ARCHAEOMETALLURGIC RESEARCH OF FINDS FROM EXCAVATIONS IN LEOPOLI - CENCELLE

Mihok Ľ.[1], Pribulová A.[1], Fröhlich L.[1], La SalviaV.[2]

[1] Technical University, Košice, Slovakia

[2] University of Chietti, Italy

ARCHEOMETALURGICKÝ VÝSKUM NÁLEZOV Z VYKOPÁVOK V LEOPOLI - CENCELLE

Mihok Ľ.[1], Pribulová A.[1], Fröhlich L.[1], La SalviaV.[2]

[1] Technická univerzita, Košice, Slovensko

[2] Univerzita Chietti, Taliansko

Abstrakt

Príspevok predstavuje výsledky archeometalurgického štúdia nálezov, týkajúcich sa výroby a spracovania železa v stredovekom meste Leopoli - Cencelle, Viterbo, Taliansko. Zvyšky tohto stredovekého mesta sú dobre viditeľné na vrchole 160 m vysokého kopca, vzdialeného asi 15 km od mora. Zachovalo sa 740 m mestských hradieb s troma bránami a siedmimi vežami. Mesto nechal postaviť pápež Leo IV (847 - 855) ako útočište pre obyvateľov pobrežia pred nájazdami Saracénov. Systematický archeologický výskum sa robí od roku 1994. Kým vykopávky v rokoch 1995 - 96 priniesli len jednotlivé nálezy trosky a mnohé nálezy železných predmetov, vykopávky v roku 1998 lokalizovali kováčsku dielňu. Ďalší objekt vedľa dielne bol charakterizovaný ako redukčná pec na tavenie železa z rúd. Cieľom archeometalurgického výskumu bolo preveriť a potvrdiť výrobu a spracovanie železa v stredovekom meste Leopoli - Cencelle.

Analýzy nálezov z výskumov 1995 - 96 už boli publikované. Analýza trosiek ukázala, že všetky analyzované trosky pochádzali z kováčskeho procesu. Analýza železných predmetov poukazala na vysokú zručnosť a znalosti miestnych kováčov, ktorí vedeli pre výrobu predmetov so špecifickými funkciami zvoliť vhodný vstupný materiál a správnu výrobnú metódu.

V nálezoch z roku 1998 bolo okrem železných predmetov aj 13 kusov trosky, respektíve troske podobného materiálu a kus železnej rudy. Chemickou a mikroskopickou analýzou trosiek bolo zistené, že časť z nich pochádzala z kováčskej výroby železných predmetov, časť z procesu tavenia železa. Tým boli potvrdené obidve tieto aktivity v stredovekom meste Cencelle. Štruktúrne zloženie vzorky železnej rudy bolo robené pomocou rentgenštruktúrnej difrakčnej analýzy. Pretože boli známe d-parametre železných rúd z talianskych ložísk, porovnaním bolo zistené, že kus železnej rudy z nálezov pochádzal z neďalekých ložísk v Allumiere.

Súbor nálezov z roku 1998 obsahoval aj železný polotovar, výsledok čiastočného spracovania výťažku z redukčnej pece. Z jeho formy a štruktúry bolo možné urobiť úsudok o veľkosti celého železného výťažku. Z toho ďalej vyplynulo, že v hutníckej dielni v meste pracovali taviace pece s vyššou výrobnosťou.

Abstract

The paper presents results of archaeometallurgic study of finds, related to production and working of iron in medieval town Leopoli - Cencelle, Viterbo, Italy. Iron objects, pieces of slag and iron ore were analyzed. Smithy techniques, used for manufacturing of iron objects, are described. Study of slags proved both iron smelting and iron working were performed at the locality.

Key words: Medieval; Iron smelting; Smithy production

1. Introduction

The medieval town of Leopolli - Cencelle is presently known as Cencelle and it is located within the territory of Tarquinia municipality in the province of Viterbo, 70 km north from Rome. The remains of a 740 m long wall with three gates and seven towers are still evident on the top of a hill 160 m. above the sea level. In contrast to this well preserved evidence, inside the city´s walls not many still standing structures are left.

According to the life of Pope Leo IV (847 - 855) as reported in the *Liber Pontificalis* of the Holy Ecumenical Roman Catholic Church, Leopoli - Cencelle was directly founded by the very Pope during the eight year of his pontificate, that is to say the 15th August 854.

Following this evidence since 1994 archaeological excavations has been carried out under the direction of Professor Letizia Ermini Pani (Chair of Medieval Archaeology, Rome University *La Sapienza*) and Professor Francois Bougard (French Academy of Rome). During these researches various relevant findings such as housing structures, fortified residential areas and workshops had been unearthed. Together with this evidence the roads´ network of the town has been as well partially discovered.

Within this area, particularly between Tolfa and Allumiere, there are several mineral ores suitable for iron mining exploitation, even if they are not very rich.

Apparently, ironmaking had a definite location within the walls of Leopoli - Cencelle at least for the period of the high Middle Ages. The workshop has been individuated in an area of the excavation within a sector known as III, room III/H indicates the smithy workshop. This very sector III, is a zone of 190 mq and it is placed in the south - eastern part of the town near the main city´s gate. Its chronology can be dated to the last phases of the site´s life around XIII/XIV centuries.

The investigation of room III/H yielded important archaeometallurgical evidence which provided several proofs of the existence in very place of a medieval ironmaking activity. In fact, already during surface cleaning of the room, beside various slags, slags´ fragments and hammerscales, an iron and several pieces of iron ore had been discovered.

Moreover, at least three pits were individuated which can be regarded as furnaces. During July 1998 excavations, other two similar structures were brought to light and excavated. The first one presents several slag and charcoal fragments inserted in its walls. The filling of this pit is homogeneous for its anthracite grey colour and its compact consistence.

Using a simple magnet it has been possible to stress that each 1.5 litre of the soil about 1/17 is formed by iron filings, hammerscales, clayey earth which absorbed FeO under a long lasting heat´s action. The rock bed underlying the soil has been affected by heat´s action as well and has became fragile.

The excavation of the other structure yielded the following evidence: under two flat stones slags, two pieces of iron ore (possibly magnetite), furnace´s refractory material, fragments of backed clay were unearthed. The underlying soil is extremly backed and conglomerated rich in slag and charcoal inclusions. It has to be noted that the supposed magnetite fragment was found mixed together with slags. More precisely, here 229 piece of slags with an average length of 1.5 cm had been unearthed..

Through the evaluation of both the remains of structure and the peculiar co - occurrence of slags, iron ore and refractory material mixed with slag it is ,thus, possible to infer that this particular

structure was an iron production furnace. Therefore, beside a major smithing activity, smal scale iron smelting was also performed within the workshop of room III/H.

It has to be stressed as well that the period of activity of the smithy workshop is chronologically contemporary with the main building expansion of Leopoli - Cencelle according to a typical medieval scheme which has always seen connected the work of building enterprises and smithy workshops [1]. Between XIII and XIV centuries Leopoli - Cencelle went through a phase of strong building restructuring carried on with the use of specialised craftsmanship. Moreover, many slags had been discovered inserted inside walls as inert building material; since these structures date to the XII century, this fact contributes to better definite the smithy chronology.

Exactly for the same period, the presence of blacksmiths inside the walls is also recorded in written documents: the 1220 treaty of alliance with Viterbo, in fact, notes different craftsmen among which are mentioned Giovanni di Divizia shield maker and Ranuccio di Giovanni blacksmith.

Summarising, room III/H was, apparently, assigned to ironmaking. Its location within the outskirts of the site, nearby the city´s walls and gate, responds to a typical feature of medieval spatial organisation: this peripheral position granted safety and easy raw material, fuel and water supply.

Archaeometallurgic research was performed in two parts. The first one analysed finds from 1995 and 1996 excavations, the second one related to 1998 excavations. Both sets of finds consisted of both pieces of slag and metallic objects. Moreover, 1998 set contained pieces of iron ore. The aim of the research was to recognize, what metallurgical activity was performed in the town and what smithy methods were used in performing of metallic objects manufacturing.

The finds of metallic objects, slags and iron ore were sampled by cutting with the help of diamond saw. The samples of slags and iron ore were analyzed by methods of chemical and microscopic anylysis, the sample of iron ore also by method of x-ray diffraction structural analysis. The samples, taken from metallic objects, were analyzed by methods of metallography.

2. 1995/96 excavations

Results of study of 1995/96 excavation finds were already published by the authors [2]. The set contained 16 samples, five pieces of slag, ten iron objects and one fragment of sheet from non - ferrous alloy. Chemical and microscopis analysis proved, all analyzed pieces of slag were smithy slags, i.e. the slag originating in process of smithy manufacturing of iron objects. All five slag samples had characteristic bowl - like shape, Fig.1.

Fig.1 Typical smithy slag

Microscopic analysis revealed all characteristic features of smithy slag. A scale, composed of iron oxides, was formed on surface of heated iron semiproducts and products. As the scale made smithy welding impossible, the smiths removed it by its reaction with silica from silica sand. Liquid ferrous silicate, product of reaction, formed mass of smithy slag. Besides ferrous silicate also remnants of silica sand entered mass of slag. Small pieces of metallic iron, mostly in form of corrosion products, were also frequently found in smithy slag. Also remnants of charcoal were typical for structure of smithy slag. Iron semiproducts used in smithy manufacturing process, contained some amount of furnace slag that also entered mass of smithy slag [3, 4].

Metallography of iron objects confirmed high skill of local blacksmiths. They were able to choose proper material and proper production method in conformity with function of manufactured object. Fragment of non - ferrous alloy sheet was made from brass.

3. 1998 excavations

Set of finds, selected for analysis, contained 13 pieces of slag or slag - like material, one piece of iron ore and one piece of black inorganic material. The set contained also four iron objects, the hoe, the object with eye, the iron semiproduct and small totally corroded fragment of iron.

Results of chemical analysis of slag samples are in Table I. As follows from the Table only the samples CC20, CC21, CC22, CC23, CC24, CC25, and CC28 represented slag. The sample CC26 was not related to production or working of iron, the sample CC 27 was iron ore, hematite.

Samples CC20, CC22, CC23, CC28 represented slag that originated in iron smelting furnace. Besides chemical analysis this fact was proved by microscopic analysis, by character of structures. Structures in the samples consisted of wüstite dendrites in two or three component silicate matrix, Fig.2.

Table I Chemical analysis of slag, wt%, n.a. = not analysed

Fig.2 Structure of slag from iron smelting

Samples CC21 and 25 represented smithy slag. Only characterization of sample CC24 was problematic. Corrosion products in structure of smithy slag are in Fig.3, remnants of silica sand in structure of smithy slag are also in Fig.3, remnants of charcoal in Fig.4.

Fig.3 Corrosion product and remnants of silica sand in structure of smithy slag

Fig.4 Remnants of charcoal in structure of smithy slag

As follows from chemical analysis, the sample CC27 represents not very rich iron ore. Iron in the ore is in ferric form. X-ray structural analysis confirmed analysed sample represented hematite iron ore. Structure, observed on metallographic surface, is in Fig.5.

Fig.5 Structure of iron ore, sample CC27

Iron oxide particles occur in form of crystals. Amount of gangue corresponds with richness of the ore.

d - values

of X-ray structural analysis are: 3.683/49; 2.700/100; 2.518/63; 1.840/62; 1.695/32; 1.599/13. The values were compared with d-values of samples from different Italian iron sources . It was found analysed sample had d-values very close to sample of Allumiere deposits.

Sample CC22 consisted of four pieces, one of them represented very rich iron ore, probably magnetite.

4. Discussion of analyses results

Analysis of two iron objects documented standard production technique. The hoe had the edge hardened by carburizing, that was not applied at the opposite side, where handle hole was made. Such preparation of iron material was correct. The use of non - carburized iron material for eye of the second analysed object was also purposeful. Interesting information follows from analysis of iron semiproduct. Iron sponge, yield of smelting has usually solid iron core in its centre and iron sponge around it. In case of the analysed semiproduct, iron sponge was on its one side, Fig.6, solid iron core on the other side, Fig.7. Fig.6 shows structure of iron sponge. White grains represent metallic iron, the voids among them are filled with slag, formed in process of iron smelting. Whole metallographic surface of sample A contained iron sponge. Metallographic surface of the sample B contained different structures of iron, from non-carburized ferritic structure to carburized hypereutectoid pearlitic structure. The structures were unhomogeneously distributed on the whole surface. Also a few particles of slag were observed. The fact suggested the yield was cut to a few smaller pieces, used for production of semiproducts. From this followed the yield and the furnace itself were larger ones. It correspondended to metallurgy of the 13th and the 14th centuries, i.e. to culmination of Cencelle town existence.

Fig.6 Metallographic analysis of iron semiproduct, sample A

Report relating to Cencelle excavations 1995 - 1996 stated all analysed slags originated in blacksmiths production of iron objects. The results related to 1998 excavations, document , a part of analysed slags originated in process of iron smelting, the second part in blacksmiths process of iron objects manufacturing. The slags, analysed in foregoing excavations, were found in different locality at

excavation site, than the ones from 1998 excavations analysed in this work. After archaeologist report, the place, where iron smelting was done, was localised at the site. This fact was also supported by finds of different kinds of iron ore. It suggested iron ore for iron smelting was transported to the site from a few sources. From this follows important production of iron existed in medieval town Leopoli - Cencelle.

Fig.7 - Metallographic analysis of iron semiproduct, sample B

5. Conclusions

The paper presents archaeometallurgic study of finds, related to production and working of iron in medieval town Leopoli - Cencelle, Italy. The finds, resulted from 1995, 1996 and 1998 excavations, were studied. The results are as follows:

Both production of iron and manufacturing of iron objects were performed in the town.

Distribution of macrostructure in analyzed iron semiproduct enabled to suppose, iron was smelted in larger volume reduction furnaces.

Pieces of different kinds of iron ores were found at the locality. One of them matched kind of iron ore, typical for nearby Allumiere source.

Standard smithy techniques were recognized from metallographic analysis of iron objects. The smiths were able to choose proper materials and proper production methods in conformity with function of manufactured iron objects.

The smiths used variety of methods for enhancing the hardness of working parts and durability of produced objects.

Spectrographic analysis of samples taken from iron objects showed most analyzed iron objects were produced in ther same source, probably in smithies of the Cencelle town.

Literature

[1] Braunstein, P.: in The Importance of Ironmaking : Technical Innovation and Social Changes, Norgberg Conference, may 8-13, 1995, ed. G. Magnusson, Stockholm: 1995, 358

[2] Mihok, Ľ., Pribulová, A., La Salvia, V.: Smithy Production in Medieval Town Leopoli - Cencelle, Východoslovenský pravek, Special Issue, 1999, pp.192 - 212

[3] Mihok, Ľ., Roth, P.: Kováčská dielňa na hrade Ľubovňa, Slovenská archeológia XLV-1, 1997, pp.183 - 192

[4] Mihok, Ľ., La Salvia,V., Roth, P.: Research of Medieval Smithy Slags, 10th International Symposium Metallography´98, Stará Lesná, 1998, pp.475 - 477