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Vanishing iron-smelting furnaces of the South Eastern Altai, Russia – Evidences for highly developed metallurgical production of ancient nomads

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Results of multidisciplinary investigations of ferrous metallurgy archaeological sites within four locations in the South Eastern Altai, Russia are presented. Radiocarbon dating applying both conventional and AMS techniques evidences for constructing and operating of iron-smelting furnaces during the Turk period: the second half of the 5^{th}-11^{th} centuries AD.

Trees (Larix Sibirica) more than 100 years old were utilized for charcoal production. Generally, larches, growth in 2nd-10th centuries AD, were used in metallurgical process in the Kuektanar-1, Kuektanar-2, and Turgun-1 sites belonging to the Chuya-Kurai metallurgical zone. The time of the last iron production for the bloomery iron-smelting furnace in the Kuektanar-1 site was reliably established falling between AD 655 and 765.

Mineral composition of slag from the Kuektanar-1 site indicates that two types of the ore - quartz-hematite and siderite, could be utilized for iron production. The high Ca, K and Al content in some slag droplets evidence for possible presence of calcite in the initial ore, or flux additives. A small amount of fluxes could come from the clay lining of the bloomery hearth.

Generally, high concentration of furnaces near the Kuektanar mouth and in the Turgun valley was determined by wide spreading of forest vegetation in an area and close location of ore occurrences. Intensive timber consumption by nomadic societies together with the progressive aridity intensification led to total deforestation of the eastern part of the Chuya depression.

1. Introduction

Since the Iron Age iron played an important role to human society (Pigott, 1999). Iron is the symbol that produces power, and military strength and fuels of the empire. Nomadic empires also developed ferrous metallurgy (Chernykh, 2008). The Altai Mountains are one of the centers of ancient civilizations located on a crossroad of migrations and cultural interconnections between East and West. Southeastern part of Russian Altai (SE Altai) successfully combines the abundance of mineral resources including iron ore and wide spread of forest vegetation still in the recent past. As a result, the art and technique of bloomery iron-smelting, man's original method for winning metallic iron from its ore, was highly developed here. Expressive confirmation of this fact can be found in local names. Thus name "Kuektanar" (the mouth of the Kuektanar river examined in this paper) means "to put on (or to make) mail armour" in Altaic language.

The metallurgical history of nomads in Russian Altai was studied in 1970s of the last century on the basis of extensive archaeological field work by Zinyakov (1988). He established specific Kosh-Agach type of bloomery iron-smelting furnaces as well as determined and described the Chuya-Kurai metallurgical zone where 29 of 32 documented in Russian Altai ferrous metallurgy sites are located. Studied iron-smelting furnaces were presumably dated to the 6^{th}–10^{th} centuries AD, based on the analysis of the accompanying inventory, as well as on some typological analogies of bloomery hearths associated with another archaeological cultures of the second half of the 1^{st} millennium AD (Zinyakov, 1988; P. 51).

Despite the fact that fragments of charcoal were discovered in

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frontal grooves and within inner filling of some bloomery hearths, by now only single radiocarbon date was reported for archaeological site Kuektanar-2: 1775 ± 35 BP (SOAN-5040 (Gutak and Rusanov, 2013)). Based on this uncalibrated date the Hunnu-Sarmatian period was suggested for time of constructing and operating iron-smelting furnace from this location. Fragments of hematite, displayed nearby, also allowed them to assume ore mining for iron production to be located in the Sailjugem range, which is about 100 km far from the place of metallurgical production in the opposite site of the Chuya intermountain depression (Fig. 1-*R*).

In the framework of our geomorphological and geoarchaeological investigations in the SE Altai, the ferrous metallurgy sites were studied in the mouth of the Kuektanar river (Chuya river valley between Chuya and Kurai intermountain depressions, Fig. 1-*K*), as well as in the Turgun river valley (western periphery of Kurai intermountain depression, Fig. 1-*T*). Today these vanishing archaeological sites can be identified in many cases only by calcined crimson substrate, which marks the location of iron-smelting furnaces on the edge of the steep riverbank in the apex of rapidly growing gullies. A lot of monuments of ancient Altai metallurgy in the Kuektanar mouth, which allowed reconstructing various parameters of furnaces and characteristics of iron production, less than fifty years after their studying by Zinyakov, due to intensive erosion and Chuya river channel migration, represent just miserable remnants – fragments of back and side walls of iron-smelting furnaces and large amount of slag in the river bank taluses.

We have already utilized these "in situ" archaeological sites for estimating upper time limit of landform development and deposits accumulation (Agatova et al., 2016). Today these unique sites are rapidly vanishing geoarchaeological archives of information about the chronology and specific features of Altai ferrous metallurgy, as well as one of the key issues that reflects anthropogenic impact of nomadic societies on the environment.

The progress of geoarchaeological studies clearly demonstrates that in order to properly understand natural landscape transformation in a region and associated archaeological evolution, extensive multidisciplinary investigations including geochronological analysis is necessary to take full advantage from geological data and various environmental proxy archives. Rapid and irrevocable disappearance of many iron-smelting furnaces doesn't give a chance or live us time for consecutive application of conventional methods. In this context multidisciplinary approach can essentially advance the study. This paper presents 1) the results of radiocarbon dating (applying both conventional and AMS techniques) and establishing tree species composition of charcoal fragments from iron-smelting furnaces in Kuektanar-1, Kuektanar-2, and Turgun-1 archaeological sites; 2) analysis of sources of fuel and raw materials for iron production; 3) reconstruction of main characteristics of iron-smelting process; 4) analysis of the anthropogenic impact of Altai nomadic metallurgy on the paleoenvironment.

2. Study area

2.1. Landscapes and archaeological setting

The high-mountain southeastern part of the Russian Altai (mountains of South Siberia), examined in this paper, has been inhabited since the Palaeolithic (Derevyanko and Markin, 1987). The extremely arid climate, widespread permafrost and low population density here support good preservation of archaeological sites and offer a unique opportunity to study the rich historical heritage of this region. A large number of publications present various archaeological surveys including mapping of individual archaeological monuments, and analysis of their typology (Derevyanko and Markin, 1987; Kubarev, 1991; Bourgeois et al., 2000; Tishkin, 2007; Gheyle, 2009 and many others). Most of archaeological sites, such as burial mounds (kurgans), ritual structures, and petroglyphs are regarded as belonging to the Bronze Age (end of 4th - beginning of 1st millennia BC), the Scythian (6th-2nd centuries BC), the Hunnu (2nd century BC - 4th century AD) and the Turk (6th-9th centuries AD) epochs. Later cultures of the Kyrgys (9th-12th centuries AD) and the Mongolian (12th-14th centuries AD) periods are less evident (Tishkin and Gorbunov, 2005). During the Kyrgys khaganate and Mongol empire, the Altai was located on their periphery and was not even mentioned in historical chronicles (Tishkin, 2007). Archaeological sites and direct written records of 15th-16th centuries are scarce. More detailed regional archaeological review was presented in the previous article (Agatova et al., 2016).

The SE Altai includes the Chuya and the Kurai intermountain depressions surrounded by ridges with altitudes of about 3500–4200 m a.s.l. (Fig. 1). The floor of the Chuya depression, the largest in the Altai Mountains, is located at 1750–2000 m a.s.l., while the floor of the Kurai depression - at 1500–1600 m a.s.l. The area is characterized by extreme ultra continental cryoarid permafrost affected environment. The mean annual temperature is about −6 °C, the mean annual precipitation is less than 200 mm in the floor of the intermountain depressions. The main moisture transfer from the west (Atlantic Ocean) with the dominant

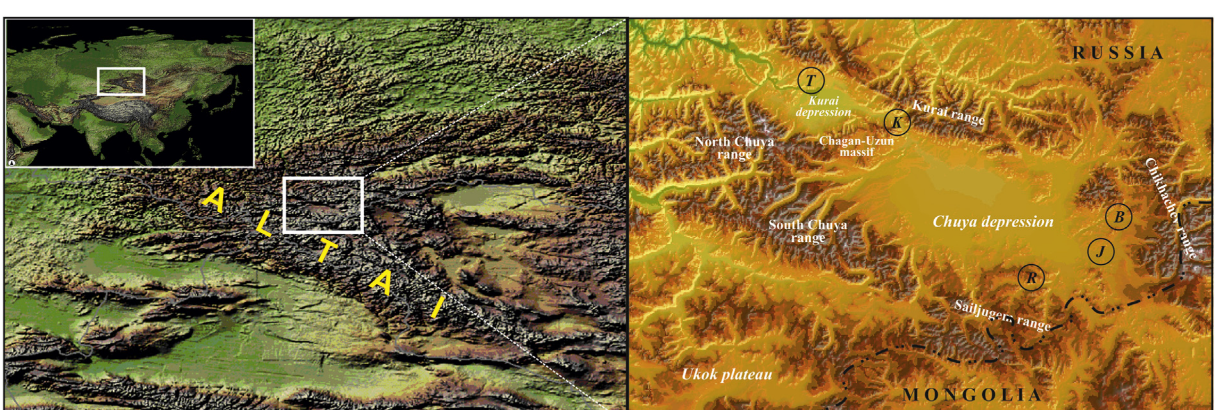

Fig. 1. Altai Mountains and southeastern part of Russian Altai, examined in the paper. Letters indicate location of the Kuektanar mouth (*K*), Turgun valley (*T*), Justyd valley (*J*), Bar-Burgazy valley (*B*), and "Rudny Log" iron ore deposit (*R*).

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