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Manufacturing Techniques of Belt and Harness Fittings of the 10th Century AD

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The present study includes approximately 900 items of belt and horse harness fittings. They have been found on the Upper Dnieper, Smolensk region, the site of the Gnezdovo settlement and cemetery dating from the end of 9th to the beginning of 11th century. One hundred and eleven samples of belt and harness decorations were investigated, using emission spectroscopy and metallography. Consequently, we may propose several reconstructions of the main fabrication techniques: (1) where a pattern was individually cut by a chisel; (2) where a wax model was composed by free-hand; (3) where the wax models were made by casting in stone, clay or metal moulds; (4) where every metal object was cast in a clay mould made by the impression of a model or a previously cast ornament. According to emission spectrography, copper with low impurities is the largest group in the selection. Different types of brass and bronze were used too. There is no connection between the type of casting and the composition of the alloys. Examination of a large number of objects permits us to conclude that belt and harness decorations from Gnezdovo were formed under the influence of different manufacturing techniques. We can identify Scandinavian, southern Russian and Volga Bulgarian among them.

Keywords: VIKING AGE, OLD RUSSIAN STATE, BELT AND HORSE HARNESS DECORATIONS, MANUFACTURING TECHNIQUES, ALLOY COMPOSITION.

Introduction

This investigation comprises a study of an extensive body of belt and horse harness fittings. They have been found at the Gnezdovo settlement and cemetery excavations carried out from 1874 to the present day. It is the biggest Viking Age cemetery in Europe, situated on the Upper Dnieper, 15 km south-west of Smolensk, Russia, dating from the end of the 9th to the beginning of the 11th century AD (Figure 1).

Gnezdovo was connected with the "inter-continental" trade route "from the Varangians to the Greeks" and has yielded a large collection of artefacts. The unusual wealth of its finds and the type of society that they reflected have become important points in the discussion about the origin and development of the early urban centres in Europe (Avdusin, 1969: 52). The great number of truly Scandinavian dress accessories, magic objects and weapons found in Gnezdovo has been estimated as the result of an immigration of Scandinavians (Jansson, 1987: 775).

At the same time, the great number of high-class artefacts, fragmentary crucibles, metal ingots and more or less finished products give eloquent evidence of the jewellery production at this site (Mühle, 1988; Pushkina, 1996).

There are numerous finds of belts and belt fittings in Gnezdovo. From the large number of finds we selected only mounts and pendant strap-ends for our study. These objects are mostly decorative non-functional details of belts and horse harnesses made by similar methods of production. The large series of similar objects allow small details to be revealed that are necessary to establish how the ornaments were made.

Methods of Examination

A total of 900 artefacts were studied under a binocular microscope at low magnification (× 10 or × 20). There are varying degrees of agreement in details on the objects with identical shape and design. The length between identical fixed points in every object of the same type has been measured. The degree of variations that appears was examined and interpreted.

The chemical composition (major and trace elements) was determined using optical emission spectrography (OES) with dc arc as the excitation source. For a quantitative analysis, the spectrogram produced

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Table 1. Optical emission spectrography analysis of belt fittings from Gnezdovo (selection)

No	Grave number	Object number	Sn	Pb	Zn	Bi	Ag	Sb	As	Fe
1	1905, K-23	812/73	2	0·25	2·4	0·004	0·02	0·06	0·25	0·06
2	1905, K-23	812/89	0·03	0·4	8	0·001	0·01	0·003	0·04	0·06
3	1905, K-23	812/70	0·6	5·5	8	0·001	0·01	0·01	0	0·08
4	1905, K-23	812/90	0·7	0·25	2	0·006	0·02	0·04	0·2	0·05
5	1905, K-23	812/91	1·6	6·8	4·2	0·001	0·01	0·01	0·05	0·05
6	1905, K-23	812/94	1·6	4·5	4·2	0·001	0·01	0·01	0·04	0·25
7	1905, K-23	812/02	0·7	1·4	2·8	0·01	0·01	0·005	0·02	0·06
8	1905, K-23	812/97	0·7	3	6	0·001	0·01	0·01	0·05	0·05
9	1952, K-80	197	0·6	1	0·4	0·03	0·004	0·01	0·03	0·06
10	1952, K-80	179	0·3	0·5	0·5	0·03	0·002	0·01	0	0·6
11	1952, K-80	215	0·3	0·3	0·02	0·03	0·02	0·03	0·2	0·3
12	1952, K-80	190	1	2	2	0·03	0·01	0	0·6	0·06
13	1952, K-80	183	0·2	0·2	0·002	0	0·03	0·02	0	0·03
14	1952, K-80	204	0·5	0·6	0·5	0·03	0·006	0·02	0·03	0·03
15	1952, K-80	202	0·2	0·5	0·02	0·04	0·03	0·03	0·04	0·03
16	1975, O1-27	17	0·5	0·5	0·2	0·03	0·003	0·01	0·03	0·03
17	1976, C-191	263	0·3	0·4	0·1	0·03	0·006	0·03	0·5	0·03
18	1976, C-191	249	0·2	0·2	0·03	0·03	0·01	0·02	1	0·03
19	1976, C-191	251	0·1	0·2	0·02	0·03	0·003	0·01	0	0·03
20	1976, C-191	273	0·1	0·3	0·03	0·03	0·004	0·02	0	0·03
21	1976, C-191	327	0·08	0·2	0·02	0·03	0·06	0·01	0·01	0·03
22	1976, C-191	255	0·3	1	2	0	0	0	0·006	0·03
23	1978, C-258	238	1	1	0	0·03	0·003	0·02	0	0·03
24	1978, C-258	241	2	2	2	0·03	0·01	0·03	1	0·04
25	1978, C-258	236	1	0·3	0·02	0·03	0·003	0·01	0·6	0·03
26	1978, C-259	326	0·3	0·2	0·02	0	0·001	0·01	0·03	0·03
27	1978, C-259	310	0·3	1	0·02	0·05	0·02	0·1	0·05	0·02
28	1978, C-259	344	0·1	0·3	0·03	0·03	0·002	0·03	0·06	0·02

is compared with those of standard alloys of known composition. The accuracy for the major elements was considered sufficient for characterization of the alloy, therefore, this study focuses on these particular elements. The artefacts were classified by their copper, tin, lead and zinc content.

The microstructure of 23 polished and etched specimens examined by metallography are very important for establishing the type of metal treatment.

Belt and Horse Harness Fittings as Handicraft Products

At the first glance, all of the objects could be divided into three different groups: (1) belt mounts that are smooth on the reverse with characteristic Viking Age ornaments (Figure 2); (2) belt mounts that are smooth on the reverse with geometrical encrusted ornaments (Figure 3); (3) mounts and pendant strap-ends decorated with floral patterns of Late Sassanian and Islamic type with the negative relief on the reverse (Figure 4). They form the main bulk of belt and horse harness fittings in Eastern Europe from the early 10th to the early 11th century. The origin of mounts of ''oriental type'' is difficult to ascertain. Many of them were made in the Volga Bulgaria area on the Middle Volga and Lower Kama (present-day Tatarstan) (Figure 1). The manufacturing technique of the last group is the most mysterious. Some archaeologists suggest the mounts with the negative relief were made with special tools, namely dies or patrices. Dies were pressed into the sheet of metal, which thereby received an impression in raised relief. The rivets, made of small pieces of wire, were soldered on to the reverse (Chalikov, 1985: 100). However, we doubt that soldering was the actual method used for attaching the rivets. Metallographic investigation reveals the main manufacturing techniques. It shows the objects have not been treated by forging (pressing). The metal structure is purely dendritic. It indicates that the rivets were always cast together with the mounts (Figure 5).

Below we propose a reconstruction of the main manufacturing processes. The commonest method of production had the following stages.

(1) Production of a pattern of the piece to be cast. The first pattern could be a permanent medium (wax, wood, metal, antler and other materials) or designed for one application only (wax, pewter).
(2) Making the master mould.
(3) Production of wax or metal copies in the master mould and final finishing work on them.
(4) Production of the moulds for metal casting (piece-moulds or investment-moulds for the lost-wax casting).
(5) Firing the moulds and casting a series of the objects.
(6) Finishing operations (filing, polishing, encrustation and coating).

Figure 1. Map of Eastern Europe showing the location of the sites mentioned in the text.

There is now general agreement that this method of fabrication had been used frequently from the early centuries of the 1st millennium AD in provincial Roman workshops and also among the Germans and Celts (Vierk, 1976; Thunmark-Nylen, 1983: 8–25; Jansson, 1985: 11–13; Craddock, 1989: 170–171; Lønborg, 1991–92).

Figure 2. Belt pendant strap ends with Scandinavian ornament that are smooth on the reverse. State Historical Museum, Inv. No. 42536.

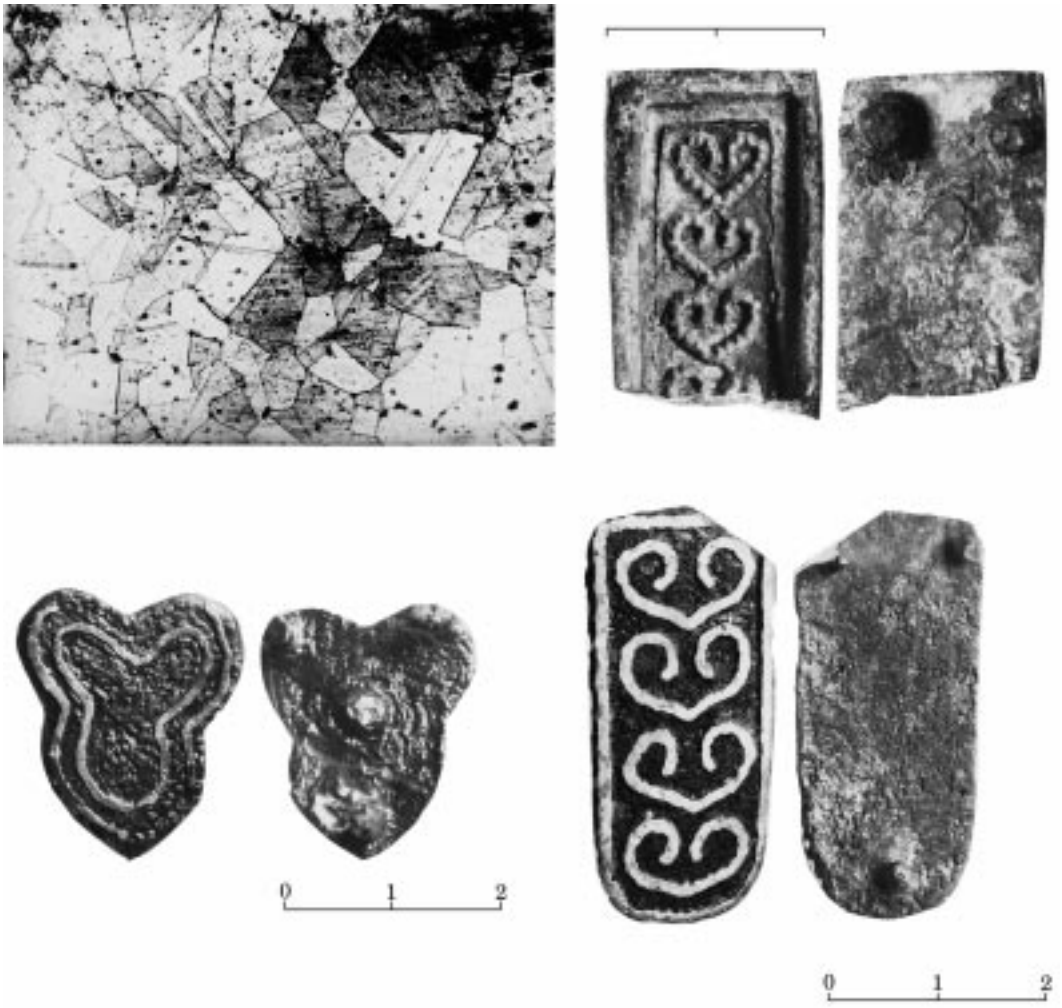

Figure 3. Belt fittings with geometrical encrusted ornament that are smooth on the reverse. Etched cross-section (× 200; width of picture 0·54 mm) shows angular recrystallized grains due to cold hammering. The silver content of the encrusted side is about 20% while the reverse has a tin content of about 0·05%. Archaeological Museum of Moscow State University, Inv. No. 1952–193, 195, 213.

Figure 4. Belt mounts with oriental floral pattern and negative relief on the reverse. Archaeological Museum of Moscow State University, Inv. No. 1950–115, 1990–276.

The most complicated question is: how was an original pattern made? There are three types of wax models characterized by distinctive features. (1) The ornaments were cut by chisel. An attribute of such a model is usually the indication of toolmarks on the surface and interrupted and uneven lines of the ornament. Wax-carving makes a detailed treated pattern possible (Figure 2) (Ryndina, 1963: 202). (2) The handmade wax model: an uncommon type of a model and used only for undecorated strap-ends. There are asymmetric objects with rough surface and wax-smooth traces (Figure 6). (3) The cast wax (or pewter) models were produced with a special clay matrix made by bronze die impressed into the lump of clay. A thin (0·5–1·5 mm) layer of melted wax was then poured into the casting matrix. It resulted in the negative relief on the reverse of the wax model (Figure 4). Metal dies for the belt mounts production were found in the Bulgarian area (Figure 7) (Chalikov, 1985: 97–103).

There is a second method for the thin wax (pewter) model's production. In this case melted wax or low-melting-point metal was poured into stone, antler, wooden or metal moulds and then poured out immediately. Casting moulds could also be used for the manufacture of more massive models (1–2 mm thickness) which are smooth on the reverse.

Stone moulds for belt fittings occur from the Crimea to Northern Europe. The most important objects have been found in Kiev (the capital and residence of the Grand Prince of Rus', present-day Ukraine) (Figure 1). There are two moulds made of local Ovruc

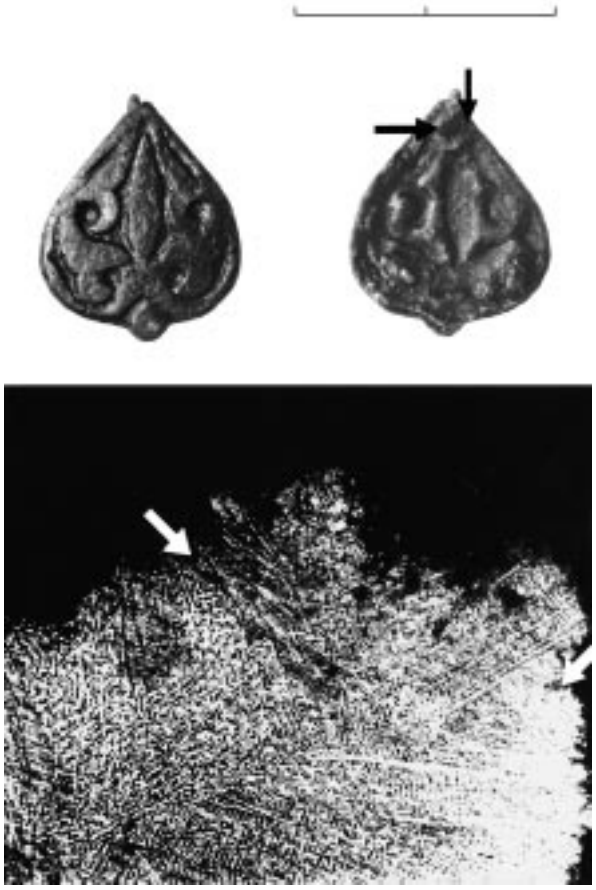

Figure 5. Belt mount with negative relief on the reverse. The section has been cut through the rivet. The mount body, as well as the rivet, has the same cast dendritic structure (× 70; width 1·3 mm). Archaeological Museum of Moscow State University, Inv. No. 1976–263.

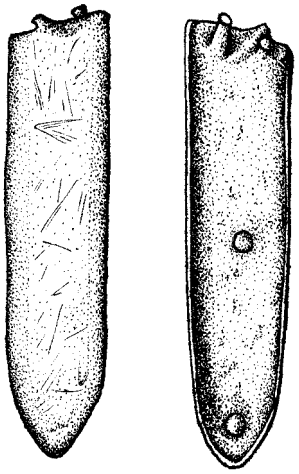

Figure 6. Belt strap-end made with handmade wax model. Archaeological Museum of Moscow State University, Inv. No. 1973–17.

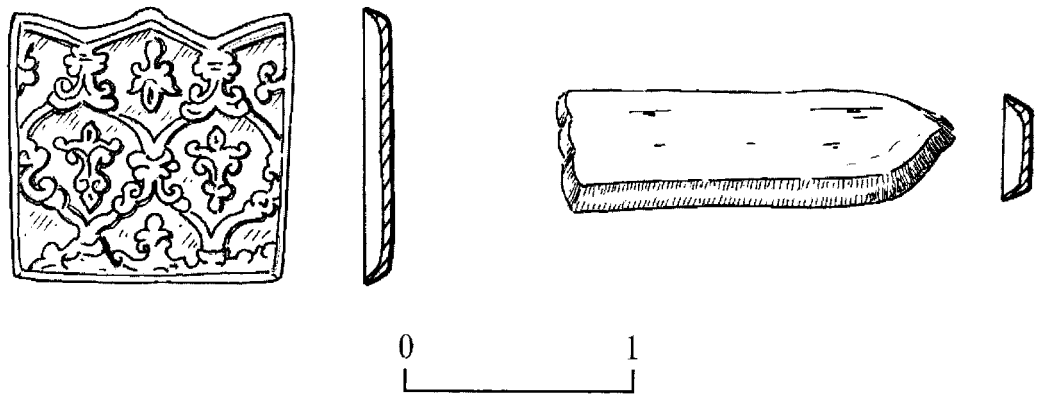

Figure 7. Bronze dies from Volga Bulgaria (after Chalikov, 1985: 99, figure 10–11).

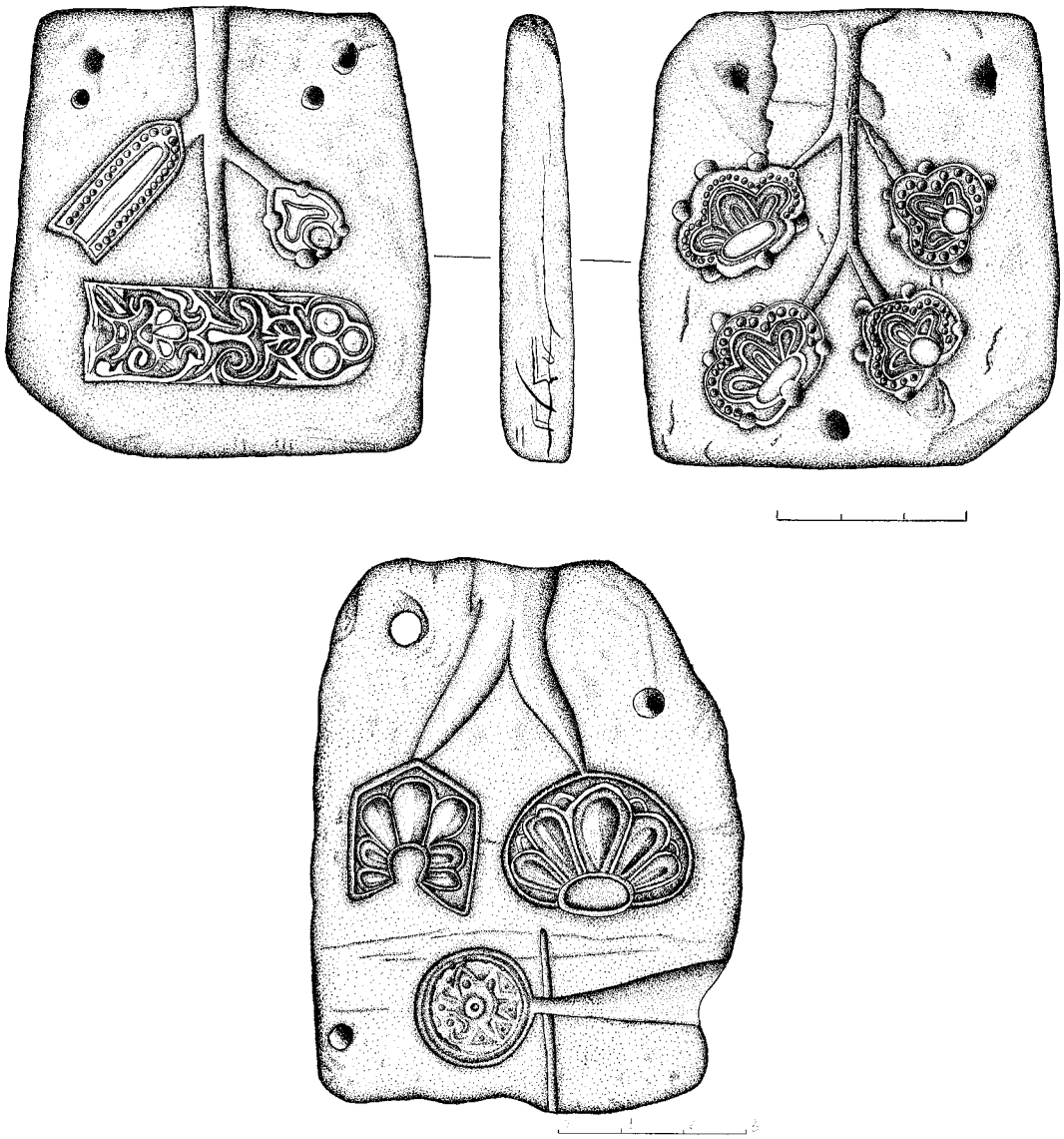

Figure 8. Slate casting moulds from Kiev (after Gupalo & Ivakin, 1980: 204, figures 4–5).

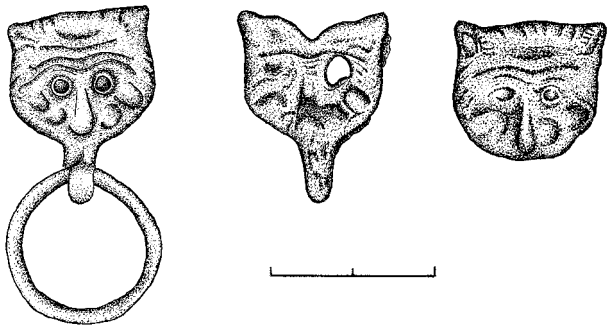

Figure 9. Belt fittings from Gnezdovo inhumation grave L-95, containing well-preserved decorated belt with 60 "cat mounts". Smolensk Museum.

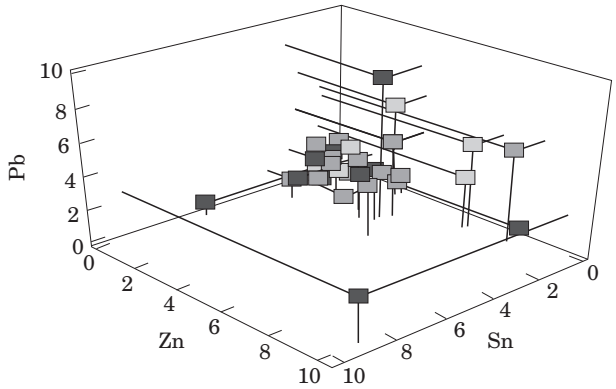

Figure 10. Diagram of the alloy composition (%) of the Gnezdovo belt and horse harness fittings.

slate but one of them has an Arabic inscription (Gupalo & Ivakin, 1980: 204, Figures 2–5). They could have been used for the production of 10 different known belt mounts from Russia, Volga Bulgaria and Sweden (Jansson, 1987: 799) (Figure 8). The moulds from Kiev have been preserved without any trace of use and probably served as a master mould for the casting of wax or pewter models only. We surmise that each wax mount, made by copying, could have been changed individually. The models were covered by liquid clay, tempered with sand and organic materials, dried, heated and used for the "waste wax" casting of the objects showing both similarities and differences (Figure 9). It explains the appreciable difference in the thickness of one series of the mounts (0·5–0·7 mm) as well as the various positions of the rivets on identical copies.

We suggest also that the great number of belt fittings with negative reliefs could have been cast in piece-moulds made by impression of previously made objects (without the use of wax). The clay mould fragments found in the different parts of Europe are mostly piece-moulds. The quantity of identical on-design moulds presupposes that this technique was dominant (Lamm, 1980; Curle, 1982; Brinch Madsen, 1984; Craddock, 1989; Ambrosiani, 1994). The design of the moulds testifies that the model was removed from the mould before pouring the metal. Despite the fact that a clay mould could probably not withstand the heat of more than one casting, such a technique allows the models to be preserved and previously made ornaments to be used as patterns.

Casting was the last operation connected with the production of many items. By metallographic examination of the surface of the material, we see, when etched, the typical crystal grains of a metal cooled down in a mould with no trace of deformation caused by forging (Figure 5). It is less common to find traces of cold-forging with light reduction connected with punching holes, deepening the ornaments, filing and removing of the casting seams.

The mounts with silver encrustation form a separate group of belt ornaments. They were found in great numbers in Gnezdovo and Chernigov (one of the main centres of the old Russian State situated in the Middle Dnieper region) (Figure 1). These mounts consist of frame and insertion. The settings for encrustation have already been cut on the original wax model. Different parts of composite mounts have been assembled by forging rivets (Figure 3).

Examination of the belt fittings under a microscope shows that the majority of them display a coating of white metal on the surface. In rare cases we observed the remains of gilding. The coating was the final operation in the manufacturing process of belt fittings. Tin covers protected metal from oxidation and led to a similarity with silver ornaments.

Alloy Composition

After studying the chemical composition of 111 samples we concluded there was no definite alloy composition for each of the three traditions. There is no stable connection between the type of casting and the composition of the alloys. The total content of alloy impurities (Sn, Pb, Zn) in copper does not exceed 10% (Figure 10). Copper, containing a small quantity of lead, zinc, tin and other minerals (less than 1%), is the largest group in the selection (57 objects). Twenty-seven samples belong to different types of brasses (copper with low zinc; copper with low zinc encountering more then a few per cent of lead) and 24 to bronze (copper with low tin to which sometimes zinc and lead have been added). This means that the technology used in the production of belt fittings (very thin plates with low relief) did not require a special alloy composition.

Conclusions

All technological operations discussed above were directed towards making large series of objects easily reproducible wherever decorated belt and horse harnesses were worn by warriors. Such techniques appeared in different places and could have been applied

not in one but several workshops at a considerable distance from each other. Many casters manufactured only on the basis of copying an ornament. Production of a certain type could have continued as long as the craftsman could get hold of an example of the type. This makes it difficult to estimate the date of the existing standard series. It could be that they have been made over a long or short period in different places without any signs to indicate otherwise on their surfaces (Jansson, 1981).

Despite an impressive quantity of belt fittings of various types in Gnezdovo, only three manufacturing traditions can be identified, and belt and harness decorations were formed under their influence. Technological and stylistic analysis leads us to identify Volga Bulgarian, Scandinavian and Middle Dnieper region traditions.

The distinctions between them are displayed in their methods for forming original models and in their material. There were mostly wax models in the Volga Bulgarian tradition, and all types of original model production were used in Scandinavian and Middle Dnieper traditions. Differences appeared also in the type of casting. Volga Bulgarian belt fittings were cast often by the ''waste wax'' method. Scandinavian and Middle Dnieper mounts were cast mostly into clay piece-moulds.

Special forging operations and encrustation are characteristic for the Middle Dnieper manufacturing tradition. Tinning and gilding are common for all regions.

Similar details of the same belt could be made from different alloys. The craftsman prepared the alloy not from one but sometimes, using ingots or scrap metal, from various sources. Damaged mounts (with broken rivets, for instance) could be reproduced wherever the owner of the belt happened to be.

An analysis of belt and horse harness fitting permits the following conclusion to be drawn: Volga Bulgarian tradition dominated in Gnezdovo (507 items). The wide distribution of metal-decorated belts of oriental type through Eastern Europe as well as the adoption of oriental dress fashion by warrior classes in Old Rus' could be explained as a result of contact with the steppe nomadic and Islamic world.

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