SEMINARI DEL CENTRO INTERUNIVERSITARIO
PER LA STORIA E L'ARCHEOLOGIA DELL'ALTO MEDIOEVO
3

From one sea to another
Trading places in the European and Mediterranean Early Middle Ages

Proceedings of the International Conference
Comacchio 27th-29th March 2009

Edited by Sauro Gelichi and Richard Hodges

BREPOLS

Guillaume Sarah*

An analysis of early medieval silver coins: towards a better understanding of the trading role of the Adriatic *emporia*?

Introduction

During the last five years, a multidisciplinary programme aiming at providing new data related to long-distance trade during the early Middle Ages has been developed. The study of the silver composition resulting from the elemental analysis of coins from this period constituted the basis of this project. A new approach to establish the determination of the composition of silver coins has been jointly developed in order to provide the most reliable results[1]. Specialists of medieval coins, early medieval trade and of ancient coin analysis have collaborated in this project in order to compare their findings and to propose the most accurate historical interpretation of the analytical data[2].

The primary general purpose of this project was to investigate the role of the major Western European *emporia* during the early Middle Ages from the point of view of identifying the geochemical fingerprint of silver coins. Relevant data for such an investigation were gathered and a number of analyses were performed. The first part of this project consisted of the characterisation of the composition of the Carolingian coins from the Cabinet des Médailles of the Bibliothèque Nationale de France. The emphasis was first upon the coins bearing the name of the main ports and *emporia* from which some silver coming from outside the Carolingian world might have been imported. As a result, nearly seven hundred coins from the Carolin-

* IRAMAT – CNRS, Centre Ernest Babelon, 3D rue de la Férollerie, 45071 Orléans Cedex 2 (France). E-mail : guillaume.sarah@cnrs-orleans.fr.

[1] G. Sarah, B. Gratuze and J.-N. Barrandon, «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 (2007), p. 1163-1167.

[2] The researchers involved in this project are : J.-N. Barrandon (†), M. Bompaire, B. Gratuze and G. Sarah, IRAMAT – CNRS, Centre Ernest Babelon, Orléans (France); M. McCormick, Harvard Univ. (USA); C. Morrisson, Centre d'Histoire et Civilisation de Byzance, CNRS, Paris (France); A. Rovelli, Univ. Viterbo (Italy).

From one sea to another, ed. by Sauro Gelichi and Richard Hodges, SCISAM 3 (Turnhout, 2012), pp. 321-336
© BREPOLS PUBLISHERS
DOI 10.1484/M.SCISAM-EB.1.101097

gian territory minted in the name of Frankish rulers from AD 751 to 877 were studied and analysed. Whereas some of the results obtained did not permit further or new historical interpretations, certain results revealed interesting trends that may prove helpful for a better understanding of early medieval trade.

The most significant contribution to understanding early medieval long-distance trade presently lays emphasis upon the emerging role of the ports of the Adriatic rim and in particular the silver minted at Venice. This paper presents these preliminary results[3], and their comparison with those presently awaiting publication that concern the analysis of contemporary Abbasid dirhams. The methodology developed for this multidisciplinary study is presented here in order to propose an overview of the analytical data and a joint historical interpretation of the results concerning both Carolingian and Islamic silver coins.

Fingerprinting silver

Due to its well-defined geological origin, silver is a metal which offers wide potentialities for provenance studies of ancient metal from the point of view of its geochemical characteristics. In some cases, the knowledge of these characteristics can be used to distinguish coins made of silver from different origins and in the most favourable cases to trace its origin. However, this analytical approach will not succeed unless the historical context is taken into account. Provenance studies of silver based upon the characterization of the geochemistry of the metal have to be carried out only if certain conditions have been established and if the historical framework makes this possible. These conditions are connected to identifying the primary production of silver either as a metal associated with specific mines or with the re-melting of older silver coins. To summarize, the coins studied should not be constituted of a mix of silver coming from different mines, or from the re-melting of coins derived from various origins. This does not seem to be a problem for an important part of the silver struck in the Islamic world during the 8th and 9th centuries. The case of the supply of silver for the mint of Venice is more complex, but some conditions seem to have favoured the emergence of a specific geochemical fingerprint.

[3] For a complete overview of the results concerning the silver minted in Carolingian Italy and at Venice during the late 8th and the early 9th century see G. Sarah, M. Bompaire, M. McCormick, A. Rovelli and C. Guerrot, «Analyses élémentaires de monnaies de Charlemagne et Louis le Pieux du Cabinet des Médailles : l'Italie carolingienne et Venise», *Revue Numismatique* 164 (2008), p. 355-406.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

Two different approaches can be used to determine intrinsic geochemical specifics of silver: elementary analysis and isotopic analysis. Elementary analysis allows the determination of the concentration of major, minor and trace elements to be established, those parts of the alloy that constitute the character of the coin. Whereas the knowledge of the fineness of the coin is a clue for understanding the minting policies of a location, a region or a ruler, the content of the trace elements can be used to separate coins made of precious metal from different origins. Isotopic analysis is another approach that can contribute to the knowledge of the circulation and the origins of the silver that was used by moneyers. However, these two different kinds of characterization have to be carried out using specifically dedicated protocols. The chemical properties of the alloys and the processes that occur between the minting of the coin and its analysis have to be considered carefully in order to obtain accurate results that would be useful for the historian.

Recent analytical improvements permit the determination of the elementary composition of silver coins with good precision and low detection limits for the trace elements. Due to complex physical and chemical phenomena that occur during the making of the coin, its circulation and after burial, the composition of the surface does not correspond to that of its core[4]. The result of this is the 'silver surface-enrichment' phenomenon, which in the past yielded overestimations of the fineness of coins as this had not been correctly considered, and indeed, on occasion had not even been taken into account. This used to constitute a limitation for the modern analyst eager to determine the composition of silver coins as these were at the time of minting: until recently, no satisfactory solution existed for some coins, especially those which were particularly thin with surfaces covered by a thick corroded layer. A new approach exists now[5] that uses concentration profiles in order to determine the content of the major elements of the alloy, in most of the cases silver and copper, as well as minor and trace elements. By this way, it is possible to represent a cross-section of the composition from the surface to the interior of the coin. The part of the concentration profiles corresponding to the surface that has been altered

[4] J. Condamin and M. Picon, «Changes Suffered by Coins in the Course of Time and the Influence of these on the Results of Different Methods of Analysis», in *Methods of Chemical and Metallurgical Investigation of Ancient Coinage*, eds. E.T. Hall and D.M. Metcalf (London, 1972) p. 49-66.

[5] Laser Ablation Inductively Coupled Plasma Mass Spectrometry or LA-ICP-MS. The application of this method to ancient silver coins is presented in G. Sarah et *al.*, *Application of LA-ICP-MS*.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

can be successfully separated from the part representing the core of the alloy. Thus, this approach facilitates the determination with precision of the composition of the core of the coin that was not altered, and in addition does not cause visible damage. Furthermore, LA-ICP-MS is a method that determines the concentration of many trace elements with low detection limits, and is consequently particularly suitable for provenance studies.

The measurement of the lead isotope ratios in different fields of geochemistry has been widely used and developed during the last three decades. In the field of archaeometry, the determination of the ratios between the stable isotopes of lead tend to be an important clue in order to separate coins made of silver from different origins or indeed, to determine its origin[6]. There are four natural isotopes of lead: ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb. The formation of the latter three results from the radioactive decay of uranium and thorium and their relative abundance varies in the mineralizations depending on the time these were formed. Consequently, their relative abundance is a geochemical characteristic of the ore that was used to produce silver coined afterwards. These ratios are not affected by the mineralurgical and metallurgical processes that took place to produce metal from the ore, so their determination in the coin can be used to identify the origin of the silver. The characterization of the lead isotope ratio in ancient coins has been investigated over several decades and some methods can be employed now in order to obtain reproducible and precise values from a negligible sampling of the objects. In most cases, this can be obtained by using a scalpel to remove some powder from the edge of the coin, causing no visible damage. Following this the powder is dissolved to perform the analysis using Thermal Ionization Mass Spectrometry (TIMS)[7]. The ratios obtained from the samples from different origins can then be compared and the separation

[6] For a general overview of the use of lead isotope analysis to study the provenance of ancient silver see Z. A. Stos-Gale, «Lead Isotope Analysis Of Coins - A Review», in *Metallurgy in numismatics Vol. 4*, eds. W. A. Oddy and M. R. Cowell (London, 1998), p. 348–366, especially on the limitations as well as some examples of applications p. 355-359. See also J. Baker, S. Stos and T. Waight, «Lead isotope analysis of archaeological metals by multiple-collector inductively coupled plasma mass spectrometry», *Archaeometry* 48 (2006), p. 45-56.

[7] The methodology used for the lead isotope analysis carried out for this publication appears in C. Pomiès, A. Cocherie, C. Guerrot, E. Marcoux and J. Lancelot, «Assessment of the precision and accuracy of lead-isotope ratios measured by TIMS for geochemical applications: example of massive sulphide deposits (Rio Tinto, Spain)», *Chemical Geology* 144 (1998), p. 137-149. Other methods than TIMS exist in geochemistry. In the field of archaeometry see J. Baker, S. Stos and T. Waight, *Lead isotope analysis of archaeological metals*.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

or clustering observed can be related to the numismatic characteristics of the coins and to the historical data concerning the production of silver.

The combination of the characterization of the trace elements and the lead isotope ratio of the silver that constitutes ancient silver coins has rarely been used in the past. An exception is the work of Z.A. Stos-Gale who reports that both types of analysis have already been performed on the same coins[8]. This author emphasizes the use of the gold and bismuth content with the lead isotope data for provenance purposes. However, the systematic combination of these two approaches, though very promising, has not been widely used for sourcing ancient silver.

The production of silver in the Carolingian and Islamic worlds ca. AD 700-900

In Latin Christendom as well as in some areas of the Islamic World of the early Middle Ages, silver was the precious metal which was most often used for minting coins. This section aims at presenting briefly current knowledge about the production of silver inside these two 'empires' and offers hypotheses about the provisioning of this precious metal.

Around AD 675, the Frankish kingdoms switched from a currency based upon an altered gold coinage of tremisses to a silver coinage of deniers. From this time, the Merovingians, followed by the Carolingians who successfully reformed and controlled all minting, struck only silver coins with few exceptions. Estimating the quantity of silver necessary to fulfil the needs of providing currency for the Carolingian realm in the course of the 8th and 9th centuries appears to be a difficult if not impossible task[9]. It seems nonetheless that there is a discrepancy between the availability of silver inside the Carolingian territory and the volume of coins within the same area[10]. The only significant silver mines identified in Western Europe for

[8] Z.A. Stos-Gale, *Lead Isotope Analysis Of Coins - A Review*, p. 358. See U. Zwicker, N. Gale and Z. Gale, «Metallographische, analytische und technologische Unterschungen sowie Messungen der Bleiisotope an Otto-Adelheid-Pfennigen und Vergleichsmünzen Meist aus dem 9.-11. Jahthundert», in *Otto-Adelheid-Pfennige. Untersuchungen zu Münzen des 10./11. Jahrhunderts*, eds. G. Hatz, V. Hatz, U. Zwicker, N. Gale and Z. Gale Eds, (Stockholm, 1991), pp. 59-78.

[9] For an overview of the estimates of the medieval period in Western Europe see M. Bompaire and F. Dumas, *Numismatique médiévale : monnaies et documents d'origine française* (Turnhout, 2000), especially pp. 529-530.

[10] D.M. Metcalf, «Analyses of the Metal Contents of Medieval Coins», in *Methods of chemical and metallurgical investigation of ancient coinage*, eds. E.T. Hall and D.M. Metcalf

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

this period are those at Melle (France). Even though this was not a major centre during the Carolingian period, a number of coins bear its name in hoards from the reign of Charlemagne until the 12th century[11]. The silver-rich galena deposit found at Melle and in its environs was undoubtedly the reason for the pre-eminence of the mint in the Frankish period. This mint appears to be one of the most prolific of the Carolingian era, at least during the reigns of Charlemagne, Louis the Pious and Charles the Bald[12]. However, some lead isotope analyses have shown that mints located within the Aquitainian kingdom, Melle was part of or nearby did not in fact use silver principally coming from this mine[13]. This raises the question of the origin of the silver that supplied these mints as well as others, located far from Melle, such as those in Frisia or in Italy.

In the Islamic world, the production of silver seems to have flourished during the 8th and 9th centuries. Some specific areas of the Abbasid caliphate were producing large quantities of silver. The main production areas were the Panjir, in the Khorassan region, currently in Northern Iran, and Chach and Ilaq in Transoxiana (Uzbekistan)[14]. These mining districts were probably the main provisioning sources of the mints which struck tens of thousands of dirhams unearthed in Central Asia, in Western Russia and in Scandinavia. Even though most of these hoards date from the 10th and 11th centuries, large scale production of silver almost certainly dates back to the 8th century[15]. Significant mining districts that would have been active as early as the 8th century have also identified in (modern) Morocco and Tunisia[16]. To summarize the available references, two main areas of the early

(London, 1972), p. 383-434, here p. 406; R. Hodges and D. Whitehouse, *Mahomet, Charlemagne et les origines de l'Europe*, French edition updated by C. Morrisson, French translation by C. Morrisson, J. Lefort and J.-P. Sodini, (Paris, 1996), p. 111.

11 However, there seems to have been coins struck bearing the name of Melle after the end of the mining exploitation. See F. Téreygeol, S. Hoelzl and P. Horn, «Le monnayage de Melle au haut Moyen Age : état de la recherche», *Bulletin de l'Association des Archéologues de Poitou-Charentes* 34 (2005), p. 49-56.

12 For a general overview of the coinage of Melle in Carolingian time see Ph. Grierson and M. Blackburn, *Medieval European Coinage 1. The Early Middle Ages (5th-10th centuries)* (Cambridge 1986), pp. 235-240.

13 *Ibidem*, and J.-N. Barrandon and F. Dumas, «Minerai de Melle et monnaies durant le haut Moyen-Age : relations établies grâce aux isotopes du plomb», *Bulletin de la Société Française de Numismatique* 45 (1990), p. 901-906.

14 J.W. Allan, *Persian Metal Technology 700-1300 A.D.* (Londres, 1979), p. 13-14.

15 Ibid., and I. Blanchard, *Mining, Metallurgy and Minting in the Middle Ages. Vol. 1. Asiatic supremacy, 425-1125* (Stuttgart, 2001), p. 229-238.

16 S. Gsell, «Vieilles exploitations minières dans l'Afrique du Nord», *Hespéris* VIII (1928),

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

medieval Islamic world were producing silver: Central Asia and the Western Maghreb. This large scale production of silver in the Islamic world may have led to changes in the gold/silver ratio in Western Europe[17].

The analysis of Carolingian and Venetian coins

Since 2005 the systematic analysis of the Carolingian coins at the Cabinet des Médailles of the Bibliothèque Nationale de France has been undertaken. More than one hundred supplementary coins from museums, hoards and private collections have been also analysed in order to obtain a better representation of the data concerning the minting of coins in Latin Christendom. Over the last five years more than seven hundred of these coins have been studied from the point of view of both their numismatic particulars and their elementary composition. As previously mentioned, one of the main initial aims of this project was to study the trace element pattern of the coins coming from the mints susceptible to having struck silver of a specific local or foreign source. The composition of the specimens issued with the mint-name of Melle have been investigated and revealed interesting trends regarding their gold and zinc levels[18]. The analysis of the coins from Quentovic, for which it is reasonable to suggest that some foreign silver from the British Isles might have been melted down and re-used by the mint, did not reveal the presence of a discriminating trace element[19]. Despite their large number, the analysis of the coins from Dorestad did not

p. 1-21; B. Rosenberger, «Les vieilles exploitations minières et les centres métallurgiques du Maroc : essai de carte historique (1[re] partie)», *Revue de Géographie du Maroc* 17 (1970), pp. 71-108, here p. 79-85 ; B. Rosenberger, «Autour d'une grande mine d'argent du Moyen Age marocain : le Jebel Aouam», *Hespéris-Tamuda* V (1964), p. 15-78.

[17] S. Bolin, «Mohammed, Charlemagne and Ruric», *Scandinavian Economic History* (1953), p. 5-39.

[18] G. Sarah, «Analyses élémentaires de monnaies de Charlemagne et de Louis le Pieux du Cabinet des Médailles : le cas de Melle», in *Actes du colloque Numismatique et Archéologie en Poitou-Charentes*, eds. A. Clairand and D. Hollard, (Niort, 2007), p. 63-83.

[19] However, it might be argued that the sampling of Quentovic coins was not sufficient as only eight examples were available for the years AD 751-840. The specimens from this mint are more numerous for the reign of Charles the Bald (thirteen for the period 840-864), that is believed by Simon Coupland to have been the more active years of this *vicus*, but nothing significant can be deduced from the analysis. See S. Coupland, «Trading places: Dorestad and Quentovic reassessed», *Early Medieval Europe* 11 (2002), p. 209-232, especially p. 210-212. Moreover, the number of early medieval Anglo-Saxon coins at the Bibliothèque Nationale de France that could be analysed for a comparative purposes was very limited.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

reveal a significant trend that would suggest that the silver used in coins minted there came from a specific source outside the Carolingian territory.

Two other coinages from Latin Christendom have been investigated to determine their elementary composition, and in particular, their trace element content.

The first coinage is truly Carolingian as it is comprises the silver issues minted in Italy bearing the name of a Frankish ruler[20]. The earliest coins can be attributed to Charlemagne's reign, and were struck from AD 781; the latest coins were issued by Lothar and were minted between 840-855. Study of the fineness of silver revealed some differences between the Italian issues and the bulk of other Carolingian coins issued for some minting periods[21]. However, the pattern of trace elements which might indicate a difference in the supply of silver between cisalpine and transalpine mints, in fact revealed nothing significant. Consequently, the study of the composition of the silver coins minted in Carolingian Italy does not seem to reveal the use of either a specific foreign or local source of silver that might have been available only beyond the Alps.

The last coinage studied comprises coins that can be both considered as Carolingian and non-Carolingian: these are Venetian issues. First, the special history of the Venetian coinage minted in the Carolingian period needs to be noted. To summarize the current knowledge about this particular mint, it seems that early 9th-century Venice struck silver deniers similar to the contemporary Carolingian issues even though they were nominally under Byzantine rule. Consequently, the status of these Carolingian-like coins minted by an authority that was not actually under the rule of the Franks is difficult to establish. The Venetian-Carolingian coins have been amply described in studies dedicated to Frankish coins, but most numismatists have pointed out that this was a marginal coinage. However, due to a lack of documentation, many questions remain concerning the conditions surrounding the minting of coins at Venice during the reigns of Louis the Pious

[20] Gold coins from Italy have not been considered as the comparison of their composition with the silver coinage is not relevant. For a general overview of the Carolingian emissions in Italy see A. Rovelli, «774. The Mints of the Kingdom of Italy: A Survey», in *774. Ipotesi su una transizione*, ed. S. Gasparri, (Turnhout, 2008), p. 119-140.

[21] Nevertheless, the number of coins considered for each minting period can be regarded as insufficient to argue that the trends observed reflect the reality of the coin minting inside and outside Carolingian Italy around AD 800. See G. Sarah et al., *Analyses élémentaires : l'Italie carolingienne et Venise*, p 373-381.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

and Lothar I. The analysis of the deniers of the first of these two rulers from the Cabinet des Médailles in Paris revealed that in spite of their similar general numismatic characteristics, they are distinguishable from several points of view: first, their intrinsic value is lower than the other Carolingian coins due to a difference both in their average weight and in their silver fineness; second, the content of two trace elements, gold and bismuth, distinguishes the silver minted at Venice from the 'authentic' Carolingian issues, and suggests that their origin was not the same. The silver minted at Venice contains lower gold levels and higher bismuth levels than contemporary specimens from Frankish mints north of the Alps. Analyses of the lead isotope ratio have also been performed, confirming the geochemical individuality of the silver used at Venice for coin minting. These observations raise many questions regarding the circumstances of the mint at Venice at the beginning of the 9th century, its relationships with the neighbouring Carolingians and the remote Byzantine authority, and the sources of the silver coined at Venice as well as in Carolingian mints. These questions cannot be answered in this short essay. The main results concerning the trace element patterns and the lead isotope ratio will be presented below in order to provide to historians of the early medieval Adriatic rim with new data that may prove helpful for understanding of the role of the port of Venice as an intermediary place for exchange, and possibly as a source of supply of foreign silver that might have been redistributed subsequently within the Carolingian empire. The first results of the analyses of contemporary Islamic silver coins are also presented in order to provide an overview of the most up-to-date available analytical data concerning Mediterranean early medieval trade.

Towards fingerprinting Carolingian, Venetian and Islamic early medieval silver

The interpretation of the composition of the early 9th-century Carolingian and Venetian coins widens the geographical frame of our investigation. On the basis of these results and taking into consideration the finds of Islamic and Byzantine coins around Western Mediterranean and in Carolingian Europe[22], the question of the role of Venice as a place where northern African or Asian silver could have been collected, re-melted and re-coined has been central to the aims of this project. The combination of numismatic, historical and analytical data has also encouraged the inquiry of previous analyses of early medieval Byzantine and Islamic coins. In order to

[22] See M. McCormick, *Origins of the European Economy. Communications and Commerce AD 300-900* (Cambridge, 2001).

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

compare the compositions published previously, it was necessary to concentrate upon only the analyses of silver coins. In addition, it was necessary to consider the geochemical specifics of Venetian silver in order to identify the same characteristics in trace-element and lead-isotope patterns in previous publications including the compositions of early medieval non-Carolingian coins. As we will see below, bearing in mind these limitations, there is only a restricted number of publications for which a comparison of the composition with Carolingian and Venetian silver is relevant.

In the early medieval period, the monetary system used in the Byzantine world combined the use of the three main metals that have been coined: gold, silver and copper. As it happens, the minting of silver *miliaresia*, following the 7th century hexagram, was far from regular and on a limited scale only during the 8th and 9th centuries. By contrast, gold and copper-based coinages were struck and used on a much larger scale. This limits the possibility of finding publications of the analysis of early medieval Byzantine silver coins. In fact, no publication exists that includes gold and bismuth contents. Furthermore, few lead isotope data are available concerning the mines located in the Byzantine territory of this period, roughly encompassing the provinces now lying within modern Turkey and Greece. Not surprisingly, the comparison of the results we obtained for the Carolingian and Venetian coins with the available databases of Byzantine material was unsuccessful.

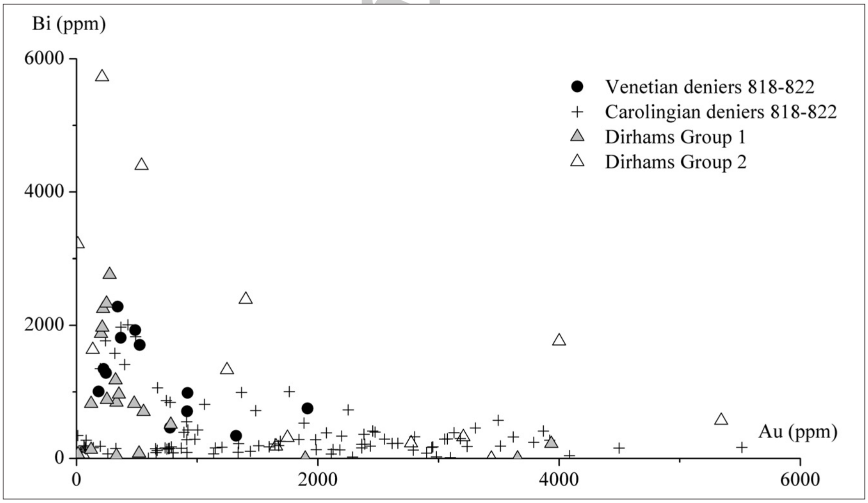
The availability of lead isotope ratio databases is also a major limitation in the study of the geochemistry of early medieval Islamic silver mines. It has to be emphasized that our investigations on this topic are under progress and that some data may have not been considered. However, no lead isotope ratio analysis has been found concerning early medieval Islamic silver, neither for the coins nor for the associated mines. On the other hand, earlier publications of elementary analyses of Umayyad and Abbasid dirhams sometimes report gold content with the silver fineness, but any mention of bismuth is rare. Although some of the values published should be considered carefully[23], the data set out in two publications converge to suggest that the silver produced at the Panjir and Central Asian mines contained remarkably high bismuth levels[24]. Furthermore, the similarity of the results concerning Venetian deniers issued by Louis the Pious and some of the early medieval Islamic silver coins might be the modern evidence of the arrival of silver

[23] Some authors reported bismuth concentrations in Islamic coins amounting to up to twenty percent. The higher values determined in this study is 0,6 %. The physical properties of a silver-bismuth alloy containing several percent of bismuth have to be verified. The possibility that the bismuth content has been over-emphasized cannot be excluded.
[24] M.R. Cowell and N.M. Lowick, «Silver from the Panjihr mines», in *Metallurgy in*

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

coins or bullion from the Arab world in Venice at the beginning of the 9th century. However, due to the difference in the methods used to determine the composition of the coins, it seemed preferable to perform our own analyses of selections of Umayyad and Abbasid dirhams in order to estimate the relevance of the presence of bismuth as a possible index of silver from either Asia or Africa being melted down and used in Carolingian Europe.

Forty Islamic coins were selected for characterization in order to identify their geochemical patterns, and especially the presence of gold and bismuth. A first group comprised coins found in Western Europe, catalogued by Michael McCormick[25]. A second group of the same types that those includes dirhams from the mints located close to mining districts that have been reported to have been particularly active during the early Middle Ages and for which it is reasonable to assume that silver was employed from a nearby exploitation. The trends concerning gold and bismuth have already been pointed out. The comparison of the contents of these two elements in the analysed Carolingian, Venetian and Islamic silver coins are presented in figure 1.



1. Comparison of the gold and bismuth content of Louis the Pious' Type 2 Carolingian and Venetian coins with early medieval Islamic silver coins. 1 % = 10000 ppm.

Numismatics, ed. W.A. Oddy, (Londres, 1988) p. 65-74; H. McKerrell and R.B.K. Stevenson, «Some Analyses of Anglo-Saxon and Associated Oriental Silver Coinage», in *Methods of chemical and metallurgical investigation of ancient coinage*, eds. E. T. Hall and D.M. Metcalf, (Londres, 1972), pp. 195-209.

25 M. McCormick, *Origins*, Appendix 3, p. 815-851.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

The positioning of the points in Figure 1 corresponding to the Carolingian, Venetian and Islamic coins is remarkable[26]. Most of the Carolingian deniers contain low or very low bismuth content, under 500 ppm for most of them. The gold levels are variable, and the points in Figure 1 representing the Carolingian coins regularly amount to less than 3000 ppm. This shows a picture of Carolingian silver that would not have contained a marked amount of bismuth. Significantly, of the more than one hundred coins of Louis the Pious' Class II deniers that have been analyzed, only seven contain more than 1000 ppm of bismuth. The interpretation made on the basis of the observation of the position in the graph of both contemporary Venetian coins and Islamic dirhams is quite different. The gold concentrations are generally lower and the bismuth levels higher. More than fifty per cent of the analysed deniers minted at Venice bearing the name of Louis the Pious contain more than 1000 ppm of this element. The ratio is lower for the dirhams considered as a whole as this value occurs only in a third of them. However, it should be noticed that unlike Venice, the Islamic coins selected do not come from a single mint, but from places located very far away from each other. If we focus on some specific mints, the proportion of coins with high bismuth levels increases significantly: 60 % for Bukhara (3 of 5 coins), and 100 % for Samarqand (3 coins) and al-Andalus (2 coins). The results concerning Samarqand and Bukhara confirm the findings of earlier publications that showed the distinctiveness of the silver that was minted in Central Asia and that may have been extracted at either Shash or Ilaq.

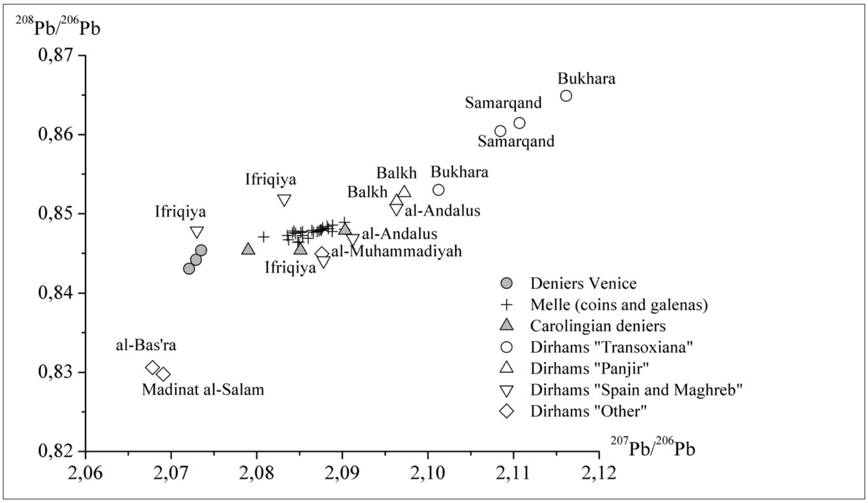
These first few results are consistent with previous publications about coins from the same area and encourage the need to make a larger number of analyses to confirm the trend described here. The interpretation of the bismuth level of the coins from Balkh is more difficult as the concentration of this element is significant for four of the five dirhams analyzed, ranging from 800 ppm to 1200 ppm, whereas it is only 77 ppm for the fifth example. This might show that silver from the Panjir mines does not contain a homogeneous amount of bismuth or that silver from another mining area was employed at Balkh. Here again, the elementary analysis revealed interesting trends and suggests proceeding further in the characterization of the geochemical signature of the silver from the Panjir mines, but the number of analyses is not sufficient to support an historical interpretation. Concerning al-Andalus, there was as far as we know no previous mention of a

[26] The observations proposed here are general: a more detailed interpretation of the results concerning the Islamic silver coins will be published soon.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

high bismuth content in the early medieval dirhams bearing the name of this mint. Obviously our two results are not based upon a sufficient sample to identify this area as a producer of bismuth-rich silver. The main sources of silver exploited in the early years of the Islamic dominion over the Iberian Peninsula have to be identified and many more analyses have to be performed in order to identify the geochemical signature of the mines and the coins struck at mints nearby.

The comparison of the gold and bismuth patterns of the Carolingian, Venetian and Islamic silver coins, although frustrating due to the limited number of results, encouraged the undertaking of selective lead isotope ratio analyses. Unfortunately all the coins for which the elementary composition had been determined could not be studied using this complementary method.



2. Comparison of the lead isotope ratio of the Carolingian, Venetian and Islamic silver coins.

The lead isotope ratio could be determined in fourteen of the forty dirhams of our selection. The coins selected for these analyses are those with high bismuth levels, most of them struck at mints that are likely to have used silver derived from local exploitation, and from some of the major mints of early medieval Islamic world. The results obtained from this analysis are presented in Figure 2. The dirhams have been separated into four groups as follows: Transoxiana for Samarqand and Bukhara; Panjir for

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

Balkh; Spain and Maghreb for Ifriqiya and al-Andalus; 'Other' for al-Bas'ra, al-Muhammadiyah and Madinat al-Salam. The values determined for coins and galenas from Melle[27] have been indicated as a point-of-reference for Carolingian and Venetian deniers as this is the only significant source of silver so far identified in Latin Christendom.

As Figure 2 shows, the lead isotope signature of the Islamic silver coins covers a wide range of values. This suggests that it might be possible to identify some specific signatures corresponding to mining areas in a large-scale investigation aiming at fingerprinting early medieval Islamic silver mines and dirhams. Notably, the points corresponding to the Venetian coins on the one hand and to the Carolingian deniers[28] on the other hand are close to each other.

Even though the number of analyses for each mint is limited, some observations can be made on the basis of the results plotted in Figure 2. First, it should be noted that the coins from Transoxiana (Boukhara and Samarqand) and from Panjir (Balkh) present $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios higher than other dirhams, Carolingian or Venetian coins. For Balkh and Samarqand, the points corresponding to the two coins from each of these mints are very close to each other and encourage the need to undertake further analyses to characterize the geochemical fingerprint of Transoxiana and Panjir silver. However, the lead isotope ratio for the coins analyzed does not match that of the Venetian deniers. This also appears to contradict the gold/bismuth pattern that suggested that silver extracted in Central Asia and Khurassan on one hand and minted at Venice during the early 9th century on the other hand could be similar from a geochemical point of view.

The location of the points on the graph of the Ifriqiya and al-Andalus coins is more scattered and less differentiated. Some of these points show a similarity with the silver known to come from Melle and the Carolingian coins, whereas a single one, from Ifriqiya, seems to be similar to the three coins from Venice. The interpretation of these few results is difficult and the clustering of points observed should not be regarded as reliable evidence of a similar origin of silver. However, the proximity in the graph of the point corresponding to a coin from Ifriqiya with the Venetian deniers might reflect the trading links of this port with Islamic Western Mediter-

[27] From F. Téreygeol, S. Hoelzl and P. Horn, «Le monnayage de Melle au haut Moyen Age : état de la recherche» *Bulletin de l'Association des Archéologues de Poitou-Charentes* 34 (2005), pp. 49-56, especially p. 50.

[28] For further explanation about the selection of the Carolingian coins whose lead isotope ratios have been determined and their interpretation see G. Sarah et al., *Analyses élémentaires : l'Italie carolingienne et Venise*, p 385-387.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER

ranean. Yet once again there is a contradiction between the gold/bismuth pattern and the lead isotope ratios: on one hand, this coin from Ifriqiya, the only one that is close to the Venetian coins in Figure 2, does not contain a significant amount of bismuth; on the other hand, the coins for which the study of the gold and bismuth concentration suggested a similarity with the deniers from Venice in their geochemical properties show very different lead isotope ratios.

Amongst the coins from other mints, the dirhams from al-Bas'ra and Madinat al-Salam both contain very low $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios. Their isotopic fingerprint is very specific and differs widely from that of all of the other coins studied, either Carolingian or Islamic. This should not be considered as a rule for all of the coins bearing the name of one of these mints, but this raises the question of the supply of silver to the capital of the Abbasid Caliphate and of a city also located in modern Iraq. The third coin of this group, from al-Muhammadiyah, has average values for the two lead isotope ratios presented in Figure 2 similar to those of Carolingian coins and ores.

Conclusion

This synthesis of analyses of early medieval Carolingian, Venetian and Islamic silver coins reveals remarkable trends both in trace element patterns and in the lead isotope ratio signatures. The limited number of results for the dirhams only permits to propose possible historical interpretation of this data with no certainty yet. There are nonetheless interesting trends that encourage the undertaking of a large scale investigation about early medieval Islamic silver. The geochemical fingerprint of ores from the most productive mines has yet to be definitively determined, as does that of coins from the local mints. It would be fruitful in further investigations to systematically consider both elementary and isotopic analyses. This would constitute an original approach in order to obtain reliable results for a better understanding of the production of silver in early medieval Islamic world and to study the relationships between Arab Caliphate and Latin Christendom from a new point of view.

© BREPOLS PUBLISHERS
THIS DOCUMENT MAY BE PRINTED FOR PRIVATE USE ONLY. THIS DOCUMENT MAY NOT
BE DISTRIBUTED, STORED IN A RETRIEVAL SYSTEM WITHOUT PERMISSION OF THE PUBLISHER