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ORIGINAL ARTICLE

Melle but not Melle? A mine's mint as a hub for Carolingian silver coinage recycling

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Abstract

The mines at Melle in Deux-Sèvres, France, are known as the only significant source of silver for the early Middle Ages until the 10th century. Though it was not a major locality, the settlement possessed a mint in the Merovingian period that became one of the major centres of coin production under the Carolingians in the ninth century. Following the decrease in Carolingian power and increase in the autonomy of local authorities from c.900, the counts of Poitou started minting a coinage in the name of Melle that remained with the same typology for the next two hundred years. This paper presents an examination of the trace elements (Au and Bi) determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) in nearly 2000 silver coins covering four centuries over the Merovingian, Carolingian and Feudal periods. It has two main objectives: first, identifying the patterns of trace elements for the coinages attributed to Melle by comparing them with those of the same periods from other mints; and second, establishing the general evolution of the trace elements in coins from Poitou and other areas are scrutinized to evaluate the contribution of fresh silver from Melle, in order to identify the silver stocks available. One main result is that part of the silver minted at Melle in the ninth century does not present the trace element patterns that characterize Melle silver, suggesting the use of the Melle mint as a hub for coining not only local silver from the mines but also for recycling and refining silver previously coined elsewhere.

KEYWORDS

archaeometallurgy, early Middle Ages, provenance, silver, trace elements

INTRODUCTION

Melle (Deux-Sèvres, France) is a famous name for specialists of early medieval history, since it is the place of the only well-attested silver mine of some significance in Western Europe before the 10th century, and was the location of a major mint for coin production, especially during the ninth century under the Carolingians. Nonetheless, many aspects of silver production and coin minting at Melle remain unclear, especially concerning the periods of those two activities, the scale of silver production, and the precise relationship between primary silver production and the volume of coin output.

In a global perspective, the exploitation of the silver-bearing minerals at Melle is attested from the fifth to the 10th centuries, whilst silver coin production attributed to Melle or bearing its name spans the late seventh to the early 12th centuries. Written sources citing Melle for this period are extremely few (Bourgeois, 2014), and one should rely on archaeology and numismatics for understanding the history of silver production and coin minting associated with Melle.

In addition to archaeology and numismatic study, analysis of the silver coins produced at Melle or in the name of Melle can be extremely useful for understanding the organization of the local silver primary production and coin minting during the early Middle Ages. The determination of trace elements as provenance markers in silver of the Carolingian period, especially for Melle, was undertaken in the past with significant results (Sarah, 2008, 2009, 2010; Sarah et al., 2008). The entire about four centuries of coin production covering the Merovingian, Carolingian and Feudal periods, during which coins are attributed to Melle or bear its name, nevertheless need to be investigated more thoroughly. The determination of Pb isotope ratios in silver coins from Melle is another approach that proved the relationship between Melle coinages and the locally produced metal for both Merovingian and Carolingian periods (Clairand & Téreygeol, 2009; Téreygeol et al., 2005). Nonetheless, this approach can generate potentially misleading results, since the isotope ratios characterize the Pb contained in the alloy and not the silver itself. Pb isotope ratio determination can be a precious clue linking coins minted from primary silver production or after remelting without mixing different sources; in cases when silver is recycled and purified by adding lead during cupellation, the Pb isotope ratios of the newly produced silver coins keep the characteristics in trace elements of the different silver stocks that were mixed, but carry a Pb isotope fingerprint corresponding to the metallic lead added for cupellation. As a consequence, one needs to be careful when making correlations between Pb isotope ratios in silver and the provenance of the precious metal, even in the case of coinages associated with a mine such as Melle.

This paper is an archaeometric study of ancient silver coins aiming at identifying patterns in trace elements (Au and Bi) in the early medieval silver coinages in a long-term perspective, starting from Merovingian coinage of *c.*670 to the end of the coinage in the name of Melle *c.*1120, by focusing on the specificities of coin productions attributed to Melle.

MELLE: DIFFERENT STORIES FOR A MINE AND A MINT

From a geological point of view, Melle is the location of a 47 km² district epigenetic strata-bound mineralization where galena (PbS) is the dominant sulphide. The galena at Melle is slightly argentiferous with 1–5‰, as is usually the case for Mississippi Valley Type deposits. The galena represents 1–2% of the average weight in the rock, but it has been stated that exploitation focusing on the richest ore concentrations could reach 5% (Téreygeol, 2017). The mineralization is embedded in karst in a depth ranging from 0 to 6 m below the surface. The

global amounts of lead and silver remaining available are estimated at 750,000 and 1400 t, respectively (Coiteux, 1982).

The Melle silver mining district is a particular case in the history of mining and metallurgical activities in Western Europe since it was exploited during the early Middle Ages only, with no later work attested neither during the later Middle Ages nor during the Modern period. Coins bearing the name of Melle are known from the sixth to 12th centuries, starting from gold *tremissis*—obviously not made from locally produced metal—to feudal debased silver deniers, the most important and most famous activity being during the ninth century under Carolingian rule. Due to the nature of the rock surrounding the ore, the mining galleries at Melle were excavated using the fire-setting technique (Téreygeol, 2001). The repeated fires allowed digging using a hammer and a stone chisel in the fragilized rock, for a few centimetres each time. The mining galleries stayed untouched since the exploitation ceased *c.*1000, so one main interest of those repeated fires is that numerous charcoals remain among the barren rock fragments in the subterranean galleries where the wood was burnt. Consequently, many radiocarbon datings could be made at different places of the accessible networks, allowing a general overview of the period of exploitation of silver-rich galena at Melle alongside an evaluation of the intensity of use over time (Téreygeol, 2017). This survey, yielding 24 radiocarbon datings, provided two main results. The first is that the exploitation started as early as the fifth century, before any silver-based coinage of any significance was minted in Gaul, and ended *c.*1000, although coinage in the name of Melle is known until the early 12th century. The second relates to the intensity of the digging, from which the evolution of the silver production can be inferred: there are a limited number of datings from the first half of the fifth century to the first half of the seventh century, then a drastic raise for the second half of the seventh century when Merovingian coinage switches from (debased) gold monometallism to silver monometallism. Mining activity remains at the same level until *c.*900 and declines during the 10th century before the exploitation stops by the early 11th century. These observations show that a high level of production was reached as early as the second half of the seventh century, although it would have been expected for a century later under Charlemagne under a centralized and organized Carolingian state. If the correlation between the number of radiocarbon datings and the quantity of silver produced is meaningful, this also shows that the amount of precious metal produced remained stable from *c.*650 to *c.*900, which was not expected.

Besides the evaluation of silver production based on the radiocarbon datings of charcoals collected in the mining galleries, Téreygeol attempted to give some figures relating to the global amount of silver produced at Melle during the early Middle Ages, extrapolated from an estimation of the total volume of extracted rock. The figures obtained are a total of 38 millions of tonnes of rock extracted over six centuries, which renders 3150 tonnes of silver for an average concentration of 5% ore in the extracted rock, in other words 4.1 tonnes/year on average, with about 15 tonnes/year during the period of silver coinage monometallism, *c.*650–900 (Téreygeol, 2013, 2017). Those figures are discussed and criticized in by Bettenay (2022, following Bartels, 2014). According to Bettenay, a comparison of Melle with other silver mines from different periods shows that the numbers given by Téreygeol are inflated. This author concludes that silver production at Melle was of a smaller scale and that the amount silver necessary for fuelling the Carolingian economy should have been obtained from trade.

It is not our purpose here to determine if one of those authors is closer than the other to the reality of the silver production at Melle between *c.*500 and *c.*1000 because of the lack of documentation that causes high uncertainties for both approaches. This paper proposes instead to contribute to the understanding of the silver production in the Melle district and the proportion of this metal in the whole Carolingian stock from the study of the trace elements in silver coins obtained from elemental analysis.

MATERIALS AND METHODS

Coin corpus

The material used in this paper is composed of 1887 silver-based coins minted from the end of the seventh to the early 12th centuries. It is beyond the scope of this paper to propose a detailed numismatic study of all the coins whose analytical results are considered here. For each group or category, when necessary, references are given to relevant publications. Most of the coins analysed come from the collection of the Département des Monnaies, médailles et antiques, Bibliothèque nationale de France. Smaller groups were lent by the Koninklijke Bibliotheek in Brussels, Belgium; the musée Bernard d'Agesci at Niort, France; the DRAC Nouvelle-Aquitaine, France; and private collectors.

Amongst those 1887 coins are 328 Merovingian silver *denarii* dating from c.670 to 751. A total of 80 of them are attributed to mints located in the Poitou region: 17 from Melle itself, 15 from Brioux-sur-Boutonne (about 10 km from Melle) and 48 from the main city and minting place of Poitiers (about 60 km from Melle). The 248 others come from different mints in the area where Merovingian silver was minted, notably from Tours (for a detailed discussion, see Schiesser & Sarah, 2017), Orléans, Paris, Rouen, Chalon, Clermont, Brioude and Marseille (Fig. 1). Clairand & Téreygeol (2009) give crucial information concerning the attribution of a particular Merovingian silver coin type to Melle, as well as Pb isotope analytical results for Merovingian coinages from Poitou and neighbouring regions.

Carolingian silver is represented by 1079 coins minted from the reign of Pippin the Short (751–68) to the early 10th century. A total of 145 are from Melle and 934 from other mints, located throughout areas of the territories under Carolingian rule under Pippin the Short, Charlemagne and Louis the Pious, and in *Francia occidentalis* only after 840 (Charles the Bald mostly, but also Pippin II of Aquitania, Eudes, Charles the Simple, Raoul, etc.). Part of those results are presented and discussed by Sarah (2008), to which the reader is referred for a general overview of the main characteristics of the Carolingian silver from c.750 to c.840. The analytical results of the coinage from Melle for the Carolingian period are discussed by Sarah (2009, 2010).

It is difficult to differentiate some early Feudal coinages from late Carolingian coinage. It is not our purpose here to discuss the identification of the first coins of Carolingian type minted by a local authority from its own initiative, or the oldest coinages bearing the name of a count or bishop that marks a significant step in a complex evolution process leading to the autonomous emission of coinages by those authorities. In the case of Melle, what can be ascertained is that following the emblematic Carolingian type with *Karolus* monogram, a new coinage bearing a legend METALO on the reverse appeared during the first half of the 10th century and was minted until the early 12th century with the same typology—the so-called phenomenon of coinage immobilization. As a consequence, considering the dating of the interruption of the exploitation of the mines of Melle estimated c.1000, the production of the METALO coinage continued during more than a century after the production of fresh silver at Melle ceased. Moreover, though the question of the location remains debated, it is likely that the location of the mint that produced the METALO coinage was not Melle any more at some point, but another place in Poitou (Jeanne-Rose, 1995).

Though some differences in the legends and styles of the coins can be identified among the coins of the METALO type, it remains a difficult task to date immobilized METALO coins when studied in isolation. For this reason, in contrary to the Merovingian and Carolingian coinages, the coins studied and analysed for the Feudal period come from hoards dated with different levels of accuracy. One exception is the oldest group which is constituted by METALO coins of the earliest style ('Javarzay style', from the name of a hoard described by Lecointre-Dupont (1840) (dating from the first half of the 10th century), with seven coins analysed being from the Bibliothèque nationale de France without information about their discovery. For the later

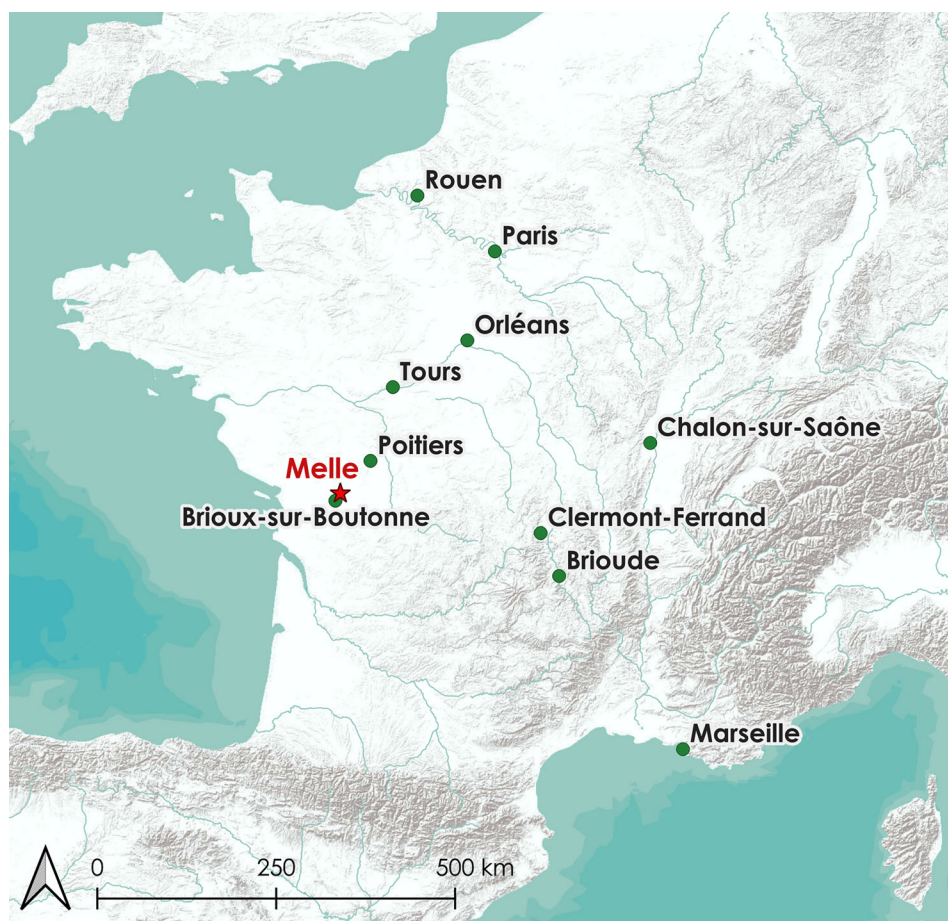


FIGURE 1 Map showing the localization of Melle and the Merovingian mints mentioned in the text (credit: L. Chanal).

immobilized coins from Poitou, the groups are defined from the hoards the METALO coins come from and the dating of those hoards: 39 from the Fécamp hoard (*c.*980) (Dumas, 1971), 20 from the Chanteloup hoard (11th century) (Richard, 1904–06) and 15 from the Melle hoard (*c.*1120) (Bouvard & Clairand, 2011). For the coinages of the Feudal period from other areas, the coins come from the hoards of ‘Loiret’ (*c.*960) (Achache et al., 2018), Fécamp (*c.*980) (Dumas, 1971) and Le Puy (*c.*1005) (Lafaurie, 1952). The total number of coins analysed for the 10th–12th centuries is 480: 81 METALO coins from Poitou and 399 from different areas located in current western, northern and central France. Some of those coinages were already discussed previously regarding the combined phenomenon of the evolution of their silver fineness and of their zinc content as a marker of the use of brass for debasing silver-based alloys (Sarah, 2019; see also Bompaire & Guerra, 2000).

The repartition of the corpus according to the groups used on the graphs is given in Table 1.

Analytical approach

All the analytical results presented in this study were obtained by laser ablation (LA) inductively coupled plasma mass spectrometry (ICP-MS) between 2005 and 2023,

TABLE 1 Number of coins in the analytical corpus by era and minting period when possible. Coins from Melle/Poitou are separated.

Era	Region/mint		Number
Merovingian	Poitou	Melle	17
		Brioux-sur-Boutonne	15
		Poitiers	48
	Touraine		100
	Others		148
	Total Merovingian		
Carolingian	Melle	Charlemagne (768–814)	22
		Louis the Pious (814–822/3)	32
		Monogram uncertain (793/4–814 or 840–c.900)	28
		Pippin II of Aquitania, Charles the Bald and immobilizations, 840–c.900	63
	Others	Pippin the Short (751–768)	25
		Charlemagne (768–814)	154
		Louis the Pious (814–840)	227
		Pippin II of Aquitania 839–852 and Charles the Bald, 840–864	93
		Charles the Bald and later, 864–c.920	435
		Total Carolingian	
Feudal	METALO	‘Javarzay style’ (c.900–c.950)	7
		Fécamp hoard (c.980)	39
		Chanteloup hoard (11th century)	20
		Melle Saint-Hilaire hoard (c.1120)	15
	Others	Loiret hoard (c.960)	58
		Fécamp hoard (c.980)	211
		Le Puy hoard (c.1005)	130
		Total feudal	
Total for all eras			1887

following the protocol described by Sarah et al. (2007) and Sarah & Gratuze (2016). The LA device was until 2014 a VG UV laser generated by a Nd YAG pulsed laser whose frequency is quadrupled to operate in the ultraviolet range at 266 nm. Since then, the LA device used is a RESOLUTION by Resonetics equipped with a 193 nm Excimer laser coupled to a S155 ablation cell by Laurin Technic. The ICP-MS was a VG Plasma Quad PQXS2 quadrupole until 2009, when it was changed for a sector field Thermo Fisher Element XR with extended dynamic range. Experiments carried out when the devices were changed proved the consistency of the results obtained by the different LA systems and mass spectrometers.

The choice of LA-ICP-MS for early medieval silver coins analysis relies on several characteristics of this method that make it particularly suitable for those artefacts. First, the sampling by LA, usually of a diameter of 70 μm , causes no visible damage to the coins, which is generally accepted by the curators of coin collections. Second, LA-ICP-MS allows to determine the concentration of major, minor and trace elements in silver with low detection limits, generally < 1 ppm (Sarah & Gratuze, 2016), with no sample preparation, and at a rate of about 15 coins per day. In usual conditions, 20 elements are measured (Ag, Cu, Pb, Au, Bi, Sn, Zn, Ni, As, Ru, Rh, Pd, Cd, In, Sb, Te, Os, Ir, Pt and Tl), the laser ablation rate is 8 Hz, the laser fluence 5 J/cm² and the duration of the analysis 300 s. Third, the combination of the progressive

penetration of the laser in the sample with the signal acquisition by the ICP-MS enables the capture of concentration profiles showing the evolution of the contents from the surface to the inside of the alloy. This approach is particularly relevant for ancient Au-Cu alloys such as early medieval coins since they are often affected by silver surface enrichment, caused by the preferential oxidation of the copper at the surface of the object, which may cause an overestimation of the determination of the silver content if not taken into account (on silver surface enrichment, see Condamine & Picon, 1972, Sarah et al., 2007, *passim*).

The analysis of ancient silver coins using concentration profiles by LA-ICP-MS generates accurate values for the major elements of the alloys (Ag and Cu) and, usually, 18 minor and trace elements brought by those two main components. In contrast to other elements, Au contents are not affected by the cupellation process that is used for primary production of silver in most cases and to purify recycled silver, and is therefore the most useful element for distinguishing between stocks of silver having different origins or 'histories' (Blet-Lemarquand et al., 2014; Pernicka, 2014). The gold profiles of silver stocks can nevertheless be transformed by the remelting of gilded silver objects or by incorporating severely debased gold to the recycling of silver. Like other impurities that can be found in silver, Bi concentrations can be affected at the very end of the cupellation process: they should be regarded as markers of provenance of the silver, but also as markers of technical practices (Flament et al., 2017; McKerrell & Stevenson, 1972; Pernicka, 2014). Keeping in mind the limitations mentioned, a combined approach of Au and Bi contents is the best way to trace silver from elemental analysis. In this study, since the Ag amount in the coinages considered can vary from about 30% to nearly 100%, the Au and Bi contents in ppm were divided by the Ag percentage for a comparison of the trace element concentration in silver.

RESULTS

Merovingian silver (c.670–751)

The results for the Merovingian coinage are shown in Figure 2. Coins attributed to Melle are distinguished, as are those from other mints located in the same region of Poitou (Brioux-sur-Boutonne and Poitiers) and from the major mint of Tours, for which it was shown previously that silver was likely to come from Melle (Schiesser & Sarah, 2017). Coins from all other mints located further from Melle (Orléans, Paris, Rouen, Chalon, Clermont, Brioude and Marseille) are represented as a same unique group.

Au in silver coinages of the Merovingian period covers an extremely wide range with Au/Ag ratios from 10 to about 70,000. The breakdown of the value is as follows: 36 coins with a ratio < 1000 (10.9%), 109 from 1000 to 10,000 (33.1%), and 184 > 10,000 (55.9%). Beyond those general remarks, some interesting trends can be noted. The coins for which the Au/Ag ratio is < 1000 are only from Poitou and Touraine (ellipse 1 in Fig. 2): six from Melle, two from Poitiers and 28 from Tours. They also tend to have lower Bi/Ag ratios (10–300), though the trend is not as marked for Bi as it is for Au. Higher Bi level in the silver of coins from Melle and Tours with low Au could reveal a mix with Ag from an undefined source. But taking this all together, those results reveal a general rule for the Merovingian silver in some of the coins from Melle, Poitiers and Tours, namely it has lower Au/Ag levels than silver produced from Melle mines that should correspond according to following results to the Melle signature.

However, this group is only a fraction of the coins from those two areas. The majority of the coins from Melle and Poitiers have Au contents that are half in the range from 1000 to 10,000 and half > 10,000. For Tours, the majority of the coins belong to the range from 1000 to 10,000 (52 coins for a total of 102) and a minor, though significant, group > 10,000 (21 coins). Notably, the coins from Brioux-sur-Boutonne, located only about 10 km from Melle, are all

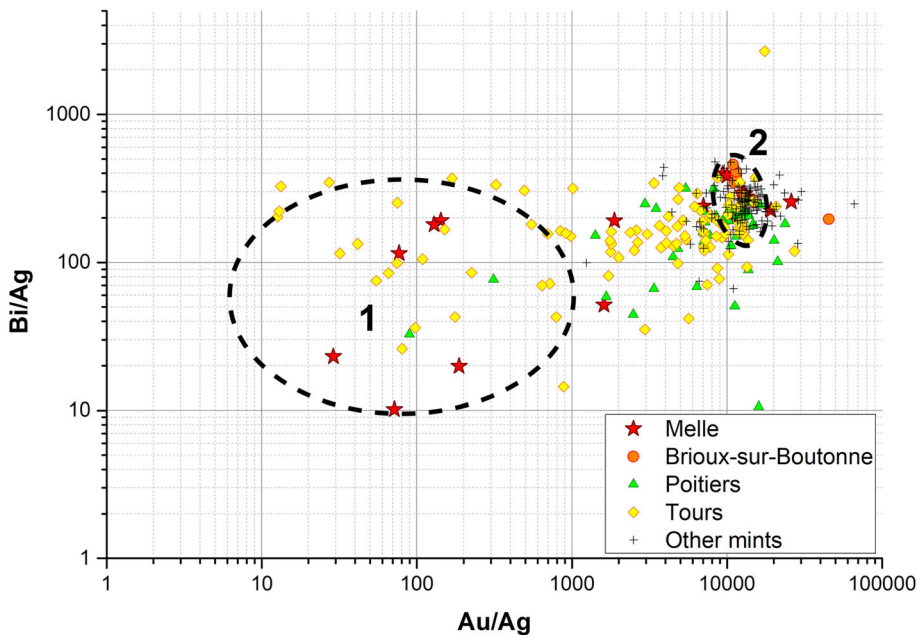


FIGURE 2 Au and Bi ratios in the silver of the Merovingian coins attributed to Melle, other mints in Poitou (Brioux-sur-Boutonne and Poitiers), Tours and other mints in different areas.

characterized by Au/Ag ratios $> 10,000$ (all in ellipse 2 in Fig. 2). This indicates that they do not contain silver from Melle—or an insignificant proportion—and were made instead from recycled silver.

For the Merovingian coins from other areas, the results shown in Figure 2 reveal a concentration of values in the range 10,000–15,000 for Au/Ag ratio (83/148 coins, 56,8%) (ellipse 2 in Fig. 2), with more or less the same number under and above this interval. The high Au/Ag ratios can be interpreted as the remelting of debased gold *tremissis* when the Merovingian coinage switched from gold to silver *c.*670. For the Bi/Ag ratios, the values range from 150 to 300 for 108 of the 148 coins from other areas than Poitou and Touraine. The concentration of the majority of the Au and Bi contents in the Merovingian coins from areas other than Poitou and Touraine could indicate that the silver used by the mints of Orléans, Paris, Rouen, Chalon, Clermont, Brioude and Marseille for this period was dominated by a homogeneous stock. It differs significantly from what we propose to identify as the ‘Melle signature’ in trace elements, that is, very low Au and low Bi (roughly Au/Ag < 1000 and Bi/Ag < 300). Therefore, the main stock of Merovingian silver was probably not ‘fresh’ metal that could be associated with a mining area, and was more likely recycled several times before the coins analysed for this study were made. The recycling of a residual late Roman silver stock is a hypothesis, but there are no data available for making comparisons.

Carolingian silver (751–*c.*900)

Compared with the Merovingian and the Feudal coinage, Carolingian coinage is much easier to link to a minting place, an authority and a period of output, in which the duration can range from a few years to several decades. This enables much more accurate classifications of the coins and interpretations of the analytical results. The corpus or Carolingian coins whose

analytical results are presented in this study is composed of 1079 coins minted from the mid-eighth century to the end of the ninth century. The purpose of this section dedicated to Carolingian silver is both to compare the trace elements patterns in the coins minted at Melle to those from other mints, and to examine the evolution of the Carolingian silver stock in a wide perspective.

Those tasks are complicated by the repetition in the typology of the coinage minted in the name of Melle—the so-called *Karolus monogram* coinage—between Charlemagne (post-reform, 793/4–814) and Charles the Bald (840–77 and immobilized until *c.*900). For the later period, starting during the reign of Charles the Bald, coinages with other typologies were minted at Melle (Sarah & Bailleul, 2014). The presence of a cross in the reverse legend for some *Karolus monogram* coins of this period enables the observation that they were not minted under Charlemagne—but for those without this cross the uncertainty remains (Sarah, 2010). Another limitation concerns the period from 822/3 to 840 under Louis the Pious, when the reverse legend was not the mint-name any more but *Christiana Religio* for all the mints of the Carolingian Empire. Some of the coins can be attributed to a particular mint but none of the coins analysed for this study dating from this period can be attributed to Melle. For the interpretation of the results, the coins from Melle dating from the Carolingian era are separated into 4 chronological groups: the pre-reform coins of Charlemagne (768–93/4), the bust-type and mint-name in the field type coins of Louis the Pious (814–22/3), the monogram coinage of uncertain dating between Charlemagne and Charles the Bald (793/4–814 or 840–*c.*900) and the coinages of Charles the Bald minted from 840 and immobilized until *c.*900 (mostly monogram coins). The coins of the other mints are taken as a whole since their patterns in trace elements do not show correlations with their periods of minting.

In a general trend (Fig. 3), the coins of Melle seem to be constituted by different stocks of silver depending on their period of minting. A first group, characterized by variable but low Au/Ag ratios (about 10–1000) and low to average Bi/Ag ratios (about 100–300) comprises nearly all coins of Charlemagne (768–814), a majority of both those of Louis the Pious dated

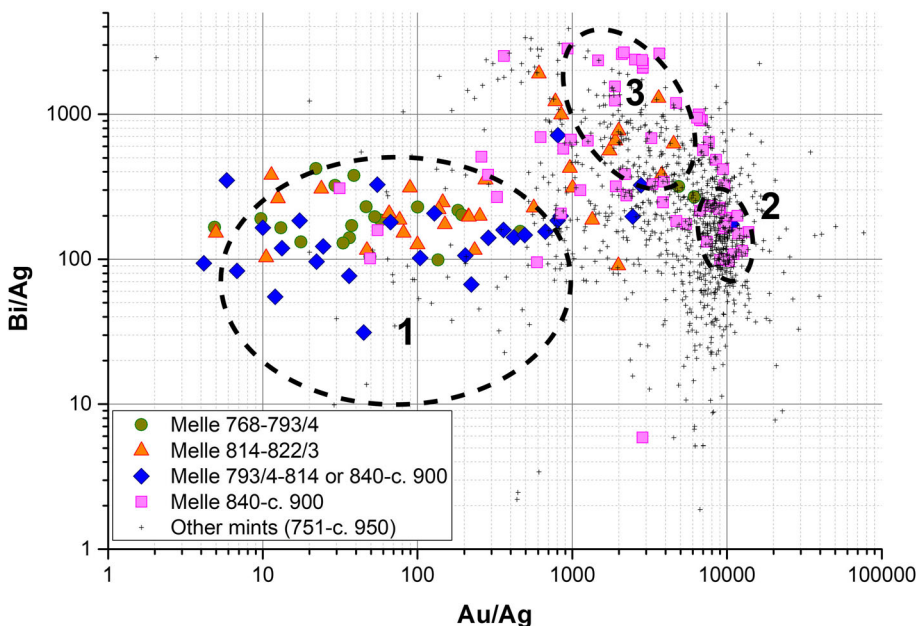


FIGURE 3 Au and Bi ratios in the silver of the Carolingian coinages attributed to Melle (four periods from 768 to *c.*900) and other mints.

between 814 and 822/3 and those with a monogram of uncertain dating (793/4–814 or 840–*c.*900), and a minority of those dated from the reign of Charles the Bald (840–77) to *c.*900 (ellipse 1 in Fig. 3, at the same position as in Fig. 2). The coins of other mints are extremely few in this part of the graph. They correspond in their trace elements signature to some of the Merovingian deniers from Melle, Poitiers and Tours discussed above. Those results on Carolingian coins confirm what was proposed above for the Merovingian coinages for defining the signature of the silver produced at Melle, with Au/Ag ratios < 1000 and Bi/Ag about 20–300.

The second group that can be observed in Figure 3 is composed of coins whose Au/Ag ratios are around 10,000 and Bi/Ag ratios ranging from about 100 to about 300. This group contains the majority of the coins from other mints, and a significant part of the monogram coins of Melle dated 840–*c.*900. Considering the Carolingian coins as a whole but leaving aside Melle, this group gathers the majority of the coins analysed and thus reflects the signature of the Carolingian silver stock. It is noteworthy that this main group of Carolingian coins shows slightly different characteristics from the main silver stock of the Merovingian period, with lower Au/Ag and Bi/Ag ratios. Those results could reflect the incorporation of the silver produced at Melle during the Carolingian era into the older silver stock that was available in Gaul during the Merovingian period, possibly resulting from the recycling of late Roman silver stock. If this hypothesis is correct, it would show that the ‘fresh’ silver from Melle was not insignificant in the whole Carolingian silver stock, but was far from dominating. Instead, the major contribution to this stock would be composed of Merovingian silver, recycled together with another stock characterized by lower Bi levels than Melle, from foreign sources that remain to be characterized.

The third group that can be observed in Figure 3 (ellipse 3) follows the same trend as the second but differs due to lower Au/Ag ratios (about 1000–6000) and higher Bi/Ag ratios (about 500–3000). It comprises a minority of the coins minted at Melle from 840 to *c.*900 and a few dozen coins from other mints, mostly from the second half of the ninth century. Though a minority in the whole group of Carolingian coins analysed, those results indicate that a source of silver was used at the Melle mint and other places with very high levels of Bi starting from *c.*840.

Considering the Carolingian coins from other mints as Melle distinguished by reign or period of output enables deeper insights into the evolution of the Carolingian silver stock from 751 to *c.*920. The results for the Au/Ag and Bi/Ag ratios of five groups of Carolingian coins from all mints but Melle are given in Figure 4: in chronological order, 25 for Pippin the Short (751–68), 154 for Charlemagne (768–814), 227 for Louis the Pious (814–40), 93 for the first period of emission of Charles the Bald (840–64, including contemporary coins of Pippin II of Aquitania) and 435 for his second period of emission (864–77) and later emissions (mostly immobilizations of the coinages of Charles the Bald, and also some for Louis II, Louis III, Eudes and Charles the Simple). The Carolingian silver that constitutes the coinage of Pippin the Short is dominated by a group characterized by Au/Ag ratios around 10,000 and Bi/Ag ratios from about 100 to about 200 (ellipse 1 in Fig. 4). Those values are close to what was observed for the Merovingian coins outside Poitou and Touraine, which was interpreted as recycled silver, possibly of Roman origin. This indicates that the silver from Melle cannot be regarded as dominant in the initial silver stock of the Carolingian period under Pippin the Short, during whose reign no coinage can be attributed to Melle.

The silver stock evolves significantly during the reign of Charlemagne (768–814) with a shift towards much lower Au/Ag ratios (ellipse 2 in Fig. 4). Following the observations above on the Merovingian coinage and the specific examination of the Carolingian coins from Melle, this can be interpreted as an influx of silver from Melle in the general stock that constitutes the Carolingian coinage *c.*800. This could be related to a reinforcement of the control applied by Charlemagne over the mines and coin production at Melle, and an intensification of the production. This probably also implies an increase in the global volume of the monetized silver stock in a growing Carolingian territory and economy.

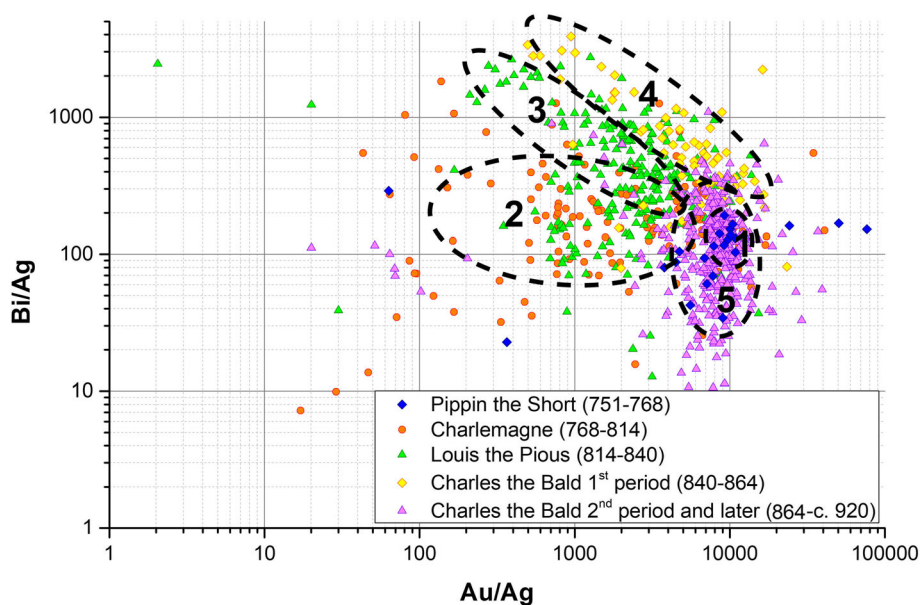


FIGURE 4 Au and Bi ratios in the silver of the Carolingian coinages attributed to all mints but Melle (five reigns or periods from 768 to c.900).

Part of the coinage of Louis the Pious has the same Au and Bi characteristics as described for Charlemagne, but only a minority. Following the main hypothesis proposed in this paper, this would imply that the silver coinages produced in the Carolingian territory under Louis the Pious contain a significant though minority contribution of the fresh silver from the Melle mines. For the same reign, a different trend is observed in Figure 4 (ellipse 3) that distinguishes this group from most of the coins of Louis the Pious, from low to higher Au/Ag and Bi/Ag ratios, with an extreme group characterized by Au/Ag ratios about 200–500 and Bi/Ag ratios about 1000–3000. As a consequence, it can be interpreted from those results that the silver used for coinage in the Carolingian territory—representing most of Western Europe—from 814 to 840 is composed in minority by metal from Melle: a majority of the stock constitutes a new trend that differentiates it from older silver coinages especially with higher Bi levels.

From those observations, we can propose that a source of silver outside of the Carolingian territory that remains unidentified was massively incorporated in the Carolingian silver stock. This trend is confirmed by the results obtained for the coinages of Charles the Bald minted before the reform of the Edict of Pitres (840–64). During this troubled period, characterized by internal conflicts between the sons of Louis the Pious and the Viking raids, the Au and Bi patterns of the Carolingian coins confirm the main trend observed for Louis the Pious. Those coins of Charles the Bald are almost always different from the Melle signature, which indicates that the fresh silver produced in Poitou was insignificant for the Carolingian silver stock of this period as a whole, and that the foreign source that appeared during the reign of Louis the Pious became dominant, with a shift towards higher Au/Ag and Bi/Ag ratios (ellipse 4 in Fig. 4). This could also be explained by decreasing activity at the Melle mines and metallurgical installations due to the instability of the early period of the reign of Charles the Bald.

This situation was only temporary and a significant change in the trace elements patterns of the Carolingian silver is observed for the coinages dated after 864 (Charles the Bald and later reigns until Charles the Simple). Those coinages of the last third of the ninth century and of the beginning of the 10th century, from *Francia occidentalis*, constitute a consistent group defined

by high Au and low Bi levels (ellipse 5 in Fig. 4) similar to what was observed for the main group of Merovingian coins and the earliest Carolingian coinage under Pippin the Short (751–68). For this period again, the contribution of the Melle silver to the general stock in circulation remains imperceptible. The Edict of Pitres in 864 is a significant moment in the history of early medieval coinage: after a period during which several coin different types existed for the same kingdom, and coins were debased and of variable fineness, the *Gratia Dei Rex* coinage introduced that year by Charles the Bald marked the last general and efficient reform of the Carolingian era, with a unified typology and enhanced standard of silver imposed on all mints (Sarah, 2010). When this monetary reform occurred, it is likely that the debased coins in circulation were recycled, refined and remelted with new silver resources characterized by higher Au and lower Bi than during the previous period, that does not fit with the Melle signature. The source of this massive influx of silver cannot be identified from the data available in the literature.

The results published by Téregeol presented above about the mining activities at Melle based on the radiocarbon dating of charcoal remains from fire-setting underground digging indicate a high level of activity during the whole ninth century. Looking at this in light of the results discussed above for the trace elements levels in the Carolingian coinage, a possible interpretation that would be suitable for both observations is that although the mine of Melle was highly productive on the scale of its own history, the rise in the need for fresh silver in a growing Carolingian economy required the mobilization of silver resources acquired outside of its own territory, either by recycling foreign coinages or by making use of newly exploited metal resources. Melle would thus appear as a major mint for coining the ‘fresh’ silver produced locally, but the results also suggest that the Carolingian authority used the metallurgical facilities located at Melle for recycling silver from other origins, starting during the reign of Charlemagne and intensifying under Louis the Pious. Following this hypothesis, there would be a discrepancy between the silver production from the mines at Melle and the amount of silver used for coin production there. The question of the total amount of silver produced during the whole duration of the exploitation of the Melle has already been tackled and discussed above in this paper (Téregeol, 2013, *contra* Bettenay, 2022). Cupellation furnaces for primary production of silver at Melle must have been numerous and the specialized knowledge of the local metallurgists—probably the most skilled of the whole Carolingian Empire—would have been regarded by the rulers as an opportunity to centralize the production of a highly standardized coinage with a great level of control and organization over mining, metallurgical and minting activities. Also, this would be consistent with the observations based on the inscriptions on the Carolingian grave stones found at Melle, that associate the names they contain to a specific group of elite different from the local authorities that would have been closely associated with the Carolingian central power (Treffort, 2007; Treffort & Uberti, 2010).

Feudal silver (c.900–c.1120)

The coinage of the Feudal period in France is hard to define since it represents a continuation of Carolingian coinage with immobilizations of royal and imperial types from the last decades of the ninth century and new coinages in the name of local authorities from c.900 for some mints or principalities only. The immobilization of older types and the persistence of the name of local rulers for coinages of some areas makes them often hard to date. For this reason, the analytical study of the French Feudal silver was tackled by taking into account as much as possible coinages from hoards that could be dated with a certain level of accuracy. Also, changes in the political organization implies that in some cases like Melle local authorities moved the mint under their rule from one place to another, although the name of the former locality remained on the coinage sometimes for several decades.

81 coins in the name of Melle (METALO legend on the reverse) are considered here, divided into 4 chronological groups: 'Javarzay style' (*c.*900–50), Fécamp hoard (constituted *c.*980), Chanteloup hoard (11th century) and Melle hoard (*c.*1120). Those coins were minted at Melle until a certain moment during the 10th century, when the counts of Poitou moved the place of minting to another place, possibly Poitiers or Niort. From the charcoal radiocarbon datings discussed above, it can be considered that the use of fresh silver from the Melle mines remains possible for the METALO coinage until *c.*1000, that is for our corpus for the Javarzay style coins, those from the Fécamp hoard, but not from the Chanteloup and Melle hoards. For the other mints, the 399 coins analysed for comparison are from mints located in different parts of modern northern, western and central France. They come from three main hoards dated from the middle of the 10th century to the early 11th century (Loiret, Fécamp and Le Puy, in respectively Achache et al., 2018; Dumas, 1971; and Lafaurie, 1952). That is a shorter chronological span than the METALO coins considered and consequently limits the possibilities of interpretation of the characteristics of the silver stock used for coinage during the Feudal period outside Poitou.

The results presented in Figure 5 for the Au/Ag and Bi/Ag ratios of the four chronological groups of METALO coins show a much lower general dispersion when compared with the Merovingian and Carolingian period. One first remark is that the part of the graph corresponding to the low to very low levels of Au and the low to mid-levels of Bi defined as the Melle trace element signature is nearly blank. Most of the values are concentrated between 4000 and 10,000 for Au/Ag and between 200 and 800 for Bi/Ag. Some slight differences can be observed between the four chronological groups of METALO coins but most of the data are included in the main group that comprises nearly all coins dated *c.*950–1005 from all areas of modern France. Only a few METALO coins of the Chanteloup hoard (11th century) have Au and Bi levels that correspond to the Melle silver signature, and a minority of those from the Fécamp hoard (*c.*980) have higher values than the main group, which would imply a foreign

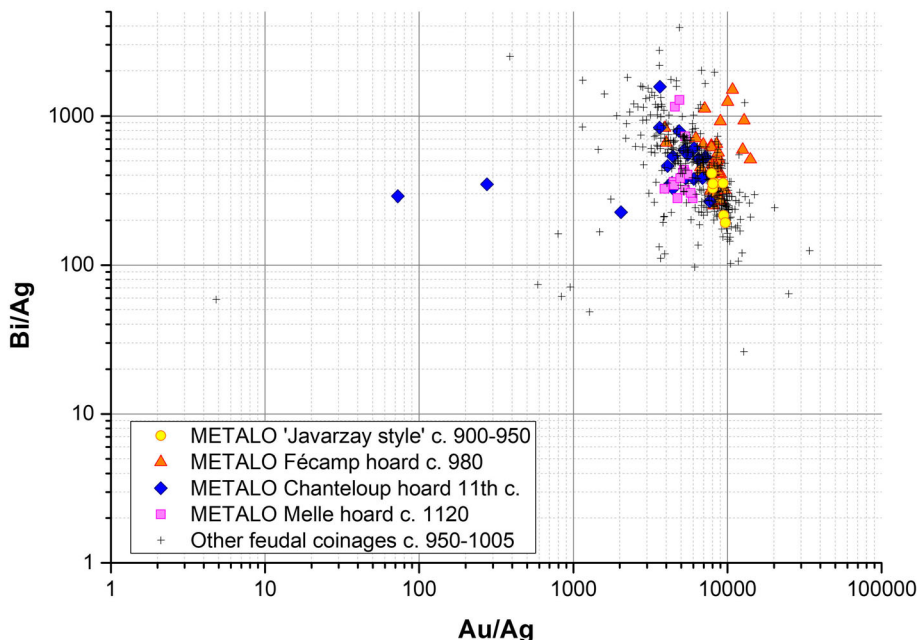


FIGURE 5 Au and Bi ratios in the silver of the feudal coinages of the METALO type from Poitou (four chronological groups from *c.*900 to *c.*1120) and of other areas (*c.*950–1005).

origin of the silver that could be linked with the move of the mint producing the METALO coinage from Melle to another place. Those results altogether show that the silver used for coinage at the mints that produced the METALO series, as well as in the other coinages dating from *c.*950 to *c.*1005, have a consistent signature in trace elements that indicates that the silver-based coins minted in Poitou are not different from those from other areas and belong to a same general stock. This would mean that a homogenization of the silver in what corresponds to modern France occurred at the beginning of the 10th century, possibly the remelting of the Carolingian coinage of the second half of the ninth century with the addition of another silver stock characterized by lower Au levels and higher Bi levels.

The political situation of the 10th century is no longer characterized by a central royal authority deciding for the different principalities under its rule, as it was the case during the Carolingian era from the mid-eighth century until the death of Charles the Bald in 877. The former Carolingian territory, for what concerns modern France, evolves in its political and economic characteristics, becoming a series of principalities having each their local powers (dukes, counts, bishops, etc.) and their own coinages. The scale of coin circulation decreases drastically and the coins are significantly debased in the course of the 10th century. For those reasons, it seems legitimate to imagine that most of these feudal principalities used the silver stock available locally, constituted by their own previous coinages due to a coin circulation of limited range, for producing a new debased coinage with a similar design. It is no surprise, then, that the successive silver in the METALO coinages minted in Poitou from *c.*900 to *c.*1120 only show minor differences in their trace elements characteristics—though the decline of the silver in the alloy is spectacular, from about 90% to about 32% (unpublished data of the author). What is unexpected is that the silver used for coinages by all minting authorities from northern, western and central France presents similar patterns in trace elements as a metal stock that was previously homogenized by recycling. When compared with the data available for previous periods (Charles the Bald second period and later, 840–*c.*920 above), the silver minted during the feudal period in France differs in its trace elements patterns and cannot be regarded as a main source of recycling. This must imply that a new silver sources was used in the French mints during the first half of the 10th century.

CONCLUSIONS

This large-scale analytical study offers new insights in the evolution of the silver stock used in Western Europe from the end of the seventh to the early 12th century, at Melle where a major mint transformed locally produced silver into coins, as well as in the different spaces covered by the Merovingian, Carolingian and Feudal coin emissions. The ‘Melle signature’ could be defined on the basis of the Au/Ag and Bi/Ag ratios and the influx of fresh silver from this mine is identified for the Merovingian and early Carolingian periods. The silver from Melle is hardly noticeable using those indicators in the rest of the coinage. Thus, it appears that the general silver stock under the Merovingians should have resulted from the recycling of older sources, and that different foreign sources of recycled or fresh metal, possibly from abroad, were mobilized during the Carolingian period, which could be correlated with the reigns and the minting periods.

The identification of trace elements patterns in the Carolingian coinage of Melle that differ from the Melle signature also indicates that the silver used at this mint was composed not only by the production of the local mines but was complemented by other stocks of metal. Based on those observations, the hypothesis is made that Melle in the ninth century was not only the place for a linear activity from ore extraction to coin production with the local silver, but was also a metallurgical and minting hub used by the Carolingian power for rationalizing and controlling not only the coin minting from fresh silver, but also the recycling, the refining and the

coining of silver from diverse origins. Finally, the results are quite surprising for the Feudal period with silver from Poitou—minted at Melle and then elsewhere—and from different areas in modern France that show similar patterns in trace elements that clearly differ from Melle's. Those results, though numerous, still need to be completed by new analysis especially for defining the characteristics in trace elements of the silver of the late Roman Empire and of the neighbours of the Carolingian Empire, especially in al Andalus.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/arcm.13041>.

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REFERENCES

- Achache, S., Bompaire, M., & Castelas, A. (2018). Le trésor dit « du Loiret ». Présentation, catalogue et étude caractérisque. In F. Duyrat (Ed.), *Trésors monétaires (Vol. Tome XXVII)*. (pp. 1-99) Bibliothèque nationale de France.
- Bartels, C. (2014). Bleiglanz als hauptsächlichliches Silbererz des Mittelalters und der frühen Neuzeit? Zur Entstehung und Geschichte eines grundlegenden Irrtums. *Der Anschnitt*, 66(6), 190–213.
- Bettenay, L. (2022). Geological and mining constraints on historical mine production: The case of early medieval Lead-Silver Mining at Melle, France. *Metalla*, 26(2), 67–86. <https://doi.org/10.46586/metalla.v26.2022.i2.67-86>
- Blet-Lemarquand, M., Nieto-Pelletier, S., & Sarah, G. (2014). L'or et l'argent monnayés. In P. Dillmann & L. Bellot-Gurlet (Eds.), *Circulation et provenance des matériaux dans les sociétés anciennes* (Editions des archives contemporaines) (pp. 133–159). Editions des archives contemporaines.
- Bompaire, M., & Guerra, M. F. (2000). Analyses de monnaies françaises du XIe siècle, le problème du zinc. In B. Kluge & B. Weisser (Eds.), *XII. Internationaler Numismatischer Kongress Berlin 1997* (Vol. II) (pp. 876–884). Gebrüder Mann Verlag.
- Bourgeois, L. (2014). Melle: la ville, les pouvoirs et les hommes (VIe-XIe siècles). In F. Téreygeol (Ed.), *Du monde franc aux califats omeyyade et abbasside: extraction et produits des mines d'argent de Melle et de Jabali* (pp. 11–28). Deutsches Bergbau Museum.
- Bouvard, P., & Clairand, A. (2011). Le dépôt monétaire de l'église Saint-Hilaire de Melle (vers 1120). In: P. Brudy & A. Béneteau Pean (Eds.), *L'Âge roman. Arts et culture en Poitou et pays charentais (Xe-XIIIe siècles)* (pp. 89–93). Gourcuff-Gradenigo, Musées de Poitiers.
- Clairand, A., & Téreygeol, F. (2009). L'atelier monétaire mérovingien de Melle (Deux-Sèvres) s: premières conclusions. In A. Clairand & D. Hollard (Eds.), *Numismatique et archéologie en Poitou-Charentes, Actes du colloque de Niort, 7–8 décembre 2007* (pp. 31–47). Société d'Études Numismatiques et Archéologiques.
- Coiteux, S. (1982). *Le métallotecte de Melle (Deux-Sèvres)*. Contexte sédimentaire et minéralisations PhD Thesis in Applied Geology, Université de Poitiers.
- Condamine, J., & Picon, M. (1972). Changes Suffered by Coins in the Course of Time and the Influence of these on the Results of Different Methods of Analysis. In E. T. Hall & D. M. Metcalf (Eds.), *Methods of chemical and metallurgical investigation of ancient coinage* (pp. 49–66). Royal Numismatic Society.

- Dumas, F. (1971). *Le Trésor de Fécamp et le monnayage en France occidentale pendant la seconde moitié du Xe siècle* (Vol. 103) (pp. 875–881). Comité des Travaux Historiques et Scientifiques. <https://doi.org/10.3406/ephe.1971.5561>
- Flament, J., Sarah, G., & Téreygeol, F. (2017). Litharge cakes from Castel-Minier (Ariège, France): Understanding strategies of the cupellation in a multi metals workshop from the 14th century. In I. M. Ruiz & A. Perea (Eds.), *Archaeometallurgy in Europe IV* (pp. 269–281). Consejo Superior de Investigaciones Científicas.
- Jeanne-Rose, O. (1995). La monnaie en Poitou au début de l'époque féodale (fin IXe–milieu XIe siècle). *Bulletin de la Société des Antiquaires de l'Ouest*, 5(X), 163–235.
- Lafaurie, J. (1952). Le trésor monétaire du puy (Haute-Loire). Contribution à l'étude de la monnaie de la fin du Xe siècle. *Revue Numismatique*, V(14), 59–169, pl. III–VI.
- Lecointre-Dupont, G. (1840). *Essai sur les monnaies frappées en Poitou et sur l'histoire monétaire de cette province*. F.A. Saurin.
- McKerrell, H., & Stevenson, R. B. K. (1972). Some Analyses of Anglo-Saxon and Associated Oriental Silver Coinage. In E. T. Hall & D. M. Metcalf (Eds.), *Methods of chemical and metallurgical investigation of ancient coinage* (pp. 195–209). Royal Numismatic Society.
- Pernicka, E. (2014). Possibilities and limitations of provenance studies of ancient silver and gold. In H. Meller, R. Risc, & E. Pernicka (Eds.), *Metalle der Macht—Frühes gold und Silber. 6. Mitteldeutscher Archäologentag vom 17. Bis 19. Oktober 2013 in Halle (Saale)* (pp. 153–164). Tagungen des Landesmuseums für Vorgeschichte Halle.
- Richard, A. (1904–1906). Rapport sur une découverte de monnaies des comtes de Poitou. *Bulletin de la Société Des Antiquaires de l'Ouest*, X, 534–545.
- Sarah, G. (2008). *Caractérisation de la composition et de la structure des alliages argent-cuivre par ICP-MS avec prélèvement par ablation laser. Application au monnayage carolingien*, PhD Thesis in Chemistry, Université d'Orléans.
- Sarah, G. (2009). Analyses élémentaires de monnaies de Charlemagne et de Louis le Pieux du Cabinet des Médailles: le cas de Melle. In A. Clairand & D. Hollard (Eds.), *Numismatique et archéologie en Poitou-Charentes, Actes du colloque de Niort, 7–8 décembre 2007* (pp. 63–83). Société d'Études Numismatiques et Archéologiques. Pl. VII–VIII.
- Sarah, G. (2010). Charlemagne, Charles the bald and the Karolus monogram coinage. A multi-disciplinary study. *Numismatic Chronicle*, 170, 227–286.
- Sarah, G. (2019). L'emploi du lait dans les monnayages d'argent médiévaux. État des connaissances actuelles et perspectives de recherche. In N. M. Larousse, M.-C. Bailly-Maître, & G. Bianchi (Eds.), *Les métaux précieux en Méditerranée médiévale. Exploitations, transformations, circulations. Actes du colloque international d'Aix-En-Provence, 6–8 octobre 2016* (pp. 289–299). Presses Universitaires de Provence.
- Sarah, G., & Baillieu, J.-P. (2014). Les monnaies de Melle pendant le règne de Charles le Chauve (840–877). Un état des connaissances. *Bulletin de la Société Française de Numismatique*, 69(2), 46–55.
- Sarah, G., Bompaire, M., McCormick, M., Rovelli, A., & Guerrot, C. (2008). Analyses élémentaires de monnaies de Charlemagne et Louis le Pieux du cabinet des Médailles: L'Italie carolingienne et Venise. *Revue Numismatique*, 164, 355–406. <https://doi.org/10.3406/numi.2008.2857>
- Sarah, G., & Gratuze, B. (2016). LA-ICP-MS Analysis of Ancient Silver Coins Using Concentration Profiles. In L. Dussubieux, M. Golutko, & B. Gratuze (Eds.), *Recent advances in laser ablation ICP-MS for archaeology* (pp. 73–87). Springer. https://doi.org/10.1007/978-3-662-49894-1_5
- Sarah, G., Gratuze, B., & Barrandon, J.-N. (2007). Application of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for the investigation of ancient silver coins. *Journal of Analytical Atomic Spectrometry*, 22(9), 1163–1167. <https://doi.org/10.1039/B704879C>
- Schiesser, P., & Sarah, G. (2017). Analyses et typologie des deniers mérovingiens présents dans le trésor de Savonnières. In M. Bompaire & G. Sarah (Eds.), *Mine, métal, monnaie, Melle* (pp. 209–258). Les voies de la quantification de l'histoire monétaire du haut Moyen Âge. Droz.
- Téreygeol, F. (2001). *Les mines d'argent carolingiennes de Melle* PhD Thesis in Archaeology., Université Paris I Panthéon-Sorbonne.
- Téreygeol, F. (2013). How to quantify medieval silver production at Melle. *Metalla*, 18(1), 5–15.
- Téreygeol, F. (2017). La quantification de la production argentifère: Melle, un cas d'école? In M. Bompaire & G. Sarah (Eds.), *Mine, métal, monnaie, Melle* (pp. 39–53). Les voies de la quantification de l'histoire monétaire du haut Moyen Âge. Droz.
- Téreygeol, F., Hoelzl, S., & Horn, P. (2005). Le monnayage de Melle au haut Moyen Âge: état de la recherche. *Bulletin de l'Association des Archéologues de Poitou-Charentes*, 34, 49–56.
- Treffort, C. (2007). *Mémoires carolingiennes. L'épithaphe entre célébration mémorielle, genre littéraire et manifeste politique (milieu du VIIIe–début XIe siècle)*. Presses Universitaires de Rennes. <https://doi.org/10.14375/NP.9782753504257>
- Treffort, C., & Uberti, M. (2010). Identité des défunts et statut du groupe dans les inscriptions funéraires des anciens diocèses de Poitiers, Saintes et Angoulême entre le IVe et le Xe siècle. In L. Bourgeois (Ed.), *Wisigoths et francs autour de la bataille de Vouillé (507). Recherches récentes Sur le haut Moyen Âge dans le Centre-Ouest de la France. Actes des XXVIIIe Journées internationales d'archéologie mérovingienne. Vouillé et Poitiers (Vienne, France), 28–30 septembre 2007* (pp. 193–213). Association française d'archéologie mérovingienne.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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