rain, but heard and wrote down a great deal of useful information (Minerali del Territorio di Massa - Tomo 3, 128-150). Among numerous ancient mining sites, Targioni Tozzetti spoke of Serra ai Bottini and Valle di Pozzoia; both toponyms referring to shaft structures. As for minerals, Targioni Tozzetti mentioned crusts of malachite (green copper hydroxycarbonate) and azurite (blue copper hydroxycarbonate), marcasite (pyrite) and also iron, lead, silver, copper and alum. After these observations on the surroundings of Massa Marittima, his next journey was to Northern Tuscany, near Massa, in the Capitanato di Pietrasanta. He spoke about the lead/silver mine of Terrinca (Miniere di Piombo di Terrinca - Tomo 4, 117-119) and, in some samples, recognized veins of galena and sphalerite, with quartz, ochre and perhaps calamine. He then went on to personally explore the La Cavetta mercury mine of Levigliani (Miniere di Mercurio di Levigliani - Tomo 4, 119-138) where the quicksilver was in a thin layer on the surface of white quartz veins and in droplets of virgin fluid metal. About 60 m towards west, there was another mine of cinnabar (red mercury sulphide). Targioni Tozzetti did not understand why these mines were abandoned; he reported a story on thefts of mercury and sabotages by miners and envisaged future profitable exploitation. Near Gallena, he saw the famous Bottino silver mine (Osservazioni fatte alle Miniere d'Argento di Gallena - Tomo 4, 145-160), but he was not able to enter

because the tunnel was filled with water. Thanks to the examination of samples collected in the past from this mine, he concluded that the mountain held a large amount of silver, although mixed with other metals. He was unable to find the reason for this state of abandon, but he maintained that it was probably due to the highly complex mix of metals and consequently to the low recovery of silver in the crucible. Later, Targioni Tozzetti spoke about several ancient mines in Valle di Castello near Pietrasanta (Miniere d'Argento, e di Rame di Val di Castello - Tomo 4, 193-204). He said that this valley was already known to be rich in metals (iron, lead, silver and copper) by the ancients, so everywhere there were pits and galleries now blocked by with earth or water. In order to overcome the shortcomings and to complete the information, he inserted in the book Reinhold Angerstein's complete report (with maps) on these mines (Relazione delle Miniere che sono nella Montagna di Seravezza, Capitanato di Pietrasanta - Tomo 4, 204-211). In 1745, Targioni Tozzetti travelled to Monterotondo on the orders of Count of Richecourt, to observe the alum mine of Monte Leo. In his book (Allume di Monteleo - Tomo 4, 312-351), he differentiated the types of alum and outlined the phases of its manufacturing. He said that this mine had been operated several times in the past (in 1604, 1652 and 1660) until the last reopening in 1744, under the superintendent Monsieur Vidau appointed by Count of Richecourt.

CARLO MARIA MAZZONI AND HIS WORK

Carlo Maria Mazzoni was born in 1720 at Calcaferro, near Mulina di Stazzema, in the territory of Massa (Northern Tuscany). His rather humble origins were in the area around Parma, from where his great-grandfather had migrated to work in the Grand Duke's ironworks (Bramanti, 2001). He graduated from Pisa "in utroque jure" (in civil and canon law) and, after some training in land-surveying, in 1759 he began to practise as a public land-surveyor, and afterwards as an engineer in the service of His Royal Highness and as overseer of the Uffizio dei Fiumi e Sciali (Rivers and canals office) of the Captaincy of Pietrasanta, as well as for the local Records Office. From 1761 he held the title of Academic Florentine. His skilful cartographic reliefs show a careful professionalism and probably training by valuable instructors, perhaps abroad (Bramanti, 2001). He worked on significant projects, among which, in 1761, the most important was the control and repair of Fiume Vecchio, a canal crossing the plain of Pietrasanta (Guarducci, 2009). Mazzoni had frequent assignments from the Lorraine government, both under Franz Stephan and Peter Leopold, since he was one of the best engineers and mapmakers in Grand Duchy. Indeed, the skill in processing and accuracy shown in his map-making technique was nothing short of excellent; he also provided abundant documentation in his works. In March 1766, Mazzoni was commissioned by Peter Leopold to collaborate with Karl Friedrich Eder, first overseer of Transylvania mines, sent to "visit and identify the mines of the Grand Duchy". Eder located a new copper deposit in Valtiberina (Tiber Valley), which Mazzoni reproduced with outstanding accuracy on his topographic map of Val di Tevere in Tuscany. Furthermore, Mazzoni dealt with the map making of some small areas of the Apuan Alps, including mine deposits: the lead-silver mine of Bottino, cinnabar in Levigliani, lead-silver in Zulfello, lead-zinc in Materrata and the mines of Angina canal near Sant'Anna di Stazzema, and Buca del Tedesco near Corchia Mountain. These maps are Mazzoni's main work and show great care in the drawing and an abundance of descriptive elements giving information on mines and Tuscan geology (Riparbelli, 1989b). Mazzoni went on with his work in hydraulic and road branches, his last work appearing in 1784 (Boncompagni and Ulivieri, 2000); the date of Mazzoni death is uncertain.

TECHNICAL ANALYSIS OF MONTAGNA ACUTI AND MONTAGNA GABBARI MAPS (APUAN ALPS)

In 1766 Mazzoni produced the *Pianta topografica ed altimetrica minerale della Montagna Acuti e de suoi monti aggiacenti nel Capitanato di Pietrasanta* (Fig. 2), integrated with the neighbouring *Pianta topografica ed altimetrica minerale della Montagna Gabbari e de suoi*

Figure 2. Map of mount Acuti with the Bottino mine
Figura 2. Mapa del monte Acuti con la mina Bottino.

monti adiacenti nel Capitanato di Pietrasanta. The legend of the first map reads: "La presente pianta confina e si unisce alla Pianta della Montagna Gabbari, ed i Monti di quella sono uniti ai monti di questa Montagna Acuti, essendo fra di loro corrispondenti in tutte le parti, e proporzioni di Planimetria e di Altimetria" (This map adjoins the map of Mount Gabbari and connects with it and its mountains are linked to the mountains of Mount Acuti, because they correspond in all parts of planimetry and altimetry). The two maps assembled together form a table of 166 x 204 cm, drawn to a scale of 1:1,680, with a planimetric view in the lower part reproducing an area of 6 km^2. Mazzoni used the Florentine pre-metric length, the *pertica*, for these maps. This unit is made up of 3.5 *braccia a panno fiorentino* (Florentine cloth arm units, each one corresponding to 0.5836 m) for a *pertica* length of 2.0426 m. The scale drawn on the map is 300 Florentine *pertica* long. In the upper part, there is a WSW towards ENE perspective view of the same area, providing a better panorama of the geographical features of the Acuti and Gabbari mountains. Mazzoni produced only one hand-drawn map for the Grand Duke since, at the time, wood engraving or copper etching was used to mass-produce other maps for the public. Mazzoni's map is made in four colours: dark brown (mountains, orography), blue (streams, creeks), black (some details and shadows) and red (toponyms, digits, and letters). The morphology of the territory is portrayed by shading technique; hatching is used to depict relief, while profile in the upper part of the map helps the observer to understand the territory. Heights are not indicated, contour lines are absent and the shaded relief has a variable direction of light, mainly from east. Hydrography is very detailed: creeks and streams are wide, with blue riverbeds and black banks. Streets and paths are drawn by two black lines and show sharp corner turns: this is a clue that a careful angular survey was probably made by using a compass. Toponyms are written in red block letters while small towns are written in bigger point size inside a scroll ornament. Different species of vegetation or types of woods are written in black block letters (scrub, low maquis, beech maquis, chestnuts). Both maps have a common grid made up of squares (Fig. 3) with the side of about 30 *pertica* units (ca. 60 metres), and numbered similarly to the Cartesian method (1-52 horizontal from left to right and 1-43 vertical from top to bottom). This network of squares can also be used for distances but its main aim is easy, exact and quick identification in planimetry and altimetry, by means of coordinates of the position of mills, furnaces, tunnels, shafts and seams indicated in the legend by numbers and letters (Fig. 4). The legend is very detailed and Mazzoni carefully describes all the tunnels, diggings, shafts and surface mining in the whole mapped area of the famous Bottino lead-silver mine (Fig. 5). He reports the presumed age of mining works, specifies whether it is from Antiquity or Roman, and also the type of host rock: *pietra morta* - dead stone i.e. sandstone - (Targioni Tozzetti, 1751; Artini, 1979), *pietra calcaria bastarda* - spurious limestone i.e. marl-limestone - and *pietra bastarda* - spurious stone i.e. marl-mudstone -. Furthermore, the host rock is represented by slate, phyllite and schist pertaining to the Tuscan Hercynian Basement (F. 260 Servizio Geologico d'Italia, 2010). Mazzoni identifies the type of veins by the metal contained or by minerals: plumbeous (lead), plumbeous-ferruginous (lead-iron), ferruginous or ochreous (iron oxides), plumbeous with green-blue dyes (lead-copper), marcasite (iron sulphide), white-yellowish marcasite, cinnabar (mercury sulphide), native quicksilver (mercury) and sulphur and/or other sulphides. The map records the direction of veins measured by a miner's compass, which seems to have been a well-established technical aid to the mining industry since 1556, as described in Georgius Agricola's *De Re Metallica*. Mazzoni uses a miner's compass with 24 divisions to measure tunnel orientation (north 0, east 6, south 12 and west 18). He probably indicates the thickness of the vein with the letter "G" followed by two or three digits. The legend describes difficult situations such as : shafts and tunnels filled with stone or water, collapsed girders and impervious tunnels or very hard rock requiring blasting powder. At the bottom of the legend, Mazzoni wrote: "Da tutti e ciascheduno de i descritti luoghi e gallerie dove si è trovato filone di qualunque sorte se ne cavarono prove" (Samples were extracted from all the described places and tunnels, where any type of vein was found).

Figure 3. Grid of squares and scale of 300 *pertica*.
Figura 3. Cuadrícula y escala de 300 perticas.

TECHNICAL ANALYSIS OF MONTAGNA CORCHIA AND MONTAGNA SOLIONI MAPS (APUAN ALPS)

In 1766, Mazzoni also produced the *Pianta topografica ed altimetrica minerale della Montagna di Corchia per alcuni monti a quella aggiacenti nel Capitanato di Pietrasanta e nel comune di Terrinca situati* and the *Pianta topografica ed altimetrica minerale della Montagna di Solioni per alcuni monti a quella aggiacenti nel Capitanato di Pietrasanta in comune Livigliani* (Fig. 6). Both maps are smaller (57 x 44 cm) than the Montagna Acuti - Gabbari map, but they have the same graphic

Figure 4. Detail of perspective view.
Figura 4. Detalle de la vista en perspectiva.

style: a planimetric view in the lower part and perspective in the upper part, and almost the same scale (1:1,576 - 1:1,702).

The surface area covers about 517 x 664 m, equal to 0.34 km^2, for the Corchia map, and 431 x 725 m, equal to 0.31 km^2, for the Solioni map. The scale drawn on the map is long - 170 and 200 Florentine *pertica*, respectively.

The upper part of the drawings contains the perspective view of the mapped area; this is from WNW towards ESE in the Corchia map, and from NNW towards SSE in the Solioni map. These two drawings are in four colours and have the same symbology as the Acuti map for orography, hydrography, vegetation and human elements, but they do not have the square grid. In the legend of the Corchia map, there are only indications of plumbeous veins, probably related to the Terrinca lead-silver mine. Whereas in the Solioni map, the legend describes native quicksilver and cinnabar veins, certainly related to the well-known Levigliani mercury mine. In fact, the map shows a furnace for mercury and an ancient mill where the stone for mercury was ground (Fig. 7). On both maps the direction and thickness of veins are indicated.

FRANCIS ANTON EEGAT AND HIS MAPS

No personal information has been found on the author of four handwritten maps in Southern Tuscany, but we can clearly read his signatures: “Fecit Francis. Anton. Eegat Sac. Caes. Majes. geomet.” (made by Francis. Anton. Eegat surveyor of the holy imperial majesty) or “F.A. Eegat. K. Hi. Markscheider” (F.A. Eegat mining topographer of the Holy Roman Emperor). Eegat translated his name into Latin, as was the custom of several authors at the time; the name Francis. (in Latin Franciscus) may be Franz in German or Frans in Flemish, and the second name Anton. (in Latin Antonius) may be Anton in German or Antoon in Flemish. The last name, Eegat, may be only a Latin translation of a Flemish name, because this is the only language to have the initial double “E”; we have hypothesized some possible Flemish names: Eeckat - Eechat - Eeckhat - Eeckhout - Eechout - Eekhout - Eechoudt - Eechkhoud - Eechoud. He signed his maps as Eegat, and probably this surname was Flemish; but as he worked for the Habsburgs and the writings in the legends and in the maps are in German, we cannot exclude the possibility that he was Bohemian, Austrian, German or Swiss. Despite extensive research, we have found nothing of his biographical details; nor did searches in the archives of Amsterdam, Vienna and Prague reveal any result, so who Eegat really was remains virtually unknown. The maps are dated 1760-1765, as reported in Miscellanea SAF, certainly after the period when Arduino was Superintendant in the Montieri Mine (1753-1757), because written in the legend of the Massa Marittima map at number 10 is “new drainage tunnels, dug by a Venetian, Arduino”.

TECHNICAL ANALYSIS OF MASSA MARITTIMA AREA AND MONTE RITUNDO MAPS (METAL BEARING HILLS)

Eegat did not write the year of production on his maps; however, in the description of the Miscellanea SAF inventory, these are estimated at approximately 1760-1765. In the Massa Marittima map, inside a scroll ornament, the heading in German is:“Grund Rüß Uber die bey Montieri, Pocheciano, Prata und Massa, gelegene theils alte verfallene Stöllen, und Schächte theils von einigen Jahren her neu angefangene Gruben” (planimetric map, partly of old collapsed tunnels and ruined shafts and partly of new opened mines in the surroundings of Montieri, Boccheggiano, Prata and Massa Marittima) (Fig. 8). This map is a table measuring 60 x 86 cm, with only the planimetric view of roughly 10.3 x 15.2 km, corresponding to an area of 156 km^2, drawn on a scale of approximately 1:19,672, using the German pre-metric unit of

Figure 5. Dotted veins with indications; O, P, Q, R, T indicate tunnels and - S indicates a shaft.
Figura 5. Trazas de puntos representando los filones con indicaciones O, P, Q, R, T para los socavones y S para los pozos.

Figure 6. Map of mount Solioni with the Levigliani mine.
Figura 6. Mapa del monte Solioni con la mina Levigliani.

Figure 7. Levigliani mine.
Figura 7. Mina Levigliani.

length of a *klafter*. The *berg klafter* (mining fathom) is made up of 6 *fuss* (feet) – 0.30 m, making a *klafter* equal 1.80 m. The scale drawn on the map is long - 2,000 German *klafter*.

The map is in four colours: black (mountains, writing), blue (streams, creeks), brown (veins) and red (tunnels, villages, digits, and letters). The whole map is drawn in ink, but some parts are also filled in watercolour. Orography is portrayed by hatching; relief is depicted using fishbone. Heights are not indicated, contour lines are absent, and relief is not shaded. Only one type of vegetation (chestnut woods) is recorded on the map, and hydrography is hurried and ambiguous, since no river has a name. The legend is concise, without any indication of petrography and only one metal (lead) is mentioned. However, Eegat carefully described all places using many specific German mining terms such as *Pinge* (sinkhole), *Halde* (mound, dump), *Schurf* (surface prospecting cut), *Verhau* (upright dig from above), *Kluft* (cleft, but used for *Gang* – vein), besides more common terms such as *Stolle* (tunnel), *Schacht* (shaft), *Grube* (digging) and *von Tag* (surface mining) (Figs. 9, 10, 11). In the legend, he also pointed out the age or status of the mining works: *uralt* (very ancient), *stille* (silent, for inactive) and *neu angefangen* (re-opened). The map gives precise locations of several mining works: in the Merse valley south of Montieri there are Cagniano (with foundry), Pogiale, Campo Chinandoli, La Carbone, Sant'Ansoni and new drainage tunnels made by a Venetian, Arduino; west of Montieri there are Zeriota, Monte Gajo and Monte Sirigajo; east of Massa Marittima there are Fonte Grilli, Poggio de Montone e Serrabottini. La Carbone is the copper mine Poggio delle Carbonaie, discovered in 1753 by Giovanni Arduino, who subsequently published a report on the mine (Arduino, 1754) and the *Pianta planimetrica della miniera nel Poggio delle Carbonaie* (Arduino, 1756) (Fig. 12). In this map, Arduino indicated rock boundaries (travertine, flint and schist) and veins, together with tunnels and mining service buildings (foundry, coal yard, grinding mill, wash tub, stable). This is undoubtedly the first mine map in Tuscany.

In Eegat's Monterotondo Marittimo map, inside a scroll ornament, the heading in German is: "Grund und Profill Rüß Uber die in Marema 5 Meillen von Monte Ritundo gelegenen offenen Allaun Gruben, an dem Grund Wasserl Risecca sambt ihm dabey befündlichen Tag Graben" (planimetric map and profile of the Alum open quarry in Maremma 5 miles from Monterotondo, near Risecca creek, together with the near surface mining pits) (Fig. 13). This quarry is the well-known Monteleo alum mine, in the surroundings of Monterotondo Marittimo, on the western side of Metal Bearing Hills, near the Cornia river. The map is 37 x 49 cm: at the top is the profile, seen in perspective from S towards N, while at the

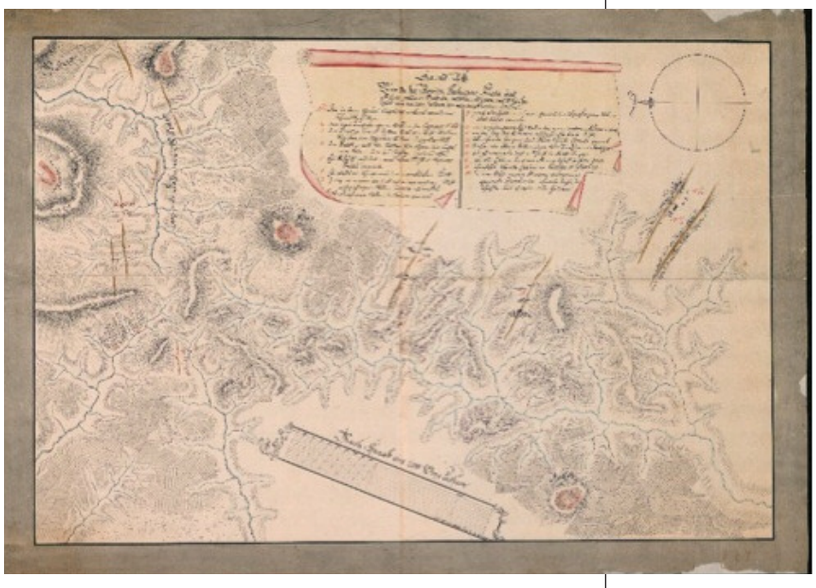

Figure 8. Map of the Massa Marittima area.
Figura 8. Mapa del area de la Massa Marittima.

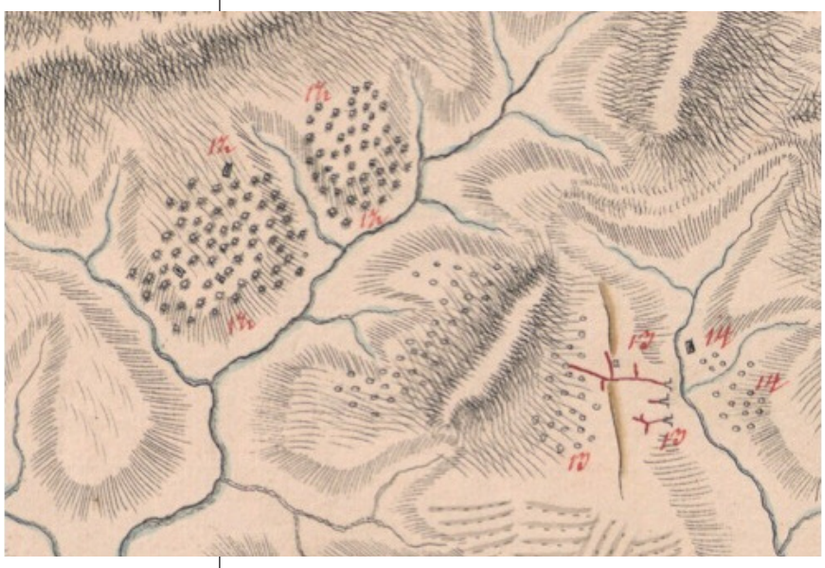

Figure 9. Fields of sinkholes (*Pinge*), old tunnels in red, and a shaft.
Figura 9. Campos de sumideros (Pinge), antiguos socavones, en rojo y un pozo.

bottom there is the planimetric view on a scale of 1:497 where the surface represented is approximately 99 x 224 m, corresponding to an area of only 0.02 km^2. The scale drawn on the map is long 40 German *berg klafter* (mining fathom). The map is in five colours: black (mountains, vegetation), blue (alum vein, creeks), light red (alum oven and laboratory), light brown and light grey (quarry surface). The whole map is drawn in black ink but some parts are in watercolour. Relief is depicted using fishbone and is not shaded. Two alum veins sloping slightly, 2 fingers and 1 finger in width (3.8 and 1.9 cm), are depicted in the quarry. On the left of the quarry, the alum burn-oven composed of four roasting furnaces (Figs. 14, 15) is drawn and, beyond Risecca creek, the alum "laboratory" (crushing plant), totally destroyed.

TECHNICAL ANALYSIS OF MONTECATINI VAL DI CÈCINA AND QUERCETO MAPS (NEAR VOLTERRA)

As with Eegat's maps, the dates for these are also estimated to be 1760-1765. In the Montecatini Val di Cècina map, inside a scroll ornament, the heading in German is: "Grund und Profill Rüß Uber den bei Monte Catini gelegenen Grubenbau" (planimetric map and profile of the mine situated near Montecatini), which is the renowned Caporciano copper mine near Montecatini (Fig. 16). The size of the map is 50 x 60 cm; at the top is the profile, seen in perspective from S towards N, and at the bottom the planimetric view on a scale of 1:3,950. In planimetry, the surface represented is about 1.3 x 2.1 km, corresponding to an area of 2.7 km^2. The scale drawn on the map is long - 300 German *berg klafter* (mining fathom). The map is in four colours: black (mountains, writing), blue (creeks and Cecina river), brown (dump and sinkhole) and red (tunnels, villages and digits). The whole map is drawn in ink but some parts are also filled in watercolour. Orography is portrayed by hatching and relief is not shaded. The legend records many details: collapsed tunnels and shafts, very ancient dumps and sinkholes, the foundry and only one open tunnel, 15 *klafter* long (27 m), "full of copper".

In the Querceto map, inside a scroll ornament, the heading in German is: "Grund und Profill Rüß Uber den nahe an Querceta gelegenen Gruben Bau" (planimetric map and profile of the mines situated near Querceto)

Figure 10. Veins, dumps (*Halde*) and shafts of Serrabottini.
Figura 10. Filones, escombreras y pozos en Serrabottini.

Figure 11. Dumps (*Halde*) and a shaft of Poggio al Montone.
Figura 11. Escombreras y un pozo en Poggio al Montone.

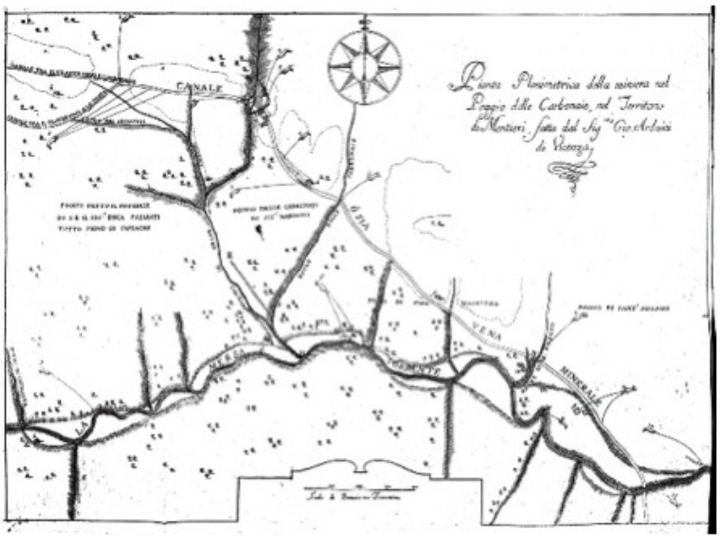

Figure 12. Map of the Carbonaie mine (Arduino, 1756).
Figura 12. Mapa de la mina Carbonaie (Arduino, 1756).

(Fig. 17). The legend gives no indication of the raw material excavated at the mine. As reported by Targioni Tozzetti in *Relazioni d'alcuni Viaggi* (1751, Tomo 2) and by Marrucci (Marrucci, 1998), this mine produced brown coal but the position of veins in the serpentinite (Servizio Geologico d'Italia, 2000), south east of Querceto, more likely points towards a copper deposit (Marrucci, 2002), as in other Tuscan ophiolites (greenstones). The size of the map is 30 x 32 cm; at the top is the profile, seen in perspective from N towards S, and at the bottom the planimetric view in the scale 1:4,656. In planimetry, the surface represented is approximately 873 x 1,265 m, corresponding to an area of 1.1 km^2. The scale drawn on the map is long - 300 German *berg klafter* (mining fathom). The map is in four colours: black (mountains, veins, writing), blue (creeks, streams), brown (terrain heaps) and red (tunnels, villages and digits). The whole map is drawn in ink but some parts are also filled in watercolour. Orography is portrayed by hatching and relief is not shaded. In the legend, surface prospecting cuts with faults, tunnels and also a big *Verhau* (upright dig from above) are recorded (Fig. 18).

CONCLUSIONS

These handwritten maps preserved in state archives or libraries are a very valuable source for the industrial archaeologist and historian. The maps establish the position of quarries and mines, together with machinery for grinding and smelting (mills, foundries) and often mounds, dumps or metallurgical remains. These graphic sources are the result of an accurate survey with the purpose of locating and recognizing old mines, abandoned or forgotten in the 18th century in Tuscany, together with nearby forests and water resources useful for energy and rebuilding. Indeed, in the Grand Duchy, the mining industry was very poor and negligible, in spite of the attempts

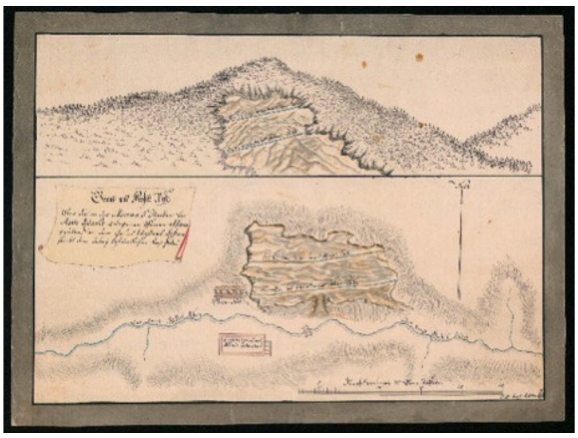

Figure 13. Map of the Monteleo mine, near Monterotondo Marittimo.
Figura 13. Mapa de la mina Monteleo cerca de Monterotondo Marittimo.

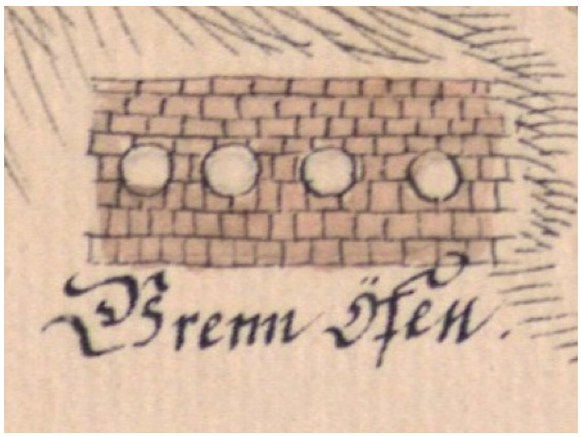

Figure 14. Detail of alum burn-oven.
Figura 14. Detalle de un horno de calcinación de alumbre.

Figure 15. Monteleo today, the ruins of alum roasting furnaces.
Figure 15. Monteleo en la actualidad: las ruinas de los hornos de calcinación para el alumbre.

Figure 16. The remains of the Caporciano mine, near Montecatini Val di Cècina.
Figura 16. Restos de la minae Caporciano mine, cerca de Montecatini Val di Cècina.

of the Medici in the 16th century. This is the beginning of mining cartography in Tuscany and it integrates the indications and the mining census by Targioni Tozzetti, who hoped for a real recovery of exploitation. Today these maps are still very useful for the archaeological study of ancient mining landscapes and for a better explanation of written records. Eegat's map of the area of Massa Marittima is a reliable enough topographic picture of the mining industry in the Massa Marittima mining district, although it was drawn with pre-metric units and without a geodetic basis. Mazzoni's maps are very interesting for the history of mining techniques, especially for the method with which he represents the direction and lay-out of veins and tunnels.

To conclude, the study of these ancient technical maps has a significant interest for the symbols chosen to represent the mining knowledge of the time, before mining academies were set up in Europe.

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AUTHOR'S CONTRIBUTIONS

The manuscript was prepared, written and revised equally by authors.

ETHICS

The State Archives of Florence (SAF), in which the maps are conserved, officially authorized and encouraged the publication.

ARCHIVES

Eegat, F.A. (1760-1765a). Carta topografica del territorio compreso tra Montieri, Boccheggiano, Prata e Massa Marittima con l'indicazione dei giacimenti minerari antichi e moderni. in: Miscellanea di piante, 29.a, State Archive of Florence (SAF).

Eegat, F.A. (1760-1765b). Pianta e veduta della miniera e dell'opificio dell'allume situato nel territorio di Monterotondo Marittimo. in: Miscellanea di piante, 29.b (SAF).

Eegat, F.A. (1760-1765c). Pianta e veduta della miniera e dell'opificio di rame situato nel territorio di Montecatini Val di Cecina. in: Miscellanea di piante, 29.c (SAF).

Eegat, F.A. (1760-1765d). Pianta e veduta di giacimenti minerari situati nel territorio di Querceto. in: Miscellanea di piante, 29.d (SAF).

Mazzoni, C.M. (1766a). - Pianta topografica ed altimetrica minerale della Montagna Acuti e de suoi monti aggiacenti nel Capitanato di Pietrasanta. in: Miscellanea di piante, 2.a (SAF).

Mazzoni, C.M. (1766b). - Pianta topografica ed altimetrica minerale della Montagna Gabbari e de suoi monti aggiacenti nel Capitanato di Pietrasanta. in: Miscellanea di piante, 2.b (SAF).

Mazzoni, C.M. (1766c). Pianta topografica ed altimetrica minerale della montagna di Corchia per alcuni monti a quella aggiacenti nel Capitanato di Pietrasanta e nel Comune di Terrinca situati. in: Miscellanea di piante, 86.a (SAF).

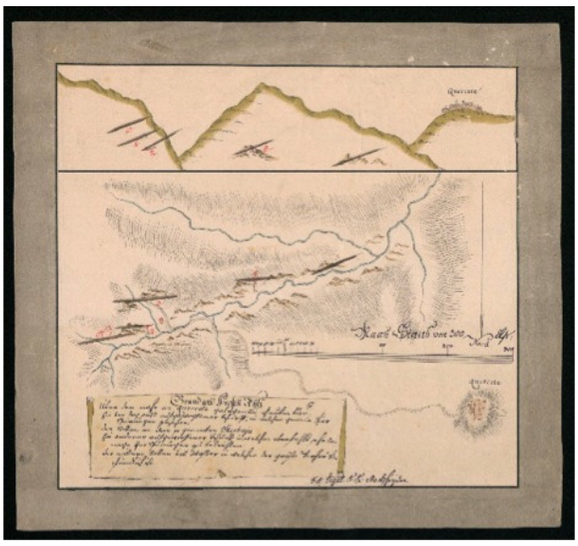

Figure 17. Map of the Querceto mine.
Figura 17. Mapa de la mina Querceto.

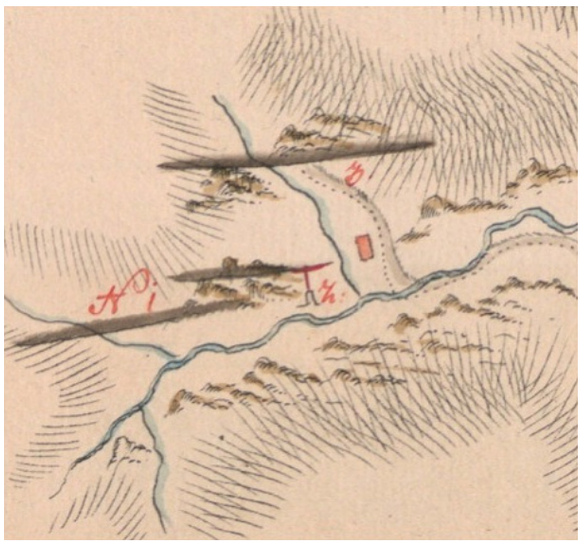

Figure 18. Surface prospecting cuts (1,3) and a tunnel, named Steccaia (2).
Figura 18. Rafas (1,3) y un tumnel llamado Steccaia (2).

Mazzoni, C.M. (1766d). Pianta topografica ed altimetrica minerale della montagna di Salioni per alcuni monti a quella aggiacenti e situati nel Capitanato di Pietrasanta in Comune di Livigliani. in: Miscellanea di piante, 86.b (SAF).

Targioni Tozzetti, G. (1743a) "Breve relazione delle osservazioni fatte sopra le miniere del Contado do Pisa, Volterra, Siena e Massa Marittima nell'autunno dell'anno 1742." 5th of March 1743 in: Fondo Consiglio di Reggenza, 170 (SAF).

Targioni Tozzetti, G. (1743b) "Dissertazione del Dott. Giovanni Targioni sopra l'utilità che si può sperare dalle miniere della Toscana" 24th of April 1743 in: Targioni Tozzetti, 209, National Central Library of Florence (NCLF).

REFERENCES

Angerstein, R.R. 1751. Relazione delle miniere che sono nella Montagna di Serravezza, Capitanato di Pietrasanta.

Arduino, G. 1754. Relazione sulla Miniera di rame di Montieri. Livorno.

Arduino, G. 1756. Pianta planimetrica della miniera nel Poggio delle Carbonaie, nel territorio di Montieri. Magazzino Toscano d'Instruzione e di Piacere, tomo II, Anton Santini, Livorno.

Artini, E. 1979. Le rocce. Hoepli, Milano.

Biringuccio, V. 1540. De la Pirotechnia. Curtio Navo, Venezia.

Boncompagni, I. and Ulivieri, D. 2000. La Versilia dei cartografi. Stradari del periodo leopoldino, Pacini, Pisa.

Bramanti, A. 2001. Agostino Silicani e Carlo Maria Mazzoni, due cartografi del '700 nativi di Stazzema in Versilia. *Le Apuane*, XXI, 91-111.

Dal Piaz, G. 1922. L'Università di Padova e la Scuola Veneta nello sviluppo e nel progresso delle Scienze Geologiche. Mem. Ist. Geol. R. Univ. Padova, 6, 1-41.

Francovich, R. and Rombai, L. 1990. Miniere e metallurgia nella Toscana preindustriale: il contributo delle fonti geo-iconografiche. *Archeologia Medievale*, Vol. 17, 695-709.

Guarducci, A., 2009. L'utopia del catasto nella Toscana di Pietro Leopoldo: la questione dell'estimo geometrico-particellare nella seconda metà del Settecento. All'insegna del giglio, Borgo San Lorenzo, 349 pp.

Guarducci, A. and Rombai, L. 2011. Cartografia e scienze territoriali nel Granducato di Toscana tra settecento e ottocento: il contributo dei tecnici europei. Ricerche Storiche, anno 41, fasc.1, 61-86.

Istituto Geografico Militare Italiano. Serie 25V (tavolette) scala 1:25.000: 96 II SO Monte Altissimo; 104 I NO Pietrasanta; 112 II SO Montecatini val di Cècina; 119 I NO Micciano; 119 II NO Frassine; 119 II SE Massa Marittima; 119 II NE Monterotondo Marittimo; 120 III NO Montieri.

Marrucci, A. 1998. La lignite nel Volterrano. *La Comunità di Pomarance*, XII, n.2, 38-42.

Marrucci, A. 2002. Alcune località cuprifere del Volterrano. *La Comunità di Pomarance*, XVI, n.4, 35-41.

Morello, N. 2003. The question on the nature of fossils in the 16th and 17th centuries. In: (Vai GB. and Cavazza W. Eds.) Four centuries of the word geology. Ulisse Aldrovandi 1603 in Bologna. Minerva Edizioni, Bologna, 127-152.

Riparbelli, A. 1989a. I Lorena e la politica mineraria in Toscana in: *La Toscana dei Lorena: riforme, territorio, società.* (Ciuffoletti Z., Rombai L., Eds.), Olschki, Firenze, 99-121.

Riparbelli, A. 1989b. Geologi e Geologia in Toscana e in Maremma. Contributo storico. Bollettino della Società storica Maremmana, n.54/55, 131-135.

Rombai, L. 1987. Geografi e cartografi nella Toscana dell'Illuminismo. La politica lorenese di aménagement del territorio e le ragioni della scienza geografica. *Rivista Geografica Italiana*, LXXXIV, 287-335.

Rombai, L. 1991. La rappresentazione del Granducato nel secolo XVIII: corografie e topografie in: *La Toscana dei Lorena nelle mappe dell'Archivio di stato di Praga*, Catalogo Mostra Documentaria, Archivio di Stato di Firenze, Firenze, 35-46.

Seccaroni, C. and Haldi, J.P. 2016. Cobalto, zaffera, smalto dall'antichità al XVIII secolo. ENEA, Frascati, 335 pp.

Servizio Geologico d'Italia 2010. Foglio 260 Viareggio, Carta Geologica d'Italia in scala 1:50.000.

Servizio Geologico d'Italia 2000. Foglio 295 Pomarance, Carta Geologica d'Italia in scala 1:50.000.

Targioni Tozzetti, G. 1751-1754. *Relazioni d'alcuni viaggi fatti in diverse parti della Toscana per osservare le produzioni naturali, e gli antichi monumenti di essa.* 1st ed, 6 vol., Stamperia Imperiale, Firenze.

Stensen, N. 1669. De solido intra solidum naturaliter contento dissertationis prodromus. Stellae, Florerenownedntiae, 78 pp.

Vaccari, E. (a cura di) 2008. Lettere di Giovanni Arduino (1714-1795) geologo. Edizioni Think, Padova, 233 pp.