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# The Alsatian Altenberg: a seven-hundred-year laboratory for silver metallurgy

## Introduction

Sainte-Marie-aux-Mines can be considered as the main silver mining district in what is now France, taking into account its accumulated production over time. Its vein system is found in the central area of the Vosges mountains, and is almost a replica of the Black Forest, but on the western side of the Rhine Graben (Fig. 1)<sup>1</sup>. In detail, mineral parageneses are complex, but three mining sectors can be defined, based on mineralogical, geological, geographical and historical criteria (Fig. 2).

The area on the left side of the Lièpvrette River is known as the “Lorraine side”. It was the property of the Dukes of Lorraine until the French Revolution. Ore lodes are oriented NW-SE and are characterised by antimoniferous tetrahedrites containing large amounts of silver. Some veins were exploited during the Middle Ages, but the peak in mining activities occurred during the 16<sup>th</sup> century.

The right side of the river, or “Alsace side”, was the property of the Lords of Ribeaupierre. It contained two mining areas, *Altenberg* and *Neuenberg*. South of the village of *Echery*, the *Neuenberg* area is composed of seven main veins, oriented E-W or NW-SE. The deposit is characterised by a great diversity of mineralisation, particularly with arsenic-bearing tetrahedrites containing fluctuating amounts of silver (up to 1%). Some veins of native arsenic have also been noted there, as well as lead and cobalt ores. The name “*Neuenberg*” is due to the relatively late exploitation of the veins, from the middle of the 16<sup>th</sup> century.

In both of these sectors, some lodes contained rich silver-bearing ores, and even native silver.

The second Alsatian area, called the *Altenberg*, is located north-east of the *Neuenberg*, again on the right side of the Lièpvrette. Its vein system is oriented NNE-SSW. Some tetrahedrites can be found but the main silver-bearing mineralisation is galena (silver content lower than 0.1%). Ores are hosted in a gangue of siderite and compact quartz. As the name of the sector suggests,

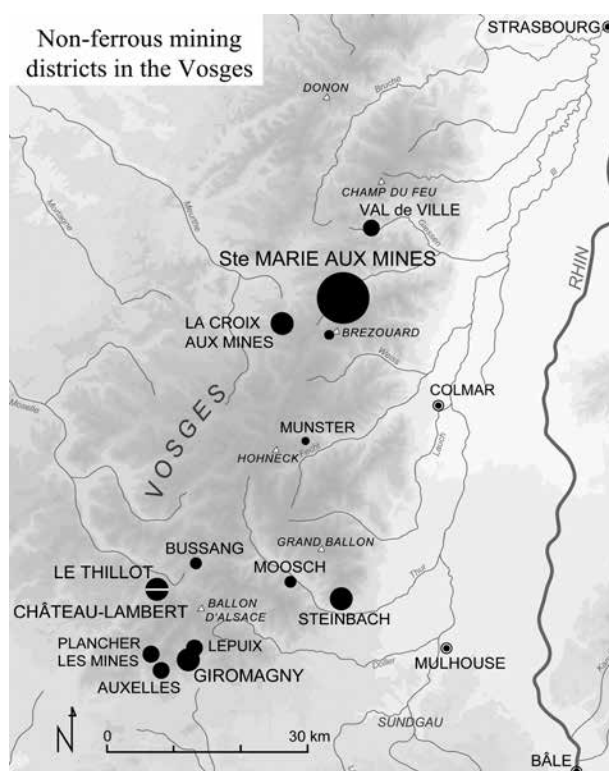


Fig. 1: Map of non-ferrous mining districts in the Vosges (from the Middle Ages to the 18<sup>th</sup> century).

mining was initiated earlier in this area. It is extremely challenging for historians to define activities during the medieval period, due to the lack of reliable historical sources. The *Chronicle* by Richer de Senones (*circa* 1265) mentions that Blidulphe, a monk, was the first to exploit the silver, in 938 or thereabouts. We know nothing about the sustainability of these mining activities, except that they were completely abandoned at the beginning of the 14<sup>th</sup> century. An agreement between Guillaume de Ribeaupierre – intimidated by the Duke of Lorraine – and Sigismond of Austria, signed in 1486, allowed the mining industry to resume, from 1502 onwards.

Initiated in 1981, archaeological excavations on the *Altenberg* were led by different teams until 1996, almost

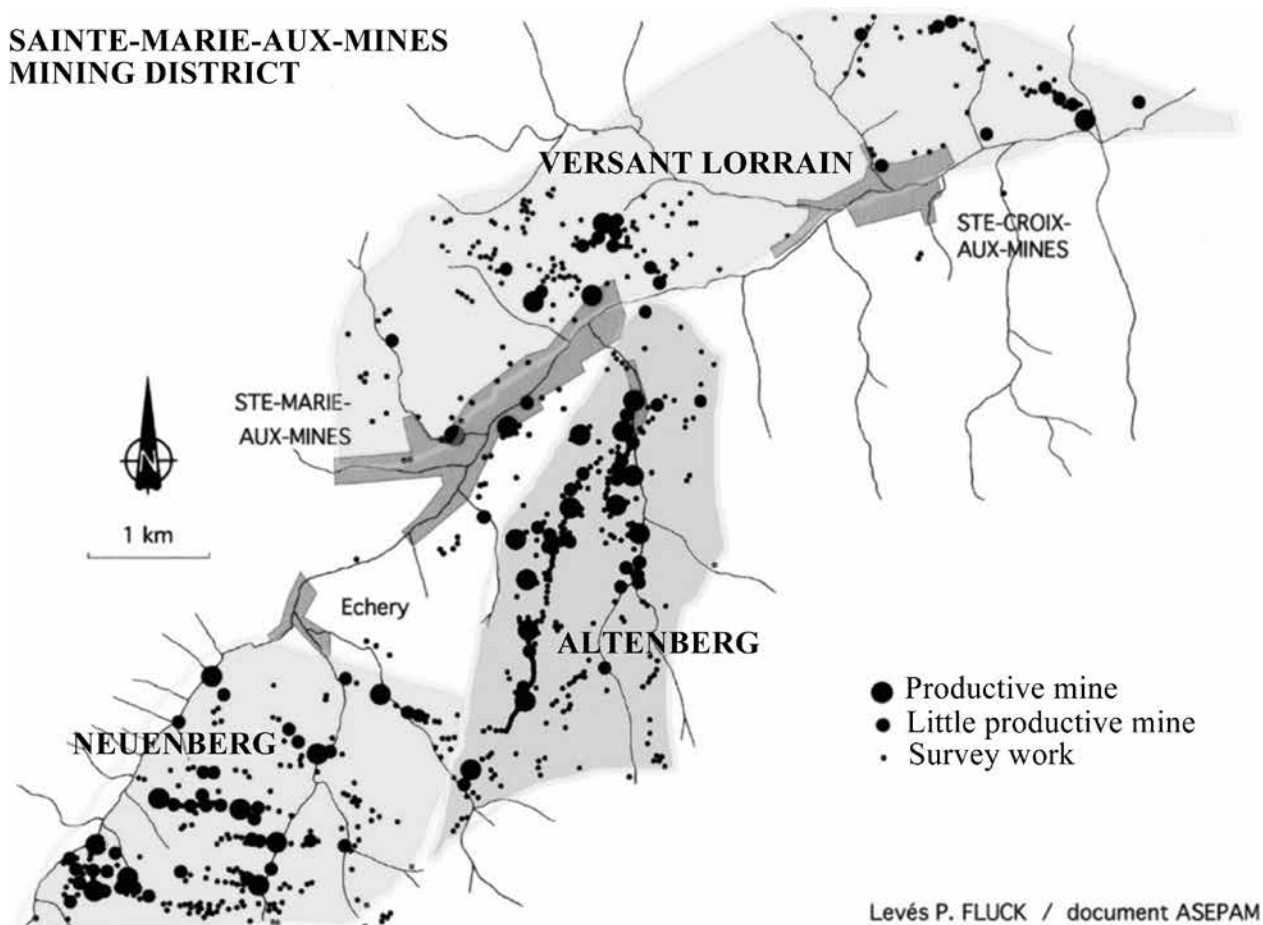


Fig. 2: Map of the mining district of Sainte-Marie-aux-Mines.

without interruption. They focused on the underground mining works but also on some surface sites. Approximately 70 percent of the investigations concerned the Renaissance period<sup>2</sup>. Nevertheless, the shape of the mining works, the exploitation of veins close to the surface by open shafts (*Pingen*), and the characteristic slag mineralogy together provide evidence of a major medieval industry. However, for the entire six-hundred-year pre-Renaissance period, confirmation by radiocarbon-dating was possible at only three sites.

This disparity between the information available for the Renaissance and for the Middle Ages has led to the elaboration of a new research programme focused on three main issues:

1 – Chronology. When did the medieval mining activities really begin? Is it possible to distinguish several activity sequences by episodes of interruption? And when did mining activity end?

2 – Extracting, ore-washing and metallurgical techniques. Assuming that the *Pingen* technique seems to characterise the beginning of the activities, is it possible to establish a chronological typology of underground

mining works? Why are the fayalitic slags found on the former metallurgical sites so different from those with a glassy texture, which characterise the Renaissance sites? Can the location of medieval smelting places in altitude, near the mines and far from any major hydraulic sources, explain this evolution? How was a medieval silver-production unit organised?

3 – Place in the local economy. At another scale, how did mining activities impact on the local economic geography? How far from the veins were the ore treatment and metallurgical structures installed? How were the timber resources managed to meet mining and smelting requirements? And finally, where and how did the metallworkers and miners live?

Between 1981 and 1996, mining archaeology in Sainte-Marie-aux-Mines was strongly characterised by a very close connection between archives and fieldwork. Indeed, this cohesion favoured an improved interpretation of underground mining networks, benefitting from the rare topographic surveys carried out by miners during the 16<sup>th</sup> century exploitation<sup>3</sup>. This method fits remarkably well with the Renaissance context, due to the exponential production of archive documents; but it cannot

be applied to medieval times. Moreover, little archaeological material linked to that period had been unearthed in this sector. In such a context, the only way to understand its medieval mining past was to undertake further archaeological operations on the *Altenberg* area.

A new research programme was therefore initiated in 2006. It initially consisted of several geophysical and archaeological surveys that led to the *Collective Research Programme* from 2008 to 2011<sup>4</sup>. Currently, a new programme is underway, for the 2012-2014 period, concerning a larger region of study, i.e. the *Oberrhein* (the Upper Rhine).

### Context of study

A preliminary chronological synthesis of the mining activities in Sainte-Marie-aux-Mines can be drawn, based on the results of this six-year study: many archaeological field surveys, one geochemical and nine geophysical surveys, twenty series of trial trench evaluations, four excavations, seven underground investigations, one airborne laser-scanning survey, one experimental archaeology programme, and three historical investigations of “new” archive collections (Fig. 3). Only 5 to 10 percent of the *Altenberg*’s estimated archaeological potential has so far been investigated. Some great evolutions in mining and metallurgical techniques can be observed. The first major conclusion is that we are forced to reconsider everything that was thought to have been known until now about the chronology of mining activities in this region. Between the settlement of the first *Echery* monks

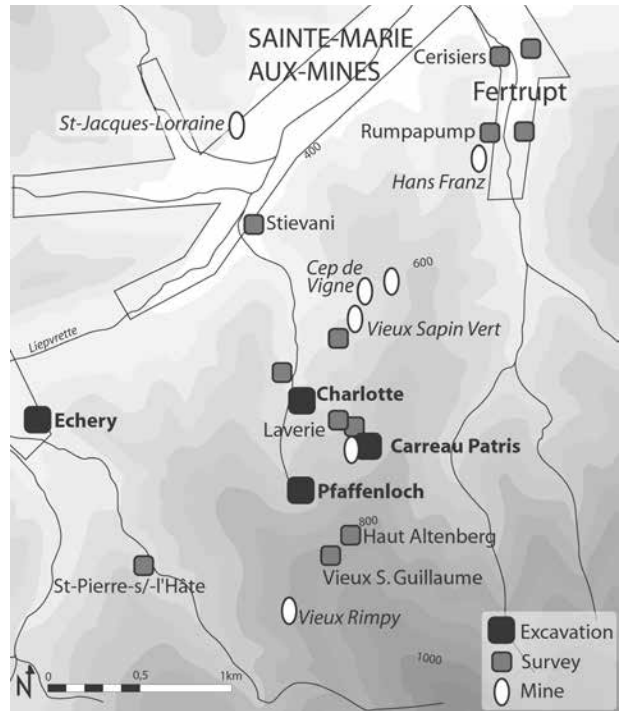


Fig. 3: Map of the *Altenberg* sector; showing various operations from 2006 to 2011 (except for field and geophysical surveys).

in about 938 and the end of the Thirty Years War in 1637, no major interruption of mining and metallurgical activities appears to have occurred.

Fig. 4 shows the synthetic chronological diagram for mining and metallurgy sites on the *Altenberg*. Most of

### ALTENBERG - ASSEMBLAGE DES DATATIONS

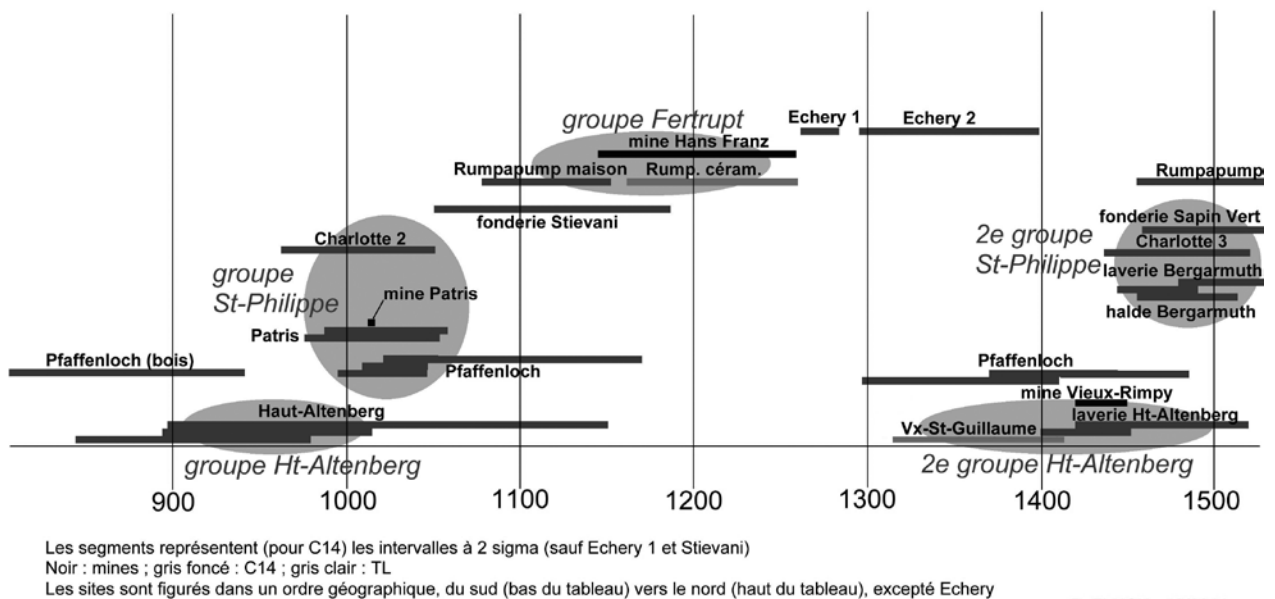


Fig. 4: Synthetic chronological diagram. Black: mines (*Patris* mine obtained by dendrochronology). Dark grey: radiocarbon dating (2 sigma intervals, except for *Echery 1* and *Stievani*). Light grey: thermoluminescence dating. At the bottom of the diagram, southern sites in the *Altenberg* area, at the top, northern sites.

these data were obtained by radiocarbon dating<sup>5</sup>, others by thermoluminescence and dendrochronological dating. Several groups can be distinguished, on the basis of chronological and geographical criteria. Although new data may subsequently modify this classification, the groups are currently defined as follows:

- “*Haut-Altenberg*”: mainly located near the top of the *Altenberg* (850 m asl), dated from the 10<sup>th</sup> century and perhaps the 11<sup>th</sup>.
- “*Saint-Philippe*”: the archaeological sites of *Pfaffenloch*, *Patris*, and *Charlotte*, from the first half of the 11<sup>th</sup> century.
- “*Fertrupt*”: the sector of the *Rumpapump* mine, in the 12<sup>th</sup> century and the beginning of the 13<sup>th</sup>.
- “*Echery*”: the foundry site, where occupation began in the late 13<sup>th</sup> century; its activity began again in the 14<sup>th</sup> century, after having been interrupted.
- “*Haut-Altenberg and Pfaffenloch*”: from 1350 until the end of the 15<sup>th</sup> century.
- Several sites in the small valley of Saint-Philippe (*Charlotte*, *Bergarmuth*, *Sapin Vert*), with some occupation during the late 15<sup>th</sup> century.

This chronological division will be respected throughout the following development, seeking to highlight, for each period, the major technical and social features.

## A newly defined *Altenberg* chronological pattern

### The *Pingen* period and the first adits

From the time the monk Blidulphe had presumably settled on the *Altenberg*, in 938, several hundred pits<sup>6</sup> were dug on the crests of the *Altenberg* vein system (Fig. 5); their density has made it possible to rediscover its maximum extent. Only those pits located on the *Haut-Altenberg* sector have been dated, matching the textual sources about Blidulphe. It can be assumed that most of these structures were dug during a relatively short period. Indeed, once the first outcrops had been located, it was much easier for surveyors to determine the azimuths and extent of the veins, and to excavate the area step by step. Archaeological surveys of these structures have shown that the first medieval prospectors took particular care in removing the surrounding altered rock before digging the pits. At these sites, archaeologists encountered a major difficulties while excavating the structures: the gneissic substratum is highly faulted, so the rock is very unstable. Nevertheless, some underground inves-

tigations, centred on the remote parts of the *Porte de Fer* mine, provided access to pit bases, allowing observation of the underground parts of the *Pingen* exploitation system. Veins were intensively excavated to a depth of about a hundred metres. The best-matching comparison in the archives is almost certainly the picture in the *Kutná Hora Gradual* (by Mathis, in 1490), describing mine shafts whose morphology seems to be closely adapted to that of the vein, resulting in highly deformed shapes. Though the adits showed a cramped, egg-shaped profile, the use of fire was rarely observed.

At the turn of the first millennium, the exploitation generally took the form of galleries dug lower on the mountain slopes, in order to crosscut the veins previously exploited from their crests. The technique of such cross-cut tunnels became the norm in this sector. A good example of these first adits is part of the *Patris* mine, dated from the early 11<sup>th</sup> century (a few years after 1014 by dendrochronology<sup>7</sup>). Its section is 1.2 m high and less than one metre wide. The adit was dug using fire and possibly *Fimmeln* (a sort of ancient handleless iron tool, cf *Agricola*), because no continuity in tool traces can be seen. Some similar galleries have been studied in the *Weinstock* and *Hans Franz* mines; the latter, dated from about 1200, sought to exploit lower parts of veins already worked by *Pingen*. Surface facilities, located one hundred metres away, were also surveyed. They consisted of a wooden building of the late 11<sup>th</sup> or 12<sup>th</sup> century, destroyed by fire. Ceramic remains were scarce but rather characteristic of the 12<sup>th</sup>-13<sup>th</sup> transition. The corresponding gallery was studied in 1996. It was reshaped in the 1520s, and renamed *Rumpapump*, according to textual sources.

### The evolution of smelting places

Foundries were built within the surface facilities located near the adits. Meticulous archaeological surveying has already identified ten smelting sites within the small valley of Saint-Philippe alone. This number may well be underestimated, because of the thick colluviums in this sector. These smelting places can be attested by the presence of fayalitic slag heaps (Figs. 6 and 7). In some cases, geophysical surveys have indicated the greatest concentration of such areas within the slag heaps, thus better focusing further surveys.

Archaeological excavations were performed on three smelting sites, called *Pfaffenloch*, *Patris* and *Charlotte*. All of them presented strata dated from the 11<sup>th</sup> century, and had later experienced one or more metallurgy-linked period of activity. None of them revealed a preserved furnace, although furnace fragments were observed. At the most, some rubefied areas were excavated, which must have served for ore-roasting, and perhaps smelting. Indeed, their soils sometimes contain a significant



Fig. 5: Map of the upper part of the *Altenberg* area, showing the open shafts (*Pingen*) and their tailings, and the location of *Vieux-Saint-Guillaume* and *Vieux-Rimpy* mines (below on the left, two galleries).

quantity of lead. Nevertheless, no structures appear to have survived, due to the relatively bad taphonomic conditions generally encountered on the *Altenberg* sites.

A slag concentration site was noticed at the foot of the *Altenberg*, at the bottom of the Saint-Philippe valley. Its location could perhaps have been motivated by the proximity of a stream. Radiocarbon dating provided a 2-sigma calibrated range of 1039-1212. These dates should be confirmed by further data. The first attested metallurgical site using hydraulic energy was situated in the neighbourhood of Echery village. A fayalitic slag-heap was also discovered there, at the foot of the *Altenberg*. A geophysical survey located the greatest slag concentration, which was investigated by two successive years of archaeological trial trenching (2006-2007) and an excavation campaign (2008). The site itself proved complex and multi-phased. Archaeological materials and absolute dating have distinguished three periods of occupation. The first goes back to the second half of the 13<sup>th</sup> century (1261-1284). It reveals an important innovation: it is, for the *Altenberg*, the oldest example of the smelters' desire to settle farther away from the veins, about two kilometres away, close to a stream. This happened during the rise of the Gothic in the Rhine area, at the time of the *Interregnum*. The scale and situation of the facilities suggest that it could have been supplied from several *Altenberg* mines. Moreover, the end of this period seems to coincide with assumptions by some historians that exploitation ceased in 1280: could these facts be connected?

This site experienced a second period of activity during the 14<sup>th</sup> century, attested by solid masonry walls, and by large quantities of material, such as stove tiles, cooking pottery and furnace tuyeres, and also by abundant industrial wastes (charcoal, fayalitic slags, etc.).

### The hydraulic energy innovation in the first ore-washing facilities

In the middle of 14<sup>th</sup> century took place what is known as the *technical breakthrough of the late Middle Ages*. Its oldest clues are the surface facilities<sup>8</sup> that were renamed, 170 years later, *Vieux-Saint-Guillaume*, on the *Haut-Altenberg*. This upheaval was first characterised by the establishment of a small canal at altitude, of about 1.5 km length, in order to operate large pumping machinery in a big shaft. The canal structure itself has not been unearthed (it may have been a wooden structure), but some ore-washing residues, consisting of alternating sand and silt deposits, were found by surveying several trenches.

Downstream of the structure known as the *Vieux-Saint-Guillaume* shaft, this canal could have been used for ore-washing operations, with remains consisting of

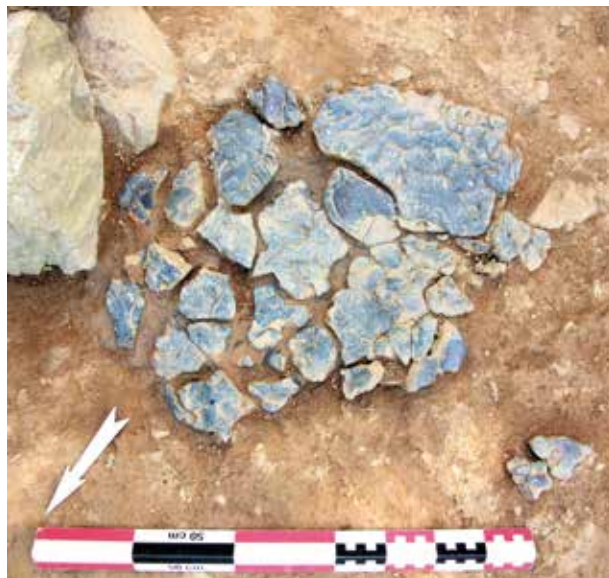


Fig. 6: A flow of fayalitic slag material, revealed in front of the *Patris* mine entrance (*Saint-Philippe* group, 11<sup>th</sup> century).

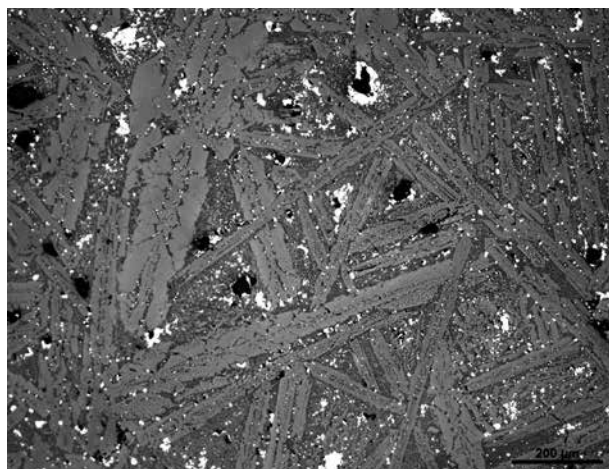


Fig. 7: Microstructure of a fayalitic slag from Pfaffenloch (*Saint-Philippe* group, 11<sup>th</sup> century).

sandy sediments and sludges up to several metres thick. Further down, about 300 metres away, the older, *Pfaffenloch* site underwent a new period of activity. In the middle of the 14<sup>th</sup> c.<sup>9</sup>, the slag heap in this place was interspersed with tailing waste materials and ore-washing wastes – sand and silt sediments – in layers. This could corroborate the first “by hand” stamp-milling operations.

This site also provides us with clues of new metallurgical practices that can be described as a “technical revolution” in this context. Until then, the siderite gangue rock was introduced into the furnace with the lead-silver ore. This process explains the concomitant presence of slag and tailing wastes within the heaps, the latter stemming from a crude sorting. This mixture produces, as activity wastes, slags presenting an iron silicate frame-

work, fayalite (Fig. 7)<sup>10</sup>. The innovation evoked consists in sorting extracted material by water, after milling “by hand”. Thus galena is sorted from its gangue by gravity, producing layers of sand and *schlamms* as remains in stratigraphy. This is the first ore-washing evidence found in Sainte-Marie-aux-Mines. Through the smelting process, the ore produces an iron-depleted slag, presenting a more vitreous structure, which was found in the most recent layers of the *Pfaffenloch* slag-heap (second half of the 14<sup>th</sup> century – Fig. 8). An astonishing fact is the resilience of the older process, for another 150 years in some parts of the *Altenberg*. For example, the smelting site named *Charlotte* saw its last period of activity in the second half of the 15<sup>th</sup> century, after a gap of about 400 years. Yet, metallurgical wastes there still present a fayalitic facies. Two hearths were also unearthed in this sequence; one of them offers some similarity with a structure found in the Westphalian *Altenberg*<sup>11</sup>. Thus, during a 250-year time lapse, the *Altenberg* constituted an original place to observe the juxtaposition of innovations and the resilience of older processes.

Other sites, investigated during the research programme, furnished information about the 15<sup>th</sup> century, for which knowledge was lacking<sup>12</sup>. The middle part of the *Altenberg* is centred on a cluster of mines, which at the beginning of the 16<sup>th</sup> century were named *Berg Armo*. In 2011, several trial trenches were dug in their vicinity, at a site called *Bergarmuth*. They revealed an unconformity between tailing waste layers, dated from the middle of 15<sup>th</sup> century, interspersed by gangue rocks resulting from “hand-milling”<sup>13</sup> (Fig. 9), and layers of sediment in a double ore-washing basin, dated from the turn of the 16<sup>th</sup> century.

### The transition to modern mining and metallurgical processes

Most of the medieval galleries opened and explored in the 1970s and 1980s are today blocked. Elaborating a typology is still possible, since meticulous measurements, topographic surveys and photographs were collected from there, as for the *Weinstock* mine. Unfortunately, no dating support could be found there. Nevertheless, some mines provided such elements, like the *Vieux-Rimpy* mine, on the upper part of the *Altenberg*. There, the 16<sup>th</sup>-century exploitation partly redrafted the former structures, which remain unchanged in other parts of the mine. The galleries then appear wider than those of the Renaissance, and the tool marks (Agricola’s *Fimmeln*?) appear more disorganised. A crosscut tunnel was dug using fire, and has been dated from the first half of the 15<sup>th</sup> century, by analysing the soot adhering to the gallery wall.

The number of dated mines also allowed an onomastic approach to be attempted. Assuming that no significant

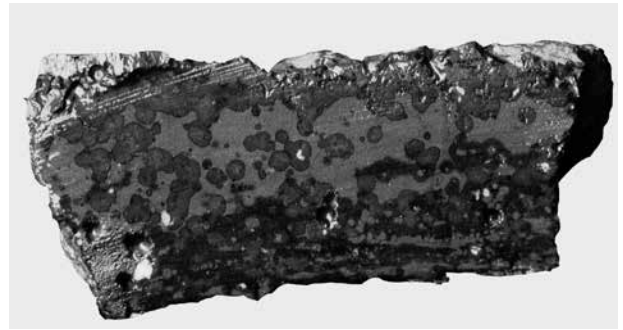


Fig. 8: Macro-section of a slag from *Pfaffenloch* 14<sup>th</sup> or 15<sup>th</sup> century, showing grey spherulites in a green glassy matrix.



Fig. 9: The tailing of *Bergarmuth* (*Saint-Philippe* group) below the washing-basin sediments, showing waste layers resulting from hand-milling of the ore.

interruption had struck mining activities in the *Altenberg*, why would the Renaissance people have needed to rename the former mine entrances? Names that are not linked to a religious lexical field, such as *Einhorren*, *Weinstock*, *Grüntann*, *der Stein*, *der Greiff*, or *Backofen*... might constitute toponymical remnants. A study focusing on written sources is currently examining this hypothesis.



The last noticeable technical change, at the turn of 16<sup>th</sup> century, was the adoption of a water-powered stamp mill, concomitantly with a new generation of foundries. These reflect technical systems that Biringuccio, and later Agricola, have described. In the lower part of the *Fertrupt* village – the most northern part of *Altenberg* – the remains of a foundry coupled to a habitat were investigated. They were located in the vicinity of a mine called *Fundgrube*, whose exploitation was initiated in 1502 (or 1506) by Lord Brunon of Ribeaupierre. The foundry contained what appears to be a crudely elaborated furnace base, and some vitreous slags containing numerous lead prills, as if the new metallurgical processes applied to well-prepared ore had not yet been mastered at that time.

The most important facility among smelting works from the most flourishing period (1520-1530) is the *Echery* foundry. It was edified by the Austrian archduke and the Lord of Ribeaupierre on the ruins of the previous buildings (see § 3). Archaeological excavations have revealed part of it; but it is especially well illustrated by exceptional archive documents containing a number of technical details.

## Conclusion

Dating obtained in 2008 and 2009 has falsified the paradigm of a total lack of activity in this sector during the end of the Middle Ages, which had previously been put forward, based on historical information. It is now possible to consider uninterrupted (or nearly-uninterrupted) mining and metallurgical activity over a 700-year period. From now on, the research issues are clear: to link the successive phases of this mining industry to major events in local history (such as the transition from a monastic to a seigniorial economy, the advent of the Echery nobles, the construction of their castle, etc.) and at the regional scale (the increasing importance of minting, etc.), throughout the medieval period. The organisation of the main mining districts at the scale of the *Oberrhein* also has to be considered. Thus, for the period 2012-2014, we seek to extend this *Collective Research Programme* to consider these questions. For example, isotopic analyses are planned on galena and lead found in different mining or smelting sites – like the *Altenberg* – and the results will be compared with those of architectural lead from monuments in the Rhine region. This is an essential step in evaluating the distribution of the metal from the mines. Furthermore, two PhD theses have been underway since 2010 and 2011, for the further development of historical and archaeological approaches<sup>14</sup>.

## Footnotes

- 1 FLUCK P., *Sainte-Marie-aux-Mines, les mines du rêve*, Editions du Patrimoine Minier, Soultz, 2000, 205 p.
- 2 For the best synthesis, see FLUCK P., « Mines et fonderies de l'Altenberg. Les leçons des fouilles 1982-1996 », dans *Société d'Histoire du Val de Lièpvre*, 28e cahier, 2006, p. 26-60.
- 3 FLUCK P., « Saint-Louis-Eisenthür (Sainte-Marie-aux-Mines, France de l'Est) : sans doute la plus belle mine d'argent de la Renaissance. Bientôt vingt ans d'ouverture au public », 13e Congrès International TICCIH, Italie (2005) [on-line site hal-archives ouvertes].
- 4 These operations were managed by P. Fluck, co-director of the CRESAT (Centre de Recherche sur les Économies, les Sociétés, les Arts et les Techniques) of the Upper-Alsace University. Among the main partners, were the University of Technology of Belfort-Montbéliard, the geophysical laboratories of the Universities of Strasbourg (Pr. M. Munsch) and Paris VI (Pr. N. Florsch), the CEA – Saclay Centre, the National Institute for Preventive Archaeological Research (INRAP) and the Pôle Archéologique Interdépartemental Rhénan. From a practical point of view, operations were performed during “Young Volunteers’ Operations” led by the ASEPAM (Speleological Association for Study and Protection of Ancient Mines) and Mining Heritage Federation. Since 2012, Pierre Fluck has been joint manager of the research programme with Joseph Gauthier, PhD in medieval archaeology and history of technology.
- 5 Most of the dating was performed by the Archeolabs laboratory, Saint-Bonnet-de-Chavagne (Isère).
- 6 The map indexing them indicates 191 pits. Some of them can be seen in Fig.5.
- 7 Performed on a sawn plank unearthed in the gallery by P. Clerc (INRAP).
- 8 Dated by thermoluminescence on a cooking pottery fragment.
- 9 Dated by radiocarbon and cooking pottery typology.
- 10 MAHE-LE CARLER, C., PLOQUIN, A., FLUCK, P., « Apport de la géochimie et de la pétrologie à la connaissance de la métallurgie primaire du plomb argentifère au Moyen Âge : les exemples du Mont Lozère (Cévennes) et de Pfaffenloch (Vosges) », in *ArchéoSciences, revue d'archéométrie*, 34, 2010, p. 159-176.
- 11 DAHM C., LOBBEDEY U., WEISGERBER G., *Der Altenberg: Bergwerk und Siedlung aus dem 13. Jahrhundert im Siegerland*, Bonn, R. Habelt, 1998, 2 vol.
- 12 Dating of basins in the lower part of the Vieux-Saint-Guillaume (first and second half of 15th c.) area, and the later Pfaffenloch foundry (middle of 15th c.).
- 13 A “Scheidstein” (mortar for ore crushing) was discovered in the same layers.
- 14 Delphine Bauer studies ceramic stove-tiles at the Université de Strasbourg; David Bourgeois studies medieval archives in the South Vosges mining districts at the Université de Haute-Alsace.