Two iron technology diffusion routes in Eastern Europe

Dvě trasy šíření znalosti zpracování železa ve východní Evropě

Vladimir I. Zavyalov – Nataliya N. Terekhova

Archaeometallographic data suggest that there were two technological models in Eastern Europe as early as the Bronze Age–Early Iron Age transition period (9th–7th centuries BC). We link their development to two routes via which knowledge of use of ferrous metals diffused from Anatolia. The first route reached the North Caucasus, the second route passed through Greece and the Balkans to Central and Eastern Europe.

archaeometallography – Eastern Europe – ferrous metals – transition period

Archeometalografická data naznačují, že již v přechodu mezi dobou bronzovou a ranou dobou železnou (9.–7. stol. př. n. l.) existovaly ve východní Evropě dva technologické modely zpracování železa. Jejich rozvoj spojujeme se dvěma trasami, kterými se znalosti užívání železných kovů z Anatolie rozšířily. První trasa překročila Zakavkazsko, druhá trasa vedla přes Řecko a Balkán do střední a východní Evropy.

archeometallografie – východní Evropa – železné kovy – přechodné období

The issue of emergence and spread of ferrous metallurgy is still relevant despite the fact that it has been on the research agenda for quite a long time. *L. Morgan* (*1935*, 28) argued that 'The production of iron was the event of events in human experience, without a parallel, and without an equal, besides which all other inventions and discoveries were inconsiderable, or at least subordinate'.

Most researchers tend to believe that telluric iron production originated in Anatolia. The region had all basic preconditions, such as focused and systematic search of ore minerals; understanding properties of minerals which could be turned to metal; pyrotechnological structures; use of artificial blowing to achieve high temperatures (when smelting); charring of wood (*Waldbaum 1978*, 23). The earliest artefacts made from iron (second half of the third millennium BC) have been found in Anatolia. The finds include an iron mace head (Troy, 2600–2400 BC), a blade of a gold handled dagger, two pins with gold heads, a pendant, a cross-shaped plaque, fragments of a knife (Alaça Höyük, 2400–2100 BC), a twisted bracelet from Tilmen Höyük (*Esin 1976*, 225; *Yalçin 1999*, 179), a piece of corroded iron (Tarsus, 2100 BC). However, this list has been recently modified. It has been established that the mace head from Troy is a piece of slag or ore rather than metallic iron (*Pernicka 1990*; *Yalçin 1999*). Initially, because of high content of nickel (up to 3.91 %), a number of researchers even believed that this artefact was made from meteoric iron (*Waldbaum 1978*, 20; *1980*, 92).

In the first half of the second millennium BC iron artefacts were widely spread across the Eastern Mediterranean. Items made from ferrous metal and dated to this period have been found not only in Anatolia, but also in Mesopotamia, Egypt, Crete and Cyprus. Iron

artefacts dated to the second half of the second millennium BC have been retrieved from sites in Greece, the Aegean islands, the Balkans, the Levant, Transcaucasia, and Eastern Europe. It was the time when the knowledge of iron metallurgy began to spread; this is attested by the presence of metallurgical centres dated to the 14th–13th centuries BC discovered in the Levant, Eastern Georgia and Serbia (*Abramishvili 1961*; *Abramishvili – Mikeladze 1970*; *Fritz et al. 1991*; *Liebowitz – Folk 1984*; *Stojić 2006*).

R. Pleiner paid a lot of attention to the issue of the diffusion of iron from Anatolia. At the same time he thought Europe to be a secondary area of iron industry development. On the maps that he made (*Pleiner 1980*, 382; *Pleiner 2000*, fig. 8), he traces the following routes of ironworking knowledge diffusion: one route passed through Greece and the Balkans to Western and Eastern Europe; another route runs through the Caucasus to the North Black Sea maritime steppes and the Volga Region (*Pleiner 1980*, 376; *2000*, 30–31). In this case R. Pleiner relied purely on archaeological data, i.e. finds of iron artefacts. Given high relevance of this issue, we would like to revisit it and offer conclusions based on the technological data. Indeed, archaeological artefacts found in Eastern Europe and results of their archaeometallographic studies conducted so far have provided an opportunity to clarify some of Pleiner's conclusions.

The earliest items made of ferrous metal and coming from Eastern European sites are dated to the end of the second millennium BC (*fig. 1*; see *Bidzilya et al. 1983*; *Grakov 1958*; *Chizhevsky 2012*; *Shramko et al. 1977*; *Shramko – Buynov 2012*). These items have been found singly, which means that knowledge of the new metal reached the local populations for the first time. Archaeometallographic studies of such finds are not numerous. Only four artefacts coming from Ukraine, namely three knives and an awl, have been examined so far. One knife was forged entirely from bloomery iron (Lyubovka /Любовка/ settlement, late 2000s – early 1000s BC: *Radzievska – Shramko 1980*, 103); another knife was made of iron and showed traces of unintentional (?) carburization (Oskol /Оскол/ settlement, 11th–9th centuries BC: *Bidzilya et al. 1983*, 18); the third knife was made from inhomogeneous bloomery steel (Chervonny Shlakh-1 /Червоный Шлах-1/ settlement, 11th–9th centuries BC: *Buynov 2003*, 6). The awl (Tashlyk 1 /Ташлык 1/ settlement, 13th century BC) was made from iron, which was slightly carburized in places. When forging the awl the blank was folded and welded several times as evidenced by chains of slag inclusions interpreted by the author as welding seams (*Bidzilya et al. 1983*, 15). Therefore, what we have is an early stage of ironworking, which does not fit entirely within the Late Bronze Age. No specific techniques typical for ironworking in Eastern Europe of that time have been recorded. The Late Bronze Age – Early Iron Age transition period in Eastern Europe falls within the 9th–mid-7th centuries BC as evidenced by artefacts recovered at the sites in the Northern Caucasus and the North Black Sea maritime steppes. This stage is characterized by a substantial increase in the number of both iron artefacts and their types.

The so-far gathered analytical (archaeometallographic) data, characterizing technology used to produce the earliest iron artefacts, support the conclusion that various technological models, underpinned by various technological traditions, began to emerge in Eastern Europe at that time. The technological model is understood to comprise three interrelated components, namely: a technical and technological stereotype, production traditions, and influence of alien cultures. The technical and technological stereotype includes a certain set of attributes and the correlation between them which characterize material, categories,

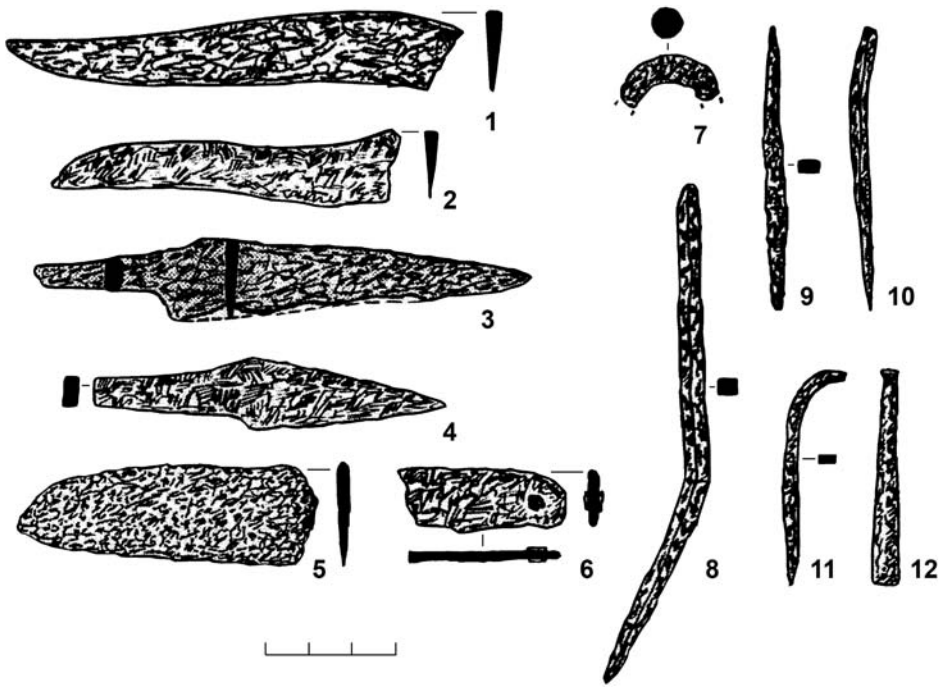

Fig. 1. The earliest iron objects from Eastern Europe 12th–9th century BC (Ukraine, by I. B. Shramko): 1 – Lyubovka /Любовка/ settlement; 2 – Kicevka /Кицевка/ settlement; 3 and 7 – barrow near Vishnevy Dol /Вишневый Дол/ village; 4 – Oskol /Оскол/ settlement; 5 – Chervony Shlyakh /Червоный Шлах/ settlement; 6, 11 and 12 – Velikaya Topolyakha /Великая Тополяха/ settlement; 9 – Bondarikha /Бондариха/ settlement; 8–10 – Tymchenki /Тимченки/ settlement.
Obr. 1. Nejstarší železné předměty z východní Evropy 12.–9. století př. n. l. (Ukrajina, od I. V. Šramka): 1 – sídliště Ljubovka; 2 – sídliště Kicevka; 3 a 7 – mohyla poblíž vsi Višnevyj Dol; 4 – sídliště Oskol; 5 – sídliště Červonyj Šlach; 6, 11, 12 – sídliště Velikaja Topoljacha; 9 – sídliště Bondaricha; 8–10 – sídliště Timčenki.

techniques and methods of making items in a specific archaeological culture. The technical and technological stereotype in blacksmith craft is a stable element of culture. Transfer of a technical and technological stereotype from generation to generation throughout a long period of time is the essence of production traditions.

Two different technological traditions have been traced by examining artefacts from sites in the Northern Caucasus dated to the Late Bronze Age – Early Iron Age transition period; the so called Eastern European tradition and the Trancaucasian/Southwest Asian tradition.

The Eastern European tradition developed in the North Black Sea steppe and forest-steppe zones in the Belozer culture period (the 11th–10/9th centuries BC: *Terekhova – Erlikh 2002*, 135). This tradition was based on the technical and technological stereotype associated with the use of simple techniques such as forging of artefacts entirely of iron or heterogeneous bloomery steel (i.e. directly from unhomogenized ingots formed from blooms). Only a few artefacts showed evidence of carburizing and heat treatment, i.e. techniques improving mechanical properties of iron objects (or parts thereof).

The use of techniques typical for ironworking such as carburizing and heat treatment is a distinctive feature of the so-called Transcaucasian technological tradition (it should be noted that heat treatment included only quenching and tempering/annealing, which have been determined by presence of sorbite or even spheroidised pearlite in the samples examined). Employment of these techniques, representing a cutting-edge technology of the time, led to a significant improvement in mechanical properties of iron objects.

As has been noted earlier, these traditions underpinned two different technological models, the so-called Eastern European model and the Caucasian model. There is numerous evidence for the Eastern European model retrieved from the sites of the steppe and forest-steppe zone in Eastern Europe dated to the 9th–8th centuries BC (Klin Yar /Клин-Яр/, Pshish /Пшиш/, Kubansky and Psekupsky /Кубанский and Псекупский/ burial grounds, Sofievka /Софиевка/, Verkhny Bishkin /Верхний Бишкин/, Subbotovo /Субботово/ (*Terekhova 1997*; *Terekhova et al. 1997*, 48–55; *Shramko et al. 1977*). Most likely, the development of the Eastern European model was influenced by the Hallstatt blacksmith traditions. Recently published archaeological materials demonstrate that the Hallstatt populations made a rather strong impact on the development of the populations who lived not only in the Carpathian Region and the West Volynia Region but also across the entire forest-steppe area of the North Black Sea maritime areas (*Kashuba 2012*, 237; *Krushelnitskaya 1991*, 24; *Levitsky – Kashuba 2011*, 153). As metallographic study of iron objects from the Hallstatt sites suggests, simple technological techniques (such as forging items out of iron and bloomery steel) were predominantly employed. Items with carburized points or cutting edges are rather rare and their heat treatment was rarely applied (*Pleiner 1980*, 388–389; *Hošek 2010*).

The second (the so-called Caucasian) model has been traced through the artefacts yielded by the sites in the North and Central Caucasus (Fars, Serzhen-Yurt, Tliysky /Фарс, Сержень-Юрт, Тлийский/ burial ground: *Voznesenskaya 1975*; *Terekhova 1999*; *2002*). It emerged on the basis of ironworking experience of the Transcaucasian centres. The technique of man-made carburizing was mastered by Transcaucasian craftsmen as early as the end of the second millennium BC (*Abramishvili 1961*; *Abramishvili – Mikeladze 1970*). The Transcaucasian centres developed under the influence of the Near East centre where carburizing and heat treatment techniques had been employed as early as the 12th century BC. For example, a sorbitic quenching as a specific method of heat treatment has been documented by examining a series of iron artefacts from Urartu (*Piaskowski – Wartke 1989*, 93). It may be argued that Transcaucasian craftsmen who maintained close cultural and historical links with Anatolia absorbed both metallurgical innovations and high-tech ironworking techniques.

These two models appear to reflect different routes by which the knowledge of the use of iron penetrated into Europe from one centre (*Terekhova – Erlikh 2002*) located in Southwest Asia. The first route associated with the 'Caucasian' model traversed the Transcaucasian Region and reached the Northern Caucasus. The second route passed through Greece and the Balkans to Central and Eastern Europe (*fig. 2*).

The data discussed above show that different technological models developed in the Early Iron Age societies although knowledge of ironworking diffused from one source (Anatolia). It seems that technically advanced methods of ironworking such as carburizing and heat treatment were developed in Asia Minor at the end of the second millennium BC

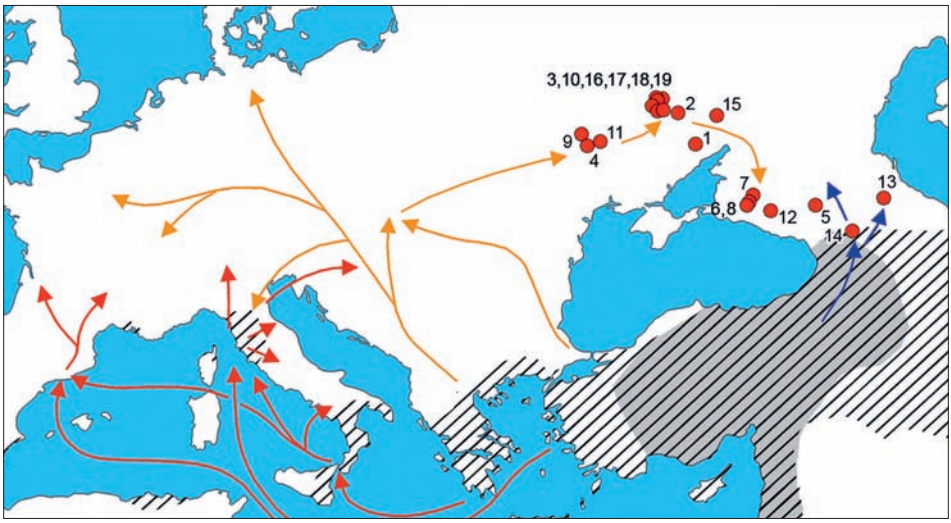

Fig. 2. Map showing directions of the diffusion of iron and the knowledge of iron metallurgy at the decline of the Bronze Age as suggested by *R. Pleiner* (*2000*, 30–31, fig. 8), corrected by authors; gray area: area of the beginning Iron Age in the Near East (15th–11th centuries BC); hatched areas: areas with a developed civilization of iron at the decline of the Bronze Age; yellow arrows: hypothesized Thraco-Hallstatt-Venetian route; blue arrows: Caucasian route; red arrows: Greek and Phoenician routes.
Archaeological sites mentioned in this article: 1 – Lyubovka /Любовка/; 2 – Oskol /Оскол/; 3 – Chervonny Shlakh-1 /Червоны Шлях-1/; 4 – Tashlyk 1 /Ташлык 1/; 5 – Klin Yar /Клин-Яр/; 6 – Pshish /Пшиш/; 7 – Kubansky cemetery Кубанский могильник; 8 – Psekupsky cemetery/ Псекупский могильник/; 9 – Sofievka /Софиевка/; 10 – Verkhny Bishkin /Верхний Бишкин/; 11 – Subbotovo /Субботово/; 12 – Fars /Фарс /; 13 – Serzhen-Yurt /Сержень-Юрт/; 14 – Tliysky cemetery /Тлийский могильник/; 15 – barrow near Vishnevy Dol /Вишневый Дол/ village; 16 – Kicevka /Кицевка/ settlement; 17 – Velikaya Topolyakha /Великая Тополяха/ settlement; 18 – Bondarikha /Бондариха/ settlement; 19 – Tymchenki /Тимченки/ settlement.
Obr. 2. Mapa znázorňující směry difúze znalosti železné metalurgie na konci doby bronzové, navržená *R. Pleinerem* (*2000*, 30–31, fig. 8) a poopravená autory článku. Šedá oblast: oblast počátku doby železné na Blízkém východě (15.–11. století př. n. l.); šrafované oblasti: oblasti s rozvinutou výrobou železa v závěru doby bronzové; žluté šipky: předpokládaná trasa thrácko-halštatsko-benátská; modré šipky: kavkazská trasa; červené šipky: řecká a fénická trasa. Archeologické lokality zmíněné v tomto článku: 1 – Ljubovka; 2 – Oskol; 3 – Červony Šljach-1; 4 – Tašlyk 1; 5 – Klin-Jar; 6 – Pšiš; 7 – Kubanskoje, mohylové pohřebiště; 8 – Psekupskoe, mohylové pohřebiště; 9 – Sofievka; 10 – Verchnij Biškin; 11 – Subbotovo; 12 – Fars; 13 – Seržen-Jurt; 14 – Tlijskoe, mohylové pohřebiště; 15 – mohyla poblíž vsi Višnevyj Dol; 16 – sídliště Kicevka; 17 – sídliště Velikaja Topoljacha; 18 – sídliště Bondaricha; 19 – sídliště Timčenki.

(*Fritz et al. 1991*; *Wheeler – Maddin 1980*). However, in the 13th–12th centuries BC links between the states of Asia Minor and the populations of the Eastern Mediterranean were disrupted by invasions of the Sea Peoples which hampered the transfer of innovative technological knowledge along the route going to the west and further to Eastern Europe. On the contrary, in the case of the north-eastern route that runs across Transcaucasia to the Northern Caucasus, there was no impediment in the diffusion of the technological knowledge. Technological innovations in Transcaucasia and the Northern Caucasus, which spread in a culturally similar environment were kept by local craftsmen as professional secrets and did not have a substantial influence on other regions of Eastern Europe. Hence, the development of the two technological models that emerged as early as the Late Bronze

Age – Early Iron Age transition period can be linked to two routes via which knowledge of ferrous metal spread from Anatolia.

References

Abramishvili, R. M. 1961: K voprosu ob osvoenii zheleza na territorii Vostochnoy Gruzii. Vestnik Gosudarstvennogo muzeya Gruzii XXII-B, 292–382.

Abramishvili, R. M. – Mikeladze, T. K. 1970: K istorii osvoeniya zheleza v Zakavkaze i Maloy Azii. In: Actes du VII-e Congrès International des sciences préhistoriques. Prague, 21–27 août, 1966, Prague: Academia, 29–31.

Bidzilya, V. I. – Voznesenskaya, G. A. – Nedopako, D. P. – Pankov, S. V. 1983: Istoriya chyornoy metallurgii i metalloobrabotki na territorii UkSSR (III v. do n.e. – III v.n.e.). Kiev: Naukova dumka.

Buynov, Yu. V. 2003: Poselennye boundary khinskoj kultury u s. Chervonyj Shlyakh na Kharkivshhyni. Vestnik Kharkovskogo gosudarstvennogo universiteta. Seriya Istoriya 35, 4–13.

Chizhevsky, A. A. 2012: K voprosu o nachale rannego zheleznogo veka v Volgo-Kame. Rossiyskiy arkheologicheskiy ezhegodnik 2, 383–399.

Esin, U. 1976: Die Anfänge der Metallwendung und Bearbeitung in Anatolien (7500–2000 v. Chr.). In: H. Müller-Karpe ed., Les débuts de la métallurgie. XIX^{e} Congrès de l'UISPP. Colloque XXIII, Nice: Centre National de la Recherche Scientifique, 209–246.

Fritz, V. – Maddin, R. – Muhly, J. D. – Stech, T. 1991: The iron from Kinneret. Materiały archeologiczne XXVI, 97–104.

Grakov, B. N. 1958: Stareyshie nahodki zheleznyih veschey v evropeyskoy chasti territorii SSSR. Sovetskaya arkheologiya 4, 3–9.

Hošek, J. 2010: Sekery s raménky pohledem metalografa. Z dějin hutnictví 40, 6–14.

Kashuba, M. T. 2012: O galshtatte i Galshtatte v Severnom Prichernomore – sovremennoe sostoyanie issledovaniy. Arkheologicheskie vesti 18, 232–252.

Krushelnitskaya, L. I. 1991: Severo-Vostochnoe Prikarpate v epohu pozdney bronzyi i rannego zheleznogo veka (problemyi etnokulturnyih protsessov). Kiev: Institut arkheologiyi NANU.

Levitsky, O. G. – Kashuba, M. T. 2011: Kurganyi u s. Kotyuzhen na yuge Srednego Podnestrovya i problema «frako-kimmeriyskih» drevnostey (opyit izucheniya «pustyih» pogrebeniy). Arkheologicheskie vesti 17, 239–258.

Liebowitz, H. – Folk, R. 1984: The Dawn of Iron Smelting in Palestine: The Late Bronze Age Smelter at Tel Yin'am. Preliminary Report. Journal of Field Archaeology 11, 265–280.

Morgan, L. 1935: Drevnee obscshestvo. Leningrad: Institut narodov Severa (Lewis H. Morgan: Ancient society).

Pernicka, E. 1990: Gewinnung und Verbreitung der Metalle in prähistorischer Zeit. Jahrbuch des Römisch-Germanischen Zentralmuseums 37, 21–129.

Piaskowski, J. – Wartke, R.-B. 1989: Technologische Untersuchungen an einigen urartäischen Eisenobjekten aus Toprakkale. Forschungen und Berichte 27, 89–113.

Pleiner, R. 1980: Early Iron Metallurgy in Europe. In: T. A. Wertime – J. D. Muhly eds., The coming of age of iron, New Haven: Yale University Press, 375–415.

Pleiner, R. 2000: Iron in Archaeology. The European Bloomery Smelters. Praha: Archeologický ústav AV ČR.

Radzievska, V. E. – Shramko, B. A. 1980: Novi arkheologichni pamyatky na Kharkivshhyni. Arkheologiya 33, 100–108.

Shramko, B. A. – Fomin, L. D. – Solntsev, L. A. 1977: Nachalnyiy etap obrabotki zheleza v Vostochnoy Evrope (doskifskiy period). Sovetskaya arkheologiya 1, 57–74.

Shramko, I. B. – Buynov, Yu. V. 2012: Perehod ot bronzyi k zhelezu v Dnepro-Donetskoy lesostepi. Rossiyskiy arkheologicheskiy ezhegodnik 2, 309–332.

Stojić, M. 2006: Ferrous metallurgy center of the Brnjica cultural group (14th–13th centuries BC) at the Hisar site in Leskovac. Metalurgija – Journal of Metallurgy 12/2–3, 105–110.

Terekhova, N. N. 1997: Rezultatyi metallograficheskogo issledovaniya kuznechnyih izdeliy predskifskogo i skifskogo vremeni iz pamyatnikov Pyatigorya i Chechni. In: Nekotoryie voprosyi kulturnyih i etniches-

kih svyazey naseleniya Severnogo Kavkaza v epohu pozdney bronzyi – rannego zheleza, Armavir: Armavirskiy gosudarstvennyiy pedagogicheskiy institute, 64–70.

Terekhova, N. N. 1999: K voprosu o proishozhdenii chyornogo metalla iz mogilnika Fars/Kladyi. In: A. M. Leskov – V. R. Erlih, Mogilnik Fars/Kladyi, Moskva: Gosudarstvennyiy muzey Vostoka, 158–161.

Terekhova, N. N. 2002: Tehnologicheskie traditsii v obrabotke chyornogo metalla iz mogilnika Serzhen-Yurt. In: V. I. Kozenkova, U istokov gorskogo mentaliteta. Mogilnik epohi pozdney bronzyi – rannego zheleza u aula Serzhen-Yurt, Chechnya, Moskva: Pamyatniki istoricheskoy myisli, 151–154.

Terekhova, N. N. – Erlikh, V. R. 2002: K probleme perehoda k rannemu zheleznomu veku na Severnom Kavkaze. Dve kulturno-istoricheskie traditsii. Materialnaya kultura Vostoka 3, 134–152.

Terekhova, N. N. – Rozanova, L. S. – Zavyalov, V. I. – Tolmachyova, M. M. 1997: Ocherki po istorii drevney zhelezoobrabotki v Vostochnoy Evrope. Moskva: Metallurgiya.

Voznesenskaya, G. A. 1975: Tehnologiya proizvodstva zheleznyih predmetov Tliyskogo mogilnika. In: B. A. Kolchin ed., Ocherki tehnologii drevneyshih proizvodstv, Moskva: Nauka, 76–116.

Waldbaum, J. C. 1978: From bronze to iron. Göteborg: Paul Åströms Förlag.

Waldbaum, J. C. 1980: The First Archaeological Appearance of Iron and the Transition to the Iron Age. In: T. A. Wertime – J. D. Muhly eds., The coming of age of iron, New Haven: Yale University Press, 69–98.

Wheeler, T. S. – Maddin, R. 1980: Metallurgy and Ancient Man. In: T. A. Wertime – J. D. Muhly eds., The coming of age of iron, New Haven: Yale University Press, 99–126.

Yalçin, Ü. 1999: Early Iron metallurgy in Anatolia. Anatolian Studies 49, 177–187.

VLADIMIR I. ZAVYALOV, Institute of Archaeology RAS, ul. Dm. Ulyanova 19, 117036 Moskva, Russia
v_zavyalov@list.ru
NATALIYA N. TEREKHOVA, Institute of Archaeology RAS, ul. Dm. Ulyanova 19, 117036 Moskva, Russia
nnterekhova33@mail.ru