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Metallografic Analisis of Iron Objects From Medieval Sites in Transcarpathian Ukraine

Introduction: Fortified settlements, settlements and cemeteries dated to the Xth – XIIIth centuries A.D. are very frequently found on the territory of Transcarpathian Ukraine (more than 100), but only a few of them were studied by stationary archaeologic research (Malaya Kopan, Vary, Choma, Bucha and some others). Survey character of archaeologic research of most of the settlements resulting in scarcity of excavated inventory, low level of excavated iron objects preservation enabled to select only very few objects (five objects from three sites) for metallographic analysis purpose.

Description of analysed objects: Two objects (hook nail, no.84 and fragment of tool head, no. 2953) were excavated at fortified settlement Malaya Kopan in medieval horizon, represented by eleven houses, three buildings and series of holes. The horizon was dated to the XIth century A.D. (Прохненко, 2004, с.273-293). The hook nail (Fig.1), was 26 cm long and was found in filling of a furnace of house X dated by ceramics to the XIth century A.D. The fragment of tool head, 8 cm long (Fig.2), was found in 0,25 m layer during research of fortification, together with pots dated to the XIth century A.D.

Fig.1. Hook nail.

Fig.2. Fragment of tool head.

The hoe, no.2271 (Fig.3) and the sickle, no.2268 (Fig.4), found in excavations of settlement Bucha together with a pole, a pit and fragments of ceramics, were dated to the XIIth – XIIIth centuries A.D. (Котигоршко, Черкун, 1993, с.14-15,17, рис.2,8).

Fig.3. Hoe.

Fig.4. Sickle.

Iron dart, no.3237/2, 12,5 cm long (Fig.5), was found in fortified settlement Stremtura. It was a part of numerous finds found in lower settlement, that were collected in Archaeology Museum at Uzhgorod University. Similar darts were found in East Europe, dated to the IXth to XIVth centuries A.D., but most of them to the XIIth to XIVth centuries A.D. (Медведев, 1968, с.64,88, табл.22,25-26,28,30Д).

Fig.5. Iron dart.

Metallographic samples were taken from all five analysed objects by cutting with a saw. Sketches of sample taking are in Fig.6. The samples were mounted in mounting resin and metallographic surfaces were prepared by grinding and polishing. The surfaces were observed under metallographic optic microscope in both non – etched and etched states. Nital 2 was used as an etching agent to reveal the structures of iron metal. All microscopic observations were documented by photography.

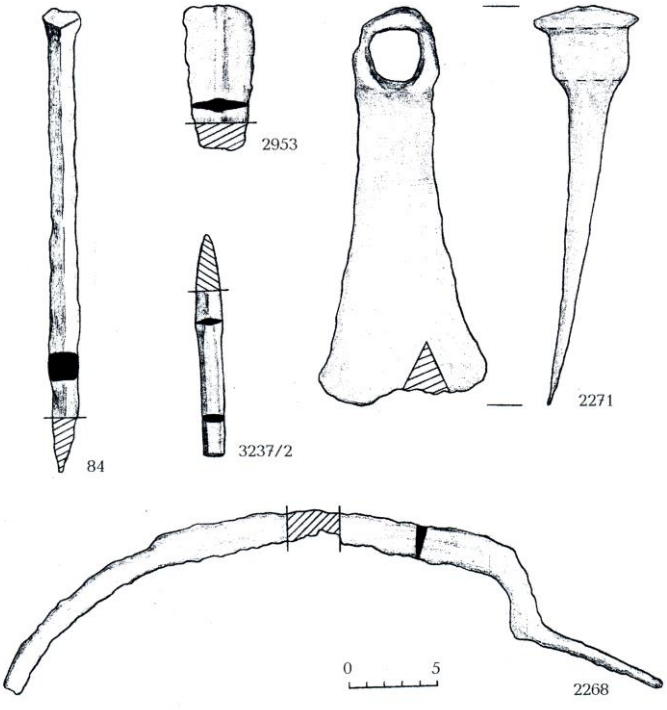

Fig.6. Sample taking of the objects.

Results of metallographic analysis: Hook nail, no.84. The sample was taken by cross – section cut (Fig.6). The sketch of analysed metallographic surface is in Fig.7. A lot of smithy inclusions and partly reacted scales particles were found on the surface prior to etching (Fig.8). Etching revealed the centre part of the surface contained non – carburized ferritic iron with coarse grained structure (Fig.9; point 1, Fig.7). On the rim of the surface carburised structures were found. Most of the rim consisted of mildly carburised iron with about 0,15 – 0,20% C (Fig.10), as observed also in point 2 (Fig.7). In one part of the surface rim deep carburised pearlitic structures with about 0,8% C were found (Fig.11; point 3, Fig.7).

Fig.7. Sketch of metallographic surface, hook nail.

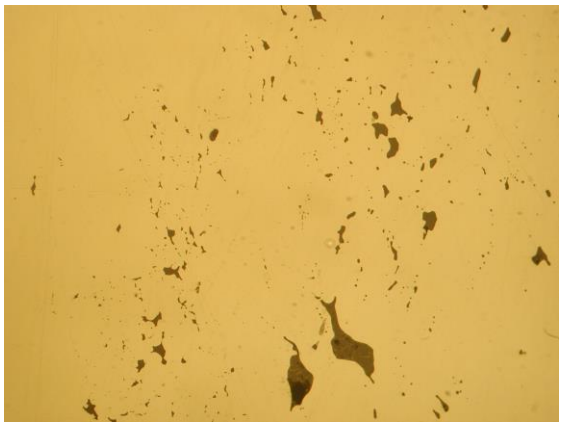

Fig.8. Smithy inclusions in sample of hook nail.

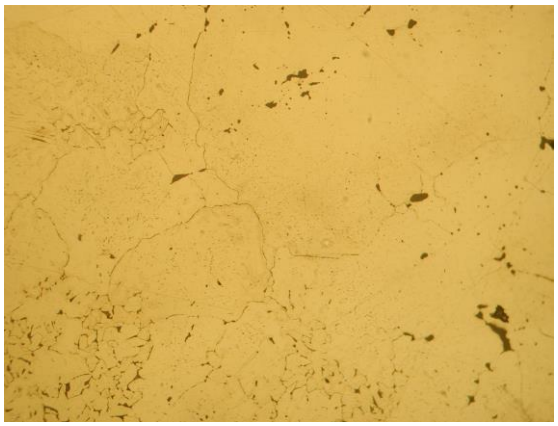

Fig.9. Non – carburised iron in sample of hook nail.

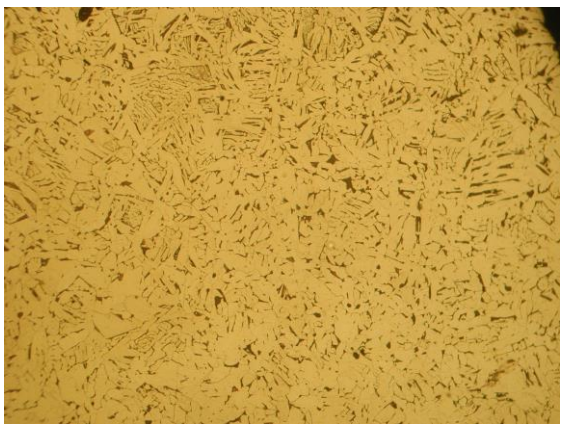

Fig.10. Mildly carburised iron in sample of hook nail.

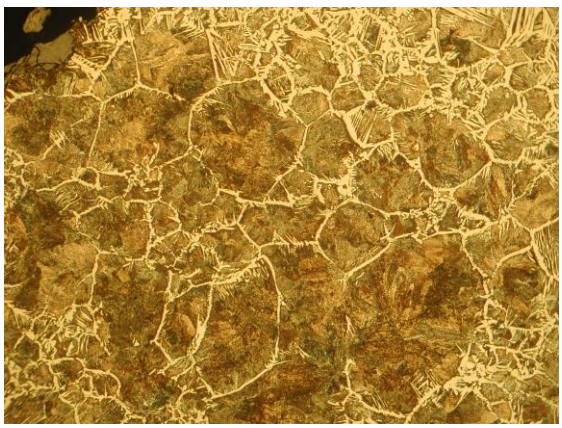

Fig.11. Deep carburised iron in sample of hook nail.

From metallographic analysis follows the nail was made from non – carburised tough iron. After preparing the final shape the tip of the nail was deep carburised. Carburised structures observed on analysed surface, resulted from penetration of carburisation from the tip.

Fragment of tool head, no.2953. The sample was taken by cross – section cut from the end of the fragment (Fig.6). The sketch of analysed metallographic surface is in Fig.12. A lot of smithy inclusions and particles of scales were recorded prior to etching (Fig.13). Etching revealed the object was manufactured by welding of two thin plates made from mildly carburised iron. The structures in point 1 (Fig.12) near the broad end of the surface are in Fig.14. Two types of structures were documented, that were different by grain size. They were divided by band of non – carburised iron, the place of weld. The structure (Fig.15; point 2, Fig.12) shows its band – like character, resulting probably from increased phosphorus content in iron. Microscopic observations near the sharper end of the surface (edge?) showed deep carburisation in this part (Fig.16; point 3, Fig.12). Estimated carbon content was about 0,5%.

Fig.12. Sketch of metallographic surface, tool head.

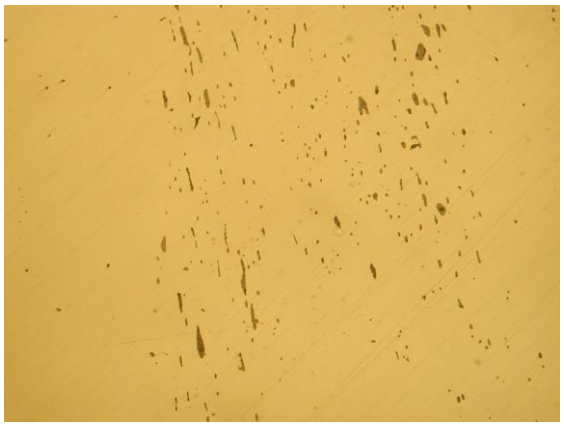

Fig.13. Smithy inclusions in sample of tool head.

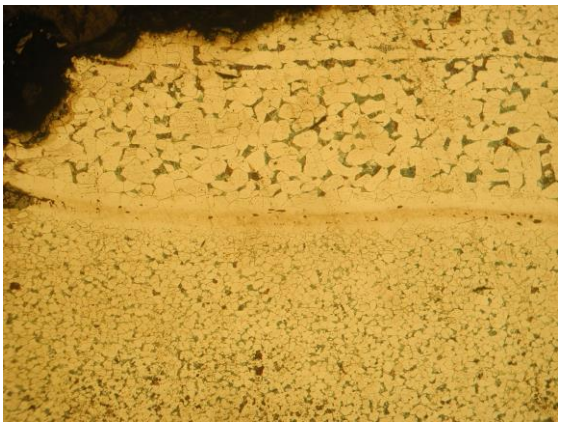

Fig.14. Mildly carburised iron in sample of tool head.

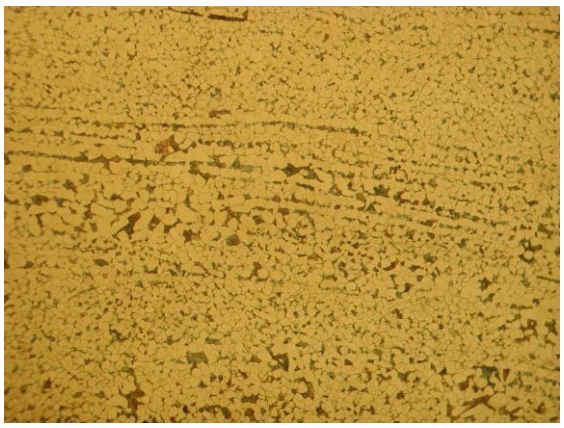

Fig.15. Band – like character of structure, sample of tool head.

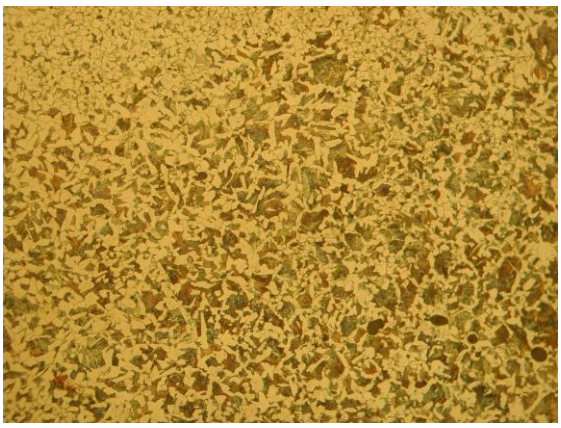

Fig.16. Deep carburised iron near the edge, sample of tool head.

From metallographic analysis follows the object was made of two iron semiproducts, both were mildly carburised. Such preparation of iron resulted in sufficient toughness and hardness of both semiproducts. Moreover, deep carburisation was found on the thin part of analysed surface, where edge was supposed. Because of hard edge the object was probably used for cutting or similar activities.

Hoe, no.2271. One sample was cut from the edge of the hoe. Method of sample taking enabled to study both material on the edge and material in the core. Sketch of the metallographic surface is in Fig.17. Bands of smithy inclusions were observed in state prior to etching. After etching the part where edge was prepared, was deep and very evenly carburised (Fig.18; point 1, Fig.17). Estimated carbon content in this place was about 0,8%. Farther in the hoe body band of carburised iron material continued near the rim, the rest showed mildly carburised ferritic – pearlitic structure (Fig.19; point 2, Fig.17). Such character and distribution of structure continued, but farther in the body bands in ferritic – pearlitic structure appeared (Fig.20; point 3, Fig.17), probably caused by increased content of phosphorus in iron. There is one interesting feature in Fig.20, band of non – carburised iron on the top, divided from the bulk by a crack. The crack probably resulted from poor welding, but what was the purpose of the band? Repair of the hoe?

Fig.17. Sketch of metallographic surface, hoe.

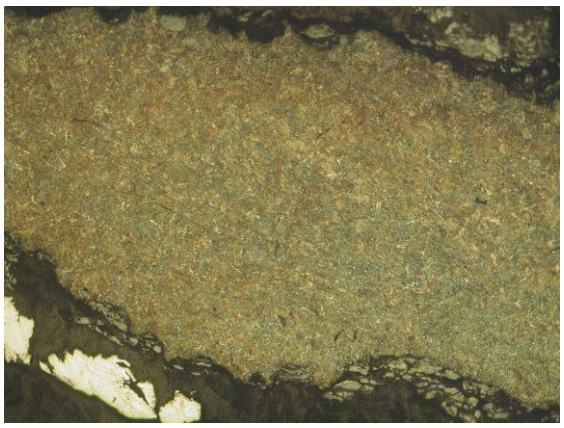

Fig.18. Deep carburised iron in sample of hoe.

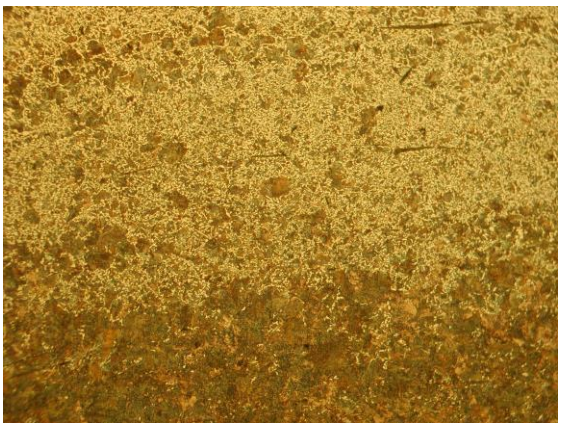

Fig.19. Mildly carburised iron in sample of hoe.

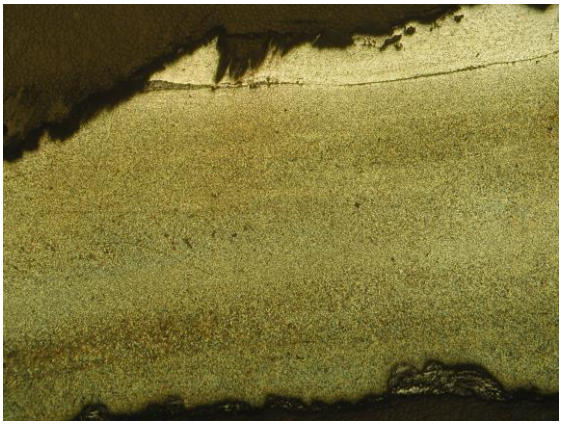

Fig.20. Band – like character of structure, sample of hoe.

The hoe was manufactured from mildly carburised iron material, suitable material for object of hoe – type. Next, the edge of the hoe was deep carburised. Homogeneity of carburisation was extraordinary, the hoe possessed high utility value.

Sickle, no.2268. The sample was taken by cross – section cut from centre of the sickle (Fig.6). Such method of sample taking enabled to study the structures both on the edge and on the back of the sickle. Sketch of analysed metallographic surface is in Fig.21. Smithy inclusions were observed on non – etched metallographic surface. Etching revealed very interesting distribution of structures. Sickle edge contained deep carburised and quenched martensitic structure (Fig.22; point 1, Fig.21). Abrupt change of structures between edge and body of the sickle is in Fig.23 (point 2, Fig.21). This distribution of structures proves use of sophisticated smithy technique in production of sickle, welding of carburised edge to the body. The body of the sickle itself was made from non – carburised coarse grained ferritic iron (Fig.24; point 3, Fig.21).

Fig.21. Sketch of metallographic surface, sickle.

Fig.22. Deep carburised and quenched iron, sickle edge.

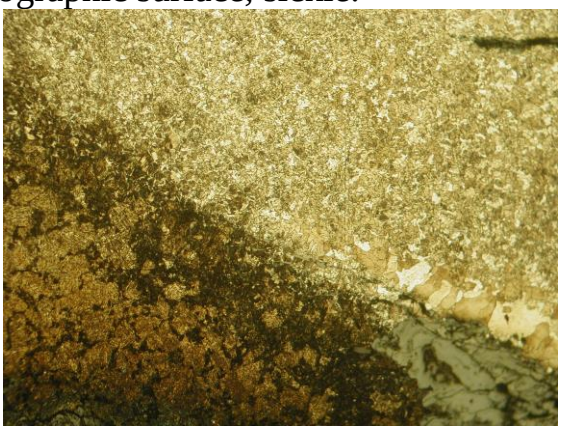

Fig.23. Boundary between edge and body of sickle.

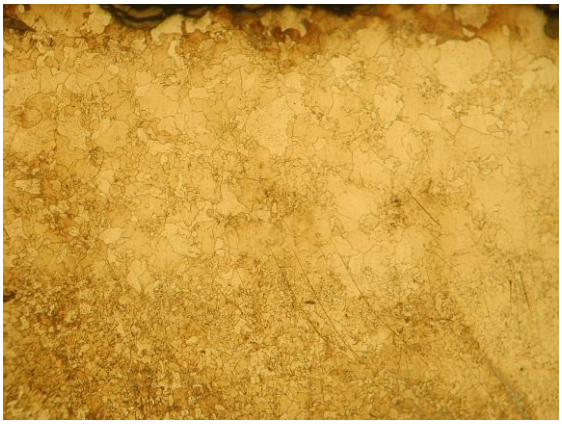

Fig.24. Non – carburised iron in body of sickle.

The sickle was produced by welding of two iron parts: non – carburised iron plate designed for sickle body and deep carburised iron plate designed for sickle edge. After preparation of final form the sickle was reheated and quenched. The sickle had tough body and very hard edge, its utility value was high.

Iron dart, no.3237/2. The sample was taken by cross – section cut near the tip of the dart (Fig.6). Sketch of analysed metallographic surface is in Fig.25. Metallographic surface, observed prior to etching, was very clean, it contained only a few non – metallic inclusions, but nor smithy inclusions nor scales particles. The inclusions, wüstite and silicates, were typical for modern steel. Etching revealed very homogeneous deep carburized structure (Fig.26), on the whole surface. Such structure is very suitable for point and head of dart, but it is too modern by its character and appearance.

Fig.25. Sketch of metallographic surface, iron dart.

Fig.26. Deep carburised iron in sample of iron dart.

Discussion of results: Four from analysed objects had typical features of medieval iron objects, e.g. smithy inclusions in the structure, remnants of scales. These features were typical for medieval (and also ancient) smithy processes. Only in structure of the fifth one, the iron dart, these features missed. All five objects were produced by methods typical for medieval blacksmiths. Analysis revealed the tip of hook nail was carburized, similarly as the edge of the tool head and edge of the hoe. All these three objects kept the tough properties of low – carburised or non – carburised iron materials situated in their cores and also utilised hardness gained from carburisation of surface or edge. The author analysed similar medieval objects from the territory of Slovakia with comparable results (Petrík, Mihok, Soláriková, 1999, pp.79-120).

The sickle represented sophisticated method of production, when the part that demanded increased hardness, was prepared and treated (carburised) separately and then it was welded to the bulk of the object. The author of the paper analysed a few iron objects produced by carburised part – welding – to the object method. Among them very important was the set of mining iron from central Slovakia, dated to the XVth century, whose tips were frequently worn – up and replaced by welding of new ones (Mihok, Pribulová, Labuda, 1998, pp.493-518).

Conclusions: The paper presents metallographic analysis of five medieval iron objects found in archaeologic sites of Transcarpathian Ukraine. The main results of the analysis are as follows:

1. Analysis of hook nail, tool head and hoe showed use of standard production techniques of medieval blacksmiths. They carburised working parts of the objects to increase their hardness: tip of the hook nail, edge of the tool head and the hoe. The bulk of

the objects was produced from non – carburised or mildly carburised iron material providing sufficient toughness of the object.

2. The sickle was manufactured by sophisticated production method, when separately produced carburised edge was welded to body of the sickle, prepared from tough non – carburised iron.

3. Analysis of iron dart proved very high level of manufacturing technology resulting in very homogeneous deep carburisation of the tip of the dart. Cleanness of iron material and character of structures were unusual for iron object dated to the XIIIth – XIVth centuries.

4. Analysis confirmed high skills of local medieval blacksmiths, their ability to manufacture iron objects of such properties that fulfilled the needs and demands of end users.

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Металлографический анализ железных предметов со средневековых пунктов Закарпатья

(Резюме)

Городища, поселения и погребальные памятники, датируемые X – XIII вв. н.э., составляют значительную группу древностей Закарпатья (более 100), однако, лишь на отдельных из них были проведены стационарные археологические исследования (Малая Копаня, Вары, Чома, Буча и др.). Разведочный характер изучения большинства поселений и, соответственно, скудность инвентарных коллекций памятников, низкий уровень сохранности железных предметов определили отбор незначительной группы вещей для металлографического анализа (5 экземпляров с трёх пунктов).

Проведённые анализы позволяют говорить о высоком уровне местных кузнецов в эпоху средневековья, использовавших различные методы изготовления изделий. Технология производства металлических предметов соответствует уровню кузнечного ремесла региона, за исключением наконечника стрелы, структура которого необычна для средневековья.

Literature

Котигорошко В.Г., Черкун Й.К. Археологические исследования в бассейне р.Верке Закарпатской обл. Украины / Отчёт о полевых исследованиях экспедиции УжДУ в 1992 г. – Ужгород, 1993. – 48 с.

Медведев А.Ф. Ручное метательное оружие. Лук и стрелы, самострел VIII - XIV вв. // САИ. - 1966. - Е1-36. - 184 с.

Прохненко І.А. Середньовічний горизонт Малокопанського городища // Carpatica – Карпатика. Давня історія Карпато – Дунайського ареалу та суміжних регіонів. – Ужгород, 2004. – Вип.31. – С.273-293.

Mihok Ľ., Pribulová A., Labuda J. Production of medieval mining irons // Archaeologia historica. - 23/98. - P.493-518.

Petrík J., Mihok Ľ., Soláriková M. Arcgaeometallurgic research of some iron objects from collection of East Slovak Museum // Historica Carpatica. – 1999. - 29-30. - P.79-120.