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The Taldysay Settlement: a Site of Ancient Metallurgy in the Zhezkazgan-Ulytau Mining and Metallurgical Center¹

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Тірек сөздер: Жезқазған-Ұлытау таулы металлургия орталығы; тұрғын үй-өндірістік кешені; металл өндірісі; металл өңдеу; мыс қорыту құралдары; руда; шлак; легирлеу (қыю)

Ключевые слова: Жезказган-Улытауский ГМЦ; производственно-жилищные комплексы; металлопроизводство; металлообработка; теплотехнические сооружения; руда; шлак; легирование

The publication examines the problems of metallurgy of the Late Bronze Age. With the use of scientific research data, it became possible to restore the entire technological process of production of metal products, starting from the extraction of copper from ore to the manufacture of complex objects from copper and copper alloys. In the Taldysay Settlement, almost the entire cycle of metal production was represented: smelting copper from ore, casting end-products, and forging them, which made it possible to obtain information on ancient technologies. The final stage of metallurgical production is metalworking, which includes various foundry and forging operations, as well as side operations: preparation of crucibles, lyachkas, casting molds, and stone tools for metal processing.

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Талдысай қонысы – Жезқазған-Ұлытау таулы-металлургия орталығындағы ежелгі ескерткіш

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Мақалада кейінгі қолда дәуірі кезеңіндегі металлургия мәселелері қарастырылған. Жаратылыстанудың ғылыми зерттеулерін пайдалана отырып, рудадан мыс алудан бастап, мыс пен мыс қоспаларынан алуан түрлі күрделі өнім өндіруге дейінгі технологиялық процесті толық қалпына келтіруге мүмкіндік туды. Талдысай қонысында рудадан мыс қорыту, бұйым жасау, өңдеу секілді металл өндірісінің әрбір сатысы түгелге жуық бар. Ежелгі технологиядан бұл да жақсы мәлімет береді. Металл өңдеу, ұстахана жұмыстары, мыс құю, ол үшін үшін тастан қалып пен ыдыс жасау – бәрі де металлургия өндірісінің соңғы сатылары саналады.

Қаржыландыру көзі: Мақала ҚР ҰҖБМ ҰК бағдарламалық-нысаналы қаржыландыру аясында дайындалған, ЖТН BR20280993.

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Поселение Талдысай – памятник древней металлургии в Жезказган-Улытауском горно-металлургическом центре

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В публикации рассматриваются проблемы металлургии позднебронзовой эпохи. С привлечением данных естественно-научных исследований представилось возможным восстановить полностью технологический процесс производства изделий, начиная от получения меди из руды до изготовления сложных предметов из меди и медных сплавов. На поселении Талдысай был представлен почти весь цикл металлопроизводства: выплавка меди из руды, литье готовых изделий, их кузнечная доработка, что сделало возможным получить сведения по древним технологиям. Завершающей стадией металлургического производства является металлообработка, включающая различные литейные и кузнечные операции, а также побочные операции: приготовление тиглей, льячек, литейных форм, каменных орудий для обработки металла.

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Introduction

The research group uses materials from the Taldysay Settlement to resolve issues related to the technical side of the metal production process. Many years of field archaeological research on the settlement contributed to the accumulation of metal products, which made it possible to carry out complex reconstruction and experimental work to recreate both the general design of smelting furnaces and the technological process of obtaining copper in them and making products from it.

In the system of the West Asian (Eurasian) Metallurgical Province (EAMP) of the Late Bronze Age (LBA), the most important producers of copper and bronze were the mining and metallurgical centers (MMC) of present Qazaqstan (Fig. 1.a).

One of the largest, the Zhezkazgan-Ulytau MMC, operated in the territory of the present Central Qazaqstan and was based on the development of the rich Zhezkazgan copper ore deposits [Berdenov 1998: 184–185]. As a result of geological and archaeological research in the 1930–1950s, numerous ancient developments and settlements for copper mining and smelting were identified [Valukinsky 1948: 33–39; Margulan 2001: 20, 53–54]. During the development of industrial quarries, all of them were destroyed. For the Taldysay Settlement, its location outside

ГОРНО-МЕТАЛЛУРГИЧЕСКИЕ ОБЛАСТИ И ЦЕНТРЫ

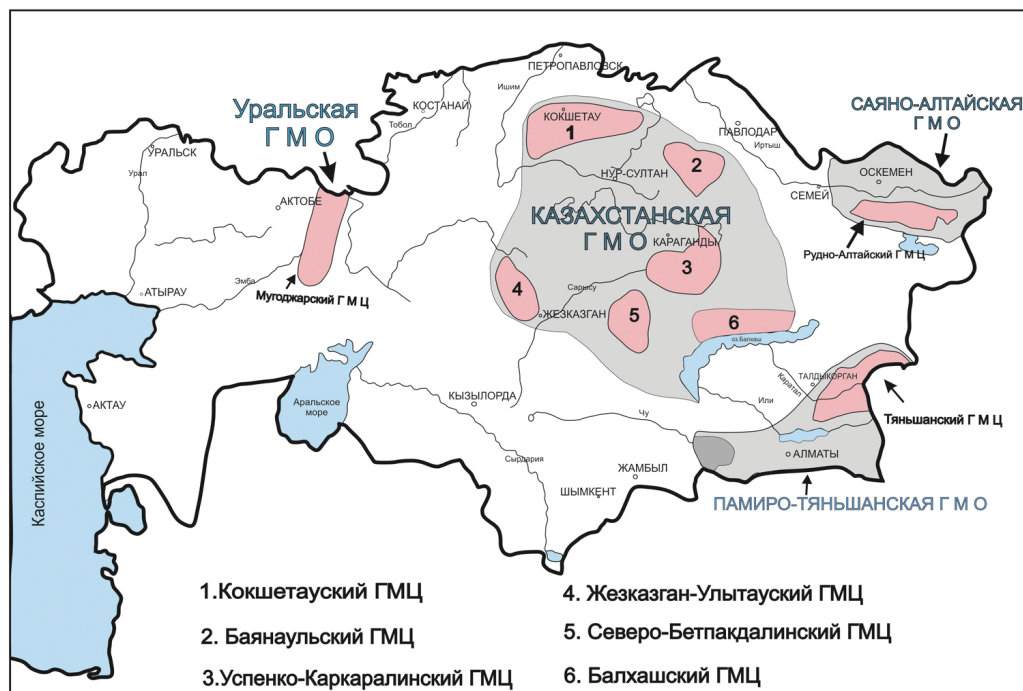


Fig. 1. a) Mining and metallurgical regions and centers of Qazaqstan (according to E.N. Chernykh, S.A. Berdenov); b) General view of the Taldysay Settlement (aerial photography by Renato Sala and Jean-Marc Deom)

1-сур. а) Қазақстанның таулы-металлургия облыстары мен орталықтары (Е.Н. Черных, С.А. Берденов бойынша); б) Талдысай қонысының жалпы көрінісі (аэрофототүсірілім: Р. Сало және Ж.-М. Деом)

Рис. 1. а) Горно-металлургические области и центры Казахстана (по Е.Н. Черных, С.А. Берденову); б) Общий вид на поселение Талдысай (аэрофотосъемка: Р. Сало и Ж.-М. Деом)

the industrial development zone turned out to be a saving grace. The settlement is in the tract of the same name at the confluence of the Ulken Zhezdy and Bala Zhezdy rivers in the present Ulytau administrative district of the Ulytau region (Fig. 1.b).

Since the early 1990s, a comprehensive study of the site has been carried out, including field and laboratory research using natural scientific methods and experimental and three-dimensional modeling (Fig. 2). These works contribute to the solution of controversial problems not only of the Zhezkazgan-Ulytau MMC, but also of the ancient copper metallurgy of Qazaqstan as a whole.

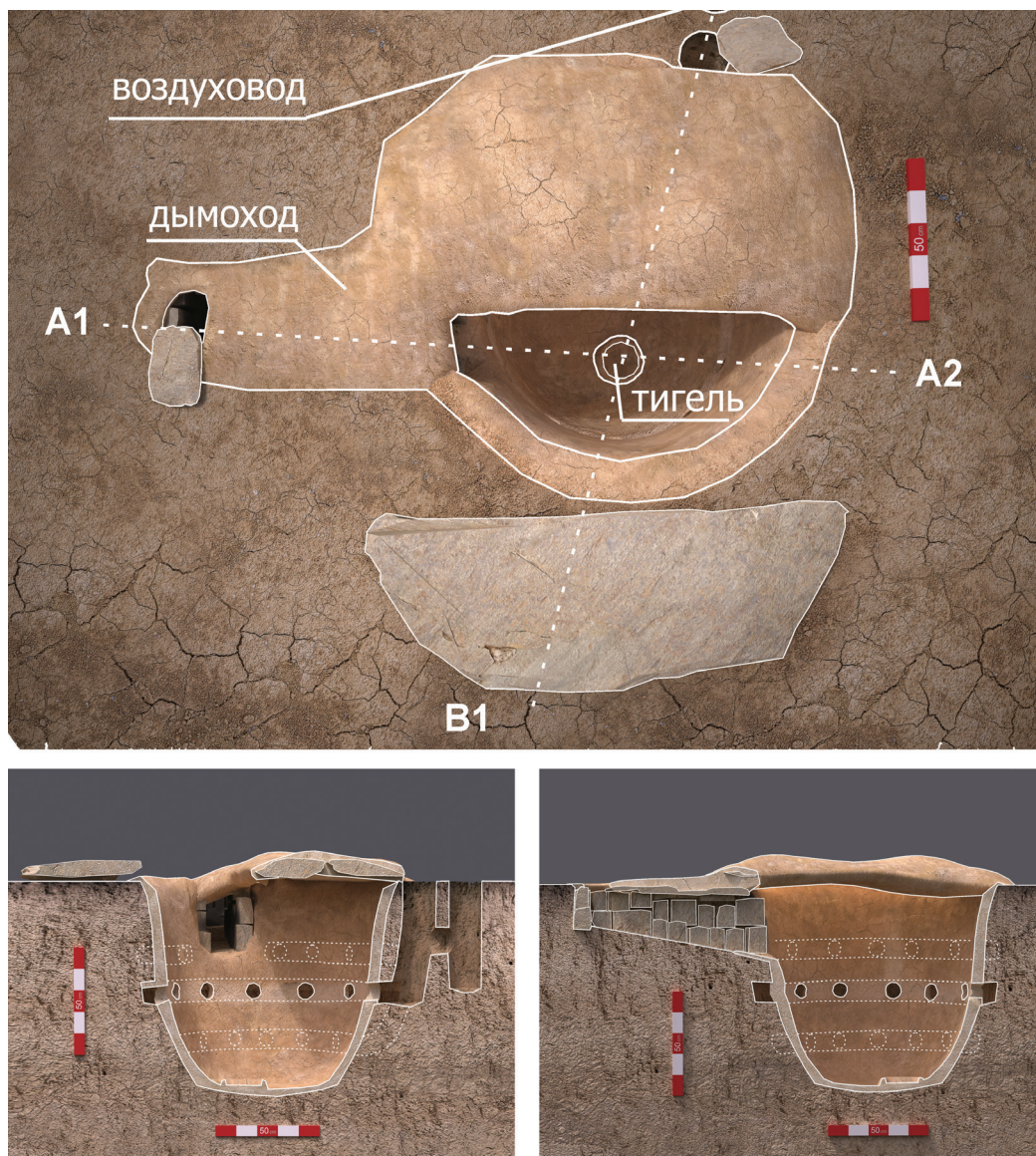


Fig.2. Taldysay Settlement. Three-dimensional graphic model of a thermal engineering structure (TES) of a half-shaft type.

2-сур. Талдысай қонысы. Мыс қорытуға арналған, жартылай жер астына қазылған ошақтың графикалық көрінісі

Рис. 2. Поселение Талдысай. Трехмерная графическая модель полушахтного теплотехнического сооружения (ТТС)

Results

At the settlement, thermal engineering structures (TES) of various types formed industrial and housing complexes, indicating the appearance of specialized settlements of metallurgists in the MMC during the Bronze Age (Fig. 3–8). Industrial and housing complexes functioned on Taldysay throughout the Late Bronze Age (2nd millennium BC), starting from the objects of the Petrovka culture (Nurtay type of sites) to the buildings of the Andronovo horizon [Ermolaeva 2016: 126–141; Ermolaeva et al. 2017: 22–38]. The metallurgical specialization of the settlement, like the entire Zhezkazgan-Ulytau MMC, was dictated by the richest deposits of oxidized and sulfide copper ore.

Open metallurgical complexes and impressive collections of different categories of finds determined the specialization of the inhabitants of the settlement in metal production, represented by the smelting of copper from ores and metalworking, consisting of various foundry

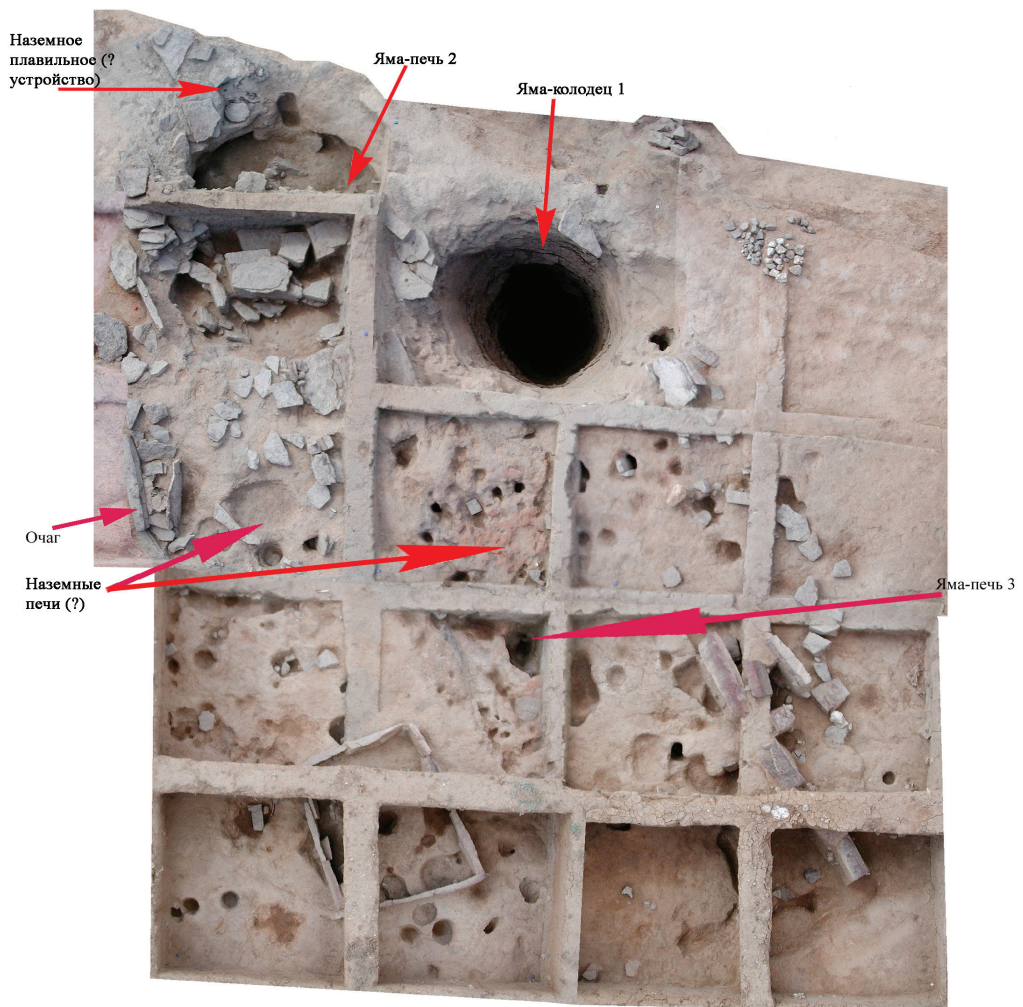


Fig. 3. Taldysay Settlement. Western Housing and Industrial Complex (WHIC). Photo collage. General view from the north side of the production site

3-сур. Талдысай қонысы. Батыс тұрғын үй-өндірістік кешені. Фотоколлаж. Өндірістік алаңның солтүстік жағынан қарағандағы көрінісі

Рис. 3. Поселение Талдысай. Западный жилищно-производственный комплекс (ЗЖПК). Фотоколлаж. Общий вид с северной стороны производственной площадки

and forging operations, as well as the preparation of crucibles, lyachkas, casting molds, and stone tools for metal processing.

According to the classification, all thermal engineering structures (TES) were divided mainly into three types according to the criteria of relation to the surface and fundamental differences in the internal and external structure.

1) Mine-type TES, sunk into the ground up to two meters or more, with long horizontal chimneys and a complex air-conducting system. Furnaces of this type operated without forced blast (Fig. 4: a, c–d).

2) TESs of the ground type were small, had a slight depth of the furnace into the ground, and operated on forced blast using bellows (Fig. 4: b).

3) The transitional option was probably a half-shaft type TES, buried half a meter to a meter into the ground. This includes TESs that were varied in their design, having similarities in individual design elements with both types of stoves, including with different options for

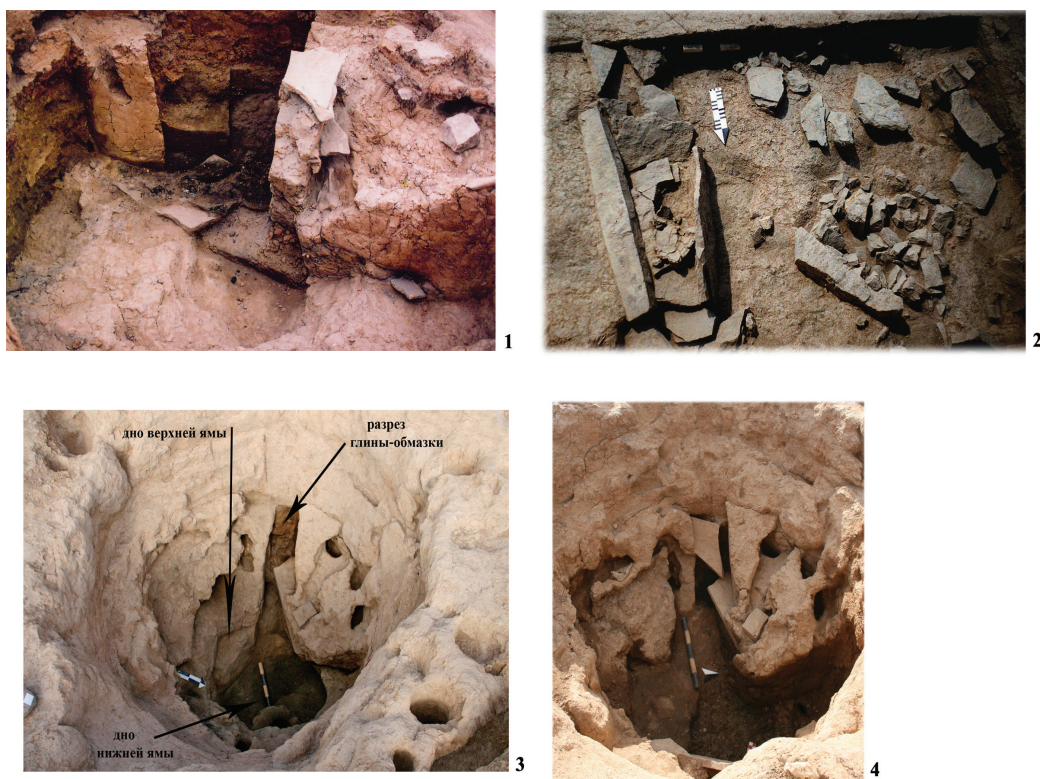


Fig. 4. Taldysay Settlement. a) Western Housing and Industrial Complex, the shaft-type thermal engineering structure; b) Western Housing and Industrial Complex, the ground-type thermal engineering structure; c–d) Eastern Housing and Industrial Complex, the thermal engineering structure of shaft type

4-сур. Талдысай қонысы. а) Батыс тұрғын үй-өндірістік кешені, мыс қорытқыш ошақ түрі; б) Батыс тұрғын үй-өндірістік кешені, жер бетіндегі мыс қорытқыш ошақ; в) Батыс тұрғын үй-өндірістік кешені, теплотехническое сооружение наземного типа; с–д) Шығыс тұрғын үй-өндірістік кешені, мыс қорытқыш ошақ

Рис. 4. Поселение Талдысай. а) Западный жилищно-производственный комплекс, теплотехническое сооружение шахтного типа; б) Западный жилищно-производственный комплекс, теплотехническое сооружение наземного типа; с–д) Восточный жилищно-производственный комплекс, теплотехническое сооружение шахтного типа

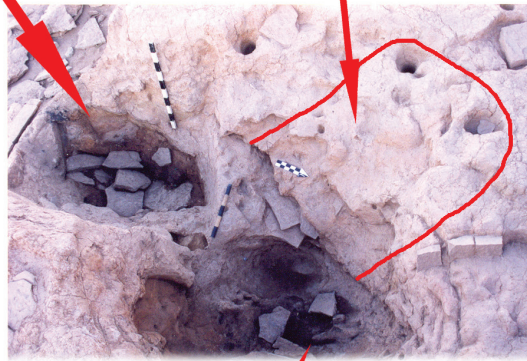




1

ЗАПАДНАЯ СЕКЦИЯ

ЮЖНАЯ СЕКЦИЯ



2

СЕВЕРНАЯ СЕКЦИЯ



3



Fig. 5. Taldysay Settlement. Eastern Housing and Industrial Complex, the three-section thermal technical structure of shaft type. a) southern section; b–c) southern, northern, and western sections

5-сур. Талдысай қонысы. Шығыс тұрғын үй-өндірістік кешені, жерді қазып жасалған мыс қорытқыш ошақ. а) оңтүстік секциясы; б–с) оңтүстік, солтүстік және батыс секциясы

Рис. 5. Поселение Талдысай. Восточный жилищно-производственный комплекс, трехсекционное теплотехническое сооружение шахтного типа. а) южная секция; б–с) южная, северная и западная секции

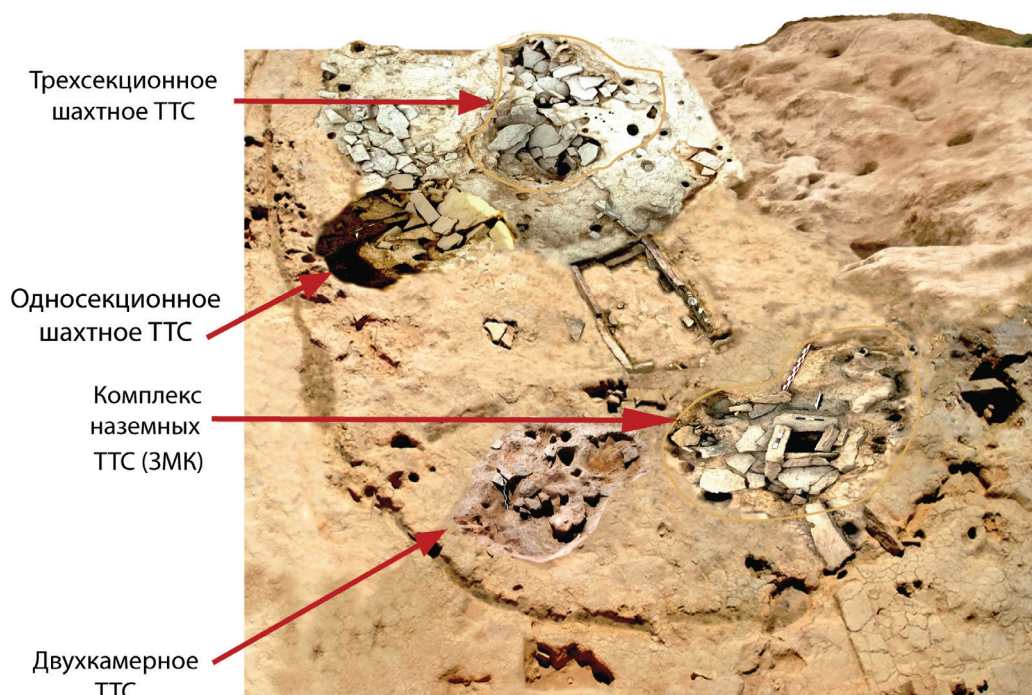


Fig. 6. Taldysay Settlement. Eastern Housing and Industrial Complex, the thermal engineering structure of shaft and ground types. Photo collage

6-сур. Талдысай қонысы. Шығыс тұрғын үй - өндірістік кешені, жер бетіне және жер астына салынған мыс қорытқыш ошақ. Фотоколлаж

Рис. 6. Поселение Талдысай. Восточный жилищно-производственный комплекс, теплотехническое сооружение шахтного и наземного типов. Фотоколлаж

chimneys (Fig. 7). The same type includes three-section TESs (Fig. 5), which could be used for roasting primary sulfides [Rusanov, Ermolaeva 2011: 36–58].

Taldysay thermal engineering structures of ground type are similar to the designs of furnaces in different regions of Eurasia: in present Northern Qazaqstan at the settlement of the Petrovka culture Semiozerka 2, at the fortified settlements of the Sintashta culture in the Southern Urals, at the Chervone Ozero-3 Settlement of the Srubna culture of the Kartamysh archaeological district of the Donetsk Mining and Metallurgical Center (Eastern Ukraine) [Grigor'ev 2000: 444–531; Brovender 2013: 127–151]. It is probable that only basic models were borrowed, based on the similarity of metallurgical processing technology, without a complete imitation of the TES designs of these regions.

Metallurgists of Sary-Arqa, working in different environmental conditions with a limited possibility of obtaining charcoal, had Zhezkazgan deposits rich in copper sulfide ore as a source of raw material, so they significantly modified the design of the TESs, transferring them mainly to the mode of natural rather than forced air injection. In shaft-type furnaces, the redistribution of sulfide copper ore was carried out.

The main parameters of the Taldysay metallurgical furnaces were replicated by Igor Rusanov, who designed three types of TES in 2012–2013. The experiment confirmed the identification of thermal engineering structures with copper smelting furnaces for smelting copper from oxidized and sulfide ores [Rusanov 2013: 364–388].

Experiments showed that the process of producing copper from secondary sulfides was simpler and less expensive: savings in fuel, labor, and time were achieved; copper smelting was more efficient with less effort and expense. The use of thermal units of such sizes as mine-type TES is



1



2



Fig. 7. Taldysay Settlement. Northern Housing and Industrial Complex, the semi-shaft type thermal engineering structure with a chimney

7-сур. Талдысай қонысы. Солтүстік тұрғын үй – өндірістік кешені, жартылай жерге қазылған, мыс қорытқыш мұржалы ошақ

Рис. 7. Поселение Талдысай. Северный жилищно-производственный комплекс, теплотехническое сооружение полушахтного типа с дымоходом

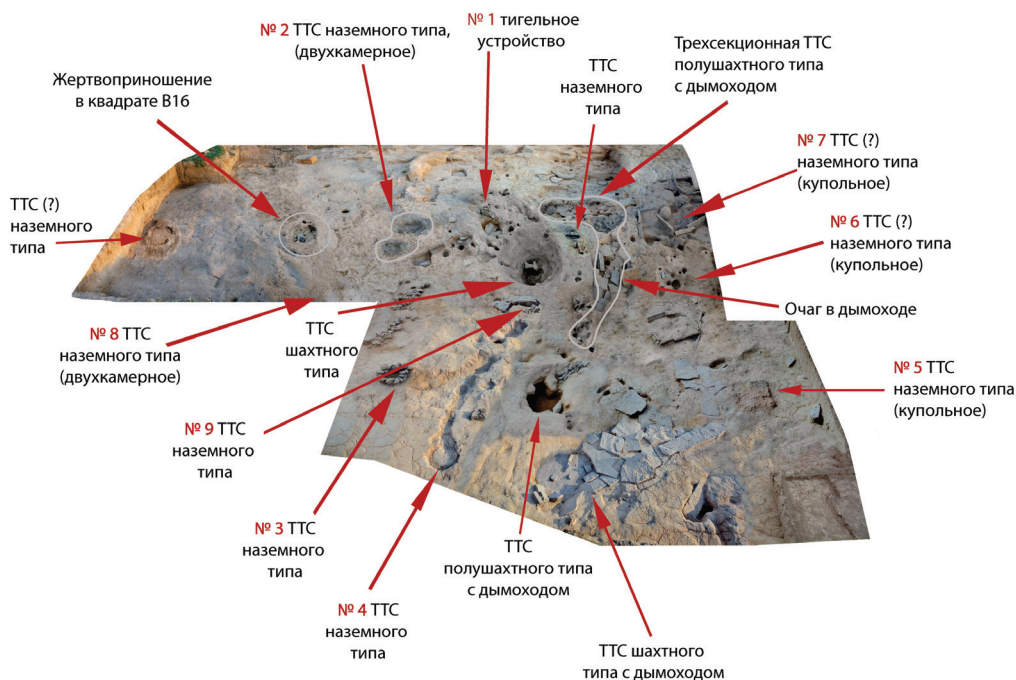


Fig. 8. Taldysay Settlement. Northern Housing and Industrial Complex. Photo collage. General view from the north. Thermal engineering structures of shaft, half-shaft, and ground types 8-сур. Талдысай қонысы. Солтүстік тұрғын үй-өндірістік кешені. Фотоколлаж. Солтүстігінен қарағандағы жалпы көрінісі. Жер бетіне және жартылай жер астына салынған ошақ
 Рис. 8. Поселение Талдысай. Северный жилищно-производственный комплекс. Фотоколлаж. Общий вид с северной стороны. Теплотехническое сооружение шахтного, полушахтного и наземного типов

due to the lack of fuel in the semi-desert region of Ulytau and the presence of easily accessible copper raw materials, i.e. secondary sulfides. Experiments and calculations confirmed that the use of a mine-type TES at Taldysay provided significant fuel savings due to the exothermal combustion of sulfur, which increases the melting point of copper.

Using the example of the Taldysay TES and the experiment carried out, it was confirmed that all pits of this type, indeed, had air ducts like the TESs of Atasu, Myrzhiik, Aqmustafa settlements of the North Betpaqдала MMC [Kadyrbaev 1983: 134–142; Kadyrbaev, Kurmankulov 1992: 245].

The study of fragments of copper ores and metallurgical slag showed that both oxidized malachite-azurite and sulfide chalcocite-covellite copper ores were used at the Taldysay Settlement. Almost the entire metallurgical cycle was carried out at the settlement: smelting copper from ore, casting products, and forging them.

The presence of not only copper smelting, but also copper foundry production is confirmed by finds of copper end-products: knives (Fig. 9: b–c), punches, chisels, awls, needles, paper clips, beads, etc., stone (Fig. 10: b) and ceramic casting molds, ceramic lyachkas, nozzles and crucibles (Fig. 10: a, c), bone and stone polishes for polishing products after casting.

Weaponry, which includes arrowheads made of stone, bone, and copper, and casting molds made of talc, is the most representative category of finds. Copper arrowheads are morphologically diverse and chronologically mark different stages of the functioning of the site during the 2nd millennium BC. (Fig. 9: a). All of them belong to the forged and cast classes. The nature of the nozzle makes arrowheads with a protruding and hidden socket from the Early Alakul period stand out among the forged ones. After being cast into a mold, each piece was subjected to extensive

forging. Knives made using forged and cast technologies (Fig. 9: b-c) are another diagnostic category of products.

South Korean archaeometallurgist Jang-Sik Park has conducted an extensive technological study of the metal. A study of the chemical composition and manufacturing technology of metal products has shown that many products were made using casting + forging technology and were subjected to extensive forging finishing. Emphasis on forging was associated with the use of unalloyed copper, where metallurgically “pure” copper was used as the starting material.

The combined use of unalloyed copper as a raw material and extensive machining as a key fabrication method demonstrates knowledge of the material properties that are determined by various thermal and mechanical treatments. In this technological tradition, thermomechanical processing has played a key role in suppressing the undesirable effects encountered when using nearly pure copper. Forging may be the primary method of shaping the material, during which noticeable reinforcement may be observed. The manufacturing method must be carefully coordinated with the chemical composition of the alloys used, which, apparently, was considered and understood by the ancient foundries. It is important to note that there were items added with tin and containing appreciable amounts of arsenic, indicating that these elements were available on a limited scale and their beneficial effects were known at the time.

Ilaria Calgaro and Miljana Radivojević from University of London analyzed experimental slags and copper ingots that were obtained by melting a charge of secondary sulfides in an experimental shaft furnace similar to the ancient one. As a result, it was confirmed that, in general, the slags and ingots obtained during Rusanov’s experiment correspond in composition and microstructure

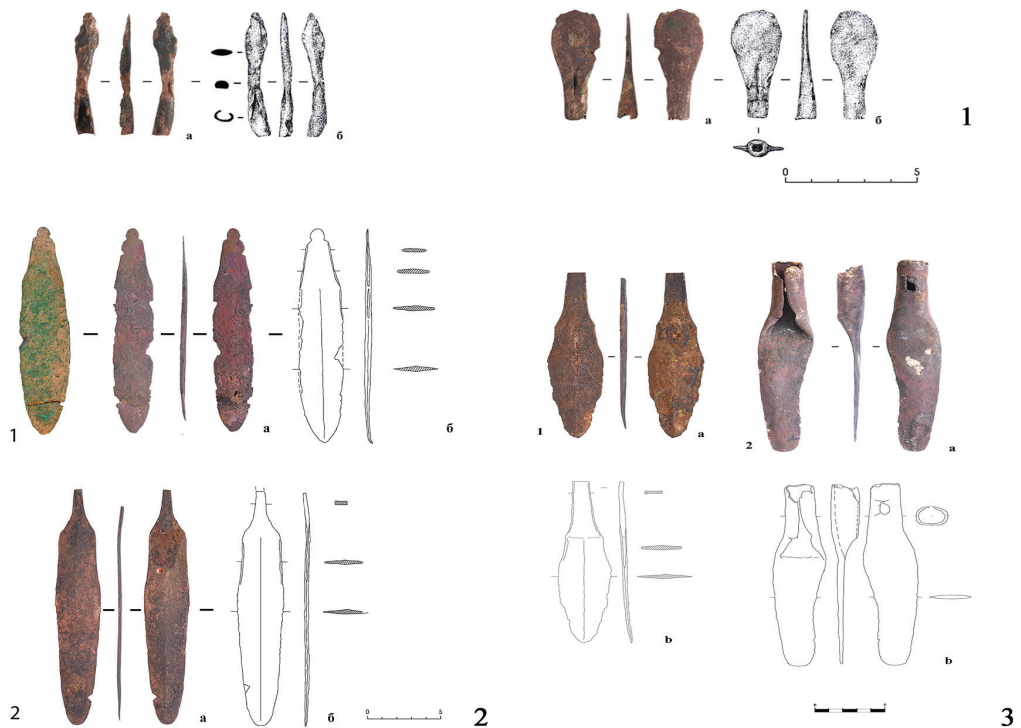


Fig. 9. Taldysay Settlement. a) metal arrowheads; b–c) metal knives

9-сур. Талдысай қонысы. а) жебенің металл ұшы; б–с) металл пышақтар

Рис. 9. Поселение Талдысай. а) металлические наконечники стрел; б–с) металлические ножи



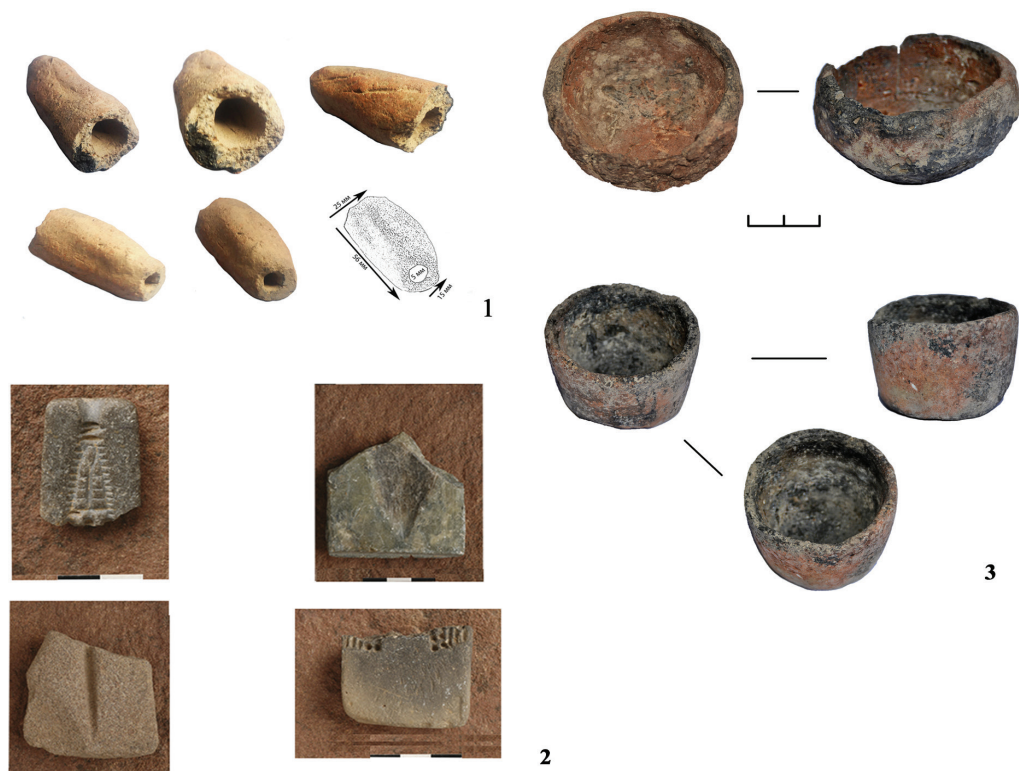


Fig. 10. Taldysay Settlement. a) clay nozzles; b) clay crucibles; c) stone casting molds
10-сур. Талдысай қонысы. а) сазтөбе; б) металл ерітетін саз ыдыс; с) тас қалыптар
Рис. 10. Поселение Талдысай. а) глиняные сопла; б) глиняные тигли; с) каменные литейные
формы



to the ingots found in the shaft furnaces of Taldysay or nearby. The analysis confirmed the actual correspondence of the functioning of experimental mine-type TES with ancient metallurgical furnaces and the reproduction of the experiment with good results, which allows to extend this information to other Bronze Age sites on which the same or similar smelting structures are located.

Conclusions

Thus, the metallurgical specialization of the population of the Zhezkazgan-Ulytau MMC was dictated by the richest deposits of oxidized and sulfide copper ore. The industrial and housing complexes identified in the settlements reflect a developed paleo economic infrastructure with mining, metallurgical and metalworking specialization, as well as the development of ceramic, leather, bone-carving, and woodworking industries. The study of the Taldysay Settlement has been carried out comprehensively. Using materials from the settlement, issues related to the technique and technology of metal production in the Late Bronze Age in the MMC have been resolved.

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