Local versions realizing the pastoral model of metal production in conditions of the steppe ecosystems in the Urals-Mygodzhary region in the Late Bronze Age

V Tkachev
ORCID 0000-0002-6355-1745

Institute of Steppe of the Ural Branch of the Russian Academy of Sciences, Orenburg, Russia
E-mail: vit-tkachev@yandex.ru

Abstract. Based on the results of the landscape-archeological studies in the Urals-Mygodzhary region and historical-ethnographic data, the problem of variability to realize the pasturable model metal production in the Late Bronze Age is discussed in the paper. The economic-cultural system is characterized by a harmonious combination of mobile livestock based on pastures and water sources' seasonal rotation and separate technological stages of mining and metallurgical production. It was maximally adapted to the local steppe ecosystems' peculiarities and promoted to save their dynamic balance due to rational use of natural-resource potential.

1. Introduction
The principal task of historical-metallurgical studies is to systematize an enormous bulk of data on mining, metallurgy, metalworking production, and exchange in the metal production sphere. It often promotes the potential of the archeological sources to reconstruct various economic-cultural systems of the paleometal epoch. A line of cultural novelties marked the beginning of the Bronze Age in the steppe of North Eurasia. The formation of the pastoral model of metal production was the most outstanding achievements of that time. This model was characterized by a set of stable technological algorithms for multistage pyrometallurgical treatment of copper ore represented, mainly, by secondary sulfides [1]. These discoveries promoted to development of practically all deposits and ore occurrences accessible in ancient times and associated with different geological structures. They acted as technological criteria of the historical epoch enveloped the long period from the IV to the II centuries BC, and called “the Bronze Age.”

The mentioned technological novelties in the Late Bronze Age (LBA) touched on the Urals-Mygodzhary region, where considerable copper resources had been placed. On the southern spurs of the Ural Mountains in LBA, the independent mining and metallurgical center (MMC) was formed. It was connected with the bearer's metal productional variants belonging to the Alakuliskaya culture [2, 3, 4]. The Urals-Mygodzhary MMC played a significant role in the most extensive historical metallurgical formation of the LBA system – the West Asian (Eurasian) metallurgical province [5].

The universal character of key technological links of the pastoral metalworking model on the vast space of the Eurasian steppe belt does not raise doubts. Nevertheless, mechanisms of its realization were not studied not enough. Variability of the economic-cultural models was determined by cultural traditions of different groups of population, presence or absence of copper sources and compound raw
material for the nonferrous metal industry, directions of contacts connected with metal traffic, and other factors.
However, peculiarities of developed steppe and mountainous-steppe geosystems, including landscape catens of different types forming the concrete human, population’s living environment had the most significant meaning.
Livestock of a different kind of mobility was in the base of the population's life support system in the Bronze epoch within the steppes of Eurasia. It was this condition, which caused an option of adaptive strategies. In this case, the character of the organization of mining and metallurgical production, to a considerable degree, depended on peculiarities of livestock sector management. Materials of LBA from the Urals-Mygodzhary region promote reconstructing some variants of realization of the metal production pastoral model characterized by the harmonious combination of mobile livestock based on the seasonal rotation of pastures and water objects and separate stages of mining and metallurgical production.

2. Materials and Methods
Model archeological micro-regions (AMR) confined to geoarchaeological industrial objects represented by ancient mines on the area of copper deposits and ore occurrences having different geological positions within the Ural ophiolitic belt were selected as reference research polygons. Regions of the study evenly spread within the Ural-Mugodzhary area that promotes to form an objective view on mechanisms of local economic-cultural models' functioning in separated steppe and mountainous-steppe ecosystems, taking into account latitudinal and altitudinal zonality and vertical differentiation of landscapes. Based on physical-geographical demarcation, the mentioned area lays within the South Ural steppe foothills-plain space and Mugodzhary that had united before in the frame of the Urals-Mugodzhary low-mountain province [6, p. 1663-1664, table 2, figure 1; 7, p. 93, figure 24; 8, p. 58-59].

In the north-west part of the region, the most studied archeological micro-regions were the Iskininskiy and Shansharskiy AMR. They are located within the Guberlinskoe riverside hillocky area and the Alimbet-Kargalinskiy range hillocky space of the Sarinskiy-Guberlinskiy district in the Central South Ural province. Copper ore objects, around which numerous archeological monuments of LBA concentrated, are located in the Great Ural split zone and are confined to hyperbasitic and talc-carbonate ore-bearing complexes connected with pyritic emplacement. These regions represented themselves as etalon samples of mountainous-steppe landscape catens.

In the northeast of the Urals-Mygodzhary MMC, landscape archeological studies of the Elenovskiy and Ushkattinskiy AMR were conducted in the Basin of Kamsak River placed in the subzone of the south steppe of the Verkhnekumakskiy hilly-residual rocks area of the Or-Kumakskiy districts in the Ural-Tobol upland province. Small groups of archeological objects are placed in the outskirts of LBA mines. They expose oxidation and secondary enrichment zones of copper pyrite and porphyritic copper deposits and ore-bearing complexes represented by pyroxenite, basalt, jasper, granitoid, and contact areas in the geological structures of the Dombarovskiy ore region.

On the south end of the Urals-Mygodzhary MMC, objects of the study were the Shuuldakskiy and Sarlybayskiy AMR in the upper reaches of the Shet-Irgiz River within the similar physical geographical space of the Kaulzhursko-Shet-Irgiz district in the East Mygodzhary plain-hilly province. Mining workings for copper in the Late Bronze Age within the South Mygodzhary (Berchogurskiy) ore region were associated with copper-pyrite-basalt ore complexes having jasper interlayers and contact zones of basalt with granitoid, where ore mineralization was connected with sulfide-siliceous lodes. In the landscape relation, the peneplain of East Mugodzhary, in its southern part, represents itself as an elevated hilly plain on the border of steppe and semi-desert zones.

The methodological base of the realized research program was a complicated approach. It is used successfully in Landscape Archaeology, isolated as an independent branch of the science in the middle of the 1970s from Settlement Archaeology. It suffered a considerable influence of post-processualism [9, p. 9-10]. The landscape approach of studying monuments of ancient history has developed more
dynamically in the USA, Australia, and Europe [10, 11, 12]. Overall, this branch's formation was the logical result of adaptation in the archeological context of the concept of the cultural landscape worked out initially in geography and then introduced into the research practice of philosophy, culturology, ethnology, linguistics, sociology. Therefore, sometimes such an approach is called archeology of cultural landscape.

Originally, Landscape Archeology was directed to connect objects of material cultures with concrete geosystems to realize adaptive strategies and transform human activity (the anthropogenic effect on the environment). Landscape Archeology represented itself as a set of specific research measures having an interdisciplinary character. Later, at the degree of phenomenological approach establishment focused on studying the structure of human experience and mind, this branch considerably widened research horizons at the expense of conceptual and socio-cultural aspects that especially characterized the British school of Landscape Archeology [13].

In the course of the study of archeological monuments and geoarchaeological industrial objects of LBA in the Ural-Mugodzhary region, almost all arsenal of landscape archeology's methods were used: GIS-technologies, including the modern techniques of cartography with the usage of devices of global positioning, decoding of satellite and air survey, instrumental topographic geodetic survey, methods of shallow geophysics (magnetometric and georadar survey), paleo-soil, palynological, archeo-zoological, paleo-anthropological, geoarchaeological, archeometrical (including isotopic) studies.

Introduction of research measures of the methods of biological, technical, and exact studies listed above promotes the humanitarian potential of material sources focusing on a human being and its activity [14, p. 41]. Comparison with historical-ethnographic data on cattle-breeding farms of the Bashkir and Kazakh population within the mentioned territories in the XVIII – the beginning of the XX c. showed high effectiveness at the level of received data interpretation.

3. Strategy of Adaptation and Economic-Cultures Models

All studied compact groups of archeological monuments coincided with copper ore objects developed in LBA are located within the steppe and mountainous-steppe ecosystems of the Ural-Mugodzary region. In the course of the landscape-archeological studies, it was ascertained that a basis of the life support system was livestock under hunting's subsidiary role. There are no signs of agriculture. Species composition of a herd corresponded to the steppe type of livestock breeding and included cattle, goats and sheep, horses, sometimes, Bactrian camels. There were not pigs. A dog was used in the economy, but it was not eaten. Hunting played a subsidiary role. Wild animal's bones reach 10% of osteological collections in settlements. Roe and wild boar inhabited in flood-plain forests along steppe rivers were commercial ungulates. Marmots, polecats, hares, corsac foxes, and foxes were the kill objects.

The adaptive strategy realized by the population of LBA in the Ural-Mugodzhary region and the developed model of the livestock represents a high degree of effectiveness. Rapid regeneration of steppe and semi-desert geosystems with the conservation of the ecological function was possible only under using mobile breeding. Simultaneously, a unique feature of the economic-cultural system was a harmonious combination of mining and metallurgical production and one of the forms of mobile livestock with year-round cattle keeping on pasture, seasonal rotation pastures, and water sources. It should be mentioned that some migrating routes coincided with trade ways where traffic of metal and alloy components for bronze-casting production happened.

In this case, archeological micro-regions should be considered compact territories within which stable economic structures of separate social units operated [15, p. 6]. However, considering the universality of the reconstructed economic-cultural model, effectiveness of which was in the coincidence of seasonal economic (livestock) and technological, industrial (mining and metallurgical) cycles, it is necessary to notice the variability of its realization.

The most widely spread type of mobile cattle-breeding economy (yaila type) in the Ural-Mugodzhary region was the model when summer pastures were located in the upper reaches of steppe
rivers beginning from orographic systems of South Ural and Mugodzhary. Winter camps were in lower reaches of rivers, in places protected from the wind, riparian forests, and sands, along with the arterial water sources.

Seasonal migrations had latitudinal or meridional direction, and insignificant amplitude did not exceed 40-80 km. The similar spatial arrangement of summer migrations (jailow) and winter stays (kystau) on the territory was typical for Kazakhs of the Zhagalbayly family from the Zhetyru and Tortkara tribes of the Alimuly association at to the ethnographic modernity [16, p. 62, 66; 17, p. 97-100].

Such system of management was formed, in particular, in the developed system of right inflows of the Irgiz river in South Mugodzhary (the Shuuldakskiy and Sarlybayskiy AMR), the basin of Kamsak river (the Elenovskiy and Ushkattinskiy AMR), in the middle flow of the Zhaksy-Kargaly river (the Shansharskiy AMR). In the last case, the correctness of given historical-ethnographical analogies is confirmed by comparing demographic parameters of the population used capacity of developed local ecological niches. In the Shasharskiy AMR study, it was ascertained that in LBA, 400-600 people could live simultaneously on the examined territory. According to the statistical group's census within the Turgay-Ural resettlement region in 1910, in this Zhaksy-Kargaly river site, together with inflows Dombar, Alabaytal, Shanshar, they registered 12 Kazakh livestock farms with a total population of 506 people [18, p. 41-42].

Ethnographic data promotes understanding the character of local mobility of people and animals in summer pastures. In steppe summer nomad's camps (jailow), Kazakhs practiced cattle grazing by concentric circles deep into the steppe from plays of the stand near a water body. Simultaneously, a relatively static stage of camps had lasted to a month, and the radius of grazing was 3-5 km for sheep and 8-15 km for horses [16, p. 106-109]. A similar system of nomadism is noticed among reindeer breeders in Yamal. However, the dynamism of rhythms of movements formed "petalled lace" is, in this case, considerably higher due to peculiarities of natural-climatic conditions and specifics of species composition of a herd consisted of reindeer only [19, p. 28, Fig. 10].

A unique feature of the described economical-cultural model operated in the Urals-Mugodzhary region in LBA is that mining and primary treatment of copper ore were organized, in most cases, in summer pastures. These areas show copper mines with industrial concentrating grounds, except seasonal settlement structures, numerous necropolises, and monuments of religious purposes (sanctuaries with petroglyphs), memorial complexes. Objects of material culture listed above show that the geographical space was developed in practical, spiritual, and semantic views. Their localization close to mining archeology monuments marks a manifestation of the exclusive right of separate groups of the population to exploit limited vital resources, which pastures and copper-ore sources were. Structural peculiarities of mine workings represented by opencast mines, shaft-sinking tunnels, etc., and open grounds for dry concentrating of copper ore, water basins used in some cases to realize of ore floatation, witness the seasonal character of work arrangement in the warm season. Mineral exploration by ore prospectors in LBA was impossible in the wintertime.

Another type of organization of mining works in copper-ore objects was registered in the course of reconnoitering research in extreme natural-climatic conditions of semi-desert zone in the southern end of the Mugodzhary mountains. The situation recorded in the South Zhamantau mine, being the most southern mining object of the Urals-Mugodzhary MMC, is the most demonstrative in this aspect. It is at a distance of 60 km of the nearest ancient mining works located on the right bank of the Shuuldak river. The examined area is characterized by inadequate water resources provision and the complete absence of wood and even shrub vegetation. In the region of South Zhamantau mine's position, only a few springs and dry gullies are noticed. They are partly filled by water only in the spring flood period.

Nevertheless, one of the largest ancient anthropogenic objects of the Urals-Mugodzhary region exploited in the Bronze Age is located here. Seven stone tools of old mining with traces of long-time exploitation were found on the surface of heaps of rock and industrial concentrating grounds. They are hacks, hammers, ore-crushing stones made from gabbro, diabase, petrified limestone.
Detailed research of the mine outskirts almost did not give results. However, a fact of appearance of the Alakuliskaya culture bearers in this region was confirmed. In 500 m to SSE from the mine, a ceramics deposit was found in the upper reaches of a nameless gully in the mountain cleavage. Morphological characteristics and ornament of separate samples correspond to standards of the Alakuliskaya potter’s tradition. In this case, we can say about the temporary season camp of miners of LBA. In 100 m from the described ground, a vertically installed block of brightly red jaspilite with the size of 40×50×70 cm is placed on the same axis in direction to the mine. The closest jaspilite emergence is in 400 m to the east. Likely, it was specially brought to the outskirt of the settlement and is a menhir. Remarkable that the menhir placed in the South Zhamantau outskirt had been split in the ancient time due to natural conditions. Simultaneously, lichen fossils were formed on the inner surface of cracks that confirm this object’s old age.

The scale of mining was significant in the studied copper-ore object in the Bronze Age. However, mining had a seasonal character and represented itself original expeditions of specialized expert groups of miners. Lack of fuel made it impossible to realize a scale pyrotechnical concentration and metallurgical treatment. The mentioned circumstances, on the background of the excess bulk of extracted ore mass, concerning demographic parameters of mobile groups of prospectors in mining, confirm a presence of inner exchange within the Urals-Mugodzhary MMC. Likely, the principal object of trade-exchange activities, in this case, was cooper ore concentrated by the dry method.

The practically opposite mining scenario in copper ore objects was registered in the north-west periphery of the Urals-Mugodzhary MMC. Here the thing of stationary interdisciplinary studies was the Ishkininskiy ARM. It was formed by the largest and most mine on the Ishkininskoe deposit area, the settlement, three burial mounds, and a line of eight ceramics deposit not forming the cultural layer that can be considered as points of regular seasonal visits by mobile groups of the population. All listed archeological objects connected and associated with the Ishkinskiy copper mine were the main dominant industrial structure with mining and metallurgical specialization.

The landscape orientation of the listed objects has significant interest for our study. The Ishkinovka settlement of cattle-breeder and miners of LBA was located 500 m to NNW from the mine, in the opposite right bank of the Aulgan stream that is the right inflow of the Dry Guberlya river. It occupied small plane ground surrounded by mountains from three sides. Ceramics deposits were found in both banks of the Aulgan stream and its nameless inflows and the Dry Guberlya river's left bank at 1 km higher of the course. Another compact group of archeological objects of LBA is placed on the right bank of the Dry Guberlya river at a considerable distance from the described monuments. In the mouth of its right inflow of the Zheriklinskiy stream, on the skirt of gently sloping watershed upland, Ishkinovka I burial ground was located.

Not far from this cemetery, on the cape-similar ground formed by the drying gully, the Bronze epoch's ceramics deposit was found. In 2 km higher to the Dry Guberlya river course, the Ishkinovka II burial mound is located. Ishkinovka III was in 1 km upper of the course, on the opposite side of the right inflow of the Yalangas river. Another deposit was found between these necropolises.

The unique feature of the Ishkininskiy AMR is that the Ishkinovka settlement belongs to the stationary category. The population lived there all year round. A character of the examined dwellings built of adobe blocks and supplied by heat engineering constructions confirms it. Added weighty argument in favor of such interpretation is results of archeological zoological studies. Identification of species and age and gender composition of a herd showed cattle, goats and sheep, and dogs in the osteological collection. Besides, it was ascertained that butchering used for food has happened in all seasons of the annual economic cycle. The other characteristic feature of the spatial organization is that necropolises connected with the settlement were placed at a considerable distance that demands to be explained.

Historical-ethnographic data on cattle-breeding farms of the Bashkir people from the Sara family of the Usergan tribe lived there since the XVIII century can considerably reconstruct the economic-cultural model. The highest interest is provoked by the fact that in 1715-1716, settlers from Yantyshevo village (Khaybulinsky districts, the Republic of Bashkortostan at present) founded Sary
aul in the site of the described settlement of LBA. Sometimes, it is called Yalan Sarasy (Steppe Sary). The initial placing of the Bashkir aul on the ground of the LBA settlement, at the least, between 1932 and 1814, was registered in the course of archeological researches thanks to findings of numismatic materials. Later, the aul was replaced at 1 km to the west in the mouth of the Aulgan stream flowing into the Dry Guberlya river. The settlement received the current name – Ishkinino in honor of the name of its founder. In the middle of the XIX century, a part of families resettled at 13 km upper of the Dry Guberlya river course, had founded Yantyurino village that existed to 1970s. The Bashkir people who lived in this country had a semi-nomadic cattle-breeding economy. They had constant winter settlements (yzma) in winter pastures (kyshlau) and migrated on seasonal fields from the spring to the late autumn returning to auls in the winter. Separate groups returned to winter stays in the early autumn to prepare dwellings by the winter, practiced periodical visits of constant settlements to control left houses. Nomad's camps of Ishkinino, the area of which occupied 15 versts, were located along rivers of Uptully, Tash-Uygan, and Burlyay-Basha. In the summer pastures (yaila) regions, the sites (torlak) with light ground dwellings were rotated during the period. It is worthy of mentioning that inhabitants of several settlements used summer camps. Different social links between clan groups happened, including mutual visit exchange [20, p. 64-65, 67, 107-110].

Such a model of yaila livestock breeding has operated in the Ishkinskiy AMR in LBA. In ancient times, necropolises often were markers of exclusive rights on the exploitation of limited vital resources. This circumstance can explain the localization of burial molds connected with settlement in summer camps. Slopes of bald mountains on the outskirts of the settlement were used as the winter pastures. However, it was vitally necessary to drive off the central part of a herd to remove summer pastures to avoid winter places' full pasturing.

The capacity of the ecosystem identified demographic parameters of paleo populations. Population number simultaneously lived within the Ishkinskiy ARM in LBA and calculated by the special methodology was 310 people. In this aspect, it is significant that according to the material of revision of 1859, firstly, given the statistical data, the population in Ishkinino was 312 people. Curiously that the following population growth led to exceed anthropogenic pressure on the local ecosystem. Catastrophic aftermaths were managed to prevent by settled out a part of families founded Yantyurino. As a result, in the mentioned settlements, by statistical materials of 1889, 220 and 211 people, respectively, lived [20, p. 27-28, Table 4].

Such coincidences cannot be casual. It indicates the matching of economical-cultural models. However, the mining and metallurgical sector of the economy is the principal difference in the industrial structure of the Ishkininskiy AMR in LBA. Expert groups released from economic livestock activity should organize seasonal copper ore extraction, conduct concentrating operations, realize pyrometallurgical treatment, annealing of charcoal, and arrange transport and exchange of mining and metallurgical products.

Thus, three variants of the pastoral model of LBA metalworking can be reconstructed in the Urals-Mygodzhary region. All of them were maximally adapted to local steppe ecosystems' peculiarities and promoted to save its dynamic balance at the expense of rational use of natural-resource potential.

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