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The Alsatian Altenberg : a seven centuries laboratory for silver metallurgy

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Introduction

First lode silver mining district for the present French territory regarding its accumulated production, the Sainte-Marie-aux-Mines vein structure develops itself in the central area of Vosges mountains (almost a replica, on the western side of the Rhine Graben, of the Schwarzwald)(fig. 1)¹. In detail, mineral parageneses are complex there. One can although define three different mining sectors, based on mineralogical, geological, geographical and historic criteria (fig. 2).

The area located on the left side of the Lièpvrette river is called “Lorraine side”, it was property of the Duke of Lorraine until the French Revolution. Ore lodes are oriented NW-SE and characterized by antimoniferous tetrahedrites containing high amount of silver. Some were exploited during the Middle Ages, but the most important mining activities took place during the 16th c.

On the right side, in the South of a village called *Echery*, the *Neuenberg* area is composed of seven main veins oriented E-W or NW-SE. It presents very various mineralization, and particularly arsenic-tetrahedrites containing fluctuating amounts of silver (up to 1%). Besides, some veins of native arsenic were also noticed there, as lead and cobalt ores. Its name is due to the relatively late discovering of its metal resources, in the middle of the 16th century.

In both of these sectors, some lodes have offered high-amount silver ores and even native silver.

The third area, called *Altenberg*, is located in the North-East of the *Neuenberg*, still on the right side of the Lièpvrette. This side was owned by the alsatian Lord of Ribeaupierre. Its vein structure is oriented NNE-SSW. Tetrahedrites can accessorially be noticed but the almost only silver-containing mineralization there is galena (silver amount lower than 0,1%), contained in a gangue of siderite and compact quartz. As its name seems to indicate, mining was initiated

¹ FLUCK P., *Sainte-Marie-aux-Mines, les mines du rêve*, Editions du Patrimoine Minier, Sultz, 2000, 205 p.

earlier in this area. Historians meet enormous difficulties in defining activities during the medieval period, due to a serious lack of reliable sources. The Richer de Senones' *Chronicle* (around 1265) set the beginning of silver exploitation, by a monk called Blidulphe, around 938. We don't know anything about those mining activities sustainability, if not their total abandonment at beginning of the 14th c. An agreement between Guillaume de Ribeaupierre – affrighted by the Duke of Lorraine – and Sigismond of Austria, signed in 1486, allowed the resumption of the mining industry, effective in 1502.

Initiated in 1981, archaeological excavations on the *Altenberg* were led by different teams, nearly without interruption until 1996, focused on the underground mining works but also on some surface sites. We can approximate that 70 percent of investigations concerned the Renaissance period². Some characteristics, as the mining works' shape, the exploitation of lodes crests by pits (*Pingen*), the slag mineralogy, testified an important medieval industry. Nevertheless, datings were scarce (only three sites dated for this six centuries period).

This disparity of information between Renaissance and Middle Age period led to elaborate a new research program focused on three questionings:

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

2 - Extracting, ore-washing and metallurgical techniques. Assuming that the *Pingen* technique seems to characterize the beginning of the activities, is it possible to establish a chronologic typology of underground mining works? Why are the fayalitic slags found on the former metallurgy sites so different from those, which offer a glassy texture, characterizing the Renaissance sites? How was a medieval silver-production unit organized? Did it really work without any hydraulic energy, since smelting places set in altitude, near or not far from the mines ?

3 - At another scale, how did the mining activities impact on the local economic geography? Although extracting structures are compelled by the ore locations, where were the ore treatment and metallurgical structures set? What was the pressure of these activities on the lumber resources? And finally, where and how did metalworkers and miners live ?

Between 1981 and 1996, mining archaeology in Sainte-Marie-aux-Mines had been strongly characterized by a very close relation between archives and fieldwork. Indeed, it particularly allowed an improved interpretation of underground mining networks, benefitting from some rare topographic surveys that have been done during the 16th c. exploitation³. This method,

² For the best synthesis, see FLUCK P., Mines et fonderies de l'Altenberg. Les leçons des fouilles 1982-1996. *Société d'Histoire du Val de Lièpvre*, 28^e cahier, 2006, pp. 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, 13^e Congrès *International TICCIH*, Italie (2006) [on line site *hal-archives ouvertes*]

which remarkably fits with the Renaissance context, due to an exponential production of archive documents, isn't at all adapted to medieval times. Moreover, the unearthed archaeological material linked to this period has been very scarce for this sector. So another methodology had to be defined: it is mainly based on multiplying archaeological surveys and excavations that could supply absolute dating supports.

A new research program was so initiated in 2006, consisting first on several geophysical and archaeological surveys, that led to a *Collective Research Program* from 2008 to 2011⁴. Furthermore, a new program is currently being elaborated, for the 2012-2014 period, concerning a larger region of study, i.e. the *Oberrhein*.

Context of study

A first chronological synthesis of the mining activities in Sainte-Marie-aux-Mines can be drawn, based on the results of this six-year work : twenty archaeological surveys, two archaeological, nine geophysical and one geochemical prospections, four excavations, seven underground investigations, an airborne laser-scanning survey, one experimental archaeology program, and three historical researches investigating “new” archives collections (fig. 3). Only 5 to 10 percents of the *Altenberg*'s estimated archaeological potential have so far been investigated. Some great evolutions in mining and metallurgic techniques can be drawn. At first, the major conclusion is that we are forced to reconsider totally what was thought till now about mining activities chronology in this region. Between the settlement of the first *Echery* monks in about 938 and the ending of the Thirty Years War in 1637, no major interruption of mining and metallurgic activities appears to have occurred. Fig. 4 shows the synthetic chronological diagram for mining- and metallurgy sites on the *Altenberg*. Most of these data has been obtained by radiocarbon dating⁵, less frequently by thermoluminescence or dendrochronological dating. Some groups can be distinguished on it, on the base of chronological and geographical criteria. However, these groups can also be influenced by the choice of sites to be investigated. These groups are defined as follows (n.b. most of the locations don't carry their original names!):

- A first “*Haut-Altenberg*” group (located most nearly from the top of the *Altenberg*, height 850 m), dated from the 10th and maybe 11th c.

⁴ These operations were managed by P. Fluck, co-director of the CRESAT (Centre de Recherche sur les Economies, les Sociétés, les Arts et les Techniques) of the Upper-Alsace University. Among the main partners, we notice 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 center, 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*.

⁵ Most of them in the *Archeolabs* laboratory, Saint-Bonnet-de-Chavagne (Isère).

- A “*Saint-Philippe*” group (so-called Pfaffenloch, Patris, Charlotte sites), from the first half of the 11th c.
- A “*Fertrupt*” group (sector of the forthcoming *Rumpapump* mine), in the 12th c. and around 1200.
- The *Echery* foundry site, which occupation began in the late 13th c.; its activity restarted in the 14th c. after having been interrupted
- A late “*Haut-Altenberg- and Pfaffenloch-group*”, from 1350 until the end of the 15th c.
- Several sites in the Saint-Philippe small valley (Charlotte, Bergarmuth, Sapin Vert), which occupation took place in the late 15th c.

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

A new defined *Altenberg* chronological pattern

1- The *Pingen* period

From the time monk Blidulphe had presumably settled on the *Altenberg*, in 938, several hundred pits⁶ were dug on the crests of *Altenberg* vein structure (fig. 5); their density made possible to reconstitute its absolute extension. Only the ones located on *Haut Altenberg* sector were dated (the dating matched the textual sources about Blidulphe !), but it can be assumed that most of these structures were dug during a relatively short period. Indeed, once the first outcrops located, it was much easier for surveyors to determine the veins’ azimuths and extensions, and to excavate it step by step. Archaeological surveys accomplished on those structures have shown that first medieval prospectors took a particular care in removing surrounding altered rock before digging the pits. Archaeologists faced a huge problem while performing excavations on such structures, due to the poor stability of highly faulted gneissic substratum as a wall rock. Nevertheless, some underground investigations, centred in the remote parts of the *Porte de Fer* mine, permitted to access pits bases and to observe the underground parts of the *Pingen* exploitation system. Lodes were there intensively excavated on a height range of about a hundred meters. The best-matching comparison in archival sources could certainly be the picture of Kutna Hora’s gradual (from Mathis, in 1490), describing mine shafts which morphology seem to be closely adapted to the vein’s, resulting in very deformed shapes. Though adits showed a cramped and egg-shaped profile, the use of fire was rarely observed.

2- First adits

⁶ The map indexing them indicates 191 pits. A part of them can be seen on fig.5.

At the turn of the millennium, the exploitation tends to take the form of galleries dug lower on the mountain slopes, in order to cross the lodes previously exploited from their crests. The technique of such crosscut tunnels became the norm in this sector. A good example of those first adits is part of the *Patris* mine, dated from the early 11th c. (few years after 1014 by dendrochronology⁷). 1,2 m high and less than one meter wide, it was dug using fire and maybe *Fimmeln* (sort of ancient handleless iron tool, cf Agricola), because no continuity in tool traces can be noticed. Some similar galleries have been studied in the *Cep de Vigne* and *Hans Franz* mines; the latter, dated from about 1200, intended to exploit lower parts of lodes already worked by *Pingen*. Surface facilities, located a hundred meters from it, were surveyed. They consist on a wooden building of late 11th or 12th c., destroyed by fire. Ceramic, which remains are scarce, is rather characteristic of the 12th-13th transition. The corresponding gallery was studied in 1996. It was reshaped in the 1520's, and renamed *Rumpapump*, according to textual sources.

3- First smelting places

Foundries were built within the surface facilities located near those adits, and on other places. Meticulous archaeological prospecting has allowed to identify ten smelting sites for the strict Saint-Philippe small valley, a number which certainly may seriously underestimate the reality, due to the generally important thickness of colluviums in this sector. These smelting places can be attested by the presence of fayalitic slags concentrations (fig. 6 and 7). In some cases, geophysical surveys have led to spot the most important concentration areas within the slag spreadings, which allows focusing further surveys.

Archaeological excavations were performed on three smelting sites: the so-called Pfaffenloch, Patris and Charlotte. All of them presented strata dated from the 11th c., but these sites present one or more other periods – generally more recent – of metallurgy-linked activities. None of them revealed conserved furnaces, although furnace fragments were observed. At the most some rubefacted areas were excavated, which purpose was certainly ore-roasting, maybe smelting (their soils may contain some significant lead amounts). Nevertheless, no conserved structure has been discovered, due to the relatively bad taphonomic conditions generally encountered on *Altenberg* sites.

4- Later foundries

A fayalitic slag spreading has been spotted at the foot of the *Altenberg*, in the Echery village surroundings. A geophysical survey has allowed locating the most important slag concentration, which was investigated through two successive years of archaeological surveying (2006-2007) and an excavation campaign (2008). The site revealed itself complex and multiphased. Archaeological material and absolute dating have permitted to distinguish

⁷ Performed on a sawn plank unearthed in the gallery by P. Clerc (INRAP).

three periods of occupation. The first goes back to the second half of 13th c. (y. 1261-1284). It shows an important innovation : it is, for the *Altenberg*, the oldest example of the smelters' will to settle farther from the veins (distant of approximately two kilometers), and in a stream's proximity. This happened right during the gothic's advent in the Rhine regions. The facilities scale and situation may suggest that it could have been supplied by different *Altenberg* mines. Moreover, the end of this period seems to coincide with some historians' assumptions that exploitation would have ceased in 1280 : could these information be put in relation?

This site knew a second period of activity during the 14th century, which is attested by a strong masonry, as by large quantities of material such as stove tiles, cooking pottery and furnace tuyères, and also by abundant industrial wastes (charcoal, fayalitic slags,...).

Another slag concentration site has been spotted on the foot of the *Altenberg*, at the bottom of Saint-Philippe small valley. Its location could have been motivated by a stream's proximity, but with no certainty. Its dating (2 sigma 1039-1212) ought to be confirmed.

5- The hydraulic energy innovation and the first ore-washing facilities

In the middle of 14th century took place what we call the *late Middle Ages technical breakthrough*. Its oldest clue is the surface facilities⁸ that were renamed, 170 years later, *Vieux-Saint-Guillaume*. This upheaval is first characterized by the establishment of an altitude small canal of about 1,5 km length in order to operate a large pumping machinery in a big shaft. The canal structure itself hasn't been unearthed (maybe it was a wooden structure), but some remains were found by surveying several trenches, consisting on alternated sand and silt deposits.

Downstream of the structure we could call *Vieux-Saint-Guillaume* shaft, this canal could have been used for ore-washing operations, which remains consist on important sandy sediments and *schlamms* buildups up to several meters thick. Further down, about 300 meters from it, the older site Pfaffenloch knew a new period of activity. In the middle of the 14th c.⁹, the slag heap in this place is interspersed with tailing waste materials and ore-washing wastes – sandy and silt sediments – layers. This could corroborate the first “hand-made” stamp milling operations.

This site also provides us with clues of new metallurgical practices that one can qualify as a “technical revolution” in this context. Till then, siderite as gangue rock was introduced in furnace with the lead ore. This process explains the concomitant presence of slag and tailing wastes within the slag heaps, the latter stemming from a crude sorting. This mixture produces, as activity wastes, slags presenting an iron silicate framework, fayalite (fig. 7). The evoked

⁸ Dated by thermoluminescence on a cooking pottery fragment.

⁹ Dated by radiocarbon and cooking pottery typology

innovation consists on sorting extracted material by water, after “hand-made” milling. Thus galena is sorted from its gangue by gravity in facilities we qualified as “*proto-laveries*”, which remains are those layers of sand and *schlamms* in stratigraphy. 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 (fig. 8). An astonishing fact is the resilience, for even one and a half century, of the ancient process in some places of the *Altenberg*. For example, the metallurgy site called *Charlotte* has known its last activity period in the second half of the 15th century, after a gap of about 400 years. Metallurgical wastes there still present a fayalitic facies. Moreover, two hearths were unearthed in this sequence; one of them offers some similarity with a structure which was found in the Westphalian *Altenberg*¹⁰. Thus, during a 250-years time laps, the *Altenberg* constituted an original place to observe the strong promiscuity of innovations and old-fashioned processes’ resilience.

Other sites, investigated during the research program, furnished information about this 15th century, for which we suffered a lack of knowledge¹¹. The medium part of the *Altenberg* is centered on a cluster of mines, which at beginning of the 16th c. were named Berg Armo; in their vicinity, several surveying trenches were performed in 2011 (a site called “*Bergarmuth*”). They revealed an unconformity between tailing wastes layers dated from the middle of 15th c., interspersed by gangue rocks stemming from “hand-milling”¹² (fig. 9), and layers of sediment in a double ore-washing basin dated from the turn of the 16th c..

6- Late Middle Ages galleries... and the textual sources explosion

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

The number of dated mines which original name is known from us also allowed attempting an onomastic approach. Assuming that no considerable interruption had struck mining activities

¹⁰ DAHM C., LOBBEDEY U., WEISGERBER G., *Der Altenberg : Bergwerk und Siedlung aus dem 13. Jahrhundert im Siegerland*, Bonn, R. Habelt, 1998, 2 vol.

¹¹ 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.).

¹² A “*Scheidstein*” (mortar for ore crushing) was discovered in the same layers.

in *Altenberg*, why would have the Renaissance people absolutely renamed the former mine porches? Names that aren't linked to a religious lexical field, such as *Einhorren*, *Weinstock*, *Grüntann*, *der Stein*, *der Greiff*, *Backofen*... might constitute toponymical remnants. A study led on written sources is currently led following this hypothesis.

7- At the turn of the 16th century

The last noticeable technical change, at the turn of 16th c., is the adoption of a water-powered stamp milling, concomitantly with a new generation of foundries. These reflect technical systems that Biringuccio, and then Agricola, have described. In the lower part of the *Fertrupt* village, the most northern part of *Altenberg*, remains of a foundry, coupled to an habitat, were investigated in the vicinity of a mine called *Fundgrube*, where exploitation was initiated in 1502 (or 1506) by Lord Brunon of Ribeaupierre. It revealed an hypothetic furnace base crudely elaborated, but also numerous vitreous slags including massive lead quantities, as if the new metallurgical processes applied to well-prepared ore wasn't mastered then.

The most well-achieved facility among smelting works of the very 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 precedent buildings (see § 4). Archaeological excavations have revealed a part of it; but it's especially well illustrated by exceptional archive documents filled with a number of technical details.

Conclusion

Datings obtained in 2008 and 2009 have totally infirmed the paradigm, elaborated following historical information, of a total lack of activity in this sector during the end of the Middle Ages. Way is now open to consider an uninterrupted (or nearly-uninterrupted) mining and metallurgical activity in a 700-year period. From now, the research issues precise themselves : to link the different successive phases of this mining industry with major events that have struck the local history (as the transition from a monastic to a seigniorial economy, the advent of *Echery* nobles, the edification of their castle,...) and the regional one (increasing importance of minting,...) throughout the medieval period. The major mining districts' organization at the scale of the *Oberrhein* also has to be considered. Thus, for the 2012-2014 period, we envisage to extend this *Collective Research Program* to consider those questionings. For example, it is planned to perform isotopic analyses on lead found in different mining or smelting sites – as the *Altenberg* – and to confront it to architectural lead from monuments in the Rhine region. It appears as an essential step evaluating the metal's spreading. Moreover, two PhD works were initiated in 2010 and 2011, to a further development of historical and archaeological approaches.

Figures

- 1 Map of non-ferrous mining districts in the Vosges (Middle-Ages to 18th c.)
- 2 Map of the mining district of Sainte-Marie-aux-Mines
- 3 Map of the Altenberg area, showing the different operations 2006-2011 (excepted field and geophysical surveys)
- 4 Synthetic chronological diagram. Black : mines (*mine Patris* obtained by dendrochronology). Dark grey : radiocarbon datings (2 sigma intervals, excepted *Echery 1* and *Stievani*). Light grey : TL datings. In the bottom of the diagram, southern sites of Altenberg area, in the top northern sites.
- 5 Map of the upper part of the Altenberg area, showing the pits (*Pingen*) and their tailings, and the location of mines "Vieux-Saint-Guillaume" and "Vieux-Rimpy" (below on the left, two galleries). P. Fluck
- 6 a flow of fayalitic slag material, location Patris
- 7 microstructure of a fayalitic slag
- 8 section of a slag from Pfaffenloch 14th or 15th c., showing grey spherulites in a green glassy matrix
- 9 the "Bergarmuth" tailing below the washing basin sediments, showing waste layers resulting from ore hand milling

Résumé français

L'Altenberg alsacien : un laboratoire de sept siècles de métallurgie de l'argent !

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Une renaissance de l'archéologie des mines et des métaux à Sainte-Marie-aux-Mines (Alsace, France) s'est esquissée en 2006, qui aboutit à la structuration d'un projet collectif de recherches pluriannuel (2008-2011) « Mines et métallurgie de l'argent à l'Altenberg, X^e – XVII^e siècles ».

Pionnière en Europe à une telle échelle, l'archéologie minière fortement impulsée dans les années 1980 avait abouti à l'affirmation d'une « école sainte-marienne », caractérisée par un va et vient permanent entre l'archive et le terrain, appliquée au domaine des sites miniers de la Renaissance. Le nouveau programme 2006-2011 s'adresse à des problématiques qui embrassent les techniques, les économies et les sociétés pour la très longue période qui précède. Mais le Moyen-Age n'a pas livré de textes, et le mobilier datant se révèle rare dans les fouilles : la méthode était donc totalement à revoir. A l'Altenberg, berceau de l'extraction minière et de la métallurgie à Sainte-Marie-aux-Mines, l'enquête s'appuie sur la multiplication des sites sondés ou fouillés, assortis de datations absolues.

Les résultats de ces investigations bouleversent ce qu'on croyait savoir : entre l'instant des premiers moines d'Echery, vers 937, et les derniers soubresauts de la Guerre de trente ans, en 1637, aucune interruption durable n'affecta l'activité extractive. Tout au plus peut-on, dans cette longue durée, détecter quelques « pics » de plus grande prospérité, autant de jalons de l'histoire : l'ère des puits alignés par centaines sur les crêtes des filons au X^e s., le boom de l'an Mil avec l'éclosion des fonderies et la généralisation des travers-bancs, le XIII^e, le XIV^e, le XV^e s. ... Mais cette histoire est jalonnée d'initiatives innovantes :

❑ première fonderie hydraulique vers 1250, qui fait le choix de s'éloigner des filons pour se fixer sur le voisinage des cours d'eau

❑ révolution technique du Bas-Moyen-Age, initiée vers 1350 par le tracé d'un canal d'altitude pour un dispositif d'exhaure

❑ abandon progressif de la métallurgie traditionnelle, qui consistait à verser dans les fours la galène et sa gangue de sidérite simplement fragmentées, et qui génère des scories fayalitiques

... pour une métallurgie appuyée sur le minerai bocardé manuellement et donc trié par l'eau, un process qui génère des scories vitreuses. Les premières « protolaveries » apparaissent ainsi dès la seconde moitié du XIV^e s. et se multiplient au courant du XV^e s., au côté de fonderies résiduelles jouant la carte de l'inertie vis-à-vis de l'innovation

❑ à la charnière des XV^e et XVI^e siècles, le bocardage hydraulique induit un changement d'échelle dans le domaine des laveries et des fonderies.

Le projet pour 2012-2014 prévoit d'étendre la « méthode Altenberg » à divers sites médiévaux d'extraction et de métallurgie de non-ferreux d'Alsace, afin de tendre vers une géographie économique des différentes époques de l'histoire, qui pourra être mise en perspective avec les découpages territoriaux, les événements politiques et économiques et le développement des sociétés dans l'ensemble de l'Oberrhein.

NOTE IMPORTANTE : depuis la présentation de ces résultats le 1.07.2011 à l'occasion de la Troisième Conférence Internationale « Archéométallurgie en Europe », des datations nouvelles ont permis d'étendre l'activité minière et métallurgique à l'Altenberg à l'époque carolingienne.