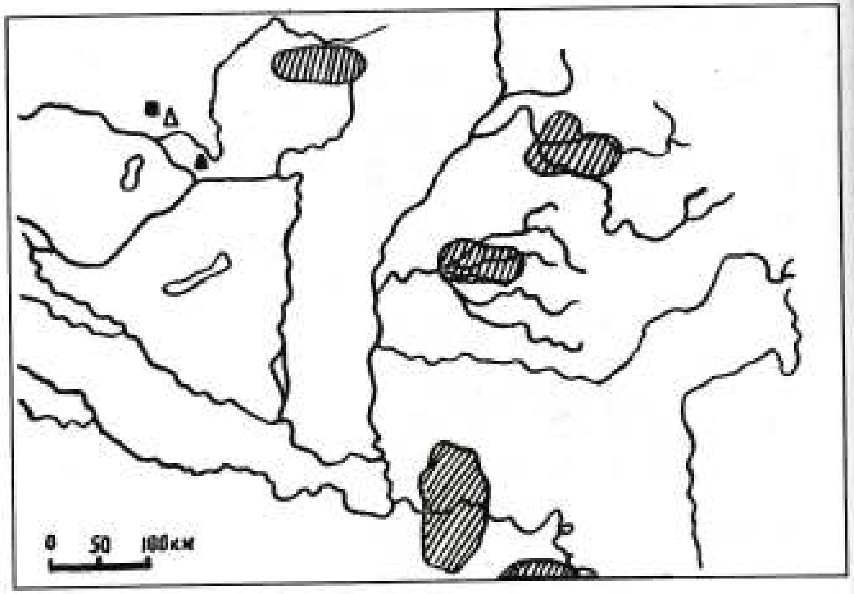

Карта 1. Балкано-Карпатские горно-металургические области.

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PRODUCTION OF BRONZE AGE GOLD OBJECTS

The paper presents study of composition and production methods of gold objects collection dated to Bronze Age. The objects, mostly jewels, were found in archaeologic excavations in Bronze Age settlement near village Nizna Mysla at the outskirts of Kosice, Eastern Slovakia. Important protohistoric site near Nizna Mysla was discovered more than one hundred years ago in Historic Hungary. The village is situated on elevation called Varhegy near confluence of three rivers: Hornad, Torysa, and Olsava. Systematic archaeologic research of the site covering 7 ha is realised since 1977.

Two separate fortified settlements were excavated at the site. Both were settlements of Otomani Culture people dated to 1700-1400 B.C. Besides homes and fortifications also graves in spacious cemetery were excavated and studied. Total 535 graves were excavated, all of them are dated to 1700-1600 B.C., i.e. to the Early Bronze Age.

From terraine situation and hundreds of various archaeological finds follows the locality near Nizna Mysla was early civilisation centre of Kosice basin. In growing settlement with cumulated property and power there were also craftsmen activities concentrated.

In Early Bronze Age first boom of non-ferrous metals metallurgy in the Carpathians basin was recorded. Specialised craftsmen were concentrated in settlements situated near ore deposits and near trading paths. Early bronze metallurgy development was connected with Otomani Culture people and reached contemporary European level.

The settlement near Nizna Mysla was one of the most important centres of Bronze Age metallurgy in the Carpathians region. Collections of metallic objects, spoils, working requisites are sufficient evidence it was metallurgy that secured prosperity and economic independence of settlement's inhabitants. In remnants of homes, settlement's layers and waste holes both intact objects and fragments from copper, bronze and gold were found together with moulds made of stone or clay, clay casting crucibles (Fig.1), massive ore crushers made of stone, clay tuyeres for connecting of bellows, etc. Character of finds from the settlement enables to suppose that final working of metals was concentrated in a few homes and around them.

Nearly all graves contained copper and bronze jewels, instruments and weapons. Gold jewels were in minority but, when compared with some other parallels dated sites in the Carpathians basin, their occurrence in Nizna Mysla site was very high. Collections of gold jewels were mainly found in graves of individuals representing privileged society level. Total information about production of gold jewels in to settlement is distorted by the fact about one fourth of graves of adults was plundered. Gold objects from Nizna Mysla settlement are similar in typology with local copper and bronze ones, which is an evidence on their local production.

Long term archeologic research resulted also i a few rarities that are unique in Central Europe in context with metallurgy. Among them are two excavated graves of adult men belonging to group of craftsmen-metallurgists. One of them is in Fig.2. Together with skeletons there were found sandstone mould, massive stone hammer for ore crushing, clay tuyere, and bronze pin with mould to which it was cast, Fig.3. The other inventory of both graves showed both individuals belonged to rich, privileged layer of settlement's inhabitants.

Composition of gold jewels

Collection of gold jewels from Nizna Mysla settlement contained temple rings, sewn-on roundels, decorative bits placed at the ends of strings, jewel in form of spiral and little gold tube. All of them belong to treasure of Slovak Nation, many of them are placed in Slovak National Treasury at Bratislava castle. Collection of gold jewels from one grave (no.386) is in Fig.4, types of temple rings are in Fig.5, gold spiral is in Fig.6.

32 objects from more than one hundred ones were selected for analysis of composition. Selected objects represented all graves and finding units where gold were found and all kinds of gold jewels. Owing to character of objects only non-destructive analysis was accepted.

All analysed objects had small dimensions enabling to place them in working chamber of electron microscope. It was the reason energy dispersive electron microanalysis was used for analysis of objects composition. Analyser Edax working with electron microscope Tesla BS 300 was used. Limitation of the method lays in its low sensitivity not allowing identification and analysis of trace elements.

Results of energy dispersive microanalysis are in Table 1. First analyses showed very high background caused by surface contamination. The contamination was eliminated by fine-grained metallographic paper grinding. Three analyses were made in different spots at every object, the results in Table I are mean values of two similar ones.

The results show that all objects were made of gold containing variable content of silver. Temple ring from grave 184 was different in composition from the other objects, it was made of alloy gold-silver with high silver content.

Sewn-on roundels from graves 92 and 123 analyses showed also low contents of iron, copper and zinc. It is necessary to note that analyses of all gold objects contained close over background very weak lines of those elements but only lines in analyses of sewn-on roundels from graves 92 and 123 were quantitatively measurable. In analyses of the other objects the analyses of iron, copper and zinc are expressed as trace ones.

Methods of gold objects production

Methods of gold objects production were estimated by macrostructure observation with the help of electron microscope. The objects were observed in secondary electron image under electron microscopes Tesla ELMI BS340 and BS343. Both polished and non-polished surfaces of the objects were observed. The structure was

observed in spots of flaws enabling to penetrate into sub-surface layers having original non-changed structures.

Fig.7 shows two arms of temple ring. It can be seen from the figure that surface of temple ring wasn't entirely smooth, there were many rough, imperfectly polished places. State of polished surface of temple ring is in Fig.8 showing marks of polishing by natural material, probably local tuffite. Identification of natural material with high silica content used for polishing was enabled by the fact that in course of polishing tuffite remained among coarse metallic grains. This non-conductive material was charged by electron beam and became luminous, as can be seen from Fig.7. Subsurface structure of material in spot of flaw is in Fig.9. As can be seen from the figure, there was coarse grained structure of as-cast state under the surface.

Only front surface of the temple ring was polished, side and rear ones remained coarse, unpolished. Fig.10 shows transition between polished front surface and unpolished side one. Here is also depicted coarse grained unpolished material in as-cast state.

From macrostructure observation follows that molten metal was cast to form of little bars, after then front surfaces of bars were polished. After necessary heat preparation final form of temple rings was prepared from bars. Hammering and beating of semifinished pieces wasn't used.

Decorative bits were made of little gold sheets. Final form of flattened tube was done by folding. Decoration bits had ornaments in form of parallel grooves. Also in this case front surface of the sheet was polished by natural tuffite. Fig.11 shows polished surface together with groove. As can be seen from the Figure polishing was made on surface with already prepared ornament grooves. Owing to form of decoration bits inner unpolished surface wasn't observed by electron microscope. Observation in flaw near place of folding showed coarse grained undeformed structure under the surface. It means gold sheets were made only by casting, not by hammering.

Very similar conclusions resulted from study of little gold tube structure. Also in this case inner surface structure wasn't observed. Crosswise grooves were made on the surface, Fig.12. It can be seen in Fig.12 polishing of the surface wasn't perfect. Grooves were made by sharp and hard object, probably hard mineral. This operation damaged the surface of the tube. After finishing grooves preparation the surface was repolished what was evidenced by the fact that polishing marks were found inside shallow grooves.

Surface of gold spiral is in Fig.13. There is a lot of flaws on polished surface. In this case whole surface of gold wire, semiproduct for spiral production, was polished. It means only place for structure of spiral observations were flaws. Such observation is depicted in Fig.14 showing coarse grained as-cast state structure. From observations follow golden wire was made by casting of molten gold into the mould. After than the wire was polished and wound to final form of spiral. Marks of hammering weren't found.

Sewn-on roundels prevailed in collection of gold objects from Nizna Mysla site. Smooth surface after polishing was found with very little marks of polishing.

Inside of the roundel is in Fig.15. It shows slightly deformed coarse grained structure suggesting not very intensive mechanic working of the object. Fig.16 shows surface of roundel in place of artificially prepared opening enabling to sewn-on the roundel. Smoot and well formed walls of the opening evidence about heating the roundel before breaking the opening.

From macrostructure of roundels follows they were produced in coarse state by casting into small moulds. After then opening were made and final form was prepared by less intensive beating on suitable forming plate. During such working some flaws on the surface resulted, Fig.17. To prepare perfect round form of the roundel some of them could be cut on sides and folded into inside, Fig.18.

Discussion of results

Energy dispersive analyses showed the gold objects were produced from gold-silver alloy with gold as a major constituent. Many possible sources of gold bearing ores are in the region of Central Carpathians but the one in Telkybanya in Hungary only 15 km far from Nizna Mysla settlement is the most probable. Moreover, the ore contains also silver as minor component. No evidence was found on preparation of gold in Nizna Mysla settlement. It can be assumed the gold was produced on site near source from where it was imported.

Very important fact following from analyses results is, that main production method was casting, not hammering or beating. Even very thin sheets were produced only by casting. This fact is supported by find of mould for casting of thin sheets used for production of decoration bits, Fig.19. As can be seen from the Figure, sheets were cast in form with decoration grooves. Very tiny objects, gold roundels, were produced also by casting. Only in this case roundels were finished by light beating. It was done in forming plate found among finds in the site, Fig.20. As casting of bronze objects to nearly final shape was common technique of craftsmen- metallurgists in the settlement it is probable the same technique was used also for production of gold objects.

Conclusions

The paper describes research of gold jewels production found in Bronze Age settlement of Otomani culture people in Nizna Mysla. Results are as follows:

- Gold jewels were made of gold-silver alloy with gold as a major constituent. It is probable, the gold bearing ore was mined in Telkybanya in Hungary only 15 km far from Nizna Mysla settlement. Gold-silver alloy was imported to the settlement.
- Only production method of gold objects was casting. Even little and thin objects were cast. This fact was confirmed by finds of sandstone moulds for casting of very thin objects.
- Surface of gold jewels was finished by polishing. Local tuffite was used as polishing material.
- Only in case of tiny sewn-on roundels final shape was made by light beating. Forming plate for such working was also found at the site.

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ПРОИЗВОДСТВО ЗОЛОТЫХ ИЗДЕЛИЙ В ЭПОХУ БРОНЗЫ

Резюме

Работа касается метода производства золотых ювелирных изделий найденных при раскопках могильника в Нижней Мишле возле г. Кошиц, датируемого эпохой средней бронзы (1700-1400 гг. до н.э.). Изделия были изготовлены из сплава золота и серебра, с главным компонентом – золотом. Несмотря на свои небольшие размеры, все они были изготовлены путём литья. При изучении их макроструктуры применение ковки не наблюдалось. Визуально отмечается наличие гравировки и дополнительной обработки краёв желобков на некоторых изделиях. Полировка поверхности предметов проводилась с помощью природного тарита.

Table I

Results of energy dispersive electron microanalysis of gold jewels, wt%.

No.	Object	Ag	Au
1	object 186: gold tube	02,72	97,28
2	grave 353: roundel	03,35	96,85
3	grave 386: decorative bit 1	15,87	84,33
4	grave 386: decorative bit 2	15,67	84,33
5	grave 386: decorative bit 3	05,56	94,44
6	grave 386: decorative bit 4	12,88	87,12
7	grave 386: decorative bit 5	08,26	91,74
8	grave 386: roundel 1	15,45	84,55
9	grave 386: roundel 2	15,68	84,32
10	grave 386: temple ring 1	12,54	87,46
11	grave 386: temple ring 2	16,47	83,53
12	grave 440: child's temple ring	09,27	90,73
13	grave 404: decorative bit 1	04,39	95,61
14	grave 404: decorative bit 2	08,20	91,80
15	grave 404: decorative bit 3	07,69	92,31
16	grave 404: decorative bit 4	05,15	94,85
17	grave 404: roundel 1	08,75	91,25
18	grave 404: roundel 2	16,75	83,25
19	grave 404: temple ring 1	05,28	94,72
20	grave 404: temple ring 2	04,48	95,52
21	grave 92: roundel	10,83	82,64
22	grave 123: roundel	14,65	79,52
23	grave 330: roundel 1	12,02	87,98
24	grave 330: roundel 2	06,79	93,21
25	grave 76: gold spiral	05,60	94.40
26	grave 3: temple ring	12,54	87,46
27	grave 115: temple ring	09,06	90,94
28	grave 277: temple ring	10,61	89,39
29	grave 153: temple ring	13,07	86,93
30	grave 197: temple ring	07,80	92,20
31	grave 184: temple ring	44,17	55,83
32	grave 11: temple ring	06,67	93,33
	grave 92: roundel –	1,72% Fe; 2,34% Cu; 2,47% Zn	
	grave 123: roundel –	0,82% Fe; 2,44% Cu; 2,57% Zn	

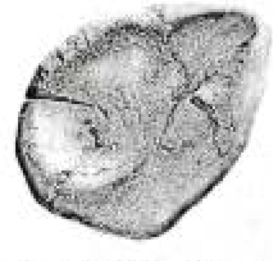

Fig.1. Clay crucible for casting of molten bronze or gold

Fig.2. Grave of craftsman-metallurgist

Fig.3. Clay tuyere, sandstone mould and bronze pin found in grave of craftsman-metallurgist

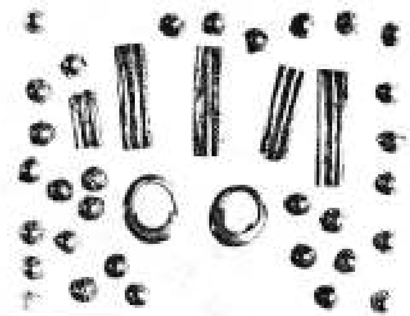

Fig.4. Collection of gold jewels from grave No. 386.

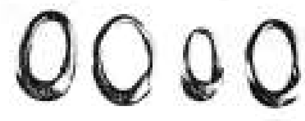

Fig. 5. Types of gold temple rings.

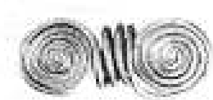

Fig. 6. Gold spiral, grave No.76.

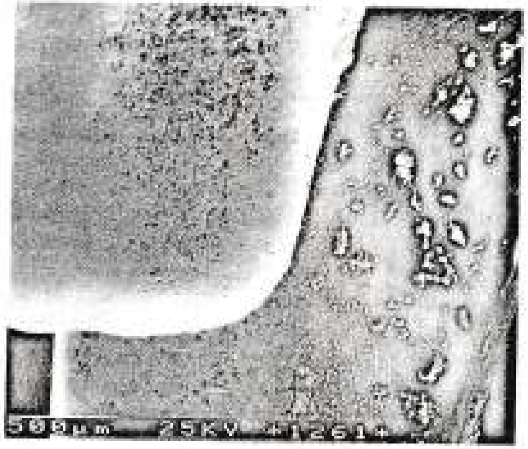

Fig.7. Surface of temple ring arms, grave no.184.

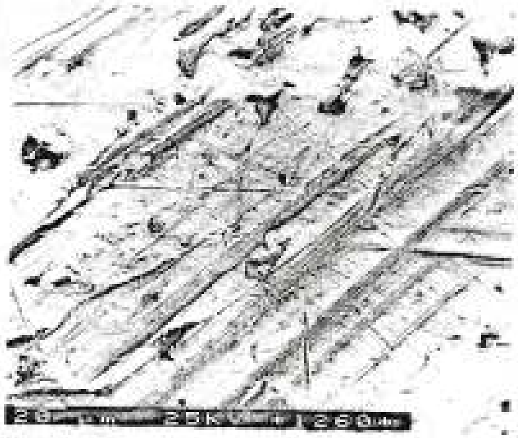

Fig.8. Polished surface of temple ring, grave no.184.

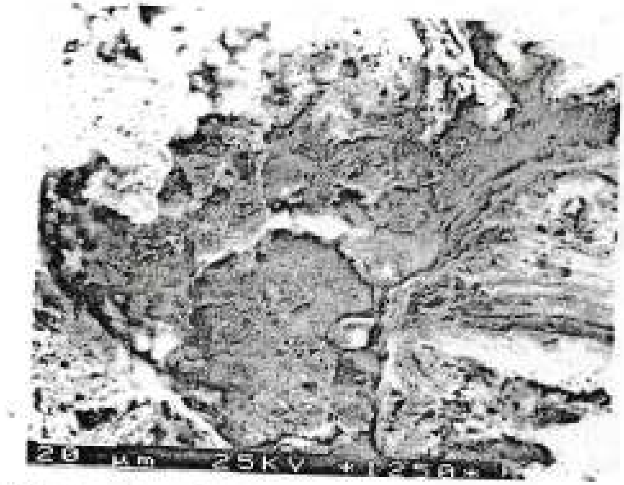

Fig.9. Structure of metal in place of flaw, temple ring, grave no.11.

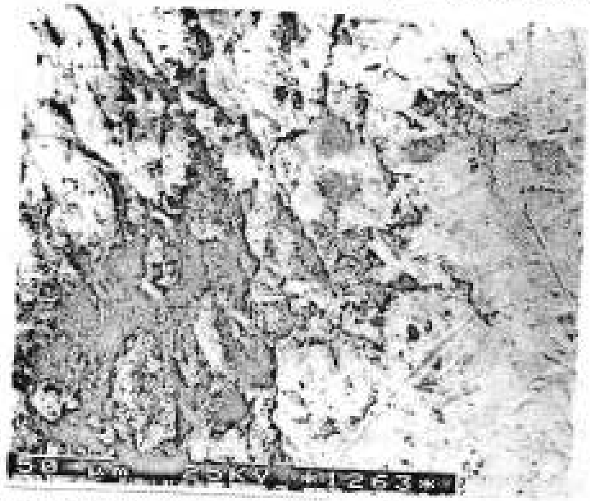

Fig.10. Transition between polished front surface and unpolished side of temple ring, grave no.184.

Fig.11. Polished surface of decoration bit, grave no.404.

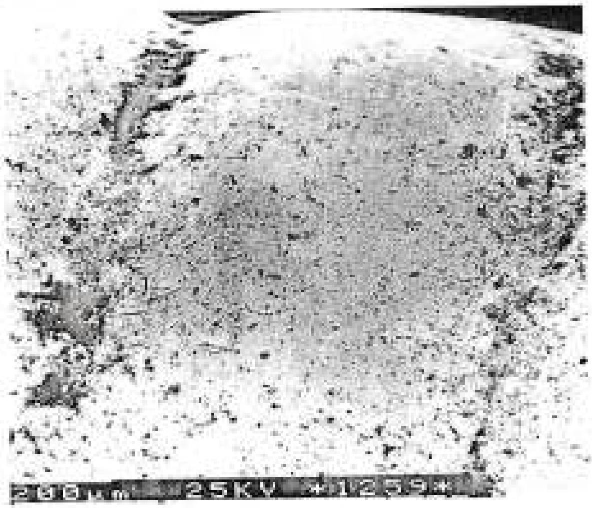

Fig.12. Crosswise grooves on polished surface of gold tube, object no.186

Fig.13. Surface of gold spiral, grave no.76.

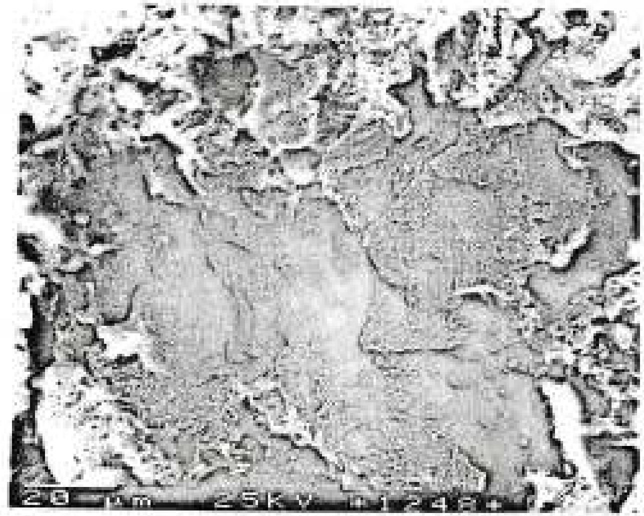

Fig.14. Coarse-grained structure in place of flaw on the surface of gold spiral, grave no.76.

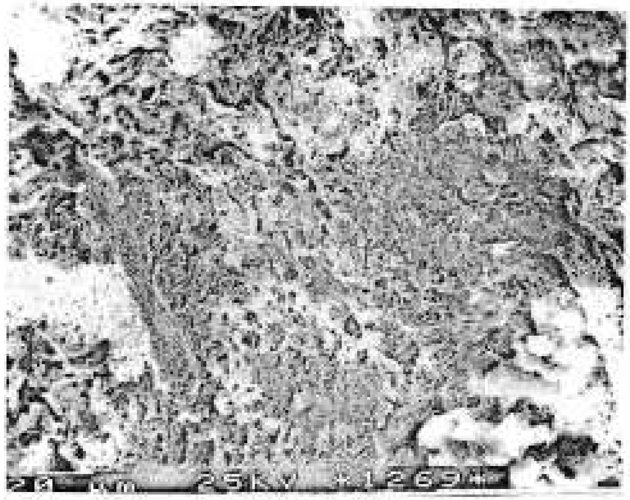

Fig.15. Structure of the inner surface of the roundel, grave no.386.

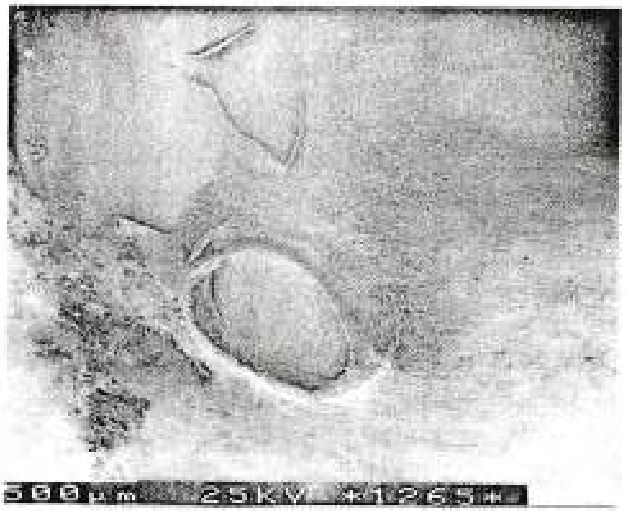

Fig.16. Surface of roundel around opening, grave no.386.

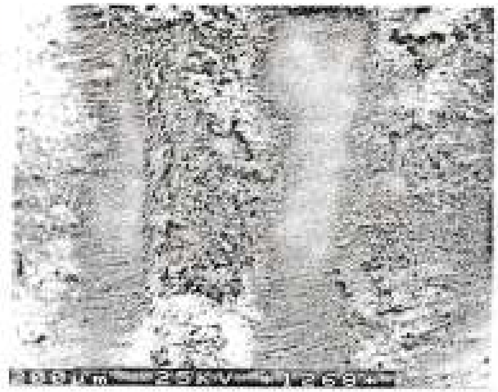

Fig.17. Flaws on polished surface of the roundel, grave no.386.

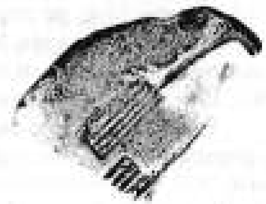

Fig.19. Mould for casting of gold sheets.

Fig.18. Folded sheet inside the roundel, grave no.123.

Fig.20. Forming plate for finishing the shape of the roundels.