Metallanalyser
av mynt

Numismatiska forskningsgruppen • Stockholm Numismatic Institute
www.archaeology.su.se/numismatiska

Metal analyses of coins

2018:1

Metal analyses of Viking-Age coins

Eeva Jonsson

Introduction

In the present paper an analysis of the silver content of Viking-Age coins will be presented. The Viking Age is here defined as the period when foreign coins were imported to present day Sweden, that is *c.* 800–1150. In other parts of the Northern Lands it may have started and ended earlier or later. A large number of scientific techniques are available to study the silver content of coins. In the present study, coins were analysed using XRF, which is a non-destructive method. Although different analyses may provide different absolute values, the present analysis will enable us to compare the silver content of very different coinages using the same method, that is the relative values would be correct. Only silver has been calibrated and the values for copper are thus probably too low. The silver content is given in lod (16 lod = 100% silver).

A silver content of *c.* 94% has been regarded as "pure" silver (e.g. McKerrell & Stevenson 1972). In their recent silver analysis of Islamic coins, N. Eniosova and R. Mitoyan defined high silver quality as over 90% purity and good silver quality as over 80% purity (Eniosova and Mitoyan 2011). In the earlier studies, coins with below 90% silver purity have been defined as sub-standard coins (e.g. Metcalf & Northover 2002, 219; K. Jonsson 2009, 59). D. M. Metcalf and J. P. Northover have pointed out, that minor differences could easily occur and would not have been detectable at the time (Metcalf & Northover 2002, 217–18). Issuing silver coins with a high or a low silver content was determined by the economic needs of the coin issuer and also of the availability of silver. The

Fig. 1. Map with a sample of the mints represented in the metal analysis.

definition of a high silver quality depends of course on the purpose of the analysis. The purpose of the present analysis is to understand the situation from the perspective of the Nordic trader. What was the right silver quality from his/her perspective? What was acceptable as fine silver in everyday transactions in the Northern areas?

The coins were regularly bent and pecked to control the fineness. By bending or breaking the silver, coins with a deceptive silver surface could be noticed. It is also believed, that the quality of silver was easy to assess for the experienced trader by pecking. The technique of pecking is associated with the Vikings. The earliest evidence for pecking on coins in the Viking context comes from the English Cuerdale hoard, Lancashire. This multi-type hoard included some 7,000 coins and it was concealed *c.* 905. The earliest pecked coins in the hoard date to the later 870s (Archibald 1990, 15; 2007, 49–52). In Scandinavia, the practise of pecking occurred later (Archibald 2007, 53). It is important to notice that only a representative selection of coins was pecked each time. The unfamiliar coins were singled out for extra testing (Archibald 1990, 15; 2007, 50–51).

It is important to notice, however, that the pattern of import of sub-standard coins suggests regional differences. According to several earlier analyses, the early dirhams were struck in pure silver and the silver content started to drop in the 940s (Noonan 1987, 247). In the 950s, the import of dirhams showed an overall decrease in Northern Europe. However, the import to Russia stayed unchanged until the 960–80s (Noonan 1989, 300). Kenneth Jonsson has pointed out, that the pattern of the dirham import *c.* 950–90 to Gotland compared to Russia is very different. Interestingly, exactly the same pattern can later be seen in the import of debased coins from Frisia to the Swedish mainland, Gotland, and Russia *c.* 1055–75 (K. Jonsson 2009, 59, 64). It is generally known that Frisia seemed to play an active role in the debasement of coins in Germany. During count Bruno III (1038–57), the silver content was very much reduced by adding copper to the silver. The import to Gotland was on a very low level. According to Jonsson, a silver content as high as of *c.* 90% seems to be the crucial point (K. Jonsson 2009, 59). He means that Gotlandic traders were reluctant to accept these sub-standard coins, while traders in Russia and on the mainland did not react to the changes.

The present study covers a total of 155 coins which are listed and illustrated in the Appendix. 104 coins come from KMK (Royal Coin Cabinet, Stockholm, of which 14 specimens from the systematic collection and 90 from hoards). In addition 55 specimens in the systematic collection of NFG (Stockholm Numismatic Institute) were analyzed.

The Viking Age (mainly 9th to 11th centuries) was a period of a massive import of coins from the East and the West to countries in northern Europe (Northern Lands) (fig. 1). As to their relative importance, reference here is usually given to the number of the corresponding number of coins found in Sweden, and the numbers found in other countries in the Northern Lands may be significantly higher or lower.

The way in which the names are rendered follows the standard adopted in CNS.

Analysis

Background – production and import

A total of 83,353 Islamic coins are known today from Swedish finds (K. Jonsson 2015, 54). About 78% of the coins have been found on Gotland (Rispling 2004, 123). The import started *c.* 800 and in the early phase of the Viking-Age coin import, *c.* 800–975 A.D., coins came nearly exclusively from the east, but the import was on a minute scale before the 830s (K. Jonsson 2009, 58). There was a peak in the coin import to Sweden 833–71 which is also attested in the huge Spillings hoard on Gotland with 14,300 coins (t.p.q. 870/71) (Rispling 2004, 123). In the late 9th century the import dropped to very low figures.

The largest quantities of Islamic coins appear in hoards deposited as late as the 950s. The hoards mainly consist of Samanid dirhams struck in the period 900–20, but the import did not take off until the 930s. The import dropped to very low figures after *c.* 955. In the period 990–1010 there was a short lived renewal of import from the east. From *c.* 990 to the mid-12th century, the import is totally dominated by coins from Germany and England (K. Jonsson 2009, 58).

One of the most interesting phenomena in Islamic coinage is the debasement of the silver content of dirhams from about 950/55 onwards in most of the Muslim world. By 1010 the fine silver coinage only continued in what is now Morocco and parts of Afghanistan and Pakistan. The eastern import ceased completely in the early 1010s, and this happened even in Russia. The debased dirhams were less desirable for Russians and Scandinavians who were interested in the quality of silver that was used in a weight economy. Similar debasements of silver occurred at the same time in India and most of Europe, with England and Germany as the only real exceptions (Album 2011, 13).

There have been only limited studies of the silver fineness for Islamic coins of most dynasties (see e.g. Album 2011, 5). In the present study, a total of 17 Islamic coins were analyzed.

Sasanian coins

The earliest Oriental coins in the present study are two Sasanian drachms, of which the first is from Xusro I (531–79) and the second from Xusro II (590–628) (fig. 2). A total of 206 Sasanian drachms are known today in Swedish finds (K. Jonsson 2015, 54). From 224 to 651 the Sasanian dynasty ruled a territory that is today approximately equal to Iran and Iraq. The Sasanian Empire was one of the most remarkable empires of the first millennium AD controlling or influencing the greater part

Area	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Sasanian	531–628	2	3.42–2.65	14	82.90–81.70	3.06–2.71

Table 1. Sasanian coins.

Fig. 2. Sasanian drachm. Xusro II (590– 628), Ohrmazd-Ardashir, 625 AD. 2.65 g.

Fig. 3. Abbasid governor. Sa'id. Tabaristan 126 PYE (777/8 AD). 1.98 g.

of Central Asia, Afghanistan, Turkmenistan, Uzbekistan, the Caucasus, Armenia, Georgia and the Near East. Sasanian drachms were imported together with Islamic dirhams during the earliest phase of the Viking-Age coin import, the early 9th century. Both analyzed Sasanian coins have a silver content of 14 lod.

Islamic coins

Sasanian drachms were used as prototypes for early Islamic coins and in 762–94 Abbasid governors of Tabaristan struck coins with Sasanian coins as prototypes. However, the latter were half drachms. In the present study, one Arab-Sasanian drachm struck by an Umayyad governor (fig. 3) and two coins struck by Abbasid governors of Tabaristan were analyzed. Only a relatively small number of these coins are known in Swedish finds. The silver content of the Arab-Sasanian drachm is 15 lod while the three analyzed coins of the Abbasid governors proved to be 15, 14 and 13 lod.

A reform of the Islamic monetary system took place in 696 when the Umayyad caliph ʿAbd al-Malik issued a new style dinar (gold coin) consisting only of inscriptions in Arabic. Two years later a standard for the silver coins was introduced. The new type was struck with a nominal weight of 2.97 grams. This new nominal was named "dirham" and established the style of the Islamic coinage for the next five centuries (Broome 1985, 9–10). They were issued by a number of dynasties. In the present study, two Umayyad dirhams were analyzed, both were struck in the city of Wasit (Iraq). The silver content of the analyzed dirhams is 15 lod.

The first major Islamic group in the finds in the Northern Lands consists of Abbasid dirhams. The Abbasid dynasty assumed the authority over the Caliphate (present day Iraq and Iran) from the Umayyads and issued dirhams from 749/50 onwards. The Abbasids moved their capital to Baghdad (Madinat al-Salam). In the present study, three dirhams struck in Basra and Madinat al-Salam were analyzed (fig. 4). The silver content of the coins is 15 lod.

After the Umayyads had lost their position as Caliph to the Abbasids, they created an independent state in Islamic Iberia along with a part of North Africa, with Córdoba as their capital. Amir Abd al-Rahman proclaimed himself caliph in 929. The Caliphate of Córdoba existed from 929 to 1031. In the present study,

Issuer	*Mint*	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Ziyad b. Abi Sufyan	BBA	670/1	1	2.62	15	88.60	0.81
Abbasid governors	Tabaristan	777/8	1	1.98	13	80.60	5.94
Abbasid governors	Tabaristan	786/7	1	1.83	15	87.60	1.97
Abbasid governors	Tabaristan	790/1	1	1.98	14	84.50	1.99

Table 2. Tabaristan coins.

Fig. 4. Abbasid dirham. Al-Mamun, Madinat al-Salam, 833 AD. 2.90 g.

Fig. 5. Buyid dirham. Abud-al-Dawla, Arrajan, 961/2 AD. 3.36 g.

one Spanish-Ummayad dirham, struck in al-Anadalus was analyzed. The silver content of the coin is 14 lod.

The production of Samanid dirhams began in the 890s and the majority of the Islamic coins in Swedish finds are struck during their dynasty. Samanid amirs had huge silver mines in Central Asia, in present day Afganistan, Uzbekistan, Tadzikistan, and Kirgizistan. Samarqand and al-Shash were the two most important Samanid mints with its most intense years of production from the 910s to the mid-920s. Balkh, Andaraba and the Samanid capital Bukhara was also an important mint. According to Roman K. Kovalev, it seems that Samanid dirhams were destined mainly for trade with northern Europe (Kovalev 2002). Merchants in Russia got the dirhams as the profit made by trading with the Arabs. Here, six Samanid dirhams struck in Bukhara, Samarqand and al-Shash were analyzed. The silver content of the analyzed dirhams is 15 and 14 lod (four and two specimens respectively).

One of the analyzed dirhams in the present study was struck by amir Abud-al-Dawla of the Buyid dynasty (also known as Buwaihids). During his reign, the Buyid dynasty became one of the most powerful Muslim dynasties. The most notable characteristic of Buiyd coinage is the stylistic variety (Treadwell 2001, xii). As mentioned before, the debasement of the silver content of dirhams from about 950/55 onwards is a well-known phenomenon. The analyzed coin was struck in Arrajan in 961/2 AD and its silver content is only 11 lod (fig. 5).

At least one major study has been carried out to analyze the metal composition of the coins struck by the different Caliphate dynasties and to trace the origin of the silver (Eniosova et. al. 2011). In the study, two hundred silver coins (e.g. Samanid dirhams struck at Samarkand, Shash, Bukhara, Andaraba, Balkh and Mádin during the first half of the tenth century) were analyzed in the Moscow

Dynasty	*Mint*	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Ummayyad	Wasit	741/2–43/4	2	2.84–2.74	15	91.50–88.20	0.00
Spanish-Ummayad	al-Andalus	859/60	1	2.65	14	87.50	1.90
Abbasid	Basra	782/3	1	2.72	15	88.30	1.10
Abbasid	Madinat al-Salam	810–33	2	2.90–2.80	15	92.00–91.90	0.00
Samanid	al-Shash	900–15/6	3	3.09–2.89	15	89.10–87.80	1.94–1.05
Samanid	Samarqand	941/2	1	3.06	14	83.90	4.44
Samanid	Bukhara	948/9	1	2.83	14	85.30	3.80
Samanid	Bukhara	952/3	1	3.32	15	89.40	0.89
Buwaihid	Arrajan	961/2	1	3.36	11	65.30	21.46

Table 3. Islamic coins.

State Historical Museum and in the Hermitage Museum in Saint Petersburg by using ED XRF equipment (Eniosova et. al. 2011). A series of coins were analysed with complete numismatic data, including the year and mint of issue, and the name of the ruler. Based on the study, there is a notable correlation between silver fineness and the mints. The sample of dirhams dates to 892–953 AD. In short, a relatively high and stable silver content was found for the mint of Andaraba. The most unstable and low silver content proved to be common for coins struck in al-Shash and Samarqand. The unusually high gold content for 14 of the 47 coins in the Samarqand selection indicate a possible separate local silver mine (Eniosova et. al. 2011, 582).The mints of al-Shash, Samarqand, Andraba and Balkh issued silver coins with an unusually high level of bismuth (Eniosova et. al. 2011, 581).

Khazar and other imitations

C. 10% of the total Islamic coin material in Viking-Age finds in the Northern Lands are Islamic imitations (Rispling 1987, 79). Many cannot be attributed. Thanks to e.g. die chains, it is known that imitations of the official Islamic coins were struck in the Khazar kingdom in the 8th and 9th centuries (Rispling 2004, 125). The Khazar kingdom was located between the Caucasus mountains and the Volga. Because of the location of the Khazar kingdom, they could benefit from the trade between the northern areas and Muslim traders. Some Khazarian imitations are distinguished by their inscriptions. One of them reads "Moses is the prophet of God" and another gives the mint as "The Land of the Khazars" (Ard al-Khazar). The coins

Fig. 6. Khazar dirham. Issuer? Ard al-Khazar 837/8. 2.91 g.

reflect Judaization of the Khazar elite by 861. One type has a royal family symbol, a trident (tamgha). This symbol has a connection with a fortress called Sarkel, located between the Black Sea and the Caspian Sea (Rispling 2004, 125). In the present study, three Khazar imitations were analyzed (fig. 6). The silver content of the coins is 15 lod (one specimen) and 14 lod (two specimens).

Volga-Bulgar imitations

Volga-Bulgar imitations are the largest group of Islamic imitations, struck in Bulgar and Suwar, both located along the river Volga. At present, 3,172 Volga-Bulgar imitations have been recorded in Swedish finds (K. Jonsson 2015, 54). The prototypes of the imitations are Abbasid and Samanid dirhams. The Volga Bulgars were strategically located along the main route between Central Asia and Northern Europe.

The Volga-Bulgar dirham coinage lasted for *c.* 90 years. It started in Bulgar *c.* 900. After 950 the coinage was sporadic and the last known Volga-Bulgar imitation was dated 997/8 (Gert Rispling pers. comm.) The coinage is problematic, because only a small part of the imitations has the name of Bulgar or Suwar. Volga-Bulgar imitations contained an even amount of silver and can generally be distinguished by their deviant calligraphy (Album 2011, 14). The

Area	*Mint*	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Khazar	Ard al-Khazar	837/8	1	2.91	14	87.40	2.44
Khazar	"Samarqand"	"786/806"	1	2.53	14	85.10	3.06
Khazar	"Qm al-Salam"	"814/15"	1	3.16	15	88.60	1.68

Table 4. Khazar and other imitations.

Area	*Mint*	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Volga- Bulgar	Bulgar	Without date	1	2.57	14	85.90	3.33
Volga- Bulgar	“Naysabur”	–	1	3.08	13	78.70	8.32
Volga- Bulgar	–	–	1	2.69	14	86.60	2.52
Volga- Bulgar	Suwar	949/50	1	2.81	14	87.00	2.04
Volga- Bulgar	Bulgar	–	1	3.36	14	86.30	2.65

Table 5. Volga-Bulgar imitations.

Fig. 7. Volga-Bulgar dirham. Talib b. Ahmad, Suwar, 949/50 AD. 2.81 g.

imitations are more or less contemporary with the originals and were intended to circulate alongside the prototypes.

In the present study, the silver content of five Volga-Bulgar imitations was analyzed. Four of the coins, struck in Bulgar and Suwar, have a silver content of 14 lod (fig. 7). One of the imitations, however, Mikail b. Ja^{c}far in “Naysabur”, has a lower silver content, 13 lod.

Byzantine coins

A total of 627 Byzantine coins from the Viking Age have been found in Sweden and a summary of their distribution by emperors and denominations until Nicephorus III (1078–81) has been published (Hammarberg et. al. 1989, Table 7.1.). The vast majority of the imported Byzantine coins belong to the period *c.* 990–1010. One exception is the late Ocksarve hoard on Gotland, which included four coins of Romanus III (1028–34) and 108 coins of Constantine IX (1042–54). It is probable that the hoard was the property of a Varangian serving in Constantinople (K. Jonsson 2009, 57). The import of Byzantine coins in the mid 11th century can be related to traders and mercenaries.

In the present study, the silver content of five Byzantine coins was analysed: a miliaresion of Basileus I and Constantine (868–79), a miliaresion of Basil II and Constantine VIII (977–89) (two specimens) and 2/3 miliaresion of Constantine X (1059–67) (two specimens) (fig. 8). Only one specimen struck by Basil I and five specimens struck by Constantine X

Fig. 8. Byzantine Empire. Constantine X (1059–67), Constantinople, 2/3 miliaresion. 1.16 g.

Issuer	*Mint*	*Nomination*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Basileus I 868–79	Constantinople	Miliaresion	1	2.01	15	88.00	1.87
Basileus II 977–89	Constantinople	Miliaresion	1	2.32	15	87.60	2.21
Basileus II 977–89	Constantinople	Miliaresion	1	2.26	14	87.40	1.97
Konstantin X 1059–67	Constantinople	2/3 miliaresion	1	1.66	14	85.20	3.22
Konstantin X 1059–67	Constantinople	2/3 miliaresion	1	1.16	13	77.80	9.59

Table 6. Byzantine coins.

(1059–67) are known from Swedish finds (Hammarberg et. al 1989, Finds 32, 71 and 89). The analyzed coins struck by Basileus I and Basil II have a silver content of 15 and 14 lod. The silver content of the later coins struck by Constantine X (1056–67) is 14 and 13 lod.

Falcon coins. Russian imitations?

In 1987 Gert Rispling published a paper dealing with Christian imitations of Islamic dirhams. He divided these coins into two categories: Imitations with a cross as motif and imitations with both cross and the head of a bird (probably falcon) as motif (Rispling 1987, 75–6, 86). The Muslim traditions (Hadith) forbade the reproduction of living creatures. On the falcon coins, however, the ban of images was not followed. A most remarkable attribute of these imitations – a cross – clearly indicates a Christian origin (Rispling 1987, 76). According to Rispling, it is worth noting that the engraving of the imitations is well executed, but the inscriptions are not written in correct Arabic. He means that the linguistic confusion seems to be intentional. The coins are far too corrupt to have been accepted as currency in the Caliphate (Rispling 1987, 78, 84). According to Rispling, the coins can be dated to *c.* 930 A.D. and were probably struck in the principality of Kiev (Rispling 1987, 84). According to Ivar Leimus, however, it seems more probable that the Falcon coins could have been struck in Novgorod or Pskov by Princess Olga, the ruler of Kievan Rus' (945–62) (Leimus 2014, 71). Olga was the first Rus ruler to convert to Christianity, in either 946 or 957 (Leimus 2014, 70 with references).

Fig. 9. Russia. Falcon coin, Novgorod or Pskov?, *c.* 950. 4,19 g.

In the present study, the silver content of three Falcon coins was analyzed (fig. 9) and they are 15 lod (two specimens) and 14 lod (one specimen).

Georgian coin

Georgia was sometimes independent and sometimes part of the Chaliphate. It has been stated that there was an independent coinage in Georgia only during the reign of David Kuropalates 990–1000. However, according to Viacheslav Kuleshov, it seems more probable that these Georgian coins were struck during David I (*c.* 876–81). Only a total of four specimens of these Georgian coins are known (Viacheslav Kuleshov pers. comm.). A single Georgian coin has been found in Sweden (K. Jonsson 2015, 54). The silver content of the coin is 15 lod (fig. 10).

Indian jital

Only one Indian silver coin from the Viking-Age has been found in Sweden. It was found

Type	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Falcon coin	*c.* 950	2	3.43–3.22	15	91.80–89.20	1.09–0.00
Falcon coin	*c.* 950	1	4.19	14	85.70	4.31

Table 7. Russia. Falcon coins.

Area	*Issuer*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Georgia	David I *c.* 876–81	1	2.12	15	88.60	1.66

Table 8. Georgian coin.

Fig. 10. Georgia. David I (*c.* 876–81)? 2.12 g.

Fig. 11. Indian jital. Ohind, *c.* 980–1000. 3.02 g.

on the Island of Öland in 2009 and is a bull-and-horseman jital struck at Ohind, located on the Indus river in the region in present day northwestern Pakistan (E. Jonsson 2013, 26). The jital was struck *c.* 980–1000 (Gert Rispling pers. comm.) and it has probably been exported to Scandinavia via Russian merchants, along the same long-distance trade routes as the Islamic dirhams. According to Ivar Leimus, a total of 21 Indian jitals are known in Europian finds (Leimus 2017, 9). The jital found on Öland was not available for the present study, but a similar specimen was chosen from the KMK systematic collection (fig. 11). The silver content of the coin is 14 lod.

Spanish coin

In the present study, one Spanish coin struck in the county of Besalú was analyzed (Botet i Sisó 1908, 87–89 var.) (fig. 12). Spanish coins are very scarce in Northern finds. Two specimens, found in Blekinge, (4.1.5.38 and 4.1.9.1) have been published. The obverse of the coin shows the hand of the Savior and the inscription BLDO (for Bisilduno). The reverse portrays a cross with the cruciform inscription SANCTA CRUX with BR-NR-DS-CO in the angles, that is, Bernardvs Comes. The coin was struck during count Bernhard II or III (1066–97/1100–11), the last counts of Besalú. It has been stated that this coinage already have the appearance of billon, that is, silver content of less than 50% (Crusafont et. al. 2013, 86–7). However, the analyzed coin is of a good standard of fineness, 14 lod.

Carolingian coins

The Carolingian empire (800–88) covered a large part of Western Europe. In 800, Charlemagne (768–814), one of the greatest rulers of European history, was crowned emperor in Rome by Pope Leo III. Charlemagne introduced a strong centralised coinage, and the medieval penny was introduced *c.* 793/4. The Empire was divided after 840 and the silver coinage continued in the kingdoms that replaced it. Carolingian coins in Scandinavian finds are, however, scarce, only 75 specimens are known from Sweden (K. Jonsson 2015,

Fig. 12. Spain. Count Bernhard II or III (1066–1111), the county of Besalú, Botet i Sisó 1908, 87–89 var. 0.46 g.

Area	*Date*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
India. Ohind	*c.* 980–1000	1	3.02	14	83.40	4.51

Table 9. Indian jital.

Area	*Issuer*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Spain	Bernhard II or III 1066–1111	1	0.46	14	85.50	4.12

Table 10. Spanish coin.

54). Many of them have not been found in hoards but in graves.

In the present study, four Carolingian coins were analyzed. Two of the coins were struck by Louis the Pious (814–40) and represent the XPISTIANA RELIGIO type. This coin type is one of the most common Carolingian type, struck *c.* 822–40 (Grierson & Blackburn 1986, 216). The analyzed coins have a silver content of 14 lod. A few examples among this type have proved to have a very high copper content. Coins with irregular (or "barbaric") style among the XPISTIANA RELIGIO type are, however, plenty. In earlier research, they have been interpreted as forgeries or the products of an "unofficial mint". They should, however, be considered as regular coins of Louis the Pious and the dies are the handicraft of unskilled craftsmen. It is not possibly to identify a possible location of the mints (Coupland 2017, 107).

According to Grierson and Blackburn, incompetent die-cutters were a regular feature of Carolingian coinage (Grierson & Blackburn 1986, 216). Also the fineness of Carolingian coinage was very variable, and not only in the later stages of coinage. Grierson and Blackburn state that one has the impression that moneyers turned into coin whatever silver came their way without any attempt to purify it first, something indeed which they may not always have been technically capable of doing (Grierson & Blackburn 1986, 194).

One of the analyzed Carolingian coins in the present study was struck by Charles the Bald (840–77) at Melle (MG 1064). However, the mint-name of this type includes a cross,

Fig. 13. Carolingian Empire. Charles the Bald (840–77), Le Mans, MG 905. 1.73 g.

METXULLO. It has been suggested, that the letter X might have been intended to distinguish feudal from royal issues. An alternative, according to Grierson & Blackburn (1986), a more probable explanation is that the coins with the letter X were not struck in Melle but elsewhere. This type had already started quite early in the reign of Charles the Bald (Grierson 1991, 238). The coin has a silver content of 13 lod.

Charles the Bald (840–77) revived the KAROLUS monogram as his main type and replaced the traditional inscription naming individual rulers with the text GDR (GRATIA DEI REX). The GDR type was still struck long after the death of Charles, which makes it difficult to distinguish the issues (Grierson 1991, 41–2). In the present study, a denier MG 905 was analyzed (fig. 13). The coin has a silver content of 14 lod.

D. M. Metcalf & J. P. Northover made a preliminary investigation of 34 Carolingian coins, mainly from the Cuerdale hoard, which was concealed *c.* 905 (Metcalf and Northover 1988, 110). The Carolingian coins in the hoard date to the last quarter of the ninth century. In short, the Carolingian coins from the late ninth century in their study were almost all of a high level of purity, at best *c.* 95%, and according to them with an intended standard

Issuer	*Mint*	*Type*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Louis the Pious 814–40	?	XR	2	1.60–1.58	14	84.70–84.10	5.89–3.77
Charles the Bald 840–77	Le Mans	MG 905	1	1.73	14	83.50	4.45
Charles the Bald 840–77	Melle	MG 1064	1	1.76	13	81.20	4.67

Table 11. Carolingian coins.

(Metcalf & Northover 1988, Table on pp. 110–11). The method of their metallanalyses was electron-probe micro-analyses (EPMA).

French coins

In the tenth century, the royal control of coinage vanished almost completely in France, and the coins of the feudal magnates, lay and ecclesiastical, replaced it. Many issues were immobilized and the name of the king on the coin does not mean that the mints were still in royal hands or that their profits went to the Crown. Token recognition of royal authority by mints appropriated by the feudal nobility was a much more common phenomenon, and according to Grierson this has been the major problem in studying French coinage in the tenth and eleventh century (Grierson 1991, 50–3). French coins are very scarce in finds in the Northern Lands, only 20 specimens are known from Sweden (K. Jonsson 2015, 54).

In the present study, the silver content of three French coins struck by the dukes of Normandy was analyzed. The earliest was struck by Richard I of Normandy, also known as Richard the Fearless. He was duke of Normandy from 942 to 996. The silver content is only 12 lod. Two of the analyzed coins were struck by Richard II (996–1026), also called Richard the Good, or by his son Richard III (1026–27). Both coins (Dumas XVI, 19) have a silver content of 14 lod (fig. 14).

There are about 30 coins of one type (Dumas XVI, 19), found in Scandinavia and the Baltics. It has been presumed that they were struck in Normandy. According to Jens Christian Moesgaard, these coins are all die-duplicates. He has stated that the coins came from Normandy to some Scandinavian city as a single parcel, before it was divided (Moesgaard 2000, 84–6). However, Moesgaard soon noticed that his interpretation was problematic in many ways: the weight of the coins is high (average 1.16 g) compared to the same type from France (average 0.83 g). Their technical level and style are different. When the silver content of two specimens was analyzed by using XRF, it could be established that the silver content of *c.* 95–90% is much higher than the *c.* 65% current in Normandy at that time. These features suggest that the coins of this type may be imitations. According to Moesgaard's preliminary hypothesis, they may have been struck in Stade or in Bohemia (Moesgaard 2008, 67–73).

Fig. 14. France. Duke Richard I/III (996–1026/7), Normandy, Rouen. 1.46 g. Imitation?

German coins

The Carolingian dynasty died out in 911. The eastern half of the former Carolingian Empire formed the bulk of the German Empire, which was created during King Conrad I (911–18). The German Empire covered Bavaria, Franconia, Saxony and Swabia. Lorraine became a German duchy in 925 and Burgundy was acquired after 1032. The first German coins began to reach Scandinavia already in the mid-tenth century. The earliest known hoard in Sweden containing a German coin was deposited after 948 (Hatz 1974, no. 3). From the 990s the Islamic coins were replaced

Area	*Issuer*	*Mint*	*Type*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Normandy	Richard I 942–96	Rouen	Dumas 733	1	1.20	12	73.70	14.02
Normandy	Richard II/III 996–1027	Rouen	Dumas XVI, 19	2	1.46–1.19	14	86.70–82.60	5.68–2.74

Table 12. French coins.

mainly with German and English coins which were imported mainly via Germany. The German and English coins arrived already well mixed as regards their mints of origin. 107,749 Viking-Age German coins are known in Swedish finds (K. Jonsson 2015, 54). During the second half of the Viking Age, *c.* 950–1125, more than 2,500 coin types were struck in more than 170 mints in Germany (K. Jonsson 2007, 109). Royal control of the coinage diminished greatly in the course of the eleventh century. Non-royal mints were for the most part in the hands of the Church. It has been estimated that there were at least twenty or thirty monetary regions in Germany (Metcalf 1998, 348). In each region only coins of one type were current.

Various series of metallurgical analyses of German coins have been conducted over the last few decades (Kraume & Hatz 1972; Zwicker & Gale 1991; Ilisch et al. 2004; Steuer et. al. 2002; Steuer 2004). Jens Christian Moesgaard recently made an attempt to present a summary of the most important results, although he pointed out that the different methods are not necessarily comparable (Moesgaard 2015, 40–2). In the present study, 30 German coins were analyzed.

One coin was struck in Oberlothringen by Bishop Dietrich II (1005–46), in Metz (Dbg 25), which is today located in northeastern France. The silver content of the coin is 14 lod.

13 coins were struck in Niederlothringen: three in Cologne, two in Deventer, one in Groningen and seven in different mints in Frisia. The largest German mint was Cologne, as reflected in the Swedish finds. Cologne was centrally located on the Rhine at the intersection of the major trade routes between east and west. The earliest of the analyzed Cologne coins was struck by Otto I (936–73) (Häv. 29). Konrad II granted minting rights to Archbishop Pilgrim (1021–36), who struck jointly with the king. Also one coin struck jointly by Emperor Konrad II (1027–36) and Archbishop Pilgrim (1021–36) was analyzed (Häv. 222). The latest of the analyzed Cologne coins is episcopal, struck by Archbishop Hermann III (1089–99) (Häv. 405). All the analyzed Cologne coins have a silver content of 14 lod. The result, that also the latest Cologne coin is of good standard of fineness, fits well with the knowledge that the coins of the archbishops of Cologne were reckoned as the best in Germany (Grierson 1991, 66).

Fig. 15. Germany. Frisia, Leeuwarden, Count Bruno III (1038–57), Dbg 502. 0,58 g.

However, by the mid-eleventh century, the weight and fineness of the silver coins were beginning to drop in many areas of Europe, and pennies of the second half tend to be markedly inferior to those of the first (Grierson 1991, 64). There are indications that Frisia played an active role connected with the debasement of the German coins (Potin 1990). In Frisia, the weight of the locally struck pfennings had been reduced already in the 10th century until it was no longer possible to reduce the weight any further. During count Bruno III (1038–57) the silver content was reduced by replacing silver with copper (K. Jonsson 2009, 64). Two Frisian coins struck by Bruno III were analyzed, one in Leeuwarden (Dbg 502) and the other in Dokkum (Dbg 499) (fig. 15). The silver content of both coins is very low, 10 lod and only 6 lod respectively. One Frisian coin was struck in Jever by Duke Bernhard II (1011–59) (Dbg 591/593 var.) and had a clearly higher standard of fineness, 13 lod. Four Frisian coins were struck in Stavoren, of which two by Count Egbert (1068–90) (Dbg 532). Two of the Stavoren coins were struck by Bishop Konrad (1076–99) (Dbg 2019). The earlier coins have a lower silver content, 13 lod resp. 12 lod, while the coins struck by Bishop Konrad are 14 lod. One coin struck in Groningen by Bishop Bernold (1027–54) (Dbg 558) has a silver purity

Fig. 16. Germany. Goslar etc., Otto-Adelheid-Pfennig, imitation, Hz VI 2b4. 1.02 g.

Fig. 17. Germany. Goslar, King Lothar (1125–33). 0.90 g.

of 14 lod. Besides, two coins struck in Deventer by Bishop Bernold (1027–54) (Dbg 571 and Dbg 568) have a silver content of 12 and only 8 lod respectively.

14 coins come from Saxony, of which one was struck in Lüneburg or Bardowick, six are Otto-Adelheid-Pfennigs struck in Goslar and elsewhere, six are later issues from Goslar and one is a late so called cross denier (Sachsenpfennig). According to the traditional view, Dbg 1557 was struck in Lüneburg by Duke Bernhard I (973–1011). Lüneburg lies in Lower Saxony, on the river Ilmenau. The coin has a silver purity of 14 lod. The Sachsenpfennig (CNP 860) was struck *c.* 1085–1100 and has a silver content of 12 lod. It is known from previous silver analyses that Sachsenpfennige lean towards local (Harz) silver resources. It is also thought that imported eastern silver was re-coined at Magdeburg.

The German coins are often difficult to date. This is especially true concerning the so called Otto-Adelheid-Pfennig (OAP), which is the most common german coin type found in Scandinavia. The date and location of the different varieties have been much debated by several scholars (for an overview, see Moesgaard 2015, 19 and references).The date of introduction of this type has been believed to be *c.* 983 (Kluge 1990, 171). According to Berndt Kluge the subtype Hatz II represents the earliest phase of the OAP-coinage (Kluge 1990). The subtypes Hatz III and IV comprise many varieties, and their date and location is still the subject of debate. In the present study, the silver content of six OAP coins was studied (Hz I–VI) (fig. 16). The coins of the types Hz I–II have a silver content of 14 lod. The silver content of the other types, some of which are later (Hz III–VI) seem to be lower, 13 lod. In general, OAP is known to match the isotope ratios of the Upper Harz, but the elemental analysis indicates that at least two distinct silver sources were used, both possibly originating in the Harz mountains, i.e. Upper Harz and Rammelsberg (Zwicker et. al. 1991, 75). A minor part of the OAP issues seems to have been struck from melted down dirhams (Steuer et. al. 2002). Large scale coin production started in the 980s.

Six coins are later issues from Goslar, of which two were struck by King Heinrich IV (1056–84) (14 and 13 lod), two by King Heinrich V (1106–11) (15 and 14 lod) and two by King Lothar (1125–33) (14 lod) (fig. 17).

One of the analyzed coins comes from Speyer (Franconia) and one from Regensburg (Bavaria). The coin from Speyer (Dbg 829) was struck by Emperor Heinrich III and dates to 1046–51. The silver content is 13 lod. The coin from Regensburg (Hahn 48) was struck by Emperor Heinrich III (1046–56) and the silver content is 12 lod.

It is to be noted that only one of the 30 analyzed coins have a silver content of 15 lod. Before the mid-11th century all others have 14–13 lod silver. Based on this small sample it is evident that the debasement in Frisia started during Count Bruno III 1038–like Deventer. Here the silver content fell as low as 10–6 lod.

Italian coins

The coins issued in northern Italy after 951 in the name of the kings and emperors of the

Mint	*Issuer*	*Type*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Metz	B. Dietrich II 1005–46	Cf. Dbg 25, obol	1	0.63	14	84.40	4.14
Cologne	Kg Otto I 936–962	Häv. 29	1	1.27	14	86.10	3.19
Cologne	Ab. Pilgrim & E. Konrad II 1027–36	Häv. 222	1	1.51	14	86.30	2.69
Cologne	Ab. Hermann III 1089–99	Häv. 405	1	1.32	14	87.10	2.26
Deventer	B. Bernold 1027–54	Dbg 571	1	0.99	8	46.80	42.60
Deventer	B. Bernold 1027–54	Dbg 568	1	0.93	12	74.60	12.17
Groningen	B. Bernold 1027–54	Dbg 558	1	0.79	14	86.70	1.81
Stavoren	B. Konrad 1076–99	Dbg 2019	2	0.52–0.47	14	85.80–85.20	4.25–3.51
Stavoren	C. Egbert III 1068–90	Dbg 532	1	0.61	13	79.80	8.99
Stavoren	C. Egbert III 1068–90	Dbg 532	1	0.72	12	73.20	14.36
Leeuwarden	C. Bruno III 1038–57	Dbg 502	1	0.58	6	35.50	54.24
Dokkum	C. Bruno III 1038–57	Dbg 499	1	0.60	10	58.50	29.42
Jever	D. Bernhard II 1011–59	Dbg 591/593 var.	1	1.20	13	78.60	7.75
Lüneburg/ Bardowick	D. Bernhard I 973–11	Dbg 1557	1	1.42	14	87.20	1.71
Goslar	E. Heinrich IV 1084–1106		1	0.74	14	85.00	3.65
Goslar	E. Heinrich IV 1084–1106		1	0.70	13	77.50	10.00
Goslar	E. Heinrich V 1111–25		1	0.61	15	89.20	1.38
Goslar	E. Heinrich V 1111–25		1	0.75	14	87.00	2.11
Goslar	Kg Lothar 1125–33	Dbg 687	2	0.98–0.90	14	83.00	5.20
Goslar etc.	Otto-Adelheid-Pfennig	Hz I, 2c	1	1.54	14	85.00	4.10
Goslar etc.	Otto-Adelheid-Pfennig	Hz II, 4b	1	1.33	14	84.90	3.77
Goslar etc.	Otto-Adelheid-Pfennig	Hz III, 7a	1	1.34	13	79.70	8.43
Goslar etc.	Otto-Adelheid-Pfennig	Hz IV, 5g	1	1.14	13	80.60	7.74
Goslar etc.	Otto-Adelheid-Pfennig	Hz V, 5d1 var.)(3g var.	1	1.51	13	80.50	7.36
Goslar etc.	Otto-Adelheid-Pfennig	Hz VI. 2b4	1	1.02	13	80.70	9.04
Magdeburg?	Sachsenpfennig 990–1000	CNP 860	1	0.96	12	73.20	11.72
Speyer	E. Heinrich III 1046-56	Dbg 829	1	1.52	13	78.60	9.57
Regensburg	E. Heinrich III 1046-56	Hahn 48	1	0.72	12	74.90	12.56

Table 13. German coins.

German Empire form a small and compact group. The coinage of south Italy developed on quite different lines. In Italy, the old pattern of Carolingian mints was retained, but the coins were smaller and less carefully struck than their predecessors (Grierson 1991, 50). Today 78 Italian coins are known in Swedish finds (K. Jonsson 2015, 54). The German emperors struck coins in the cities of Lucca, Milan, Pavia, Venice and Verona. Verona is the most common mint, followed by Pavia and Milan. The coins found in Sweden were probably imported via southern Germany, where small amounts of Italian coins were in circulation. The revised attributions in MEC 12 have been applied here (Day, Matzke, and Saccocci 2016, 38ff.).

In the present study, the silver content of five Italian coins was analyzed. Three of these coins were struck in Verona, of which two

Mint	*Issuer*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Pavia	E. Otto III 996–1002, Posthumous?	1	1.17	15	91.20	0.00
Pavia	Kg Heinrich II 1002–14	1	1.13	14	83.80	4.17
Verona	E. Otto III 996–1002	2	0.82–0.68	14	86.90–82.00	5.71–2.42
Verona	Anonymous 1004–14/24	1	0.62	14	81.40	7.45

Table 14. Italian coins.

by Otto III (966–1002) and one anonymous (1024–26) (fig. 18). The silver content of the Veronese coins is 14 lod. Two of the Italian coins were struck in Pavia during the reigns of E. Otto III (996–1002) and King Heinrich II (1002–14). The silver content of these coins is 14 and 15 lod respectively.

Bohemian coins

The duchy of Bohemia was formed in the 10th century and a local coinage probably started after 970. Bohemia had a well-developed coinage with a single central mint and uniform models (Suchodolski 2015, 87). The main link between Bohemia and the Nordic regions was an over land trade route connecting Regensburg (Bavaria) with Prague, Cracow, the Baltic areas, and Russia with its capital Kiev (Hásková 1990, 87). A total of 378 Bohemian coins are known in Swedish finds (K. Jonsson 2015, 54) and they are more likely to have been imported via Germany.

The silver content of five Bohemian coins was analyzed. Two were struck in Prague, of which one by Duke Boleslav II (967–99) (Cach 1970, 29) and the other by Duke Oldřich (1012–34) (Cach 1970, 288). Two of the coins were struck by Duke Bretislav I (1037–55) (Cach 1970, 312 and 322). The youngest of the coins was struck by Duke Vratislav II (1061–92) in Olmütz (Cach 1972, 333) (fig. 19). Some metallurgical analyses of Bohemian coins have been conducted earlier. Jędrzej Frynas has compiled a table of the results, but the method of the different studies is not mentioned (Frynas 2015, 18–9). According to Frynas, it is known that during Duke Bretislav I (1034–55) the average fineness was very high (90%), but the silver content decreased drastically (average 50%) during his son Vratislav II (1061–92) (Frynas 2015, 18). The earlier coins (967–1034) in the present study have a silver content of 15 lod (two specimens) and the later coins (1037–92) have a silver content of 14 lod (three specimens).

Polish coins

A local coinage in Poland probably started in Poznań *c.* 992 by Boleslaus I, also called the Brave. He was duke of Poland from 992 and crowned as the first Polish king in 1025. During his time the Polish territory was greatly expanded. Later the coins of Boleslaus were presumably minted at the main centres like Gniezno, Poznań and Ostrów Lednicki, but also at smaller ones. The early Polish coinage already ceased in the early 1020s (Suchodolski 2015, 70, 75, 85, 87). Only a total of 14 Polish coins are known in Swedish finds (K. Jonsson 2015, 54). Here, two Polish coins

Fig. 18. Italy. Verona, Issuer? (1004–14/24). 0.62 g.

Fig. 19. Bohemia. Olmütz, Duke Vratislav II (1061–92), Cach 333. 1.03 g.

Mint	*Issuer*	*Type*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Prag	Boleslav II 967–999	Cach 29	1	1.14	15	88.50	1.81
Prag	Oldřich 1012–34	Cach 288	1	1.06	15	87.60	1.97
Unknown	Bretislav I 1037–55	Cach 312, 322	2	1.11–1.01	14	84.70–83.90	5.22–4.23
Olmütz	Vratislav II 1061–92	Cach 333	1	1.03	14	84.40	4.19

Table 15. Bohemian coins.

Mint	*Issuer*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Posen?	Boleslaus I *c.* 992–1025	2	2.11–1.10	15	92.10–92.00	0.00

Table 16. Polish coins.

were analyzed (Stronczyński no. 7) (fig. 20). Both coins were struck by Boleslaus and have a silver content of 15 lod.

There was also a vast imitative coinage on present Polish territory during the eleventh century (Bogucki and Magiera 2015, 119–28 and references), but they have not been included here.

Russian coin

The oldest specimens of Old Rus′ coins were struck by Vladimir I, also called the Great. He was a prince of Novgorod, grand prince of Kiev, and ruler of Kievan Rus’ from 980 to 1015. Only a total of six Russian coins are known in Swedish finds (K. Jonsson 2015, 54). One Russian coin (Sotnikova and Spasski 1982 no. 226–I) was analyzed, struck by Jaroslav I (sole ruler of Russia from 1036 to 1054), also called the wise, Vladimir I′s son and successor (fig. 21). The coin can be dated to *c.* 1034–36 (Pritsak 1998, 82). The silver content is 15 lod.

Sotnikova and Spasski made an interesting discovery regarding the early Russian coinage that in each successive issue of the silver coins, there is a wide variation in the silver fineness (sometimes as much as between 30% and 96%) (Sotnikova and Spasski 1982, 139). Specimens with a high silver content had been struck with the same dies as specimens with a low silver content. Most interestingly, it is only the coins with a high silver content which are found in Russian hoards (Sotnikova and Spasski 1982).

Hungarian coins

Hungary was established as a kingdom in 1000/1 when Stephen I (1000/1–38), also known as King Saint Stephen, was crowned. The coins were minted using Bavarian prototypes and there were two weight standards. Both standards denote denars but were based on the Carolingian pound and the Scandinavian mark (average weight 1.24 g and 0.80 g respectively) (Hlinka 1979, 383). The coins in Swedish finds are concentrated to the reigns of Stephen I (1000/1–38), Peter (1038–41) and Andreas (1046–60). A total of 144 Hungarian

Fig. 20. Poland. Posen? Duke Boleslaus I (*c.* 992–1025), Stronczyński no. 7. 2.11 g.

Fig. 21. Russia. Novgorod, Jaroslav (1034–36), Sotnikova and Spasski 1982 no. 226–I. 1.38 g.

Mint	Issuer	Date	Number	Weight	Lod	Silver	Copper
Novgorod	Jaroslav	1034–36	1	1.38	15	88.80	1.51

Table 17. Russian coin.

Mint	Issuer	Type	Nos.	Weight	Lod	Silver	Copper
Gran?	Kg Stephen I 1000/1–38	Huszár 1	1	0.87	13	81.00	7.54
Gran?	Kg Stephen I (imitation?) 1000/1–38	Huszár 5	1	0.72	12	74.40	13.10
Gran?	Kg Andreas I 1046–60	Huszár 8	2	0.49–0.42	13	79.40–78.60	8.41–7.91
Gran?	Kg Andreas I 1046–60	Huszár 9	1	0.73	12	70.70	17.35

Table 18. Hungarian coins.

coins are known in the Swedish finds (K. Jonsson 2015, 54). Some metallurgical analyses of Hungarian coins have been conducted before. Jędrzej Frynas has compiled a table of the earlier results, but the method of the studies is not mentioned (Frynas 2015, 135).

Five Hungarian coins were analyzed. The earliest was struck by King Stephen I (1000/1–38) (Huszár 1) and one of the coins could be an imitation of Stephen I´s coins (Huszár 5). The silver content of the coins is 13 and 12 lod respectively. Three of the coins were struck by king Andreas I (1046–60) (Huszár 8–9) (fig. 22). One of the coins from Andreas I has a silver content of 13 lod and two coins have 12 lod.

English coins

The coinage of late Anglo-Saxon England was produced by a large number of moneyers in more than 90 towns. After the reform of Edgar *c.* 973 the name of the moneyer and mint on the reverse of the coins became universal practise for the first time. Edgar´s reform introduced a uniform national coinage in England, and after the reform the land had the best organized coinage in Europe (Grierson 1991, 71). No coins before the reform were analyzed.

Fig. 22. Hungary. Gran? King Andreas I (1046–60), Huszár 8. 0.49 g.

A total of 43,184 English coins are known in Swedish finds (K. Jonsson 2015, 54). The silver content of 23 English coins was analysed, from the reigns of Æthelred II (978–1016) to Henry II (1154–89) (the latter being post Viking Age, but included for comparison). According to the traditional view, there was no change at all in fineness from Edgar's reform to that of William II (e.g. Grierson 1991, 71). This view has largely been revised (Metcalf & Northover 1986, 2002). In their analyses, small but real differences between mint-towns because of slightly different practical ways of refining the silver were discovered (Metcalf & Northover 1986). There may even have been systematic differences between individual moneyers – it seems that the moneyers sometimes oversaw the refinement of the silver (Metcalf & Northover 1986, 40). The evidence shows that, in Cnut *Quatrefoil* type at least, the coins with a lower silver content tended to be produced late in the validity period (Metcalf & Northover 2002, 232–33).

Five of the coins in the present study were struck for Æthelred II (978–1016), also known as the Unready.The history of his reign consists of a series of Viking raids, culminating in the conquest of England by the Danes. The coins of Æthelred II commenced with a continuation of the *Small Cross* type, which only

Fig. 23. England. Cnut (1016–35), Quatrefoil type 1017–23, Shaftesbury, moneyer Bolla. 1.25 g.

Fig. 24. England. William II (1087–1100), Cross-in-Quatrefoil type 1089–92, Winchester, moneyer Wimund. 1.37 g.

lasted about one year before being replaced by issues with a Hand (North 1994, 37). One specimen of the *First Hand* type (*c.* 979–85) and one specimen of the *Second Hand* type (*c.* 985–91) were analysed, both struck in London and both coins have a silver content of 13 lod. The third analysed issue in the present study is Æthelred II *Long Cross* (*c.* 997–1003), which is the most common English type found in Sweden. The coin has a silver content of 13 lod. The coin of Æthelred II Helmet type (*c.* 1003–9) struck in Winchester has a silver content of 14 lod and the penny of Æthelred II *Last Small Cross* type (*c.* 1009–16) from Chester is of 13 lod purity.

The rest of the eleventh century was a century of great political events: the Danish conquest under Cnut, the restoration of the West Saxon dynasty in the person of Edward the Confessor in 1042 and finally the Norman Conquest in 1066 (Grierson 1990, 72). Five of the analysed coins were struck for Cnut (1016–35). Cnut, also known as the Great, also took possession of the kingdom of Denmark in 1018 and reached the height of his power nine years later when he was acknowledged king of Norway. His reign brought peace and security to England after many years of Viking raids (North 1994, 38). In the present study, two specimens of the Cnut *Quatrefoil type* (*c.* 1017–23) were analysed (fig. 23). One specimen was struck in York and the other in Shaftesbury. The coins have a silver content of 14 and 13 lod respectively. Two coins are of the Cnut´s *Pointed Helmet* type (*c.* 1023–29) struck in Lincoln and in London. The coin from Lincoln is of 14 lod purity and the coin struck in London is of 13 lod purity. The latest of Cnut´s coins is of the *Short Cross* type (*c.* 1029–35) struck in London with 13 lod silver content.

Two coins were struck during the short reign of Harold I (joint king 1035–37, sole king 1037–40). The first coin is of the *Jewel Cross* type (*c.* 1035–37) struck in Wareham and has a silver content of 14 lod. The second coin of Harold I is of the *Fleur-de-lis* type (*c.* 1038–40) and struck in Lincoln. The silver content is 13 lod.

Two coins are of the Edward the Confessor (also known as Saint Edward the Confessor) (1042–66) *Radiate/Small Cross* type struck in York *c.* 1044–46. The silver content of the coins is 14 and 13 lod respectively. Two coins were struck by William I (1066–87), of which the first is of the *Two Stars* type (*c.* 1074–77) and the second of the *Paxs* type (*c.* 1083–86). These coins have a silver content of 13 lod. The three coins from the reign of William II (1087–1100) also keep a good standard of fineness: two coins of the *Cross-in-Quatrefoil* type (*c.* 1089–92) have a silver content of 13 lod, and a coin of the *Cross Voided* type (*c.* 1092–95) also has a silver content of 13 lod (fig. 24).

Four English coins dating to the twelfth century were analysed. Two of the coins are of Henry I (1100–35) *Quatrefoil-and-Piles* type (*c.* 1111–13). The silver content of the coins is 13 and 12 lod respectively. Two of the analyzed coins belong to Henry II *Cross-and-Crosslets* (*Tealby*) type, introduced in 1158. The coins

Issuer	Type	Date c.	Mint	Nos.	Weight	Lod	Silver	Copper
Æ II	First Hand	979–985	London	1	1.47	14	84.00–86.40	2.45–4.42
Æ II	Second Hand	985–91	London	1	1.30	14	85.60	3.02
Æ II	Long Cross	997–1003	London	1	1.53	14	84.00	4.42
Æ II	Helmet	1003–9	Winchester	1	1.50	15	87.90	1.55
Æ II	Last Small Cross	1009–16	Chester	1	1.33	14	86.40	2.45
Cn	Quatrefoil	1017–23	Shaftesbury York	2	1.25–1.01	14	88.00–84.60	5.04–1.55
Cn	Pointed Helmet	1023–29	Chester	1	0.99	15	91.60	0.00
Cn	Pointed Helmet	1023–29	London	1	1.01	14	83.00	3.88
Cn	Short Cross	1029–35	London	1	0.99	14	86.70	2.30
H I	Jewel Cross	1036–38	Wareham	1	1.18	15	88.10	1.67
H I	Fleur-de-lis	1038–40	Lincoln	1	0.99	13	76.60	9.59
E C	Radiate/Small Cross	1044–46	York	1	1.04	15	88.90	1.58
E C	Radiate/Small Cross	1044–46	York	1	0.92	14	85.10	3.72
W I	Two stars	1074–77	Lincoln	1	1.23	14	85.30	2.88
W I	Paxs	1083–86	London	1	1.36	14	83.30	5.09
W II	Cross-in-Quatrefoil	1089–92	London Winchester	2	1.37–1.07	14	83.00–82.40	5.78–4.24
W II	Cross Voided	1092–95	Bedford	1	1.34	14	86.00	2.62
Hy I	Quatrefoil and Piles	1111–13	London	1	1.41	14	82.80	6.78
Hy I	Quatrefoil and Piles	1111–13	Exeter	1	1.37	13	76.60	10.70
Hy II	Cross-and-Crosslets	1158–80	Canterbury Durham	1	1.54–1.41	14	85.20–84.60	3.59–2.62

Table 19. English coins. Æ - Æthelred II, Cn - Cnut, H I - Harold I, E C - Edward the Confessor, W I - William I, W II - William II, Hy I - Henry I, Hy II - Henry II.

were struck in 1158–61 in Canterbury and 1161–65 in Durham and their silver content is 13 lod.

Hiberno-Norse and Hiberno-Manx coins

At the end of the tenth century, at the same time when national coinages started in Denmark, Sweden, and Norway, the Scandinavians in Dublin also commenced their own independent coinage *c.* 995. The coinage was initiated by the king of Dublin, Sihtric III (989–1036), also called "Silkbeard", who ruled over the town for more than 45 years. By that time, Dublin was the most important town in the western part of the British Isles. Minting began with imitations of Æthelred II *Crux* type (in England dated to *c.* 991–97). The earliest coins were struck either in the name of Æthelred or in that of Sihtric. Dublin has been referred to as "Viking" or "Scandinavian" until *c.* 980, but thereafter acquired a distinctive local culture. This culture has been called "Hiberno-Norse" or "Hiberno-Scandinavian", because there was a blending of people of Norwegian, Danish, Danelaw and Irish origin in Dublin (Blackburn 2011, 91–2). The Hiberno-Norse coinage has been divided into seven phases, dating from *c.* 995 to the twelfth century (Dolley 1966, 119–50).

In the present paper, the silver content of five Irish coins struck in Dublin was analyzed. Two of the coins are *Long Cross* issues, belonging to phase I (*c.* 995–1020) and one coin is a *Long Cross* issue belonging to phase II (*c.* 1015–35). The silver content of these coins is 14 lod. One coin dates to phase III (*c.* 1035–55) and it has also a silver content of 14 lod. One coin dates to phase V (*c.* 1065–95) (fig. 25) and has a silver content of 15 lod.

The Isle of Man lay in the middle of the

Issuer	Type	Date c.	Mint	Nos.	Weight	Lod	Silver	Copper
Sihtric	Long Cross (SIHTRIC)	995–1020	Dublin	2	1.44–1.28	14	87.40–82.90	4.98–2.62
Sihtric	Long Cross, phase II	1015–35	Dublin	1	1.20	14	85.70	3.03
?	Long Cross, phase III	1035–55	Dublin	1	83.30	14	83.30	5.09
?	Phase V	1065–95	Dublin	1	0.68	15	87.60	2.23

Tabel 20. Ireland. Hiberno-Norse coins.

Issuer	Type	Date c.	Mint	Nos.	Weight	Lod	Silver	Copper
?	Long Cross	1025–35	?	2	1.12–0.99	14	87.00–86.40	2.85–2.72

Table 21. Ireland. Hiberno-Manx coins.

Irish Sea, along the sea routes. It has been assumed that the Scandinavian settlement of the Island took place in the mid-ninth century or later. From the Isle of Man it was possible to control the traffic and trade between Scotland, Ireland, northern Wales and the English coast. A total of 538 Hiberno-Norse and only 4 Hiberno-Manx coins are known in Swedish finds (K. Jonsson 2015, 54). In the present analysis the silver content of two Hiberno-Manx coins is presented (fig. 26). The silver content of the both coins is 14 lod.

Kristin Bornholdt Collins has previously commented on the coinage of the Isle of Man in the light of metallurgical analyses (Bornholdt 1999). She points to fluctuations and chances in the trace elements and alloy over the course of the coinage, even amongst die-linked groups and duplicate coins. She means that this indicate that the mint was not regulated to the extent that the silver was adjusted to a standard composition, but it seems instead that silver was used as it came and different batches of silver were used even with the same set of dies (Bornholdt 1999, 206).

Nordic coins

In her doctoral thesis, Brita Malmer analyzed a series of early Scandinavian coins, which she named Nordic and divided into 13 combination groups. The earliest were struck in Hedeby and Ribe *c.* 825–40 (Malmer 1966, 182). A total of 769 Nordic coins are known in Swedish finds (K. Jonsson 2015, 54). In the present study, the silver content of a total of 12 Nordic coins were analyzed.

According to Malmer, the first coinage (KG 3) took place around the year 825 and the prototype was Carolingian coins from Dorestad (Malmer 1966, 204–09). In the present study, two specimens of the earliest group KG 3 were analyzed (fig. 27). The silver content of the coins is 15 lod. Group KG 5, which also belongs to the older pictorial Carolingian type, is represented by two specimens. The silver content of the coins is 14 lod. Groups KG 8 and KG 9 belong to

Fig. 25. Ireland. Issuer? Phase V *c.* 1065–95, Dublin. 0.68 g.

Fig. 26. Isle of Man. Issuer? Long Cross type after *c.* 1025/30, Mint? 1.12 g.

a younger coin type and date to the 950s–80s, are also represented by two specimens each. The silver content of the coins is 15 and 14 lod. According to Moesgaard, the Carolus-Dorestad imitations from Hedeby were predominantly made from silver of one single origin which has not been located (Moesgaard 2015, 42 with references).

After the Carolus-Dorestad imitations the so called cross coins (groups KG 10–KG 12) were struck in Hedeby, *c.* 975/80–85/90. The Cross coinage was the first one to make up a substantial part of the Danish currency. Metallurgical analyses of a group of coins have been conducted in 2009 by Maria Filomena Guerra in order to determine the origin of the metal used by King Harold Bluetooth (Moesgaard 2015, chapter II). In order to attempt to define the silver supplies used to produce the Danish cross coinage minted by Harold Bluetooth, a selection of coins covering the entire reign of the king (39 specimens), a small set of Carolus-Dorestad imitations struck earlier in Hedeby (5 specimens) were analyzed by PIXE (Particle Induced X-ray Emission) (Table II.1 and Guerra 2015, 110–11). According to Guerra, the coins struck by Harold are clearly separated into two chemical groups: one containing more than 90% silver, and another from *c.* 80% up to 90% (Guerra 2015, 113–14). In the present study, two specimens of type KG 10

Fig. 27. Nordic coin. Combination group KG 3 *c.* 825–40, Hedeby. 0.41 g.

were analyzed. The silver content of 14 lod thus corresponds to the results of Guerra.

According to Malmer and also to Moesgaard, the last group, KG 13, is a later group, struck elsewhere, possibly in the region of Mälardalen (Malmer 1966, 217; Moesgaard 2015, 46). This group was not at all analyzed as a part of Moesgaard's and Guerra's study. In the present study, two specimens of KG 13 were analyzed (fig. 28). The silver content of the coins is 14 and 13 lod.

Scandinavian imitations

Imitations, which started to be struck around 995 and based on English prototypes, but which cannot be assigned to a specific area are called Scandinavian. The inscriptions can be completely blundered, or sometimes a mint and the name of an English king have been given. They are imitations of the English coin types *Crux* (*c.* 991–97), *Long Cross* (*c.* 997–1003), *Helmet* (*c.* 1003–09), *Last Small Cross* (1009–17) and *Quatrefoil* (*c.* 1017–23)

Group	*Date c.*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
KG 3	825–40	2	0.79–0.41	15	88.30–87.70	1.51
KG 5	825–40	2	0.96–0.76	14	87.30–84.80	3.40–2.00
KG 8	955	1	0.56	15	92.70	0.00
KG 8	955	1	0.49	14	86.70	2.70
KG 9b	950–90	1	0.32	14	86.80	3.75
KG 9d	950–90	1	0.24	14	82.40	6.02
KG 10a	975–90	2	0.29–0.26	14	84.20–83.40	5.39–4.72
KG 13	995	1	0.25	14	86.10	2.90
KG 13	995	1	0.33	13	80.20	9.49

Table 22. Nordic coins.

Fig. 28. Nordic coin. Combination group KG 13 *c.* 995, Mint? 0.25 g.

Fig. 29. Scandinavia. Æthelred II, Long Cross type *c.* 997–1003. 2.28 g.

as well as a few later types (Malmer 1997, 13–4). A total of 2,116 Scandinavian imitations are known in Swedish finds (K. Jonsson 2015, 54).

Brita Malmer published the Æthelred II and early Cnut imitations in two volumes. The first volume (Malmer 1989) dealt with the first phase of the Swedish Sigtuna coinage *c.* 995–1005. The second volume (Malmer 1997) covered the Æthelred II and early Cnut imitations produced in Scandinavia, together with a part of the later Swedish Sigtuna coinage including the early reign of Anund. The main emphasis in both cases was an analysis of the styles and no metal analyses were undertaken.

In the present study, a small sample of five Anglo-Scandinavian coins of common types *c.* 997–1023 was analyzed (fig. 29). It can be concluded that the silver content is stable at 14 lod, except for one coin with 13 lod. The specimen with a lower silver content is a mule with an obverse of *Long Cross* type and with a *Small Cross* reverse.

Danish coins

A royal Danish coinage probably started in Lund *c.* 995 during Sven Forkbeard (984–1014). Only one type was struck with the name of Sven Forkbeard, but thereafter a coinage with blundered legends continued for a few decades. A coinage struck at a number of mints began during the reign of Cnut the Great (1018–35), who was king of England (1016–35), Denmark (1018–35) and Norway (1028–35). During his reign the king´s name is often given. Now several Danish towns had a mint: Lund, Roskilde, Slagelse, Ringsted, Odense, Viborg, Ørbæk, Ribe, and Hedeby. The coinage in mints other than Lund was, however, often on a limited scale. The types were often of a local character. King Cnut the Holy (1080–86) is generally regarded as the first Danish king who struck debased coins, with only about 60% silver content (Becker 1988, 128). A total of 5,317 Danish coins are known in Swedish finds (K. Jonsson 2015, 54).

The phenomenon of debasement and introduction of national currencies in Viking-Age Scandinavia has been studied by several scholars. Metallurgical analyses of Danish coins were made by Georg Galster (1955), Svein H. Gullbekk (2000) and Frédéric Elfver (2007). Several scholars have argued for an introduction of a national currency during the reign of Sven Estridsen. Svein H. Gullbekk analyzed the silver content of 20 coins from the reign of Hardeknut to Sven Estridsen (Gullbekk 2000, 126). His conclusion was, based on

Area	*Chain*	*Dies (Malmer)*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Scandinavia	136	9.257.1334	1	2.28	14	83.40	4.49
Scandinavia	125	9.467.1825	1	1.64	13	77.70	12.22
Scandinavia	Single	9.1815.1974	2	1.46	14	83.80	4.44–4.16
Scandinavia	6-link	9.349.1379	1	2.31	14	84.70	5.15

Table 23. Scandinavian imitations.

Issuer	*Mint*	*Type*	*Nos.*	*Weight*	*Lod*	*Silver*	*Copper*
Hardeknut 1035–42	Lund	Hbg 1	1	0.95	13	80.30	9.40
Hardeknut 1035–42	Lund	Hbg 1	2	0.96–0.92	12	73.70–71.60	13.89–13.64
Sven Estridsen 1047–76	Lund	Hbg 13	1	0.89	12	74.30	10.93
Sven Estridsen 1047–76	Lund	Hbg 28	1	0.94	13	77.00	9.48

Table 24. Danish coins.

the analysis, that a general debasement and a change of weight standard took place during the latter part of the reign of Sven Estridsen. The motifs on the coins also became national rather than Anglo-Saxon. Frédéric Elfver, on the other hand, argues that it was not until the end of the 11th century that a general debasement of the Danish coinage occurred (Elfver 2007, 214). According to him, the coins of Sven Estridsen were consistently of a high silver content (90–95%). The analysis of Elfver was done using XRF in combination with SEM/EDS, while Gullbekk`s results are based on neutron activation analysis.

In the present paper, the silver content of five Danish coins was analyzed. The coins were struck in Lund during the reigns of Hardeknut (Hbg 1, three specimens) and Sven Estridsen (Hbg 13 and Hbg 28, one specimen each) (fig. 30). The latter can be dated to *c.* 1055–60. The silver content of Hbg 1 is only 13 and 12 lod. The coins of Sven Estridsen have a silver content of only 13 and 12 lod. In other words, the results correspond with those of Gullbekk.

Fig. 30. Denmark. Sven Estridsen 1047–76, Hbg 13, Lund. 0.89 g.

Norwegian coins

The first coins of Norway were struck during the reign of Olav Tryggvason (995–1000) *c.* 995. This earliest coinage was extremely modest and can be understood as a short experiment. The mint is not rendered on the coins. After at least a 15 year intermission, Olav Haraldsen (1015–28, 1035) issued a sporadic coinage. There was an intermission again during the reign of Magnus the Good (1035–47) and it was not until Harald Hårdrule (1047–66) when the Norwegian coinage became continuous. In other words, a large scale minting began considerably later in Norway than in Denmark. A number of modern metallurgical analyses of Norwegian coins have been published and mainly concentrate on the coinage of King Harald; Skaare & Steinnes 1966 (neutron activation); Dolley and Skaare 1973 (XRF); Skaare 1976 (neutron activation). In Swedish finds, a total of 232 Norwegian coins are known (K. Jonsson 2015, 54).

Regarding the Norwegian coinage, the general debasement occurred during the reign of King Harald Hardrule (1046–66) from the late 1050s onwards. The economic crisis is known under the name of "Haraldsslått". At this stage the silver content of the Norwegian coins dropped drastically from an initial *c.* 90% to a median value of 33% (Skaare 1976, 112–13). The debased coinage continued for a few decades and these coins were struck on a major scale.

The later part of the Viking-Age Norwegian coinage (1050–beginning of the 12th century) was covered by Brita Malmer (Malmer 1961). She examined the weight and the silver content of the Norwegian coins from three Swedish Lapp offering sites (Rautasjaure, Unna Saiva and Gråträsk) by using the touchstone method. According to Malmer, the silver content for the coins struck in the name of Magnus Bareleg

Issuer	Type	Nos.	Weight	Lod	Silver	Copper
Olav Kyrre 1067–93		1	0.66	13	77.60	5.97
Magnus Bareleg 1093–1103	Skaare 2, 6, 7	3	0.50–0.44	15	88.20–87.60	1.86–1.71
Magnus Bareleg 1093–1103	Skaare 4	1	0.52	14	87.10	2.62

Table 25. Norwegian coins.

(1093–1103) is more than 600/1000 (Malmer 1961, 293). Malmer noticed, however, that the average values given in her study are actually too low and should always be increased by *c.* 50/1000 (Malmer 1961, 291).

In the present study, the silver content of five late Norwegian coins was analyzed, of which the earliest is anonymous, struck during the reign of Olav Kyrre (1067–93). The silver content of the coin is 13 lod. During the reign of Magnus Bareleg (1093–1103), it was decided to strike pennies of half weight, but with a much higher silver content. One specimen in the present study was struck in his name. The silver content of the coin is 14 lod. Three of the analyzed Norwegian coins are anonymous, but struck during the reign of Magnus Bareleg (fig. 31). The silver content of the coins is 15 lod.

Swedish coins

The earliest Swedish imitations with legible legends were struck during Olof Eriksson (Skötkonung) at Sigtuna *c.* 995. Sigtuna is situated by Lake Mälaren, north of present day Stockholm. The minting in the town was based on English prototypes, but imitations of Byzantine coins were also produced. The dating of the Sigtuna coinage is based on the date of the English prototypes. In the early phase a few dies that were used in Sigtuna had been made in England and some dies were possibly imported from/ exported to south Scandinavia. The Sigtuna coinage lasted for a generation. A special feature in the Sigtuna coinage is the high proportion of square flans.

Fig. 31. Norway. Magnus Bareleg (1093–1103), Skaare 2, Mint? 0.46 g.

A total of 781 Sigtuna coins are known in Swedish finds (K. Jonsson 2015, 54). There is a small sample of five Sigtuna coins in this survey. Three of them are of the oldest Sigtuna type, Æthelred II *Crux* type, which belongs to the 990's (Malmer 1989, 11). According to Malmer, the production of this type seems to have started when the *Crux* type was still current in England. The silver content of the coins is 15 and 14 lod. Two of the Swedish coins are of Anund Jacob *Pointed Helmet* type, based on the second type of Cnut the Great struck in England *c.* 1023–29. This type was also rapidly imitated in Sigtuna. During the early Sigtuna coinage the weight of the coins was fluctuating. Interestingly, also a halfpenny (a penny officially divided into halves) was produced during the *Pointed Helmet* type (Malmer 2010, 67). The production volumes decreased significantly during the final phase of the coinage and it ceased *c.* 1030. The silver content of the coins is 14 and 13 lod respectively.

Malmer (2010) analysed the silver content of ten Sigtuna coins from *c.* 995–1020. According to her, an average silver content of 89,7% is fully comparable to those during the corresponding time in Germany, England and Denmark (Malmer 2010, 344). The results of the present study show somewhat lower figures than those of Malmer.

Summary and conclusions

In the present study, the silver content of 155 Viking-Age coins was analyzed (Table 27). The aim was to re-exam the traditional

Issuer	Mint	Type	Date c.	Nos.	Weight	Lod	Silver	Copper
Olof Eriksson	Sigtuna	Crux	995–997	1	3.04	15	88.20	2.04
Olof Eriksson	Sigtuna	Crux	995–997	2	1.95–1.62	14	87.40–86.70	2.30–2.05
Anund Jacob	Sigtuna	Pointed Helmet	1023–30	1	1.37	14	83.30	4.26
Anund Jacob	Sigtuna	Pointed Helmet	1023–30	1	1.33	13	81.10	6.09

Table 26. Swedish coins.

Fig. 32. Sweden. Anund Jacob, Pointed Helmet type *c.* 1023–29, Sigtuna, moneyer Thormoth. 1.37g.

interpretations of the silver content of different coinages during the Viking Age, and to offer an overview on the subject. The main question is what level of silver purity was considered as fine silver in everyday transactions in the Northern Lands and what variation was tolerated? The study covers coins from the sixth century until the middle of the twelfth century. The earliest coins in the present study, Sasanian drachms, were imported during the earliest phase of the Viking-Age coin import, in the first half of the 9th century. For comparison, the latest coin was struck in England after 1158, that is after the Viking Age. The lowest silver content in the present study is 6 lod (35,50%). This coin was struck in Leeuwarden in Frisia in 1038–57. The highest silver content of the study is surprisingly low, only 15 lod (92,10%). This coin with the highest silver content was struck in Poland during Boleslaus I (995–1025).

The second aim of the study was to find possible inconsistencies in the silver content. In this sense, a Spanish coin struck in the county of Besalú during Count Bernhard II or III (1066–97/ 1100–11) (Botet i Sisó 1908, 87–89 var.) was a surprise. It has been tought that this type already bore the appearance of billon, that is to say, silver of less than 50%. The coin has, however, a much higher silver content than has been measured in this group before, 14 lod (85,50%).

Summing up silver contents, *c.* 21% of the coins have a silver content of 15 lod, 53% have a silver content of 14 lod, almost 17% have a silver content of 13 lod and around 6% have a silver content of 12 lod. Only less than 3% of the coins have a silver content of 11 lod or less. Three of the 30 German coins were at the bottom of the range. Two of them were Frisian and one was struck in Deventer. The 23 English coins yield a more normal distribution, between 15 and 13 lod. On the basis of these figures the silver content can be divided into three categories: 1 - high 15-14½ lod (92–85%); 2 - good 14½-13 lod (85–75%); 3 - low 13 lod and less (<75%). Almost 68% of the coins belong to the second category. A silver content of 13 lod (*c.* 75%) or more seems to be what could be accepted as fine silver in everyday transactions. More than 91% of the coins are comfortably above this value and around 6.5% are slightly under it. Only less than 6% of the coins have a silver content of more than 14½ lod (90%).

According to Metcalf and Northover, it is unlikely that 5% or more copper content could survive the refining process. In such cases the copper was added (Metcalf and Northover 1986, 42). In the present study, *c.* 32% of the coins are mixed with more than 5% copper. *C.* 9,5% of the coins have more than 10% copper.

Despite the considerable number of studies on the silver content of different Viking-Age coinages, there is still a strong belief in the high purity of the Viking-Age coins, except the obviously debased Frisian issues. The

Area	*Date*	*No. of coins*	*Highest*	*Lowest*
Sasanian	531–628	2	14	14
Islamic	670/1–961/2	13	15	11
Khazar	837/8–75	3	15	14
Volga Bulgar	900–50	5	14	13
Byzantium	867–1067	5	15	13
Russia?	*c.* 950	3	15	14
Georgia	876–81	1	15	15
India	980–1000	1	14	14
Spain	1066–1111	1	14	14
Carolingian	814–77	4	14	13
France	942–1027	3	14	12
Germany	983–1133	30	15	6
Italy	983–1024	5	15	14
Bohemia	970–1061/92	5	15	14
Poland	992–1025	2	15	15
Russia	1034–36	1	15	15
Hungary	1015–60	5	13	12
England	979–1180	22	15	13
Ireland	995–1095	5	15	14
Isle of Man	1025–35	1	14	14
Nordic	825–995	12	15	13
Scandinavia	997–1017	5	14	13
Denmark	1035–60	5	13	12
Norway	1067–1103	5	15	13
Sweden	995–1030	5	15	13

Table 27. Summary.

major discovery of the study was that this belief really is doubtful. Results of the study are preliminary and further studies are needed.

Bibliography

Album, S. 2011. *A checklist of Islamic coins.* Santa Rosa, 2011.

Archibald, M. M. 1990. Pecking and bending: the evidence of British finds. *Sigtuna Papers. Proceedings of the Sigtuna Symposium on the Viking-Age Coinage 1–4 June 1989.* Comm. N.S., 6 (eds. K. Jonsson and B. Malmer). Stockholm 1990, 11–24.

Archibald, M. M. 2007. The evidence of pecking on coins from the Cuerdale hoard, summary version. *Silver Economy in the Viking Age* (eds. J. Graham-Campbell and G. Williams). Walnut Creek, 2007, 49–53.

Becker, C. J. 1988. Danske mønter som historisk kildemateriale i 1000-talet. *Festskrift til Olaf Olsen på 60-års dagen den 7. juni 1988* . (ed. A. Andersen). København, 1988, 119–36.

Blackburn, M. 2011. *Viking coinage and currency in the British Isles.* London, 2011.

Bogucki, M. and Magiera, J. 2015. Lund – Odense – Lund – Kołobrzeg. Danish influences in the Zemuzil Bomeraniorum coinage. *Myntstudier. Festskrift till*

Kenneth Jonsson (eds. T. Talvio and M. Wijk). Stockholm, 2015, 119–28.

Bornholdt, K. 1999. Myth or Mint? The evidence for a Viking-Age coinage from the Isle of Man. *Recent Archaeological Research on the Isle of Man.* BAR British Series 278 (ed. P. J. Davey). Oxford, 1999, 199–220.

Botet i Sisó, J. 1908. *Les monedas Catalanes*, I. Barcelona, 1908.

Broome, M. 1985. *A Handbook of Islamic Coins*. London, 1985.

Cach, F. 1970. *Nejstarši české mince,* I–III. Prague, 1970.

CNP – Gumowski, M. *Corpus Nummorum Poloniae* I. Kraków, 1939.

CNS - *Corpus Nummorum Saeculorum IX - XI qui in Suecia reperti sunt* 1.1- . Stockholm, 1975 -.

Coupland, S. 2017. On good and bad coin in Carolingian Europe. *Nummi et Humanitas. Studia ofiarowane profesorowi Stanisławowi Suchodolskieumu w 80 rocznicę urodzin* (eds. M. Bogucki, W. Garbaczewski, and G. Śnieżko). Warszawa, 2017, 91–112.

Crusafont, M., Balaguer, M. A. and Grierson, P. 2013. *Medieval European Coinage: with a Catalogue of the Coins in the Fitzwilliam Museum, Cambridge. 6 The Iberian Peninsula.* Cambridge, 2013.

Day, R., Matzke, M. and Saccocci, A. 2016. *Medieval European Coinage: with a Catalogue of the Coins in the Fitzwilliam Museum, Cambridge. 12, Italy (I). Northern Italy.* Cambridge, 2016.

Dbg – Dannenberg, H. *Die deutschen Münzen der sächsischen und fränkischen Kaiserzeit* 1–4. Berlin, 1876–1905.

Dolley, R. H. M. 1966. *Sylloge of Coins of the British Isles* (8). *The Hiberno-Norse Coins in the British Museum*. London, 1966.

Dolley, R.H.M. and Skaare, K. 1973. To penninger fra Harald Hårdråde funnet på Vesterhavsöyerne. *Nordisk Numismatisk Unions Medlemsblad* 1973:8, 221–6.

Dumas, F. 1971. *Le trésor de Fécamp et le monnayage en Francie occidentale pendant la seconde moitié du Xe siécle. Mémoires de la section d'archéologie*. Paris, 1971.

Eniosova, N. and Mitoyan, R. 2011. Arabic coins as a silver source for Slavonic and Scandinavian jewellers in the tenth century AD. *Proceedings of the 37th International Symposium on Archaeometry, 12th–16th May 2008, Siena, Italy.* I (ed. M. Turbanti). Berlin, 2011, 579–84.

Elfver, F. 2007. General debasement during the reign of Svend Estridsen? The coinage of Lund c. 1035–1050 and some metal analyses. *Cultural interaction between east and west. Archaelogy, artefacts and human contacts in northern Europe* (eds. U. Fransson, M. Svedin, S. Bergerbrant, and F. Androshchuk). Stockholm, 2007, 212–16.

Frynas, J. G. 2015. *Medieval coins of Bohemia, Hungary and Poland.* London, 2015.

Galster, G. 1955. Græse-fundet og andre fund på Sjælland af mønter fra kongerne Niels og Erik Emune. *Aarbøger for nordisk Oldkyndighet og Historie 1955.*

Grierson, P. and Blackburn, M. 1986. *Medieval European coinage: with a catalogue of the coins in the Fitzwilliam Museum, Cambridge. 1 Early Middle Ages (5th–10th centuries).* Cambridge, 1986.

Grierson, P. 1991. *The Coins of Medieval Europe.* London, 1991.

Guerra, M. F. 2015. II. Cross coins struck by Harold Bluetooth: Evolution of the silver alloys and assessment of the origin of silver. *King Harold's Cross Coinage. Christian Coins for the Merchants of Haithabu and the King's Soldiers* (eds. J. C. Moesgaard et al.). Publication from the National Museum, Studies in Archaeology & History Vol. 20:2 Jelling Series. Copenhagen 2015, 109–25.

Gullbekk, S. H. 2000. Myntforringelse i Danmark og innføring av monopolmynt under Sven Estridsen (1047–74). *Nordisk Numismatisk Årsskrift* 1994–96.

Copenhagen, 2000, 111–29.
Hahn, W. *Moneta Radasponensis. Bayerns Münzprägung im 9., 10. und 11. Jahrhundert.* Braunschweig, 1976.
Hammarberg, I., Malmer, B. and Zachrisson, T. 1989. *Byzantine Coins found in Sweden.* Commentationes de Nummis Saeculorum IX-XI in Suecia repertis, Nova Series 2. Stockholm, 1989.
Hásková, J. 1990. Scandinavian influences on the Denarius coins of Bohemia. Sigtuna papers. *Proceedings of the Sigtuna Symposium on the Viking-Age Coinage 1–4 June 1989. Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* N.S. 6 (eds. K. Jonsson and B. Malmer). Stockholm, 1990, 87–90.
Hatz, G. 1974. *Handel und Verkehr zwischen dem Deutschen Reich und Schweden in der späten Wikingerzeit. Die deutschen Münzen des 10. und 11. Jahrhunderts in Schweden.* Lund, 1974.
Hbg – P. Hauberg. *Myntforhold og udmyntninger i Danmark indtil 1146.* København, 1900.
Hlinka 1979. – Die bisherigen Erkenntnisse über die Münze BRESLAVVA CIVITAS. *Rapports du IIIe Congrés International d'Archéologie Slave,* Bratislava 7–14 septembre 1975, 375–84.
Hz – V. Hatz. Zur Frage der Otto-Adelheid-Pfennige. Versuch einer Systematisierung auf Grund des schwedischen Fundmaterials. *Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* Partes I. Stockholm, 1961, 105–44
Häv – Hävernick, W. *Die Münzen von Köln.* Die Münzen und Medaillen von Köln. I. Köln, 1935.
Ilisch, L., Lorenz, S., Stern, W. B. and Steuer, H. 2004 (eds.). *Dirham und Rappenpfennig*, vol. 2. Mittelalterliche Münzprägung in Südwestdeutschland. Bonn, 2004.
Jonsson, E. 2013. *En rik handelsmans silverskatt.* Stockholm, 2013.
Jonsson, K. 1992. Hoards and single-finds from the middle and northern Baltic Sea region c. 1050–1150. *Studia Baltica Stockholmensia* 9. Stockholm, 1992, 79–89.
Jonsson, K. 2007. Coin circulation in Viking-Age Germany. *Money Circulation in Antiquity, the Middle Ages and Modern Times: Time, Range, Intensity. International Symposium of the 50th anniversary of Wiadomóski Numizmatyczne, Warsaw, 13–14 October, 2006* (eds. S. Suchodolski and M. Bogucki). Warszawa-Kraków 2007, 109–26.
Jonsson, K. 2009. Eastern contacts based on the coin finds. *Situne Dei* 2009. Sigtuna 2009, 57–67.
Jonsson, K. 2015. Viking-Age coins found in Sweden. *Small Things, wide Horizons. Studies in Honour of Birgitta Hårdh* (eds. L. Larsson, F. Ekengren, B. Helgesson, and B. Söderberg). Oxford, 2015, 51–7.
Kluge, B. 1990. Überlegungen zu den Otto-Adelheid-Pfennigen. Stempelkritische Untersuchungen der Typen Hatz II (Dbg. 1166, 1170) und AMEN (Dbg. 1171). *Sigtuna Papers. Proceedings of the Sigtuna Symposium on the Viking-Age Coinage 1–4 June 1989.* Commentationes de nummis saeculorum IX-XI in Suecia repertis. N.S. 6 (eds. K. Jonsson and B. Malmer). Stockholm, 1990, 167–81.
Kovalev, R. K. 2002. Dirham mint output of Samanid Samarqand and its connection to the beginnings of trade with Northern Europe (10th century). *Histoire et Mesure* [Monnaie et espace], 17/3–4 (2002), 197–216.
Kraume, E. and Hatz, V. 1972. Silberanalysen deutscher Münzen des 10. Jahrhunderts. *Hamburger Beiträge zur Numismatik* 21–3, 1967/69 (1972). Hamburg 1972, 35–8.
Leimus, I. 2014. En ny fuglemønt fra Estland. *Nordisk Numismatisk Unions Medlemsblad* 2014: 3, 69–72.
Leimus, I. 2017. Ett nytt estländskt fynd med mynt från Ohind. *Myntstudier* 2017:1, 9–10.
Malmer, B. 1961. Contribution to the

numismatic history of Norway during the eleventh century. *Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* Partes I. Stockholm, 1961, 223–376.

Malmer, B. 1966. *Nordiska mynt före år 1000.* Lund, 1966.

Malmer, B. 1989. *The Sigtuna coinage c. 995–1005. Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* N.S. 4. Stockholm, 1989.

Malmer, B. 1997. *The Anglo-Scandinavian coinage c. 995–1020. Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* N.S. 9. Stockholm, 1997.

Malmer, B. 2010. *Den svenska mynthistorien. Vikingatiden ca 995–1030.* Stockholm, 2010.

McKerrell, H. and Stevenson, R. 1972. Some analyses of Anglo-Saxon and associated Oriental silver Coinage. *Methods of Chemical and Metallurgical Investigation of Ancient Coinage* (eds. E. T. Hall and D. M. Metcalf). London, 195–209.

Metcalf, D. M. and Northover, J. P. 1986. Interpreting the alloy of the later Anglo-Saxon coinage. *The British Numismatic Journal* 56 (1986). London, 1986, 35–63.

Metcalf, D. M. and Northover, J. P. 1988. Carolingian and Viking coins from the Cuerdale hoard: an interpretation and comparison of their metal contents. *The Numismatic Chronicle* Vol. 148 (1988). London, 1988, 97–116.

Metcalf, D. M. 1998. Viking-Age Numismatics 4. The currency of German and Anglo-Saxon coins in the Northern Lands. *The Numismatic Chronicle,* Vol. 158 (1998). London, 1998, 345–71.

Metcalf, D. M. and Northover, J. P. 2002. Sporadic debasement in the English coinage, c. 1009–1052. *The Numismatic Chronicle,* Vol. 162 (2002), London, 2002, 217–36.

MG - Morrisson, K. F. & Grunthal, H. 1967. *Carolingian Coinage.* New York, 1967.

Moesgaard, J. C. 2000. Eksporten af normanniske mønter till Østersøområdet i vikingetiden. *Nordisk Numismatisk Unions Medlemsblad* 2000:4, 84–6.

Moesgaard, J. C. 2008. Efterligning af en normannisk mønt fra 1000-tallet. *Scripta varia numismatico Tukka Talvio sexagenario dedicate.* Publications of the Finnish Numismatic Society no. 6 (ed. O. Järvinen). Helsinki, 2008, 67–74.

Moesgaard, J. C. et. al. 2015. *King Harold's Cross Coinage. Christian Coins for the Merchants of Haithabu and the King's Soldiers.* Publications from the National Museum. Studies in Archaeology & History Vol. 20:2. Copenhagen, 2015.

Noonan, T.S. 1987. The onset of the silver crisis in Central Asia. *Archivum Eurasic Medii Aevi*, vol 7. Wiesbaden 1987, 221–48.

Noonan, T. S. 1989. When did dirham imports into tenth-century Sweden decline? *LLt. Festskrift till L. O. Lagerqvist.* Numismatiska Meddelanden XXXVII. Stockholm, 1989, 295–301.

North, J. J. 1994. *English Hammered Coinage. Volume I. Early Anglo-Saxon to Henry III c. 600–1272.* London, 1994.

Potin, V. 1990. Funde westeuropäischer Denare im Norden der Sowjetunion. *Sigtuna Papers. Proceedings of the Sigtuna Symposium on the Viking-Age Coinage 1–4 June 1989.* Commentationes de nummis saeculorum IX-XI in Suecia repertis. N.S., 6. (eds. K. Jonsson and B. Malmer). Stockholm, 1990, 265–73.

Pritsak, O. 1998. *The Origins of the Old Rus' Weights and Monetary Systems. Two Studies in Western Eurasian Metrology and Numismatics in the Seventh to Eleventh Centuries.* Cambridge and Massachusets, 1998.

Rispling, G. 1987. Coins with crosses and bird heads – Christian imitations of Islamic coins? *Fornvännen* 82 (1987), 75–87.

Rispling, G. 2004. Spännande mynt i Spillingsskatten. *Gotländskt Arkiv* 2004, 123–32.

Skaare, K. 1976. *Coins and Coinage in Viking-Age Norway*. Lund, 1976.

Skaare, K. and Steinnes, E. 1966. Mynter i atomreaktoren aktiveringsanalyse av norske middelaldermynter. *Nordisk Numismatisk Unions Medlemsblad* 1966:5, 81–9.

Sotnikova, M. P. and Spasskij, i. G. 1982. *Russian Coins of the X–XI Centuries A.D. Recent Research and Corpus in Commemoration of the Millenary of the Earliest Russian Coinage.* British Archaeological Reports. International Series, 136. Oxford, 1982.

Steuer, H., Stern, W. B. and Goldenberg, G. 2002. Der Wechsel von der Münzgeld- zur Gewichtsgeldwirtschaft in Haithabu um 900 und die Herkunft des Münzsilbers in 9. und 10. jahrhundert. *Haithabu und die frühe Stadtentwicklung in nördlichen Europa*. Neumünster, 2002, 133–67.

Steuer, H. 2004. Münzprägung, Silberströme und Bergbau um das Jahr 1000 in Europa – wirtschaftlicher Aufbruch und technische Innovation. *Aufbruch ins zweite Jahrtausend. Innovation und Kontinuität in der Mitte des Mittelalters* (eds. A. Hubel and B. Schneidmüller). Ostfildern, 2004, 117–49.

Stronczyński, K. 1883–1885. *Dawne monety polskie. Dynastyi Piastów i Jagiellonów*, I–III. Piotrków, 1883–1885.

Suchodolski, S. 2015. The beginning of Polish coinage in the light of recent research. *Wiadomości Numizmatyczne, R. LIX 2015 zeszyt 1–2 (199–200). Polish Numismatic News* IX. Warszawa, 2015, 67–94.

Treadwell, L. 2001. *Buyid Coinage. A Die Corpus (322–445 A.H.)*. Oxford, 2001.

Zwicker, U. and Gale, Z. 1991. Metallographische, analytische und technologische Untersuchungen sowie Messungen der Bleiisotope an Otto-Adelheid-Pfenningen und Vergleichsmünzen meist aus 9.-11. Jahrhundert. Ein Beitrag zur Münzprägung der Sächsischen Kaiser. *Otto-Adelheid-Pfennige. Untersuchungen zu Münzen des 10./11. Jahrhunderts* (eds. G. Hatz, V. Hatz, U. Zwicker, N. Gale. and Z. Gale). Stockholm, 1991, 59–146. *Commentationes de Nummis Saeculorum IX-XI in Suecia repertis.* N.S. 7.

Abreviations

Titles

Ab – Archbishop
B – Bishop
C – Count
D – Duke
E – Emperor
Kg – King

Names

Æ – Æthelred II
Cn – Cnut
EdC – Edward the Confessor
H I – Harold I
Hy I – Henry I
Hy II – Henry II
W I – William I
W II – William II

Metal element analysis of medieval coins using XRF

Sven Isaksson

The analyses were performed using an Olympus Delta Premium DP-6000-CC X-ray fluorescence analyzer mounted in a Delta portable workbench. The analyzer is equipped with an X-ray tube containing an Rh anode with a maximum power of 4 W. Two beams were used in the application; 40 kV for 10 seconds and 10 kV for 30 seconds, giving a total time of analysis of 40 seconds. This relatively short time of analysis still produced good X-ray spectra of about 10 k (*c.* 8-15 k) counts per second.

Instrument blanks (SiO_2) and silver alloys of known silver contents were analysed in parallel with the samples. The samples were placed on sheets of Chemplex Prolene Thin-film (4.0 μm thick. Common impurities at PPM levels: Ca, P, Fe, Zn, Cu, Zr, Ti and Al) in the workbench sample compartment and positioned on the instrument measurement window. Data were collected and X-ray spectra inspected using the Innov-X Delta software.

Measurements of seven of the most common coin metals (Cu, Zn, Ag, Sn, Sb, Au and Pb; cf. Constantinescu et al. 2009) were extracted from the data. The relative standard deviation (RSD) for the major components (Ag, Sn, Cu) were between 0.86 and 1.97 % and for the minor components (Zn, Sb, Au, Pb) between 6.9 and 25.5 %. Using an external calibration curve ($r^2 = 0.976$) based on reference silver alloy samples, the silver measurements of the coins were corrected and the amounts of the other metals adjusted accordingly. The relative deviation was found to be 6.3 ± 3.9 %.

Litteratur

Blet-Lemarqand, M. & Ponting, M.J. 2009. Scientific and technical applications. *A survey of numismatic research 2002-2007* (red. M. Amandry & D. Bateson). Glasgow 2009, 714-719.

Cowell, M.R. 2003. A short review of the application of scientific techniques to coinage. *A survey of numismatic research 1996-2001* (red. *C.* Alfaro & A. Burnett). Madrid 2003, 929-933.

Editorial comments

Kenneth Jonsson

Background

Metal analyses have long been a neglected area of numismatic research. They are important for providing information on long range changes in coinage and for evaluating economic development and also various other aspects of coinage. SEM (scanning electron microscopy) and XRF (x-ray fluorescence) are the two most widely used methods for coins analysis, although there are advantages and disadvantages to most methods (see e.g. Cowell 2003 and also Blet-Lemarqand Ponting 2009 and references given there). In 2015 the Archaeological Research Laboratory, Stockholm University, acquired portable XRF (pXRF) equipment which made it possible to carry out numerous analyses. The Gunnar Ekström foundation has most generously paid for the analyses described here using material which the Royal Coin Cabinet (KMK), Stockholm munificently provided.

In an XRF test a beam is sent to a coin and the x-ray reflection gives information about the proportion of different metals.

Metals

The tables show values for silver (Ag), copper (Cu) and tin (Sn). Values for another four metals are given in the appendix: zinc (Zn), antimony (Sb), gold (Au), and lead (Pb). Silver has been calibrated based on three known standards, while other metals have not been calibrated because of lack of known standards for these metals. Only values for silver and other metals are included and have been recalculated to correspond to a total of 100%. The analysis shows that tin has an average percentage corresponding to *c.* 10% of the value for silver. Since silver and tin are close together in the x-ray energy spectrum, it is evident that the figure for tin is much too high and the values for tin should be ignored. What is important is that the silver content will always be correct since it is calibrated.

The silver content

During the (late) middle ages the silver content was measured in lod, where 16 lod = 100%. Thus 1 lod = 6,25% +. If the silver content is <1% then it is recorded here as 0 lod.

Appendix

The appendix contains values for each coin as well as photos of the coins.

Weight in pure silver

The value of the pure silver in a coin as well as the cost of striking the coin and the profit of the issuer (seigniorage) formed the basis for the denomination.

Coin standard

The coin standard (weight and silver content) was fixed in a written decree.

Analyses

Sven Isaksson, at Archaeological Research Laboratory, Stockholm University, was responsible for the actual XRF analyses and he provides information above about the technical side of the analyses.

Source criticism

Since the measurements were made on the surface of the coins, the results can be affected by various contaminations as patina, verdigris, corrosion, soaking, or processes at the time of striking. The analysed coins nearly all come from the systematic collection of the Royal Coin Cabinet, where they usually have been kept for a very long time (often more than 100 years), and then they have also not been cleaned in modern times.

Editorial

This series of metal analysis is published by the Stockholm Numismatic Institute, Stockholm University, with Kenneth Jonsson as editor, layout by Ylva Holmberg Jansson and photos by Kenneth Jonsson. It is part of a project to analyse the metal content of coins from different periods using XRF.

At the moment the plan is to publish nine issues covering different periods and areas. Each study is written by a student. The metal analyses published in this series have generously been paid for by the Gunnar Ekström foundation and carried out by Sven Isaksson at the Archaeological Research Laboratory, Stockholm University. The material has generously been made available for analysis by the Royal Coin Cabinet, Stockholm and comes from their systematic collection as well as from finds.

Studies based on material from the Nordic countries will be published in Swedish with an English summary. Material from other countries will be published in English. Each study will be based on analyses of *c.* 150 coins.

Although the silver content (Ag) is the most important, figures for copper (Cu), and tin (Sn), are included in the written analysis. Figures for another four metals, zinc (Zn), antimony (Sb), gold (Au), and lead (Pb), are given in an appendix where each coin is also illustrated.

Stockholms universitet