BRONZE AGE HUMAN COMMUNITIES IN THE SOUTHERN URALS STEPPE:

SINTASHTA-PETROVKA SOCIAL AND SUBSISTENCE ORGANIZATION

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2013

Submitted to the Graduate Faculty of

The Dietrich School of Arts and Sciences in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2018

UNIVERSITY OF PITTSBURGH

KENNETH P. DIETRICH SCHOOL OF ARTS AND SCIENCES

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Why and how exactly social complexity develops through time from small-scale groups to the level of large and complex institutions is an essential social science question. Through studying the Late Bronze Age Sintashta-Petrovka chiefdoms of the southern Urals (cal. 2050–1750 BC), this research aims to contribute to an understanding of variation in the organization of local communities in chiefdoms. It set out to document a segment of the Sintashta-Petrovka population not previously recognized in the archaeological record and learn about how this segment of the population related to the rest of the society. The Sintashta-Petrovka development provides a comparative case study of a pastoral society divided into sedentary and mobile segments.

Subsurface testing on the peripheries of three Sintashta-Petrovka communities suggests that a group of mobile herders lived outside the walls of the nucleated villages on a seasonal basis. During the summer, this group moved away from the village to pasture livestock farther off in the valley, and during the winter returned to shelter adjacent to the settlement. This finding illuminates the functioning of the year-round settlements as centers of production during the summer so as to provide for herd maintenance and breeding and winter shelter against harsh environmental conditions.

The question of why individuals chose in this context to form mutually dependent relationships with other families and thus give up some of their independence can be answered with a combination of two necessities: to remain a community in a newly settled ecological niche and to protect animals from environmental risk and theft. Those who were skillful at managing communal construction of walled villages and protecting people from military threats became the most prominent members of the society. These people formed the core of the chiefdoms but were not able to accumulate much wealth and other possessions. Instead, they acquired high social prestige that could even be transferred to their children. However, this set of relationships did not last longer than 300 years. Once occupation of the region was well established the need for functions served by elites disappeared, and centralized chiefly communities disintegrated into smaller unfortified villages.

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To Hannah and Ole Nydhal

ACKNOWLEDGMENTS

Archaeology is always a collective effort, and many individuals contributed to the completion of this work. First and foremost, I should mention my advisor Dr. Robert D. Drennan whose guidance shaped my research agenda and the way of thinking, but wisdom and support made the entire process exciting and joyful. Any of Pitt alumni who studied under his supervising would agree that we are lucky to be his students, and I am sure that after the graduation our learning from Dick is not finished.

I am also grateful to the members of my dissertation committee: Loukas Barton, Marc Bermann and Francis Allard for their opinions and lasting support, as well as to all the faculty members of the Pitt Anthropology. Among them, I would like to express my gratitude to Bryan Hanks who made possible my appearance at Pitt but also taught me a great deal of human lessons. I wish Bryan will learn about the karmic law of cause and effect and achieve peace of mind. The last but not the least person in this list is Claire Ebert whose help and friendship are priceless.

Throughout my life in archaeology, I have worked and learned from many great scholars and colleagues in Russia whom I owe many thanks. Andrey V. Epimakhov is the person who launched my career and who is a true teacher of mine. However, I would not be able to become a professional without the support of Ludmila N. Koryakova, Nikolay B. Vinogradov, and Nataliya A. Berseneva. Regarding this dissertation, I received a lot of help from my own generation of researchers, namely Artyom Yakimov, Vlada Molchanova, Evgeniya Goncharova and Polina Medvedeva. Also, I would like to mention the students of the Russian universities who worked with me throughout the years: Eduard Meyer, Nastya Fedotova, Tatiana Makarova, Sofia Suleimanova, Maria Golovina and Alexey Bersenev. Some of the people mentioned above are full professionals,

1.0 SOCIAL INEQUALITY AND SOURCES OF POWER AMONG EARLY COMPLEX SOCIETIES: SETTING A COMPARATIVE APPROACH

Growth of local communities, the emergence of regional-scale interconnections, and accompanying changes in the social organization have long been a focus of scientists studying the beginnings of pre-state societies around the globe. When demographic growth exceeds the capacity of direct face-to-face communication between group members, fragmentation of large human collectives into smaller groups is likely (Drennan et al. 2011:151; Johnson 1982; Bandy 2004; Alberti 2014). However, if growing local communities do not fission, new means of providing for social integration emerge, and varied forms of social inequality and hierarchy often develop. The common label for such preventive tools is social complexity, which reflects the existence of varied social roles, several levels of information flow, and concentration of power (Alden 1979; Engels et al. 1972; Flannery 1972; Pauketat et al. 2002; Redmond 1994; Renfrew 1973; Rosenswig 2007; Steponaitis 1991; Wittfogel 1957).

Why and how exactly does social complexity develop through time from small-scale groups to the level of large and complex institutions? Why do individuals choose to integrate and give up their independence? – These are essential social science questions.

To answer these questions scholars have sought the universal paths of societal changes during the growth of human society. Evolutionary schemes, developed by Sahlins (1958, 1963), Service (1962) and Fried (1967), helped to recognize that, on the one hand, general patterns of social development always can be found in any human society. Some scholars insist on the homogeneity of scenarios of just how complex society arose, such as Carneiro who links its emergence with conflict and warfare (Carneiro 1998). Other social scientists show that a large amount of variability of societal forms and trajectories are always present among pre-state societies (Sanders and Webster 1978).

Developing the concept of early complex society, Earle (1987, 1997, 2002), after Mann (1986), argues that complexity could grow up on different foundations, which belong to three main social realms. Earle distinguishes (1) economic power as the ability to give or deny necessary and desired goods, which include food, housing, and prestige goods and wealth. Moreover, he discusses (2) warrior power as an aggrandizing strategy, which is based on an ability to coerce by force or the threat of force. Finally, he points out (3) ideological power to subject people based on the ability to present followers with religiously/conceptually sanctioned narratives for compliance and support (Earle 2011:33). Different combinations of those three bases may be used by aspiring individuals to achieve their social, economic and political goals, which creates varied trajectories of development of early complex societies.

In one instance, aspiring groups may start to accumulate wealth through gaining more surplus. In order to do that, they need better access to vital resources, labor pool and/or productive efficiency. Next step is the subordination of closest neighbors to achieve more power. At this point, the goal of increasing surplus is no longer in the realm of survival and reproduction but has became political. In conjunction, the economy turns to be political economy (Earle 2007). Among dimensions of change, wealth, prestige, and productive differentiation may start to grow significantly. In another case, warfare may be a way to subordinate others. Simply, nobody questions armed muscle, in Earle's own words. To do so, a strong charismatic leader surrounds him/herself with followers, and together they act violently gaining resources and power. The role of a leader, in this case, is to re-distribute goods and valuables among his/her supporters and manipulate them psychologically to make warriors loyal and keep them under control. Redmond (1994) has shown that through alliances and reciprocal obligations a war leader can achieve a level of power when he overcomes limitations of local authority and then wields centralized decision-making on a regional scale. In other words, such a war leader has a chance to become a paramount chief. Also, Redmond suggested that an aging military head encourages his sons to distinguish themselves in warfare and to lead war parties. He teaches them how to behave charismatically and passes warrior skills on to his sons, who then inherit leadership. By doing that he institutionalizes a legitimate position of power (Redmond 1994). Along the dimensions of change, this scenario can be seen through proxies of conflict and increasing the prestige of a warrior's status. Warriors' burials with weapons and war-related skeletal trauma are quick hints.

Nucleation of people and building of fortification are other proxies. Observing them one may conclude that an increasing level of conflict allows some people to gain political power. However, warfare itself may be caused not just by political reasons, but also by population pressure, differential resource concentration, etc. (Carneiro 1981, 1998). The third scenario suggests that the realm of ideology may be a powerful tool to subordinate others. Ideology closely related to religious beliefs can justify leaders' power by linking it to the supernatural, like ancestors, totems or gods. Use of this strategy can be traced through research on sacred places, shrines, and burials.

Earle's concept turns into the following conclusion: complex societies often do share similar attributes and consequences of change. However, these attributes are not necessarily universal, and recent archaeological studies around the world have demonstrated much variability in forms of complex societies (Stein 1994; Wilson et al. 2006; Kuijt 2008; Drennan et al. 2010; Frachetti 2012). A classic case study is the Moundville "chiefdom" (AD 900–1650) in the Black Warrior River valley of the southeastern U.S. (Steponaitis 1991; Welch 1991; Wilson 2007; and others). Some have argued that Moundville's political economy could be based on elites' control over the production and distribution of valuable objects, such as prestige goods of exotic materials or the stone axes that were critical for clearing trees from farmland. There is evidence that such desirable possessions were produced at Moundville and distributed to smaller centers and hinterland farmsteads. Moundville itself was fortified with a palisade, enclosing about 120 ha. Conflict may thus have played a role in bringing people together for protection even at the expense of some loss of autonomy to increasingly powerful leaders. Spatial proximity to sacred places and residence on the tops of mounds signified the importance of particular households in the political order (Steponaitis 1991; Welch 1996).

In another classic instance from the Americas, the strong social hierarchy in the Valley of Oaxaca during the Rosario and Monte Alban Early I phases involved productive differentiation and economic interdependence between households. Moreover, motivation of Oaxaca elites played a role in increasing of wealth and expansion of power by bringing more people under their control through the forcible domination of smaller villages (Drennan and Peterson 2008:375–379). As a result, an especially strongly centralized chiefdom appeared in the Valley of Oaxaca (Kowalewski et al. 1989).

In some other cases, such as the Regional Classic period in the Alto Magdalena of Colombia (AD 1–900), some individuals appear to have gained higher social rank largely through the special rituals and religious roles that they played (Drennan 1995; Drennan and Peterson 2006; Peterson and Drennan 2005, 2012; Gonzalez Fernandez 2007). The standard of living of these important people and their households differed little from the rest of the community, showing only very slight wealth accumulation or access to exotic goods. Craft specialization was poorly developed and not monopolized or managed by high-status households (Gonzalez Fernandez 2007:117), and the level of economic interdependence between households was low (Drennan and Peterson 2008:367). The social positions of leaders were marked almost exclusively through their burial ceremonies involving monumental tombs, plazas, and statues. Substantial social differentiation existed in the Alto Magdalena even though there is very little evidence of the economic differentiation and craft specialization that characterize other examples of emerging of social complexity.

Examples of early social complexity in the Eurasian Steppes are enlightening as well, although they have not been the subject of as much comparative analysis. At least some degree of social complexity may be traced even among highly mobile herding groups living far from centers of power and with little access to agricultural products. Houle (2009, 2010) has suggested that emerging elites might have controlled non-material resources by creating sacred spaces among Late Bronze Age pastoral groups in the Khanuy Valley in Mongolia. Communal rituals may have been the principal means of gaining and maintaining positions of high status and prestige (Houle 2010:189). Frachetti (2008; 2009; 2012) has identified what he calls a "non-uniform" mode of social complexity in Central Asia. On the one hand, control over sacred ritual spaces in the productively constrained region of Tamgaly allowed local groups of mobile pastoralists to develop managerial power over exchange with other mobile communities. On the other hand, populations of neighboring Begash enjoyed a rich ecological setting that allowed some groups to accumulate wealth in the form of exotic and prestige goods, which may be evidence of social differentiation among households. However, a mobile herding way of life did not lead to the emergence of far-reaching institutionalized forms of political hierarchy (Frachetti 2009:34–35). Frachetti's research in Semyrech'ye demonstrates that some aspects of social complexity, such as wealth and ritual differentiation between households and communities may be well developed, even though political institutions and ordered hierarchies may remain comparatively simple – or vice-versa (Frachetti 2012:19–20).

As a matter of convenience, different trajectories and pathways from egalitarian societies towards larger sociopolitical organization might be labeled as the process of "chiefdomization" and societies in this way as "chiefdoms", even though they can take very different socio-political forms. Consequently, the term "chiefdom" is used in this dissertation research to refer the early steps of community growth and establishing of regional integration. The process of "chiefdomization" might be defined then as the process of transcending the direct relationships of kin groups by constructing equitant layers of social structures on the top of the community, as well as relationships of interdependency between spatially distributed groups of people. Emphasizing the regional integration and demography, Carneiro suggests that a chiefdom is a political unit comprising some villages or communities under the permanent control of a paramount chief, which transcend village autonomy (Carneiro 1981:45). Nevertheless, due to the geographical diversity, as well as the variability of socio-political forms and scales of demography, there are always variations in the spatial scale of chiefdoms and the ways they are organized and integrated (Chifeng International... 2011; Peterson and Drennan 2012). From ritual-based complex societies of early 'Ubaid period in Mesopotamia (Adams 1981; Stein 1994, 1996; McMahon 2008), and classic Hawaiian chiefdoms (Sahlins 1958; Earle 1997) to Nomadic Empires of the Great Belt of Eurasian Steppes (Kradin 2003, 2014) the high degree of the variability of the "chiefdomization" process has been unfolded.

Thus, increasing the number of the cases showing the variability of the process is not necessarily an ultimate goal for archaeology as social science (Drennan and Peterson 2006, 2008, 2012; Peterson and Drennan 2005, 2012). However, efforts to understand the variation in organization of local and supra-local communities contribute to broader understanding of the developmental dynamics of social complexity and might show particular conditions under which complexity developed, as well as diverse strategies of how emerged social institutions were cemented (Drennan et al. 2011:152).

1.1 HOUSEHOLDS, COMMUNITIES, AND POWER

At the local level, the emergence and development of complex societies mean the appearance of new kinds of communities that had not existed before. Often, but not always, these

evolved communities are larger than their predecessors and consist of an increased number of households. Leaders of these new social organizations create political entities resting on their households and ties with neighbors. In other words, elites live together with their families, forming a household, and so do commoners. Therefore, a focus on changing relationships between the households that make up local communities, understanding variability, and diversity of households within communities are particularly useful ways to investigate social complexity (Wilk and Rathje 1982; Wilk and Netting 1984; Netting et al. 1984; Clark and Blake 1994; Hendon 1996; Gijseghem and Vaughn 2008; Eerkens 2009).

There are various ways in which relationships between households shape social complexity within local communities. The main goal for a household is to maintain sustainability. Hence, inclusion into a social network with neighbors increases the chance of survival and reproduction. For this reason, households within a community often seem to be engaged in different productive activities, and, thus, form relationships of economic interdependence (Blanton 1994). As a result, some households accumulate surplus, resources, labor pool or knowledge that allow them to increase wealth. The members of these more powerful households often share high social status, enjoy better lifestyles, and/or play special roles in the decision-making process for the whole community (Costin and Earle 1989; Welch 1991; Peterson and Shelach 2012). Such social elites are often highly visible in the archaeological record since they often lived in bigger and more elaborate houses or received special treatment in death. Poorer and smaller households surround more powerful ones, relying on their protection and decreasing subsistence risk, providing vital resources and goods in exchange. Thus, wealthier households can include their neighbors into economic networks, which allows projecting their will: the greater the productivity, the greater the power (Sahlins 1958:xi). In particular, productivity depends on the available labor force. As Stein points out, emergent elites draw on two main sources of labor – their households and the broader social group in which they claim membership (Stein 1994:41). At this point, social differentiation starts to grow significantly, and one or another basis of elites' supremacy appears (Earle 1997).

On the other hand, elite households are not always significantly wealthier than the rest of the community, and, thus, their social power is drawn from other sources. Due to competition between households for resources, prestige, or better lifestyles, the potential for conflict may increase while communities grow. In this case, strong households with trained warriors can display

force and manage military power for defensive or raiding purposes. The consequence is increasing the social prestige of such families which may speed up the emergence of social institutions, responsible for resolving and managing conflicts (Carneiro 1981, 1998; Redmond 1994). The ability to organize public works for a community, maintain a subsistence system and manage shared resources may provide respect and gives elite households power to set strategic goals. Once a subsistence system became stable, such responsibilities also may be institutionalized (Stein 1994). Finally, religion and ritual or ceremonial activities may also provide an arena for manipulating social relationships (Potter 2000; Rick 2004). In Earle's explanation, ideological power is based on the ability to present followers with religiously sanctioned narratives for compliance and support (Earle 2011:32–33).

Archaeological indicators of the discussed social processes are lifestyles and post-mortem treatment of the individuals that belonged to the same community (Smith 1987). The lifestyles are visible through size and elaboration of the house, and the artifact assemblages that can be found in association. The larger the average area per family member, the more investment of labor and resources shown in building, the richer and more diverse the artifact assemblage (including the presence of luxury goods and attributes of specific professional occupations), the richer and, probably, more powerful the family is. And, to the contrary, if the house shows low investment in residential architecture, possessions are few and mostly related to everyday subsistence production, the household is poorer and of lower-status. Sometimes, however, the low level of surplus production or cultural constrains do not allow accumulation of many possessions or investment in construction projects, and the lifestyles of the high-status members of society and their low-status counterparts do not differ much. In such situations, the relationship to the super-natural might be the only way to learn about the process of social stratification (Costin and Earle 1989; Drennan and Peterson 2006).

To give a synopsis, archaeology has especially powerful tools to study the heterogeneity of households within a single local community. This approach is arguably helpful for better understanding of just how elites gain and cement power, as well as what they provide in exchange for subordinated families, and has its application in the current dissertation research.

1.2 EARLY STEPPE ADAPTATION, PASTORALISM, AND FORMING OF SOCIAL INEQUALITY

Animal breeding and herding became a dominant subsistent strategy in Inner Eurasia after domesticated animals appeared in Central Europe in the Neolithic (Zeder 2008). However, variability within subsistence strategies makes any typological labeling blurred and over-simplifies a picture of the functioning of pastoral societies (e.g., Khazanov 1984). On the one hand, there is a fundamental difference in lifestyle between two major economic systems: sedentary farming and mobile pastoralism. This difference is conditioned by the nature of subsistence strategies, which require either year-round sedentism or seasonal movements, depending on vital resources. Farming is concentrated on cultivating products directly consumed by humans and domesticated animals. Complex and variable agricultural systems allow production of a large amount of surplus and provide a critical buffer for periods of shortage. Pastoralism is a subsistence economy that converts wild resources, which are unsuitable for the human digestive system, into products for human consumption and utility (Ingold 1980; Anthony 2007). On the other hand, due to the high variability and heterogeneity of pastoral societies, it is difficult to define what is a pure mobile pastoral society. Pastoralists vary their subsistence strategies and social structures depending on the composition of herds, particular environmental conditions, natural hazards, closeness to sedentary societies, interactions with other groups, exchange and trade (Dyson-Hudson & Dyson-Hudson 1980:16–17; Dwyer and Istomin 2008; Frachetti 2012). In many cases, these groups employ multi-resource strategies, which include livestock breeding, hunting, gathering, fishing, and trade for agricultural products with sedentary neighbors. Often, but not always, they may switch completely to plant cultivation, if certain conditions make them settle (Spengler et al. 2014; Spengler 2015; Lightfoot et al. 2015). Often, but not always, they may form a complex economic system of exchange with farmers (Dyson-Hudson & Dyson-Hudson 1980).

In general, the assumed difference in social functionality between agricultural and pastoral societies is based on the ecological approach, supposing that different environmental sets of economies lead towards fundamentally different social organization (Khazanov 1984). However, at least some anthropologists disagree about the merits of the ecological approach and argue that

such determination is not always true (Dyson-Hudson & Dyson-Hudson 1980; Chang and Koster 1986). From their point of view, many factors, beyond adaptation to the ecological niche and economic rationality, determine the functionality of a pastoral society. Even though herders often are highly dispersed and mobile, variable mechanisms of social organization do appear among them, and, in some cases, they are similar to those in agricultural societies. To deal with this variability better, Cribb (1991) has suggested a more flexible approach that plots societies along two gradual dimensions (nomadic/sedentary, agricultural/pastoral). In this way, variabilities and similarities can be demonstrated through comparison of social realms. These realms are relationships of property, political leadership, land tenure and ownership, community and social organization.

Property is an important attribute of pastoral societies. However, land property is less valuable than in the agricultural world, meaning that gaining access to a place is more important for mobile groups than occupying it (Dyson-Hudson & Dyson-Hudson 1980). The possessions of pastoral people are herds, and the notion of individual property is no less developed among them than among farmers. For example, a typical family of the African Maasai people is an economically independent unit and may gain much livestock, but animals of many households are herded together (Shahack-Gross et al. 2004:1396). A pastoralist is able to accumulate wealth, often counted as the number of animals, but due to perishability of herd capital this way of wealth accumulation is riskier in comparison with agricultural ways to achieve welfare. For this reason, appropriate risk management strategies are essential for pastoralists to maintain their well-being and stable affluence. Risk can be defined as exposure to a position of which one is uncertain (Holton 2004), and risk management is a process of decision-making and execution, to reduce the likelihood of an unfavorable outcome and minimize the possible damages caused (Marston 2011). Among these risk management strategies are multi-species herds, including diverse resources in the subsistence strategy (i.e., gathering, hunting and fishing, horticulture), joining markets and maintaining social debts, raiding and warfare (Cashdan 1990). The measure of wealth in pastoral societies, thus, may be different in comparison with agriculturalists, but accumulating wealth is necessary as a method of decreasing risk and increasing survival chances when the pastoral economy is in crisis.

Regarding land tenure and ownership, in his 2008 monograph, Frachetti has suggested a concept of pastoralist landscape, meaning that in pastoralist groups' perception land ownership is not a rigid construct where boundaries are defined, and access is restricted. In many cases, pas-

toralists develop a notion of common property as something held jointly (for example, sources of fresh water for animals, or hunting games). This is extremely important for herders since mobility orbits can vary strategically in reaction to short-term fluctuations in the natural environment such as extremely wet or cold summers (Frachetti 2008:22). However, once the ability to move freely and gain access to resources is declining, pastoralists may become highly territorial. For example, once Kirghiz groups lost their access to long-distance movements due to the establishment of strict borders of the Soviet Union and British India, they adopted the practice of short seasonal movements within valleys, which were assigned to specific groups. In this case, social complexity emerged in conjunction with notion of land tenure, since political leadership emerged to resolve disputes (Dyson-Hudson & Dyson-Hudson 1980:30–31)

There are many variable forms of political leadership among pastoralists, regardless of a notoriously mobile lifestyle. Their spectrum varies as much as the range of political leadership in sedentary groups and is better described in terms of processes, rather than as a strict cultural typology. Even though in many cases political leaders do not have very different lifestyles than their followers, they are less engaged with everyday subsistence labor and can accumulate significant wealth in the form of prestige goods. Such a way of achieving well-being and power is especially common for mobile pastoralists, who travel long distances and form significant networks of exchange. The degree of complexity of political institutions varies among pastoralists from simple forms of integration, such as among the Maasai people of Africa, to aggressively expanding nomadic empires, such as the Mongols.

As with realms discussed above, community and social organization vary a lot among sedentary people as well, so it is impossible to say that there are fundamentally different types, but rather a multi-dimensional spectrum of organization. As an example, the case of the Kalmyks, the Mongol people of the Lower Volga Region can be examined (Erdniyev 1985). Being included in the Russian Empire in the 18th century AD, Kalmyks, who kept their social hierarchies and political organization, are described in the official sources of the Russian administration. The Kalmyks were organized into social-territorial entities, which were divided to the smaller and smaller sub-entities. The simplest group consisted of several mobile families, which moved across an ascribed territory. Social stratification was anchored in a form of bondage, in which all commoners

were the property of elites, and all elites depended on the Khan, the highest leader. The Khan took an oath of allegiance to the Russian Tsar, and his power was transferred to his direct offspring.

Summarizing, pastoral communities demonstrate significant variability and particular ways of adaptation and this should be taken into account when considering ancient herders. This non-uniformity is especially important while analyzing societies of Bronze Age Eurasia that are often believed to be pastoral and at least partly mobile (Kohl 2007).

1.3 THE INNER EURASIAN STEPPES IN THE BRONZE AGE

Socially and economically differentiated communities have been seen as a feature of one of the key periods of Old World prehistory, the Bronze Age (Anthony et al. 2005; Anthony 2007; Drennan et al. 2011; Frachetti 2009). In Inner Eurasia, this period is characterized by the wide spread of a productive economy, often taken to be the result of the expansion across a vast area of culturally similar groups of people speaking Indo-European languages. During this period, new subsistence strategies (e.g., farming, pastoralism, agro-pastoralism, multi-resource pastoralism and otherwise mixed subsistence strategies) emerged in Inner Eurasia in tandem with impressive innovations (metallurgy of non-ferrous metals, horse domestication, and wheeled transport). The adoption and distribution of these practices in the steppes are associated with visible shifts in the socio-economic organization of prehistoric groups towards greater, yet highly variable societal complexity (Kuzmina 1994, 2008, 2007; Allard 2005; Anthony 2007, 2009; Koryakova and Epimakhov 2007; Frachetti 2008, 2012; Peterson 2009). The archaeological record of the Eurasian Steppes contributes a unique perspective on socio-political organization, which opens new avenues for analyzing complex social systems (Honeychurch and Amartuvshin 2007:58–59; see also Chernykh 2008; Bandy and Fox 2010; Bendrey 2011; Frachetti 2012; Spengler 2015).

One instance is the Sintashta-Petrovka archaeological phenomenon (Fig. 1.1). This is situated within the southern Ural Mountains of Russia and the northern part of the Republic of Kazakhstan (Vinogradov 1982a; 2011; Zdanovich 1988; Gening et al. 1992; Grigoriev 2002; Koryakova and Epimakhov 2007; Frachetti 2009, etc.). Sintashta-Petrovka represents a shift in the social history of the Eastern Eurasian Steppes from dispersed mobile groups of herders to nu-

Figure 1.1 Research area: map of the Sintashta-Petrovka archaeological sites

Settlements: 101 – Stepnoye; 102 – Shibaeyvo 1; 103 – Chernorechye 3; 104 – Bakhta; 105 – Paris; 106 – Isiney; 107 – Kuisak; 108 – Ust'ye; 109 – Rodniki; 110 – Konoplyanka; 111 – Zhurumbay; 112 – Arkaim; 113 – Sintashta; 114 – Sintashta 2; 115 - Kamennyi Ambar; 116 – Alandskoye; 117 – Chekatay; 118 – Selek; 119 – Sarym-Sakly; 120 – Kamysty; 121 – Kizilskoye; 122 – Bersuat; 123 – Andreyevskoe; 124 – Ulak; 125 – Streletskoye; 126 – Zarechnoye 4; 127 – Kamennyi Brod.

Cemeteries: 201 – Ozernoye 1; 202 – Krivoe Ozero; 203 – Stepnoye M; 204 – Kamennyi Ambar-5; 205 – Stepnoye 1; 206 – Tsarev Kurgan; 207 – Ubagan 2; 208 – Solntse 2; 209 – Bolshekaraganskyi; 210 – Aleksandrovsky 4; 211 – Sintashta; 212 – Solonchanka 1a; 213 – Knyazhenskyi; 214 – Bestamak; 215 – Ishkinovka 1; 216 – Ishkinovka 2; 217 – Novo–Kumakskyi; 218 – Zhaman–Kargala 1; 219 – Tanabergen 2; 220 – Novo-Petrovka; 221 – Semiozernoye 2; 222 – Khalvayi 3

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cleated walled communities, possibly, ruled by elites. At the end of the third millennium BC, at least 25 Sintashta fortified settlements emerged between the Ural and Tobol rivers, usually at low spots on the banks of small steppe streams. The quintessential archaeological evidence of Sintashta-Petrovka communities takes the form of highly nucleated and fortified settlements paired with easily-recognized kurgan (burial mound) cemeteries. This pattern spread across Northern Central Eurasia in a relatively short period of about 300 years (cal. 2050–1750 BC), and the period consists of two chronological phases (Hanks et al. 2007). The earlier Sintashta phase (cal. 2050–1850 BC) is distinguished from the later Petrovka phase (cal. 1850–1750 BC) by some differences in ceramic styles and some techniques of bronze metallurgy (Degtyareva et al. 2001; Vinogradov 2013). Bronze Age subsistence patterns apparently relied on a wide variety of resources, among which meat and milk production played a major role (Outram et al. 2009; Bachura 2013). A large number of wild plant taxa, as well as fish, are reported from excavations of settlements (Lebedeva 2005; Ryabogina and Ivanov 2011; Rühl et al. 2014). Stable isotope studies also suggest a major role for livestock products and freshwater fish with some contribution of wild plants (Privat 2002, 2004; Ventresca Miller 2013; Ventresca Miller et al. 2014; Lightfoot et al. 2015; Stobbe et al. 2016). The residential architecture strongly suggests fully sedentary year-round residence for at least part of the Sintashta-Petrovka population.

For decades, archaeology in the Eurasian Steppes has concentrated heavily on the excavation of kurgans, which are biased toward the representation of distinguished members of society (Kohl 2007:128–130). From the very beginning of research on Sintashta mortuary practices (Gening 1977; Smirnov and Kuzmina 1977; Zdanovich 1988), scholars have recognized well-developed age, gender, prestige, and rank differentiation (Epimakhov 2002; Anthony 2007; Vinogradov 2011; Epimakhov and Berseneva 2012). The most outstanding graves are individual male burials accompanied by weaponry (projectile weapons and chariots), the insignia of power (stone mace heads), craft tools, and a specific set of sacrificed animals (horses, cows, and dogs). For example, the burials associated with the fortified settlement of Ust'ye included six excavated kurgan mounds at the Solntse 2 cemetery. Although all had been disturbed by looters, there were at least two adults buried with chariots and one with sacrificed horses (Epimakhov 1996b). Chariots – the most famous and spectacular material component of Sintashta-Petrovka society – are known exclusively from burial contexts. Two-wheeled vehicles represent complex technol-

ogy, incorporating some crucial innovations and the investment of substantial resources. Highly developed craft and military skills were required for their production and use. Burials with chariots probably represent military elites who used them (Anthony 2009; Chechushkov 2011; Frachetti 2012:17) and played especially important social roles in Sintashta-Petrovka societies. This pattern strongly suggests that military leadership extended into the realm of ideology and general social prestige (Earle 2011:32–33).

Only recently, after large-scale excavations of several settlements – Sintashta, Petrovka 2, Novonikolskoye 1, Arkaim, Alandskoye, Ust'ye and Kamennyi Ambar – we have begun to learn about the Sintashta-Petrovka complex society. The areas within the fortifications of the known Sintashta settlements vary from 0.7 ha to 3.4 ha, which makes them very small compared to the principal settlements of other early complex societies (for example, Moundville). All 25 densely packed Sintashta-Petrovka settlements are enclosed with walls and ditches. It is argued for Sintashta and Arkaim that sites were strengthened with bastions and killing alleys (Gening et al. 1992; Zdanovich 2011); however, there are no traces of military catastrophes, as well as no military-related trauma on human remains (Hanks 2009:151). Moreover, the military functioning of the settlements has been questioned and their primary focus on livestock husbandry suggested (Anisimov 2009). In the Sintashta-Petrovka settlements, up to 60 houses were placed immediately adjacent to each other, indicating extremely dense packing of inhabitants within settlements. For instance, at Ust'ye, magnetometry indicates about 35 houses of both Sintashta and Petrovka phases within the enclosure (Hanks et al. 2013:401–402). Of these, 11 have been tested and six excavated fully. Their size averages 240±8 m^2 (67% CL), so they are relatively large and standardized dwellings that would have housed a total population of at least several hundred people. The spatial organization of houses is two parallel rows with a street between them. Neighboring structures in each row share intermediate walls, and 80% of them have wells.

It has often been observed that differences in elaboration between the residences within any fortified settlement are very slight. The recently published material on Ust'ye (Vinogradov 2013) demonstrates the difficulty of distinguishing ranked social groups based on households' architecture. Very similar patterns of household architecture make Zdanovich (1997) conclude that whatever social hierarchy may have existed in Sintashta-Petrovka communities, it did not create different standards of living for households of different rank. A similar observation can be

made about wealth, productive differentiation, and craft specialization (Costin 1991). For Ust'ye, an examination of the proportions of different classes of mundane artifacts (ceramic vessels, slag, copper ore, arrowheads, bronze knives, spindle whorls, grinding stones, ornaments, bronze ingots, awls, sickles, picks, and hammerstones) reveals some differences in assemblage diversity. Houses 5 and 11 have the most diverse artifact assemblages, with Simpson's Index (1 – L) values of 0.63 (0.58–0.67 at 95% CL) and 0.54 (0.38–0.64 at 95% CL) respectively. The indexes for houses 1 and 3 are 0.42 (0.27–0.54 at 95% CL) and 0.43 (0.34–0.50 at 95% CL). The least diverse assemblages are from houses 2 and 10, with values of 0.35 (0.16–0.51 at 95% CL) and 0.16 (0.00–0.37 at 95% CL). While the samples are small and the error ranges wide, some households do seem to have more diverse assemblages than others, an observation that could be related to slight differences in productive activities and/or wealth. There are also slight differences in the proportions of bronze ingots and ornaments, which could be related to differences in wealth. However, the strong differences between assemblages we might expect to see between commoners and leaders who buried with chariots, sacrificed horses, bronze weapons, and insignia of power fail to appear.

Almost all excavated sites yielded abundant evidence of metallurgical production. For example, excavations covering 3000 m² at the fortified settlement of Ust'ye have exposed 11 residential structures and 16 features related to the manufacture of bronze. Artifacts included two tuyères, more than 5.5 kg of different types of copper ore, 1.4 kg of copper ingots, 13.5 kg (1146 pieces) of slag, and 182 drop-shaped casting remnants (Vinogradov 2013:428–429). Another 226 pieces (0.9 kg) of slag were recently recovered from a test pit outside the walls of the site (Chechushkov 2012; Hanks et al. 2013). Altogether, at least 62 furnaces for metal production have been excavated in Sintashta-Petrovka settlements (Grigoriev 2013). The presence of metal production at several localities is undeniable, although the scale of production remains under discussion. Anthony argues that Sintashta settlements mark a sharp increase in metal production in the Eurasian Steppe to supply demand across a large area in Central Asia as well as internal needs and that large quantities of bronze were produced and consumed (Anthony 2007:435; also, Peterson 2009:208). In contrast, Doonan et al. (2014:766) have concluded that the scale of production was much smaller, at least at the site of Stepnoye. In any event, metal production was one significant activity at the fortified Sintashta-Petrovka settlements. The bronze sickles and

casting molds recovered, suggest a kind of useful products of fortified settlements that people involved to food production might have consumed. Like Moundville, control of craft might have provided a source of power for elites in the fortified settlements (Steponaitis 1991). Some bronze tools, such as chisels, adzes, and handsaws seem more abundantly represented at some fortified settlements than at others, raising the possibility of a stronger focus on different craft products and some degree of exchange and interdependence between fortified settlements.

There is no general agreement among scholars on population estimates. For instance, Zdanovich (1995:35) estimates 2500 people within the walls at Arkaim. He bases his conclusion an average house size of 140 m^2 and the idea that Arkaim households consisted of an extended family of several generations, similar to Iroquois longhouse inhabitants. He also suggests that the entire population did not live in the "town" all the time, but moved around. The fully permanent residents were shamans, warriors, and craftsmen, i.e., elites and attached specialists. On the other hand, Epimakhov (1996a) estimates a much lower 600–800 inhabitants, reducing the available living space to allow for economic activities which also took place inside the dwellings. For Kohl (2007) an estimate of 400 inhabitants seems more plausible for Arkaim. In any case, even the lowest of these population estimates compares favorably with local communities observed to have a complex social organization or argued by some to require complex social organization (e.g., Alberti 2014). By comparison, the largest communities of early regional polities in regions around the globe can be as low as 150–600 for Hongshan societies (4500–3000 BC) in the Chifeng region of eastern Inner Mongolia and northeastern China (Peterson and Drennan 2005) and as high as 2500 for the Terminal Formative period (300 BC–AD 100) in the Basin of Mexico (Sanders et al. 1979:52). It is evident, however, that the small number of people buried in kurgans (no more than 100 per cemetery) represent only a tiny segment of any variant of estimated populations of the fortified settlements, most of whom must have been treated in far simpler ways at death.

Summarizing, excavated households represent very strongly similar architectural patterns, similar levels of wealth and prestige, little productive differentiation, and no evidence of elites amassing wealth through control of craft or subsistence production or any other mechanism (Earle 1987). These observations sharply contradict the burial record, where strong social differentiation is visible. The description above recalls the Regional Classic period elites of the

Alto Magdalena whose standard of living differed little if at all from anyone else's. Their elaborate tombs and sculptures suggest supernatural powers and ritual roles were much more import- ant bases of their social prominence than economic control or accumulation of wealth (Drennan 1995:96–97). On the other hand, craft activities (especially metal production) are highly obvious in the Sintashta-Petrovka settlements. Defensive functions could also have played some role for the entire population. This benefit might attract people in an unstable or wild environment to spend much of their time in or near such settlements (Earle 2011:32–33). Since the construction of ditches and outer walls, as well as dwellings with shared walls, requires planning and organiza- tion, purposeful collective effort must have been a key feature of Sintashta-Petrovka communities (Vinogradov 2013; Zdanovich 1995). Sintashta-Petrovka communities thus evidence substantial investment of effort in non-subsistence activities, potentially resulting in a subsistence deficit in an economy with a heavy emphasis on herding. Altogether, this makes it plausible to think of the known Sintashta-Petrovka communities as special places where elites for whom military activi- ties were important resided, and where metal production and possibly other crafts were carried out. It remains unclear just how a subsistence economy relying heavily on herding was managed from these substantial sedentary communities. Moving herds around the landscape seasonally is generally thought to be a part of subsistence strategy in Inner Eurasia (Frachetti 2008; Bachura 2013). In this area migration to exploit seasonal pastures is the best strategy for maintaining a regular supply of food for livestock due to shortages of capital or of labor pool to produce, harvest, and store fodder (Dyson-Hudson and Dyson-Hudson 1980:17). The recent stable isotope studies support this notion showing high likelihood that during the Bronze Age livestock was raised locally (Kiseleva et al. 2017).

The above raises the possibility that the residential remains that have been excavated within the fortifications of Sintashta-Petrovka communities represent only a portion of the popu- lation (Hanks and Doonan 2009, Johnson and Hanks 2012). It could be (along with the general lines suggested by D. Zdanovich [1997]) that the archaeological remains of the ordinary people who made up the majority of the population, built the impressive fortifications and stoked the sub- sistence economy have gone largely undetected. In global comparative perspective, many soci- eties with the features known for Sintashta-Petrovka organization consisted of elite central-place settlements and hinterland populations. In such a scenario, the "missing" portion of the Sintashta

population would reside in smaller unfortified settlements scattered around in the vicinity of the fortified ones. However, smaller settlements of this kind are almost entirely unknown for Sintashta-Petrovka times. A systematic pedestrian survey in the region of the fortified settlements of Stepnoye and Chernorech'ye yielded tiny quantities of Sintashta-Petrovka materials on the surface within the walls (Johnson 2015). The only unfortified settlements of Kamennyi Brod near Arkaim and Strelets'koye near Stepnoye had very few inhabitants and cannot be taken to represent a substantial population of commoners meaningfully. The unfortified settlement of Kulevchi 3 does date to Sintashta-Petrovka times, but as a specialized metal production settlement distant (23 km) from the nearest known fortified center (Vinogradov 1982b; Degtyareva et al. 2001), it does not constitute evidence of a population of commoners. In the Arkaim valley, 71 unfortified settlements were explored, but artifacts were collected from only five of them, all disturbed by modern human activities, such as plowing (Batanina and Ivanova 1995). Except for Kamennyi Brod, unfortified settlements in the Arkaim valley are attributed to the next phase of the Bronze Age following Sintashta-Petrovka (Batanina and Ivanova 1995; Maliutina and Zdanovich 2012).

1.4 THE BRONZE AGE ARCHAEOLOGICAL CULTURES AND CHRONOLOGY

The concept of archaeological culture has been utilized by Eurasian archaeologists for many decades to serve very different purposes from organizing materials to distinguishing ethnic groups and speakers of particular languages (Merpert 1974; Smirnov and Kuzmina 1977; Kuzmina 1994, etc.). In the steppes of the Urals and Kazakhstan, the archaeological cultures are mainly linked to ceramic styles, while other patterns of life are more arguable.

Vinogradov (1982:32–56) distinguishes two principal groups of ceramic vessels which are the Petrovka and Alakul' types. His classification is based on morphological similarities and dissimilarities of full forms and techniques and patterns of ornamentation (Fig. 1.2). The Petrovka group is characterized by the sharp-edged shoulder and the conical body. In some cases, the neck can be out-curved, while in other cases it is upright with broad thinning under the rim. Carved ornamentation covers the upper part of the vessel and consists of zig-zags, triangles, multiple wavy or straight lines, and geometric shapes. As for the ceramic vessels found at Sintashta settle-

ments and cemeteries, Vinogradov includes them in the same group as those found in the Petro-vka sites of Northern Kazakhstan. The Alakul' group of ceramics is distinguishable by the slightly swollen body, the ledged shoulder and straight neck and rim. The ornamentation schemes of the Alakul' pottery derive from the Petrovka ones but are characterized by more elaborate techniques and complicated shapes, such as meanders and rhombuses.

Later, Zdanovich (1988:109–115) developed Vinogradov's typology by adding that the important technological difference between two types is the Petrovka technique of using another vessel or a wooden template to shape the body of a vessel. The Alakul' pots are made with the clay coil/slab technique without a template. The author explicitly says that ceramics from the Sin-tashta archaeological site belong to the Petrovka tradition of pottery, though with attributes of the ceramic traditions of other archaeological cultures.

Vinogradov and Alaeva (Vinogradov 2013:143–178) analyzed the ceramic collection from Ust'ye. Their classification is a continuation of the earlier Vinogradov work, but the Sintashta ceramics are distinguished from the Petrovka ceramics, and the latter sare also labeled early-Al-akul'. The analysis is heavily based on neck morphology and decoration of the vessels. The differ-
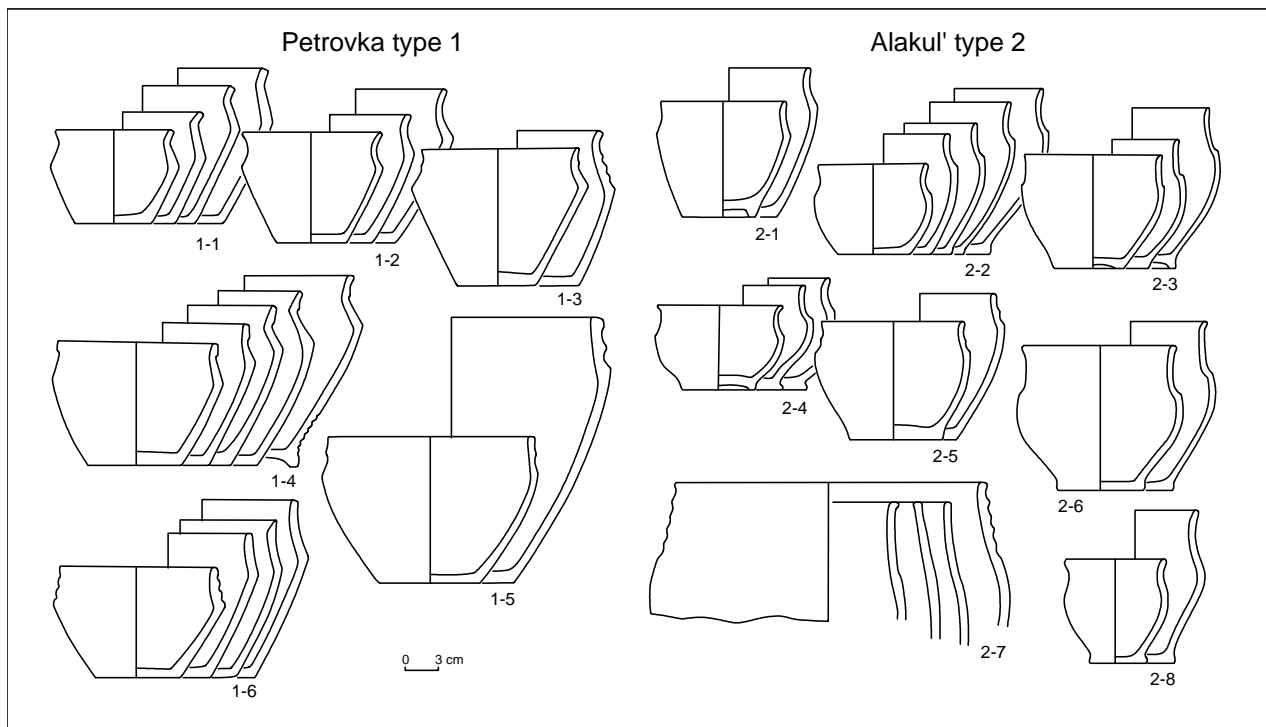
Figure 1.2 The Bronze Age ceramic typology according to Vinogradov's classification scheme
(redrawn after: Vinogradov 1982)

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ences between the two groups are the more elaborate and varied ornamentation techniques used by the Sintashta potters and the straight neck with broad thinning under the rim of the Petrovka vessels. Excavation at Ust'ye showed that the Sintashta tradition of pottery preceded the Petrovka one since the surrounding wall of the Petrovka phase buried the Sintashta houses and many undoubtfully Sintashta ceramic sherds. Moreover, the Sintashta pottery is interpreted as a result of the melding of many cultural-ethnic groups, specifically by including Abashevo women from the western side of the Urals into Sinhtashta communities and their connection to the Srubnaya culture. The Petrovka tradition is seen as a result of the unification of several pottery traditions which gave way to Alakul' pottery (Vinigradov 2013:175–178).

In the same monograph, Gutkov (Vinogradov 2013:179–184) published his results of technological analysis of the sherds. He concludes that despite the differences between the types (the presence of silty raw materials in Sintashta vessels alone, the more complicated recipes of the molding masses of Petrovka ceramics), they also have common features that along with the methods of formation of the Petrovka type of ceramics testifies to their genetic continuity (Vinogradov 2013:184).

Several separate publications have been devoted to the analysis of Sintashta ceramics in itself. For instance, Tkachev and Khavansky (2006) developed an elaborate classification scheme based on Pearson's correlation coefficient. In their scheme pots, jars, bowls, and dishes are distinguished morphologically. The authors concluded that it is difficult to identify successive stages and all complexes have all types of ceramics. Panteleyva (2013) analyzed ceramic sherds yielded by the excavation inside the walls of Kamennyi Ambar and compared them to those from the nearby cemetery of Kamennyi Ambar-5. Like other authors, in the settlement ceramics, she finds the group of sharp-edged jars and straight-neck bowls, which are explicitly included into the Petrovka type distinguished by both Vinogradov and Zdanovich. The specific Petrovka ceramics, thus, can be identified by the upright neck with broad thinning under the rim. Moreover, Panteleyva concludes that utilitarian vessels from the settlement morphologically differ from the ritual pots from the cemetery, since only jars can be found buried with the deceased.

Importantly, all archaeologists agree that morphology of the whole vessel or at least its upper parts (shoulder, neck, rim) can be used for meaningful delineation of the cultural types. Thus, Vinogradov points out explicitly that sherds from body parts of vessels cannot be used for the

purposes of classification (Vinogradov 1980:32–33). This creates an obstacle for studying cultural layers with low preservation and requires employing another kind of analysis.

The different points of view on ceramic typologies gave rise to life many competing hypotheses about chronology and social development during the Bronze Age. Thus, D. Zdanovich (1997) sees the Sintashta fortified settlements as elite central places surrounded by hinterlands and Petrovka as the following phase of the same development. Vinogradov (2011) interprets the Sintashta settlements as specialized communities of multi-ethnic metallurgists, while the Petrovka ones are the ordinary villages of pre-Alakul' pastoralists. For Vinogradov, the difference is crucial, since it relates to different ethnic components of the archaeological cultures. G. Zdanovich (2011) argues that the difference between the Sintashta and Petrovka communities in the shapes of the enclosures and, thus, the pattern of house organization, is due to competitive cultures. The Sintashta settlements organized in a circular pattern are seen as cultural antagonists of the Petrovka sites organized as rectangles. However, excavations at Arkaim, Ust'ye and Kamennyi Ambar disprove this idea, since both types of ceramics can be found at settlements of either shape.

From my point of view, distinguishing the Sintashta and the Petrovka archaeological cultural types blurs the picture (e.g., Vinogradov 2011, 2017; Zdanovich 2011). It is established that Sintashta ceramics occur in deeper stratigraphic positions than Petrovka sherds (Vinogradov 2013; Krause and Koryakova 2013:185), hence, the differences in ceramic styles and metal-working techniques correlate with chronology (Epimakhov 2007) and, probably, can be explained as style preferences of successive generations and technological development. However, the variability fails to link to the socio-political and economic differences between two archaeological phenomena, since the Petrovka houses are within the Sintashta enclosures. The burial rites and rituals also do not demonstrate any significant differences (Zdanovich 1988).

However, the Srubnaya-Alakul' ceramics appear in very difference contexts (Zdanovich 1988:117–131). At Kamennyi Ambar, this ceramic type is found in the overlying stratigraphic horizon consisting of un-clustered houses in an unfortified settlement (Krause and Koryakova 2013:185). The substantial difference in the lifestyle is the key factor for distinguishing the two archaeological phenomena (Sharapov 2017).

Another important issue is the system of relative chronology of Bronze Age Eurasia that was established on the basis of typological and chemical analysis of metal artifacts (Chernykh

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1978, 1992, 2008; Ryndina and Degtyareva 2002; Tkachev 2007). According to this system, the Bronze Age can be divided into three sub-phases: the Early, the Middle, and the Late. Each period is characterized by uniform technologies and traditions of copper metallurgy, present across vast areas. The upper and lower limits are not necessarily simultaneous in various regions but are stretched according to the spread and adoption of technologies, stagnation processes, etc. The Early and Middle phases of the Bronze Age correspond to the development and diffusion of the so-called Circumpontic Metallurgical Province: the phenomenon that integrates the technological and morphological standards of metal-working, particular categories, and forms of tools and weapons, as well as the use of copper-arsenic alloys. The Late Bronze Age corresponds to the formation and spread of the Eurasian Metallurgical Province, which differs sharply from the former by relying on new sources of metal in Asia (from the eastern Ural Mountains, through Kazakhstan, and up to the western Altai Mountains), and large-scale production of tin bronzes. In accordance with the scheme, the Sintashta-Petrovka phenomenon can be attributed to the Late Bronze Age as a formative period of the Eurasian Metallurgical Province (Chernykh 2008:79–85).

However, there is a terminological confusion in the description of the relative chronology of the Bronze Age inthe professional literature both in Russian and English. For example, in his 2007 monograph, Anthony attributes the Sintashta culture to the Middle Bronze Age. Anthony comes to that conclusion by comparison of two radiocarbon dates from the Sintashta Cemetery with the chronology of the Yamnaya (Pit-Grave) culture (Anthony 2007:371–379). Importantly, the systematic radiocarbon chronology of Bronze Age Eurasia has been established only recently (Trifonov 2001; Hanks et al. 2007; Chernykh 2008; Krause and Koryakova 2013). Over 200 samples demonstrate a chronological position for the Sintashta development that follows the essentially Middle Bronze Age cultures. As a result, Epimakhov (2010) has suggested a periodization of the Bronze Age of the Ural Region, which avoids a traditional three-stage system and links periods with the associated archaeological cultures. All the cultural developments considered in this dissertation are attributed to the Late Bronze Age, according to Chernykh's scheme cited above. The following sequence of archaeological cultures – based on the sample of radiocarbon dates (Epimakhov 2007a; 2010a), – is adopted: (1) the Sintashta-Petrovka phase 1 dated to cal. 2050–1750 BC and (2) the Srubnaya-Alakul' phase 2 dated to cal. 1750–1350 BC.

1.5 THE RESEARCH REGION: CLIMATE AND ENVIRONMENT

The research region extends to the east from the Ural Mountains on their southern end. Today this territory mainly belongs to the Chelyabinsk Region of Russia, and to Northern Kazakhstan. This area is known as the Transural peneplain, a middle part of the Great Belt of the Eurasian Steppes. The most recent ecological research suggests climate similar to modern conditions during the Late Bronze Age, at least for the micro-region along the Karagaily-Ayat River (Stobbe et al. 2016:13–14), which is the focus of this research. This permits application of present climatic and environmental data, described below, for comprehending ancient societies and practices.

In general, the area of study lies in the north temperate zone approximately between 50° and 55° north latitude. The landscape of the Trans-Urals peneplain varies from rolling steppe with some hills on the west to almost flat plain in the east. Altitude gradually declines from 400–350 m above sea level on the west to 200–190 m on the east. The Ural Mountains condition the climate by blocking the flow of air from the west, and providing a tunnel for cold and dry arctic air. In the summer season, continental tropical air flows up from Asia, bringing hot weather. The southeastern part of the region is windy with 300–320 windy days annually on average. The maximum speed of wind achieves 20–25 m per second. The climate is characterized as continental with mean temperatures below 0°C (32°F) in winter and above +10°C (50°F) during the summer months. The absolute winter minimum recorded as low as -50°C (-58°F). Precipitation declines from 500 mm annually in the north to 300 mm in the south, with the largest amount during the warm months (75%–78% of annual precipitation). The area of study belongs to south steppe region, which is considered as the zone of insufficient humidity (300 mm a year). The annual average for snowfall is 24-30 cm, and it usually snows for 153–155 days. Water from snow does not exceed 22% of annual precipitation (Levit 2005).

The Ural and the Tobol are the two major rivers in the southern Trans-Urals that form the watershed and landscapes. The interfluve is shaped by the beds of smaller tributaries that flow either west towards the Ural or east towards the Tobol. The largest source of water is precipitation, providing 80%–90% of the rivers' volume. For this reason, water flows at low speed (0.1 m per second and up to 2 m per second in rapids) during the dry summer months, but in the flood period, the volume increases sharply, and the level rises 1–2 m (Levit 2005).

1.6 A CASE STUDY: THE KARAGAILY-AYAT RIVER VALLEY

The valley of the Karagaily-Ayat River is located 250 km south of the City of Chelyabinsk. The Karagaily-Ayat is a tributary of the Ayat River in the Tobol Basin. It is a small tributary, 20 m wide on average, that flows some 106 km slowly from west to east across the open space of the Transural peneplain. The river originates where the Yandyrka River (flowing from the north-west) and the Akmulla River (from the north) converge. A wide valley is formed by the main bed, abandoned river channels, and seasonal tributaries; in some localities the valley reaches several kilometers in width (Kostuykov 1993; Stobbe et al. 2016). Wormwood-fescue grasses and groves of birch and pine trees create a typical forest-steppe landscape of the Karagaily-Ayat valley, abundant with diverse wild resources. Prevalent soils are haplic Chernozems (Borolls) that lie on top of loam or alluvial sand (Krause and Koryakova 2013:25).

The distribution of archaeological sites in the Karagaily-Ayat River valley has been previously studied by pedestrian surveys (Vinogradov 1982a; Kostyukov 1993; Tairov 1996) and analysis of aerial photography (Zdanovich and Batanina 2007; Batanina and Levit 2008). Kostyukov's map covers the territory from Varshavka village almost all the way to the Russia-Kazakhstan border. Batanina and Levit's report adds the upper portion of the river and territories near the international border. Kostyukov and Tairov described the sites and collected materials from the surface, as well as dug test pits, which allowed chronological attribution. Batanina and Levit counted and mapped individual house depressions on each settlement. According to these sources, there are three fortified settlements of the Sintashta-Petrovka period, and 15 unfortified of later parts of the Bronze Age (Fig. 1.3).

The fortified settlements of Kamennyi Ambar (Fig. 1.4), Konoplyanka (Fig. 1.5), and Zhurumbay (Fig. 1.6) are found in the upstream portion of the Karagaily-Ayat River valley. These settlements are located about 10 km from one another, occupying low spots next to the floodplain. Large-scale projects have recently yielded a number of AMS radiocarbon dates, data about artifacts and ecofacts, and substantial information on house structures and household artifact assemblages (ceramics, projectile points, metal-working tools, copper ore, smelting waste [slag], other miscellaneous household items, and ornaments), especially at Kamennyi Ambar, the east-
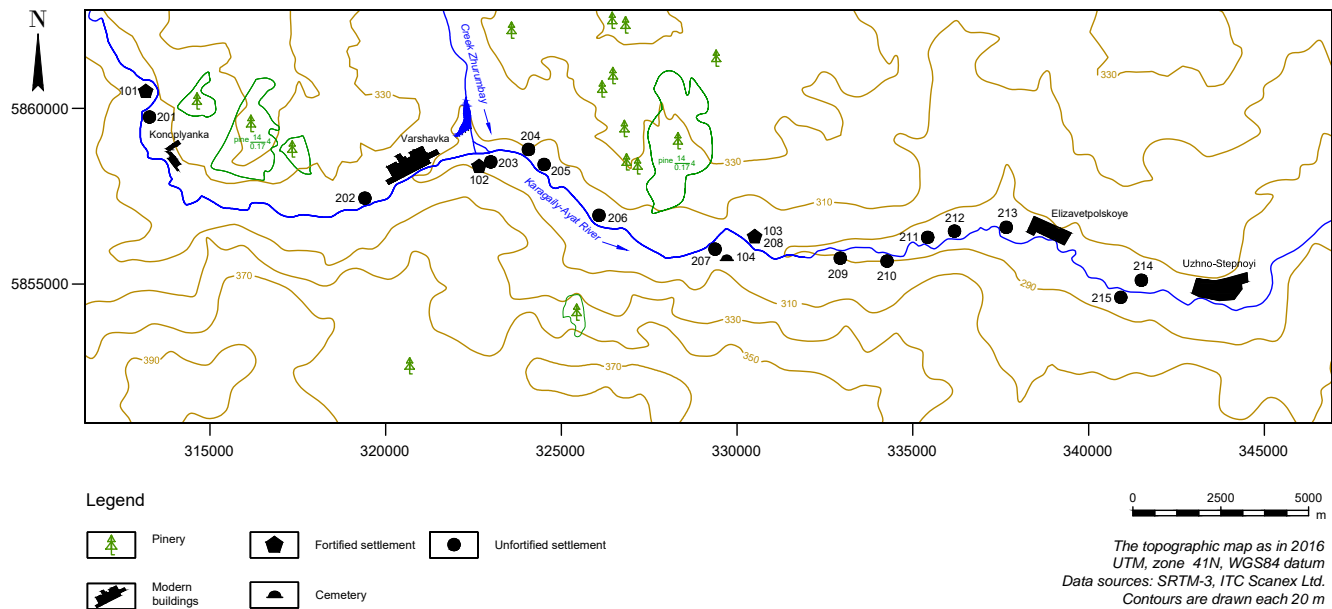
Figure 1.3 The map of the Bronze Age sites in the Karagaily-Ayat Valley

Sites of Phase 1: 101 – Konoplyanka; 102 – Zhurumbay; 103 – Kamennyi Ambar; 104 – Kamennyi Ambar-5

Sites of Phase 2: 201 – Konoplyanka 1; 202 – Varshavskoye-1; 203 – Zhurumbay-1; 204 – Varshavskoye-3; 205 – Varshavskoye-5; 206 – Varshavskoye-9; 207 – Kamennyi Ambar-8; 208 – Kamennyi Ambar; 209 – Elizavetpolskoye-3; 210 – Elizavetpolskoye-2; 211 – Karagayli-26; 212 – Elizavetpolskoye-7; 213 – Elizavetpolskoye-9; 214 – Yuzhno-Stepnoyi (1); 215 – Yuzhno-Stepnoyi (2)

ernmost of the three "towns" in the valley (Koryakova et al. 2011; Krause and Koryakova 2013). Its fortifications and architectural remains within the walls have been documented through the stratigraphic exposure of 1888 m². The rectangular plan of the wall and shallow ditch enclose 1.8 ha. Magnetometry indicates at least 35–40 buildings within the fortifications, organized in rows. However, the excavation of the middle area revealed the two stages of occupation: first, the bigger enclosure was constructed, but after several decades the southern part was abandoned, and the settlement's size decreased from 1.8 ha to 0.9 ha. The presence of a stone axe in one house (L. Koryakova, personal communication, 2013) and cheek-pieces from chariot harness in a neighboring structure (Bersenev et al. 2014) suggest elites fitting the pattern of other Sintashta-Petrovka communities. Three kurgan mounds in the cemetery of Kamennyi Ambar-5 yielded classic Sintashta material (including chariots) and ritual patterns and were interpreted as the cemetery of the fortified settlement (Epimakhov 2005). House structures inside the walls average 215 m² for which ten persons per house seems a very conservative estimate. At this rate, the 25–40 houses
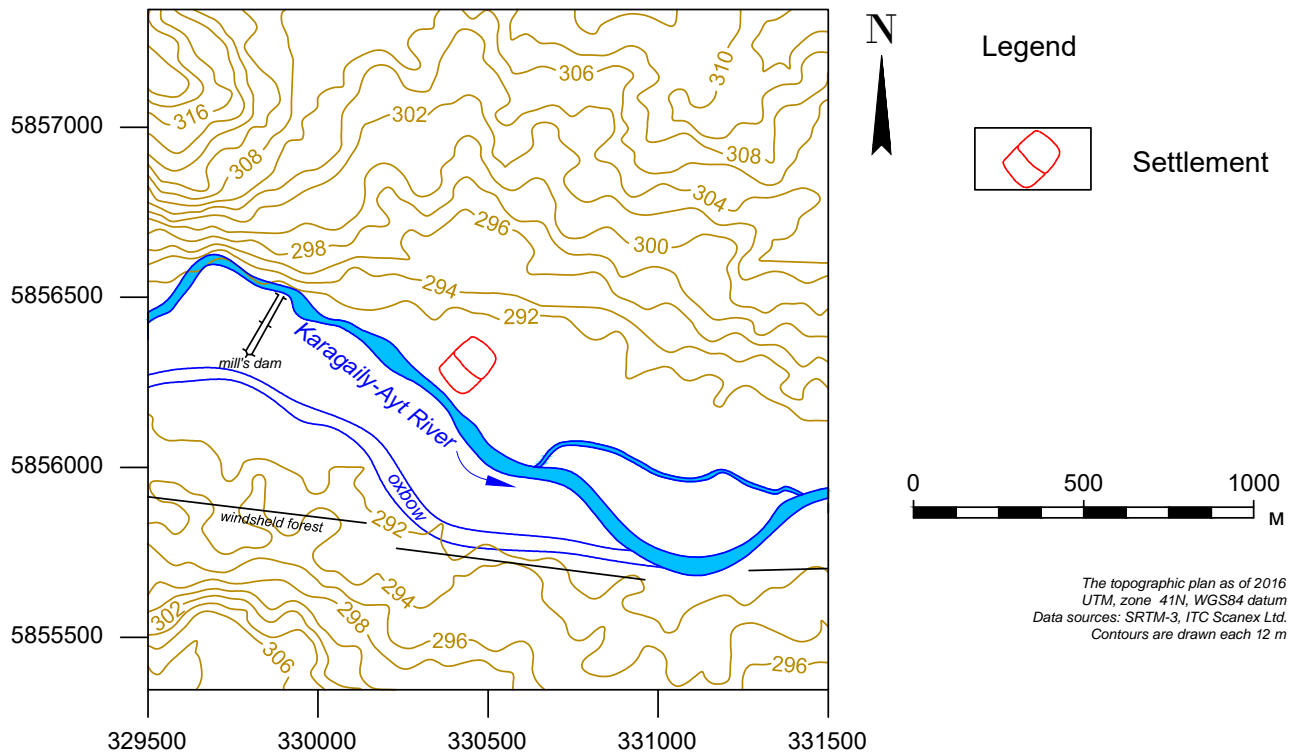
Figure 1.4 The topographic map of the Kamennyi Ambar area

would represent a population of at least 250–400 through an occupation span of some 300 years indicated by 12 radiocarbon dates. This amounts to at least five generations, for a minimum total of 1,250–2,000 burials. The approximately 100 individuals in the excavated kurgan burials represent, as has been argued for other Sintashta communities, only a small part of the population living within the walls.

Zhurumbay is the largest of the three settlements, located midway between the other two. Satellite images indicate a 2.4 ha roundish settlement with at least 30–35 buildings. Konoplyanka is near the source of the Karagaily-Ayat River and is the smallest of the three "towns" at 1.1 ha. An excavated area of 96 m^2 yielded artifacts, again including ceramics, slag, drops of metal, and assorted household items, as well as radiocarbon dates. Magnetometer survey reveals fortifications enclosing 22–24 houses in two parallel rows (Noskevich and Fedorova 2012). Small excavation has been conducted at the site (Sharapova et al. 2014), and its material assemblage is characterized by Sintashta-Petrovka ceramics and various stone tools recovered from this excavation and a brief archaeological survey (Zdanovich and Batanina 2007:82–86).
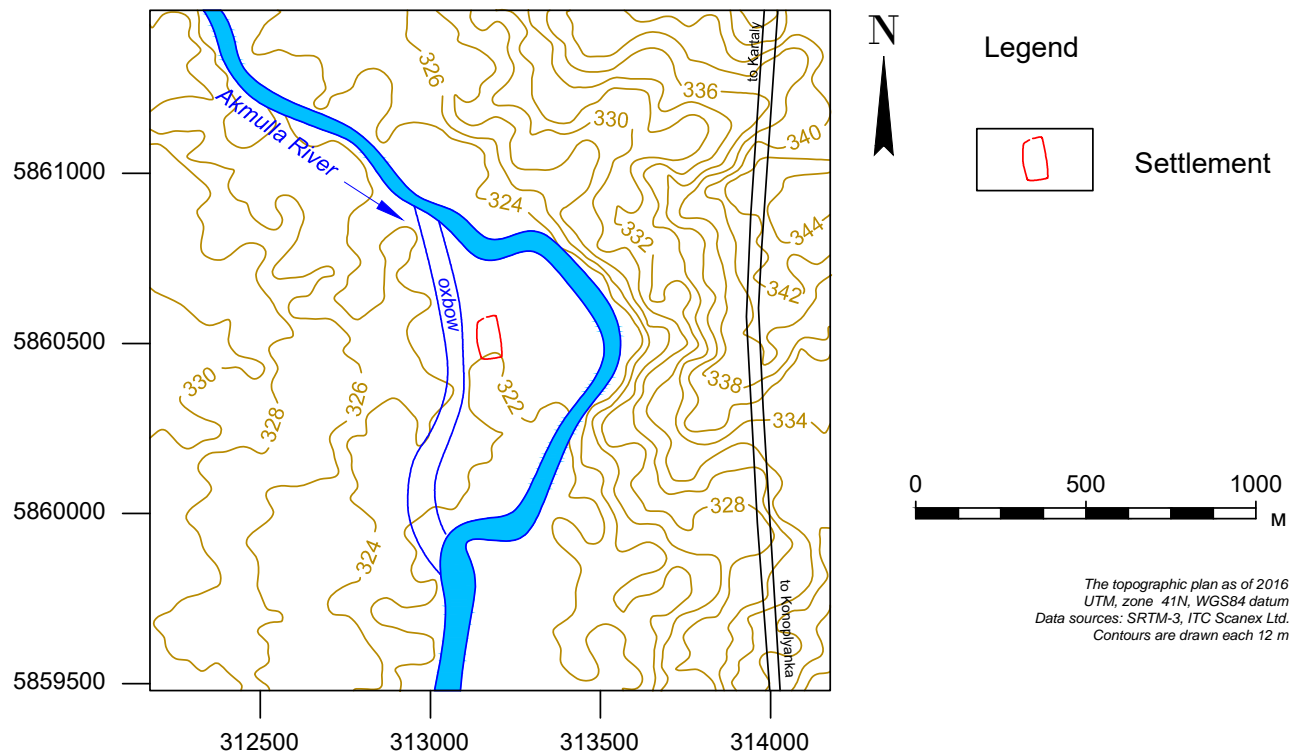
Figure 1.5 The topographic map of the Konoplyanka area

Remains outside the walls of all three settlements have been studied in only a brief and preliminary way. The plans of magnetic anomalies of all three sites do not show identifiable structures outside the enclosures. There are magnetic anomalies outside the enclosure of Kamennyi Ambar, which appeared to be "remarkably weaker than inside" (Krause and Koryakova 2013:56). Some amorphous anomalies to the west and northwest of the walls are difficult to interpret (Merrony et al. 2009; Batanina and Hanks 2013:214). There are also amorphous anomalies to the north outside the wall of Konoplyanka (Fedorova and Noskevich 2012). At Zhurumbay, the eastern part of the site was surveyed with magnetometry indicating amorphous positive anomalies to the north-east of the walls (Krause and Koryakova 2013:60–62). These preliminary results show consistent indications of cultural remains outside the enclosures of the known Sintashta-Petrovka settlements, but reveal little information about their nature. Testing just outside Kamennyi Ambar yielded scatters of ceramic sherds, a horse skull and a stone structure (B. Hanks, personal communication, 2016). These three fortified settlements are relatively close together. Traveling from one to the next would require less than four hours' walking time or less than one hour on horseback. The nature of possible economic relationships be-
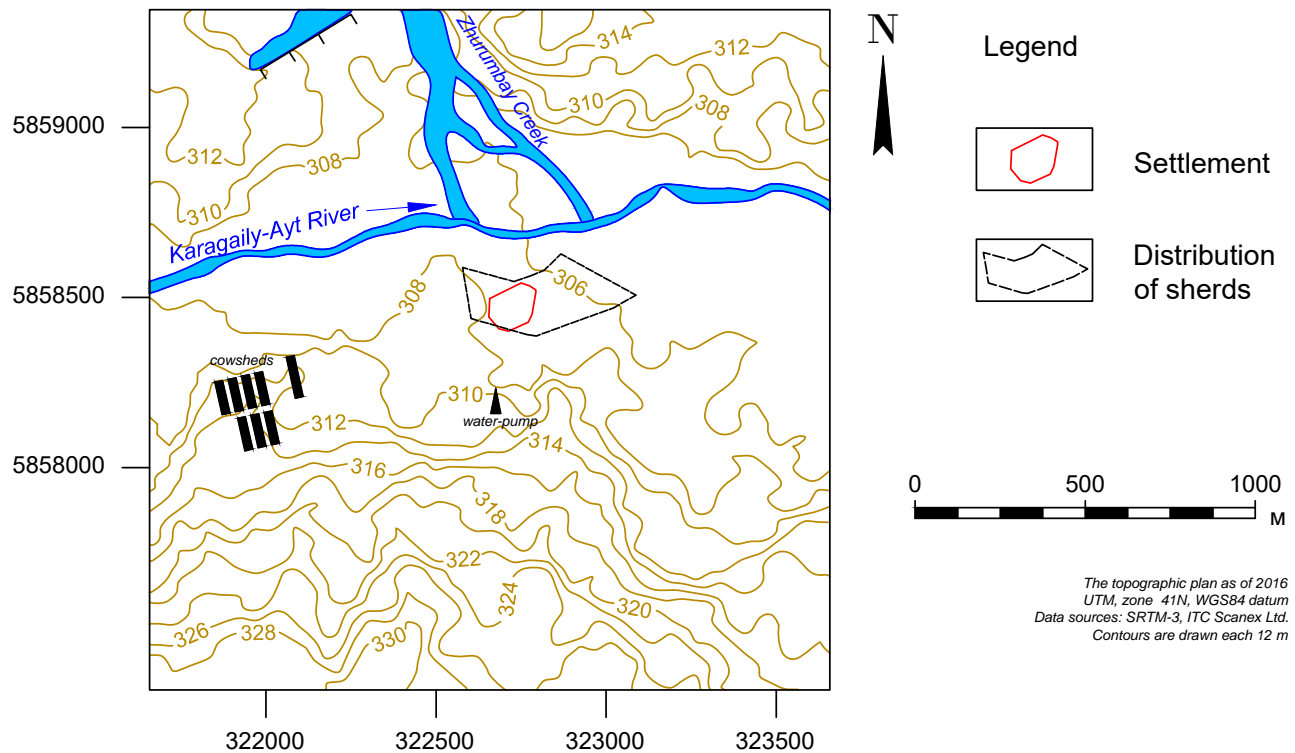
Figure 1.6 The topographic map of the Zhurumbay area

tween them is entirely unknown, although at this distance exchange of specialized products and economic interdependence are obvious possibilities.

1.7 RESEARCH OBJECTIVES

The current research aims to complement previous archaeological investigations of Sintashta-Petrovka chiefdoms, which have taught us a great deal about lifestyles within settlements and elite burials. The burials represent only a part of the Sintashta-Petrovka population, and the remains of residences and activities inside the walls may similarly represent only a portion of a community – possibly a part that could be recognized as elite and emphasizing craft production if its remains could be compared to remains outside the enclosures.

The possibility of a substantial lower-status population focused more on subsistence production, remains an intriguing but undocumented possibility. This research questions if remnants of another segment of the Sintashta-Petrovka population might be found adjacent to the fortified

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settlements but just outside the walls. Several kinds of evidence already available indicate that more investigation of remains just outside their walls is merited. If such a population was documented, our accounts of the nature of Sintashta-Petrovka communities and the relationships between their constituent households would change considerably. Asymmetrical relationships between households involving prestige and/or wealth might be documented, as might complementary productive differentiation and substantial economic interdependence. Whether or not such a population existed, how it was distributed, what its principal productive activities were, and how it related to the known populations of enclosed settlements and elites in kurgan burials are all things that must be known in order to position Sintashta-Petrovka communities in the range of variation we have come to understand for early complex societies elsewhere in the Steppes and beyond.

Documenting the possibly missing part of the population and relationships between social groups allows further investigation of settlement rationality that remain a mystery (Anisimov 2009). Finding out if lower-status people lived either within the walls or outside them would illuminate the functioning of the settlements as administrative and ritual centers, fortresses or seasonal shelters against harsh environmental conditions. In conjunction, an ultimate goal of identifying sources of political power, the shape of which might be discerned looking through the prism of the spatial distribution of social groups and the functions of the settlements, is pursued. Solving this problem with the example of the Sintashta-Petrovka development would provide a unique comparative case study of a pastoral society with at least some part of the society being sedentary, and some part being mobile.

Relationships between local communities remain another mystery, and an attempt to understand their nature would provide insight into just how each of them functioned: independently, with mutual economic benefit, or in competitive and violent environments. The discard of materials by residents of the houses inside the walls would also create middens that represent activities carried out within the enclosures, providing data sets for comparison of the settlements to each other.

This dissertation research contributes knowledge needed for such a comparative analysis by answering the following research questions:

1. To what extent do the remains outside the walls indicate actual residence there?

2. Were any residences outside the walls those of year-round occupants or of people who moved seasonally between the fortified settlements and a more distant hinterland?

3. If real residence is present, did the residents have less wealth or prestige than occupants of houses inside the walls?

4. Whether residences are indicated or not, what kinds of activities took place and how do they differ from activities inside the walls as shown by previous excavations as well as by the disposal of garbage from inside the walls?

5. How do Konoplyanka and Zhurumbay differ from Kamennyi Ambar in the balance of productive activities indicated by artifacts and ecofacts deposited in the area around their walls?

6. How did the people choose the spots in the local environments to locate the settlements?

2.0 OUTSIDERS? CULTURAL REMAINS OUTSIDE THE WALLS OF THE BRONZE AGE SETTLEMENTS IN THE KARAGAILY-AYAT RIVER VALLEY

The Bronze Age sites of the Karagaily-Ayat valley have been in the scope of archaeological attention at least since the 1980s when Kamennyi Ambar was first briefly visited by surveyors (Kostyukov 1993) and two other settlements discovered by Iya Batanina through the analysis of aerial photography. The researchers positioned the settlements on the map and conducted their preliminary descriptions, including measuring the walls and ditches and spotting houses.

In his brief field report, Kostyukov (1993) described the settlement of Kamennyi Ambar as a rectangle with smoothed corners that covers the area of about 2 ha. The surveyor outlined the boundaries of the fortified part by mapping the tops of rock slabs that shielded the front side of the earthen wall. Ten depressions were counted within the walls, but no houses spotted outside. After the analysis of aerial photography, Zdanovich and Batanina suggested that the settlement was heavily fortified with two walls with a ditch in-between them. Their measurement of the fortified area ends up with 2.4 ha and 10–12 house depressions of the Srubnaya-Alakul' phase. Moreover, according to the remote sensing advocates, another 42 house depressions of the Srubnaya-Alakul' phase can be seen in the photography, with 21 of them placed right on top of the fortified settlement, and other 21 scattered along the river in both directions from the walls. The total area covered by the cultural remains was measured as 6 ha (Zdanovich and Batanina 2007:99–101).

In the 2000s, large-scale and multi-technique projects were conducted by the Russian-American and Russian-German teams in the Karagaily-Ayat valley. Thus, in 2004, Hanks conducted a first instrumental topographic survey of Kamennyi Ambar and excavated ten 1 m by 1 m test pits outside the wall (Epimakhov 2007). These results supported Zdanovich and Batanina's idea that the cultural layers can be found adjacent to the walled site. In the same year, first brief

geophysics survey was conducted by Collin Merrony (Merrony et al. 2005). For this investigation, a flux-gate gradiometer was used. Though the resolution of this plan did not allow to count the houses in the studied area, it precisely outlined the ditch and helped to measure the inhabited space within the walls. According to this plan, the ditch encloses a rectangular area of 1.8 ha. The corners of the trench are rounded, but its sides are straight.

More precise cesium magnetometry carried out by a German geophysicist Arno Patzelt, allowed to reconstruct the inner structure of Kamennyi Ambar, including distinguishing two parts of the fortified settlement separated by the intermediate ditch and counting 30–40 Sintashta-Petrov-ka houses. According to the magnetic map, the Sintashta-Petrovka buildings are organized in four parallel rows with two of them adjacent to the main wall on the opposite sides, and two of them placed in the center of the residential core back-to-back (Fig. 2.1). The houses within each row shared their intermediate walls, resembling a multi-apartment building (Krause and Koryakova 2013:56–60). This organization pattern is well known after other excavated Sintashta-Petrovka communities at Arkaim, Sintashta, Petrovka II, Ust'ye I and Novonikolskoye 1.

The necessity of systematic study of broader areas outside the walls has been previously demonstrated by Hanks and Doonan (2009:350), who applied a coring strategy for purposes of geochemical survey. There are auger probes taken at the settlements of Stepnoye and Ust'ye to examine the level of copper, phosphorus and other elements in the space of soil. An auger with a diameter of 3 cm and length of 10 cm was used and the soil recovered for express chemical analysis included visible carbon. This allowed to spot anomalies of copper related to the deposition of metallurgical slag near Ust'ye and convincingly demonstrated the efficiency of coring (Chechushkov 2012; Hanks 2013:5; Doonan et al. 2013:214).

In 2004, Bryan Hanks for the first time started the systematic archaeological exploration outside the walls of Kamennyi Ambar. He excavated seven 1 m by 1 m test pits placed along the western side of the settlement and recovered 47 ceramic sherds of the Bronze Age (Epimakhov, personal communication, 2016). One of the sherds is assigned to the Sintashta pottery tradition, and one belongs to the ceramic assemblage of the Final Bronze Age (the Sargarino-Alekseyevka cultural type), while the rest can only be attributed to the Late Bronze Age. At the bottom of the test pit 2, he also found an animal skull (a sheep?) intentionally located in a bowl-shaped hole.
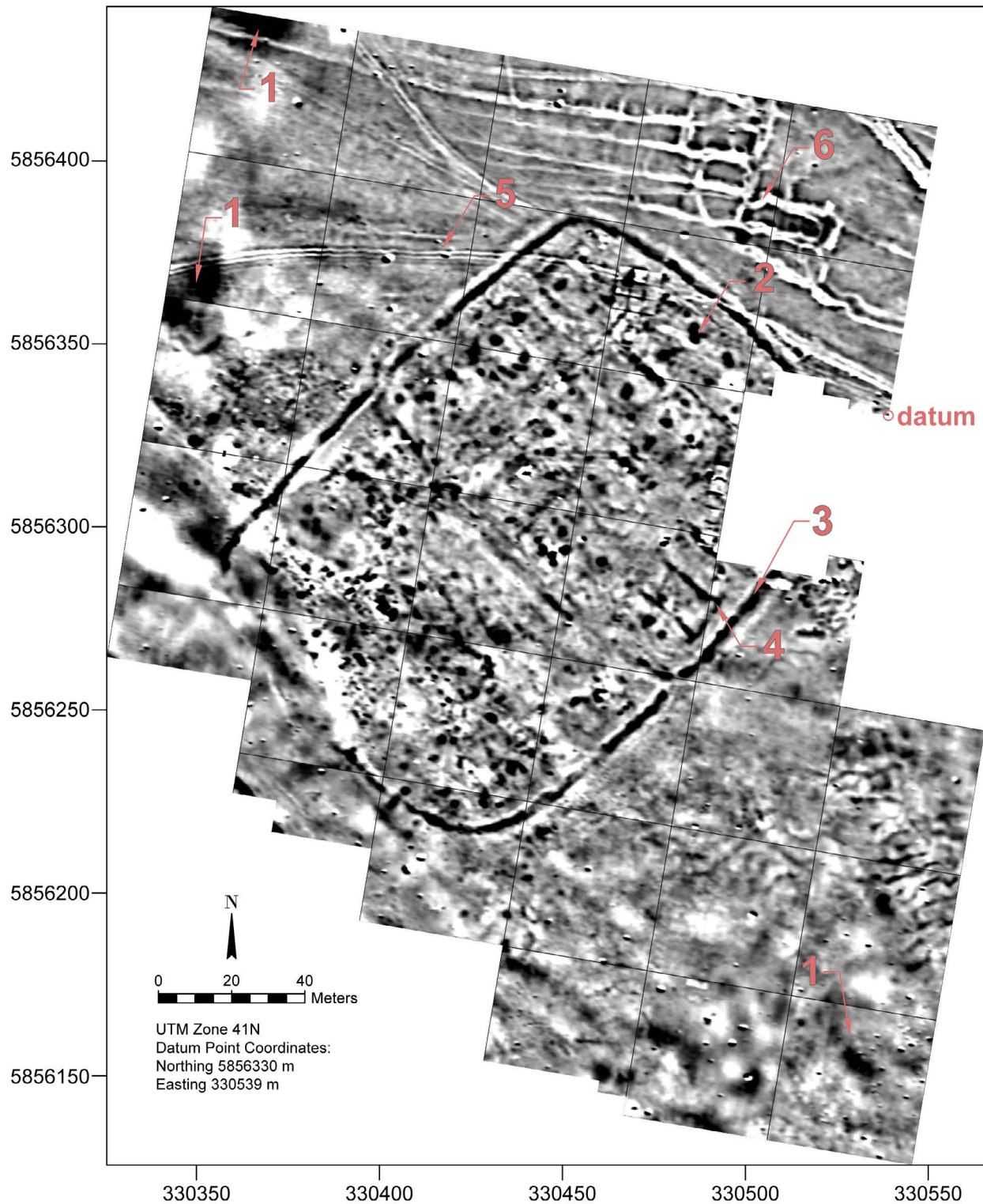
Figure 2.1 Plan of magnetic anomalies of Kamennyi Ambar

1 – possible prehistoric pit; 2 – prehistoric pit; 3 – ditch; 4 – houses' walls; 5 – modern road; 6 – modern channel. House structures and well-defined features are clearly visible in the rectangular area enclosed by the wall and ditch. Strong but amorphous anomalies are visible outside the walls to the northwest and, to a lesser extent, to the south-east (Modified after: Krause and Koryakova 2013:57)

The large-scale excavations (2,384 m^2) of the inner area of Kamennyi Ambar was conducted in 2005–2013 under the umbrella of the Russian-German research project under the supervision of Ludmila Koryakova and Rüdiger Krause. The study provided crucial data for reconstruction of the building sequence within the fortified core and for learning about the architecture of the fortifications and the residential structures (Koryakova et al. 2011; Krause and Koryakova 2013). Accordingly, three main building phases can be delineated in the settlement's history (Fig. 2.2).

Initially, the area of 1.8 ha was enclosed with the ditch and the wall, and up to 30–46 rectangular houses constructed. This earliest sub-phase 1-1 is associated with the classic Sintashta pottery that also tends to occupy the deepest stratigraphic position (Koryakova et al. 2011).

During sub-phase 1-2, a new wall was erected, and a ditch was dug right through the center of the habitational core, and the settlement was divided into two parts. Perhaps, the southern part was abandoned, since the new enclosure was constructed in order to surround the northern part of 0.9 ha (Berseneva 2014). This building horizon is associated with the later Sintashta generations and the following people of the Petrovka tradition. Moreover, it is evident that houses of the general Sintashta-Petrovka phase were repeatedly rebuilt and renovated (Koryakova and Kuzmina 2017).

The final building phase is associated with the houses of the Srubnaya-Alakul' development (the phase 2 of the settlement), and their chronological position following the Petrovka occupation is shown stratigraphically. Ten to twelve depressions, visually accounted on the surface by Kostyukov (1993), belong to this phase as confirmed by the excavation one of them (house 3). The significant differences with the previous tradition are a lack of strict organization building in rows, a roughly round-shaped dwelling (Epimakhov 2010b) and, perhaps, the absence of fortification.

As the rest of the Sintashta-Petrovka settlements, Kamennyi Ambar was built up of wood, unbaked clay, dirt and other locally available materials. The embankment was constructed out of earth collected after ditch excavation and, probably, had a height of at least 2 m. Its face was enhanced with rock slabs that came from the nearby sources – no more than 200 m apart. The surrounding ditch varies in depth from 130 cm to 190 cm, but its latest southern part does not exceed 100 cm (Krause and Koryakova 2013:85–128, 192).

1   2
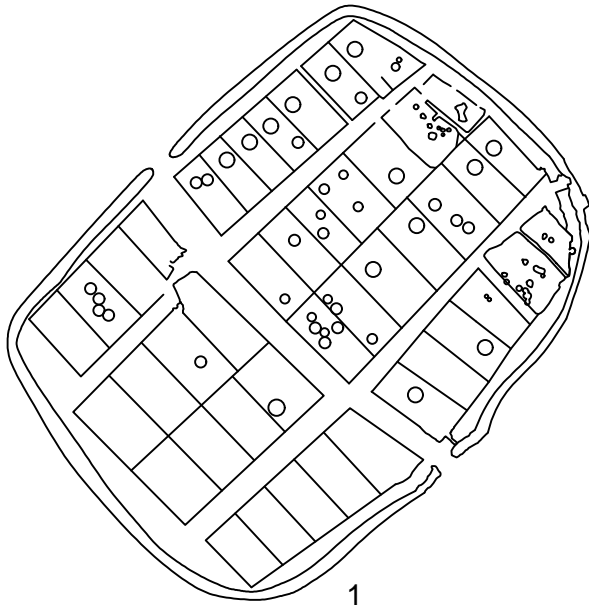
Sintashta sub-phase 1-1   Sintashta-Petrovka sub-phase 1-2
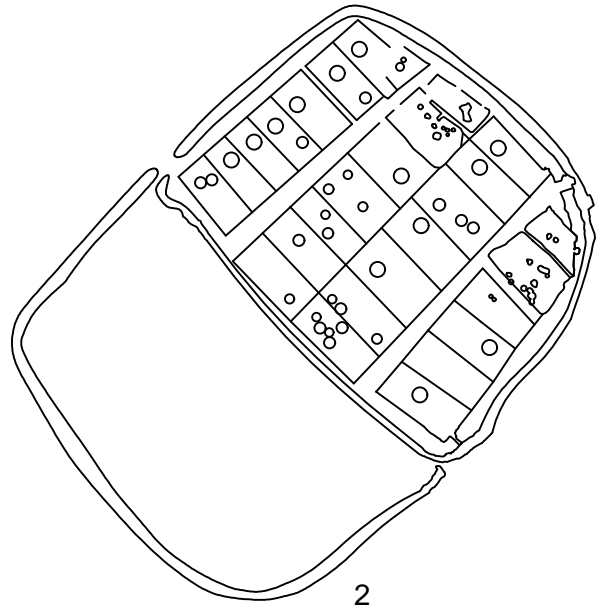
Sintashta-Petrovka phase 1 (cal. 2050–1750 BC)

3

excavated boundary

topography contour line
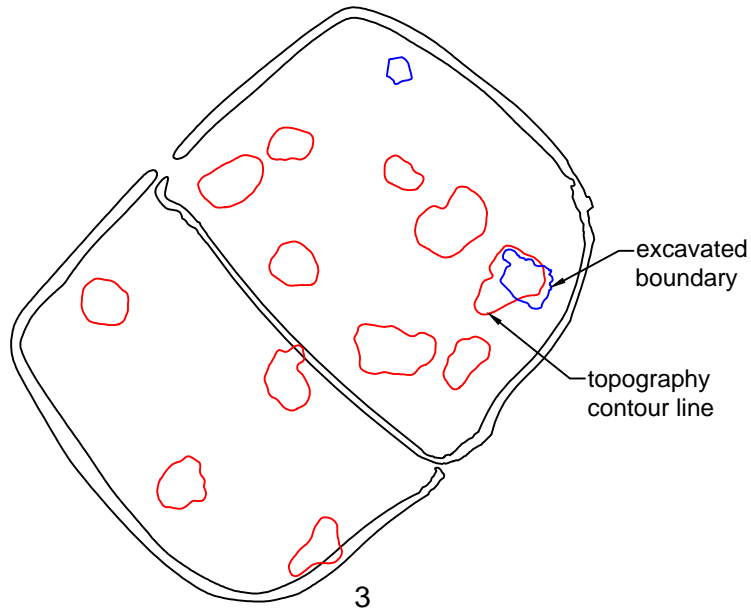
Srubnaya-Alakul' phase 2 (cal. 1750–1350 BC)

Figure 2.2 The chronological sequence of habitation at Kamennyi Ambar

There are six structures of the Sintashta-Petrovka phase and two buildings of the Srubnaya-Alakul' phase excavated within the walls. All houses were dugouts built with a frame-and-posts technique. The earthen intermediate walls of the Sintashta buildings were built on tops of unexcavated interspaces. The posts were organized in parallel rows adjusting to interspaces, and wooden planks hold soil that filled gaps between houses. Four Sintashta-Petrovka domestic structures vary in sizes from 140 m^2 to approximately 270 m^2 (n = 4; $\bar{x}$ = 215.5±89.6 m^2 at 95% confidence), which is not significantly different from the house mean size for the settlements of Arkaim, Sintashta and Ust'ye (n = 22; $\bar{x}$ = 165.3±27.5 m^2 at 95% confidence).

Two excavated Srubnaya-Alakul' buildings 3 and 6 have areas of 153 m^2 and 40 m^2, respectively. In total, 42 house depressions of this phase were accounted by Zdanovich and Batanina (2007). However, no evidence of house structure was encountered away from the walls by the magnetometry (Krause and Koryakova 2013:85–128), nor by the 1992 field survey (Kostyukov 1993). The map of micro-topography conducted by the author of this dissertation counts 10–12 depressions, placed roughly within the walls of the fortified settlement without any clear organizational pattern. Reliability of this conclusion is supported by a good agreement between shape and boundary of the house 3 on the map and on the excavation plot (Fig. 2.3). According to the micro-topography, the mean area of the Srubnaya-Alakul' depression is 163±41 m^2 at 95% confidence. Thus, the smallest structure 6, probably, represents not a dwelling, but a secondary household building.

As evident on the magnetic map and confirmed by excavations, the interior of each Sintashta-Petrovka house included a well or several of them. In some cases, the wells were rebuilt several times: an initial well would be refilled, and a new one excavated right next to it. This procedure could be repeated several times within the same residential area. It has repeatedly been argued that the beed for of wells in the close proximity to the river arose from the daily watering of domestic animals that were kept in the houses during the winters (Anisimov 2009; Epimakhov 2012). This can be supported by kill-off profiles, that shows slaughtering of semi-adult animals during the fall through the winter and until the early summer (Bachura et al. 2011).

Another essential interior feature is a hearth and/or a furnace, at least some of which were associated with metal production since clay nozzles (a tube of varying cross-sectional area, used to direct the flow of air into the furnace to maintain the temperature) and metallurgical waste were
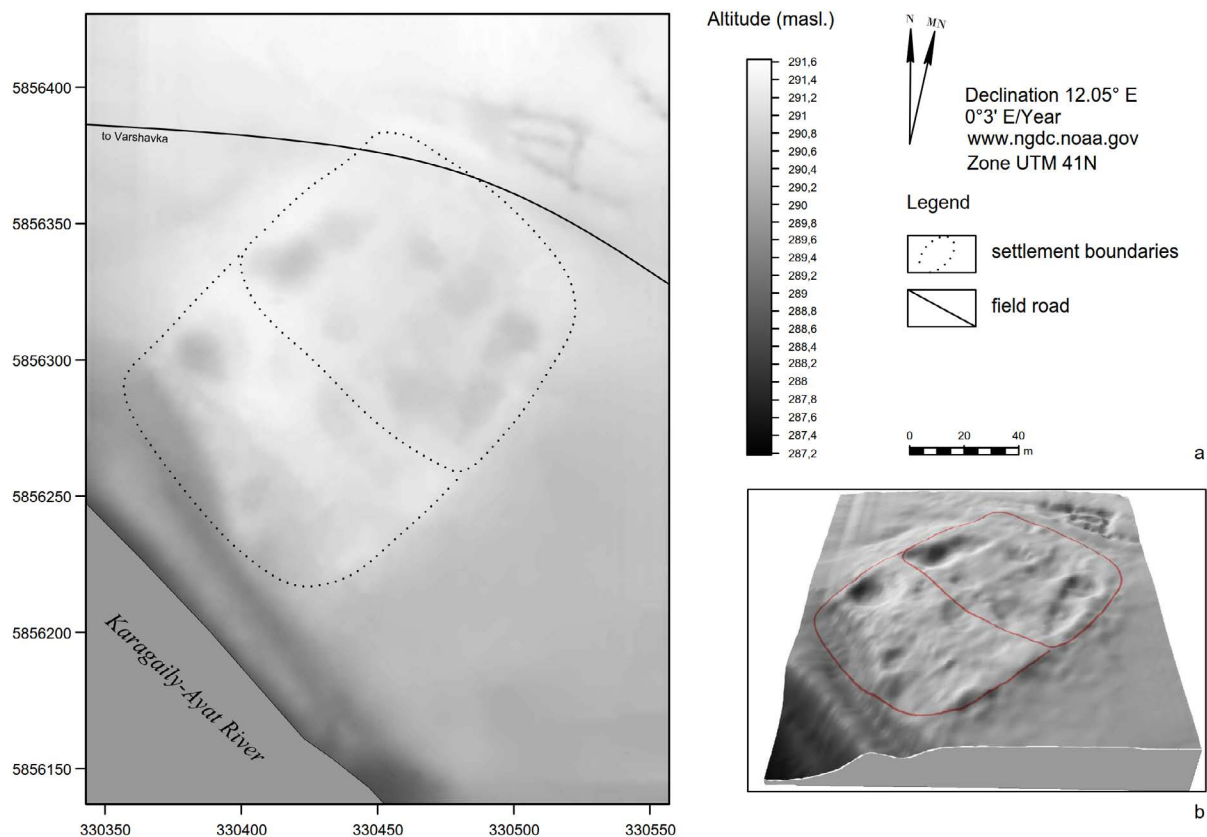
Figure 2.3 The topography of Kamennyi Ambar

a – the topographic map of the site

b – the 3-dimensional representation of the model

found within the houses. However, a surprisingly small quantity of metallurgical slag was yielded by the excavations (107 specimens), which lead the principal investigators to suggest that many metallurgical activities were carried on outside (Krause and Koryakova 2013:207–215).

The artefactual complex of the habitational core includes 25 categories of artifacts, as a minimum. In fact, there are even more categories distinguished, but some of them occurred only a single specimen, while some might be combined together like bone and lithic arrowheads, or ornaments of different materials. However, the assemblage represents the variety of household activities, including pottery production, leather and bone work, weaving and textile making, metallurgy, as well as subsistence economy, like arrowheads for hunting and hooks for fishing (Krause and Koryakova 2013:147–170).

The faunal assemblage of Kamennyi Ambar consists of domestic animals suitable for moving, like cattle and horses, but a few pig bones were also present. This evidence, as well

as lack of domesticated plants in the botanical samples, allowed investigators to conclude that animal husbandry was the primary subsistence activity of the inhabitants (Krause and Koryakova 2013:348). This conclusion does not deviate from the conventional wisdom that interprets the Bronze Age societies of Eurasian steppes as pastoral (Bendrey 2011; Spengler 2014; Ventresca Miller et al. 2014; Lightfoot et al. 2015).

Summarizing, the patterns of life within the habitational cores were studied and described in great detail. Thus, from 30 to 46 Sintashta-Petrovka households were identified within the walls of Kamennyi Ambar by geophysics and large-scale excavations. However, the critical issue for understanding social-political development – demography of the local communities – has not been in the scope of the investigators, and thus remains to be investigated and discussed.

Roughly, if the number of individuals per house is taken as from 5 to 10, the total number of inhabitants might vary from 150–230 to 300–460 people living together in the households of the sub-phase 1-1. When the enclosed settlement decreased in size during the sub-phase 2, the corresponding population would have declined to 125–250 people. As evident from the map of micro-topography, the Srubnaya-Alakul' settlement is even smaller with a maximum 50–120 people. However, the previous study was focused on excavating the enclosed settlement and, even though seasonal mobility was suggested after studying the faunal remains, the investigators did not try to find the possible semi-mobile families. This leads to the necessity of learning about the nearby localities that might help to reveal this hidden part of the population.

Moreover, the topic of productive and wealth differentiation between the households that comprise the local community also remains underinvestigated. The investigators conducted the primary analysis of the material assemblage, distinguished and quantified the artifact and ceramic types, but the differences between the households were not explored. As a result, no inferences about the socio-political organization can be made, and the Sintashta-Petrovka nucleated communities cannot be meaningfully compared to other complex societies around the globe.

Finally, the question why people built nucleated and clustered settlements and later abandoned this practice has also not been discussed. What led people to build the enclosed settlements? What were the labor investments and how did they compare to the population estimates? Who planned and managed the construction work and why was this practice maintained for only a relatively short period of time? These are the issues without answers. Developing of these top-

ics will shed light on the organizational patterns of local communitiers and on the social forces responsible for reating enclosed settlements in the Bronze Age.

2.1 STUDYING CULTURAL REMAINS OUTSIDE THE WALLS

Detailed study of the larger area outside the walls of the settlements is one of the possible ways to learn about the ephemeral parts of local communities. This research relies on the published results of previously done geophysical surveys (Fedorova, Noskevich 2012; Krause, Koryakova 2013) that revealed the pattern of organized and nucleated settlement within the walls. However, the magnetic anomalies outside the well-defined ditches of the archaeological settlements are chaotically scattered across the area of about 3.2 ha and do not allow interpretation without further archaeological examination – as can be seen on the Kamennyi Ambar magnetic map (Fig. 2.1).

To do so, the current research employs a combined methodology of (1) cross-sectioning of the slopes of natural ravines, (2) core drilling, (3) surface collection along transects set 25 m apart and within a 3 m radius around each core, (3) stratigraphic excavations and (4) smaller-scale magnetometry that is focused on the area that yielded the highest densities of materials. This methodology aims to find out about possible cultural deposits, to collect a sample of artifacts and ecofacts that can provide a comparison with assemblages from the enclosure, and to learn about anthropogenic impact into the local landscape (Fig. 2.4).

Worth noting that distinguishing of cultural deposits in the steppe zone of the southern Urals and Western Siberia is closely linked to studying soil morphology since an archaeological site is a product of human activities and their impact on an ancient landscape and soil, taphonomic processes and subsequent natural deposition (Dergacheva 1997). Specifically, the Bronze Age cultural layer can be understood as a soil horizon that resulted from the intentional change of an ancient surface and subsurface, garbage dumping and scattering on the landscape, decomposition of organic building materials and the following pedogenesis (Maliutina and Zdanovich 2012; Bikmulina et al. 2017). The characteristics of soil regarding their typology (humus, clay), stratigraphy, particle size distribution and the inclusion of artificial materials are primary attributes
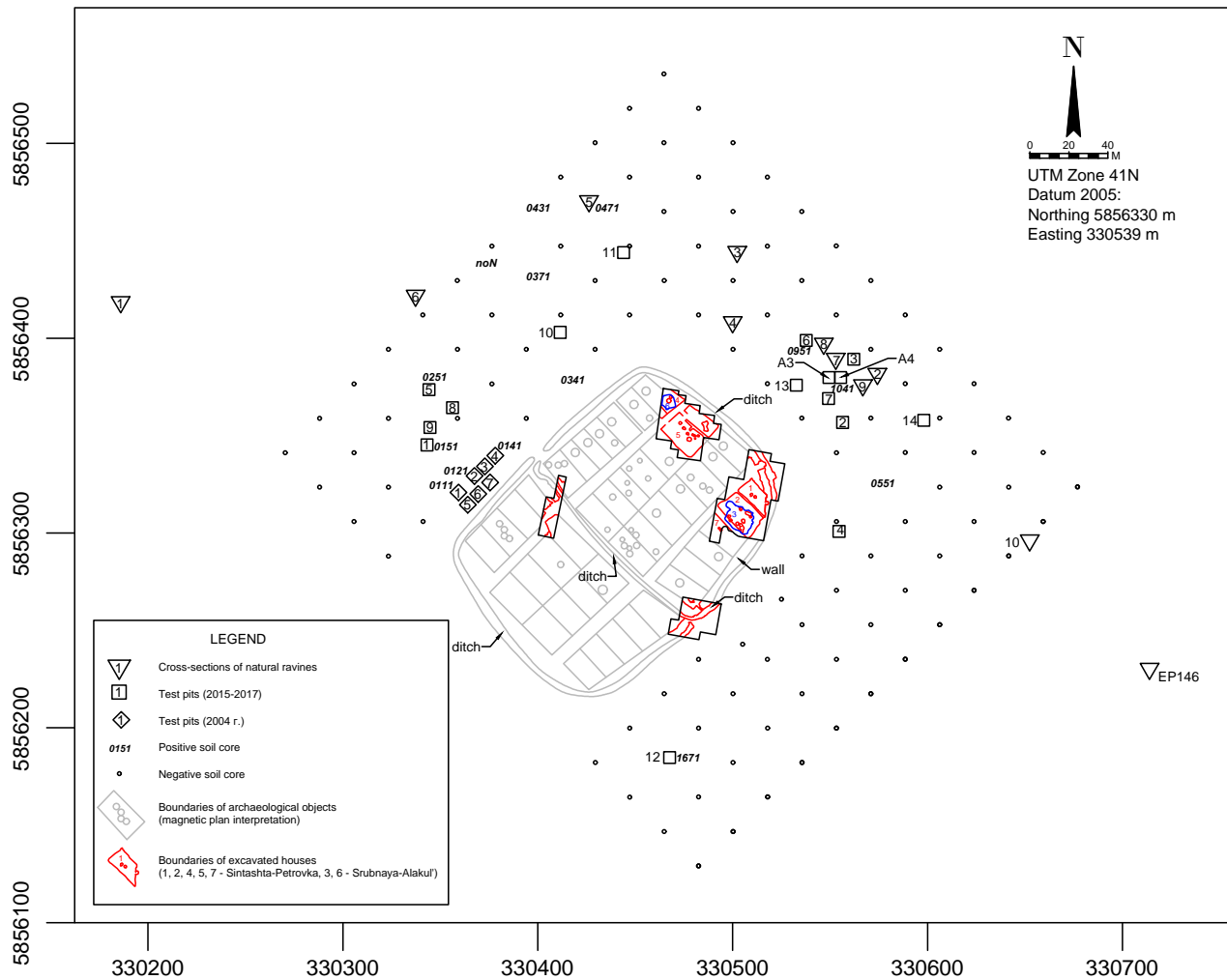
Figure 2.4 Synthetic map of the archaeological survey of the outskirts of Kamennyi Ambar

of a cultural layer that helps to distinguish it from a natural layer. The goal of finding cultural layers outside the walls of Kamennyi Ambar was achieved through cross-sectioning of the slopes of natural ravines, core drilling, and surface collection, but sub-surface testing played a crucial role due to poor visibility of archaeological materials (sherds, lithics, slag) on the modern surface (Batanina and Ivanova 1995; Johnson 2015; Sharapov 2017)

The field methods used were designed concerning the national archaeological standards. The detailed reports on the fieldwork in the Russian language are deposited into the archive of the Institute of Archaeology of the Russian Academy of Sciences in Moscow. All the excavated materials are in permanent storage in the Southern Urals State Historical Museum, Chelyabinsk (Russia).

2.1.1 Soil Characteristics and Distribution of Cultural Layers near Kamennyi Ambar

Seven cross-sections (CS-KA-1–6, 10) of the slopes of natural ravines were arbitrarily distributed near Kamennyi Ambar with an average distance of 150 m, following the courses of the natural drainage. The slopes were vertically scraped with a shovel from the top down until the appearance of clay subsoil. In the horizontal dimension units 1–6 are 1 m wide, and unit 10 is 2 m wide, while the vertical dimensions vary from 35 cm to 110 cm depending on the thickness of soil. The vertical sections were deepened into the slopes of ravines from 10 to 65 cm, and unit 4 had a dimension of 100 cm by 150 cm. Three additional elongated cross-sections 7, 8, and 9 were placed along the north wall of the settlement, approximately, 60 m apart. The units followed the south slope of the natural ravine that extends west-east parallel to the river (Fig. 2.5). The cross-sectioning helped reveal the attributes of the natural deposits, described in detail elsewhere (Krause and Koryakova 2013:25) and to locate the areas of cultural impacts. Among ten cross sections, the four without artifacts and ecofacts were considered natural, and the six with modified soils and objects were deemed to be cultural (Fig. 2.6).

The exemplary situation of natural deposit is portrayed by the units with neither artifacts nor transformed soils (CS-KA-1, 5, 6, 10 and Test Pit Y-146, which was excavated by Dr. Yakimov in 2014). The cross-section CS-KA-1 is a typical instance that located about 200 m west from Kamennyi Ambar. The "O" horizon of sod formed by decomposed steppe grasses and their roots intermixed with sandy loam. The sod layer is thin and does not exceed 5–6 cm in depth. The "A" horizon, or topsoil is composed of humus. This horizon changes in color from light to dark gray to almost black (Munsel 7.5YYR3/2, 10YR4/1 and 3/1). It is dense and lumpy and has a thickness of 50 cm, but it may vary from 15 to 60 cm. The "B" horizon is comprised of heavy loam or clay, yellow/brown in color (10YR5/6). If it is not disturbed by humans, then it can be considered as "sterile." Other examples of the typical soil composition with no sherds found in the cross-sections are CS-KA-5, 6 and 10; their distribution roughly outlines the edges of impacted areas outside the settlement.

On the other hand, attribution of human activities is possible by studying the units that include cultural materials (CS-KA-2, 3, 4, 7–9). Sherds, bones, pieces of slag and burnt material
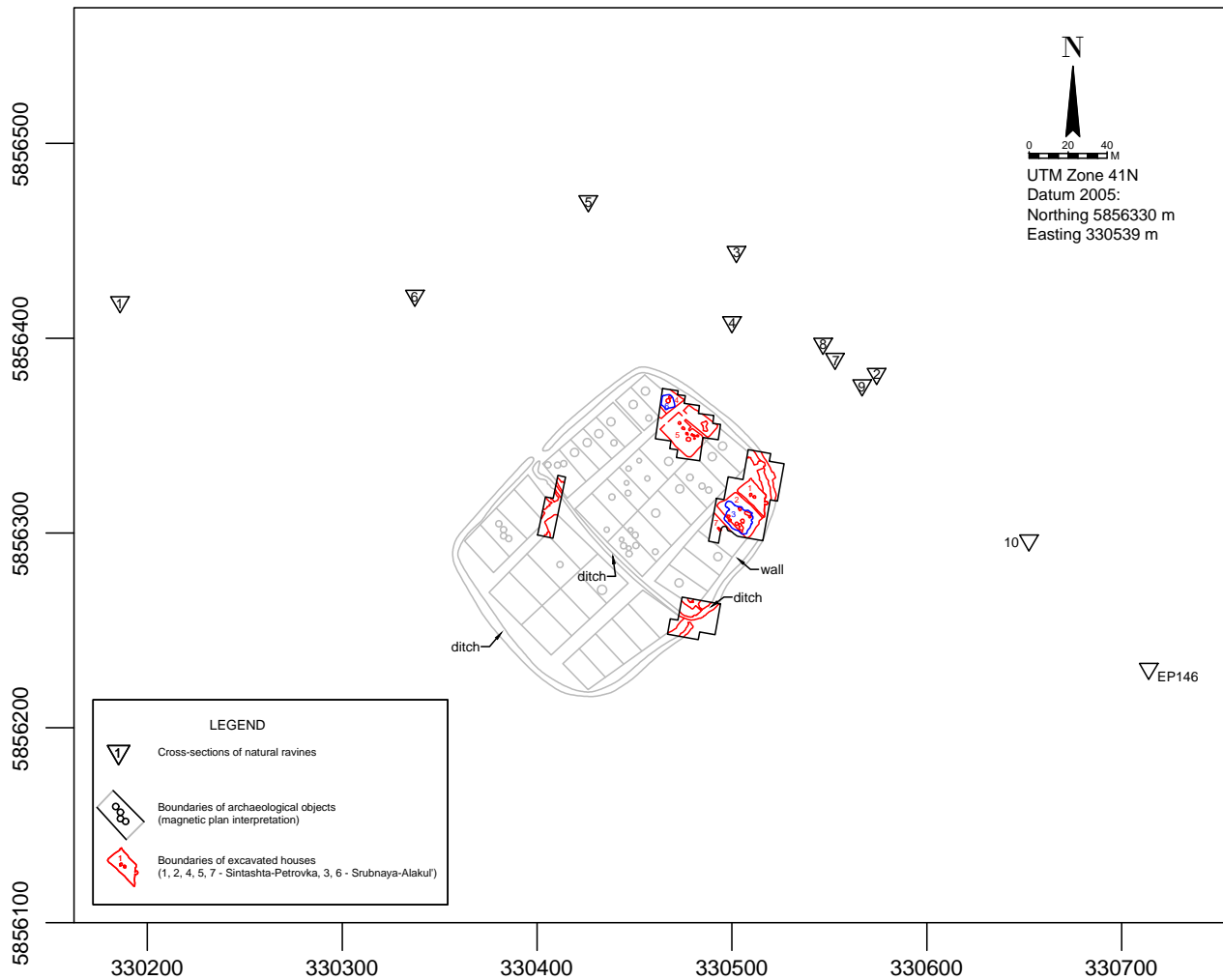
Figure 2.5 Location of the ravine cross-sections

are associated with the "A" "B" or "AB" soil horizons that vary in thickness from 5 to 40 cm. The structure of an impacted "A" horizon is less dense, depleted in organics and intermixed with loam or clay. The typical appearance of cultural deposition is brown or grayish brown in color (Munsell 10YR4/3 and 7.5YR5/2). One instance is the cross-section CS-KA-2 placed north to the settlement, where seven ceramic sherds (two of the Sintashta-Petrovka phase), a piece of metallurgical slag, six tiny fragments of animal bones and pieces of baked clay were found. According to Dr. Artyom Yakimov of the Institute of the Earth's Cryosphere of the RAS, in cross-section 2, the "O" horizon appeared to be depressed and as thin as 3 cm. The "AB" horizon is the layer of diluvium, comprised of dark grayish brown humus loam. It covers the "A1" horizon of dark gray loam. It consists of small prismatic soil particles that tend to disintegrate even more, which suggests se-
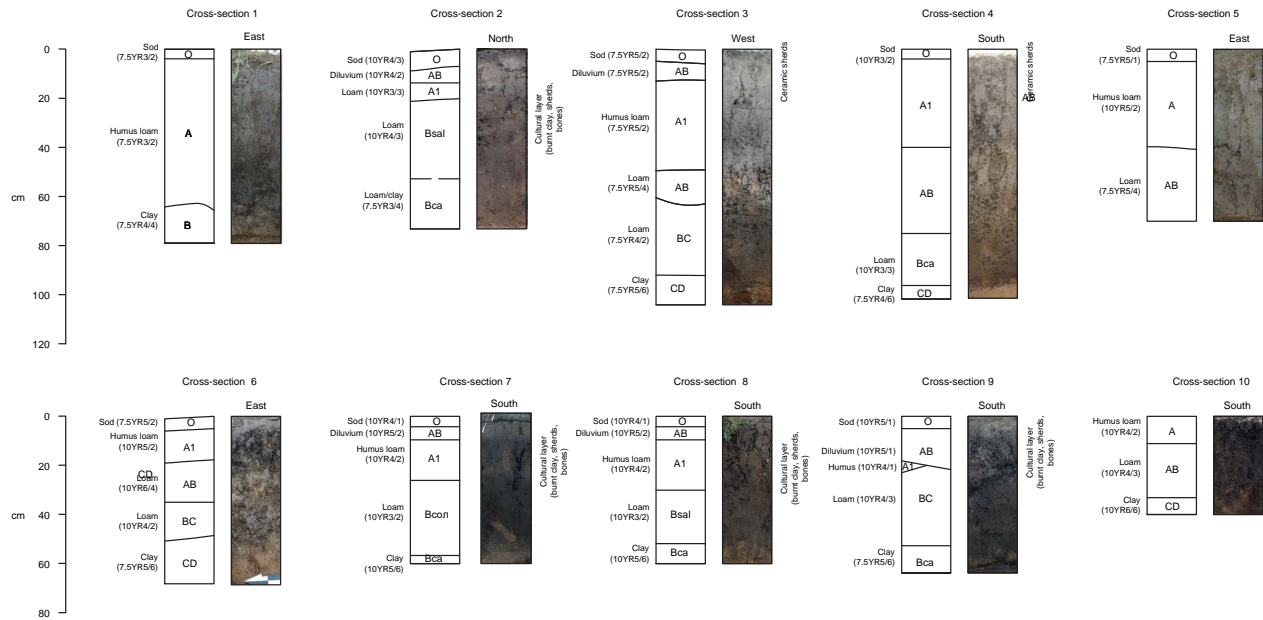
Figure 2.6 The profiles of cross-sections near Kamennyi Ambar

Cross-sections CS-KA-2, 7, 8 and 9 demonstrate the unmistakable evidence for the cultural layer (reddish pieces of burnt clay, light grey deposition of depleted humus)

Figure 2.7 The profile of line 6 (sectors Р, П, О, Н) of the Excavation Unit 2 inside Kamennyi Ambar

The cultural layer demonstrates the similar pattern of depleted humus, but higher intensity of burnt materials (modified after Epimakhov 2007, fig. 71)

vere erosion and mechanical grinding. The cultural materials are associated with the "A1" horizon which allows interpretation as a cultural layer. Presumably, its type and particle' structure reflects heavy human impact on the ancient surface, that repeatedly eroded it and caused the change in soil composition. The "B" horizon is heavy brown saline clay with a visible edge at a depth of 18 cm (Fig. 2.5). Similar soil situation can be observed in the areas between the buildings ("streets") inside the enclosure (Epimakhov 2007b) (Fig. 2.7).

In the cross-sections CS-KA-3 and 4, cultural materials are found at the depth from 10 to 20 cm in association with the "AB/A1" soil horizons. There are two sherds of the Bronze Age located in the upper centimeters of unit 3, and another eight pieces found in CS-KA-4. In total, there
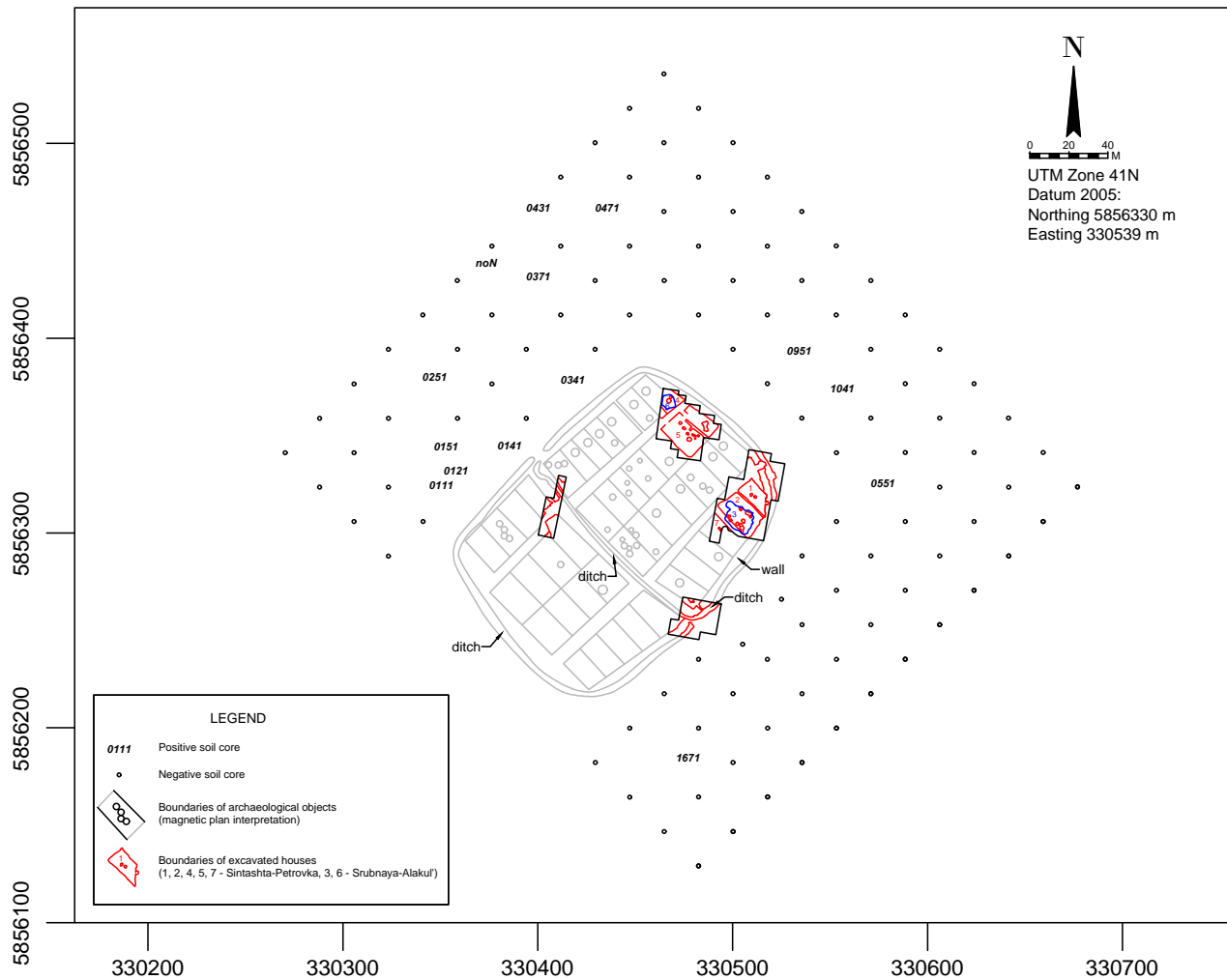
Figure 2.8 Location of the cores

are 20 pieces of ceramic sherds, all attributed to the Late Bronze Age, and at least four of them to the Sintashta-Petrovka phase, a fragment of metallurgical slag and a piece of bone.

In order to study the extension of cultural deposit, found with the CS-KA-2, the elongated cross-sections 7, 8, and 9 are placed along the north wall of the settlement (CS-KA-7, 13, and 3 m wide, respectively). The study of their stratigraphy helped to find that the cultural layer of 5–35 cm thick depleted humus/loam ("A1") with inclusions of sherds, bones, tools, slag and baked clay. Its structure is identical to the structure of the "A1" horizon in CS-KA-1, described above. According to these sections, the layer runs at least for 35 m along the north wall of the settlement. There are 83 pieces of ceramic, including those of Sintashta and Petrovka (20 specimens). Eight of these

sherds are assembled to two small vitrified vessels. Moreover, the cultural deposit has yielded a unique polished stone plate used, possibly, as a tool to saw wood.

The materials in CS-KA-3 and deposits revealed by CS-KA-7–9 might represent the same area, that runs at least for 95 m along the north wall of the settlement. On the other hand, the unit 10 placed 130 m east from the north-east corner of the settlement, and the cross-section CS-KA-6, which is located 120 m west of the north-west corner, yielded no signs of impacted soils or artifacts and, thus, these loci can be considered as approximate limits of the cultural layer distribution.

To sum up the cross-sectioning stage, the cultural layer was found outside the walls of Kamennyi Ambar. The arfifactual materials are embedded into the soil, forming a dual-natured de-posit of depleted humus or loam clearly distinguishable from the regular stratigraphy of steppe soil. It is distributed along the north wall of the site and includes material culture of the Late Bronze Age.

The following stage of studying of distribution of cultural depositions was core drilling (Fig. 2.8). The preliminary tasks were to develop a tool, a technique of coring and a recording system. For the survey, a hollow auger with an inner diameter of 10 cm and a 100-cm-long observation window employed. The auger was hammered into the soil to a depth of 20 to 30 cm, pulled back, and then a sample observed. If necessary, the drill is hammered down to the next horizon of 20–30 cm until the layer of archaeologically sterile soil is reached. Recorded characteristics of soil included its color, texture, type, stratigraphy, and the presence of artifacts and faunal remains. After these observations were made, the soil was hand-sorted or screened, if necessary. At a depth of 10–20 cm from the surface, that appeared to associate with the cultural deposits in the cross-sections, samples of soils were taken for the further laboratory chemical analysis. Levels of phosphates, strontium, and copper are used to document the distribution of human activities in the zone outside the walls of the fortified settlement of Kamennyi Ambar (Chang and Koster 1986:117; Sageidet 2000; Kalinin et al. 2009; Holliday et al. 2010).

The area of Kamennyi Ambar surrounded by the ditch is a rectangle of about 155 m by 120 m. Extensive shovel testing near Sarym-Sakly and magnetometer survey at Kamennyi Am-bar (Sharapov 2017; Krause and Koryakova 2013), led to an estimate that cultural deposits may extend a maximum of 100 m beyond the walls. Cores are drilled throughout this area at intervals of 25 m, beginning 20 m from the outer boundary of the ditch and working outward to determine

the extent of this cultural deposition in all directions. This spacing corresponded to a total of 126 cores and four additional cores in-between that covered the area of 5.2 ha with 24.2 cores per hectare (Fig. 2.4)

Only 14 of 130 (10.7%) cores yielded evidence of the cultural layers. Several attributes were taken as evidence stand for cultural layers, they are: 1) artifacts and ecofacts, such as ceramic sherds, metallurgical slag, lithics and stone tools, animal bones; 2) depleted humus with pieces of baked clay or charcoal. The fourteen samples with identifiable attributes of cultural layers contained either baked clay, charcoal or artifacts and ecofacts, or these features together (Table 2.1).

Table 2.1 Cores with the attributes of cultural layers near Kamennyi Ambar

Core number	Attributes of cultural layers	Depth from the surface of finds concentration
0111	Bones	0/10
0341	Bones	10/20
0551	Bones	10/20
noN	Ceramic sherds (7 specimens)	0/10
0151	A ceramic sherd (1 specimen)	0/10
0121	Ceramic sherds (1 specimen), bones, a stone tool (1 specimen)	0/10
0141	Ceramic sherds (12 specimens), baked clay, depleted humus and charcoal	0/60
1671	Ceramic sherds (8 specimens), baked clay and depleted humus	0/20
0251	Ceramic sherd (23 specimens), slag (4 specimens), a stone flake (1 specimen), baked clay and depleted humus	0/10
0371	Ceramic sherds (7 specimens), bones, charcoal	0/10
0431	Baked clay and depleted humus	10/20
0471	Baked clay and depleted humus	50/60
0951	Baked clay and depleted humus	30/50
1041	Baked clay and depleted humus	30/50

Three cores yielded only pieces of animal bones (cores 0111, 0341, 0551), and provide less secure evidence for the presence of a cultural layer (since unidentifiable bones could belong to wild fauna). Seven cores yielded intense evidence for past human activities (cores *noN, 0151, 0121, 0141, 1671, 0251, 0371*), such as ceramic sherds and stone artifacts, as well as pieces of baked clay and charcoal. Finally, soil profiles recovered with four other cores (cores 0*431, 0471, 0951, 1041*) resembled those identified with cross-sections, where cultural materials were found in conjunction with baked clay and depleted humus. Spatial distribution of these 14 cores around the site allows outlining roughly an impacted area of about 20,000 m² (Fig. 2.4).

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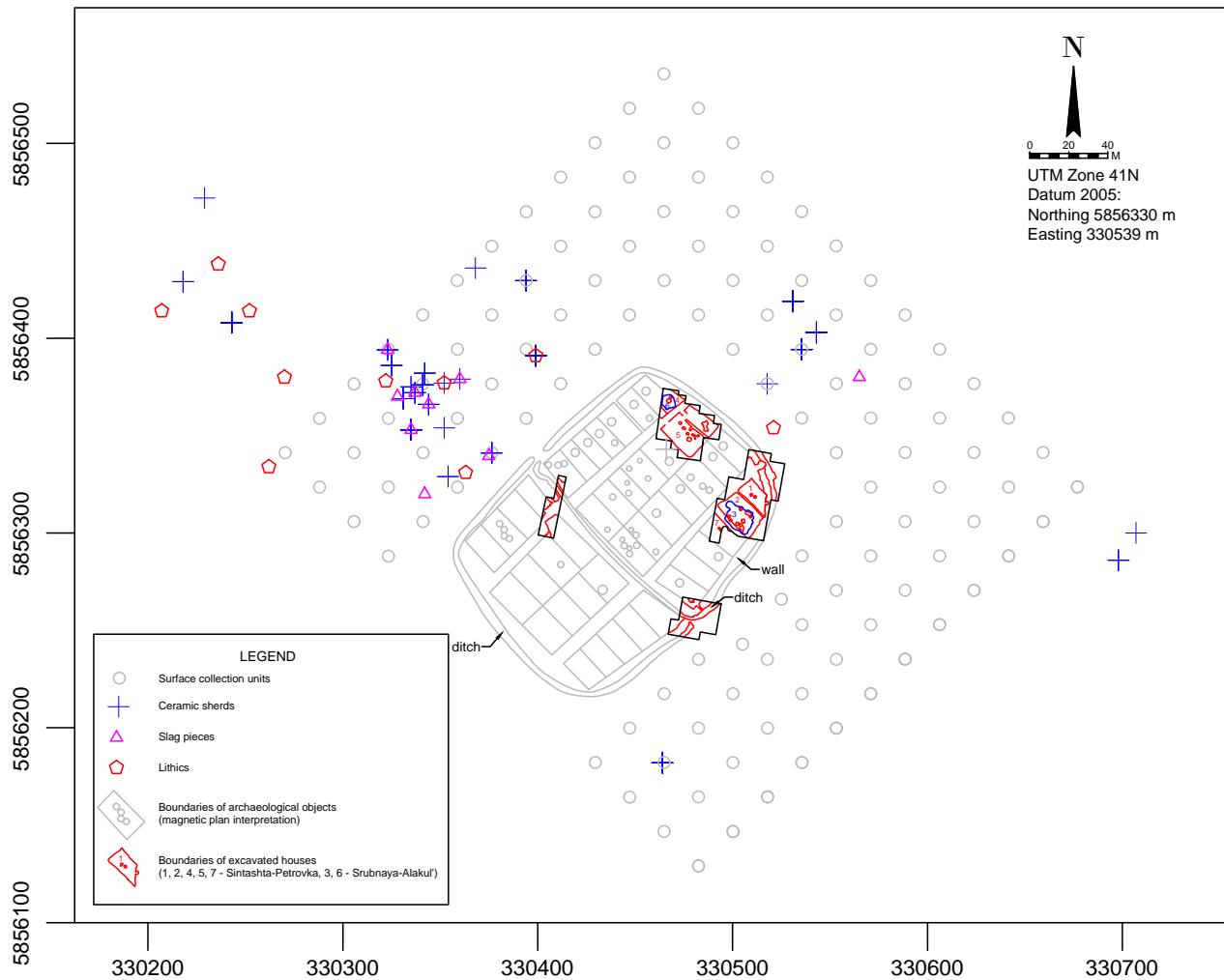
Figure 2.9 Location of surface collection units and surface findings

Among the materials recovered are 59 pieces of ceramics, 19 fragments of animal bones, six pieces of metallurgical slag and two lithic artifacts. In all cases, discoveries of the artifacts and faunal remains appeared at the depths from 0 cm to 20 cm (cores *0111, 0121, 0141, 0151, 0251, 0341, noN, 0371, 0551, 1671*). This observation suggests that the materials are more likely remains of garbage disposed on the ancient surface and covered by the following pedogenetic process. However, signs of more intense cultural deposits like those in the cross-sections were also present, since in two cases pieces of baked clay, charcoal and ash were found at a depth of 30–60 cm (cores *0141, 0471, 0951, 1041*). Interestingly, findings of artifacts do spatially correlate with anomalies visible on the magnetic plan west from the enclosure. The first spot is a positive anomaly located to the east from the settlement. The second place is a less visible rectangular

structure about 30 m to the north from the palisade. The size of this arrangement is 38 m x 23 m and its area is 839 m^2. The nature of these anomalies will be discussed below in this chapter.

Surface collection was conducted along longitudinal transects set 25 m apart for distributing of cores and near each drilled core within a radius of 3 m from its center. Any material scattered within the survey zone has been picked up and coordinates recorded with a portable GPS unit (Fig. 2.9). The survey zone was limited to the southwest of the wall where the bank of the modern river lies. In total, 91 ceramic sherds, 14 lithic artifacts, 11 pieces of slag and four fragments of animal bones were collected. Distribution of ceramic sherds on the surface corresponds well with the cultural layers attributed by the cores and sections, particularly in the area to the west and north from the walls. However, a few specimens of Bronze Age sherds were accidentally found as far 218 meters to the west and 193 meters to the east, where no systematic work was done.

Regarding the spatial distribution of the Late Bronze Age cultural depositions, recovered samples of cores demonstrate the spread of cultural layer for about 100 meters outside the enclosure. Drawing a line that connects the cross-sections and the cores with the cultural deposits, the estimated area of cultural deposits would be roughly 2 ha or 38% of 5.2 ha covered by the survey. At the same time, the habitation area within the walls is quite similar with about 1.6 ha at sub-phase 1-1 and 0.8 ha at sub-phase 1-2. However, as evident from the cross-sections, the cultural layer outside the walls is uneven and patchy, which allows the conclusion that not whole 2 ha were used for the same purposes and with the same intensity.

Summarizing, the combined strategy of slope sectioning, core drilling and surface collection allowed to roughly outline the activity zone of the Late Bronze Age of 2 ha outside the enclosure (Fig. 2.4). This area yielded artefactual materials; in total, 276 items were collected in the area of 7.5 ha from the surface, cores, and sections, which corresponds to 36.8 specimens per ha, or 0.003 per m^2. In all cases, artifacts and faunal remains were associated with the surface or topsoil of depleted humus, no deeper than 30 cm. Among them are 243 ceramic sherds. The general classification scheme developed by Vinogradov (1982) and Zdanovich (1988) was used to distinguish between Sintashta-Petrovka Phase 1 and Srubnaya-Alakul' Phase-2 sherds. Accordingly, 33 sherds can be ascribed to the chronological phase 1, and three fragments have features of the chronological phase 2. The remaining 207 sherds cannot be attributed with cer-

tainty. Nineteen pieces of metallurgical slag are dated to the Sintashta-Petrovka phase by their morphological characteristics (Grigoryev 2013). The recognized Sintashta-Petrovka materials are well represented in the sample (18.8%) suggesting that remains outside the walls were left by various activities, such as dwelling and residential dumping, and then scattered on the ancient surface and covered by later natural deposits. To discover what kind of events were carried out outside the walls and how they were distributed spatially, we should turn now to the results of stratigraphic excavations, detailed geophysics and analysis of chemical residues.

2.1.2 Cultural Materials near Kamennyi Ambar Exposed by the Test Pits

The second stage of the field research consisted of test-pitting at places where the cross-sections and the cores showed the presence of artifacts, cultural deposits, hearths, or other features which are visible in the magnetometry results to the west, northwest, and north of Kamennyi Ambar (Krause and Koryakova 2013:58–59). These stratigraphic tests vary in sizes to permit recovery of a reasonable sample of artifacts and ecofacts and to recognize human-made features covered by natural deposits and study transformed soils. Distribution of the test pits around the sites aims to characterize possible households and their activities through artifact and ecofact assemblages (Fig. 2.10).

The stratigraphic excavation followed the principles of the Wheeler-Kenyon system of archaeological excavations, which is the same method of work typically used on deposits within the fortified settlements (Gening et al. 1992; Krause and Koryakova 2013; Vinogradov 2013). The choice of method allowed to collect a sample that is comparable to the datasets recovered by the above-mentioned Russian-German project. The excavation is done by arbitrary 10 cm thick levels, carefully scraping the soil horizontally with shovels. Whenever any soil changes indicative of changing cultural deposits or features were seen, excavation shifted to trowels as necessary. All excavated soils were screened through 10 mm mesh, and soil from some of the excavated test pits collected for flotation to recover botanical remains. Every excavated level was drawn on graph paper, colors identified with the Munsell Color Chart and then the level photographed, as well as the remains of all structures, hearths, pits and other features. The locations of unique
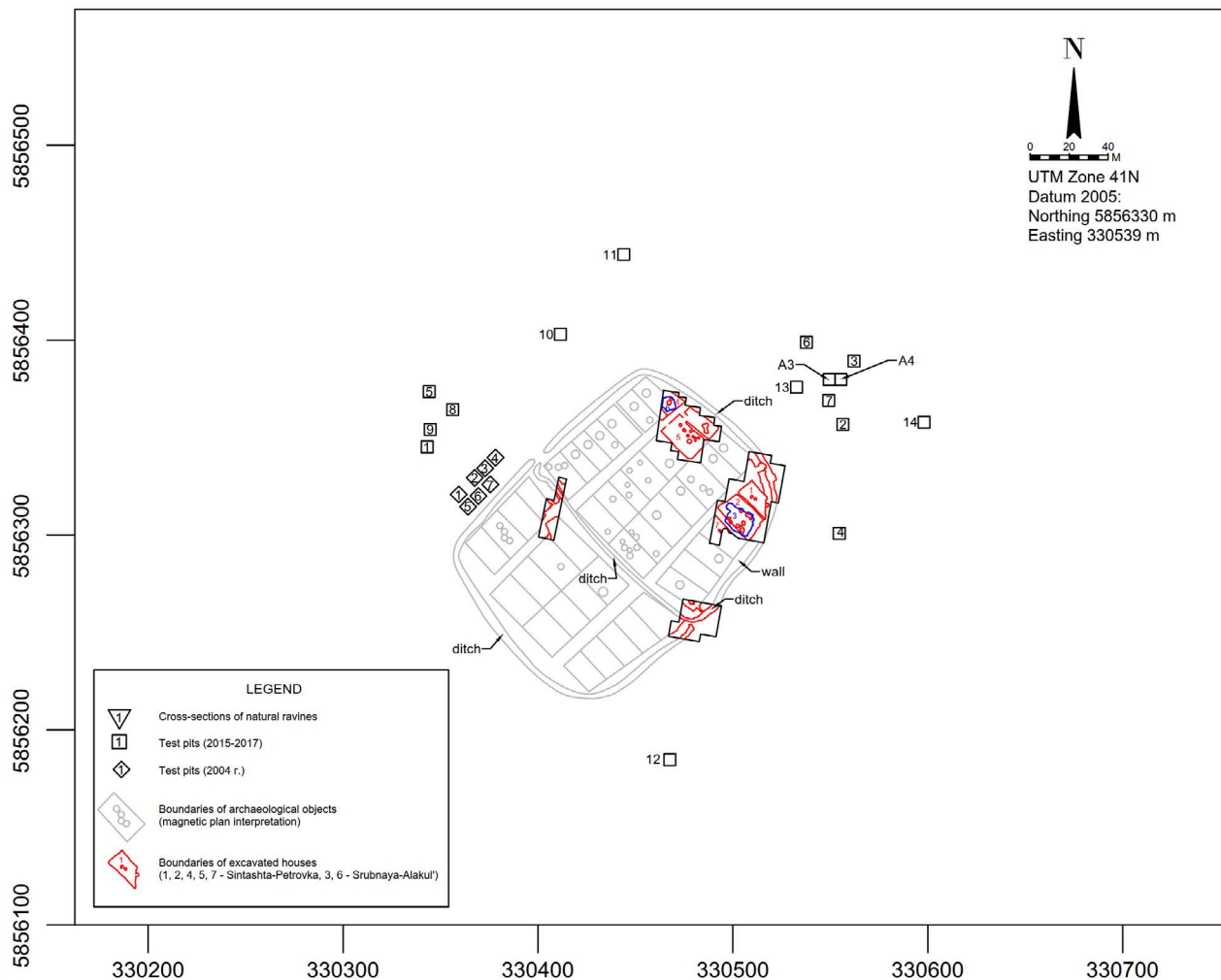
Figure 2.10 Location of the test pits

finds were measured and plotted on the plans. The profiles of excavated units were recorded in the same way.

During the 2015–2017 field seasons, fourteen stratigraphic excavation units were opened. There are six 1 m by 1 m, six 1 m by 2 m, and two single 2 m by 2 m tests, that cover the area of 26 m^2, in total. The stratigraphy and materials of the selected units (TP-KA-4, 7 and 12) that help to comprehend the nature of cultural deposits around Kamennyi Ambar will be described in the following pages.

The test pit TP-KA-4 had a size of 1 m by 2 m, and it is located 40 m east of the northeast corner of the settlement. Cultural material was found at the depth from 0 to 30 cm. There are two fragments of metallurgical slag, a ceramic sherd and a cattle's tooth uncovered. The soil stratig-raphy is similar to a natural deposition in the cross-section 3 and 4 since there are five identifiable

natural strata with inclusions of the cultural materials (Fig. 2.11 and 2.12). No horizon of human impact can be attributed like thoose observed with CS-KA-2, 7–9.

Stratum 1 (level +1/-4 cm): The "O" horizon of sod is brown humus with the inclusion of grassroots, 4 cm thick. No finds of artifacts were made, but the layer yielded a bovine's lower molar (m1-2) and a fragment of mammal bone.

Stratum 2 (level -4/-22 cm): At a depth of 4 cm from the surface, brown humus (Munsell 7.5YR5/2) of the "A" horizon appeared. The thickness of the layer did not exceed 20 cm within which two pieces of metallurgical slag and a bovine tooth were found (MNI = 1).

Stratum 3 (level -18/-35 cm): The layer of dark gray humus loam with organics (Munsell 7.5YR5/2) was identified first at a depth of 18 cm from the surface. It was distinguishable from the overlying stratum due to its color and texture and was attributed as the "AB" horizon. The edge between two strata was blurry, what suggests the natural character of its formation. A piece of ceramic, the calcified lower end of the humerus and the fragment of the upper end of the meta-tarsal bone of a sheep/goat, and two fragments of mammalian bones found at the upper level of the horizon (MNI = 1).

Stratum 4 (level -30/-64 cm): At a depth of 30/35 cm from the surface, a layer of brown loam appears (the "B" horizon). No finds made.

Stratum 5 (level -64/-70 cm): The deposition of yellowish red clay (Munsell 7.5YR6/6) appeared at a depth of 64 cm from the surface. No finds made, and the layer was considered as a "sterile" stratum, so the excavation was stopped.

The strata observed above demonstrate a natural process of soil accumulation. The rare cultural materials occurred because of garbage scattered on the surface, that was later covered by the steppe humus. Vertical distribution of the finds can be explained by their later movement within the profile, probably, due to seasonal earth cracking and changing of the water table.

The test pit TP-KA-7 had a size of 1 m by 2 m, and it was located 45 m north of the northeast corner of the settlement. The spot was chosen due to the proximity of the cross-sections that yielded the Sintashta-Petrovka ceramic sherds and metallurgical slag. There are five identifiable strata (Fig. 2.13 and 2.14) that resulted from the combination of natural and artificial processes, like those that responsible for creation the profile of the cross-sections CA-KA-2, 7–9.
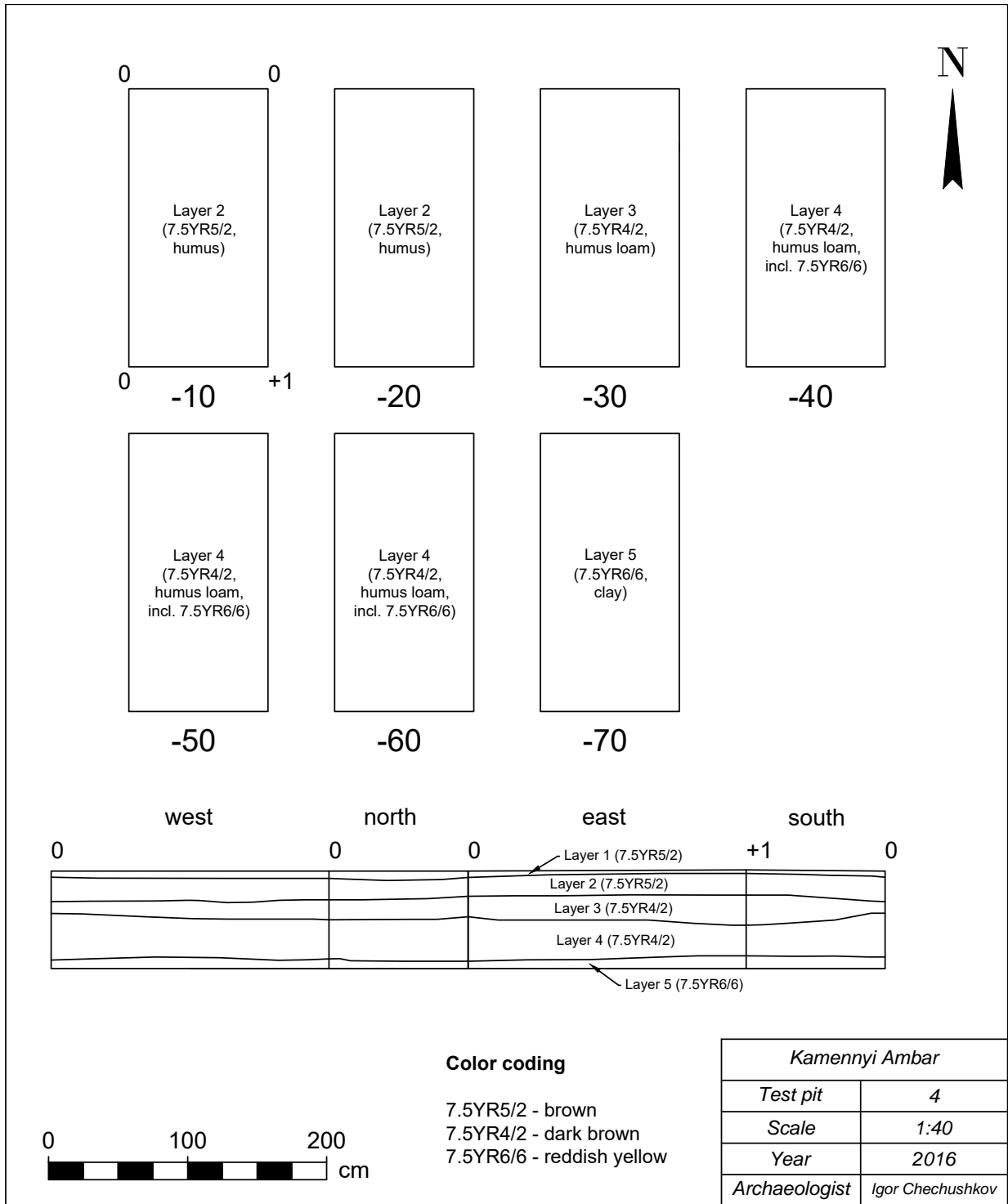
Figure 2.11 Kamennyi Ambar, Test Pit TP-KA-4: arbitrary levels and profiles

Figure 2.12 Kamennyi Ambar, Test Pit TP-KA-4, profiles

1 – west profile; 2 – north profile; 3 – south profile; 4 – east profile
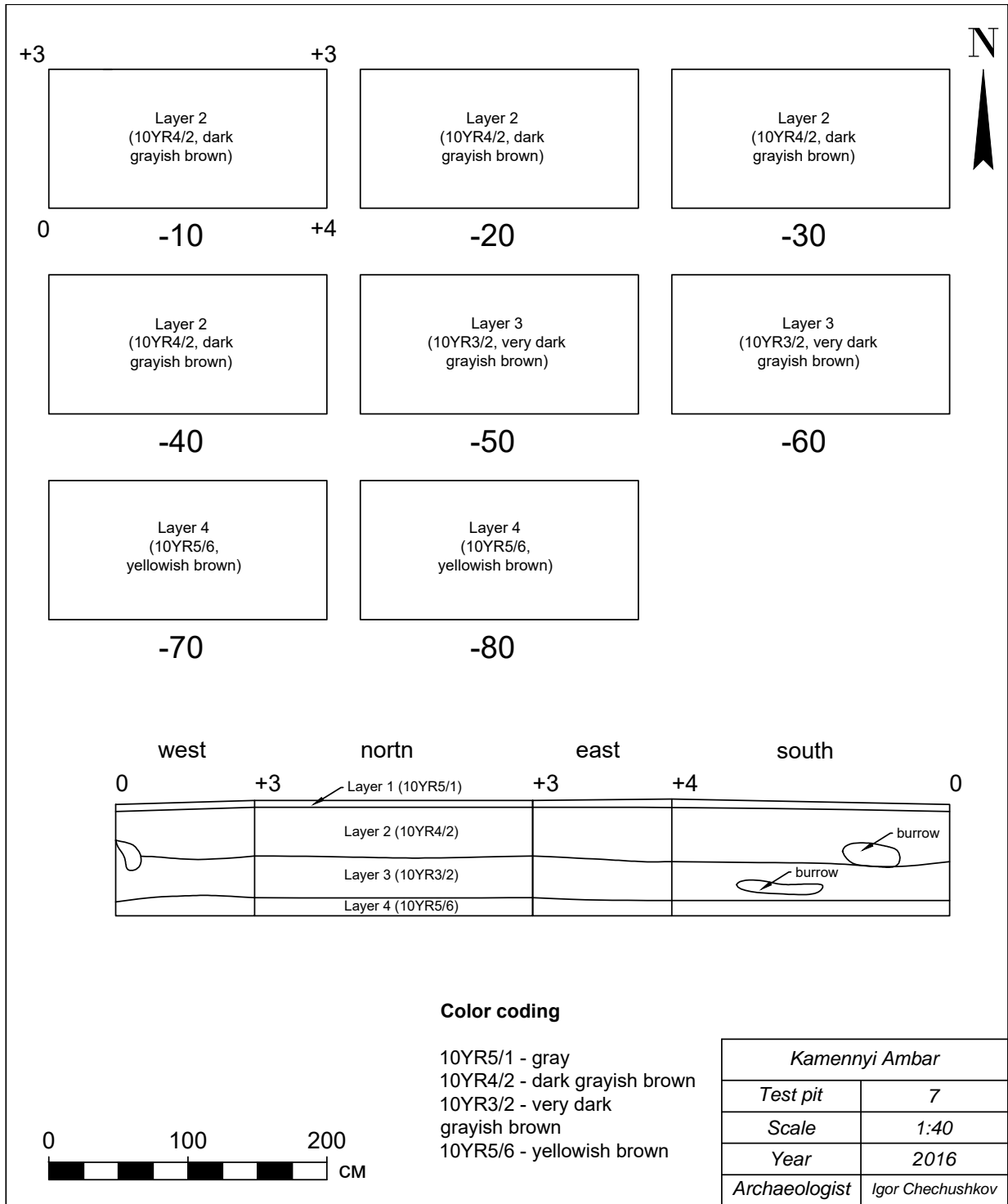
Figure 2.13 Kamennyi Ambar, Test Pit TP-KA-7, arbitrary levels and profiles

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Figure 2.14 Kamennyi Ambar, Test Pit TP-KA-7, profiles

1 – west profile; 2 – north profile; 3 – south profile; 4 – east profile
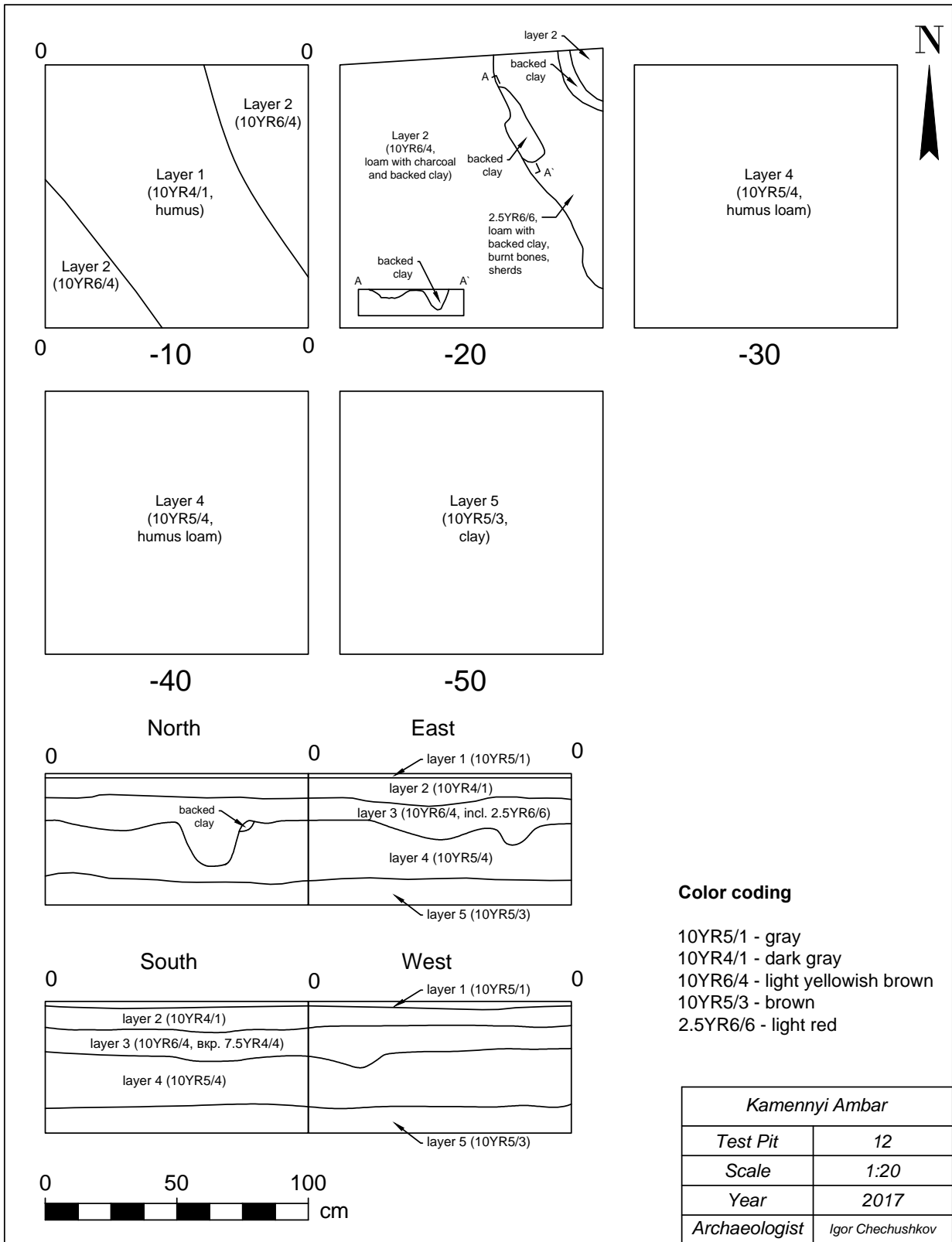
Figure 2.15 Kamennyi Ambar, Test Pit TP-KA-12, arbitrary levels and profiles
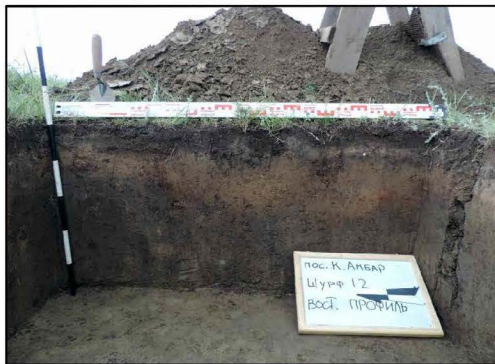
Figure 2.16 Kamennyi Ambar, Test Pit TP-KA-12, profiles

1 – west profile; 2 – north profile; 3 – south profile; 4 – east profile; 5 – cross-section of a bonfire

Stratum 1 (level +1/-4 cm): The 4 to 8 cm thick "O" horizon of sod is gray sandy humus with the inclusion of grassroots. A sherd of the Srubnaya-Alakul' vessel found on the surface.

Stratum 2 (level -4/-40 cm): At a depth of 4-8 cm from the surface, the "AB" horizon of dark grayish brown loam (Munsell 10YR4/2) appeared. The stratum represents a depleted "A" horizon that was heavily impacted by human activities. Similarly to "A1" horizon found in the cross-section 1, the evidence that suggest such impact are (1) a low level of organic material in soil, (2) inter-mixture of different types of soils and absence of edges between them, (3) a high level of carbon-ates that are not typical for organic-rich soil, and (4) pieces of baked clay and charcoal. Finally, 52 ceramic sherds, a lithic and a piece of metallurgical slag have been found within this stratum. Importantly, there is an ample collection of ceramic sherds that can be safely assigned to the Sintashta-Petrovka tradition of pottery (18 specimens). Altogether, these facts suggest that the ancient surface was heavily disturbed by humans and the activities occurred during the Bronze Age phase 1. Within the faunal remains are a calcified fragment of bovine bone, upper end of the horse humerus and calcified piece of the lower end of the bovine humerus, a fragment of the bovine metatarsal bones, two fragments of bovine teeth, and 17 other fragments of mammalian bones, 9 of which are calcined (MNI = 2).

Stratum 3 (level -40/-70 cm): The layer of very dark grayish brown heavy loam (Munsell 10YR3/2) is identifiable first at a depth of 30 cm from the surface. It is distinguishable from the overlying stratum due to its color and texture and can be attributed as the "AB" horizon. The edge between two layers is blurry, what suggests the natural character of its formation. There are no find-ings made within the stratum, but the transition zone is marked by small red pieces of baked clay.

Stratum 5 (level -64/-70 cm): The deposition of brown clay (Munsell 10YR5/6) appears at a depth of 70 cm from the surface. No finds made, and the layer was considered as a "sterile" stratum.

Similar to the cross-sections, the observed characteristics of soils and densities of cultural materials suggest the appearance of the cultural layer at this spot outside the walls of the settle-ment. The overall artifact density is 27 specimens per m², which makes it the third richest spot among all studied.

The cultural layers observed outside the walls have stratigraphy and soils like those found in the uninhabited areas between the dwellings inside the walls. However, the artifact density of

such areas is less dense than those outside the walls (for example, the "street" before Houses 1 and 2 has the average density of ceramics is 8.7±1.6 sherds/m^2).

Test pit TP-KA-12 had a size of 1 m by 1 m, and it was located 52 m east-southeast from the southeast corner of the settlement. The spot was chosen due to the fact of discovering the cultural deposit in the core 1671. There five strata were identified (Fig. 2.15 and 2.16). The evidence suggests that they were produced with the massive contribution of human activities and following taphonomy processes.

Stratum 1 (level 0/-4 cm): The 2-4 cm thick "O" horizon of sod is gray sandy humus with the inclusion of grassroots, degraded by present-day overgrazing.

Stratum 2 (level -4/-8 cm): A thin layer of gray humus.

Stratum 3 (level -8/-25/-45 cm): At a depth of 8–10 cm from the surface, the horizon of light yellowish-brown loam (Munsell 10YR6/4) with the inclusion of baked clay and cultural materials appeared. At a depth of 20 cm from the surface, an outline of a bonfire or similar feature turned up in the northeast part of the excavation area. The structure had clear boundaries in the horizontal plane, but the deposition varied a lot in its vertical thickness (from 8 to 25 cm). Within this stratum, 36 ceramic sherds, six pieces of metallurgical slag, 46 fragments of animal bones and a lithic found. Three pieces of pottery can be safely attributed to the Sintashta tradition. The facts suggest that in the stratum 2 the activity area around a fireplace or a furnace was observed.

Stratum 4 (level -30/-40 cm): The layer of brown humus loam (Munsell 10YR5/4) was identified first at a depth of 30 cm from the surface. It was distinguishable from the overlying stratum due to its color and texture and can be attributed as the "AB" horizon. The boundary between two layers was clear, what supports the artificial origin of the overlying stratum 2. Seven fragments of calcinate bones found within in the level.

Stratum 5 (level -40/-50 cm): The deposition of brown clay (Munsell 10YR5/3) appears at a depth of 40 cm from the surface. No finds made, and the layer was considered as a "sterile" stratum, so the excavation was stopped.

As in the case of the TP-KA-7, the observed attributes of soils in the considered unit and the densities of cultural materials (42 specimens per m^2) suggest the presence of the cultural layer to the east and southeast from the walls of the settlement. The overall artifact density is the highest oberved, which indicates the intense utilization of the spot.

The rest of the test pits yielded variable patterns of soil and artifacts depositions. Thus, the stratigraphy in the locations of the test pit TP-KA-1, 11 and 14 show extremely thin (5 cm) and patchy deposition of depleted soil with tiny pieces of baked clay in the upper centimeters of the "A" horizon and little materials. Presumably, it suggests the extension of the cultural layer along the north and west walls, as it is shown by the cross-sections 5, 7–9, but demonstrates the periphery of human impact.

By presence or absence of depleted humus of "A1" or "AB" horizons (cultural layers) the fourteen units can be divided into two groups. Group 1 embraces the locations of the cultural layer and consists of the test pits 1–3, 5–8, 10, 12–14. Group 2 is the locations where the presence of the culturally impacted soil is doubtful (4 and 9). Evidently, Group 1 has more members and, thus, it puts forward for consideration the three vital facts. They are (1) the presence of the cultural layer, (2) its uneven and patchy distribution around the enclosure, and (3) its different appearance in comparison with the soils of the domestic context inside the compound. The explanation of these facts requires the further exploration.

2.1.3 Cultural Deposits of the Late Bronze Age North of the Wall

The third stage of the research consisted of larger scale stratigraphic excavations at Kamennyi Ambar. The excavation units A3 and A4 were located 52 m north from the northeast corner of the settlement, in the area that has already yielded cultural depositions of the Bronze Age (the test pits TP-KA-7 and 13). The excavation aimed to open a bigger area inside the rectangular anomaly visible on the magnetic plan (Fig. 2.1). Two units of 2 m by 2 m each were adjusted one to another latitudinally, with a bulk in-between them to allow stratigraphic observations (8 m^2 in total). The composite description of the soil stratigraphy and objects sectioned in the horizontal plane is the following.

Stratum 1 (level 0/-14 cm): The layer of sod is degraded by present-day overgrazing and as thin as 2–4 cm. It overlies the 10–13 cm thick "A1" horizon of very dark grayish brown loam (Munsell 10YR3/2). The layer yielded 11 sherds and a piece of the Sintashta metallurgical the slag.

Stratum 2 (level -14/-27 cm): The "Bsal" horizon is the layer of dark brown saltine loam (Munsell 10YR3/3). The layer yielded 15 ceramic sherds of the Bronze Age, including one piece attributed to the Sintashta tradition, and an intriguing finding of a small portion of ochre.

Stratum 3 (level -27/-60 cm): At a depth of about 25–27 cm from the surface, the horizon of dark brown depleted loam (Munsell 10YR4/3) appeared. The particles are small and prismatic, what suggests the somehow moderate degree of erosion. The boundary with the upper layer of salinized loam is marked by inclusions of pink, orange and brown pieces of baked clay that spread down within the stratum. On the cleaned off surface at a depth of 60 cm, the spots of overheated clay and large burnt pieces were clearly spotted. They did not seem to be arranged systematically but recalled a similar and nicely visible structure found by Test Pit TP-KA-12. The collection of artifacts consists of 59 specimens of ceramics, three of them of phase 1, and one of the Final Bronze Age, two pieces of metallurgical slag, a crystal of quartz and five pieces of talc. The animal bones, including a fish vertebra, sum up to the total weight of 727 g. Attributed by Dr. Bachura bones belong to cattle, a horse, and caprine animals (MNI=4). Many more other bones are in small fragments and calcined (the total weight of bones from the stratum is 611 g).

Stratum 3 (level -60/-95 cm): The boundary of "A1" horizon of very dark brown loam with some organic material (Munsell 10YR2/2) was first identified at a depth of 55 cm from the surface. This layer is distinguishable from the overlapping horizon by slight differences in color and texture, but mostly due to decreased number of artifacts. The edge between two strata is vague and drawn arbitrary. Within this stratum, 17 sherds, five pieces of slag, a stone tool and a piece of hematite found. Attributed bones are calcined and belong to cattle and a caprine animal (MNI=2) (the total weight of the bones from the strata is 189 g).

Stratum 5 (level -95/-130 cm): The deposition of heavy dark yellowish brown loam/clay (Munsell 10YR/6) appears at a depth of 95 cm from the surface. No finds made, and the layer was considered as a "sterile" stratum, so the excavation was stopped.

The excavated area revealed a pattern of depleted humus loam with inclusions of artifacts, ecofacts, and baked clay (the total weight of the collected pieces is 413 g, but we did not collect pieces which size smaller than about 2 by 2 cm; Fig. 2.17). The abundance of baked clay and spots of heated soil suggest that the area was exposed to repeated intense fires, what also supported by the presence of calcined bones. The observed stratigraphy recalls the test pits 6, 7

Figure 2.17 Pieces of baked clay yielded by the cultural layer in outskirts of Kamennyi Ambar

At the bottom, the remains of bonfire at the modern archaeological camp. Baked clay has similar appearence

and 12, where the most abundant materials were also found, but the thickness of the culture layer within the units A3/A4 is greater and surpasses 30 cm. Regarding the collection of artifacts, the overall density is 14.2 per 1 m^2 for the both adjusted units. There are 104 ceramic sherds, but only five of them can be safely attributed to the phase 1, and one piece is typical of the Final Bronze Age tradition. The lamellar shaped sandstone tool with use wear on its edges is of considerable interest, since, presumably, it was used in pottery production for clay modeling and carving. Five pieces of talc are also evidence of earthenware production. The attributed animal bones belong to the subfamilies of bovine, caprine, and horse.

2.1.4 Collection of Arfifacts from the Cultural Layers near Kamennyi Ambar

The cultural layer Kamennyi Ambar yielded total of 810 artifacts (Fig. 2.18, 2.19 and 2.20). Ceramic sherds are the most common findings from the cultural layers near Kamennyi Ambar (670 sherds, or 82% of collection), but only 109 sherds (16%) can be safely culturally attributed in accordance with the Vinogradov-Zdanovich general classification scheme (see Chapter 1). Among them, 88 sherds (81% of identified) belong to the Sintashta-Petrovka phase. These are the sherds with the sharp-edged shoulder, the out-curved rim or upright with rim with broad thinning under it. The decoration techniques include geometric shapes and typical Sintashta pine-tree-like ornaments. The rest of identified sherds (22 specimens or 19% of recognized sherds) belong to the Srubnaya-Alakul' phase of the site. They are characterized by the ledged straight neck and rim, and geometrical ornamentation. The Sintashta-Petrovka sherds prevail in the collection with the proportion between 73.3% and 88.7% (or 81%±7.7% at 95% CL) of the identified sherds, while the Srubnaya-Alakul' sherds have only between 11.3% and 26.7% (or 19%±7.7% at 95% CL). This observation suggests that the cultural layer outside the wall of the nucleated settlement could be mainly created during the Sintashta-Petrovka chronological phase.

It worth noting that cultural identification of sherds is complicated by the absence of full forms of vessels. As it was mentioned in Chapter 1, the Sintashta-Petrovka pottery differs from the Alakul' pottery with the morphology of shoulder, neck, and rim, but the considerable number of collected sherds are from the lower parts of vessels. With the attempt to increase the pro-
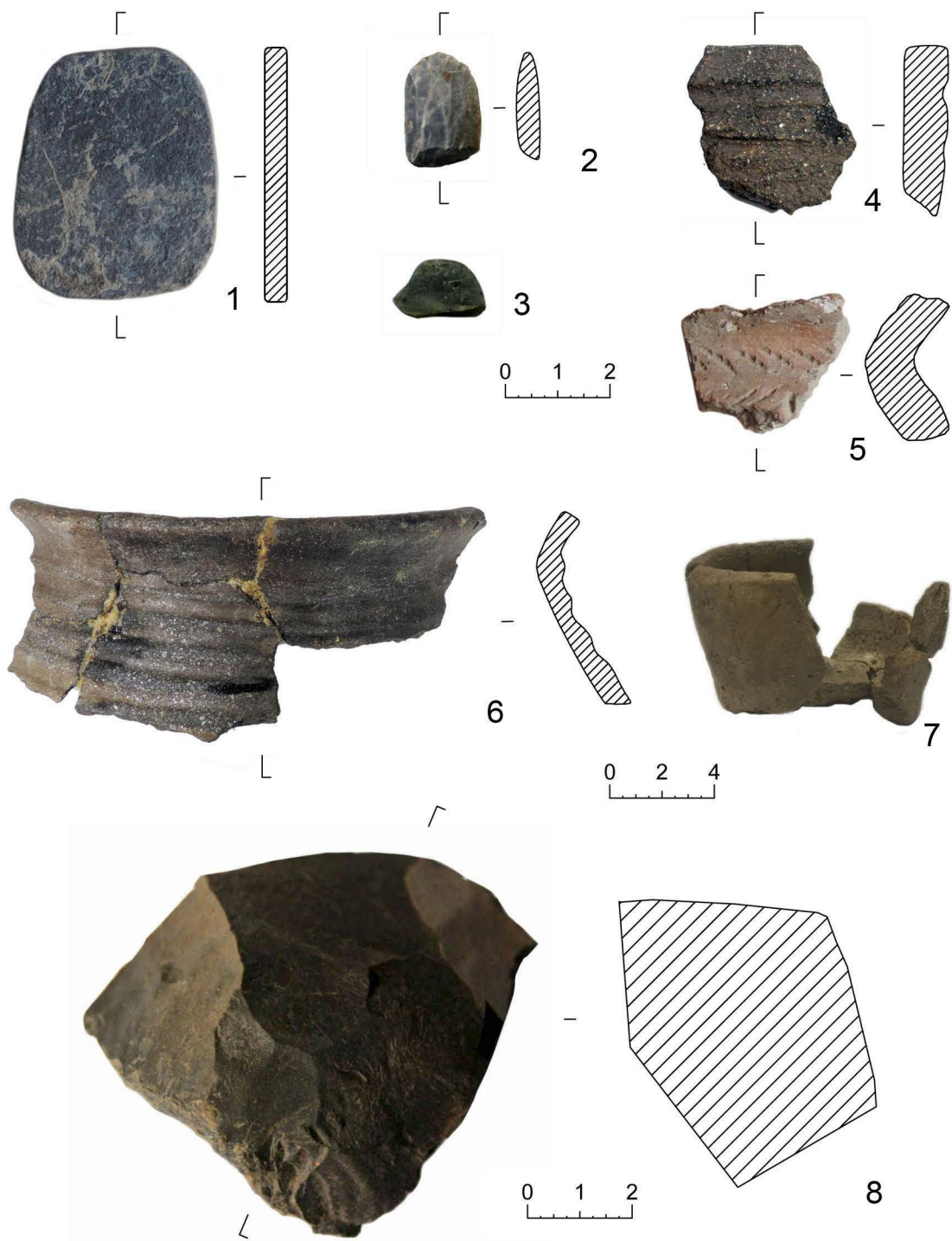
Figure 2.18 Findings yielded by the cultural layer in outskirts of Kamennyi Ambar
1 – a stone pottery tool; 2 – a lithic tool; 3 – a stone decoration (?); 4 – a neck of the Petrovka type; 5 – a shoulder of
the Sintashta type; 6 – a Sintashta type jar; 7 – a vessel with traces of high temperature; 8 – a stone hammer
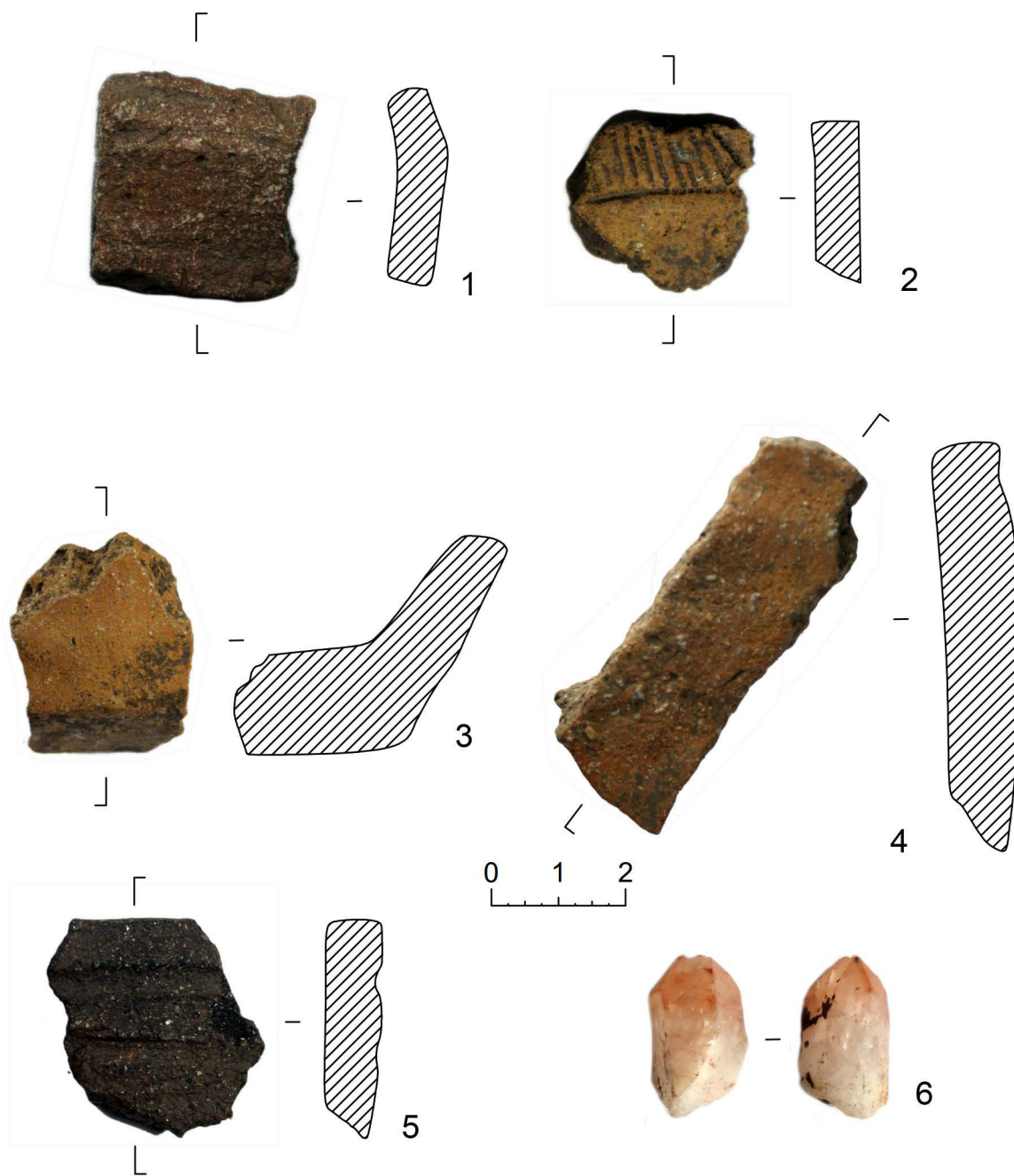
Figure 2.19 Findings yielded by the cultural layer in outskirts of Kamennyi Ambar

1 – a shoulder of the Sintashta-Petrovka type; 2 – a body sherd of the Srubnaya-Alakul' type (?); 3 – a bottom of the Sintashta-Petrovka type; 4 – a body sherd of the Sintashta-Petrovka type; 5 – a rim of the Sintashta-Petrovka type; 6 – a crystal of rose quartz
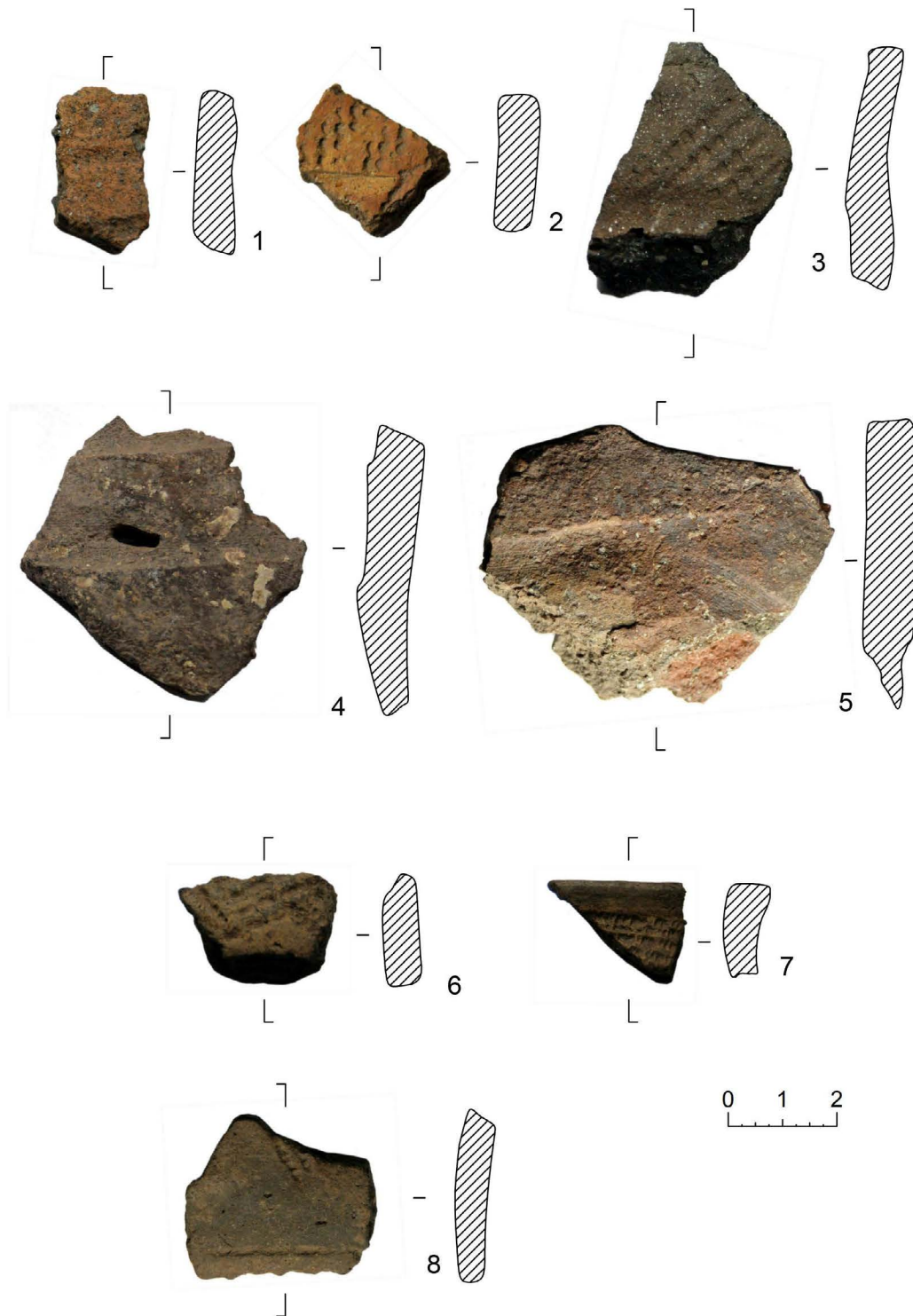
Figure 2.20 Findings yielded by the cultural layer in outskirts of Kamennyi Ambar

1 – a rim of the Srubnaya-Alakul' type; 2 – a rim of the Srubnaya-Alakul' type; 3 – a rim of the Srubnaya-Alakul' type;
4 – a neck of the Petrovka type (?); 5 – a body sherd of the Sintashta-Petrovka; 6 – a body sherd of the Srubnaya-Al-
akul' type; 7– a rim of the Srubnaya-Alakul' type; 8 – (?); 4 – a body sherd of the Srubnaya-Alakul' type

portion of identifiable sherds, analysis of modeling techniques was conducted on the sample 105 sherds (analyst – Vadim Mukhametdinov, the Bashkortostan State University, Ufa). Among them, 14 sherds of the Sintashta-Petrovka morphological type and 6 sherds of Srubnaya-Alakul' morphological type. The analytical method developed in the Institute of Archaeology of RAS and includes identification of raw material, pastes, and their proportions, molding mass, using of modeling template, surface treatment and firing (Dubovsteva et al. 2016).

The next step is the calculation of Gower's (1985) similarity coefficient for each pair of analyst sherds and then plotting the configuration of similarity scores of values with multidimensional scaling, using SYSTAT 13. The resulting scatterplot is a metaphorical space where the most similar sherds are placed closer to each other and increasing distance means increasing morphological difference (Drennan 2009:285–297). The three-dimensional configuration was chosen for further analysis since stress-values do not indicate a significant drop in adding dimensions after the second (stress drops from 0.24 to 0.19 if the second dimension added, to 0.17 with the third, and only to 0.16 with the fourth). The last tool applied is a k-means analysis, that is a distinguishing of clusters of cases within the two-dimensional space, produced by dimensioning of the similarity scores (Kintigh and Ammerman 1982).

The resulting plot (Fig. 2.21) demonstrates two clear groups of sherds, distinguished by the type of firing (reduction or oxidation firing). However, the difference between the Sintashta-Petrovka and Srubnaya-Alakul' sherds failed to appear, since they presented in both groups. Reduction of some analyzed variables to raw material and pastes do not create any difference since identifiable sherds still fail to group in any meaningful way. Consequently, while vessels of two periods differ morphologically, the
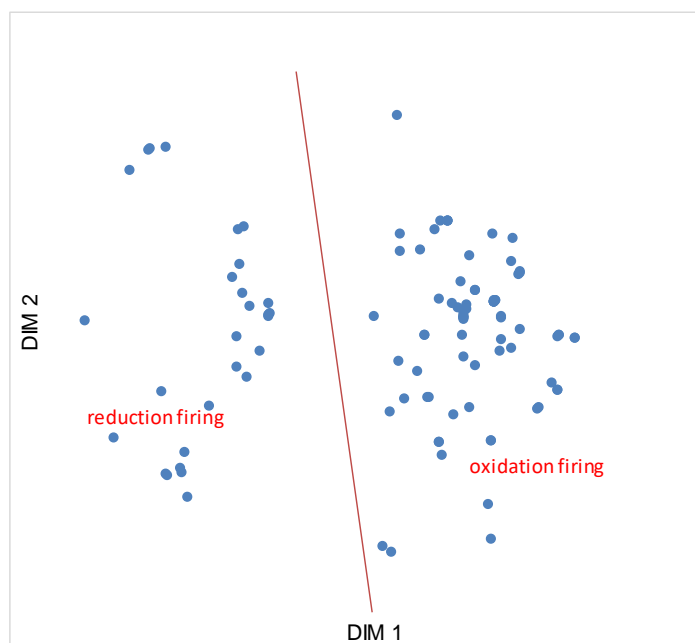
Figure 2.21 Sherds similarity graph: clear clusters are visible on the two-dimensional configuration graph

continuation of the Sintashta-Petrovka technologies and methods of pottery making in the succeeding phase can be concluded.

Metallurgical slag was collected in the amount of 63 pieces (7% of the collection). The X-ray fluorescence analysis of metallurgical slags ($n = 26$) was conducted in the Institute of Mineralogy, Ural Branch of the Russian Academy of Sciences, on the portable device INNOV-X α 400 (Process Analytical mode, 30 sec. exposure time, analyst – Maksim Ankushev). The analysis demonstrated the presence of specimens with a high content of chromite, as well as examples with high contents of tin and lead. The similar types of slag were found within the walls, suggesting contemporaneity of the materials from the outside (Krause and Koryakova 2013:187–199). The presence of slag outside the walls supports the idea of metallurgical production outside the walls, possibly for the purpose of fire-safety (Krause and Koryakova 2013:203–232).

There are 36 specimens of stone and lithic artifacts (4% of collection), such as blades (7 pcs.), flakes (7 pcs.), crystals of quartz (8 pcs.), pieces of talc (4 pcs.), a ceramic-production tool for treatment of surface, a limestone plate with polishing and linear micro-traces (a saw?), a grind-stone, two granite hammers, a possible stone pendant, and tool of unidentified function (4 pcs.). Raw materials for the majority of these tools are available locally, within the catchment zone with 1 km radius: a source of limestone is found only 500 m west from the settlement, while granites are located 300–400 m north. In some cases, the lithic artifacts (flakes and blades) were deposited in the same contexts with the Bronze Age ceramic sherds allowing to say that such tools were actively used at that time. Crystals of quartz found in the cultural layers inside the walls (23 pcs.) and a rauchtopaz were found under Kurgan 4 of Kamennyi Ambar-5 (Epimakhov 2005) pointing high value of such stones for the people. Their relatively high proportion outside the walls suggests that people outside tried to accumulate these semi-pressures stones purposefully. Finally, the craft tools allow the conclusion that some such activities took place outside too.

2.1.5 Results of Geophysics

The large-scale geophysics surveys at Kamennyi Ambar demonstrated that within the walls the positively-magnetic features are organized in the regular manner (Merrony et al. 2005;
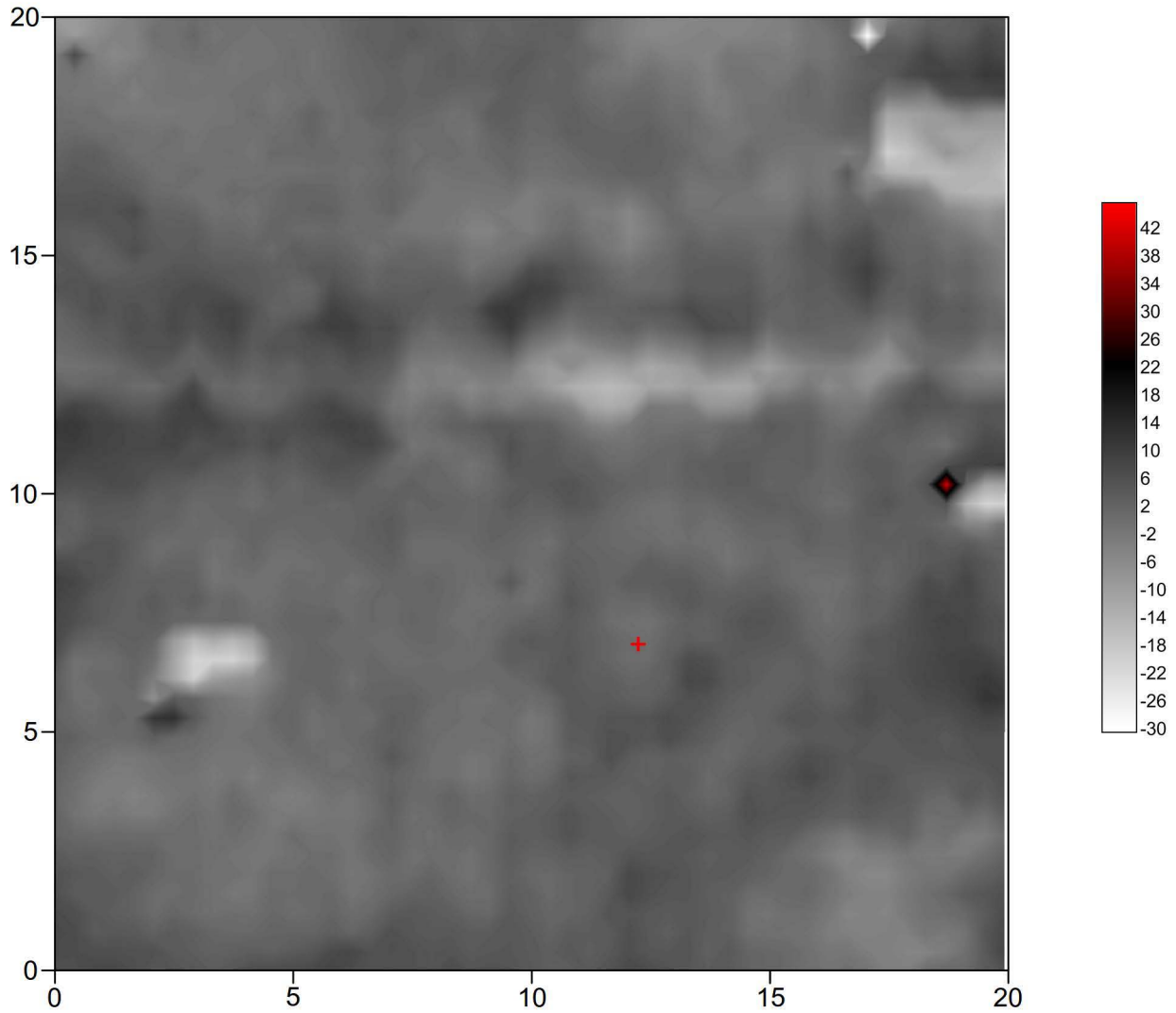
Figure 2.22 Results of the magnetic survey of 2017: + – the center of the possible circular structure

Krause and Koryakova 2013:56–59). Such organization allowed their interpretation as the four rows of blocked houses surrounded by the wall and the ditch. Some positive magnetic anomalies also can be seen outside. Testing one of them with TP-KA-8 and 9 did not reveal any structures, like hearths, wells or post-holes. Investigation part of the rectangular anomaly northeast from the wall with test pit TP-KA-6 revealed abundant archaeological materials and possible evidence of hay, and also the "A1" horizon of modified humus with a thickness of about 20 cm. At the same time, there is a positive anomaly (2–3 nT) in the spot, where the test pit 12 revealed a bonfire. To sum up, the magnetic anomalies outside the wall seen on the large-scale map are not regular, scattered and, thus, are more difficult for the direct interpretation.

Discovery of an intense cultural layer to the north from the settlement generated the hypothesis that remains of structures might be located there, possibly organized as regularly patterned magnetic anomalies. In 2017, to test this hypothesis, high-resolution (0.5 m by 0.5 m) magnetometer survey was conducted by Dr. Vladislav Noskevich of the Institute of Geophysics of the UB RAS, after the program of coring and test-pitting had been finished in this area. The survey area is 576 m^2, north from the settlement's northeast corner.

As evident from the map of magnetic anomalies (Fig. 2.22), no regular structures, like those within the walls, can be found in the surveyed zone. There are neither rectangular patterns that would resemble a subterranean house, nor magnetically strong (4–6 nT) circles that within the walls are associated with wells and furnaces. The east-west anomaly, placed right in the center of the plot, is a depression on the surface that has been caused either by natural processes or a recent disturbance (possibly a 20th-century road). There is a circular anomaly of potential interest with a diameter of about 4 meters, with its center at 20 m East and 7.5 m North. Importantly, this kind of structure cannot be seen on the previously published maps. Even though this pattern did not receive archaeological study, this might represent a horizon of disturbed soil, related to specific activities, like its counterpart in test pit TP-KA-6, mentioned above.

In conclusion, the cultural layer outside the walls is substantially different from its counterpart inside and cannot be reliably recognized by standard remote sensing approaches, which makes subsurface testing a crucially important thing. However, more detailed survey, conducted together with the archaeological study provides some clues and allows judgments about the presence of the archaeological structures.

2.1.6 Geochemical Analysis of Soils around Kamennyi Ambar

Human activities impact the environment in a variety of ways, including identifiable chemical traces. In general, variation in values of trace elements, like phosphorus, calcium, magnesium, zinc or copper may indicate productive activities, accumulation of refuse or products of human and animal metabolism. Once added to soil, phosphorus in its common form of phosphate and heavy elements like calcium or strontium are stable and generally immobile (Holliday 2004;
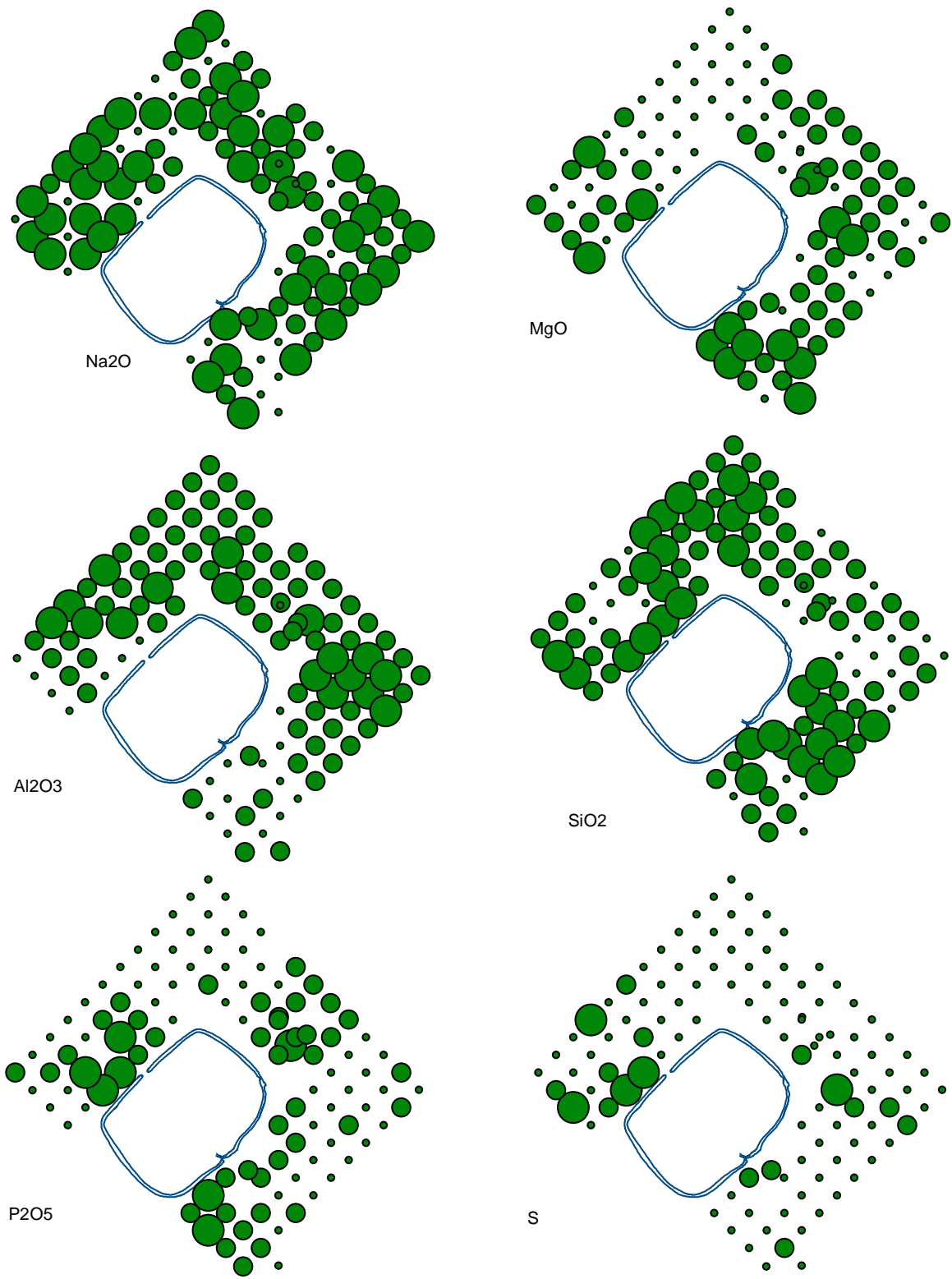
Figure 2.23 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)
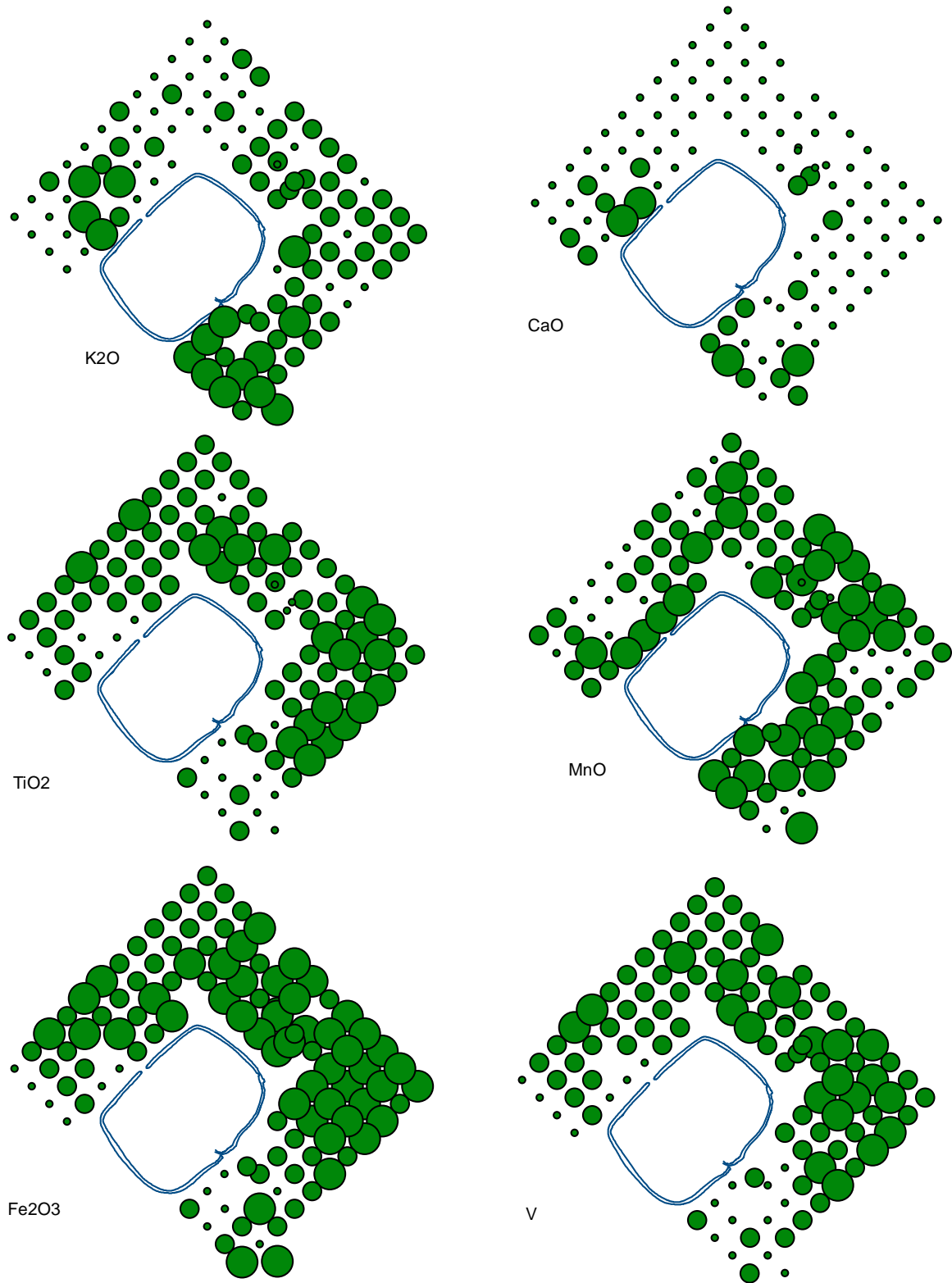
Figure 2.24 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)
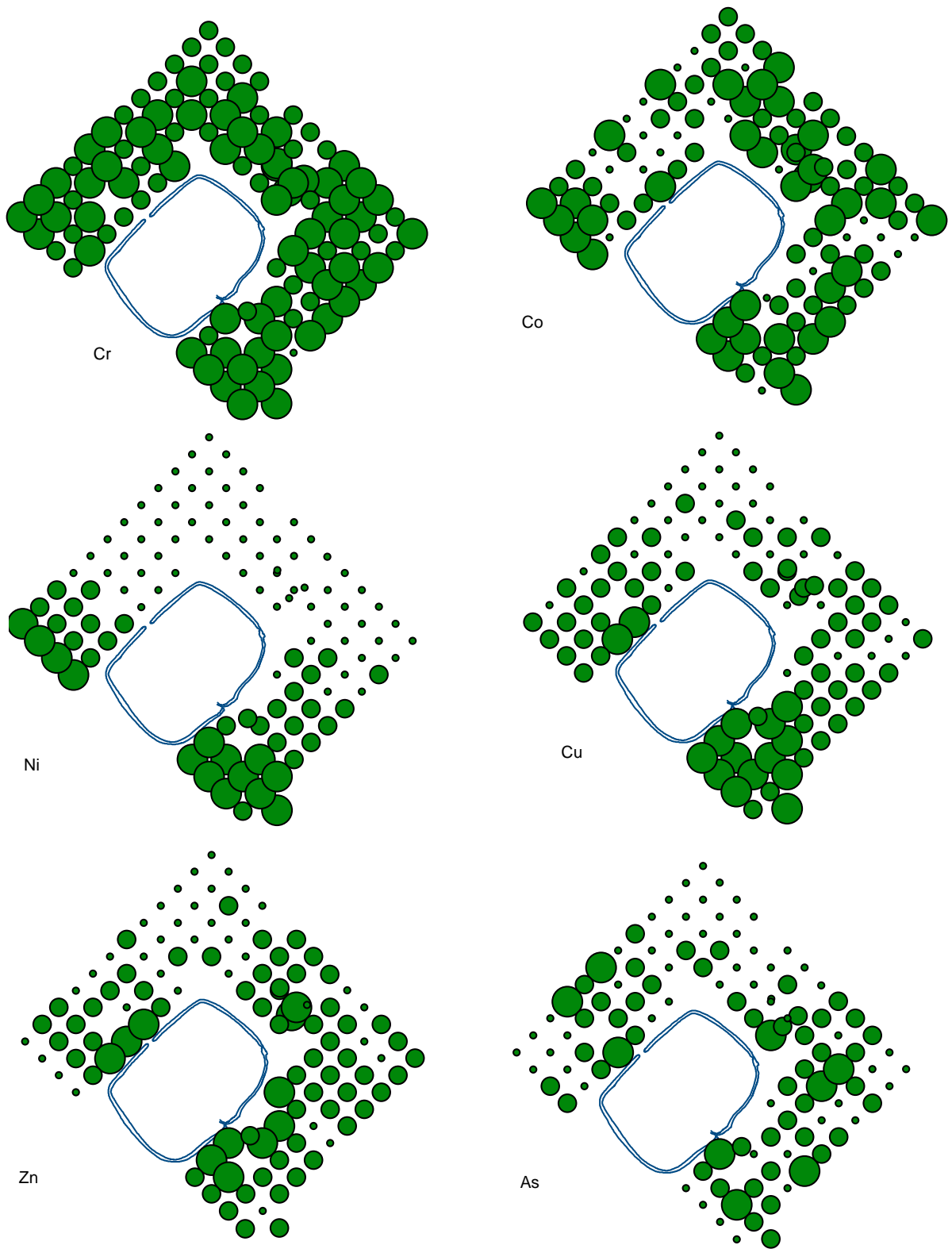
Figure 2.25 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)
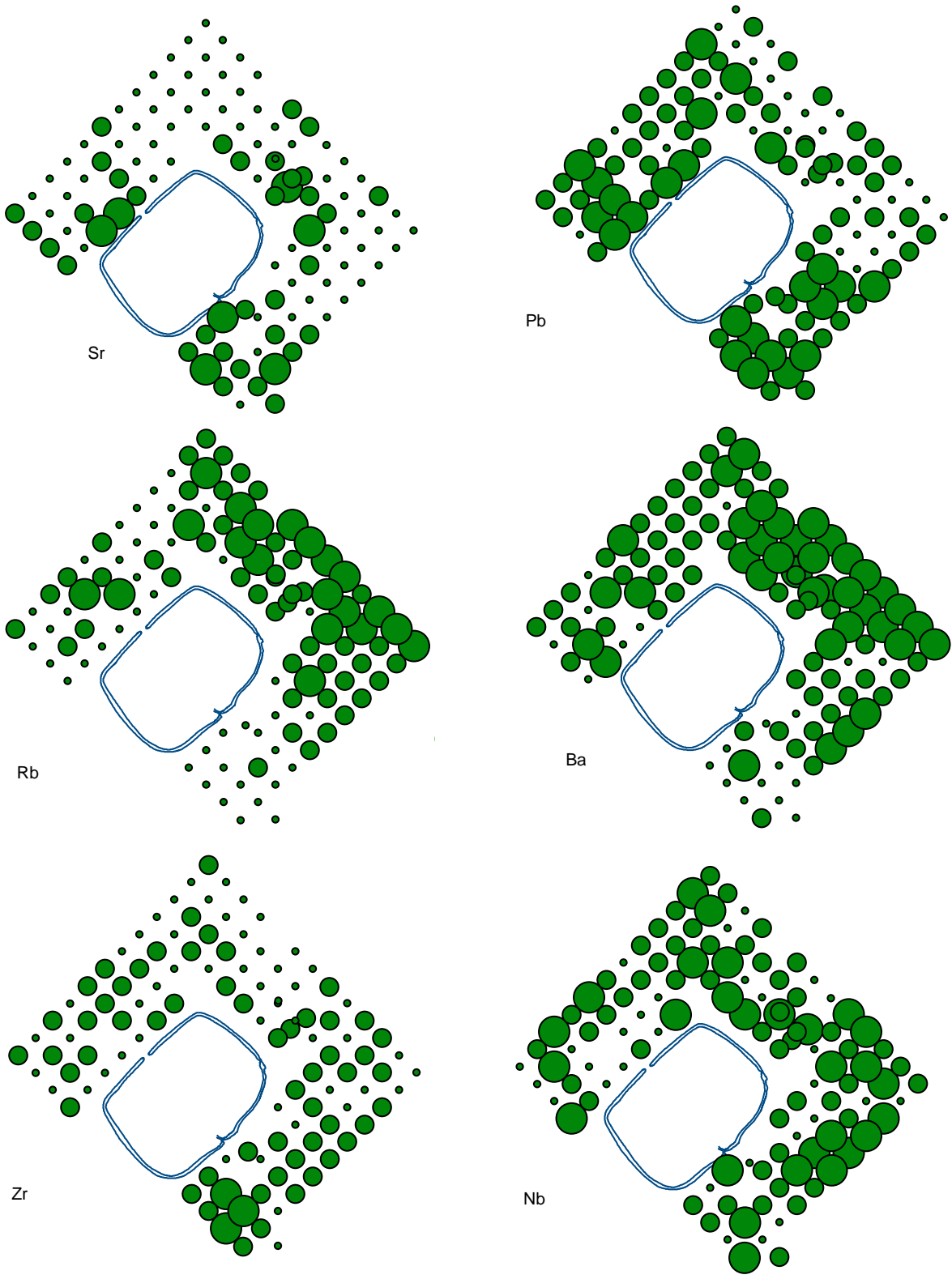
Figure 2.26 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)
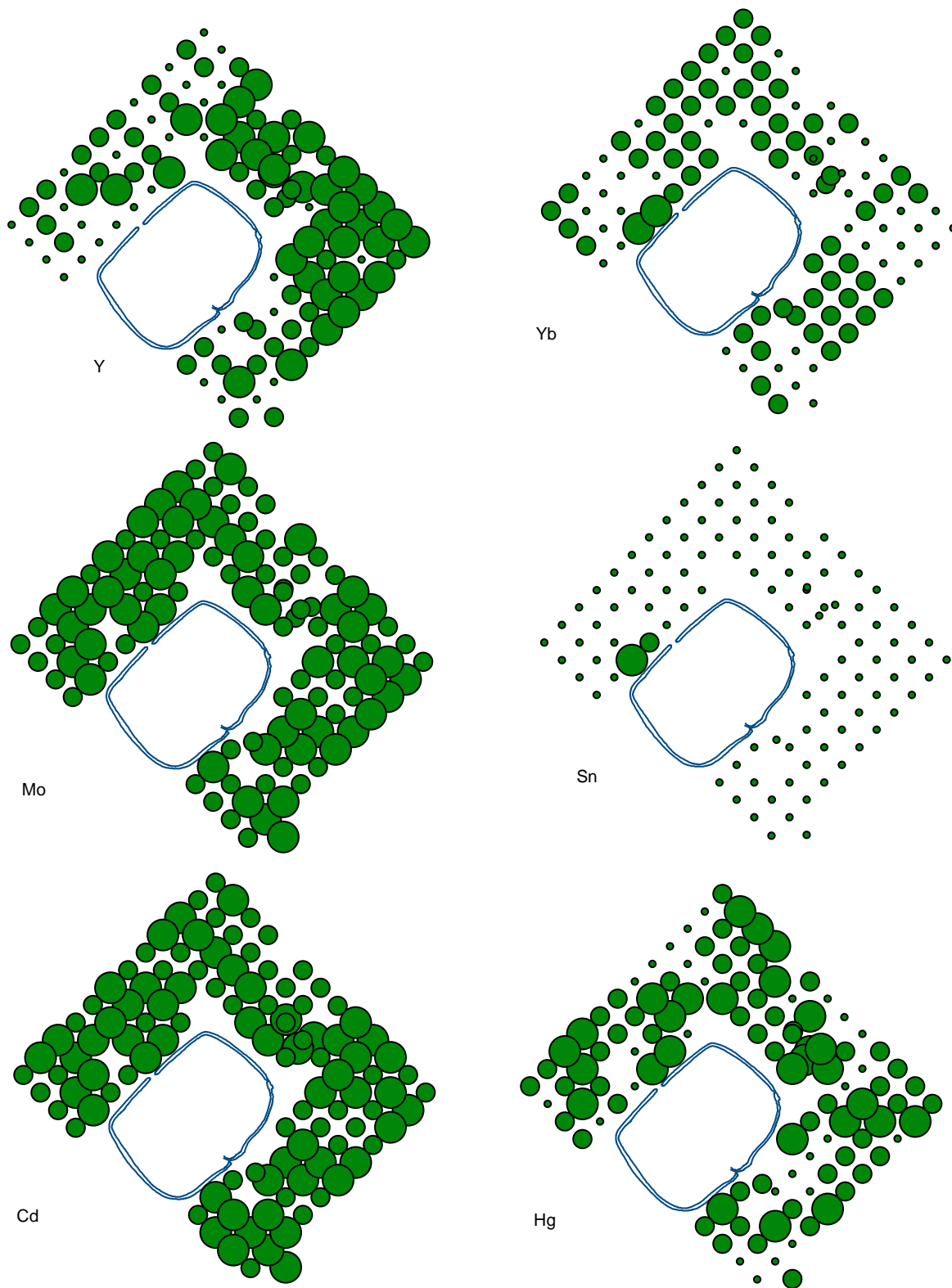
Figure 2.27 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)
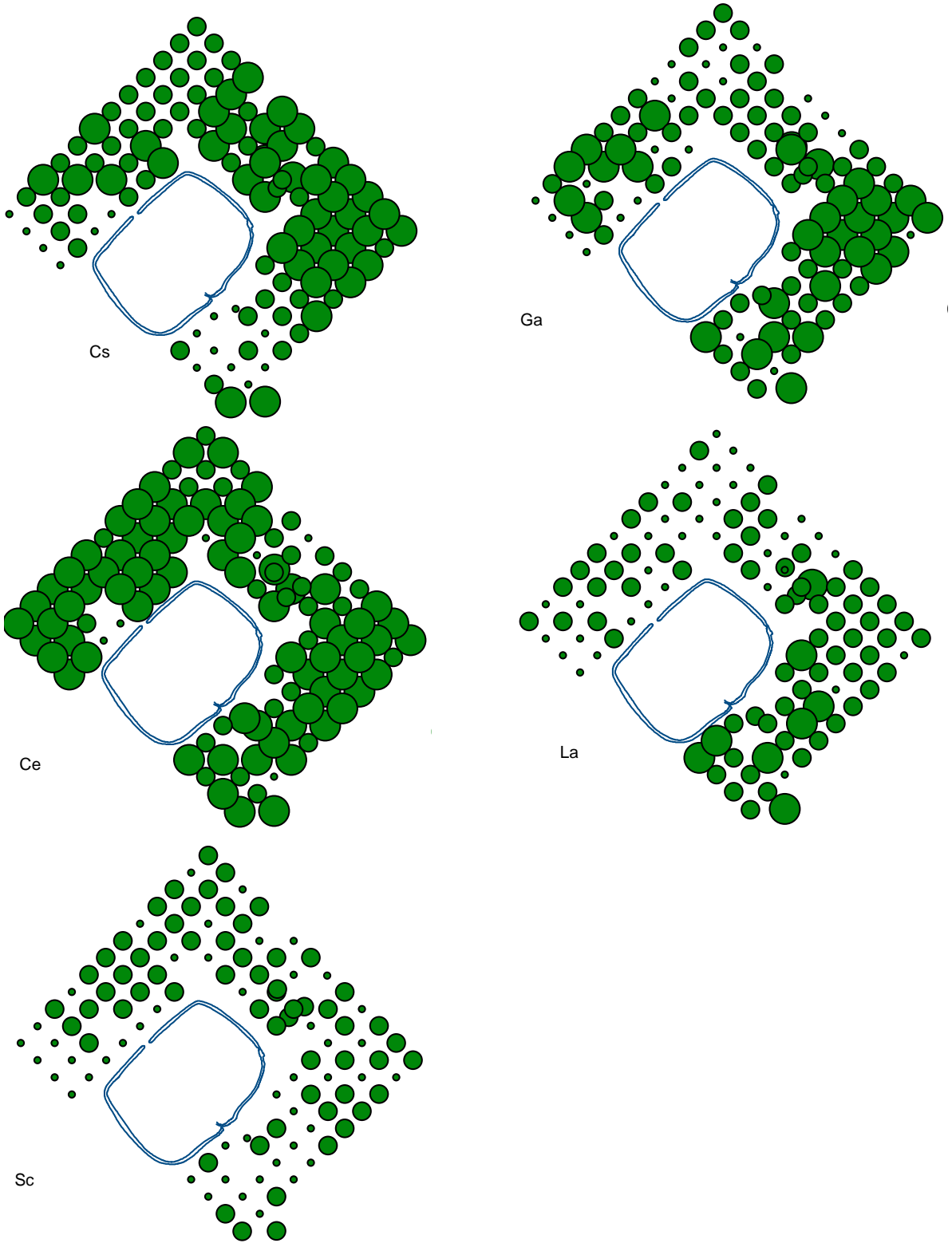
Figure 2.28 Distribution of chemical elements around the walled site of Kamennyi Ambar (standardized values)

Holliday and Gartner 2006; Kalinin et al. 2009). For this reason, studying the soil chemical composition is another possible way to identify, interpret, and delineate the cultural layer outside the walls of Kamennyi Ambar (Fig. 2.23–2.28).

Soil samples were collected vertically at 5 cm, or 10 cm intervals in the test pits TP-KA-6 ($n = 13$), TP-KA-7 ($n = 10$), TP-KA-A4 ($n = 11$) and in the cross-section CS-KA-2 ($n = 6$). Moreover, Dr. Yakimov in a comparable way collected the samples from Test Pit Y-146 located 500 m east from the wall (no presence of cultural deposits recorded) and from the cultural layer inside the settlement (Excavation 7, Profile H). The values of trace elements in two later profiles can be used to establish baselines for determination of chemical anomalies in the deposition outside the settlement wall. Moreover, samples were collected at the depths 0/-10 cm and -10/-20 cm from 110 cores to trace zonal accumulation of the trace elements.

Dr. Kalinin of the Institute of Physical, Chemical and Biological Problems of Soil Science of the Russian Academy of Sciences conducted the analysis of chemical composition utilizing the "Spectroscan MAKC-GVM" WDXRF spectrometer. This machine can determine elements from sodium to uranium and values of thirty-four elements/compounds measured in total (Appendix A). The spectrometer operation is based on irradiation of the sample with primary X-rays generated by an X-ray tube, registration of the secondary fluorescence from the sample elements preliminary diffracted on a crystal, and calculation of the elements concentration with the help of calibration equation, which is a relation between the element concentration and intensity of the registered secondary emission from the element. The measurements are given as relative proportions of elements or chemical compounds in the probe (the official website of Spectron Ltd – https://www.spectronxray.ru).

Analysis of soil chemical composition consisted of five consecutive steps: 1) testing of relationship between elements, 2) comparison of vertical distribution of primary trace elements (phosphorus and iron) in Pit 146, the archaeological survey test pits and Excavation 7, 3) comparison of mean values of elements between the natural deposit, the cultural layer outside and the cultural layer inside, 4) statistical estimation of phosphorus content in the cultural layers and natural soil, and 5) delineation of the cultural layer boundaries in accordance with the values of phosphorus.

The first step aims to find the set of tracing elements by studying the correlation between the values of sub-surface elements at the depth -10/-20 cm from 110 soil cores (Pearson's r). The sample analyzed is from the depth of -10/-20 cm to decrease the impact of modern phosphorus that may come from modern grazing. The resulting correlation matrix formed the similarity coefficients for a multidimensional scaling analysis with SYSTAT 13 (Fig. 2.29). The two-dimensional plot demonstrates two clusters: a Group of Phosphorus (typically used as a trace element of animal metabolism) and a Group of Iron (a
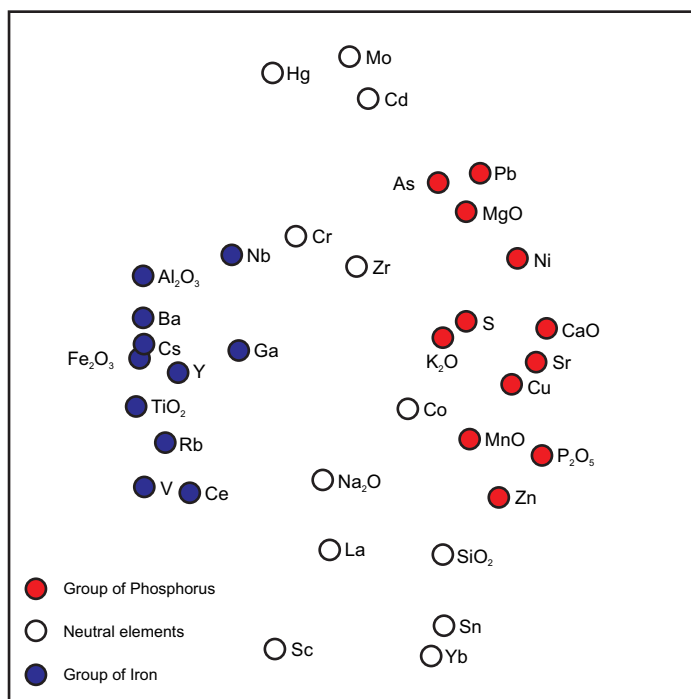
Figure 2.29 Multidimensional scaling of correlation matrix (Pearson's *r*) with the Group of Phosphorus and the Group of Iron colored

common element in the Ural Mountains) with other elements between the primary clusters. As is evident from the scatterplot, phosphorus oxide (P_2O_5) has a tendency to correlate positively with strontium (*r* = 0,75), zinc (*r* = 0,73), calcium (*r* = 0,62), copper (*r* = 0,56), potassium (*r* = 0,39), magnesium (*r* = 0,35), sulfur (*r* = 0,34), manganese (*r* = 0,33), lead (*r* = 0,25) and arsenic (*r* = 0,23). Some of these elements can be products of human and animal metabolism (sulfur), results of decay of biological tissues (calcium) or originate as a result of productive activities (copper, lead). The clustering, then, indicates the set of elements of which higher accumulation can be employed to find and characterize areas of human activities outside the walls.

On the other hand, iron has a tendency to correlate positively with cesium (*r* = 0,99), aluminum (*r* = 0,86), yttrium (*r* = 0,78), vanadium (*r* = 0,76), rubidium (*r* = 0,68), titanium (*r* = 0,67), barium (*r* = 0,62), germanium (*r* = 0,58) and cerium (*r* = 0,35). These are not common trace elements in archaeology and may indicate the impact on soil formation by the Ural Mountains geology.

The correlations between the two groups are negative, meaning that an increasing share of an element from one group coincides with a decreasing share of an element from another
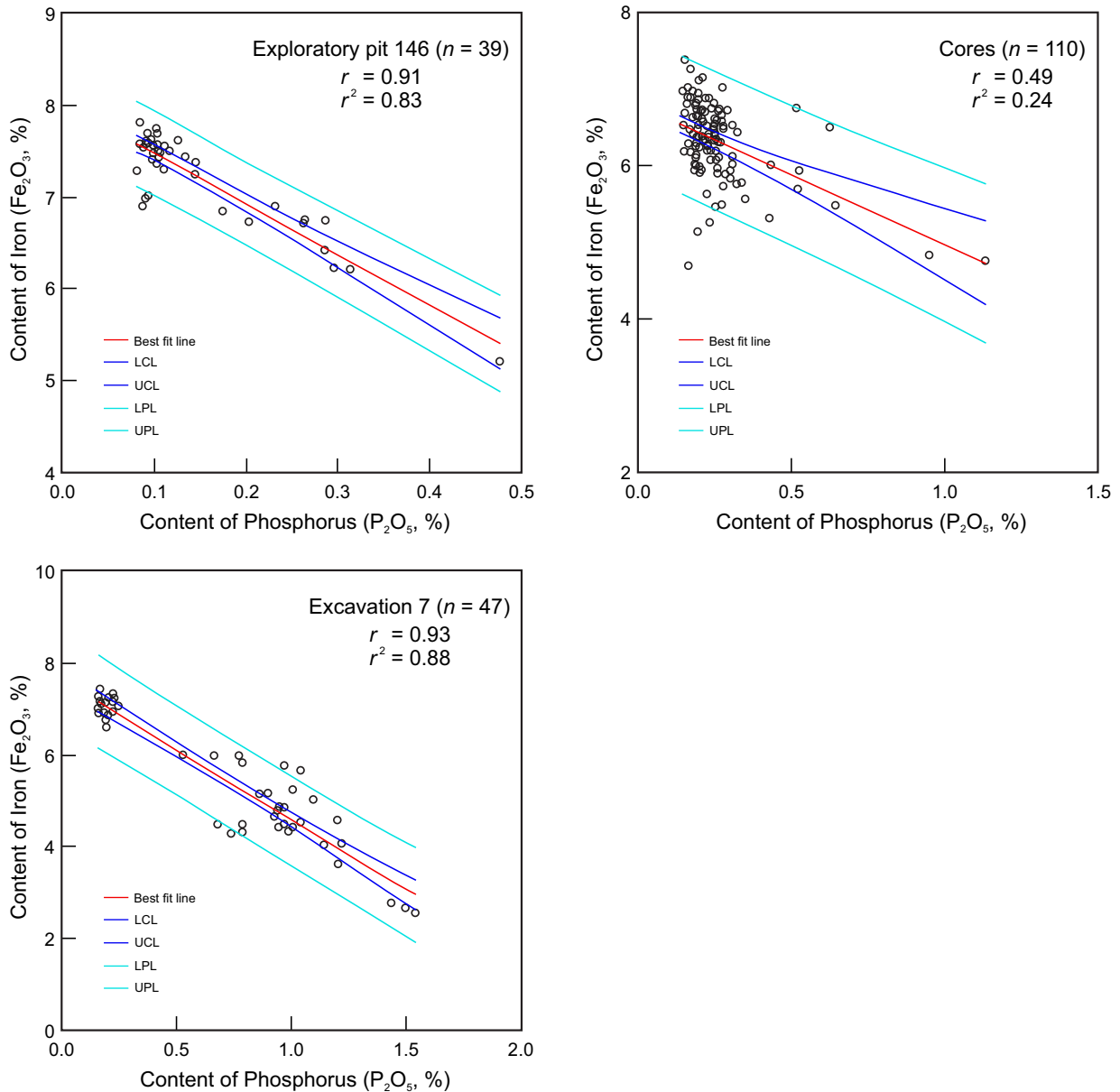
Figure 2.30 Regression graphs of phosphorus and iron correlation

group. For example, the correlation coefficients of phosphorus are -0.49 with iron, -0.73 with titanium and -0.62 with aluminum, indicating that an increase in level of phosphorus coincides with a decreasing level of metals in the soil. The same observation can be made inside the settlement: a high level of phosphorus in the cultural layer correlates strongly with a low content of iron (r = -0.93, 88% of variability explained). The plausible interpretation of this phenomenon is that human activities impacted soil evolution by adding products of animal metabolism and decreasing the contribution of local geology and vegetation. In other words, a relatively low level of elements from Group of Iron can be used as a secondary indicator of human activities (Fig. 2.30).
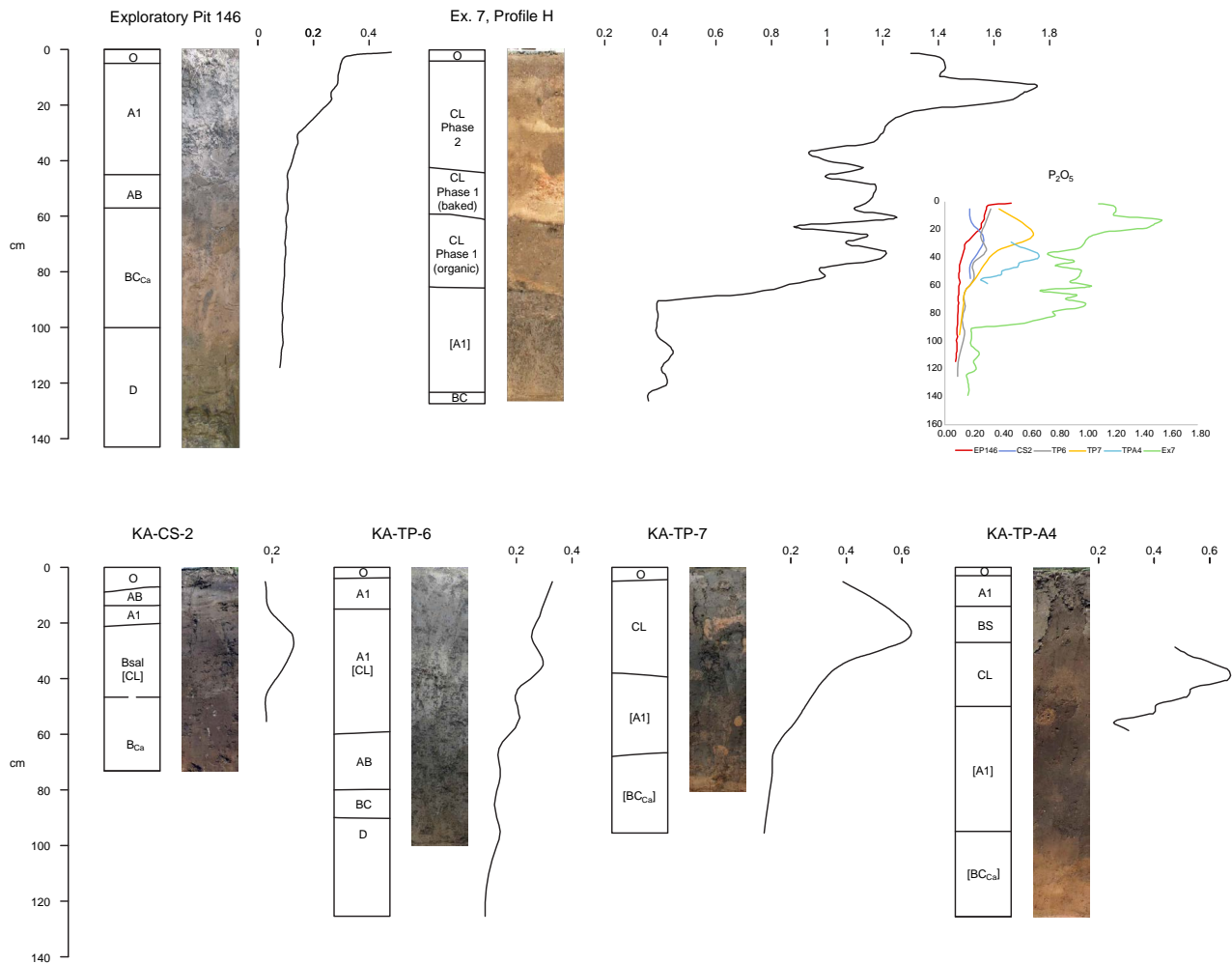
Figure 2.31 Comparison of levels in phosphorus in the natural soil deposition, the cultural layers inside the wall, outside the wall

The second step of the analysis is looking at the vertical distribution of phosphorus and iron (as meaningful trace elements that have a strong tendency to negatively correlate with each other) within the profiles in the test pits TP-KA-6, 7, A4, the cross-section CS-KA-2, Pit 146 and in Excavation 7 (Fig. 2.31 and Fig. 2.32).

Regarding phosphorus, Test Pit Y-146 demonstrates a higher value of 0.48% in topsoil, that rapidly drops to 0.31% in the next measurement, and it continually decreases to 0.08% at a depth of 114 cm. Presumably, the highest concentration of phosphorus in the topsoil is a result of modern cattle grazing, while the rest of the values represent more natural processes. In cross-section CS-KA-2, the curve starts with a value of 0.17% in the topsoil, then increases to 0.27% in the horizon -20/-30 cm and drops again in the lower horizons. The distribution curve in TP-KA-6, in general, follows the pattern of the curve from Exploratory Pit 146, but there is a peak
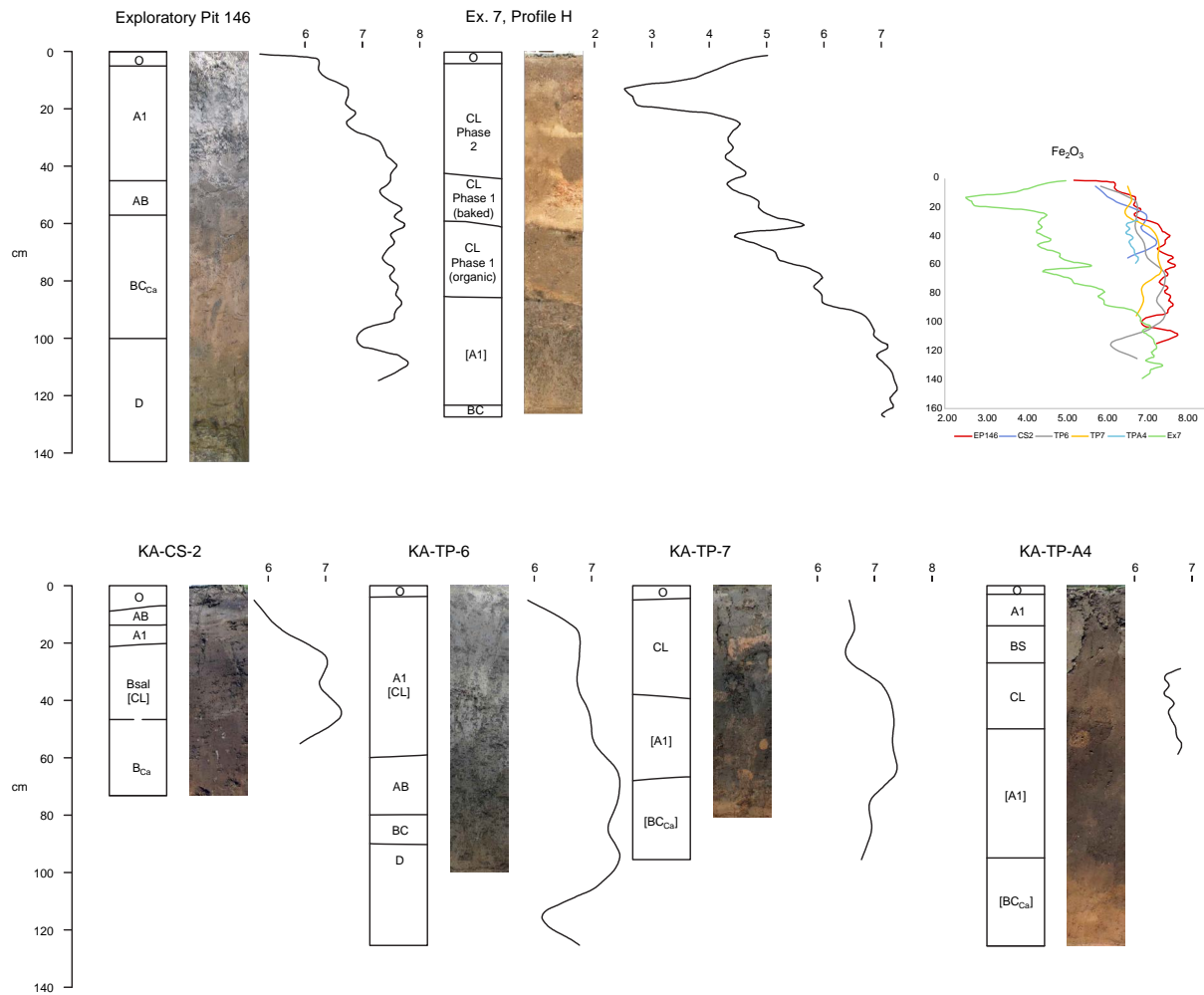
Figure 2.32 Comparison of levels in iron in the natural soil deposition, the cultural layers inside the wall, outside the wall

with the values of 0.25%–0.29% at the depth -15/-35 cm which does not exist in the curve of natural accumulation. A similar observation can be made about the distribution of phosphorus in TP-KA-7, with the exception that the peak values are higher (0.54%–0.62%) and accumulated at the depth -15/-25 cm. Finally, in the test pit TP-KA-A4, the samples were collected every 5 cm at the depths -25/-60 cm in order to gather more data about the cultural layer. The curve starts with a relatively high value of 0.47%, reaches 0.67% at -37 cm and then smoothly drops to 0.30% at -58 cm (Fig. 2.31).

Comparison with field observation of profiles is necessary to interpret the observed differences between the naturally deposited soil and soil modified by human activities. Thus, in the cross-section CS-KA-2, the highest value is 0.27% at -25 cm, or within the layer where the Sintashta ceramic sherds were found. In TP-KA-6, the peak of 0.29% is at -35 cm and also correlates

with the layer of depleted humus with ceramics, metallurgical slag, and animal bones. The peak of 0.62% also lies in the layer with cultural material in TP-KA-7. Finally, the peaks of 0.66%–0.67% were recorded within the most evident cultural layer at the depths -35/-40 cm in TP-KA-A4 (Fig. 2.31).

Consideration of stratigraphy is also crucial before analyzing the distribution of phosphorus in the cultural layer of the settlement. Thus, the investigators of the settlement within the walls distinguish two layers in profile H, where the samples were taken in increments of 3 cm. The upper layer of yellowish loam (0/-45 cm) is filled with ceramic sherds of Phase 2 (Srubnaya-Alakul') and interpreted as the remains of the latest occupation. At a depth of -45/-60 cm, under yellowish loam, there is a layer of reddish very baked loam with charcoal, which covers a layer of grey soil (-65/-90). These two layers are the remains of a Sintashta-Petrovka building of Phase 1, that was only slightly dug into the ground. At a depth of -90 cm, a layer of buried humus was recorded, and sterile clay was reached at a depth of -125 cm (Epimakhov 2011) (Fig. 2.31).

In the topsoil, the value of phosphorus is significantly higher than anywhere outside the walls with 1.09%; then it reaches a peak of 1.54% at a depth of -12 cm and then drops to 0.78% at -39 cm. These values characterize the layer of yellowish loam attributed to the Srubnaya-Alakul' phase of the settlement that might be contaminated by modern phosphorus. At a depth of -42 cm, where the Sintashta-Petrovka remains lie, the phosphorus concentration grows again to 0.92% and hits 1.04% at -60 cm. The value in between reddish loam and grey soil drops to 0.67% at -63 cm, then the curve reaches another peak of 1% at -72 cm and starts to fall again. The significant drop to 0.19% happens at a depth of -90 cm, where the layer of buried soil begins and to 0.16% at a depth of -123 cm, where the sterile layers begin. In sum, the profile demonstrates significant differences in the distribution of phosphorus between two cultural layers, buried soil and the sterile layer (Fig. 2.31).

In comparison to the values from outside, the cultural layer inside the wall demonstrate higher values of phosphates and even the buried soils seem to be impacted by activities in the houses, though the values in the deepest horizons are closer to normal. However, the level of phosphorus in the cultural layer from outside the wall also demonstrates anomalies in the accumulation of phosphorus, when compared to the values in the natural deposits, even though the values in the cultural layer outside are lower than those inside the walls.

Iron practically mirrors the picture of phosphorus distribution: in Test Test Pit Y-146, the curve rapidly rises from the lowest percentage of 5.21% in topsoil through 6.85% at -27 cm to the peak of 7.69% at a depth of -87 cm. The values that shape curves in the test pits are slightly lower than in the natural deposit, and they are dramatically lower inside the settlement. The negative peak mirrors the positive peak in the upper layer, and the situation goes on the same in the lower layer before the curve intersects the curve of normal deposition at a depth of -100 cm. This distribution of the curves supports the conclusion of the chemical analysis of the cores that phosphorus correlates negatively with iron and other metals (Fig. 2.32).

The third step of analysis is an evaluation of differences in mean values of elements in natural soil (Test Pit Y-146—all measurements included in the analysis), the cultural layer outside the walls (CS-KA-2, TP-KA-6, 7, A4— all measurements included in the analysis) and the cultural layer inside the walls (Ex. 7—only measurements from the Sintashta layer at -40/-95 cm included in the analysis). Next, the relative differences between the mean values in the cultural layers (both inside and outside the walls) and the natural deposit in Test Pit Y-146 ($n = 39$) were calculated (cultural layer value divided by non-cultural layer value). Following, there is the analysis of twenty-six elements or their compounds with rare-earths excluded (cerium, lanthanum, scandium, yttrium, ytterbium) and the are data summarized in Table 2.2.

In TP-KA-A4, the samples ($n = 11$) were collected only from the cultural layer at a depth of -28/-58 cm and, the differences are very pronounced. The values of cadmium, arsenic, molybdenum, phosphorus, and sulfur are more than two times higher in this cultural layer than in Test Pit Y-146. The values of five other elements (lead, magnesium, niobium, manganese, and potassium) are only slightly higher than in Test Pit Y-146, and only small differences can be seen in values of strontium, barium, sodium, rubidium, calcium, silicon and mercury. The values of the remaining nine elements (aluminum, zinc, iron, cesium, cobalt, nickel, gallium, copper and vanadium) are lower in the cultural layer of TP-KA-A4. In terms of trace elements, the higher values of phosphorus, molybdenum, magnesium manganese suggest biological activity, while low values for metals support the idea that the soil was modified by human activities.

While some variability can be observed in cases of TP-KA-6 ($n = 13$), TP-KA-7 ($n = 10$) and CS-KA-2 ($n = 6$), in general, they resemble the patterns observed in the cultural layer of TP-KA-A4. However, the cultural layers exposed by these tests reflect less intensive activity, which
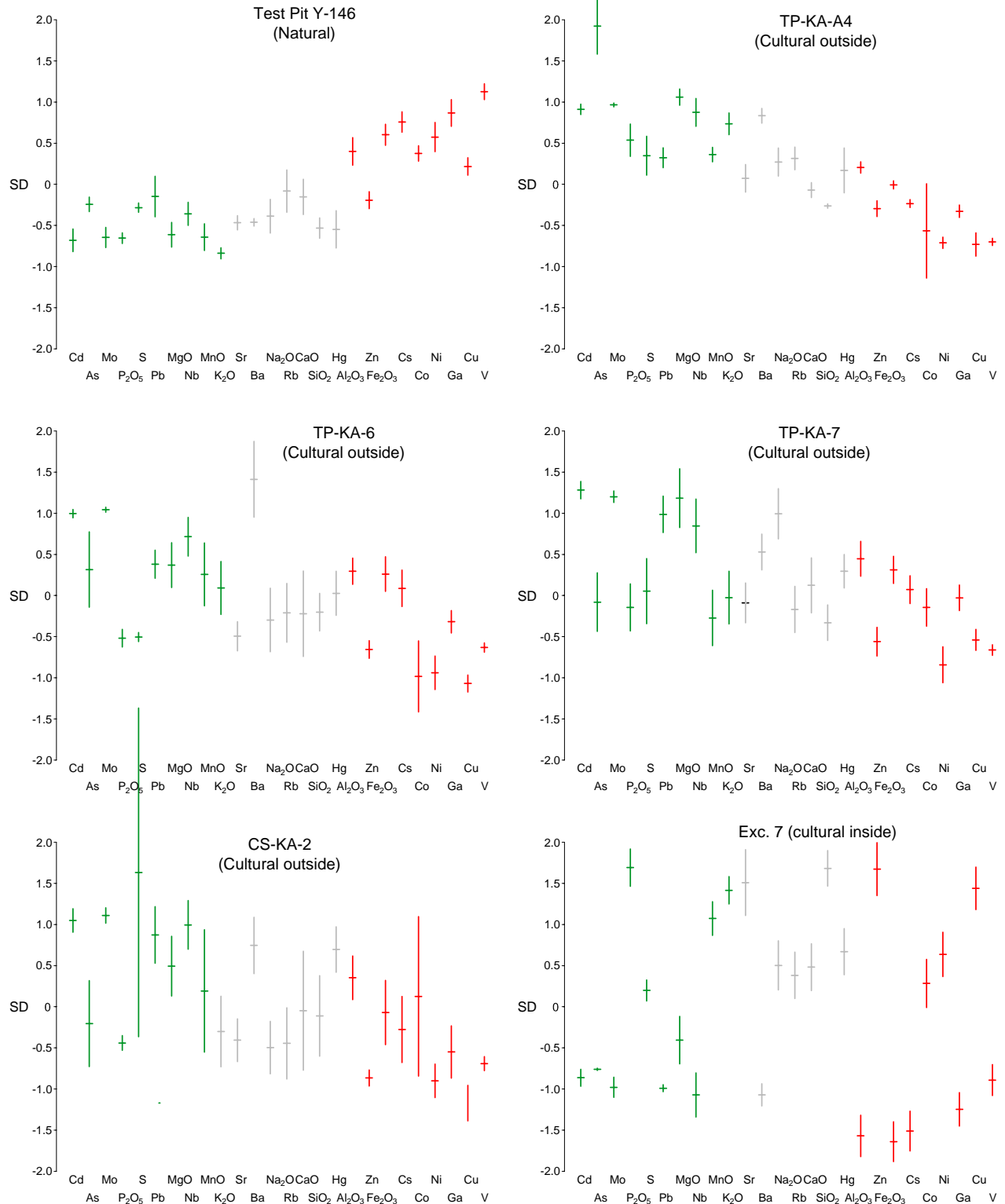
Figure 2.33 Comparison of the mean values of elements in the natural soil deposition, the cultural layers outside the wall and inside the wall

can explain relatively lower values for phosphorus. At the same time, another biological trace element (molybdenum, an element involved in the production of uric acid), is relatively high in these locations. Its presence suggests that people, indeed, occupied the areas of interest.

The cultural layer of the Sintashta house (Ex-7) inside the wall has distinct chemical characteristics. In terms of ten elements that strongly differentiate the cultural layer outside the walls from the deposits in Test Pit Y-146, the deposit inside the walls is enriched only by phosphorus and somewhat by sulfur, manganese, and potassium. It differs less from Test Pit Y-1246 in terms of cadmium, arsenic, molybdenum, lead, manganese, and niobium. However, it shows relatively high values of calcium, zinc, and copper—the elements with lower values in the cultural layer outside the walls. In other words, the cultural deposit from the house differs from both natural soil and from the cultural layer outside the walls. The most significant difference is the high amount of phosphorus inside the walls. which could result from keeping animals inside the house.

Table 2.2 Mean values of elements and their relative differences

	Y-146	TP-KA-A4	cultural/ non-cultural	TP-KA-6	cultural/ non-cultural	TP-KA-7	cultural/ non-cultural	CS-KA-2	cultural/ non-cultural	Ex-7	cultural/ non-cultural
Cd	0.0000	0.0001	6.000	0.0001	6.000	0.0001	7.000	0.0001	6.000	0.0000	1.000
As	0.0008	0.0042	5.123	0.0017	2.062	0.0011	1.309	0.0009	1.074	0.0000	0.025
Mo	0.0001	0.0003	3.857	0.0003	4.000	0.0003	4.286	0.0003	4.000	0.0000	0.429
P_2O_5	0.1481	0.4878	3.295	0.1866	1W.260	0.2933	1.981	0.2091	1.412	0.8175	5.522
S	0.1121	0.2298	2.050	0.0717	0.640	0.1752	1.563	0.4700	4.193	0.2022	1.804
Pb	0.0007	0.0011	1.544	0.0011	1.603	0.0016	2.294	0.0015	2.162	0.0000	0.044
MgO	1.7465	2.5967	W1.487	2.2354	1.280	2.6615	1.524	2.3006	1.317	1.9406	1.111
Nb	0.0011	0.0015	1.407	0.0015	1.352	0.0015	1.398	0.0016	1.444	0.0008	0.759
MnO	0.1131	0.1471	1.300	0.1435	1.269	0.1256	1.111	0.1413	1.249	0.1711	1.513
K_2O	2.1265	2.6285	1.236	2.4233	1.140	2.3859	1.122	2.2977	1.081	2.8452	1.338
Sr	0.0201	0.0244	1.216	0.0199	0.989	0.0231	1.151	0.0206	1.024	0.0360	1.791
Ba	0.0559	0.0668	1.195	0.0717	1.282	0.0643	1.149	0.0661	1.182	0.0508	0.908
Na_2O	1.1490	1.2342	1.074	1.1606	1.010	1.3284	1.156	1.1348	0.988	1.2645	1.101
Rb	0.0104	0.0112	1.073	0.0102	0.977	0.0102	0.985	0.0097	0.934	0.0113	1.086
CaO	2.7432	2.9213	1.065	2.5946	0.946	3.3381	1.217	2.9669	1.082	4.1097	1.498
SiO_2	51.347	52.809	1.028	53.148	1.035	52.442	1.021	53.643	1.045	63.422	1.235
Hg	0.0000	0.0000	1.000	0.0000	1.000	0.0000	1.000	0.0000	1.000	0.0000	1.000
Al_2O_3	17.979	17.445	0.970	17.694	0.984	18.104	1.007	17.850	0.993	12.6238	0.702
Zn	0.0107	0.0103	0.956	0.0086	0.800	0.0090	0.842	0.0076	0.709	0.019	1.807
Fe_2O_3	7.2130	6.6778	0.926	6.9123	0.958	6.9574	0.965	6.6220	0.918	5.2426	0.727
Cs	0.0008	0.0007	0.885	0.0007	0.923	0.0007	0.923	0.0007	0.872	0.0006	0.731
Co	0.0028	0.0024	0.855	0.0022	0.789	0.0025	0.920	0.0027	0.964	0.0027	0.985

	Y-146	TP-KA-A4	cultural/non-cultural	TP-KA-6	cultural/non-cultural	TP-KA-7	cultural/non-cultural	CS-KA-2	cultural/non-cultural	Ex-7	cultural/non-cultural
Ni	0.0089	0.0072	0.809	0.0069	0.774	0.0070	0.788	0.0069	0.779	0.0090	1.010
Ga	0.0021	0.0017	0.790	0.0017	0.790	0.0018	0.841	0.0016	0.748	0.0013	0.626
Cu	0.0080	0.0060	0.756	0.0054	0.670	0.0064	0.806	0.0051	0.643	0.0105	1.314
V	0.0194	0.0119	0.613	0.0122	0.628	0.0121	0.621	0.0119	0.614	0.0111	0.569
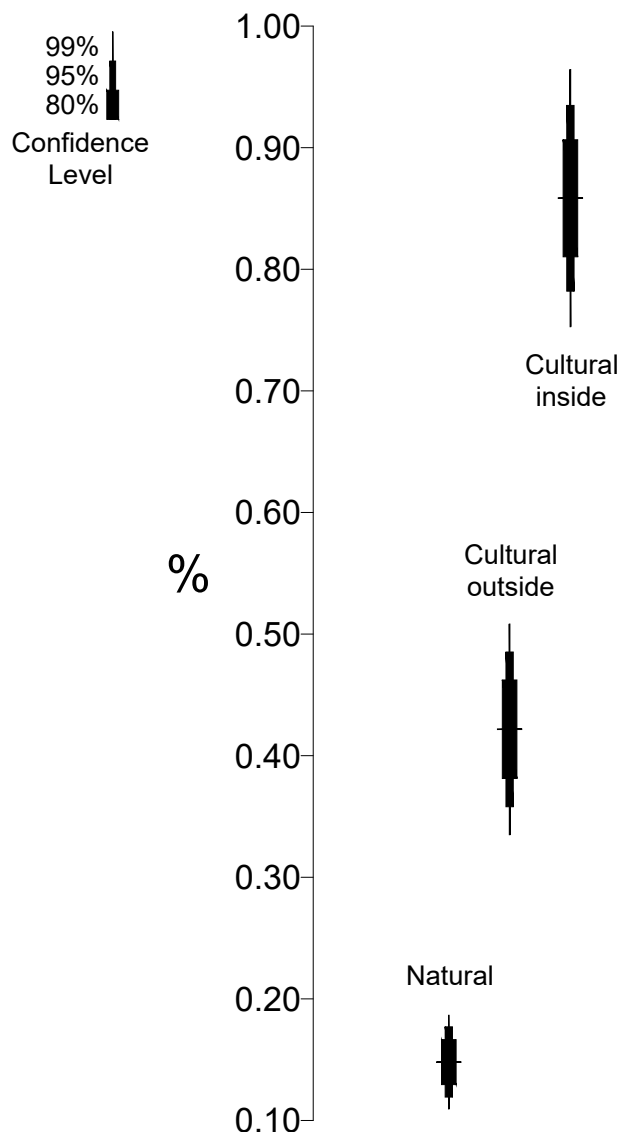
Figure 2.34 Comparison of the mean values of phosphorus in the natural soil deposition, the cultural layers outside the wall and inside the wall

Finally, the differences can be presented graphically as mean values plotted with error ranges attached (80% CL). Before calculation of the error ranges the values were standardized for each element. The mean of all the values, for example, for aluminum in the analysis was subtracted from each individual aluminum value and the result was divided by the standard deviation of all the aluminum measurements. The same was done for each element in turn. The aim was to express the values for all the elements on a comparable scale of how unusually high or low any given measurement was for its particular element.

The plots (Fig. 2.33) support the observation above: the tendencies of element values are mirrored in the cultural layer outside in comparison to the natural deposit. However, soil inside the house demonstrates significantly different composition in contrast to other samples.

The fourth step is a countinuation of the previous step with statistical estimation

of phosphorus content in the cultural layers and natural soil. The mean value of phosphorus in the natural soil as indicated by Test Pit Y-146 is 0.15±0.03% (at 95% CL). The test pits suggest that the cultural layer outside the wall contains 0.42±0.06% (at 95% CL) of phosphorus on average. According to the sample from the Sintashta-Petrovka layer inside, the average level of phosphorus inside the wall is 0.86±0.08% (at 95% CL) (Fig. 2.34).

The fifth step is a delineation of the cultural layer boundaries by exploring the zonal accumulation of phosphorus oxide as the most common trace element of human and animal metabolism. Drennan and Peterson (2006; 2008; Peterson and Drennan 2005) developed the way of representation of correlates of human activities as smoothed topographic surfaces and contour lines interpolated with the method of weighted inverse distances to a power.

The map is based on the sample from the depth of -10/-20 cm from 110 cores, assuming that the deeper horizons are less contaminated with modern phosphorus from grazing. It can be shown as the following: the average value of phosphorus at a depth of 0/-10 cm is 0.29 ± 0.05%, and at a depth of -10/-20 cm is 0.25±0.03%. The mean values differ, and although the difference is not statically significant ($t = 1.468$, $p = 0.144$), there is still an 85.6% chance that the means are different. Also, as it was discussed above, the profile of phosphorus content in Test Pit Y-146 shows its high content precisely in the uppermost horizon (0.34±0.12% at a depth of 0/-10 and 0.26±0.35% at a depth of -10/-20 cm).

The measured values were plotted as circles with a radius of 5 m since the location of sampling in the field was determined by a handheld GPS device with a precision of ±3–5 m and then the smoothed surface was interpolated with inverse distance raised to the power of 0.25 (Fig. 2.35). A contour line representing the phosphorus oxide value of the enriched zone in Test Pit Y-146 (0.26% at a depth of -10/-20 cm) was chosen to delimit the zone of abnormally high phosphorus content.

By this method, the total area of the zone of high phosphorus content outside the Kamennyi Ambar walls is 20,730 m^2 or about 2 ha. It extends approximately 80 m from the wall, which agrees well with the boundary of the cultural layer drawn after the archaeological subsurface testing (47% of the area intersects, r = 0.499, p <0.001) and can be used to refine it (Fig. 2.35 and 2.36).
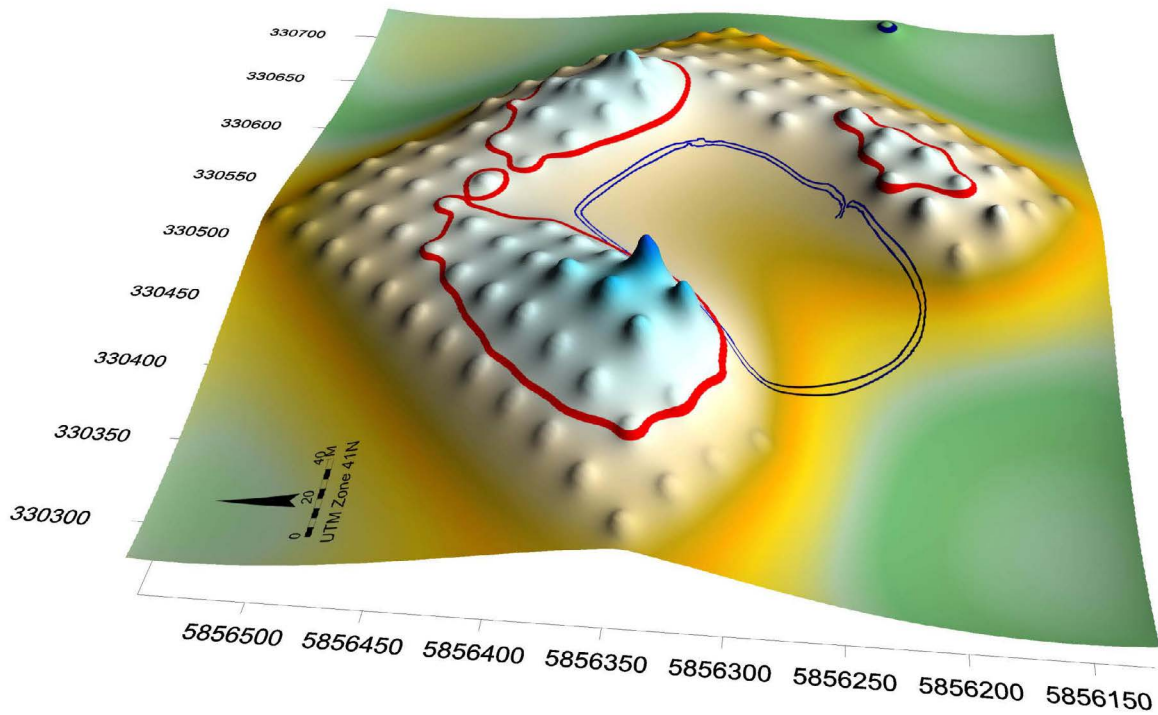
Figure 2.35 Smoothed surface representation of the phosphorus content outside the wall (inverse distance to the power 0.25)
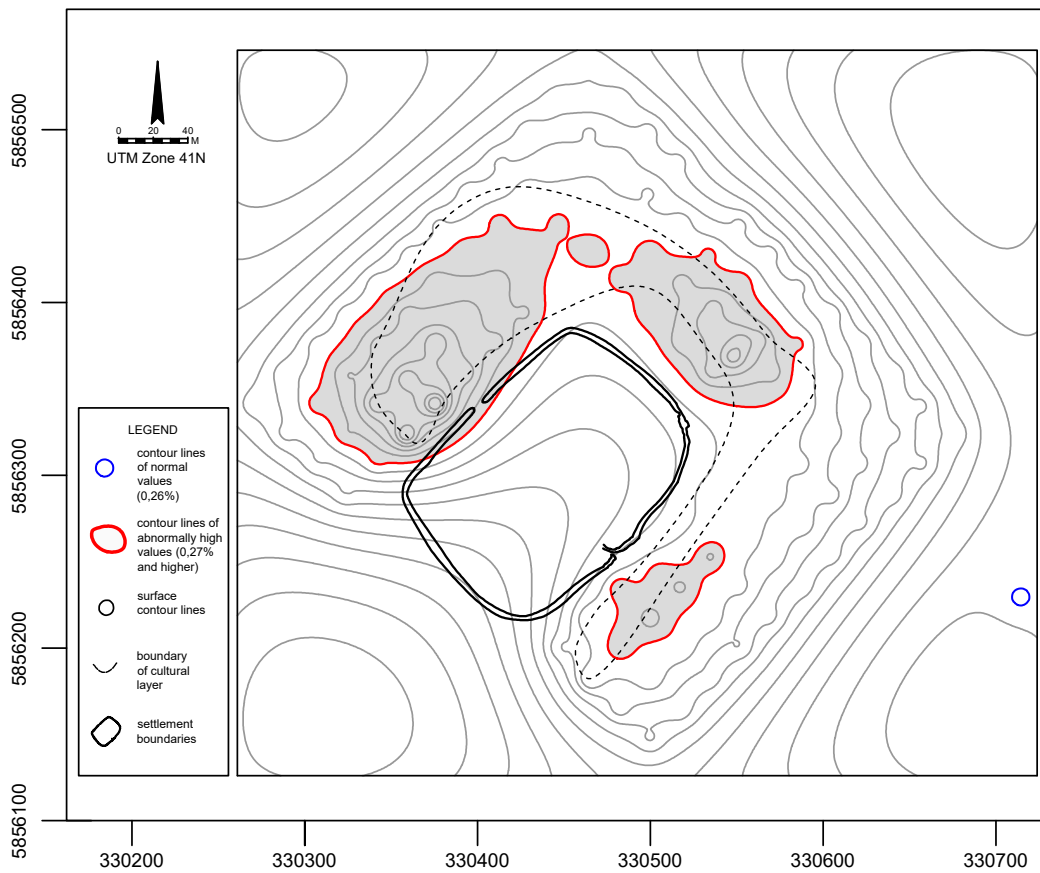
Figure 2.36 The outline of the cultural layer in accordance with the content of phosphorus and as delineated by the subsurface testing

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2.1.7 Analysis of Faunal Remains

The faunal assemblage collected near three Bronze Age settlements was submitted to analysis to Dr. Olga Bachura of the Institute of Ecology of Plants and Animals of the UB RAS, who also partly analyzed osteological collections from other Sintashta-Petrovka settlements (Bachura 2013). At Kamennyi Ambar, the sample consists of the remains of common domestic animals, namely, the subfamilies of bovine, caprine, and equine. The sample includes 108 identified bones of these mammals, which converts to 20/108 butchered individuals (MNI/NISP). Proportionally, the clustered sample yielded 4%±1% of equine bones, 86%±8% of bovine remains and 9%±6% bones of small cattle (at 80% CL).

Though the collection is too small for comparison between sites, it can be concluded that proportions from outside the walls do not deviate from the the observation that the inside assemblage consists of 52% bovine bones, sheep and/or goats represent 42%, and horse bones are only 6% of the total number. The significant differences are (1) that these three taxa represent just a part of the spectrum of domestic and wild animals, found within the walls (which includes pig, dog, beaver, fox, wolf, bear, elk, saiga, and others) and (2) that the overall densities of bone are much lower outside the walls. Thus, the mean density of bones outside the walls is 18±14 specimens per m^2 (at 95% CL), while within the walls the mean number of bones is 117±139 per m² (at 95% CL with a finite population corrector applied). The large standard deviations in both cases stand for considerable variability within each sample, however, the conclusion that within the walls the density is far higher, is inescapable. The density of other cultural materials does not differ nearly so much between inside and outside the walls. It seems plausible that the extremely high densities of bone inside the walls was created in Srubnaya-Alakul' times after the fortified settlement was mostly abandoned, since otherwise the Sintashta-Perovka houses would look extremely littered.

Another important observation is that 18% of the entire osteological collection from the outside the wall is calcined or demonstrates the signs of intense heat (including both identifiable and unidentifiable bones). To explain how the paleo-Eskimo survived in the circumpolar zone in prehistory, Odgaard (2014) has conducted an archaeological and experimental study of hearths and concluded that bones can be used as fuel to maintain fire during the winter months when oth-

er resources are not available. This suggests that burnt bones from the outside collection might be produced by the same practice since the winter in the Urals is long and cold (Levit 2005). Presence of baked clays and the hearth in the TP-KA-12 seem to support this idea.

The counts of faunal remains are in Table 2.3.

Table 2.3 Faunal remains from Kamennyi Ambar

Unit	Equine	Bovinae	Caprinae	Mammal	MNI Equine	MNI Bovinae	MNI Caprinae	Total MNI
KA-CS-2				6				0
KA-CS-8		1	1			1	1	2
KA-CS-9			1				1	1
SC-KA-15	1			1				0
Core-KA-0121		1	2	1		1	1	2
TP-KA-1				12				0
TP-KA-3				1				0
TP-KA-4		1	2	1		1	1	2
TP-KA-5	1	1		6		1	1	2
TP-KA-6		68		7		1		1
TP-KA-7	1	5		22	1	2		3
TP-KA-8				4				0
TP-KA-9		1		1		1		1
TP-KA-13		2						0
TP-KA-A3	1	4	4	1	1	1	1	3
TP-KA-A4	1	9		3	1	2		3
Total	5	93	10	66	3	11	6	20

The season of the year of an individual's death can be estimated based on the seasonal incremental banding of cementum on the roots of animal teeth. The method looks for the formation of basic (winter) line (Krause and Koryakova 2013:285). The age of an animal at death is studied by counting later intermediate lines relative to previous intermediate lines. The results are summarized in Table 2.4.

Table 2.4 Age composition and seasons of slaughtered animals

Site	Subfamily	Teeth	Age	Slaughtering season
TP-KA-A4, -40/-50	Bovinae	p4	5–6	Late fall
TP-KA-A3, -60/-70	Caprinae	m1-2	2–3	–
Core-KA-0121	Caprinae	m3	3–4+	Fall

Although only three instances could be identified in this way, all three animals were adult at the time of death and two of them died in the fall. These facts suggest that animals could have been killed for the subsistence purposes after achieving full body-weight.

In conclusion, the sub-surface study revealed the evidence of animals slaughtered near Kamennyi Ambar. All animals belonged to mobile herds, and no evidence of sedentary animal husbandry was found. This last fact differentiates the outside assemblage from the inside one since the bones of domestic pig were found inside. The density of bones is lower outside, suggesting that the cultural layer outside that yielded the bones does not represent midden deposits of kitchen remains, like those within the enclosed settlement. Instead, these ecofacts where deposited by people who consumed far less meat, or consumed a smaller number of animals at the location near the walled site.

2.1.8 Botanical Remains

Soil samples were collected in units TP-KA-1, 2, 3, 6, A3 and A4 for further analysis of macro-botanical remains. More than one and as many as 11 samples were collected if stratigraphy allowed distinguishing between cultural and natural deposits. A minimum of 8 liters of soil were collected per sample. In total, the eighteen soil samples were submitted to Ng Chuyen Yan of the University of Pittsburgh for the analysis of plant macro-remains. The main questions were whether the remains of domestic plants could be found in the cultural layers and whether the evidence of hay keeping was present outside the walls. The second question is more crucial for the purposes of the present research since it sheds light on the subsistence practices of the Bronze Age herders.

All positive samples were gained from the same locality to the north-east of the settlement (TP-KA6, TP-KA-A3/A4). Unsurprisingly, the samples have not revealed signs of agriculture (Stobbe et al. 2016). However, they are still of considerable interest for the purposes of this research. The summary of the results of paleobotanical study is in Table 2.5 with units yielding no identifiable plant remains omitted.

Table 2.5 Counts of plant macro-remains from the tests pits near Kamennyi Ambar

	Chenopodiaceae	Atriplex	Euphorbia	Stipa	Lamiáceae	Fabaceae	Vicia	Medicago	Unknown
TP-KA-6, stratum 3		1	1	7		2	7	4	
TP-KA-A3/4, stratum 3	3				1	1			2
TP-KA-A3/4, stratum 4	3				1				1

A total of 45 carbonized seeds and fragments of seeds were found in the 180 liters of soil, which corresponds to 0.2±0.1 seed per liter. This value is significantly lower than the six specimens of grassland species per liter, yielded by the domestic contexts inside the enclosure (Rühl et al. 2015, Table 1). Presumably, this relates to the substantial difference in the architectural patterns outside and within the walls, where more durable constructions preserved more light-weight materials, but also might relate to more intensive and persistent use of the area inside the wall. Over 65% of the discovered plant macro-remains are identifiable at least to a family level and belong to wild species, native to the steppes of the southern Urals (Ryabinina 2003; Stobbe et al. 2016). The family of Amaranthaceae (represented in the sample by goosefoot seeds – Chenopodium album/urbicum L., Chenopodium rubrum L., and Atriplex) is a typical ruderal plant that grows on waste ground or among the refuse. On the other hand, test pits placed north of the walled settlement in the steppe sub-zone yielded seeds of members of the meadow community that tends to grow closer to the river in the well-watered zone (the Fabaceae family). Finally, as can be expected, there are typical steppe grasses, feather grass (Stipa) and succulent plants (Euphorbia).

Considering ubiquity that disregards absolute count and takes into account the number of positive samples, reveals other patterns (Table 2.6).

Table 2.6 Ubiquity of plant macro-remains from the tests pits near Kamennyi Ambar

Genus/species	Counts of seeds	Positive samples	Ubiquity/ samples with seed	Ubiquity/all samples	% samples with seeds	% all samples
Vicia cracca L.	1	1	0.13	0.06	13%	6%
Vicia spp.	6	4	0.50	0.22	50%	22%
Medicago spp.	4	2	0.25	0.11	25%	11%
Fabaceae Total	13	7	0.88	0.39	88%	39%
Atriplex patula L.	1	1	0.13	0.06	13%	6%
Chenpodium album/ urbicum L.	2	1	0.13	0.06	13%	6%
Chenopodium rubrum L.	4	2	0.25	0.11	25%	11%
Stipa spp.	8	3	0.38	0.17	38%	17%
Euphoria sp.	1	1	0.13	0.06	13%	6%
Lamiceae	2	2	0.25	0.11	25%	11%
Unknown	3	2	0.25	0.11	25%	11%

Surprisingly, the Fabaceae family demonstrates a relatively high rate (39% of all samples). The typical species for the locality are Stipa and Lamiceae, but together they represent only 28% of the whole sample. One possible explanation is that remains of intentionally brought grasses

have been preserved in the cultural layers, or that seeds came into the locality with dung. However, their abundance in the sample from the unit TP-KA-6, together with the fact that humus is less depleted, suggest that grasses could be stored as a stack of hay. Today, the haymaking season starts in the Karagayli-Ayat valley in mid-June or early July, while grasses are fresh and can be dried out before it starts raining in September. Modern machinery allows a nuclear family to collect hay for 5–10 cows in a matter of two-three weeks (Proskuryakov, personal communication, 2016). Consequently, haymaking and collecting of other types of winter provisions would be one of the most essential practices of the sedentary inhabitants of the enclosed settlement during the summertime.

2.2 INTERPRETATION OF THE CULTURAL LAYER NEAR KAMENNYI AMBAR

As demonstrated above, there are no traces of architectural features recorded outside the walls that are comparable to the structures that constituted the inner space of the walled settlement, like post-holes, linear boundaries of subterranean structures or wells. This observation points out the very different nature of the ancient activities that took place outside the walls. The only evidence for reconstructing these activities are the ways in which they affected the soils and the anthropogenic materials.

The convincing signs of cultural deposits are revealed by all sixteen opened units, including 1) artifacts and ecofacts, such as ceramic sherds, metallurgical slag, lithics and stone tools, animal bones; 2) depleted humus with pieces of baked clay and charcoal. Significant differences in the densities of artefactual materials that range from 1.5 to 42 artifacts per square meter, require attention and explanation. The overall weights vary from 1.5 g to 259 g per unit. The densities by count strongly positively correlate to the weights of the artifacts per m² ($r = 0.84$, $p < 0.01$, $r^2 = 0.71$), so the sample is not badly biased by different rates of artifact breakage.

The consideration of the artifact densities provides insights into variable depositional and taphonomic processes, responsible for creating the present-day archaeological situation at the site. For further analysis, densities are calculated as quantity of artifacts per m², irrespective of the volume of the excavated unit, which makes possible the comparison of zones with variable

thicknesses of cultural layers and surface collection. Actual counts of objects and overall densities are presented in Table 2.7 below.

Table 2.7 Counts and densities of artifacts yielded by the stratigraphic tests near Kamennyi Ambar

Test pit	Area (m²)	Ceramics	Slag	Lithic/ stone	Total	Total weight (g)	Density per m²	Cultural layer thickness (cm)
TP-KA-1	4	26	5	3	34	98.0 (+331.1 g of a stone tool)	8.5	5
TP-KA-2	4	23	3	1	27	79.3	6.7	10
TP-KA-3	2	13	2	3	18	46.0	9.0	5
TP-KA-4	2	1	2	0	3	13.0	1.5	0
TP-KA-5	2	28	3	1	32	259.0	16.0	10
TP-KA-6	2	22	6	1	29	175.5	14.5	20
TP-KA-7	2	53	1	1	55	156	27.0	20
TP-KA-8	1	26	5	0	31	73.5	31.0	5
TP-KA-9	1	2	0	1	3	1.5	3.0	0
TP-KA-10	1	5	0	0	5	10.5	5.0	10
TP-KA-11	1	2	0	0	3	9.0	3.0	5
TP-KA-12	1	35	6	1	42	155	42.0	20
TP-KA-13	2	19	2	0	21	111	10.5	15
TP-KA-14	1	7	0	0	7	23	7.0	5
TP-KA-A3	4	52	5	0	57	195.0	14.2	33
TP-KA-A4	4	52	3	2	57	216.5	14.2	33

As evident from the table, the artifact densities vary considerably throughout the studied area. The units with the low densities (less than 10 specimens per m²) are TP-KA-1, 2, 3, 4, 9, 10, 11 and 14, while the densest accumulations can be found in pits TP-KA-7, 8 and 12 (more than 20 per m²). The intermediate densities are in the test pits TP-KA-5, 6, 13 and TP-KA-A3/A4. Moreover, the artifact densities tend to positively correlate with the thickness of the cultural layer, though the correlation is of only moderate strength and significance ($r = 0.39$, $p = 0.13$). The appearance of the buried cultural layers and the low surface density (0.003 specimen per m²) shows the uneven and patchy nature of the cultural deposits, but does not explain it.

To further comprehend the nature of the cultural layer, the vertical distributions of artifacts can be examined (Table 2.8). A quick look at Table 2.8 highlights differences in the formation histories of the discovered cultural deposit. As evident from the table, the test pits TP-KA-5, 6, 7, 12, 13 and A3/A4 are clearly different from the TP-KA-1, 2, 3, 4, 8, 9, 10, 11 and 14. This also recalls

the test pits grouping by the impacted soils, even though, the group 2 without clear feature of depleted humus consists only two cases (4 and 9).

Table 2.8 Densities per m² of artifacts per arbitrary level in the stratigraphic tests near Kamennyi Ambar

Level (cm)	TP-KA-1	TP-KA-2	TP-KA-3	TP-KA-4	TP-KA-5	TP-KA-6	TP-KA-7	TP-KA-8	TP-KA-9	TP-KA-10	TP-KA-11	TP-KA-12	TP-KA-13	TP-KA-14	TP-KA-A3	TP-KA-A4
0/10	7.5	6.25	6.5	1	12.5	1.5	2.5	30	2	4	1	32	0.5	0	1.5	1.5
10/20	0	1	2.5	0	1	1.5	2	0	0	1	1	10	0	7	1.75	2.25
20/30	0	0	0	0.5	2.5	5.5	17.5	0	1	0	0	0	5	0	0.25	1.75
30/40	0	0	0	0	0	6	5.5	0	0	0	0	0	1.5	0	2.5	0.75
40/50	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	4	6.5
50/60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.25	1
60/70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
70/80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.25
80/90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90/100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
Total average	7.5	7.2	9	1.5	16	14.5	27.5	30	3	5	2	42	10.5	7	14.7	14.2

Thus, the artifact distributions along the profiles do differ from locus to locus. The excavation units TP-KA-1, 2, 3, 4, 8, 9, 10, 11 and 14 revealed artifact accumulations, but no other significant attributes of human activities. Presumably, the artifacts concentrated near the surface (0–10 cm) mirror the processes of discarding of the materials upon the ancient surface and the scattering of remains on the ancient surface after deposition. On the other hand, the excavation units TP-KA-5, 6, 7, 12, 13 and A3/A4 revealed high artifact densities and thick deposits of cultural materials and such important attributes of anthropogenic impact as depleted humus, baked clay and charcoal. Presumably, the resulting cultural layer is due to processes other than dumping of garbage upon the surface and represents intensive use of the area for varied human activities. The comparison highlights similarities of the exposed cultural layers with the areas inside the walls. Specifically, very similar accumulations can be found in the spaces between houses within the walls, which were impacted by intensive walking on the ancient undisturbed surface. Thus, the soil profile in the units P6/H6 of the Excavation Area 2-3 (the "street" between two rows of houses in the northeast part of the walled area) demonstrates a 40-50 cm thick accumulation of depleted humus with inclusions of baked clay, almost identical to the cultural layer exposed by
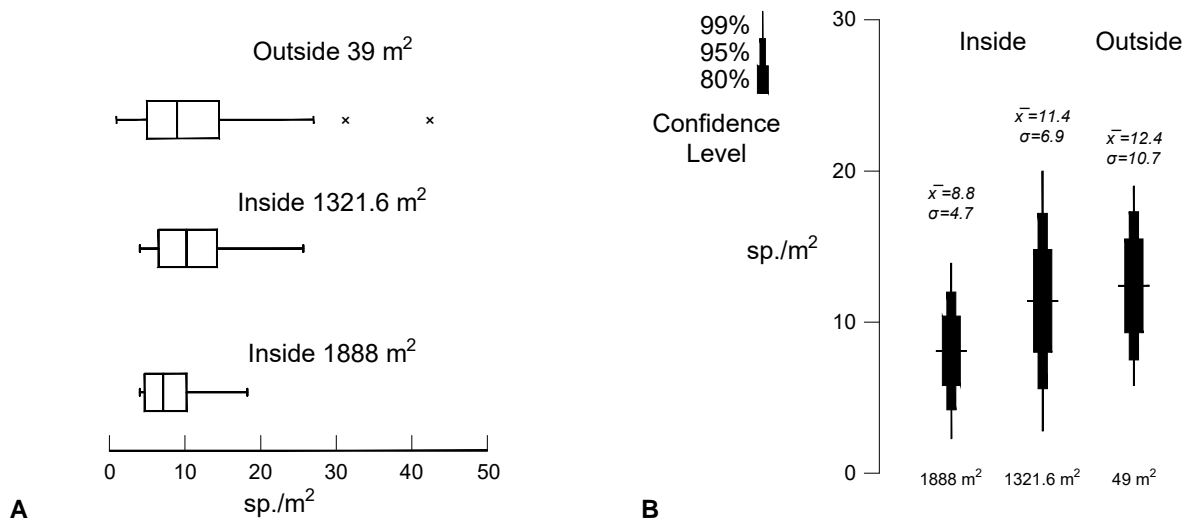
Figure 2.37 Comparison of artifact densities
A – Box plot of densities from inside and outside the walls;
B – Estimated mean densities of artifacts from inside and outside the walls

units TP-KA-A3/A4 outside the walls. The significant difference is that densities of artifact materials in such areas inside the walls is lower than outside. Thus, the adjusted to the aforementioned profile units P6/7-П6/7 and O6/7-H6/7 yielded 6.2 ceramic sherds per m[2], which is similar to those areas outside interpreted as artifact scatters on the surface. However, another type of dwelling and/or productive activities might be mirrored in a relatively similar artifact density, the presence of kitchen remains and bonfires.

To explore these two possibilities, comparison of artifact densities between inside and outside loci can be made. The two cluster samples of the 23 units of variable size from the inside and eight excavation units of variable size from the outside are used for the comparison (1888 m[2]) (Berseneva 2013; Epimakhov 2007, 2010, 2011; Koryakova 2007; 2012; Sharapova 2006). As is evident from the box plot (Fig. 2.37A), the overall density of artefactual materials yielded by sixteen test pits excavated for purposes of this research in 2015–2017 and seven excavated in 2004 is highly variable ($\sigma = 10.7$ artefacts per m[2]), which makes perfect sense if one recalls the patchy nature of the spatial distribution, although the inter-quartile ranges of the outside and inside samples are not dramatically different and their median values are comparable. Further, roughly 30% of the excavated inside area is under fortifications so the actual domestic and economic context can be reduced by this proportion. Thus, the median value of the whole inside sample is 7.15

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specimens per m² (IQR = 5.35), the value of the sample with the reduced denominator is 10.2 specimens/m² (IQR = 7.8), while the outside sample has the median of 9 specimens per m² (IQR = 10.38).

In terms of the mean density values (Fig. 2.37B), the overall measure of the cluster sample of objects recovered from excavation within the walls is 8.8±3.9 specimens per m² (95% CL; n = 8; σ = 4.7), the overall density of the sample from the domestic contexts ends up with 11.4±5.8 specimens per m² (95% CL; n = 8; σ = 6.9). At the same time, the mean density of all 23 test pits is 12.4±4.9 specimens per m² (95% CL; n = 23; σ = 10.7). The comparison demonstrates that standard deviations in both samples are large which leads to the large estimation errors. This can be explained by the uneven distribution of artifacts across the sampled areas, suggesting different patterns of their accumulation. However, the sample from the outside area demonstrates both slightly larger mean and standard deviation, which reflects different patterns of garbage accumulation.

The residential areas inside the enclosure show a density of sherds and other artifacts similar to that encountered outside the walls, suggesting that a significant part of the garbage produced by inhabitants of the enclosure was disposed of within the housing core. The highest densities are recorded within House 1, as in an excavation unit K9 that had over 45 identifiable (and many more of unidentifiable) ceramic sherds per square meter (Epimakhov 2007b:75 and fig. 112). The highest densities outside are comparable: 31 and 42 specimens per square meter. In other words, there is no outside area with sharply higher density, which would represent a garbage dump. This conclusion can also be supported by the fact, that an ash-dump was found inside the walls (Krause and Koryakova 2013:113), but neither core-drilling nor test-pitting revealed traces of a possible midden in the form of an ash-dump.

Another way to test the hypothesis that the outside deposits did not originate from garbage dumped from the inside is a comparison between the mean number and average weights of ceramic sherds from both areas. As in the case with the overall artifact densities, the sherd density inside the walls 7.8±3.8 per m² (or 11±5.7 for the 30% reduced area at 95% CL), while outside the walls it ends up with 10.9±4.3 sherds per m². Surprisingly, the mean densities are identical, and the two-sample t-test fails to support difference (t = 0.01, p = 0.99). As for the average sherd weights, the sample from the unfortified part has a 10% trimmed mean of 2.6±0.3 g

(at 95% CL; $n = 603$). Meanwhile, a random sample of 50 sherds from inside the walls, weighed for the purpose of this comparison, demonstrates a 10% trimmed mean of 25.1±7.5 g (at 95% CL). Even though the inside sample is biased by excavators, who did not collect sherds smaller than 2 cm by 2 cm, the observed difference is substantial and highly significant ($t = 5.97$, $p < 0.005$). If the outside sample is biased in the same way way by eliminating all sherds smaller than 2 cm by 2 cm ($n = 294$), the 10% trimmed mean is 5.4±0.5 g, which is still significantly lower than the average weight of the sherds from the inside. Finally, multiplication of the mean sherd density by the mean sherd weight allows comparison of two areas regarding average weight of sherds per m². Thus, in the inside the average weight is 195.7±28.5 g/m² (or 276.5±42.7 g/m² for the 30% reduced area), and on the outside of the enclosure the average weight of the intentionally biased sample is 58.8±2.2 g/m² (sherds smaller 2 cm by 2 cm eliminated from the calculation).

The observed values highlight substantial differences between the two compared samples. Basically, the lower mean weight stands for the smaller number of ceramic materials embedded in the cultural layer outside the walls – initial materials became the comparable number of sherds per m², but their overall mass was lower. Again, this leads to the conclusion of the independent nature of the outside cultural layer, that cannot be explained by dumping from the inside. The behavior of intentional dumping of broken vessels by the several generations of the inside inhabitants would produce a sample of sherds with a significantly higher mean density and overall weight per m².

The cross-cultural comparison of human behavior supports the conclusion of the independent nature of the deposits outside. The ethnographic example from Mesoamerica, which is reasonable to bring due to the similar sedentary ways of life, suggests that house debris tends to be arranged in concentric rings extending outwards from the residence. It is expected that a residential lot is the cleanest area, and house refuse is dumped at its periphery, but with minimum possible effort and time (Hayden and Cannon 1983; Killion 1992). If the sample from the outside represents the behavior of regular garbage dumping from the residential area inside, cluster sampling of the patchy deposit would have demonstrated a far higher mean number of artifacts and animal bones resulting from the depositing of waste by many households over the course of about 100 years. Since we do not see such a pattern,

the plausible explanations are either that only a small part of the inside garbage went outside, or that the garbage was produced outside independently. At the same time, if inhabitants from inside had dumped their garbage in specific places only, the sample would have a far bigger standard deviation. Post-depositional decay of artifacts, which could be responsible for smaller sherd sizes and lower densities, would have created a similar pattern inside the walls. However, the inside ceramic materials are larger in size, suggesting that similar post-depositional processes (soil accumulation, moving things, animals and humans smashing things while walking, seasonal water and rainfall eroding things out, freeze cracking things, etc.) did not create similar patterns inside and outside. Taken together, these observations suggest that it is unlikely that the outside cultural layers and materials resulted from the practice of dumping garbage from inside.

Thus, another type of habitation or/and different activities remain only possible explanations of the explored cultural layers. If so, the artifact assemblage from the outside is expected to differ from the inside one not only in regard to densities but also in composition (Smith 1987; Costin 1991). Productive and life-style differentiation can be explored further by comparison of the diversity of two samples with the Simpson's L index (Seaby and Henderson 2007). The calculated index L (here, 1-L) takes a value from 0 to 1, where 0 is the value representing the least diverse assemblage and 1 is a value that stays for the most diverse assemblage. In other words, it is anticipated that if assemblages do differ from each other regarding diversity, then the different productive activities responsible for their creation.

There are 25 categories of objects distinguished by this analysis, following the list of artifacts found in the enclosed settlement (Krause and Koryakova 2013:147–168, Tables 7.1–7.4) Ceramic sherds have been excluded from the datasets, since pottery is the most common category in both samples anyway. Finally, some similar artifacts were combined into single categories (Table 2.9).

Table 2.9 Counts and proportions of artifact categories from the inside and outside

Category	Inside counts	Inside %	Outside counts	Outside %
Flakes, lithics	190	24.9	13	12.4
Slag	107	14.0	63	60.0
Talc objects	85	11.1	10	9.5
Metallurgy waste	62	8.1	0	0.0

Category	Inside counts	Inside %	Outside counts	Outside %
Household objects	53	6.9	0	0.0
Stone discs	43	5.6	0	0.0
Ore	42	5.5	0	0.0
Spindle whorls	30	3.9	0	0.0
Abrasives, grindstones	29	3.8	3	2.9
Metal and bone leather-work tools	27	3.5	0	0.0
Crystals of quartz	23	3.0	8	7.6
Grounding stones, pestles, plates, anvils	20	2.6	3	2.9
Arrowheads	15	2.0	0	0.0
Ornaments	8	1.0	0	0.0
Bronze clamps	5	0.7	0	0.0
Moulds	5	0.7	0	0.0
Bronze knifes	4	0.5	0	0.0
Polishers	4	0.5	0	0.0
Wooden objects	4	0.5	0	0.0
Hammers	3	0.4	1	1.0
Bronze Ingots	2	0.3	0	0.0
Cheekpieces	2	0.3	0	0.0
Pottery with slag remains	1	0.1	2	1.9
Stone axes	1	0.1	0	0.0
Ochre and hematite	0	0.0	2	1.9

The value of Simpson's *L* diversity index (1-*L*) for the inside sample is 0.88 (0.87–0.89 at 95% CL), standing for a very diverse assemblage, while the composition of the outside collection is less diverse with an index of 0.61 (0.51–0.7 at 95% CL). The difference is both substantial (the mean difference is 0.27, and the bootstrapped error ranges do not intersect) and highly significant ($p < 0.01$). The outside assemblage is also less rich, with only nine categories represented, compared to all 25 in the inside assemblage.

This observation leads to two important conclusions. First, as has been said above, the composition of the assemblage from the outside does not adequately represent a mixture of many households' activities within the walls with the waste deposited outside, since in this case the sample outside is expected to be more diverse. Combined with the lower artifact densities and the lower density of kitchen waste (faunal remains), these observations indicate that the excavated materials were not garbage from the inside dumped outside the walls. Their explanation as evidence of human activities, like production or habitation, is inescapable. Second, whatever activities took place in the areas outside the walls, they are a more restricted range of activities

than took place inside, since the sample is less diverse and less rich. One possible explanation is that outside the walls, people used less durable organic materials that were not as well preserved.

Diversity analysis wraps together many categories, but productive differentiation can further be studied by looking at the actual proportion that each category that contributes into the assemblage. The most abundant category in the outside sample is metallurgical slag with a total weight of 406 g and a count of 63, which corresponds to 60%. At the same time, the total number of slag pieces from within the walls is 107, which constitutes only 14% of the assemblage. Importantly, the overall slag density is also far higher outside the walls (2.2 per m² outside versus 0.1 per m² inside).

The second most abundant category in the outside sample is lithic artifacts (13 specimens, or 12.4%), including flakes, micro-liths, blades, and scrapers, that in some cases were associated with the Bronze Age cultural layer (TP-KA-12). The importance of lithic technology in the Bronze Age is undoubted since things like flint projectile points are well represented in the burial and habitation contexts everywhere. This category is also abundant in the households within the walls with a proportion of 24.9%. Stone tools of three distinct types (hammers, grinding stones and abrasives) together stand for 6.7% of the complex, which is not different from the cumulative 6.8% in the inside assemblage. The unit TP-KA-A3 yielded finds of ochre and hematite (2.9%) that have no recorded analogs within the enclosure. At the same time, 16 of 25 categories, including metal artifacts, are not represented in the outside sample at all, which contributes to the lower value of Simpson's *L* diversity index.

Thus, the studied samples do differ from each other regarding diversity and composition. In general, the artefact assemblages demonstrates that a variety of daily activities (using knives, abrasives, and grinding stones) and craft activities (ceramic and textile production, carpetentry, leatherwork, metalwork) were carried out by the households inside the walls. Due to their technological complexity, some of these crafts require at least some degree of sedentism. For example, manufacturing of textiles consists of yarn spinning and weaving on a loom, which both consume more time and labor than everyday cooking. Presumably, the inhabitants of at least some houses could focus on craft production for exchange with other households. Finally, such objects as the stone axe and cheekpieces, found in House 5, are the direct evidence for military leadership roles of those who lived in this household.

The sample from the outside is less diverse, showing a focus on cheap tools for daily use (lithic blades, scrapers, abrasives, and grinding stones) and production of ceramics (talc pieces). No evidence for carpentry, leatherwork or textile production was recorded outside, suggesting that all of these activities were concentrated within the walled settlement.

Metallurgical slag is the most abundant category in the outside sample. This fact suggests the possibility that special metallurgical occasions could take place outside the walls of Kamennyi Ambar, as was hypothesized by the investigators of the nucleated core (Krause and Koryakova 2013:222). Possibly, the settlement inhabitants used the open space for smelting ores, which would a reasonable thing to do, given the fact that their houses were built of wood. The magnetic maps did not reveal anomalies that can be directly interpreted as furnaces. However, their presence within the walls is visible only due to their connection to the regularly distributed wells.

On the other hand, the attributes of the outside cultural layers (such as ceramic sherds, faunal and botanical remains, as well as soil depleted in humus and high levels of phosphorus and molybdenum) cannot be explained exclusively by rare and occasional ore smelting events. The comparison with other areas of the Eurasian Steppes, like the Volga Region in Russia, suggests that such areas might be herders' seasonal camps. For example, evidence for a seasonal camp in the form of a scatter sherds was found found 15 km from the Final Bronze Age settlement of Kent in northern Kazakhastan (Evdokimov and Varfolomeev 2002:62). In another instance a Srubnaya culture permanent settlement and five seasonal camps were encountered by the Samara River Project (Anthony et al. 2005; Anthony et al. 2016). The radiocarbon dates place them between 1800 BC and 1700 BC. The permanent settlement of Krasnosamarskoye 1 was located on the river's fluvial terrace and surrounded by a shallow trench. The subterranean rectangular house, excavated in the course of the project, had an area of 110 m² and an inside well – the typical characteristics of the Sintashta-Petrovka year-round dwellings. Five other Srubnaya culture sites were discovered approximately 25 km away from Krasnosamarskoye I, on the banks of the small tributary Peschanyi Dol. The sites did not have any buildings, but only scatters of sherds, completely covered by later sediments and found during a subsurface shovel-test survey. The principal investigator has interpreted these sites as seasonal herding camps since two of them had a high percentage of lithics and a relatively low percentage of animal bone; while the permanent settlement had more animal bone than ceramic sherds, and a low proportion of lithics. Regarding

weight, two camps yielded 78 g/m³ and 37 g/m³ of sherds and lithics (Anthony et al. 2005:410). The mean density of materials exposed by test-pitting near the walls of Kamennyi Ambar is 80±48 g/m³, or only slightly higher than at the herder camps in the Samara Valley.

This comparison strongly suggests that the outside area of Kamennyi Ambar could be occupied by a semi-mobile group of people who lived there only part-time, presumably, during the winters. People lived in movable tents that cannot be easily found archaeologically but probably seen on the magnetic maps as circular anomalies. These possible outsiders used significantly less durable materials that could not be preserved but also relied on stone and lithic tools (lithics are relatively more common in the outside sample, than in the inside sample). Pieces of backed clay found everywhere outside the walls (the overall density of fragments larger than 2 cm by 2 cm is 8.4±3.6 g per m² at 95% CL) are remains of their fireplaces, and one of them together with the Sintashta ceramics and a lithic artifact have been partly exposed in the TP-KA-12. Faunal remains again can be used to support this reconstruction. First, the animals were primarily slaughtered in the late fall and early winter, when herders returned to the central place with the herds (Bachura et al. 2011). About 18% of identifiable bones from the test pits are calcined, which suggests that they were used as fuel to maintain a fire. The rest of the livestock was kept inside the walled settlement, to protect the animals from extremely low winter temperatures, wind, and hungry carnivores, supported by possible evidence of hay storage outside the walls.

During the spring, when the time came to send the livestock to the summer pastures, herders left the center of sedentary life. Though this work has not been not done yet in the Karagayli-Ayat River valley, possible summer occupations of the Sintashta-Petrovka period wwere attributed to summer camps of mobile herders in the Zingeyka River valley, about 100 km west (Sharapov 2017:112–113). Precisely the same pattern is followed by the modern inhabitants of Varshavka village located 10 km west of Kamennyi Ambar. They move their livestock on a seasonal basis to graze on scattered pastures and prevent over-grazing near the village (Stobbe 2016; Grebenshikova, personal communication, 2016).

Summarizing, the artifact assemblage from outside the walls at Kamennyi Ambar might represent two kinds of seasonal events: winter habitation of pastoral families and summertime ore smelting carried out by more sedentary craft specialists. If this is true, then two segments of

scociety that carried out these activities can be distinguished based on the recovered sample: the pastoral herders and the craft specialists.

2.3 CULTURAL LAYERS NEAR KONOPLYANKA AND ZHURUMBAY

The final stage of the field research extended beyond Kamennyi Ambar to Konoplyanka and Zhurumbay. This stage did not aim to document structures and features but only to recover a sample of artifacts and ecofacts from the areas outside the walls of the other two walled sites for comparison to those recovered from Kamennyi Ambar. Since the aim of work at these locations was the recovery of a sample of artifacts and ecofacts, stratigraphic tests were 1 m by 1 m, the minimum size for stratigraphic excavations permitted by Russian National Regulations. This makes it possible to distribute more tests more broadly across the area to be sampled and result in a sample more accurately representing each site than a smaller number of 1 m by 2 m tests. Ten 1 m by 1 m test pits were excavated at locations where some artifacts or ecofacts were spotted on the surface of the areas outside the Konoplyanka and Zhurumbay walls, following the same excavation methodology described above for Kamennyi Ambar.

The fortified settlement of Konoplyanka is located on an oxbow island next to a bayou and a floodplain. Zdanovich and Batanina's map of Konoplyanka outlines an area of 1.1 ha and about 21 houses within the walls, which was confirmed by magnetometry. However, following satellite [?] imagery analysis, the authors insisted that the settlement was a heavily fortified stronghold and its construction required a significant amount of labor (Zdanovich and Batanina 2007:118). Neither geophysics (Fig. 2.38) nor the instrumental topographic plan of the surface conducted for the current research (Fig. 2.39) revealed the existence of developed fortifications much different from any other Sintashta settlement. On the magnetic plan, the 3-meters-wide ditch that surrounds a fairly normal Sintashta wall is evident, and no additional fortifications (like a wall in-between two rows of houses) can be found (Berseneva 2011; Krause and Koryakova 2013:62–63). The interpretation of aerial imagery is only preliminary, and should not be taken as a precise description of cultural remains, including houses and the scale of fortification without further on the ground study.

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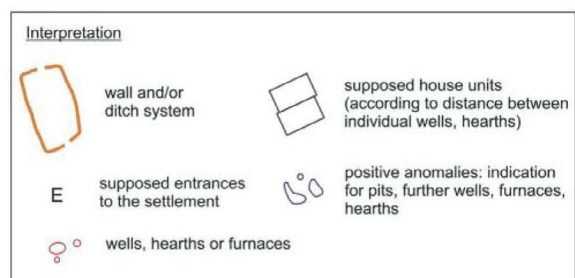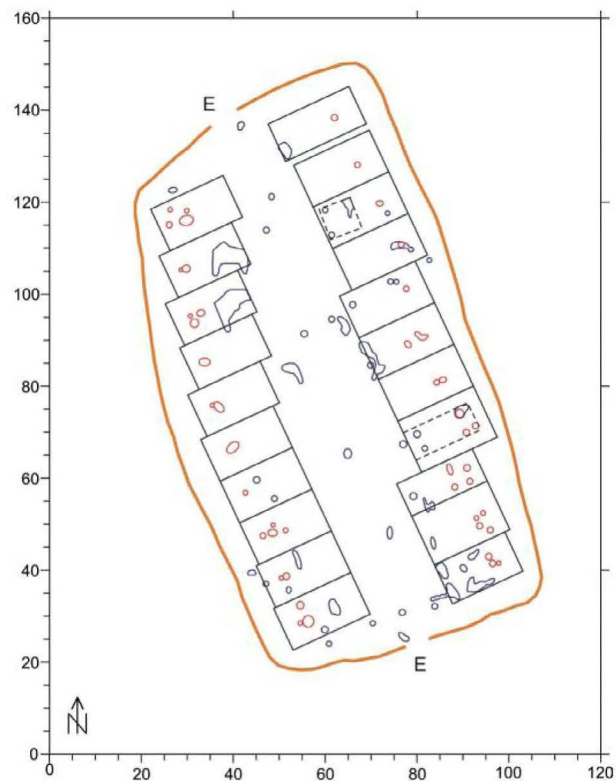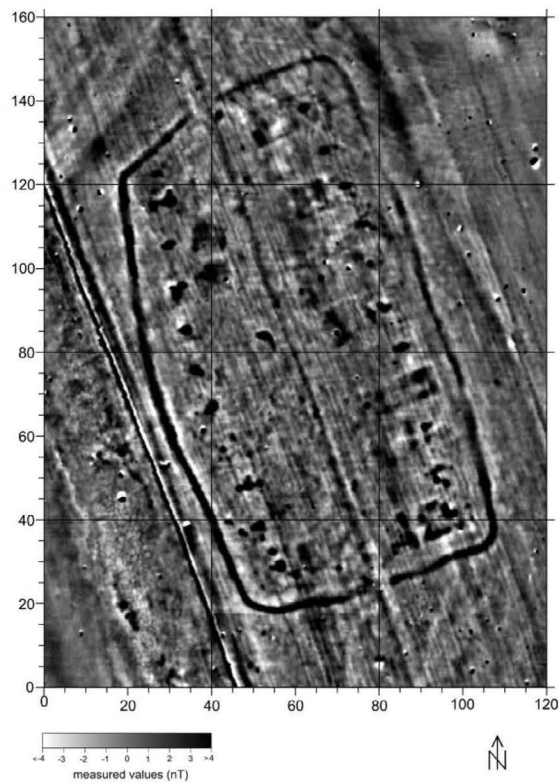
**Figure 2.38 The map of magnetic anomalies at Konoplyanka and their interpretation
(modifed after Krause and Koryakova 2013:63–64)**

The prior micro-topographic mapping supported that the walled area of Konoplyanka is 1.1 ha. Since the dry river bed surrounds it, the area explored with the soil auger was 5.3 ha, so 86 cores were drilled, in total (Fig. 2.40). The soil situation near this site is influenced by migration of the river's bed and by recent plowing. The degraded "O" horizon is thin and does not exceed 2–4 cm. The "A" horizon is gray sandy humus with some differentiation in color or texture allowing distinguishing a plowing horizon from natural deposits. The depth of this horizon varies from 20 to 70 cm. The "B" horizon is either alluvial sand or clay, clearly distinguishable from the "A" horizon.
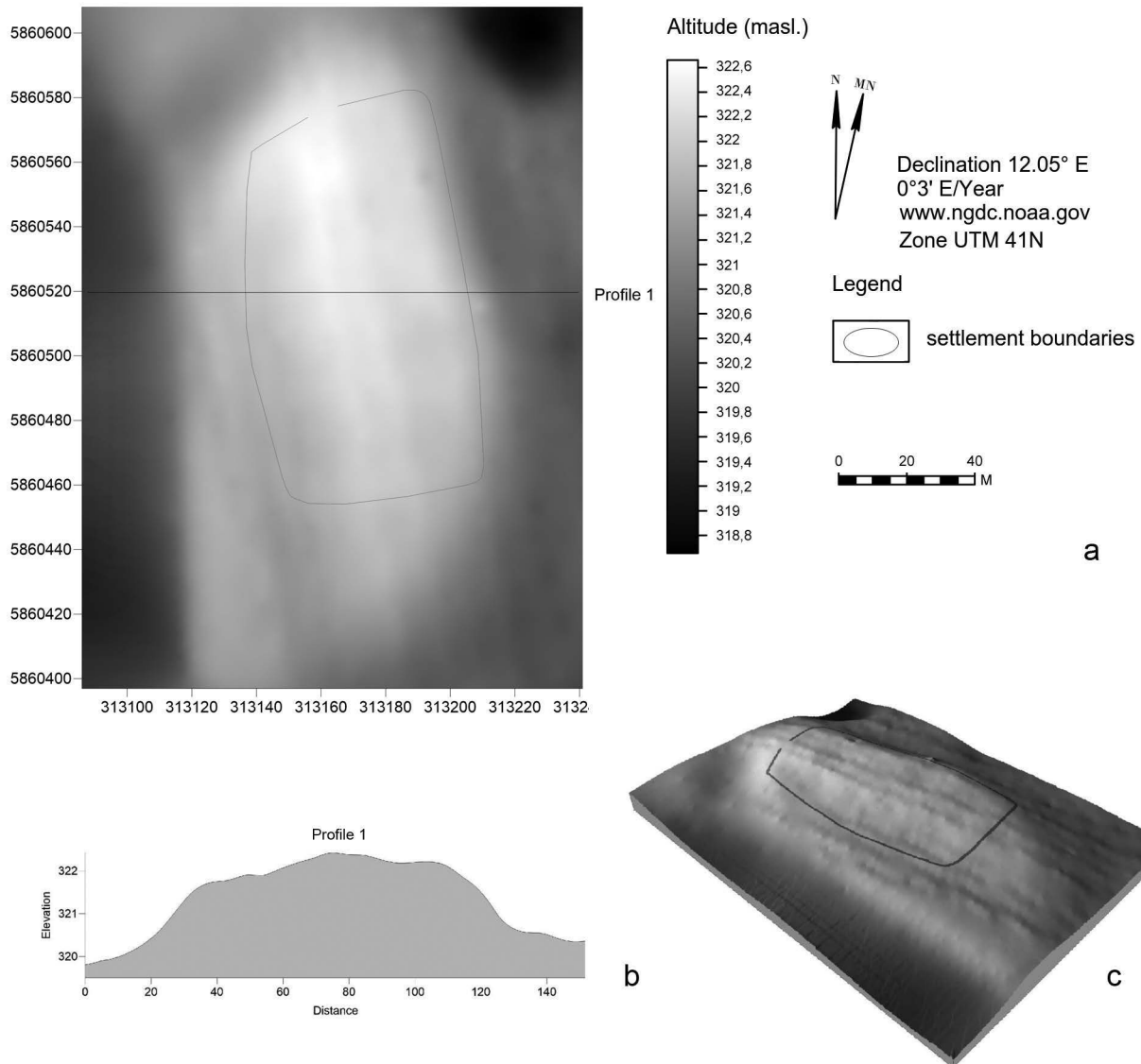
Figure 2.39 The micro-topography of Konoplyanka
a – the topographic map of the site
b – the profile 1 across the center of the settlement
c – the 3-dimensional representation of the model

The surface collection was done near each drilled core within a radius of 3 m from the core. In total, 27 ceramic sherds, 1 lithic artifact and 5 fragments of animal bones were collected. Nineteen objects were found to the south and two to the north of the walls. None of the sherds can be identified to a specific culture, but two are attributed to the Sintashta-Petrovka period. One of these was found within the walls, and another one 35 m away to the south. In other words, there are cul-
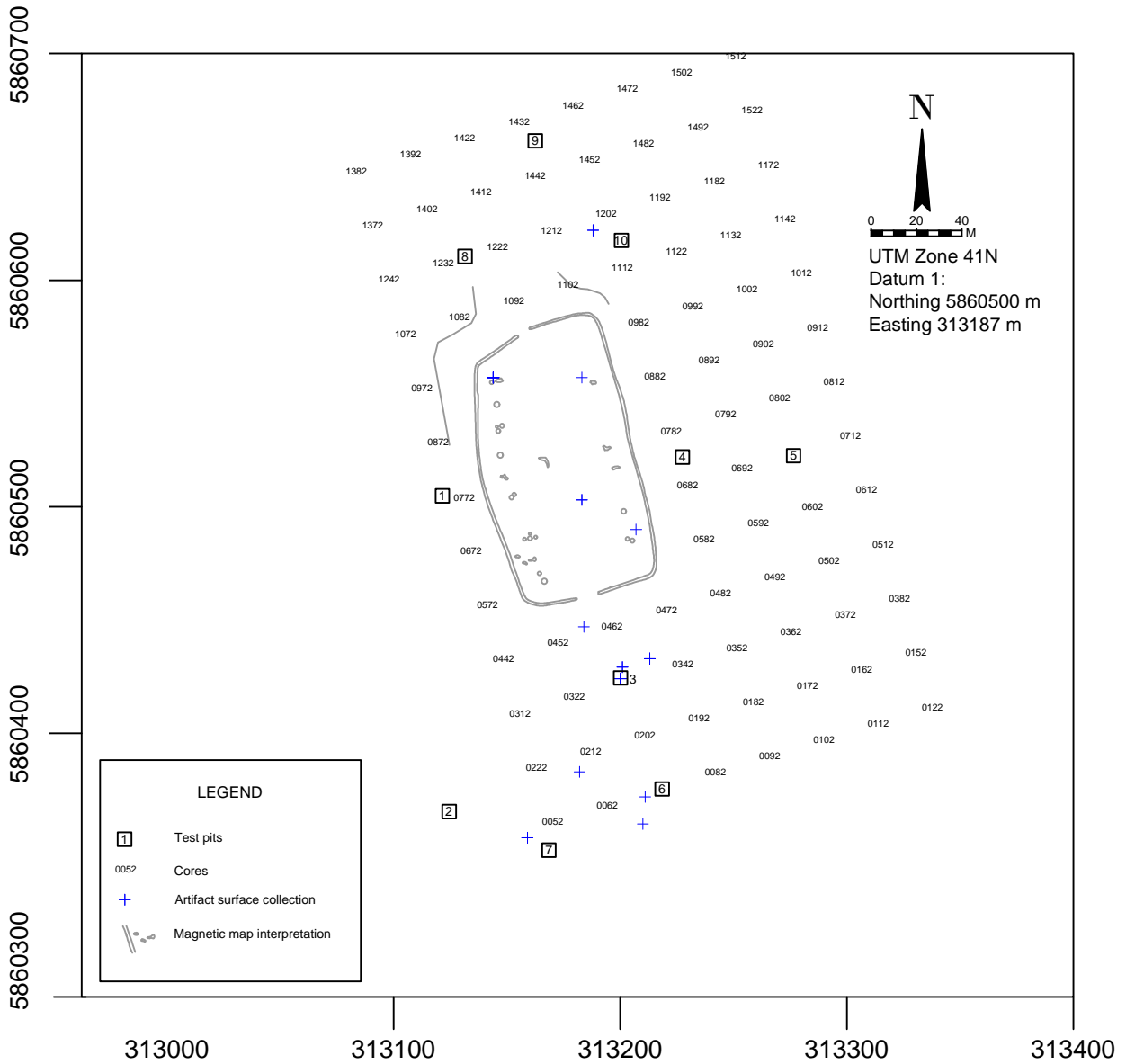
Figure 2.40 Distribution of the cores, test pits and surface findings near Konoplyanka

tural materials on the surface around Konoplyanka (Fig. 2.44), although core-drilling did not reveal evidence for cultural layers, likely due to the intense post-depositional plowing of the area.

The settlement of Zhurumbay is located on the fluvial terrace of the right bank of the river, approximately 120 meters from the modern stream. According to Batanina's analysis, the area of Zhurumbay is 1.4 ha, and its enclosure measured as a ditch 3–8 meters wide and a wall 5–15 meters wide. Moreover, there is a total of 30 houses counted for the settlement, all of them in-
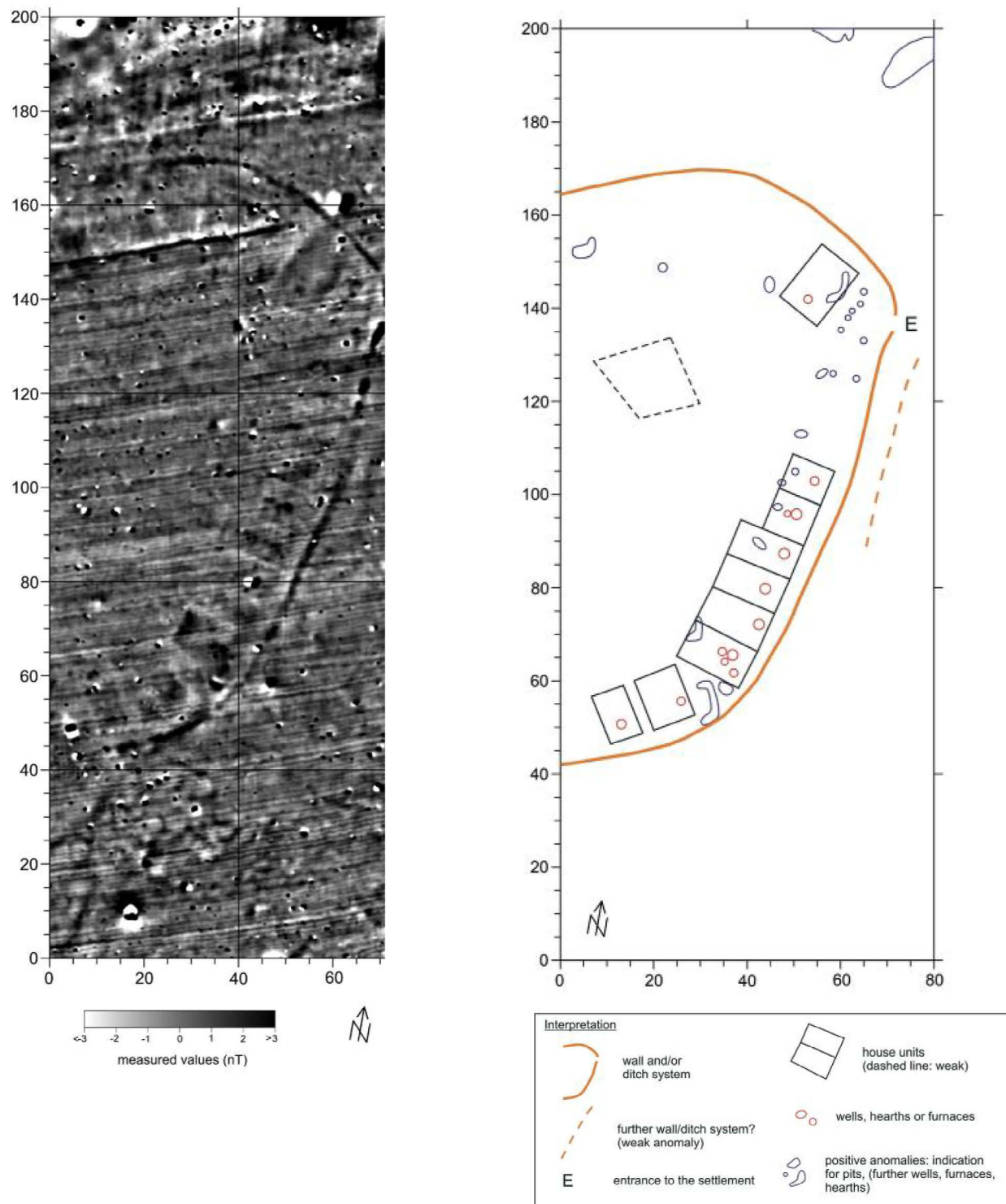
Figure 2.41 The map of magnetic anomalies of Zhurumbay and its interpretation
(modifed after Krause and Koryakova 2013:60–61)

terpreted as belonging to the Sintashta-Petrovka phase (Zdanovich and Batanina 2007:82–86). During the pedestrian survey, Kostyukov (1993) collected about 60 ceramic sherds and after their analysis concluded that the settlement was mainly inhabited during the Srubnaya-Alakul' phase. Later on, the dimensions of the enclosed site reconstructed from aerial imagery were proved to be imprecise. Application of geophysics and total station mapping techniques allowed
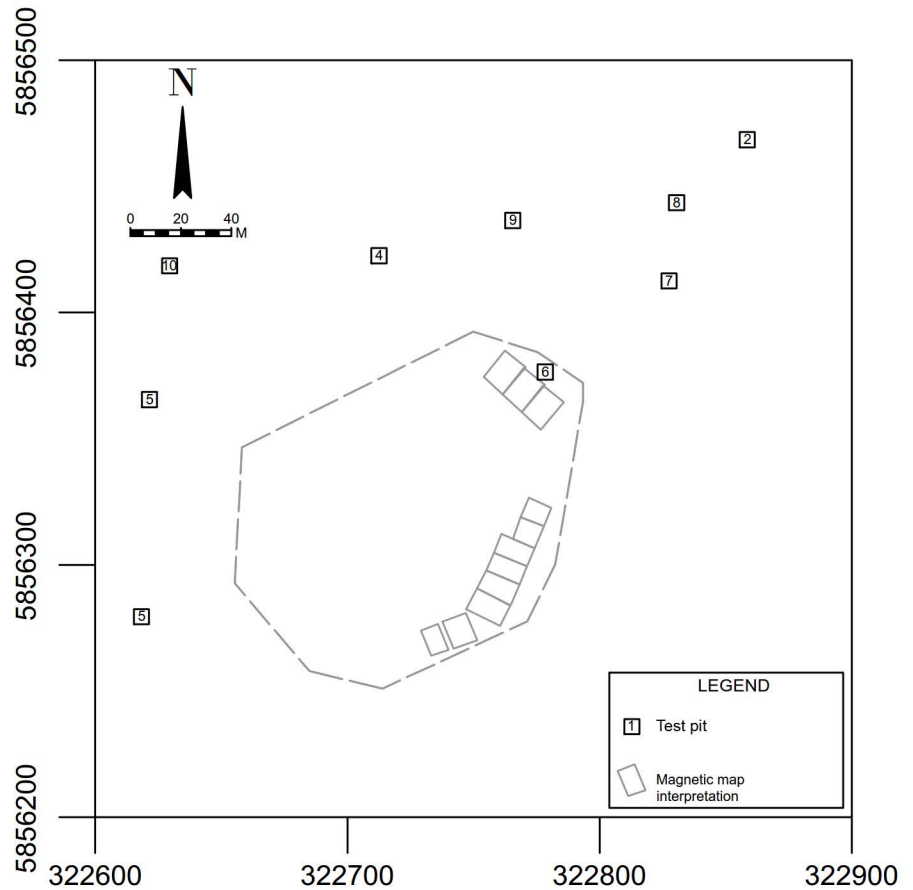
Figure 2.42 Distribution of test pits near Zhurumbay

calculation of more accurate numbers. Thus, according to Panteleyeva (2009), the area of the walled settlement is 2.4 ha, while the width of the ditch is revealed on the plan of magnetic anomalies as 4 meters. Unfortunately, the precise number of houses remained unknown, since the settlement was plowed out, but the magnetometer survey of the roughly half of the site encountered at least 9-12 houses adjacent to the east wall (Krause and Koryakova 2013:60–62) (Fig. 2.41). Thus, the total number of buildings might be estimated as 20–30, if there was only one circle, and 30–40, if there was an additional inner circle, as at Arkaim or Sintashta.

The roughly circular enclosed area at Zhurumbay is about 1.4 ha, and the area around this to be explored was 8.2 ha, so 132 samples were made (Fig. 2.42). The area of the site has been under intense agricultural production for at least 50 years, and it is still being cultivated. For this reason, soil did not stick inside the auger and it was necessary to switch the method of sub-surface testing to a shovel-test survey. The tests of 20 cm by 20 cm were dug until the sterile soil of brown clay was reached. Since the profiles appeared to be very uniform in most samples, it was

impossible to collect data about the ancient anthropogenic impact on the landscape. The degraded "O" horizon is present only in the area to the north of the site. However, even there, the soil is disturbed by previous plowing, a field road and by a present-day embankment. The "O" horizon is thin and does not exceed 3–4 cm. The "A" horizon is degraded gray sandy humus without any differentiation in color or texture. The depth of this horizon varies from 10 to 60 cm with a mean of 31.2±2.8 cm (95% CL). The "B" horizon is either alluvial sand or clay, clearly distinguishable from the plowed layer. Forty-three sherds have been yielded by ten samples. All sherds were found at the depth from 0 to 10 cm, with only one exception when a piece of a pot was buried at a depth of 30 cm; moreover, a bone fragment and two fragments of metallurgical slag were found.

Since the site was under plowing during the fieldwork, intensive surface collection was chosen as the most efficient methodology. It implied walking along transects spaced approximately 10 meters apart. If scatters of artifacts appeared on the surface, everything was collected within a radius of 3 meters and the geographical coordinates of the center recorded with a portable GPS unit (Drennan et al. 2015:149). The surface collection covered an area of roughly 13.9 ha, including the territory of the fortified settlement. There were 794 finds in total collected from the surface. Among them are 733 ceramic sherds, 31 lithic and stone artifacts, 21 pieces of metallurgical slag and nine fragments of animal bones. Finds extended out to 120 m from the walls of the enclosed settlement, with single item as far as 300 m. It is hard to say if the spatial distribution of the collected artifacts correlates with ancient activities, or if it was severely affected by plowing. There are 20 Sintashta-Petrovka sherds (2% of all sherds from the samples and surface collection). However, only six of them were found 20–25 m from the walls, and the rest were well inside. The 95 Srubnaya-Alakul' ceramics tend to spread eastward from the fortified site, which corresponds with houses that appeared on the aerial photography (Zdanovich and Batanina 2007:85). As we can see, this result replicates the conclusion made by Kostyukov. The overall density of the material is 59.7 specimens per ha or 0.006 per m^2. The fact that this density value was established after survey of an area twice as large of Kamennyi Ambar suggests that artifacts were somehow moved around by the post-depositional plowing (in fact, for as much as 100 meters), but the original survey density does not differ much from the average surface density at Kamennyi Ambar (0.003 per m²).

Thus, surface collection revealed artefactual materials outside the walls of Zhurumbay (Fig. 2.43). These materials might represent actual cultural layers, but also might be scattered

around by post-depositional plowing. The question of how post-depositional processes influence archaeological features is highly controversial. It is unclear if vertical stratigraphy and spatial distribution of materials are severely affected or destroyed by plowing. In their experimental study, Navazo and Díez (2008) have demonstrated that artifacts can be moved away from the original places as far as 100 m. On the other hand, Hawkins (1998) has found at least some correspondence between the surface and sub-surface re-
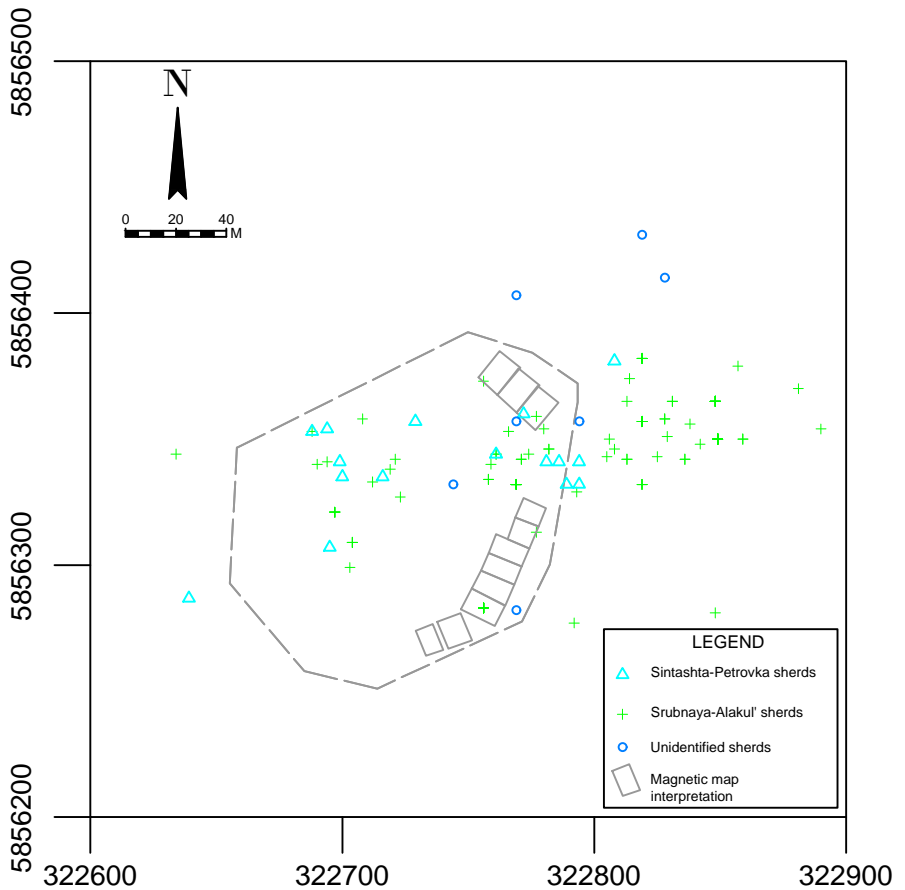
Figure 2.43 Distribution of ceramic sherds on surface near Zhurumbay

mains in the ploughzone. King (2004) concluded that while stratigraphy is indeed destroyed, the horizontal distribution of materials on the plow-disturbed contexts is affected only minimally.

To demonstrate the reliability of the data from the surface collection despite the degree of soil disturbance, one should recall the fact that Kamennyi Ambar has never been plowed. Moreover, the spatial distribution of the materials on Zhurumbay has correspondence with the enclosure and the visible house depression. For this reason, it can be concluded that the allocation of artifacts outside the walls has at least some degree of correspondence with the actual cultural depositions. The position taken here is that it is unlikely that all ceramic sherds and other artifacts from the outside were moved out during post-depositional plowing.

Thus, it is possible to say that cultural layers are present outside the walls of Zhurumbay. However, it is hard to judge their nature due to the poor preservation of the site. The east-west

orientation of plowing suggests that spreading of artefacts to the northeast from the walls might signify outside activities, despite soil disturbance. The fact that the surface density is similar to that at Kamennyi Ambar seems to support this conclusion.

Test-pitting near Zhurumbay and Konoplyanka also yielded some artefactual materials. The counts of materials from the tests near Zhurumbay and Konoplyanka are accumulated in Table 2.10.

Table 2.10 Counts of artifacts yielded by test pits near Zhurumbay and Knoplyanka

Zhurumbay	Ceram- ics	Slag	Lithic	Total	Konoplyanka	Ceram- ics	Slag	Lithic	Total
TP-ZH-1	18	0	0	18	TP-KN-1	0	0	0	0
TP-ZH-2	0	9	0	9	TP-KN-2	0	0	0	0
TP-ZH-3	0	0	0	0	TP-KN-3	32	1	0	33
TP-ZH-4	0	0	1	1	TP-KN-4	4	0	0	4
TP-ZH-5	0	0	0	0	TP-KN-5	1	0	0	1
TP-ZH-6	35	0	2	37	TP-KN-6	0	0	0	0
TP-ZH-7	21	9	0	30	TP-KN-7	0	0	0	0
TP-ZH-8	1	0	0	1	TP-KN-8	0	0	0	0
TP-ZH-9	0	2	0	2	TP-KN-9	3	0	0	3
TP-ZH-10	0	0	0	0	TP-KN-10	0	0	0	0

As is evident from the table, some test pits yielded a considerable number of artifacts and ecofacts, which supports the idea that the surface collected artifacts outside the walls were not just spread out there by post-depositional plowing. Thus, the test pit TP-ZH-7 placed approx-imately 57 m to the northeast from Zhurumbay, exposed 21 fragments of ceramic pots and nine pieces of metallurgical slag. Among pieces of ceramics, two parts belong to the pottery tradition of phase 1 and eight can be attributed to phase 2. As for Konoplyanka, a similar composition of artifact assemblage was observed in the test pit TP-KN-3 (located 40 m to the south). There are 32 pieces of ceramics and one piece of metallurgical slag. At least one sherd and a piece of slag can be attributed to the Sintashta-Petrovka phase.

According to the test-pitting, the overall density of sub-surface materials for Zhurumbay is 9.8±9.8 artifacts per m² and 4.1±7.3 m² for Konoplyanka (at 95% CL). These densities are both smaller than at Kamennyi Ambar and have larger standard deviations. Partly, this can be explained by a smaller sample size. However, there is a substantial difference in the overall num-bers too, which most likely relates to the destruction of the low-density cultural layer by post-dep-ositional plowing.

Turning to the results of analysis of the faunal assemblage, that can be found in Table 2.11, it should be noted that the bones resemble the pattern at Kamennyi Ambar. At Zhurumbay and Konopyanka the same kinds of species were found, even though the MNI suggests a smaller number of slaughtered animals (again, due to the smaller sample size). The critical part of this story is that the relative densities are quite similar, and the values of the samples do not differ from each other by orders of magnitude.

Table 2.11 Faunal remains from Zhurumbay and Konoplyanka

Counts	Equine	Bovinae	Caprinae	Mammal	Bird	MNI Equine	MNI Bovinae	MNI Caprinae	Total MNI
SC-KON-10				1					0
SC-KON-4	1					1			1
TP-KON-3	1	5	2	45	1		2	1	3
TP-KON-4		1		17			1		1
TP-KON-8		13	2	2			2	1	3
Core-ZH-136		1					1		1
TP-ZH-1			1					1	1
TP-ZH-6		22	3	7			1	1	2
TP-ZH-7				1					0
SC-ZH-156				1					0
SC-ZH-21				1					0
Total	2	44	8	75	1	2	5	4	11

Finally, the test pits near Konoplyanka yielded well preserved faunal remains that allowed learning about the patterns of animal slaughtering, studied by Dr. Bachura. The age of an animal at death was studied by counting of later intermediate lines relative to previous intermediate lines. The results are summarized in Table 2.12.

Table 2.12 Age composition and seasons of slaughtered animals from Zhurumbay and Konoplyanka

Site	Subfamily	Teeth	Age	Slaughtering season
TP-KON-8, 0-20	Bovinae	m1-2	3–5+	late fall/early winter
TP-KON-8, 0-20	Bovinae	pm-m	?	late fall/early winter
TP-KON-8, 0-20	Bovinae	pm-m	?	late fall/early winter
TP-KON-8, 0-20	Bovinae	p2-4	?	?
TP-KON-8, 0-20	Bovinae	m3	3+	summer
TP-KON-8, 0-20	Bovinae	m1-2	2–3+	late fall/early winter

As can be observed in the table, a tendency towards the seasonal killing of full-grown animals is suggested by the sample of seven teeth from Konoplyanka and one specimen from
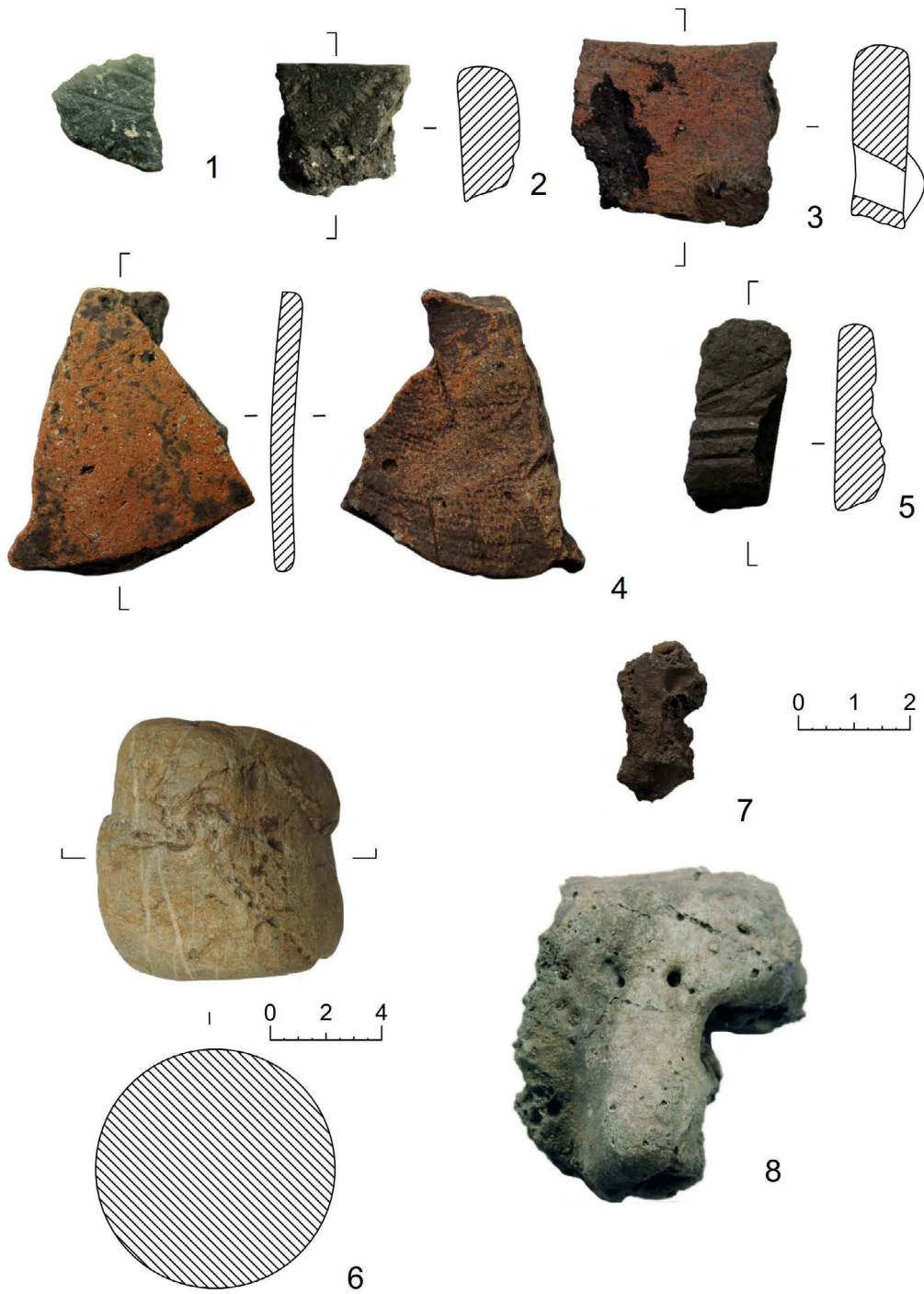
Figure 2.44 Findings yielded by the cultural layers in outskirts of Konoplyanka and Zhurumbay
1 – Konoplyanka, a stone ornament; 2 – Konoplyanka, a rim of the Petrovka type; 3 – Konoplyanka, a rim of the
Sintashta type; 4 – Konoplyanka, a body sherd of the Srubnaya-Alakul' type; 5 – Konoplyanka, a rim of the Petrovka
type; 6 – Zhurumbay, a stone hammer; 7–8 – Zhurumbay, metallurgical slag

Kamennyi Ambar. A similar pattern has been found within the walls of Kamennyi Ambar, as well as in the other Sintashta-Petrovka settlements. Seasonal killing is a reasonable practice for a pastoral society that tries to maintain herd size at a reasonable level and cannot afford keeping too many animals during the winter. As a result, mass-killing of animals occurred during fall or winter, when meat can be stored and resources saved. It is reasonable to assume that during the summer the majority of animals were pastured in the river valley and moved according to degradation of pastures, exactly in the same way as is practiced by the people of the modern Varshavka village (Bachura et al. 2011; Stobbe et al. 2016).

Summarizing, the results of the field research at Zhurumbay and Konoplyanka also indicated the presence of cultural layers outside their walls, even though they are represented only by artifacts and faunal remains. These cultural layers were accumulated as consequences of diverse human activities, and since there is no stratigraphic data, the likeliest explanation is that concluded for Kamennyi Ambar. Possibly, these cultural remains were produced by the residence of a group of people, involved in herding who stayed near the walls of the settlements only on a seasonal basis, and moved somewhere else during the summer.

2.4 SUMMARY

The field investigation of the outskirts of three Sintashta-Petrovka archaeological sites revealed undoubted presence of cultural deposits and evidence of impact to paleosols. The cultural layers contained ceramic sherds of the Bronze Age, metallurgical slag, stone and lithic tools and artifacts, as well as traces of fires and depleted humus due to the active human pressure on the ancient surface. In addition, the cultural layers contained ecofacts, including bones of domesticated animals (cow, horse and sheep/goat) and macro-remains of plants that could be intentionally collected and preserved as hay. Geochemical study outside the walls of Kamennyi Ambar revealed anomalies of higher concentration of phosphates and other elements, suggesting that human activities impacted the chemical composition of surrounding soils.

The discovered cultural layers are dense and comparable to those that can be found within the walls of the settlements, with the difference that no traces of permanent architecture were

found outside the walls of any of the three settlements. Taken together this suggests that the outside area of Kamennyi Ambar could have been occupied by a semi-mobile group of people who lived there only part-time, presumably, during the winter. People lived in movable tents that cannot be easily found archaeologically but might be seen on magnetic maps as circular anomalies. This part of the population probably stayed near the settlement only during the wintertime, when the livestock had to be kept safe. During the spring, when the time came to send the livestock to the summer pastures, herders left the center of sedentary life. The cultural deposits from the outside, then, represent two kinds of seasonal events: the winter habitation of pastoral families and summertime ore smelting carried out by more sedentary craft specialists.

3.0 LOCAL COMMUNITIES IN THE LATE BRONZE AGE

In Chapter 2, materials exposed by the field research near three Sintashta-Petrovka settlements were presented. It is suggested that the discovered cultural layers outside their walls might represent seasonal herders' camps adjacent to the walled settlements. However, what the composition of the local community was and how a settlement functioned as a population center remain to be discovered. These topics include the local demography and its dynamics in time and reconstruction of the labor burden that communities shared in order to build and maintain the walled settlements.

3.1 DEMOGRAPHY AND ITS DYNAMICS THROUGH TIME

3.1.1 ^{14}C Modeled Age of the Occupation Duration at Kamennyi Ambar

On the limited series of eighteen AMS radiocarbon dates, the principal investigators of the site estimated the following duration span: 2045–1980 cal BC for the Sintashta-Petrovka phase (1-σ calibrated range) and 1835–1760 cal BC for the Srubnaya-Alakul' phase (1-σ calibrated range), with the much longer span at 2-σ ranges, indicating the need for further modeling work. Moreover, the authors admitted that the estimated periods came into conflict with the results of the radiocarbon dating of the nearby Sintashta phase cemetery of Kamennyi Ambar-5, which dated to 1960–1770 cal BC (Krause and Koryakova 2013:139–140).

However, the principal investigators did not use the powerful tools of Bayesian statistics in full. Bayesian statistical modeling of radiocarbon dates incorporates a priori contextual information to constrain the probability distributions of calibrated dates for each radiocarbon measurement (Bronk Ramsey 2015). Applying Bayesian statistical modeling to a larger dataset of 41 radiocarbon dates helped to improve the accuracy and resolution of the chronology and estimate the duration of occupation at the settlement. The samples came from different contexts (wood inside the wells, house floors, earthen filling of the ditch), but the majority of them from wood, charcoal or other organic materials preserved inside the wells. Thirty-eight dates came from Sintashta-Petrovka contexts, and three from the later phase. The disproportion in samples does not allow us to confidently estimate the duration of the Srubnaya-Alakul' phase but provides an opportunity to build a chronological model.

Date calibrations and Bayesian models were produced in OxCal v.4.3 (Bronk Ramsey 2009) using the IntCal13 Northern Hemisphere atmospheric curve (Reimer et al. 2013). Dates were modeled in a sequence within two phases to estimate the duration span of the Sintashta-Petrovka phase. The outlier model was also applied due to the observation that some individual calibrated dates appeared to be as old as 4000–3900 BP. This age of the Sintashta-Petrovka is hardly acceptable since it contradicts conventional archaeological wisdom and the set of radiocarbon dates from other sites (Hanks et al. 2005). Moreover, the oldest dates came from a sample of soil, which also suggests they may be "old wood" (Schiffer 1986). Boundaries (i.e., events not directly dated) were placed between phases in order to estimate the span of events. Additional boundaries were placed at the beginning of each sequence to provide an estimate of the time range for the initiation and termination of use of the structure or of site occupation.

The outlier model indicates the following (Fig. 3.1). The span of events that covers the 68.2% area under the calibration curve took only 40 years, or 90 years if the calibration curve covers 81.6% of occasions. However, the events covered for 95.4% took 335 ^{14}C years. Apparently, the latter is due to the outliers, that should not be taken into account.

The boundaries of the Sintashta-Petrovka phase date between 1910 cal BC and 1870 cal BC at the 1-σ range. The median points of the starting and ending boundaries are 1900 cal BC and 1880 cal BC, indicating the only 20-years-long period when the major events could have happened.
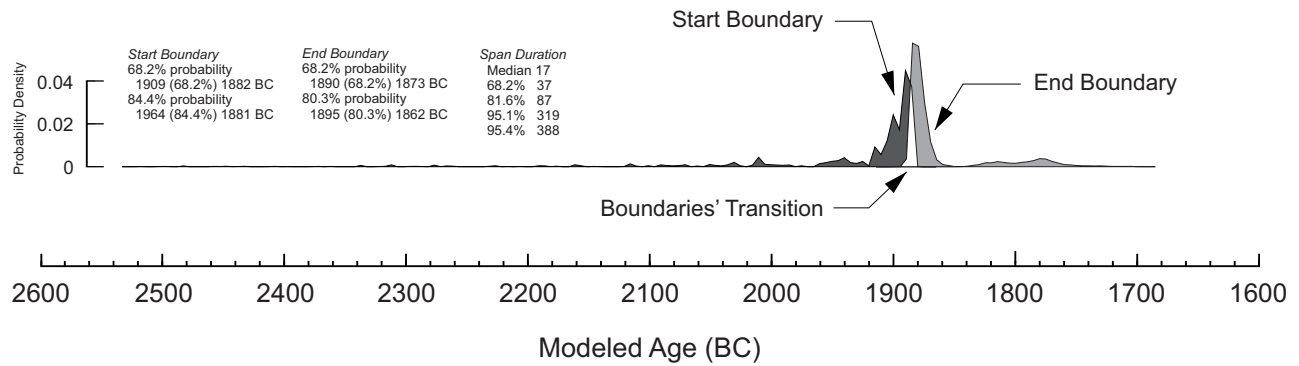
Figure 3.1 The ^{14}C Outlier Model: Boundaries of the Sintashta-Petrovka Phase 1 at Kamennyi Ambar

The limited series of Srubnaya-Alakul' samples indicates that the events happened no earlier than 1890 cal BC, with a median point for the starting boundary of 1855 cal BC.

In sum, the modeled radiocarbon dates indicate that occupation events occurred during the Sintashta-Petrovka phase at Kamennyi Ambar between 1910 and 1870 cal BC (at 68.2% confidence). The earliest date is constrained by the radiocarbon dates from the nearby cemetery Kamennyi Ambar-5, while the later date limit can be justified by the dates from the Srubnaya-Alakul' context. If this information is taken into account, the phase 1 habitation took place between 1950 cal BC and 1850 cal BC (1-σ calibrated range). In other words, the modeled sequence suggests the fortified core was occupied for approximately 50–100 years. Regardless of the actual age of the site, chronological control over the habitation span is the most critical for the further analysis of the local community development.

3.1.2 Demography of the Local Communities in the Valley of Karagaily-Ayt

To comprehend the past society the issue of the community's size and its dynamic through time should be addressed since demography is one of the key elements that constitute the social complexity. Often, the emergence of social institutions of power can be understood as the response to scalar stress. The most common approach to demographic estimation for sedentary society is multiplying available living space by some index of area per person. The high cross-cultural variability of the average living area is one of the obstacles of this approach (Brown 1987; Porčić 2012). Another issue is that family organization takes many different forms, so the average family size often remains unknown. Moreover, this approach cannot be easily applied

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to the semi-mobile and mobile groups that did not leave traces of houses. In such a situation, an area-sherd density index (i.e., the area of a site multiplied by the density of sherds) can be used to achieve estimations. Comparison of indexes allows establishing a relative demography of the local communities (Drennan et al. 2015).

The interiors of the walled settlements provide information on the average area and an approximate number of houses allowing simple calculations. As was discussed in Chapter 2, if the family size is taken as from 5 to 10, the demographic scale varies from 150–230 to 300–460 people living at Kamennyi Ambar during sub-phase 1-1 and 125–250 people during sub-phase 2. However, a more reasonable and detailed model requires a different approach. Here it is based on the assumption that the buildings inside the walls served multiple purposes, including keeping the community's animals during the winter-time. In order to estimate the average number of people per house the demographic model is built on a series of assumptions:

1) The maps of magnetic anomalies represent households with enough precision to allow counting them and measuring their areas (46 at Kamennyi Ambar, 21 at Konoplyanka and 30 at Zhurumbay).

2) The Late Bronze Age population heavily relied on herding for subsistence with the herd composition of 50% cows, 40% sheep; 4% horses and 6% of other animals (Krause and Koryakova 2013:239–284).

3) People had to keep at least a part of the domestic animals' in stalls in the winter (females with newborns). This claim can be supported by the chemical analysis of the house floor at Kamennyi Ambar that demonstrated high phosphate values, which allows thinking that periodically animals were kept inside the walled village (see Chapter 1 and Krause and Koryakova 2013:33–34). A similar interpretation was suggested for the Late Bronze Age unfortified settlement in the Tobol region, where stall-like areas were found inside the houses (Zakh 1995:69). Furthermore, this possibility can be supported by ethnographic observations. Maasai settlements are organized as enclosed areas where people and animals live next to each other (Shahack-Gross et al. 2004). Thus, the number of animals that could be kept in the house is a limiting constraint for living area. However, there is no reason to believe that some houses were exclusively used for keeping animals and not for human living, since intensively excavated settlements like Sintashta and Arkaim yielded household items in each structure.

4) All things being equal, minimum caloric requirements were met by eating meat of the domestic animals exclusively. Even though this assumption is partly supported by the staple isotopes analysis (Ventresca Miller et al. 2014), the excavated materials from Kamennyi Ambar also suggest people consumed fish, small game and, probably, a variety of wild plants, which could increase caloric intake to the presently accepted level of 2,000–3,000 kcal per adult person per day. However, no other sources are encountered in the model, but calories that can be provided by three major species that constituted the Late Bronze Age herds (cattle, sheep, and horses). Thus, the minimum numbers of animals estimated as the combination of these three species with preference to the livestock, as it has the highest NISP values (up to 50%) at Kamennyi Ambar (Krause and Koryakova 2013:240), plus offspring to allow reproduction.

5) A daily caloric requirement introduced into the model is 1,600 kcal per person per day, regardless sex and age of individuals. This intake is specified as a minimum requirement for an adult woman by Dietary Guideline for Americans in 2015–2020, issued by the USDA (2015), and is taken as average for the whole spectrum of ages and genders. Annual caloric demand is 584,000 kcal per person.

6) The nutrition values of meats are derived from *The USDA's National Nutrient Database for Standard Reference Release 28*, available on-line at https://ndb.nal.usda.gov/. While actual values may vary depending on the type of product, it is accepted that a cow weighing 300 kg yields about 150 kg of products for consumption. The average nutritional value is 2,000 kcal per kg of consumable product, yielding 300,000 kcal in total. A butchered sheep yields only 20,000 kcal (10 kg [50%] of consumable products and 2,000 kcal per kg), and a horse is a low-ranked animal with the nutrition value of 1,600 kcal per kg and 240,000 kcal in total (an average animal's weight introduced to the model is 300 kg and 50% of weight yields calories). The summary of the model's input is in Table 3.1.

Table 3.1 The model caloric inputs

	Weight, kg	Products, kg (50% of initial weight)	The nutritional value, kcal per kg	Total kcal per animal
Cow	300	150	2,000	300,000
Sheep	20	10	2,000	20,000
Horse	300	150	1,600	240,000

6) The USDA's Plans of Farm Buildings for the Northeastern States (1951) provides the basis for estimation of living space per animal. Thus, 1 m² per sheep, 3 m² per cow, and 4 m² per

horse are introduced into the model as approximate space demands for the adult animals, while for the offspring the model reserved half as much space.

Based on these assumptions, the model aims to estimate the number of people who could live year-round inside three walled-settlements sharing the space with the animals. The model, though, does not aim to reconstruct the subsistence practices but instead can be verified by the recent data on the ancient economy (Krause and Koryakova 2013:239–284; Rühl et al. 2015). Thus, Stobbe and colleagues calculated that the autonomous economic zone around Kamennyi Ambar could feed up to 816 cattle, 10,274 sheep and 343 horses (Stobbe et al. 2016:15).

The first step in modeling the demography of Kamennyi Ambar is to estimate the number of people who lived in each house structure (with their animals in the winter), based on the space available. The model includes the calculation of the animals needed for a family of 4, 6, 8, 10, 12, 14 and 16 people living together in the roofed area and share space with animals (Table 3.2). The model is calculated to meet two pre-conditions, the human caloric requirement in kilocalories per year, and the proportional composition of the herd, if possible. The areas of the 46 house structures range from 110 m² to 350 m² with a mean of 239±18 m² (at 95% CL), as measured by the plan of magnetic anomalies. The area of each house is derived from the map of magnetic anomalies and the space available calculated for each building separately. The required area to keep the estimated number of animals is subtracted from the area of each house. From this, 8 m² is subtracted to allow for wells and other structural features like furnaces (based on the recon-struction of House 5 by Koryakova and Kuzmina [2017]). The resulting number is divided by the number of people in the group, and then the mean remaining area calculated with the error range added. The resulting number is a mean value of available living area per person, which can be evaluated by comparison with the cross-cultural average.

Table 3.2 Summary of the inputs and outputs of the population model for Kamennyi Ambar

Family size	Caloric require-ment (kcal/year)	Cows (n / %)	Sheep (n / %)	Horses (n / %)	Total stall area per house (m²)
1	584,000	-	-	-	-
4	2,336,000	8 / 100%	0 / 0%	0 / 0%	32
6	3,504,000	10 / 71%	9 / 14%	1 / 14%	60
8	4,672,000	14 / 52%	12 / 44%	1 / 4%	80
10	5,840,000	17 / 53%	13 / 41%	2 / 6%	101
12	7,008,000	21 / 55%	15 / 39%	2 / 5%	119
14	8,176,000	25 / 68%	10 / 27%	2 / 5%	127

Family size	Caloric require-ment (kcal/year)	Cows (n / %)	Sheep (n / %)	Horses (n / %)	Total stall area per house (m²)
16	9,344,000	27 / 48%	26 / 46%	3 / 3%	155
18	10,512,000	30 / 48%	28 / 45%	4 / 6%	186

The number of cattle, sheep, and horses needed by a family of four (two adults and two children) is estimated at 8 cows with calves, 0 sheep, and 0 horses because 4 butchered cows yield 2,400,000 kcal per year which meets the minimum annual requirement of 2,336,000 kcal for a family of four (1,600 kcal per person multiplied by 4 and multiplied by 365 days). Minimum space needed to keep 8 cows with calves to allow reproduction of a herd is 32 m² (3 m² per cow and 1.5 m² per calf). At Kamennyi Ambar, this configuration would allow 56.8±4.6 m² (at 95% CL) of living space per person, what seems to be an unreasonably large living area. The total numbers of animals at Kamennyi Ambar sum up to 736 cows with calves.

A family of 6 persons requires 3,504,000 kcal per year. This level of caloric intake can be met through the configuration of 10 cows, 9 sheep, and 1 horse. This configuration requires 60 m² of stall area (40 m² for cows with calves, 14 m² for sheep with lambs and 6 m² for horses with foals) leaving 28.6±3 m² (at 95% CL) of available living space per person. The total number of animals at Kamennyi Ambar during the sub-phase 1-1 sums up to 920 cows with calves, 828 sheep with lambs and 92 horses with foals.

A family of 8 persons requires 4,672,000 kcal per year. This level of caloric intake can be met through the configuration of 14 cows, 12 sheep, and 1 horse. This configuration requires 80 m² of stall area (56 m² for cows with calves, 18 m² for sheep with lambs and 6 m² for horses with foals) leaving 19.1±2.3 m² (at 95% CL) of available living space per person. The total number of animals at Kamennyi Ambar during the sub-phase 1-1 sums up to 1,288 cows with calves, 1,104 sheep with lambs and 92 horses with foals.

A family of 10 persons requires 5,840,000 kcal per year. This level of caloric intake can be met through the configuration of 17 cows, 13 sheep, and 2 horses. This configuration requires 100 m² of stall area (68 m² for cows with calves, 20 m² for sheep with lambs and 12 m² for horses with foals) leaving 12.9±1.8 m² (at 95% CL) of available living space per person. The total number of animals at Kamennyi Ambar during the sub-phase 1-1 sums up to 1,564 cows with calves (53%), 1,196 sheep with lambs (41%) and 184 horses with foals (6%). Importantly, this configuration agrees well with the proportion of animal remains from the excavation of Kamennyi Ambar and

reconstructed herd composition with the herd composition of 50% cows, 40% sheep, 6% horses and 4% of other animals (Krause and Koryakova 2013:239–284).

A family of 12 persons requires 7,008,000 kcal per year. This level of caloric intake can be met through the configuration of 21 cows, 15 sheep, and 2 horses. This configuration requires 119 m² of stall area (84 m² for cows with calves, 23 m² for sheep with lambs and 12 m² for horses with foals) leaving 9.3±1.5 m² (at 95% CL) of available living space per person. The total numbers of animals at Kamennyi Ambar sum up to 1,932 cows with calves, 1,380 sheep with lambs and 184 horses with foals.

A family of 14 persons requires 8,176,000 kcal per year. This level of caloric intake can be met through the configuration of 25 cows, 10 sheep, and 2 horses. This configuration requires 127 m² of stall area (100 m² for cows with calves, 15 m² for sheep with lambs and 12 m² for horses with foals) leaving 7.5±1.3 m² (at 95% CL) of available living space per person. The total number of animals at Kamennyi Ambar during the sub-phase 1-1 sums up to 2,300 cows with calves, 920 sheep with lambs and 184 horses with foals.

A family of 16 persons requires 9,344,000 kcal per year. This level of caloric intake can be met through the configuration of 27 cows, 15 sheep, and 4 horses. This configuration requires 155 m² of stall area (108 m² for cows with calves, 23 m² for sheep with lambs and 24 m² for horses with foals) leaving 4.7±1.1 m² (at 95% CL) of available living space per person. The total numbers of animals at Kamennyi Ambar sum up to 2,484 cows with calves, 1,380 sheep with lambs and 368 horses with foals.

Finally, a family of 18 persons requires 10,512,000 kcal per year. This level of caloric intake can be met through the configuration of 30 cows, 28 sheep, and 4 horses. This configuration requires 186 m² of stall area (120 m² for cows with calves, 42 m² for sheep with lambs and 24 m² for horses with foals) leaving 2.6±1.1 m² (at 95% CL) of available living space per person. In other words, there is virtually no room to host such large collective. Moreover, the negative area values started to appear in the model once the number of people achieved 16 persons per house.

The model can be additionally supported by ethnographic data for the Lower Volga Region, where a family of 10–13 people required 100 sheep, 4 cows and 4 camels to survive an entire year (Merpert 1974:114). This converts to 4,160,000 kcal per year, which corresponds to 8–10 people per family in the model caloric input, supporting the plausibility of the approach taken here.

In sum, the average house inside Kamennyi Ambar can either host a small nuclear family of four and the corresponding number of animals leaving approximately 225–230 m² for living and other activities (56.8±4.6 m² per person), or a large extended family of eighteen and the corresponding number of animals leaving approximately 45–50 m² for living and other activites (2.6±1.1 m² per person). The estimation for minimum people implies unreasonably large houses and would require additional construction work, while the maximum possible family would not have much space for habitation and for performing daily household activities. Thus, the caloric model provides the basis to assess the lower limit as 6 and the upper limit as 14, and the mean number of people that lived in the house, that thus became 10. A family of this size would utilize the available space in the most efficient way, since the total estimated living and activity area is about 130 m², which is enough for habitation and craft activities (12.9±1.8 m² per person).

The validation of this approach can be derived from Brown (1987), who has found the global average living area is 6.1±1.4 m² per person. As suggested above, at Kamennyi Ambar the average available living area for the family of four after subtraction the activity area is 50.2±4.6 m² per person, for a family of ten people the available area is 12.9±1.8 m² per person; and a family of sixteen would have an average living space of 4.7±1.1 m² per person. Finally, a family of eighteen people would have 2.6±1.1 m² per person. The comparison suggests that the average size of a group of people per house was between 8 and 12.

The second step in modeling the demography of Kamennyi Ambar is estimating of the total number of people within the walled area. In accordance with the caloric model, the number of people simultaneously living in 46 houses at Kamennyi Ambar would be between 276 and 644 with a median estimated population of 460 persons. The application the same logic to Konoplyan-ka and Zhurumbay allows arriving at a range between 168 and 252 people and between 240 and 360 people living simultaneously within the enclosure, respectively.

One way to validate the demographic model is to compare the total number of animals needed to support the population with the overall productivity of the catchment zone around Kamennyi Ambar. Pursuing a similar purpose, Stobbe and her colleagues calculated that the autonomous economic zone around Kamennyi Ambar with a radius of 4 km could feed up to 816 cattle, 10,274 sheep and 343 horses (Stobbe et al. 2016:15). However, even though these numbers agree with the possible productivity, they contradict the observed herd composition of 50% cows,

40% sheep, 6% horses and 4% of other animals. According to the model, the total fresh forage near Kamennyi Ambar is 22,777.04 t per year (presumably), calculated from the following inputs:

- a catchment zone limited by a radius of 4 km. Otherwise, the buffers for Kamennyi Ambar and Zhurumbay intersect;
- the area of mapped vegetation units is 4,166.57 ha for the steppe zone and 503.55 for the meadow steppe zone;
- the steppe zone productivity is 4.5 t of fresh forage per ha;
- the meadow steppe zone productivity is 8 t of fresh forage per ha.

However, the calculation is apparently based on average productivity of Northern Eurasia (Walter and Breckle 1986) and does not take into account the local variability of uncultivated areas. In fact, more localized and empirically evaluated measures of productivity of uncultivated meadows in various parts of modern Russia and Kazakhstan, would yield substantially lower numbers. As is evident from Table 3.3, the productivity in the southern Urals and the neighboring regions varies from 0.8 to 3 t of hay per hectare with an average of 1.8 t per ha. Specifically, in the valley of Karagaily-Ayat, the average modern productivity is about 1 t per ha (Grebenshikova 2017, personal communication). The level of productivity that appeared in Stobbe and colleagues' model can be achieved only with intentional cultivation and use of modern chemical fertilizers, as is scientifically demonstrated for the southern Trans-Urals (Kramarenko 2009:16).The more appropriate numbers allow estimation of 7,499.8 t in the steppe zone and 1,510.6 t in the meadow steppe zone for the catchment zone near Kamennyi Ambar with a radius of 4 km, or 9,010.5 t of forage, in total.

Table 3.3 Productivity of different regions in Northern Eurasia

Zone	Hay (t/ha)	Reference
Steppe	1.5–3	Agricultural Encyclopedic Dictionary (1989)
Steppe (the Village of Birsuat, Akmola District, northern Kazakhstan)	2.2	Bahralinova 2017:57
Foothils (Kabardino-Balkaria, Russia)	0.8	Berbekova and Magomedov 2014
Steppe (southern Urals, Russia)	1.5	Feklin 2012
Eurasian Steppe	0.5–1.5	Kuzmina 1994:200
Ob'–Irtysh floodplain (Nizhnevartovsk District, Russia)	1.5–1.7	Korkin and Kushanova 2015

Zone	Hay (t/ha)	Reference
Steppe (near the modern Varshavka village, Chelyabinsk Region, Russia)	1	Grebenshikova 2017, personal communication
Dry meadows (Vologda Region, Russia)	0.8–1	Sazhinov 1941:13
Low meadows (Vologda Region, Russia)	1.5–2.5	Sazhinov 1941:14
Floodplain meadows (Vologda Region, Russia)	2–3	Sazhinov 1941:15

Is 9,010.5 t of forage enough to support the population of animals owned by the community of the walled part of Kamennyi Ambar? The model developed by Stobbe and her colleagues assumes that a cow needs 0.045 t of fresh forage/day, a horse consumes 0.009 t of fresh forage/day, and a sheep demands 0.002 t of fresh forage/day. At first glance, these inputs meet the calculated productivity of pastures near Kamennyi Ambar, but the question arises of whether a cow really eats four times more than a horse. Presumably, Stobbe and colleagues' parameter of 0.009 t of fresh forage/day for a horse is based on a mixed modern diet (crops, hay, and vegetables) and not applicable to the Bronze Age. As a result, these inputs also require adjustment.

A brief survey through the modern literature on animal husbandry suggests that a cow requires 10–15 kg of hay/day, a horse needs 10–15 kg of hay/day, and a sheep consumes 2–4 kg of hay/day (Bishop 2005; Fermerskoye khozyaystvo 2008). These numbers convert to 3.6–5.5 t of forage per animal per year for cows and horses, and 0.7–1.4 t of forage per sheep per year. For the purpose of the model, it is assumed that young animals consume half the fodder needed for adults.

To verify the proposed model of the demography of the walled area at Kamennyi Ambar, Stobbe and colleagues' estimation of proportions of different zones can be used. Table 3.4 summarizes calculations for fodder to feed animals year-round depending on the family size. It suggests that the catchment zone with a radius of 4 km could support the minimum needs of animals if each family had up to 10–12 members and relied exclusively on meat protein. However, the herd of this size would place ongoing pressure on the pastures and quickly result in over-grazing.

Table 3.4 Total amount of fodder depending on the family size

Family size	Cows with calves	Sheep with lambs	Horses with foals	Minimum forage demand, t/year	Maximum forage demand, t/year
4	736	0	0	1,987	3,036
6	920	828	92	3,167	5,044
8	1,288	1,104	92	4,306	6,852
10	1,564	1,196	184	5,348	8,466
12	1,932	1,380	184	6,438	10,178
14	2,300	9,20	184	7,190	11,213
16	2,484	1,380	368	8,425	13,214
18	2,760	2,576	368	9,798	15,608

The ethnographic data on herd size and composition from the Lower Volga Region can also be called on to evaluate the model. Thus, the settlement herd composed of 93% sheep, 4% cows and 4% camels (Merpert 1974:114) would require the total forage of 6,817–12,696 t of foder per year if the average family size is ten. Again, this herd can be supported by the catchment zone with a radius of 4 km from the Kamennyi Ambar.

The third step in modeling the demography of Kamennyi Ambar is estimating the number of people who could live outside the enclosure. This task is especially complicated because 1) the remains of the houses cannot be measured and counted and 2) we will try to reconstruct occupation for sub-phases 1-1 and 1-2 separately, but the sherds of these two sub-phases cannot be distinguished by stylistic characteristics belonging to the Sintashta-Petrovka culture.

The most plausible approach to solve this problem is the calculation of area-density indexes of the ceramic materials and calculating the number of people based on the occupied area and proportional relationships of the indexes from both parts of the settlement. The area-density index is a combination of an estimated density of materials per m² and a studied area in ha. The index is based on the assumption that a longer occupation span or a larger number of people or both correspond to higher densities of materials. A higher area-density index means that there are more materials either because they are spread across a larger area, or because they are packed more densely, or both (Drennan et al. 2015:34–35). As discussed in Chapter 2, the reflective index is the average weight of ceramic sherds per m², because sherds are more broken up outside the walls than inside. Moreover, it is unknown what proportions of total ceramic sherds were exposed by the excavations inside and outside the walls, which makes it impossible to compare the two

samples on the basis of numbers. However, it is possible to assume that the samples accurately represent average masses of ceramic materials in both areas.

Several steps are necessary to estimate the size of the outside population at Kamennyi Ambar.

1) The median population inside the walls has been estimated above. Thus, during sub-phase 1-1, when all 46 houses were occupied, the median population was 460 people. During sub-phase 1-2, when only 29 houses in the northern half of the walled area were occupied, the median population was 290 people (see Fig. 2.2 for the sub-phases). These population estimates will be used further as the basis to estimate the outside population that can be expressed as a portion of the inside population.

Table 3.5 Median population of Kamennyi Ambar base of house counts

	No. of Houses	Population Factor	Med. Population
Sub-phase 1-1	46	10	460
Sub-phase 1-2	29	10	290

2) The area-density index is the only relative measure that can be estimated and compared for both areas – inside and outside the walls. The area-density index for the inside calculated in the following way.

2.1) Calculation of the densities for the two sub-phases inside the wall. The average density of ceramics for the entire area within the walls is 11 sherds/m², and the average weight of a sherd is 25.1 g. Multiplication of density by number by the average weight yields the average of 276.1 g/m² of sherd density by weight. However, the stratigraphy of the intermediate ditch demonstrated that the southern part of the settlement functioned only during sub-phase 1-1, while the northern part of the settlement functioned during both sub-phases (1-1 and 1-2). Thus, the average density represents a palimpsest of two chronological sub-phases, which should be separated for accurate representation. Since the sherds of sub-phases 1-1 and 1-2 cannot be distinguished stylistically and counted separately where they occur together in the northern half of the walled area, it is assumed that sub-phase 1-1 sherds occur in this northern half at the same density as in the southern half (where the entire sherd density is attributable to sub-phase 1-1 since this area was not occupied in sub-phase 1-2). The average density of the ceramic sherds from the southern part is 8.6 sherds/m², which converts to a density of 215.9 g/m² by weight. The observed sherd density in the northern half of the walled area is 276.1 g/m². If we attribute a density of 215.9 g/

m² to sub-phase 1-1, this leaves a density of 60.2 g/m² attributable to sub-phase 1-2 (276.1 g/m² [entire phase 1] – 215 g/m² [sub-phase 1-1] = 60.2 g/m² [sub-phase 1-2]).

Table 3.6 Area-Density Index calculation for the inside

	Sherd density by count (sherds/m²)	Average weight (g)	Sherd density by weight (g/m²)	Living Area (ha)	Area-Density Index	Proportional relation of densities
Sub-phase 1-1	8.6	25.1	215.9	1.2	258.8	78%
Sub-phase 1-2	2.4	25.1	60.2	0.7	42.2	22%
Total	11.0	25.1	276.1	1.2	300.9	100%

2.2) Estimation of the duration of sub-phases 1-1 and 1-2. Since the 29 houses of the northern half of the walled area were occupied throughout sub-phases 1-1 and 1-2, the higher sherd density for sub-phase 1-1 must be because people were depositing garbage (i.e. sherds) for a longer time there. Of the total deposition represented by a sherd density of 276.1 g/m², 215.9 g/m² (78%) is attributable to sub-phase 1-1, and 60.2 g/m² (22%) is attributable to sub-phase 1-2. Thus 78% of the 100-year occupation (some 78 years) is attributed to sub-phase 1-1 and 22% (some 22 years) to sub-phase 1-2.

2.3) Calculation of the area-density index for each sub-phase inside the wall. The total occupied area within the wall (occupied during sub-phase 1-1) is 1.2 ha, and the total occupied area in the northern half of the walled area (occupied during sub-phase 1-2) is 0.7 ha. Multiplication of the sherd density by these areas allows establishing the area-density index corresponding to each sub-phase. For sub-phase 1-1, the occupied area (1.2 ha) times the sherd density (215.9 g/m²) yields an area-density index of 258.8. For sub-phase 1-2 the occupied area (0.7 ha) times the sherd density (60.2 g/m²) yields an area-density index of 42.2. The sum of these two area-density indices gives a total area-density index for the occupation within the walls of 300.7.

3) Total occupation inside the walls can be expressed in terms of person-years. During sub-phase 1-1, 460 people lived there for 78 years (460 x 78 = 35,880 person-years), and during sub-phase 1-2, 290 people lived there for 22 years (290 x 22 = 6,380 person-years), for a total of 42,260 person-years. These 42,260 person-years of occupation produced an area-density index of 300.9 (above). The area-density index can be converted into a population estimate in person-years, then, by multiplying it by the conversion factor pf 140.45 (300.9 x 140.45 = 42,260 person-years).

4) The population outside the walls can be estimated in the following way.

4.1) The average density of the ceramic sherds from outside is 10.9 sherds/m². Of this density only 81% is assigned to the Sintashta-Petrovka phase because only 81% of the stylistically identifiable sherds recovered outside the walls are Sintashta-Petrovka (the other 19% being Srubnaya-Alkul'). So, the Sintashta-Petrovka sherd density outside the walls comes to 8.8 sherds/m² (81% of 10.9 sherds/m²). The average weight of the sherds recovered outside the walls is 5.4 g, so the density by weight is 47.7 g/m² (8.8 sherds/m² x 5.4 g) This density applies to the estimated 2.0 ha covered by the occupation outside the walls, yielding a total area-density index outside the walls of 95.4 (47.7 g/m² x 2.0 ha). At the same conversion factor as for inside the walls, this represents 13,399 person-years of occupation (95.4 x 140.45).

4.2) If the ratio of people living inside the walls to those living outside the walls remained constant through both sub-phases of the Kamennyi Ambar occupation, then these person-years of occupation outside the walls can be divided between the two sub-phases in the same proportions as inside the walls. Inside the walls 85% of the total person-years of occupation pertain to sub-phase 1-1 (35,880 sub-phase 1-1 person-years divided by 42,260 total person-years). And the remaining 15% of the person-years of occupation inside the walls pertain to sub-phase 1-2. Applying these proportions to the person-years of occupation outside the walls yields 11,389 person-years for sub-phase 1-1 (85% of 13,399) and 2,010 person-years for sub-phase 1-1 (15% of 13,399). Since sub-phase 1-1 lasted some 78 years, the average estimated population outside the walls during that phase would be 146 if they lived there year-round (11,389 person-years/78 years). During sub-phase 1-2 the average estimated population outside the walls would be 91 if they lived there year-round (2,010 person-years/22 years). If these populations represented herders who lived outside the Kamennyi Ambar walls only six months of each year, then it would take twice this many to accumulate the amount of garbage (i.e. sherd) deposition calculated. Thus, the estimated average population outside the walls during sub-phase 1-1 would be 292 and that during sub-phase 1-2 would be 182.

5) Finally, the error range estimated for the inside can be added to the estimate of the outside population. Above, it was suggested that the inside population of sub-phase 1-1 could vary between 276 and 644 people with the median of 460, or 460±40%. The error range of 40% yields the final estimation of 292±117 for sub-phase 1-1 and 182±73 for sub-phase 1-2. In sum, the sub-phase 1-1 population outside the walls is estimated at between about 200 and 400, and the sub-

phase 1-2 population outside the walls at between about 100 and 250 based on the accumulated ceramic deposition. To the extent that some of the ceramic deposition outside the walls is attributable to the activities of those who lived inside the walls, then these numbers would need to be reduced somewhat. Consistent with arguments presented above in Chapter 2, however, a substantial majority of the cultural deposition outside the walls seems attributable to people in residence there.

The summary of the demographic model is in Table 3.7.

Table 3.7 Estimated population at Kamennyi Ambar based on the area-density index

	Sub-phase 1-1	Sub-phase 1-2
Inside	460±184	290±116
Outside	292±117	182±73

The estimated population can be validated with the ethnographic data. Thus, nowadays herders in Mongolia still utilize mobile homes (yurts) on seasonal basis. The distances between yurts in camps can be measured on Google Earth and a median value estimated. Applied to the cultural layer's area of 2 ha, such value allows approximating the number of yurts that could be placed around Kamennyi Ambar.

Thus, 13 locations it total were found on the satellite images on the northern outskirts of the modern City of Ulaanbaatar. Yurts tend to group together in units of 3-4 tents, and groups might be spread hundreds of meters from each other. The distances were measured within such small groups to eliminate the bias of the large values in the calculation. The sample of 34 measurements has a median value of 38±8 m (at 95% CL).

The average radius of a modern Mongolian yurt is 2.9 m (Mauvieux et al. 2014), so the spacing of 38 m between such structures allows 18 of them on the area of 2 ha. The area inside one tent is 26.4 m², that is enough to host a family of 6–12 people, as estimated for the houses inside the walls. Thus, the population of such a camp can be estimated as between 108 and 216 people.

Two methods based om the area of the cultural deposits independently indicate that the seasonal population around Kamennyi Ambar was between 100 and 400 individuals. However, the estimate based on the ceramic densities could be skewed to the higher side by the unknown proportion of the garbage deposited from the inside, and the total estimated area could be used for other purposes besides living. In addition to the estimate above, the upper constraint for the population can be set by applying the logic of the calories-animal model, as was done for the estimation of people inside the walls, also assuming that the animals needed for the outside

population lived in the houses during the wintertime. Table 3.8 summarizes the calculations for different configurations of the population outside the walls and inside each house of the walled core. It is quite clear that a population above 200 people would require a larger number of animals and significant barn area to keep them in the winters. Moreover, with the average of 10 people inside each house, people would run out of living space if the inside community was even slightly more than 200 persons. Thus, this size of the outside population seems to be the most plausible.

Table 3.8 Animals and barn area to support the outside population and the available living space for the families inside the houses

Number of people – total kcal	Cows with calves	Sheep with lambs	Horses with foals	Additional barn area, house/m²	Average living space available for the families of variable size after adding additional animals need to maintain the outside population, m²							
					4	6	8	10	12	14	16	18
100 – 58,400,000	340	260	40	42.8	39	22	14	9	6	4	2	0
200 – 116,800,000	680	520	80	85.7	29	14	18	5	2	1	-1	-2
300 – 175,200,000	1,020	780	120	128.5	20	7	3	0	-1	-2	-3	-5
400 – 233,600,000	1,360	1,040	160	171.3	10	0	-2	-4	-5	-5	-6	-7

Finally, the additional animals require additional fodder. The catchment zone around Kamennyi Ambar with a radius of 4 km yields approximately 9,010.5 t of forage per year. If the inside population during sub-phase 1-1 was 460 people, their herd required 7,948–12,144 t/year of fodder. Combined together with the demand in fodder for the animals of 100 people, the total need increases to 13,872–14,784 t/year of fodder, as evident from Table 3.9 below. Thus, the catchment zone constrains the population estimate for the inside and outside to their lower limits (276 people inside and 175 people outside during sub-phase 1-1 and 174 people inside and 109 people outside during sub-phase 1-2).

Table 3.9 Total forage needed to support inside and outside populations

Number of people	Minimum forage demand, t/year	Maximum forage demand, t/year	Total forage needed to support population of 46 houses inside depending on the family size and people outside depending on size of the population, t/year (min/max)							
			4	6	8	10	12	14	16	18
100	1,728	2,640	3,715 / 5,676	4,830 / 7,683	6,033 / 9,491	10.194 /11,106	11,905 / 12,817	12,940 / 13,852	14,941 / 15853	17,335/ 18,247
200	3,456	5,280	5,443 / 8,316	6,623 / 10,323	7,761 / 12,131	11,922 / 13,746	13,633 / 15,457	14,668 / 16,492	16,669 / 18,493	19,063 / 20,887
300	5,181	7,920	7,168 / 10,956	8,348 / 12,963	9,486 / 14,771	13,647 / 16,386	15,358 / 18,097	16,393 / 19,132	18,394 / 21,133	20,788 / 23,527
400	6,912	10,560	8,899 / 13,596	10,079 / 15,603	11,217 / 17,411	15,378 / 19,026	17,089 / 20,737	18,124 / 21,772	20,125 / 23,773	22,519 / 26,167

The above analysis proposes several scenarios of the demographic history at Kamennyi Ambar. Considering the walled core independently, 46 houses of sub-phase 1-1 could host 276 to 644 people with a median population of 460 persons, and between 174 and 406 people with a median population of 290 people during sub-phase 1-2. The calories-animal model that requires reserving house space to keep the animals suggests that the configuration of the average 460 people inside and additional 200 people outside is plausible as it leaves about 5 m² of living area per person inside the settlement (which is close to the cross-cultural average) and allows keeping all necessary animals. On the other hand, this configuration requires more fodder, consequently, a larger catchment area. The possible way to increase the pasture zone for the inhabitants of three settlements is to move their herds outwards, or towards the east for the community at Kamennyi Ambar and towards the west for the community at Zhurumbay (north and west directions are less possible since the river flows from west to east). However, another explanation could be that the settlements did not function simultaneously, and, thus, pasture zones were not limited by the catchment zones of the neighboring communities. If this was a case, then a configuration of 460±184 (70%) people inside and 200±80 (30%) people outside is the most probable as the demographic peak.

The caloric model logic applied to Konoplyanka and Zhurumbay allows arriving at an average of 210 and 300 persons inside of the two settlements, respectively. Then, the estimate of 30% outside brings the outside populations to 63 people at Konoplyanka and 90 persons at Zhurumbay. The summary of the demographic modeling is in Table 3.10. In the table, inside populations are calculated for the range of 8–12 people per house, medians for outside people as 64% of the inside population ± the error range of 40%).

Table 3.10 Summary of the demography modeling for three Sintashta-Petrovka settlements

	Inside, minimum	Inside, median	Inside, maximum	Outside, minimum	Outside, median	Outside, maximum
Kamennyi Ambar, sub-phase 1-1	246	460	644	180	297	414
Kamennyi Ambar, sub-phase 1-2	174	290	406	107	182	255
Zhurumbay	240	300	360	116	192	266
Konoplyanka	168	210	252	80	134	188

The estimates arrived at are based on various assumptions, and thus should be treated as relative approximations. However, the estimated populations do not deviate from the population

of 50 Arkaim's houses, proposed by Kohl (400) and Epimakhov (600–800). The estimated demographic level of the Sintashta-Petrovka society also fits the estimate of the size of the sedentary community of Hongshan societies of eastern Inner Mongolia (150–600 people). The evaluation of the outside population based ion the ceramic densities (about 60%) is larger than the 30% of regional population calculated by Sharapov (2017:146) for Sarym-Sakly (311–464 persons inside and 147–221 outside). However, since this model likely overestimates the total number of people, the actual number is closer to the one proposed for the Zingeyka Valley.

The archaeological basis to discuss population dynamics of a local community during the Late Bronze Age can be found only at Kamennyi Ambar, where two horizons are distinguished stratigraphically. The early horizon Sintashta-Petrovka was discussed in detail above. In the Srubnaya-Alakul' phase 2, the number of houses decreased to 10–12, and their average size also dropped significantly from the average of 239.7±18 m² to 163±41 m², judging from the modern surface area of the house depressions, measured during the micro-topographic survey. If the subsistence practice of extensive herding did not change during the Late Bronze Age, a similar approach could be employed to estimate the number of inhabitants of the Srubnaya-Alakul' buildings. Thus, the average living area for a family of 10 would be 4.9±4 m² per person, which is below the worldwide average and allows very little living space in the smaller dwellings. On the other hand, the family of six would have 8.6±4.1 m² of living area per person available, which is reasonably close to the Brown's average of 6.1±1.4 m²/person. Thus, the average population of the Srubnaya-Alakul' phase 2 building is 6, and the total number of village inhabitants is 60–72.

At first glance, the Kamennyi Ambar local community demonstrates negative population dynamics and a significant drop in the inhabitants from 400–1,000 to 60–70. All three settlements of the Sintashta-Petrovka phase total to the population of about 1,300-2,800 people, with a median value of about 2,050 individuals.

According, to Kostyukov's (1993) pedestrian survey and Batanina and Levit's (2008) analysis of aerial photography, there are at least fifteen settlements of the Srubnaya-Alakul' phase in the river valley (Table 3.11; Fig. 1.3). Kostyukov's report provides data on the areas of house depressions allowing calculation of the average areas and application of different population indexes. Thus, most villages seem to be relatively consistent in their attributes. However, houses at Zhurumbay-1 and Karagayli-26 are on average larger allowing higher population estimates.

Table 3.11 The phase 2 settlements in the Karagaily-Ayat Valley

	Culture	Number of Depressions	Average house area (m2)	Population index	Population	Reference
Konoplyanka 1	Srub-no-Al-akul'?	13	?	6	78	Batanina and Levit 2008
Varshavskoye-1	Alekseye-vo-Sarga-rinskaya	8	137±30	6	48	Kostyukov 1993
Zhurumbay-1	Srub-no-Alakul'	8	242±59	10	80	Kostyukov 1993, Batanina and Levit 2008
Varshavskoye-3	Srub-no-Alakul'	9	132±58	6	54	Kostyukov 1993
Varshavskoye-5	Srub-no-Alakul'	9	122±49	6	54	Kostyukov 1993
Varshavskoye-9	Srub-no-Alakul'	4	184±49	6	24	Kostyukov 1993
Kamennyi Am-bar-8	Srub-no-Alakul'	4	49±66	6	24	Kostyukov 1993
Kamennyi Ambar	Srub-no-Alakul'	12	163±41	6	72	–
Elizavetpo-lskoye-3	Srub-no-Alakul'	7	158±88	6	42	Kostyukov 1993
Elizavetpo-lskoye-2	Petrovka/ Alakul'	Not recorded	–	–	–	Kostyukov 1993
Karagayli-26	Petrovka/ Alakul'	3	469±338	10	30	Kostyukov 1993
Elizavetpo-lskoye-7	Petrovka/ Alakul'	9(?)	?	6	54	Kostyukov 1993
Elizavetpo-lskoye-9	Srub-no-Alakul'	9(?)	?	6	54	Kostyukov 1993
Yuzhno-Step-noyi (1)	Srub-no-Al-akul'?	7	?	6	42	Batanina and Levit 2008
Yuzhno-Step-noyi (2)	Srub-no-Al-akul'?	10	?	6	60	Batanina and Levit 2008
Total		100			716	

The supra-local population of the valley that lived in the permanent houses, thus, sums up to 716 people. However, there is no reason to think that the relatively more mobile population disappeared at that phase. Allowing the same proportion of 60%, estimated for the phase 1, the number of less visible people ends up at about 430 people. In other words, the total population of the valley in the Srubnaya-Alakul' phase could be about 1,100–1,200 persons, or lower than the possible maximum in phase 1. Nevertheless, the drop of the population is not significant, and the population ranges of two phases intersect enough to say that human demography remained

relatively stable during the Bronze Age. Intriguingly, in the neighboring valley of the Zingeyka river, the population model suggests a different story with an increase in the number of people during the later phase up to 2,000–3,000 individuals (Sharapov 2017:84). Due to the different methodological nature of these two estimates (full coverage survey in the Zingeyka Valley versus counting the houses in the Karagaily-Ayat valley), the above number of 900–1000 persons for the Karagaily-Ayat valley should be thus taken as a lower limit, and the possibility that the actual number was higher should be kept in mind.

3.2 BUILDING A SETTLEMENT

3.2.1 Reconstruction of an Enclosure

Understanding of the social forces responsible for creating the fortified settlements demands knowledge of the available labor force and efforts needed for the collective projects. In other words, the questions of whether 300–600 people are enough to build the average settlement and how long it would take are at the core of learning about the society. However, the preceding logical step is a reconstruction of the primary features of the typical Sintashta-Petrovka village. Luckily enough, well-excavated sites demonstrate a lot of similarities regarding their architecture and interior design, so knowing attributes from the excavated sites leads to the rational reconstruction of less studied ones. Moreover, the modern techniques of remote sensing add crucial pieces of information, allowing learning from micro-topography of the sites and their geophysical characteristics.

According to Zdanovich and Batanina's interpretation of the aerial photography, Kamennyi Ambar was surrounded by an impressive fortification system of inner and outer walls with a ditch between them. The wall's overall base width is 9 m (Zdanovich and Batanina 2007:96–103). The micro-topographic survey conducted at the settlement did not support this description. According to the map, the settlement was surrounded by a single wall with a ditch outside it. Excavation at the site indicates that the base of the wall had a width of 4–5 meters, however, its height is a

more complicated matter. The sample of heights ($n = 30$) derived from the micro-topography allows saying that the modern height of the wall is only 0.24±0.06 meters (95% CL), evidently, the result of post-depositional taphonomy. An interesting attempt to reconstruct the wall's height was undertaken by the excavators of the enclosed settlement. They constructed an embankment and covered its surface with stone slabs that originally served as wall facing. The height of the reconstructed facing became 1.5 m, but it was suggested that the ancient wall reached 2 m in height (Krause and Koryakova 2013:95).

Another approach to reconstructing the height of the rampart was suggested by the investigators of the settlement of Sintashta. They assumed that earthen body of the original wall equals the volume of the ditch, thus making possible an estimate of the wall's height (Gening et al. 1992:32). The method to solve this problem mathematically was developed for reconstructing the Iron Age fortresses in the Altai Mountains region (Kyzlasov 2011). Assuming that the shape of the trench is a split cylinder, the formula for volume is:

$Vsc=(\pi R^2 H)/2$ (3.1)

However, the required value of the problem is the radius of the cylinder (R), that represents the height of the wall. The height of cylinder (H) and volume (V) can be derived from the archaeological investigation, like length and volume of the corresponding ditch (Fig. 3.2). Thus, the formula for estimating the wall's height takes the form:

$R=\sqrt{(Vsc/\pi H)}\times 2$ (3.2)

According to the map of magnetic anomalies, the length of the Kamennyi Ambar's ditch in phase 1 is 471 m, its depth is 1.5±0.5 m, and its width is 2.6±0.3 m (at 95% CL). Solving formula 3.1, the estimated volume of dirt excavated from the ditch varies from 710 to 2899 m³ with a mean value of 1620 m³. The mean wall width, as measured on the map of excavation, is 4±0.5 m. The shape of the wall as similar to a shape of half-cylinder can be justified by the cross-section from Excavation 8. As can be seen in Figure 3.3, the remains of the earthen wall resemble a half-cylinder form, which was designed in this way to prevent the wall from collapsing.
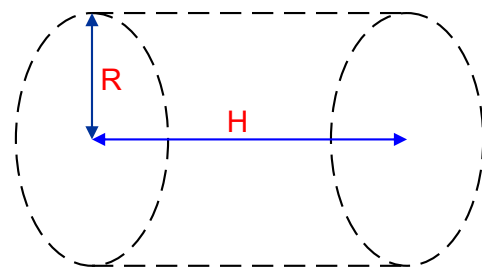
Figure 3.2 The dimensions of cylinder to solve the problem of wall's height

Solving formula 3.2 for all three variables, one obtains the values of radius, or the wall's height: 1.4 m (minimum); 2.1 m (average) and 2.8 m (maximum). The results of calculations are in Table 3.12.

Table 3.12 Estimation of the wall height at Kamennyi Ambar

	Ditch depth (95% CL)	Volume of ditch	Half-radius	Wall height (radius)
Minimum	1.0	710	0.7	1.4
Average	1.5	1,620	1.0	2.1
Maximum	2.0	2,899	1.4	2.8

Another way to estimate the wall height is the estimation of the volume of soil of the actual excavated area in the northern part of Excavation 8 (Berseneva 2014:53–54; Fig. 3.3).

The basic assumption is that remains of the ruined wall filled the ditch, and the sum of the volumes of foundation and filling represents the actual volume of the wall. The first step is model-
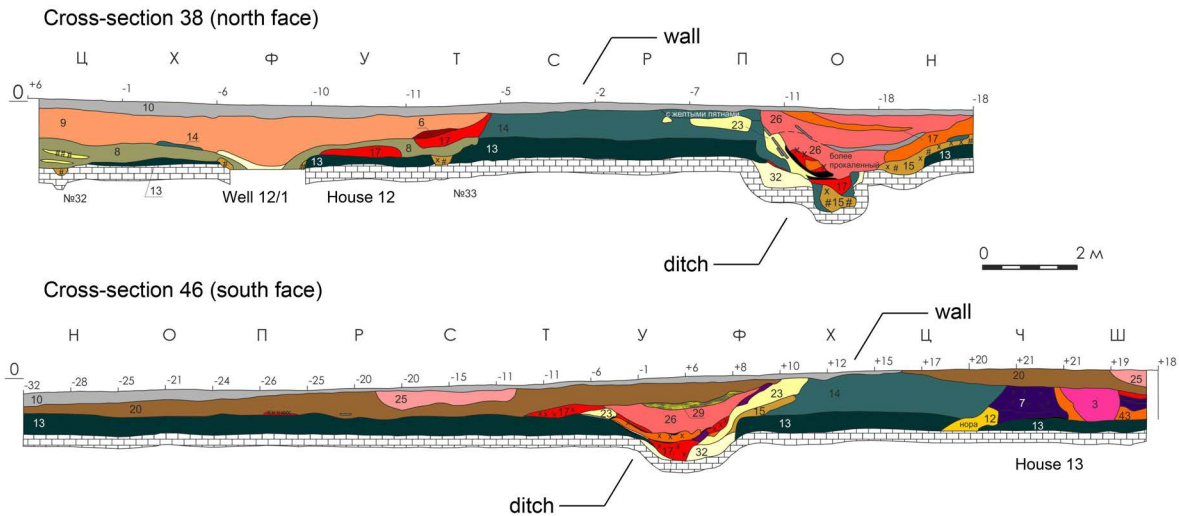
Figure 3.3 Excavation 8 at Kamennyi Ambar with the ditch and wall visible (modified after Berseneva 2013:156)

ing of earthen filling in the northern part of the unit. This 3-dimensional object was modeled using Autodesk AutoCAD 2017 software that provides tools for modeling and calculates a volume of any complex three-dimensional shape. The body of soil intersects the foundation of the wall and the ditch and is limited by two overlieing horizontal surfaces. The horizontal dimensions of the model are 12 m (*x*-axis) by 4 m (*y*-axis). The top surface is the micro-topography of the modern ground level prior to excavation. The bottom surface is the level of the wall's foundation and outlines of the ditch, as recorded by excavations. The model suggested that the body of soil between two surfaces corresponds to 35.7 m³ (Fig. 3.4).

The second step is creating the 3-dimensional object of comparable volume that can represent an embankment, shaped like an oval half-cylinder. The dimensions of the wall's part in the modeled area are 4.5 m (width) and 4.8 m (length). Once these aspects are applied to the modeled volume of 35.7 m³, an object with a height of about 2.6 m can be created (Fig. 3.5). This number is the estimated height of the wall in this part of the settlement.

It is important to note that the estimation is extended to the entire site, because the difference between the wall walk and the modern-day surface outside is 0.3 m. This value is at the upper limit of the error range for the present-day wall height, as derived from the map of micro-topography (0.24±0.06 m). This comparison suggests that at the modeled part the wall was least destroyed. Thus the estimate of the volume of soil fill is the most reliable. After adding the error range derived from the present-day height, the height of the ancient wall can be established as 2.6±0.65 m (the error range is ±25% of the mean value, so the calculation of 25% of 2.6 allows to add the error of 0.65).

In sum, three methods independently suggest that the actual height of the wall at Kamennyi Ambar lies in the range between 1.5 and 3 m.

The construction of a house is a less complicated issue since the main features of the houses are well studied at Sintashta, Arkaim, Ust'ye and other fortified settlements. According to the map of magnetic anomalies, at Kamennyi Ambar, the mean house area is about 240±18 m² (at 95% CL) (the numbers derived from the magnetic map are rounded down to the closest ten). The houses had a post-and-plank design, and Koryakova and Kuzmina's (2017) reconstruction of the House 5 provides the average distance of 3 m between posts. Together with the average area, this makes it possible to estimate an average number of 26±2 posts per house. With the average diameter of a post taken as 0.4 m and height of 3 m, the volume of wood needed for posts per house equals 10.5±0.8 m³. On the materials from Bronze Age Denmark, Coles (2006) has suggested that the use of woven panels is one of the most efficient ways to construct the inner walls and estimated that one panel of 3 m x1.5 m takes 1 hour of work of a skilled worker. According to this estimation, the average house at Kamennyi Ambar would need 22 such panels to construct the inner walls. Finally, each house had wells. Examples from Ust'ye and Sintashta suggest that usually there are two wells per house, though at Kamennyi Ambar the situation is more complicated. Some houses can have as many as seven wells. However, such numbers
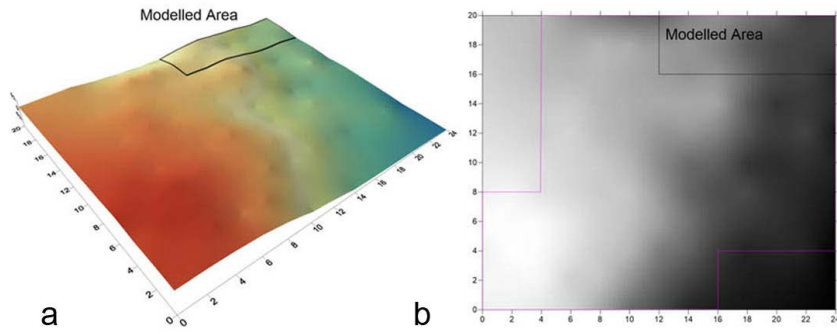
Figure 3.4 Digital models of Excavation 8

a – 3-D model of the modern surface before excavation

b – 2-D model of the modern surface before excavation

c – 3-D model of the excavated surface showing the ditch and the modelled volume between two modelled surfaces
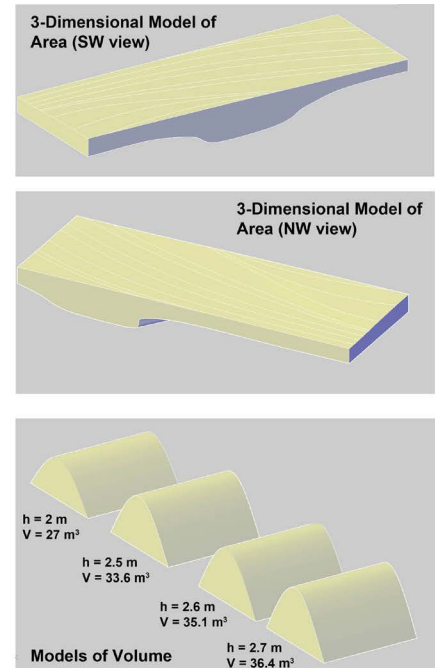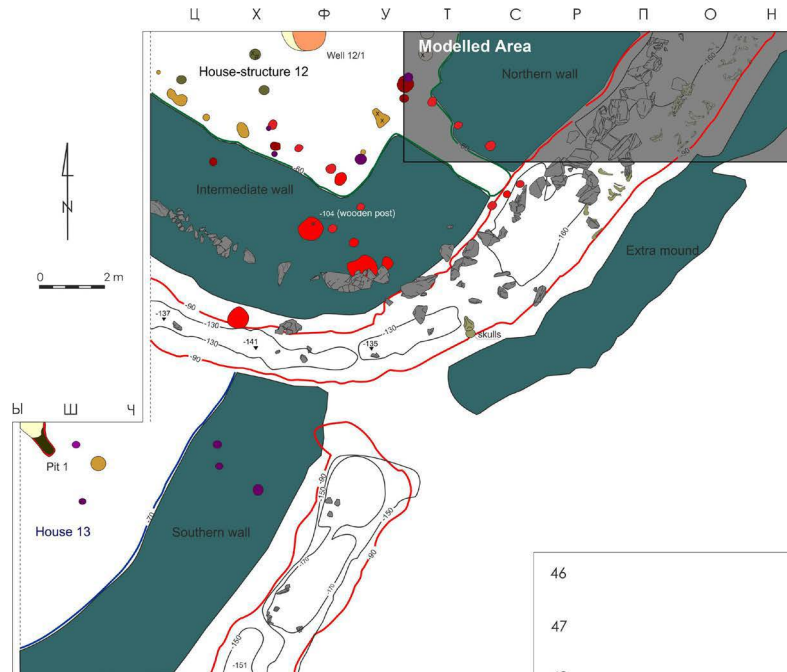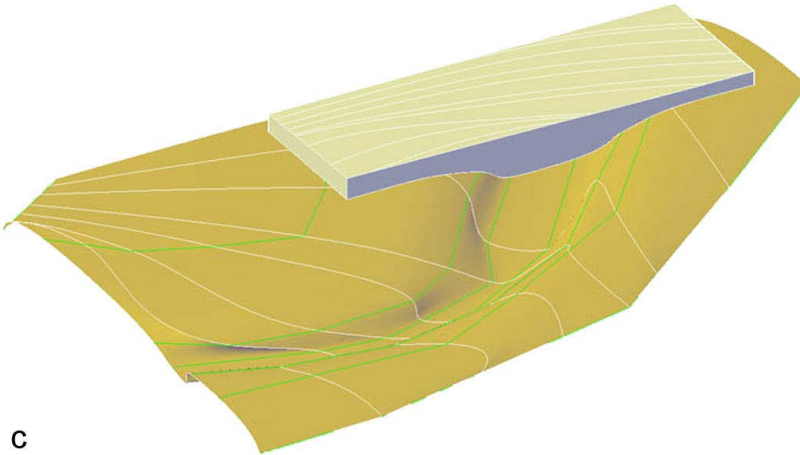
Figure 3.5 Map of Excavation 8 (modified after Berseneva et al. 2015) (left), 3-dimensional models representing the volume between the modern surface and the bottom and models of the volume (right)

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should be disregarded as examples of replacing damaged wells. With an average radius of 0.5 m and an average depth of 3 m, each well has a volume of 2.4 m³.

The variables discussed above provide initial data for estimation of the labor force and effort needed to construct the three settlements of the Karagaily-Ayat valley.

3.2.2 Estimation of Labor Force and Effort

Investment in public works provides a collective with material well-being using protection or effective production and also allows inspired individuals to promote their statuses through project planning and organization (Drennan and Peterson 2012:74–76; Peterson and Drennan 2012:122–124). The organized and nucleated Sintashta settlements demonstrated pre-planning and organization of collective effort since the construction of the houses would require the simultaneous erection of the wall and excavation of the ditch for the material. However, what were the labor demands and necessary time to build a settlement? The answer to this question sheds light on the magnitude of the burden that the community experienced during the construction project.

The most direct way to estimate the amount of work is to build a settlement, which is also a quite impractical thing to do. Instead, a combination of data from numerous archaeological experiments allows a rough estimation of person-days needed for the building of such a project. In other words, initial time parameters were derived from the archaeological or other special literature and put together into the model that allowed the estimation. Importantly, the approach does not aim to calculate an exact number of people, materials and days needed to build a settlement, since all initial parameters are not available anyway, but the goal is to estimate the scale of the project. Did it require 50 people and a month to build Kamennyi Ambar or did the project demand 5,000 workers and five years? Placing the estimate in relation with these extremes is the reasonable way to learn about the capability of leaders to mobilize collective labor.

Estimation of the labor force is based on the following variables:
- the number of cubic m of earth dug for the initial house pits;
- the number of trees needed for the posts;

- the time required to cut the trees, to move them into the construction area, to erect the inner walls and dig two wells per house;
- the number of cubic m of earth dug for the ditch;
- the energy needed for preparation and bringing to the construction area the slabs of granite necessary to face the side of the surrounding wall;
- the number of cubic m of earth to erect the embankment.

Then, the initial settings were calculated following data provided by the principal investigators of Kamennyi Ambar directly or derived from the field reports (Table 3.13).

Table 3.13 Initial data used for estimation of labor effort needed to build Kamennyi Ambar

	Variable	95% error
Average volume of a house pits (based on interpretation of magnetic map and excavated houses), m³	120	9
Average number of posts per house	26	2
Volume of wood posts per house, m³	10.5	0.8
Weight of posts per house (800 kg/ m³)	8,388	640
Number of woven panels (3 m by 1.5 m) for inner walls per house	22	0
Volume of a well, m3 (two wells per house)	2.4	0
Volume of the ditch, m³	1,833	82
Max. estimated volume of the surrounding wall, m³	5,798	0
Volume of granite slabs for the wall face, m³	141	0
Weight of granite slabs, kg (specific gravity 2,900 kg/m²)	40,977,0	0

The initial data to calculate investment in each kind of work primarily were derived from the experimental work of Erasmus (1965), Semenov (1968), Pozorski (1980), Abrams (1994) and Coles (2006). Labor investment coefficients used for modeling are presented in Table 3.14.

Table 3.14 Model inputs for calculation of amoung of labor for constructing a settlement

Work	Input	Measurement	Reference
Construction of rock and clay fill, person-day	5.5	m³	Erasmus 1965; Pozorksi 1976
Excavation of earth, person-day	2.6	m³	Abrams 1994
Excavation of rocks, person-day	7,200	kg	Abrams 1994
Transport of rocks 500 m, person-day	500	kg	Erasmus 1965
Tree cutting (diameter of tree is 40 cm)	1	hour	Semenov 1968
Transportation of trees 2000 m, person-day	125	kg	Abrams 1994
Wooden panel making, hours per panel	1	hour	Coles 2006
Post-and-planks house construction, person-day	60	day	Koryakova and Kuzmina 2017; personal experience

Calculation with the variables and inputs presented in the tables allows an estimate of a total of 10,284±427 person-day needed for construction work to erect a settlement that would

look like the one at Kamennyi Ambar in sub-phase 1-1. Hence, a collective of 100 people would be able to build the enclosed settlement in a matter of 102±4 days. Konoplyanka and Zhurumbay provide less information for input. However, essential variables like length of ditches and number of houses can be estimated in both cases by the magnetic plans. Keeping the rest of the constraints as they were input to the Kamennyi Ambar model, the resulting numbers for Konoplyanka and Zhurumbay are 5,070±271 and 6,117±363 person-days, respectively. In other words, construction projects at these two sites could be conducted in about 45–65 days by the collectives of 100 workers. Of course, the estimated period is too precise and exact to be true. However, the model allows saying that the settlement could be built during a season by a relatively small group of people who contributed their efforts to the construction project.

Importantly, the total amount of work required by the fortifications is significantly less than the total amount of work needed to build the houses. At Kamennyi Ambar, the construction of the wall and the ditch required about 2610 person-days, and about 2,100 person-days at Konoplyanka and about 2,500 person-days at Zhurumbay. At the same time, the models suggest that construction of an individual Sintashta-Petrovka house required between 90 and 180 person-days (126 is a pooled mean of three independent models). Presumably, the labor pool for building a single home was provided by the immediate inhabitants of the building, while the ditch and the wall were constructed collectively. Thus, the overall burden of the collective work was even less than the estimated values.

Demographic estimation for Kamennyi Ambar puts its entire population between 300 and 900 people, which makes it possible to think that the settlement could be built even quicker if the community faced risks of conflict or winter. This notion can also be supported by the fact that the Arkaim embankment was constructed in the second half of the summer, meaning that the first half was devoted to the digging of the pits for houses and the ditch (Prihod'ko et al. 2014:47). This suggests that the wall could be built in a very short time with more intensive labor (for example, the model suggests that at Kamennyi Ambar the ditch excavation and wall construction project requires about 2,110 person-days; the collective of 300 people would be able to finish this work in about 7 days; and the average burden per person is 0.14 person-days). Overall, the estimated labor effort suggests that the construction project did not constitute a significant burden on the population since the overall magnitude is less than 1 work day per person per year. This estimate

is supported by the data from other regions and does not contradict the idea that the magnitude of the burden that a community experienced in realizing public works is not necessarily overwhelmingly high (Peterson and Drennan 2012).

To sum up, the estimation of the amount of labor suggests that the collective effort needed for the construction projects at the Late Bronze Age settlements in the Karagaily-Ayat valley was relatively little in comparison with work demanded by the building of habitational space of an individual family. However, the necessity to plan the work in advance was still there, since the settlements demonstrate simultaneous efforts in the construction of their enclosures.

3.2.3 Wealth Differentiation Between the Households

In Chapter 2, the differences in wealth between the inner and possible outer part of the population of Kamennyi Ambar have been discussed. The inside material assemblage demonstrates a higher degree of both richness and diversity and this led to the conclusion that the outside materials may represent a semi-mobile group of people who used significantly less durable materials and accumulated fewer possessions. Subdivision of the inside sample by households provides insight about possible wealth differentiation and economic specialization between the households (Table 3.15).

Table 3.15 The artifact assemblages from the houses at Kamennyi Ambar (extracted from Krause and Koryakova 2013:146–169)

	House 1 (phase 1)	House 2 (phase 1)	House 4 (phase 1)	House 5 (phase 1)	House 3 (phase 2)	House 6 (phase 2)
Abrasives, grindstones	13	7	1	5	3	0
Arrowheads	2	2	1	0	0	0
Bronze ingots	0	1	0	1	0	0
Bronze knifes	0	1	0	0	1	0
Cheekpieces	0	2	0	0	0	0
Clamps	1	4	0	0	0	1
Crystals of quartz	0	2	0	2	0	0
Flakes, lithics	4	7	3	0	5	0
Hammers	1	1	0	1	0	0
Household objects	9	13	4	10	15	2
Metal and bone leather tools	5	10	4	6	1	1
Metallurgy waste	17	27	1	11	6	0
Molds	1	1	1	1	1	0

Ochre and hematite	0	0	0	0	0	0
Ore	1	16	6	14	1	4
Ornaments	2	3	0	2	0	0
Pestles, plates, anvils, adze	5	9	3	2	1	0
Polishers	0	0	0	0	0	1
Pottery with slag remains	0	0	0	0	0	0
Slag	25	36	3	27	16	0
Spindle whorls	0	7	2	6	12	3
Stone axes	0	0	0	1	0	0
Stone discs	6	16	2	14	4	1
Talc objects	65	7	5	5	0	3
Where: phase 1 = Sintashta-Petrovka phase 1; phase 2 = Srybnaya-Alakul' phase 2						

First, the artifact assemblage from the inside can be consolidated into groups as household items, tools of different industries, weapons and luxury possessions. Specifically, four groups can be distinguished, which are 1) bone-working tools, 2) tools for ceramic production (polishers, talc objects, metal clamps), 3) individual decorations and crystals of quartz, 4) house-hold items (stone disks, flakes and lithics), 5) bone tools for leather-working, 6) tools for metal working, production of metals (hammers, pestles, molds, abrasives) and objects, related to the process (petrified ceramics, ore, ingots and waste), 7) textile production tools (spindle whorls) and 8) weapons and status-related objects (arrowheads, cheekpieces, stone axes).

As is evident from Table 3.16 and Figures 3.6 and 3.7 there are differences among the four buildings attributed to the Sintashta-Petrovka phase (Houses 1, 2, 4 and 5). House 1 demonstrates the highest proportion of tools and objects, related to the ceramic production (42%), and a comparable amount of the metallurgy artifacts (38%). While evidence of metallurgy is abundant in other buildings, the tools of ceramic production are in the highest proportion in comparison to other buildings, suggesting that it could be a specialized activity. The household items are less abundant in this artifact assemblage (13%) and smaller in proportions in comparison with the houses 2 (22%) and 5 (22%). Other types of artifacts also have relatively small proportions. Moreover, House 1 is also the smallest of all excavated buildings with an area of 136 m², suggesting the possibility of non-residential productive specialization of the building.

House 2 demonstrates the highest proportion of metal production tools and artifacts, including waste and pieces of ore (56%). The percentage of household items (22%) is comparable
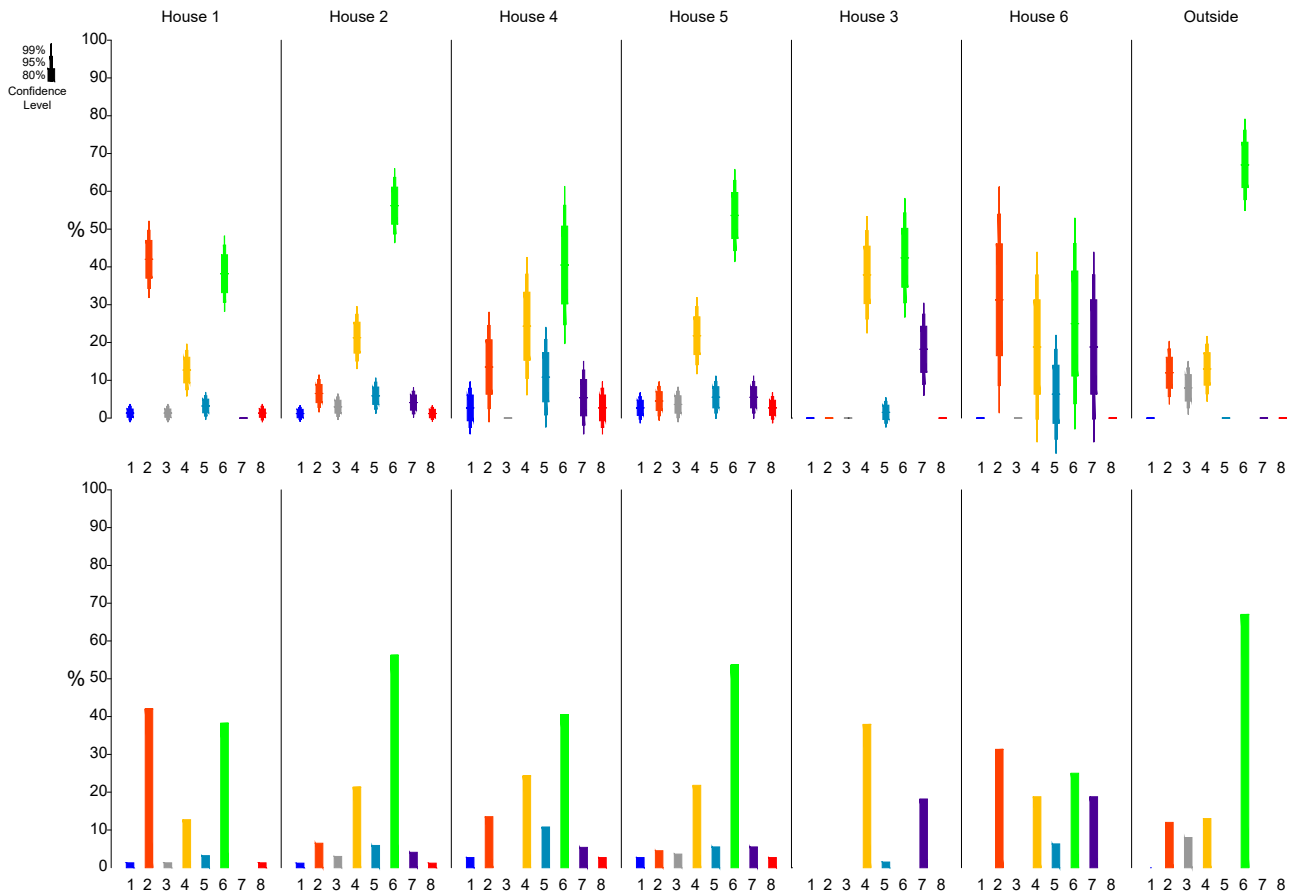
Figure 3.6 Proportions of artifacts of principal categories yielded by six houses at Kamennyi Ambar
1 – bone-working tools; 2 – ceramic production tools; 3 – decoration; 4 – household items; 5 – leather-working tools; 6 – metallurgy production; 7 – textile production tools; 8 – weapons and cheekpieces

with houses 4 and 5. The artifact assemblage of House 2 consists of 3% non-utilitarian objects like three ornaments, two crystals of quartz, which is the second-ranked proportion after house 5.

House 4 has the high proportion of metallurgy-related objects (41%), the highest proportion of leather-working tools among all houses (11%) and the second-ranked proportion of clay-modeling tools (14%), suggesting some degree of specification of the inhabitants in these crafts.

In general, House 5 is a complicated palimpsest of three construction phases, but the artifact assemblage cannot be meaningfully separated (Koryakova and Kuzmina 2017). Nevertheless, the assemblage replicates the composition of objects found in House 2, with the significant difference that the most precious objects clearly associated with the social elites were found

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there. These objects are two cheekpieces that were used in the bridles of chariot horses and a stone axe.

Houses 3 and 6 are dated to the following phase 2 and demonstrate a significantly different structure of material assemblages, including lower proportions of metallurgy-related objects and absence of non-utilitarian tools and luxury possessions.

The comparison suggests that House 1 was a relatively poor household specialized in ceramic production, which is not a typical activity for other households. Houses 2 and 5 both represent a focus on metal-working, but findings of luxury goods in House 5 suggest that at least some degree of social differentiation can be seen in the household assemblages. House 4 replicates the assemblages from Houses 2 and 5, but with possibility of specialization in craft production.

Excluding the most abundant metallurgy-related objects from the analysis supports the above conclusion: house 1 has the most abundant ceramic-production tools and fewer household items. At the same time, these everyday possessions are much better represented in houses 2, 4 and 5, sharing the similar proportions. House 5 demonstrates the highest proportions of weapons and status-related objects and decorations, suggesting that this household could be the richest among those studied.

Finally, two Srubnaya-Alakul' houses (3 and 6) demonstrate less specialized material culture with a focus on the every-day tools.

Table 3.16 Consolidated artifact assemblages from six houses at Kamennyi Ambar

(counts and column proportions)

	House 1 (phase 1)		House 2 (phase 1)		House 4 (phase 1)		House 5 (phase 1)		House 3 (phase 2)		House 6 (phase 2)	
	#	%	#	%	#	%	#	%	#	%	#	%
Bone-working tools	2	1	2	1	1	3	3	3	0	0	0	0
Ceramic production tools	66	42	11	7	5	14	5	5	0	0	5	31
Decoration	2	1	5	3	0	0	4	4	0	0	0	0
Household items	20	13	37	22	9	24	24	22	25	38	3	19
Leather-working tools	5	3	10	6	4	11	6	5	1	2	1	6
Metallurgy production	60	38	95	56	15	41	59	54	28	42	4	25
Textile production tools	0	0	7	4	2	5	6	5	12	18	3	19
Weapons, military and status-related objects	2	1	2	1	1	3	3	3	0	0	0	0
Total	157	100	169	100	37	100	110	100	66	100	16	100
Where: phase 1 = Sintashta-Petrovka phase 1; phase 2 = Srybnaya-Alakul' phase 2												
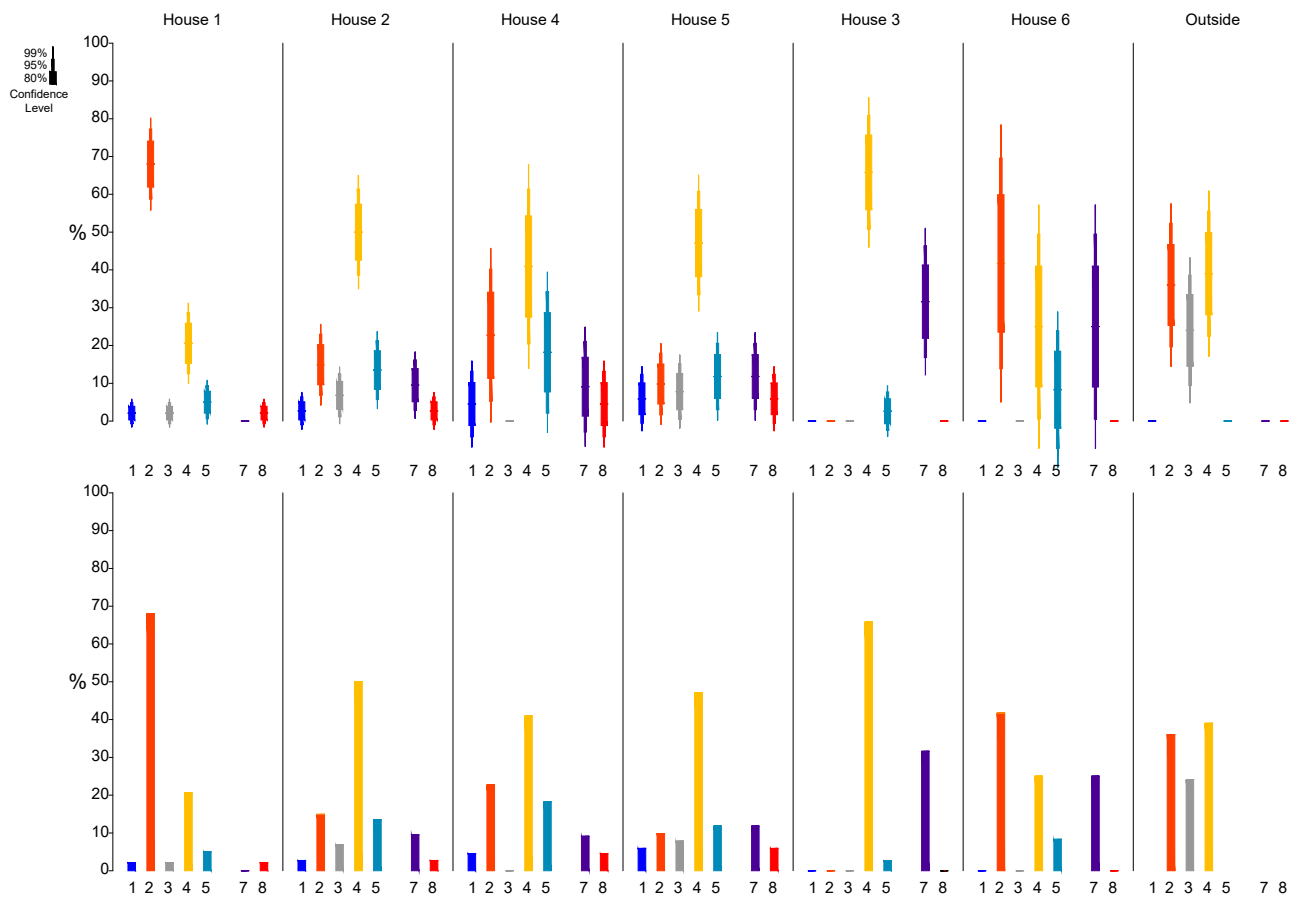
Figure 3.7 Proportions of artifacts of principal categories (metallurgy-related objects excluded) yielded by six houses at Kamennyi Ambar

The analysis of richness and diversity (Fig. 3.8) of the artifact assemblages demonstrates that the least diverse assemblage was in House 1 (0.78 with a 95% confidence interval between 0.72 and 0.82), which is also a smallest excavated dwelling with a total area of 144 m². Worth noting that its lower limit of the error range is uncomfortably close to the upper limit of the outside sample's index error range. In fact, at the 99% confidence level, these two error ranges overlap. However, houses 2 and 4 demonstrate significantly higher values of 0.9 (0.87–0.91 at 95% CL) and 0.92 for (0.86–0.93 at 95% CL), respectively. The cumulative value of House 5 is 0.89 (0.84–0. 90 at 95% CL). Houses 2 and 4 are also bigger in size, and it is possible to say that the diversity index increases with area (House 2 – 273 m², House 4 is about 260 m², and the total area of House 5 is 245 m²). The comparison can be done with the artefact assemblage from Ust'ye, discussed above in Chapter 1. The analysis of the Ust'ye data set revealed some differences between the houses in terms of productive activities and/or wealth.

Importantly, the strong differences between assemblages we might expect to see between commoners and leaders who were buried with chariots, sacrificed horses, bronze weapons, and insignia of power fail to appear. Similarly, at Kamennyi Ambar some households do demonstrate more diverse artifact assemblages than others, as well as bigger sizes, that could be related to differences in productive activities and/or wealth differentiation between families. The focus on specific objects of ceramic production in House 1 suggests some degree of productive specialization, while the elite goods in House 5 clearly point to the presence of elite members of the society.
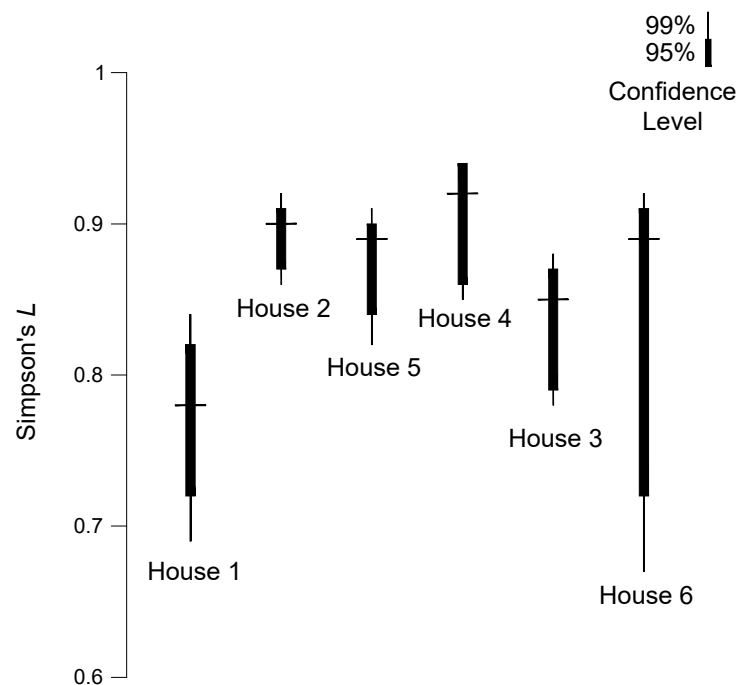
Figure 3.8 Richness and diversity indexes with the error ranges attached

3.3 COMPARING THE SETTLEMENTS

After the most fundamental features of all three settlements in the Karagaily-Ayat valley have been discussed, the settlements can be compared to each other to highlight their demographic dynamics. The summary of the key attributes is in Table 3.17.

Table 3.17 Comparison of the settlements during the Sintashta-Petrovka phase

	Area (ha)	Number of houses inside	Mean inside population	Mean outside population	Total population	Construction effort (person-days)
Kamennyi Ambar (phase 1-1 / sub-phase 1-2)	1.8/0.9	46/29	460/290	297/182	757/472	10,284±427
Zhurumbay	1.4	30	300	123	423	6,117±363
Konoplyanka	1.1	21	210	86	296	5,070±271

According to the study, Kamennyi Ambar was the largest center of all three during its sub-phase 1-1. It also required the largest investment in construction work, but a team of 100 people would be able to finish this work during one field season. However, at some point of habitation history, the community experienced a rapid decline due to unknown reasons. The population of the enclosed core decreased by half, leaving half of the previously enclosed core uninhabited.

Less is known about population dynamics of the two remaining communities, but the archaeological snapshots make it possible to judge the highest possible population numbers. In comparison, however, neither Zhurumbay nor Konoplyanka achieved the same level of population as the community at Kamennyi Ambar during its apex. The sizes of these two communities were more comparable to the size of Kamennyi Ambar during its sub-phase 1-2. In conjunction, the construction effort at these settlements was significantly lower and required either fewer people or less time.

There are two possible social scenarios that explain the settlement situation during the Sintashta-Petrovka phase. The first scenario considers all three communities as simultaneous. The catchment zone analysis, discussed above, concluded that the ecological niche was barely sufficient to provide enough biomass for all three villages to maintain caloric requirements, but it would not have been impossible. In this case, Kamennyi Ambar at its apex would seem the regional population center attracting more people and forming a more complex societal construct. Therefore, a greater labor force would be available for the local elites to construct more elaborate or larger architecture.

Nevertheless, no significant differences in architectural patterns are obvious for Kamennyi Ambar that would make it an outstanding population center that attracted more people by its special features, like temples or exceptional fortification. This fact suggests a second social scenario to explain population dynamics during the Late Bronze Age. It is possible to think about all three sites as the same community that moved around the landscape during the Late Bronze Age in order to keep the pasture grounds from degradation. The comparable sizes of all three communities during the sub-phase 1-2 of Kamennyi Ambar support this scenario, showing that this was certainly possible. Moreover, this scenario has more explanatory power if applied to the following Srubnaya-Alakul' phase, since it does not suggest rapid population decline between the two periods. To the contrary, the overall population of the valley would experience slight increase in numbers with 250–550 people during Sintashta-Petrovka times and 700–800 persons during the following phase.

3.4 SUMMARY

According to the Bayesian model of the Kamennyi Ambar chronology, the occupation of the fortified settlement lasted only about 100 years. The ceramic densities suggest that sub-phase 1-1, when the whole enclosed settlement area was occupied, took about 70–80 years, while sub-phase 1-2, when the southern part of the walled settlement was abandoned, lasted only for another 20–30 years, or so.

Based on the caloric requirements and available barn space model, the demography of the walled part of Kamennyi Ambar during sub-phase 1-1 is evaluated as between 276 and 644 people. The application of the same logic to Konoplyanka and Zhurumbay allows arriving at the range between 168 and 252 people and between 240 and 360 people living simultaneously within the two enclosures, respectively. The possible outside population of herders who lived near the settlements on a seasonal basis is estimated at about 40%–60% of the inside groups, which roughly agrees with the similar estimates for the Zingeyka River region. The total simultaneous population of the Sintashta-Petrovka period can be seen as either the sum of the population for the three settlements (between 1,300 and 2,800 people), or as the maximum for one of them (about 1,000 people for Kamennyi Ambar), since three settlements could represent the same community moving around. In the period of the Srubnaya-Alakul' culture, the local population at the walled settlements experienced a significant drop. However, the analysis suggests that the overall population of the valley remained close to or somewhat smaller than the previous Sintashta-Petrovka phase with a total of about 1,100–1,200 people in 15 recorded unfortified settlements.

Analysis of investment in public works for building a settlement suggests that any of them could be built in a matter of one season by 100 people, or by a relatively small group of people who contributed their efforts for a relatively short amount of time. Importantly, the total amount of work required by the walls is significantly less than the total amount of work needed to build the houses, suggesting that the overall burden of the collective work was less than that of family work. However, the necessity to plan the work in advance was still there, since the settlements demonstrate simultaneous efforts in the construction of their enclosures.

In terms of wealth and productive differentiation, the inside assemblage of Kamennyi Ambar demonstrates a higher degree of richness and diversity in its material assemblage, leading to the conclusion that the outside materials may represent a semi-mobile group of people who used significantly less durable materials and accumulated less possessions. As for the diversity within the inside artifact assemblage, some households at Kamennyi Ambar demonstrate more diverse artifact assemblages than others, as well as bigger sizes, that could be related to differences in productive activities and/or wealth differentiation between families. A focus on specific objects of ceramic production in House 1 suggests some degree of productive specialization, while the elite goods in House 5 clearly point out the presence of elite members of the society.

There are two possible social scenarios that explain the settlement situation during the Sintashta-Petrovka phase. The first scenario considers all three communities as simultaneous and the second scenario suggests seeing the three sites as the same community that moved around the landscape during the Late Bronze Age in order to keep the pasture grounds from degradation.

4.0 LIFE-STYLES AND SOCIAL ORGANIZATION IN THE LATE BRONZE AGE

4.1 PREDICTING A SETTLEMENT: HOW TO FIND THE BEST SPOT?

The previous chapters identified that the Sintashta-Petrovka local communities of the Karagaily-Ayat River Valley could have consisted of two segments of relatively settled inhabitants of the walled cores and more mobile groups of herders. The large Sintashta-Petrovka houses inside the walls were used for residence, but also as barns to keep communal livestock in the wintertime. However, many scholars tend to believe that security concerns and hostile social environments were the main reasons for erecting the surrounding walls of the settlements. To evaluate thr need for collective work in settlement construction and explore rationality beyond choosing a particular place on the terrain, this chapter will explore the natural environments of the Karagaily-Ayat River Valley and the settlement suitability for protection against natural disasters and unexpected attack.

4.1.1 Local Climate and Wind Prediction

Climatic conditions to a great extent determine the ways in which local communities live. The present-day environmental conditions in the region around the Karagaily-Ayat River Valley developed in the Holocene, approximately 11,700 years ago, and are characterized by cycles of relatively dry and cold conditions punctuated by wetter and warmer periods. In the region of study, the Ural Mountains influence the climate by blocking the flow of air from the west and south and
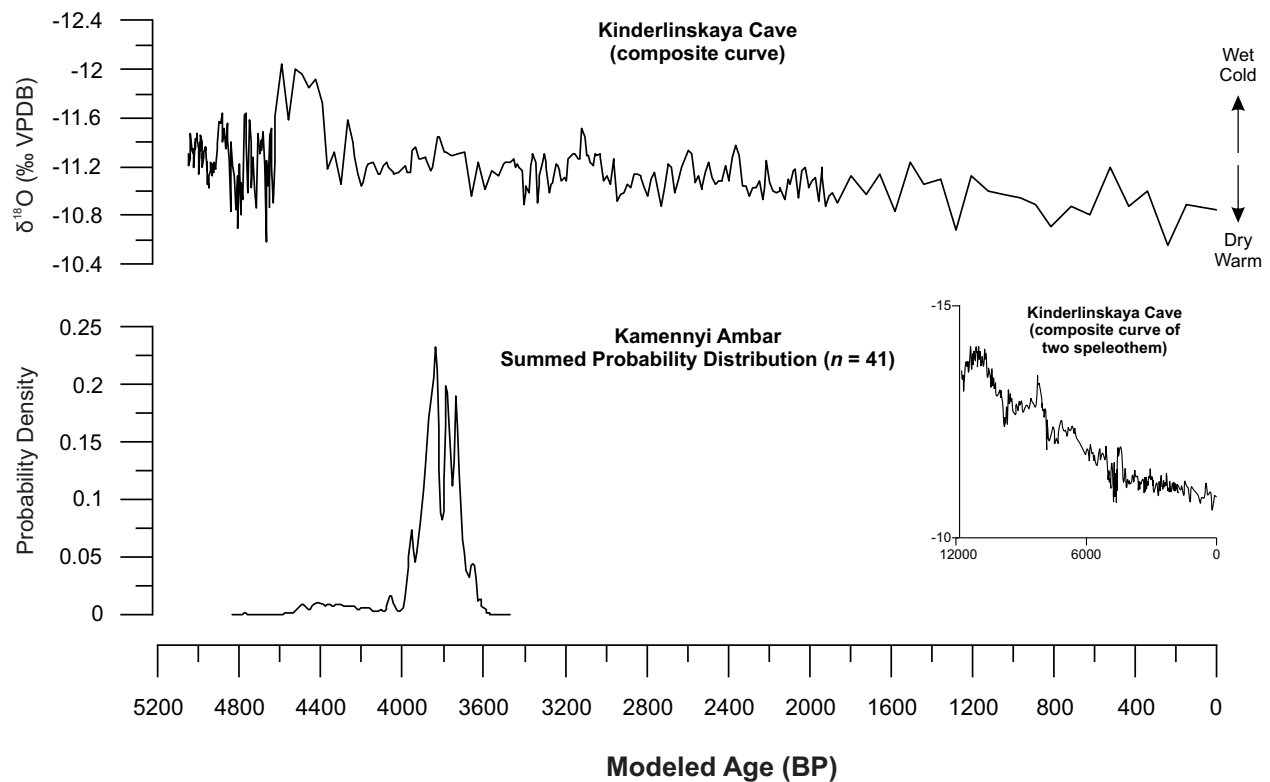
Figure 4.1 Climate change in Holocene

A composite curve of δ18O values from the Kinderlinskaya Cave in southern Urals (Baker et al. 2017) and summed probability distribution for Kamennyi Ambar (intersection suggest relatively of two curves suggest little change in δ^{18}O values since cal. 4000 BP and modern times)

providing a tunnel for cold and dry arctic air. In the summer, continental tropical air flows up from Asia, bringing hot weather. The present-day climate is continental, with mean temperatures below 0°C in winter and above +10°C during the summer months (Levit 2005).

Prior to analysis of past behaviors, the climatic conditions between 4,000 and 3,600 cal BP should be understood first. According to regional paleo-soil archives, the general climate of the southern Trans-Urals was dryer than today and dominated by southern chernozem soils (borolls), as opposed to modern common chernozem and steppe grasses (Tairov 2003:31). On the other hand, comparison of paleo-soils around Arkaim with similar analyses from northern Kazakhstan demonstrated only slight impact of drier conditions on the steppes of Transurals (Plekhanova et al. 2007:40). Stable oxygen isotope data (δ^{18}O) from two speleothems collected from the Kinder-linskaya Cave, located in the southern Urals, document a long-term trend of warming winter temperatures throughout the Holocene (Baker et al. 2017) (Fig. 4.1). Values of δ^{18}O are widely used

to track global changes in temperature through the resulting impact on the water cycle (Southon et al. 2016). Though Kinderlinskaya Cave is located on the western face of the Urals, comparisons to global paleoclimate records (e.g., Greenland ice sheet precipitation; Gajewski 2015) suggests that warming temperatures developed across broader portions of Eurasia throughout the Holocene.

To compare climatic conditions during the Late Bronze Age and the present day, the curve of composite $\delta^{18}O$ values (per mil VPDB) from the two stalagmites from the Kinderlinskaya Cave are matched with the summed probability distribution of forty-one radiocarbon measurements from Kamennyi Ambar (Fig. 4.1). The comparison suggests that the $\delta^{18}O$ values are slightly lower in the Late Bronze Age, reflecting dryer and cooler climatic conditions in the Urals. Additionally, Baker et al. (2017:434) estimated similar average annual winter (October–March) temperatures of approximately -10.5°C for both the present day and 4000 cal BP. Finally, pollen archives from the Karagaily-Ayat Valley suggest that the vegetation patterns are comparable with the modern, leading to the conclusion that at the local scale the climatic conditions of the Late Bronze Age were similar to the present (Stobbe et al. 2016:14).

Thus, consideration of three independent lines of evidence allows application of the present-day observations of average temperatures, wind speed and directions and seasonal water accumulation to model the general environmental conditions in the past.

Wind is a natural movement of air of any velocity on a large scale. In the global scale, it caused by the sun's radiation that heats up the atmosphere and the rotation of the Earth. In the northern hemisphere, the westerlies (anti-trades) are the prevailing winds, blowing from the west and southwest toward the east and northeast. The anti-trades play a crucial role in creating local environments and climate conditions of the Eurasian Steppes by carrying precipitation and warm air from the tropical zones. They cause much weather variation whenever there is a convergence of the warm and light northern westerlies and cold and denser polar winds (American Meteorological Society 2005). Regarding the comparison of the Late Bronze Age to the present day in the northern hemisphere, there are no other significant conditions like glaciers that would have changed the air flow during the Holocene.

At the local scale, the wind is responsible for the everyday life experience of humans and animals by bringing precipitation, damaging shelters, and moving dust and fire. The region of

study is windy with an annual average of 310 windy days. The maximum speed of the wind reaches 20–25 meters per second (72–90 km/h) (Levit 2005). The assumption made here is that in the past people chose to live in relatively calm spots of the local landscapes to prevent themselves from unpleasant or dangerous conditions. Then, modeling the wind conditions at the regional scale might provide a plausible explanation for settlement locations.

In order to model the local wind blow, the day-by-day raw data from the Arkaim meteorological station was used. This meteorological station is the closest to the research area, located only about 60 km southwest of the modern Varshavka village, which—together with the similarity of landscapes—permits direct application of the gathered data. The records for five years of observations were derived from the annual reports for 1998, 2003, 2004, 2007 and 2010, allowing representation of annual fluctuations (Kislenko 2004, 2005, 2008, 2011). The gathered data are the direction of the wind in degrees (an average of three observations per day) and speed of wind in meters per second, registered at the height of 10 meters above the ground.

Wind chill is a part of everyday experience during the wintertime. According to the National Climate Data and Information Archive of Canada, wind chill is an index to indicate how cold the weather feels to the average person. It is derived by combining temperature and wind velocity values into one number to reflect the perceived temperature. For this reason, the average temperatures in degrees Celsius were also gathered from the Arkaim dataset.

The standard Wind Chill formula used in The 1971-2000 Canadian Climate Normals is:

$W=13.2+0.6215T\_air-11.37V^{0.16}+0.3965T\_air \times V^{0.16}$ (4.1),

where

W is the wind chill index, based on the Celsius temperature scale.

T_air is the air temperature in degrees Celsius (°C).

V is the wind speed at 10 m (standard anemometer height), in kilometers per hour (km/h).

For example, if the outside temperature is -10°C and the wind chill index is -20°C, it means that a person's face will feel more or less as cold as it would on a calm day when the temperature is -20°C. According to the journal of meteorological observations at Arkaim, on January 24, 1998, the air temperature was -31°C with the wind blowing at 28.8 km/h. Solving formula 4.1, the wind chill index was -47°C, making this day the coldest in the whole winter.

Application of the Canadian Normals to the southern Urals Region can be justified by the location of the region in the northern temperate climatic zone and use of the International System of Units (SI system) for measuring temperature and speed of wind, both, in Russia and Canada (Government of Canada 2017).

The observed mean wind speed is 3.7±0.1 m/s (n = 1,733, 95% CL), with 3.6±0.2 m/s during the winters (n = 827, 95% CL) and 3.8±0.1 m/s during the summertime (n = 906, 95% CL), including quiet days. The observed averages can be classified as a gentle breeze in the Beaufort scale (Huler 2007). The higher average speed of summer winds contradicts the general theory that predicts the opposite for the north westerlies, however, the difference is not high and can be perhaps explained by local fluctuations. The direction of wind changes several times a day. However, the records for five years (N = 1,538) suggest the southwest direction (270°) dominates in the study area (n = 223) (Fig. 4.2).

The average annual value of wind speed and the dominating wind direction are the input values to calculate the wind speed at the local terrains. The individual wind models are based on a digital elevation model (ASTER GDEM ver. 2) with a resolution of 100 m by 100 meters (Fujisada et al. 2005), retrieved from the U.S. Geological Survey website. The modeled areas are limited by buffers with a radius of 3 km around each settlement. A specialized software package is used to compute the models of wind speed for each cell of the DEM. WindNinja is a computer program developed by The Fire, Fuel, and Smoke Science Program of the Rocky Mountain Research Station of the U.S. Forest Service. The program computes spatially varying wind fields for wildland fire and other applications requiring high-resolution wind prediction in complex terrain. WindNinja uses a surface wind measurement to build a wind field for the area. Other required inputs for
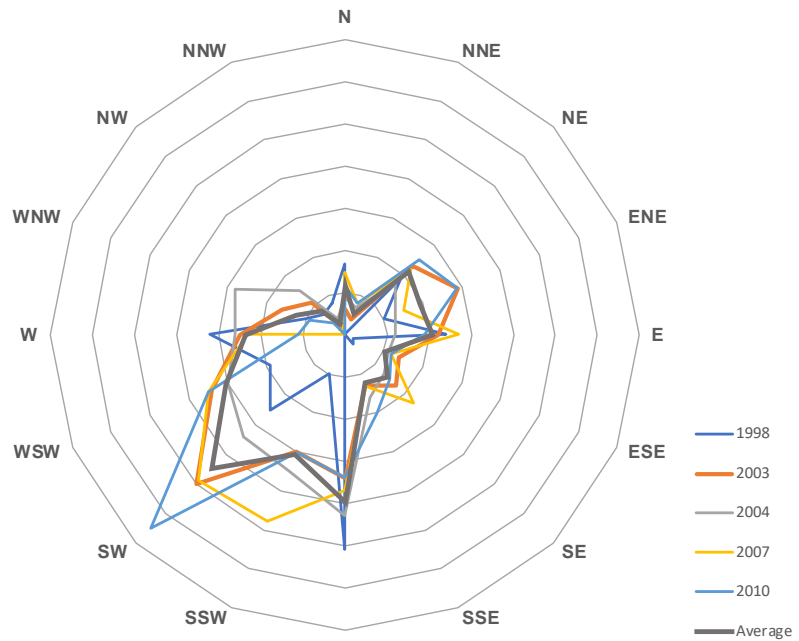
Figure 4.2 The wind rose diagram for Arkaim

A – Kamennyi Ambar
B – Konoplyanka
C – Zhurumbay

Wind Speed

🟩	Low
🟨	Moderate
🟥	High
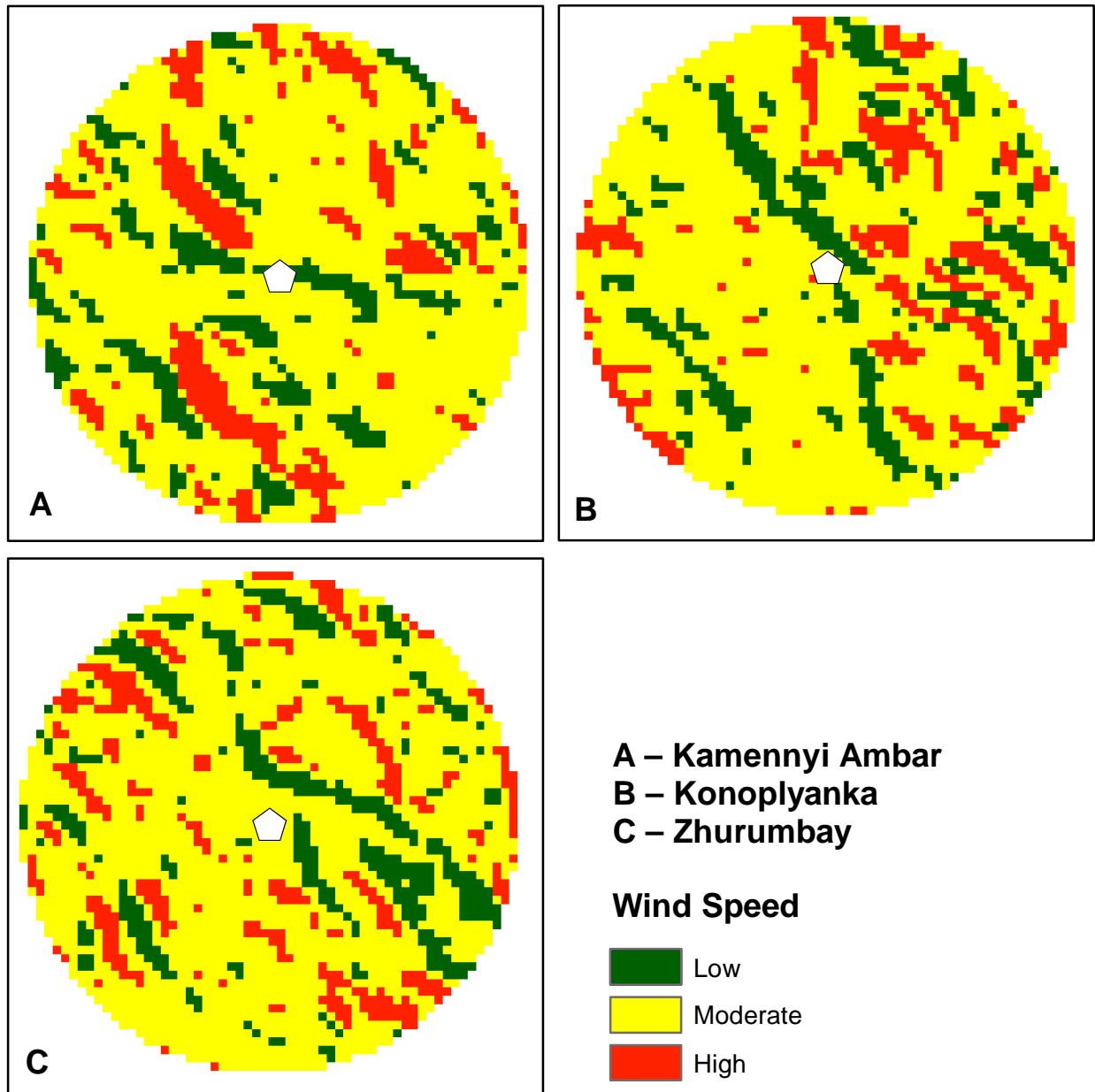
Figure 4.3 Wind speed within the buffer zones around the settlements

simulation include elevation data for the modeling area, date and time, and dominant vegetation type. The software is typically run on domain sizes up to 50 kilometers by 50 kilometers and at resolutions of around 100 meters (Forthofer et al. 2009; Wagenbrenner et al. 2016).

    The WindNinja modeling output is a map of wind speed where a specific value is assigned to every 100 m by 100 m cell of the DEM (Fig. 4.3). These values are inputs for creating a raster of wind speed within the circular domains with a radius of 3 km. The final models of local winds are rasters created with ESRI ArcGIS 10.5. The cells of each raster are classified into three groups as

low, moderate and high-speed winds to predict if the inhabitants of the walled settlements chose the optimal spots on the landscapes to protect from the strongest winds. For the model, moderate winds are defined as within the range of one standard deviation from the mean speed value, while the extreme values are either classified as low or high-speed winds. For Kamennyi Ambar, winds between 3.58 m/s and 3.66 m/s are classified as low, 3.66 m/s and 3.74 m/s as moderate, and 3.74 m/s and 3.9 m/s as high winds. For Zhurumbay winds between 3.56 m/s and 3.67 m/s are classified as low, 3.67 m/s and 3.73 m/s as moderate, and 3.73 m/s and 3.85 m/s as high. Finally, Konoplyanka winds between 3.57 m/s and 3.66 m/s are classified as low, 3.66 m/s and 3.73 m/s as moderate, and 3.73 m/s and 3.86 m/s as high.

The WindNinja models show that Kamennyi Ambar is situated in an area of low to moderate winds (from 3.64 m/s to 3.66 m/s). In other words, in a relatively calm spot on the surrounding terrain. The location of Zhurumbay is characterized by moderate winds of 3.70 m/s, and the closest calmer spot is about 300 m east. The settlement of Konoplyanka is in a spot of low wind with a modeled speed of 3.66 m/s, and surrounded by calm areas. In other words, all three locations provided the Sintashta-Petrovka communities with relatively quiet spots where the average wind speed was about 3.6 m/s (low to moderate).

According to the five-years-long meteorological observation at Arkaim, the average winter temperature is -14.2°C, which suggests that the average wind chill index is -21.2°C (formula 4.1). At the same time, the lowest mean temperature recorded at Arkaim in January 2010 was -21°C. Combined with the maximum modeled wind speed of 3.9 m/s in the windiest areas around Kamennyi Ambar, this value predicts the wind chill index of -31.9°C. With the absolute modern winter regional minimum of -50°C, the average wind chill index for all three locations is -64.8°C. Such low temperatures make it virtually impossible for humans to survive without shelter, and an attempt to minimize the impact of chilly wind seems to be a reasonable assumption.

In sum, the chosen spots are optimal in the given environment to maintain highest possible temperatures and prevent heat loss in the cold months. Together with the erected wall and densely packed houses, this strategy allowed the inhabitants of the nucleated settlements to protect their livestock and especially newborns in the harsh winter conditions. On the other hand, the possible inhabitants of the unfortified mobile camps could use the adjacent walls to shield themselves from the strongest winds on especially cold winter days. Thus, the calmest spots are

located within 100 m north of the settlement, where the most intense cultural layer is located, as exposed by the TP-KA-A3/A4 and by the cross-sections CS-KA-7, 8 and 9.

4.1.2 Local Landscapes and Hydrology

The Ural and the Tobol are the two major rivers in the southern Trans-Urals that form the watershed and local landscapes. The interfluve is shaped by the beds of the smaller tributaries that flow either west towards the Ural or east towards the Tobol. The river system was formed during the late Pleistocene and early Holocene and remained relatively the same until the present day, even though the rivers have a tendency to meander and change their beds (Lavrushin and Spiridonova 1995).

Three studied local communities are found on the banks of the Karagaily-Ayat river that belongs to the Tobol basin. It slowly flows from the west so east, cutting through the rolling hills of the Transural peneplain and forming its own valley. The settlements are located near the water: the south boundary of Kamennyi Ambar is only 20 m from the bank, but there is an old river channel located 260 m to the south (Fig. 4.4). The north boundary of Zhurumbay is 130 m from the bank. At the site of Konoplyanka, the modern riverbed is located at 300 m east of the settlement wall. However, the hydrological situation in this locality is complex, since the river changed its course several times during the Holocene. Based on the sediment study, Sharapova et al. (2014) concluded that the modern river bed was formed during the 1st millennium AD, while in the Sintashta-Petrovka period the river flowed along the old channel, located 50 meters west of the settlement wall.

The modern environmental record shows that while the summer's river flow is slow, in the flood period the volume increases sharply and the level rises as much as 2–2.5 meters. However, the rapid rise of water could occur during the summer or fall due to extreme rainfalls (Levit 2005; Padalko 2016). Rapid water flow is a considerable threat for the dirt-wooden architecture of the Sintashta-Petrovka settlements, and the assumption taken here is that inhabitants of the settlements preferred to find less risky locations to prevent themselves from occasional floods. For example, during the spring flood of 1998, the water table of the Bolshaya Karaganka River raised for 2.5 m (Kislenko 2004) and Arkaim was fully surrounded by water.
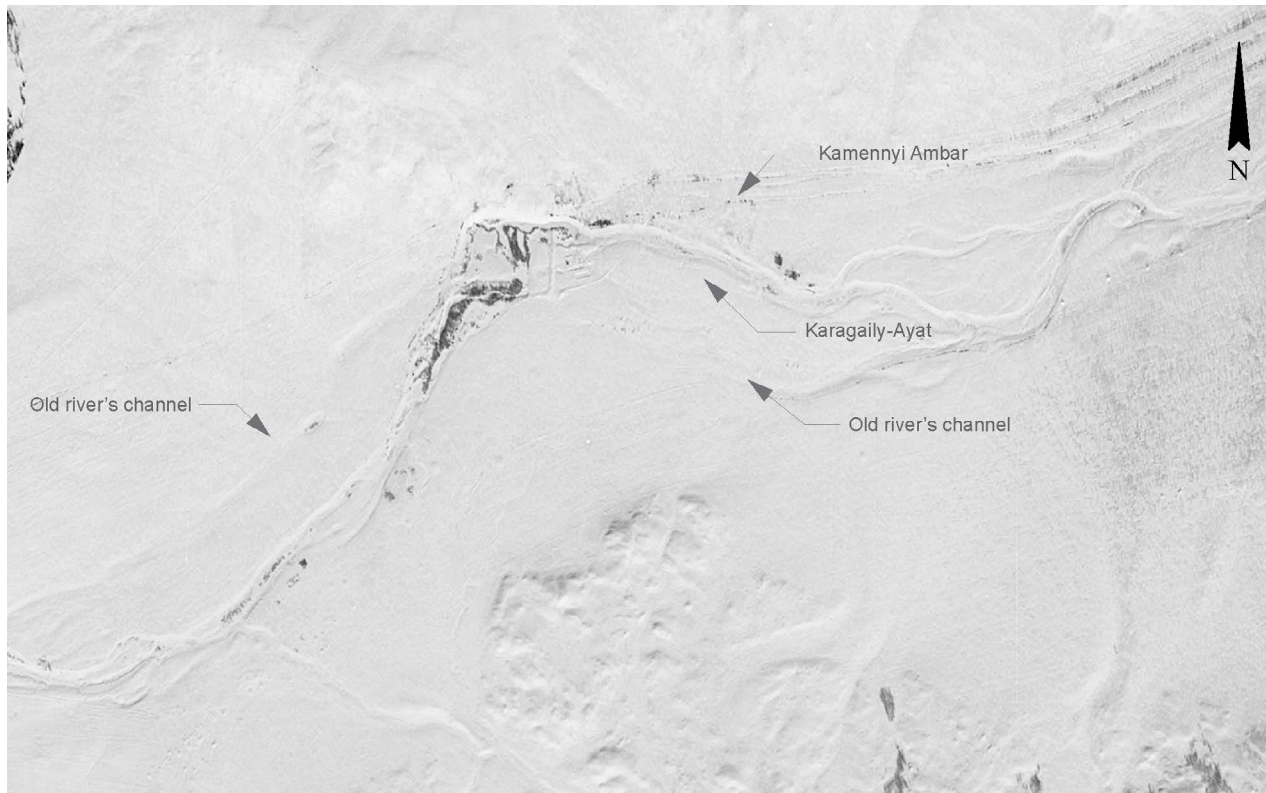
Figure 4.4 The area near Kamennyi Ambar as appeared on the Corona Satellite image during the winter of 1963 (freely available on the USGS web-site at https://www.usgs.gov/)

Both, the modern river and old beds are visible on the image allowing locating of the settlement in relation to the water stream

The digital elevation model with the cell size of 100 m by 100 m (ASTER GDEM ver. 2) was used to calculate the flow accumulation within each settlement's domain (3 km radius). The ESRI ArcGIS 10.5 Flow Accumulation tool was used to calculate accumulated flow as the weight of all cells flowing into each downslope cell in the output raster (this method of deriving accumulated flow from a DEM is presented in Jenson and Domingue [1988]). The output rasters are classified into three categories, which are low (0 inflowing cells), moderate (0 to 100 inflowing cells) and high (more than 100 inflowing cells) risk of flood. Moreover, the modern and old channels of the river are drawn from the satellite image, and then the value of 100 assigned to each cell within the channels. This value added to the rasters of flow accumulation where they intersect with the river to allow representation of its channels.

The result of modeling of water flow is maps of the possible seasonal channels and the river bed (Fig. 4.5). Their comparison with the settlement locations predicts whether the communities were in danger of being flooded with the seasonal water or rise of the river. Thus, Kamennyi Ambar

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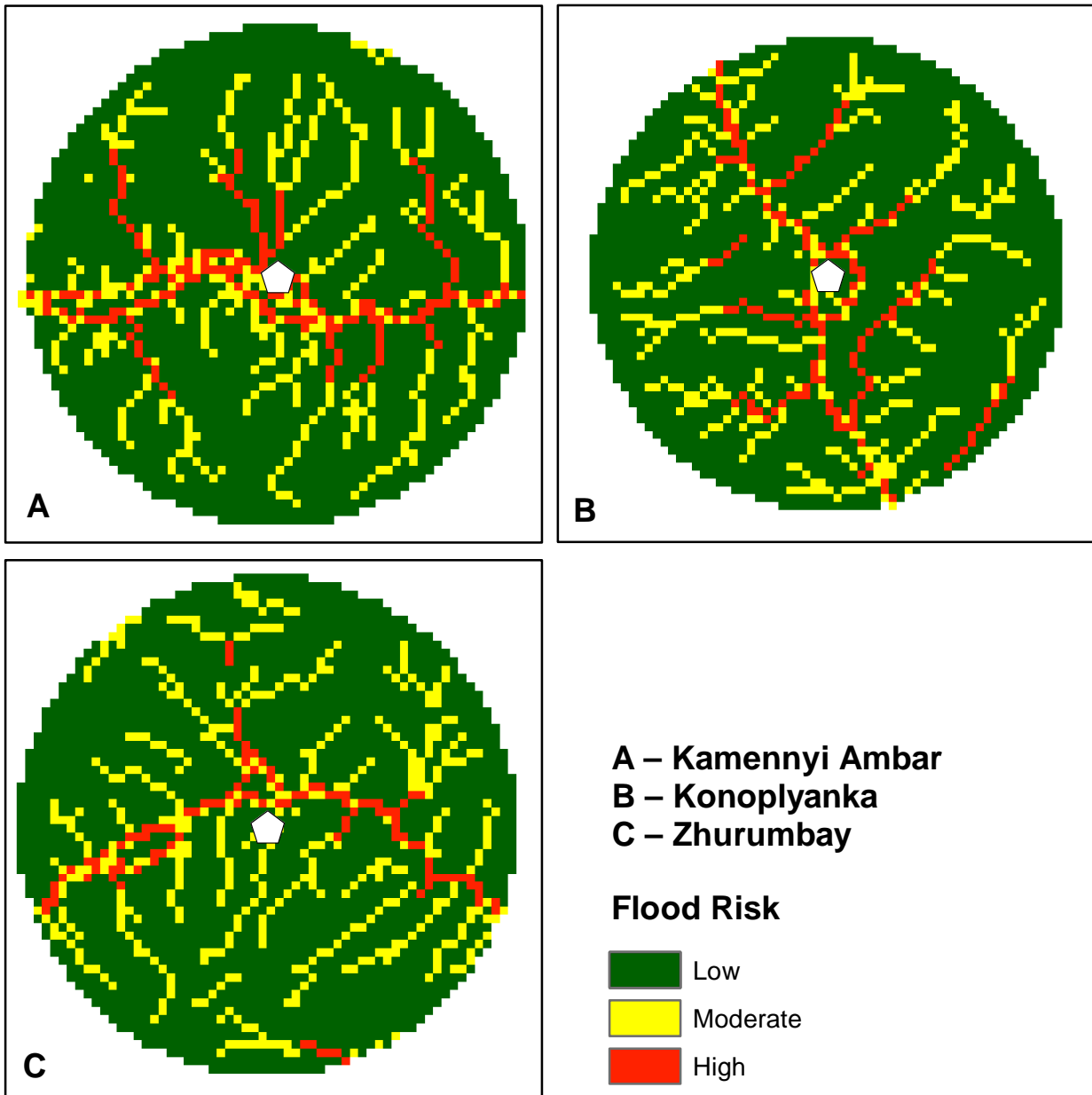
Figure 4.5 Flow accumulation models within the buffer zones around the settlements

is located in the relatively flood-safe area with the seasonal channels about 200 meters away in all

directions, even though right next to the modern river. Since there is the old bed, located farther

south of the settlement, it seems to be plausible that the river flowed through this channel in the

Bronze Age. The location of Zhurumbay is at moderate risk of flood since possible seasonal chan-

nels are predicted by the model to be at the same spot. Finally, Konoplyanka is surrounded by the

river's channels, but the site itself is located on a relatively safe elevated area. If the river indeed

flowed through the channel west from the walls, as suggested by Sharapova et al. (2014), the walled

settlement could have experienced some danger of flood. However, the map of micro-topography suggests that the site was placed on the highest possible spot—the difference in elevation between the center part of the settlement and the bank of the old channel is about 2 m.

It is self-evident that the inhabitants of the nucleated settlements chosen to live very close to the river. As discussed in Chapter 3, up to 3,000 animals could be kept within the walls during the wintertime. Hence, the demand for water was high, since an adult horse or a cow needs about 50 liters of water per day. Every house within the walls had its own well, or few of them, however, this would be first used for the human consumption to avoid contamination, so the location of the barns near the river was the simplest solution to water the animals (Anisimov 2009).

Nevertheless, the models of flow accumulation suggest that flood could be a considerable threat for the settlements that had to be deal with. One possible explanation is that the walls and ditches that surrounded the settlements were protective measures against seasonal waters. This notion can be supported by several established facts. Even though the climatic conditions during the Bronze Age were like today's, a relatively more humid climate predominated between approximately 2400 and 1600 cal. BC (Stobbe et al. 2016:14) in the Karagaily-Ayat Valley, which could have increased annual amount of precipitation. The stone slab facings of the Kamennyi Ambar and Alandskoye walls (Zdanovich and Batanina 2007:56–59) can be reasonably explained as erosion protection, including protection from flood (Petrov 2009:31). Finally, according to the sediment study, the earliest construction phase of the big Sintashta kurgan was conducted in humid conditions, and the surrounding ditch served to channel water (Khokhlova et al. 2008). If this was the case, then the Sintashta "fortified towns" were well-thought artificial ecological niches, serving to protect communities of herders from the harsh environmental conditions like heavy wind in the winter and seasonal floods (Zdanovich and Batanina 2007:185–188).

4.1.3 Local Landscape and Visibility as A Defensive Measure

Since the initial excavations of Sintashta, Petrovka, and Arkaim, all sites of that type were interpreted as fortified settlements. The argument is that densely packed houses surrounded by earthen walls and ditches were constructed in this way due to the need for defense (Gening et al.

1992:23–43). However, as discussed above, the environmental factors could also have impacted the patterns of architecture. Hence, to evaluate defensibility of the settlements other features of local landscapes should be taken into account. One of them is visibility that likely to plays a role in risk management strategies in dangerous social environments, especially for a community with a constant threat of being attacked by an enemy. For this reason, in many other examples around the world, people chose to build their fortresses in spots that allow better visibility and protection or to clear up the immediate areas around sites (Rappaport 1965; Llobera 2006; Arkush 2011). Thus, it can be expected that the Sintashta-Petrovka fortified settlements should be preferably located in the spots that decreased accessibility and allowed better visibility of the local landscapes to warn communities in case of a military threat. To test this hypothesis, the analysis of viewshed, or area visible from a particular place, is undertaken here (Howard 2007:281–282).

The spots of local landscapes that provide the best visibility are identified through running Viewshed 2 Tool of ESRI ArcGIS 10.5. A viewshed identifies the cells in an input raster that can be seen from one or more observation locations. Each cell in the output raster receives a value that indicates how many observer points can be seen from each location. If there is only one observer point, each cell that can see that observer point is given a value of 1. The output raster indicates cells on a DEM that can be seen from each observation point (ArcGIS Desktop On-line Help). Worth noting that the viewshed is a very unnatural model since it reflects only patterns of the terrain model with no light and shade, no vegetation and no other natural factors (Howard 2007:282). However, as was mentioned above, the environmental conditions and landscape of the valley remained relatively stable during the Holocene allowing modeling visibility for the modern landscape.

The visibility models for the Karagaily-Ayat Valley are based on a terrain model (ASTER GDEM ver. 2) with a resolution of 100 m by 100 m (Fujisada et al. 2005). The model extends to a distance of 10 km in each direction from the boundaries of 3-km-radius buffer zone around each of the three sites allowing modeling of viewsheds up to 10 km from observation points within the 3-km buffer. The visibility limit of 10 km was established empirically during the fieldwork: knowing the local landmarks and distances between them allows saying how far it is possible to see from the most elevated points of the local terrain. Potential observation points were spaced at 100 m intervals, each one located at the center of one of the DEM's cells (n = 2,820 for Kamennyi Am-

bar, $n = 2,825$ for Konoplyanka, $n = 2,822$ for Zhurumbay). The observer's elevation for modeling purposes is 2 m (an average height for a person astride a horse).

The number of visible cells was calculated for each potential observation point located within the 3-km-radius buffer zones. Next, the number of visible 1 ha cells was assigned to each viewpoint within these domains. These numbers were the z-values of resulting rasters that became the maps of local visibility. The cells of each raster were classified into three groups of low, moderate and high visibility to investigate whether the inhabitants of the walled settlements had chosen optimal spots on the landscapes for observing large parts of the surrounding territory. The cells classified as moderate visibility are within one standard deviation from the mean visibility value, while the values greater than one standard deviation from the mean are classified as either low or high visibility (Table 4.1).

Table 4.1 Classification of visibility within the 3-km-radius buffer zones around the settlements of the Karagaily-Ayat Valley

	Kamennyi Ambar	Konoplyanka	Zhurumbay
Low visibility (ha)	716–2,062	510–2,107	468–2,059
Moderate visibility (ha)	2,062–4,491	2,107–4,889	2,059–5,402
High visibility (ha)	4,491–7,975	4,889–10,547	5,402–9,998

According to the modeled maps of visibility, Kamennyi Ambar's location has moderate visibility (2,196 ha, or 1.5% of the whole DEM of 146,082 ha), while an observer at Konoplyanka could see 2,889 ha (1.9% of the whole DEM), and 2,664 ha are visible from the location of Zhurumbay (1.8% of the whole DEM). The modeled values are less than the mean visibility for all three settlements (Table 4.2), but they lie within one standard deviation of the mean values for the buffer zones. It is worth noting, though, that Kamennyi Ambar and Zhurumbay are just next to spots of low visibility (Fig. 4.6).

Table 4.2 The visibility values of the settlements' buffer zones in the Karagaily-Ayat Valley (3 km radius from each settlement)

	Visibility within buffer zone around Kamennyi Ambar	Visibility within buffer zone around Konoplyanka	Visibility within buffer zone around Zhurumbay
Minimum	716.0	510.0	468.0
Maximum	7,975.0	10,547.0	9,998.0
Arithmetic Mean	3,277.6	3,522.8	3,755.0
Standard Deviation	1,222.3	1,379.3	1,669.3
Standard Error of Arithmetic Mean	22.9	25.9	31.3
95.0% LCL of Arithmetic Mean	3,232.5	3,472.0	3,693.5

	Visibility within buffer zone around Kamennyi Ambar	Visibility within buffer zone around Konoplyanka	Visibility within buffer zone around Zhurumbay
95.0% UCL of Arithmetic Mean	3,322.6	3,573.6	3,816.5
Visibility from the site	2,196.0	2,899.0	2.664.0
Difference between visibility at the site and mean values (ha)	-388.6	-633.8	-1,091

As one might expect, visibility has a tendency to correlate positively with the elevation—the higher the spot, the better visibility ($r = 0.6$, 43% of the variance is explained for the Kamennyi Ambar buffer zone, $r = 0.4$, 14% of the variance is explained for the Konoplyanka buffer zone and $r = 0.7$, 49% of the variance is explained for the Zhurumbay buffer zone). Contrary to this principle, the settlements are located in relatively lower parts of the landscape, resulting in low total visibility. Moreover, it is unlikely that the inhabitants of one settlement would have preferred the significantly higher spots on the landscape to compete with other two settlements. To illustrate this point, Table 4.3 provides information on the mean altitude values for each 3-km-radius domain and the elevation of the settlements. In all three cases, the sites are below the mean landscape altitudes and their confidence intervals.

Table 4.3 The mean elevation of the settlements in the Karagaily-Ayat Valley

	Kamennyi Ambar	Konoplyanka	Zhurumbay
Min.	285.0	317.2	297.0
Max.	352.0	368.0	349.0
Mean	310.5	337.4	319.2
St. Dev.	13.8	12.4	11.3
Standard Error of Arithmetic Mean	0.02	0.02	0.2
95% LCL of Arithmetic Mean	310.0	336.9	319.2
95% UCL of Arithmetic Mean	311.0	337.9	320.0
Site altitude (masl)	291.0	321	308.0
Difference between site's elevation and mean altitude	-19.5	-16.4	-11.2

If the inhabitants of the walled settlements wished to increase their ability to see around, they could have built up elevated platforms. Archaeological records do not provide data to support this hypothesis. However, the tops of the surrounding walls could have been used for this purpose. As suggested in Chapter 3, the walls could have reached the height of 3 m, which together with the average person's height of 1.6 m would allow elevating an observer to a height of about 4.5 m. This parameter was applied to the loci of the settlements to re-model the viewsheds and test again whether visibility played a role in settlement location. With this additional height, visibility increased,
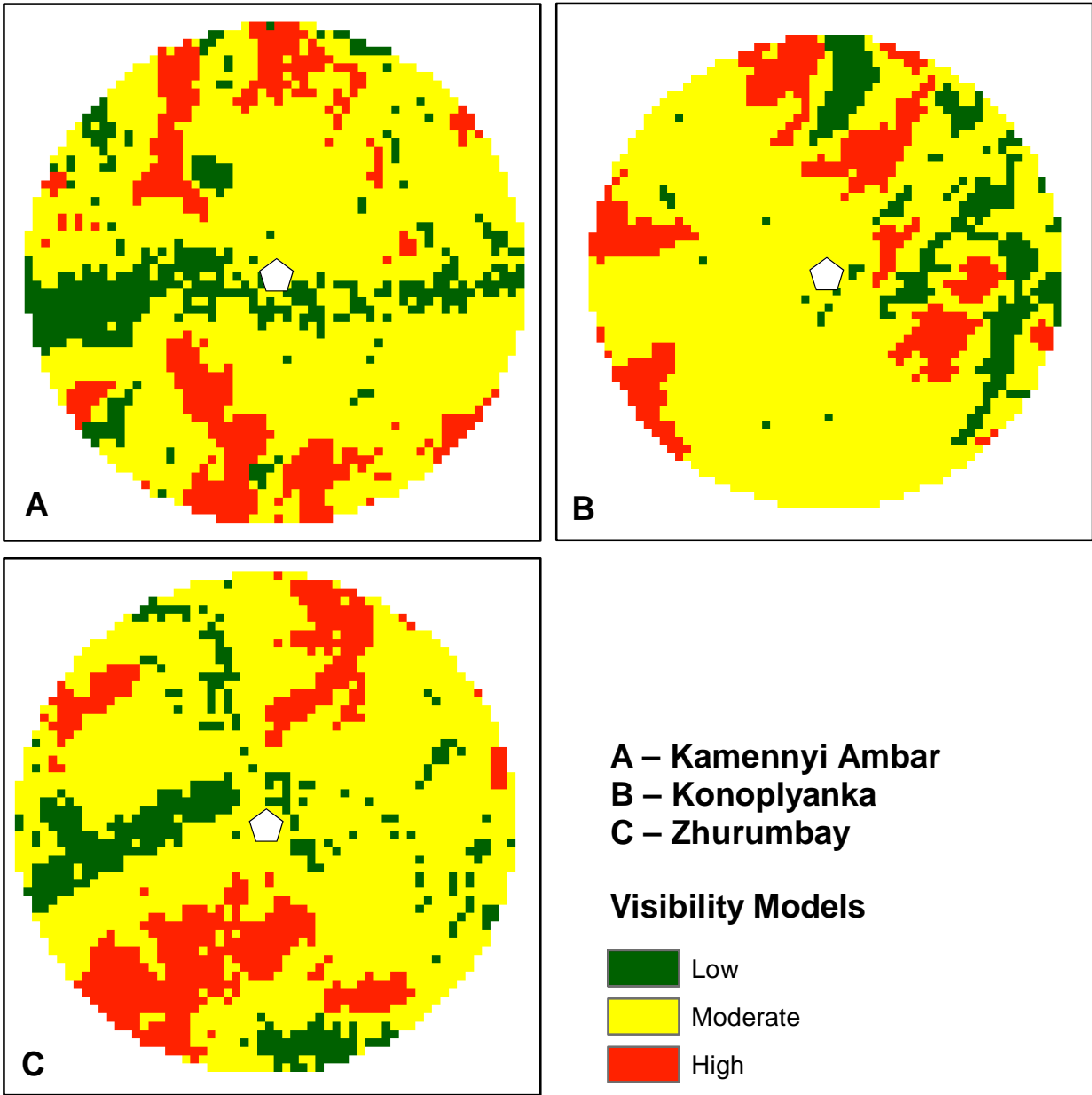
Figure 4.6 Visibility models within the buffer zones around the settlements

but in no case, did it increase significantly. Observing from the wall of Kamennyi Ambar, a watcher could see 2,598 ha of surrounding area, which is still lower than the mean observing area for the buffer zone (3,277 ha). At Konoplyanka, potential visibility would increase to 3,499 ha, which is only slightly lower than the average visibility (3,522 ha), but still far lower than the visibility at the best spots on the tops of surrounding hills (10,547 ha). Finally, a watcher at Zhurumbay would see 3,293 ha of the landscape, which is classified as low visibility (the average is 3,755 ha).

Figure 4.7 The panoramic view of the Karagaily-Ayat Valley from the hill south from Kamennyi Ambar

Two settlements—Zhurumbay and Kamennyi Ambar—are visible. The linear distance between them is about 8 km

Another possibility to visually control the landscape for defensive purposes is to establish outposts on the peaks of the tallest hills. It is reasonable to assume that in the course of 50–100 years such an outpost would leave material evidence that can be traced archaeologically—hearths, ceramic sherds, and bones left by the watch. To test this hypothesis, survey was conducted in two locations predicted by the visibility model within the Kamennyi Ambar buffer zone. Location 1 is a hilltop 1,600 m south of the settlement on the opposite bank of the river (altitude 327 masl.). Empirical observation suggests that about 20 km along the river valley are readily visible from this viewpoint on a bright day, including the locations of Kamennyi Ambar and Zhurumbay (Fig. 4.7). The corresponding viewshed for the most suitable viewpoint at Location 1 indicates that 7,048 ha is visible in all directions. Location 2 is a hillock about 1,300 m east-north-east of the settlement (altitude 304 masl.). In total, 4,498 ha of the valley is visible from this viewpoint. During the survey, 3.5 ha in Location 1 and about 1 ha in Location 2 were covered by shovel tests, spread approximately 10 m apart. The shovel probes had dimensions of 20 cm by 20 cm in a horizontal plane and were from 10 cm to 20 cm in depth. No artifacts or cultural layers were identified at either location, suggesting the absence of long-term watching outposts in these locations. In this case, a potential enemy approaching Kamennyi Ambar would be spotted only at a distance of 1000 m north. 1,500 m west, and 1,100 m east. With a walking speed of 5 km/h, these distances could be covered by the potential attackers in a matter of minutes, providing them with the advantage of a surprise attack. Moreover, ethnographic sources suggest that night raids are the most common form of attack in small-scale societies (Arkush 2005:8), meaning that in the case of Sintashta-Petrovka, an enemy could use the disadvantage of wooden constructions to set them on fire in the dark.

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To summarize, the models indicate that visibility did not influence settlement locations. In all cases the sites were located in lower spots of the landscape close to the river, which is also typical for other Bronze Age villages of the region (Kuzmina 1994:69; Zdanovich and Batanina 2007:180). For example, the peaks of hills in the Arkaim valley have altitudes of 350 masl and 330 masl, while the site itself is located at the altitude of 319 masl. If the social environment of the Late Bronze Age was hostile and the communities were under threat of attack, the settlements would be in locations with better visibility—on the peaks of surrounding hills, as predicted by the models.

4.1.4 Summary of Environmental Models: Local Environments, Defensibility, and Niche Construction

Creating cumulative predictive rasters is the last step in seeking an explanation of settlement location. Predictive models are heuristic tools for projecting spatial variables into unstudied places to get an idea of where archaeological sites might be located (Wescott and Brandon 2000:8). Cumulative rasters were created by overlaying maps of wind speed, waterflow accumulations, and visibility. The z-values were drawn from the maps and reclassified into three score-assigned categories varying from one to three. The lowest score of one stands for low visibility, high flood risk, and high-speed wind, and vice-versa for the highest score of three. Moderate zones are assigned a score of two. Next, the z values of the reclassified cells are summed up to calculate z values of resulting predictive rasters. The summed z values vary from three to nine, with the lowest z values standing for less desirable spots on the landscape, and the highest z value for the best locations. Thus, a cell characterized by high-speed wind, high flood risk and low visibility has a value of three (1+1+1), and a cell with low-speed wind, low flood risk, and high visibility have a value of nine (3+3+3) (Table 4.4).

Table 4.4 Reclassification of the predictive models

Score	Wind speed	Flood risk	Visibility
1	High	High	Low
2	Moderate	Moderate	Moderate
3	Low	Low	High

The scores of the summed rasters are further reclassified into three groups as poor (3 to 4), good (5 to 7) and excellent (8 to 9) locations. The lower-ranked zones are expected to be bad

locations for settlement, while the highest-ranked zones are expected to spatially correlate with settlement locations. The predictive models suggest that concerning three variables, the buffer zone around Kamennyi Ambar consists of 8% poorly located areas, 79% of good located areas and 13% of excellent locations. For Konoplyanka the proportions in the same order are 5%, 80%, and 15%, and for Zhurumbay the proportions are 5%, 76%, and 19%. Evidently, the domains around the settlements consist of good areas of moderate winds, low flood risk and moderate visibility for 70%–80%. The excellent locations have a smaller presence on the landscape (10% to 20%) and in all three cases tend to locate further from the geometrical centers of the buffer zones on the rolling hills of the trans-Urals Peneplain. The poor locations have the lowest proportions (5% to 10%) and tend to concentrate in the valley near the river (Table 4.5).

Table 4.5 Area classification within the 3-km-radius buffer zones

	Kamennyi Ambar	Konoplyanka	Zhurumbay
Poor	222 ha / 8%	155 ha / 5%	146 ha / 5%
Good	2,224 ha / 79%	2,254 ha / 80%	2,136 ha / 76%
Excellent	374 ha / 13%	416 ha / 15%	540 ha / 19%
Total	2,820 ha / 100%	2,825 ha / 100%	2,822 ha / 100%

The resulting models suggest that environmental factors played some role in settlement location, even though not all three settlements are found in the best spots. Thus, the area chosen for Konoplyanka received the highest score, though the visibility there is low. Contrary to the models, the two other Sintashta-Petrovka settlements are not found in excellent locations with high scores. Kamennyi Ambar is located in a position classified as relatively good, but it is marginal between highly preferable low-wind spots and the area with high flood risk due to the closeness to the river. The major drawback of the location is low visibility. Zhurumbay is also found in a good position on the land next to a shallow seasonal water channel, which was not necessarily active in the Late Bronze Age (Fig. 4.8). This confirms the conclusion that the specific locations of the walled communities were dictated by the need for access to water with little rgard for visibility. At the same time, the walls and ditches could effectively resist seasonal floods and protect inhabitants and their animals from losing heat during the cold winters. Moreover, the same measures would protect livestock and transport animals from predators like wolves and bears, also common for the area (Kuzmina 1994; Anisimov 2009).
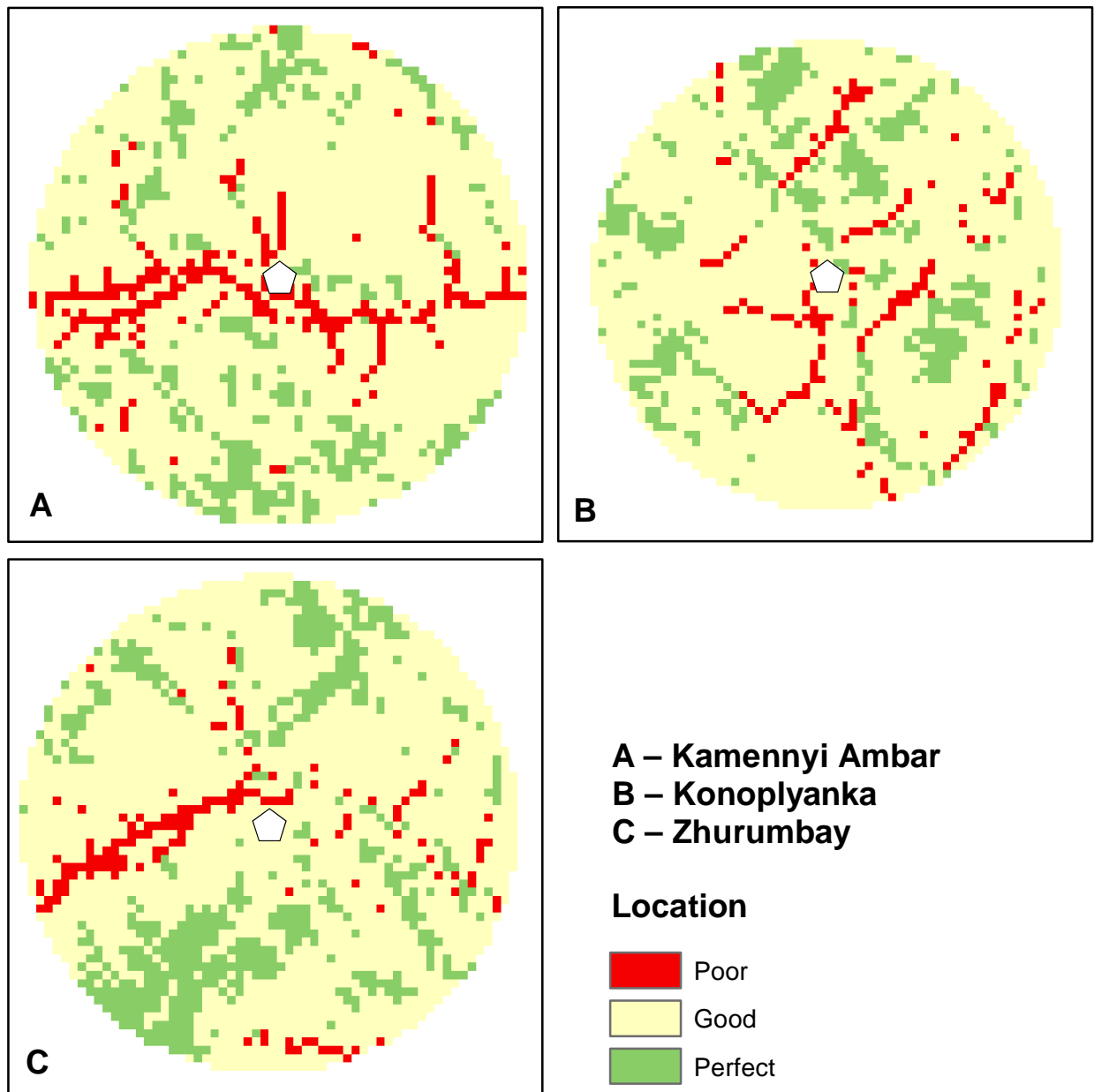
Figure 4.8 Predictive models for the settlements locations

A more traditional view, though, interprets the surrounding embankments and ditches as defensive measures. The ultimate defensive measure is a fort or a system of fortifications, that usually consists of ditches, walls, entrances and gates, towers, fortified households and other secondary defensive features (Arkush 2011:62). The military purpose of walls is to shield inhabitants of a settlement against a direct strike by an enemy, which is usually achieved by surrounding the protected area. However, an enclosure does not necessarily have to be completely encircling,

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since natural barriers are commonly used as an extension of fortification. These are usually in the form of inaccessible terrain such as steep cliffs, deep chasms, rivers, swamps and other naturally defensive features of the landscape (Keeley et al. 2007:57–80). The Sintashta-Petrovka settlements are entirely enclosed, but located on easily accessible spots of the terrain——none of them are located on cliffs or surrounded bywater year-round or protected by deep chasms. Finally, high places are obviously advantageous for reasons of better visibility and longer effective range of projectile weapons (Kelly 2000; Roscoe 2008; Arkush 2011). However, none of the three settlements of the valley are located in such positions, nor are the rest of the Sintashta-Petrovka sites (Zdanovich and Batanina 2007). The relatively elevated positions of Konoplyanka and Arkaim allow flood protection but do not increase defensibility much, since the elevation of the terrain does not exceed 2 m in either case.

In some cases, multiple lines of walls could be constructed to enhance a fort's defensive capacity, combining an outer wall with an inner wall that serves to protect more vulnerable or important parts of a community. If an enemy penetrates the outer wall, a fort's defenders can retreat to the inner part and use a clear space in between as a killing alley (Arkush 2011:68). Indeed, just such patterns found at Sintashta, Arkaim, Sarym-Sakly and some other settlements make archaeologists think of them as effective forts (Anthony 2007:393-395). However, the walled villages in the Karagaily-Ayat Valley have only one line of walls each. Other archaeologists have noted that if walls do not exceed 2–3 m in height, they could be barriers for livestock to prevent straying (especially at night) and to protect them from non-human predators (Keeley et al. 2007:81). This idea fits with the estimated height of the Sintashta-Petrovka walls: 3–3.5 m for Sintashta (Gening et al. 1992:32), 1.7–2.6 m for Ust'ye, 2–3 m for Sarym-Sakly (Chechushkov et al. 2018), and 2–3.2 m for Kammenyi Ambar.

Ditches are also fortification features, since the earthen material for walls was commonly obtained through excavation. A ditch is usually located outside of a fort following an outer wall, becoming the first line of defense that increases height and inaccessibility of an embankment. Typically, the depth and width of a ditch have the same dimensions and constructive features all along the length of a wall, though some segments could be reinforced with optional defensive measures.

The excavated settlements (Ust'ye, Kamennyi Ambar, Sintashta) provide data to test the homogeneity of ditch dimensions. Their dimensions were measured on published drawings with

a minimum of twenty measurements per site. Statistical analysis indicates that the average width is 3.6±0.4 m (at 95% CL). However, the measurements range from 1 m to 8.8 m, resulting in a very large standard deviation (σ = 1.4, n = 60). Importantly, significant differences in widths can be seen along the ditch of the same settlement, as in the cases of Sintashta and Kamennyi Ambar (Gening et al. 1992; Krause and Koryakova 2013:97). Further, the excavated ditches are rarely deeper than 2 m ($\bar{x}$ = 1.6±0.2 m at 95% CL), and sometimes as shallow as 1.2 m. Moreover, none of the studied cases are characterized by V-shaped profiles, considered to be the most effective for defense since it is the most difficult to cross (Keeley et al. 2007:60). On the contrary, the profiles of the excavated moats are usually trapezoidal or rounded, with ledges on both sides. At Kamennyi Ambar, the deepest sections showed evidence of still water suggesting that the ditch functioned as drainage (Berseneva et al. 2015:8). A considerable exception is the ditch at the settlement of Alandskoe, that exceeds 3 m in both dimensions at least in some segments (Zdanovich 2011:51, fig. 5). Perhaps, variations in depths and design may be due to the difference in specific geographic conditions, since this site is located on the spit of land between two rivers with a high risk of flooding, and slab facing of the walls would help them resist flood waters especially well. In sum, the studied cases of walled villages show a high degree of heterogeneity and lead to the conclusion that no universal design for a ditch existed.

Detailed artistic reconstructions of the enclosures created for Sintashta and Arkaim were made by their principal investigators and subsequently borrowed by the authors of the secondary literature on the Eurasian Bronze Age (Gening et al. 1992; Zdanovich 1995; Anthony 2007). In these reconstructions a rider would have a view of the walled settlements as developed strongholds, comparable to Early Medieval castles (Rappaport 1965). However, detailed examination of the initial drawings, published for Sintashta and Arkaim do not support this view. First, bastions are depicted in the graphic reconstruction of Sintashta, but the only archaeological evidence for their existence is the irregular outline of the inner boundary of the ditch (Gening et al.1992:29). However, to be effective, such bastions must be built in a regular pattern, with overlapping shooting lines. Otherwise, their defensive value drops sharply. On the plans, we see the irregular outlines of the ditch, which can be explained as the result of taphonomy. Second, the authors reconstruct buttresses that were used as observation towers and rifle niches (Gening et al. 1992:32). The general plan of the excavation shows that the grooves under the so-called foundations of buttresses

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cut through the body of the main wall, and do not adhere to it, which contradicts the reconstruction drawing and the function it implies for this architectural element. Thus, the existence of such buttresses is doubtful, and the unevenly distributed grooves can be explained either as exploratory probes of soils during construction or as drains. Third, questions arise about the reconstruction of the entrances to the settlement. It remains unclear why the entrances had such a different design: complex structures of moats were recorded at the southern entrance to the settlement facing the river and were not found on the northern side, which would have been attacked in the first place. The southern entrance, most likely, was regularly under threat of flooding, so there was a need to drain the rising water into the moat and then discharge it with the help of drainage moats. In sum, the reconstruction of the Sintashta fortified settlement over-complicates the real picture and cannot be used as basic data for discussing the function of the walls as fortifications.

The fortification features of the settlements were not universal even at the same site. Walls were not strengthened by bastions or towers, and the ditches do not represent a very difficult obstacle for attacking infantry. The settlements are in the lower parts of the terrain, allowing a potential enemy to covertly approach them, especially in the dark. The strategy of settlement design and location and construction can be explained as creating artificial ecological niches that provided communities with safety in the harsh climate of the Eurasian Steppes. Interestingly, in the following period, the Srubnaya-Alakul' unfortified settlements were still located in similar environmental settings, although they were not protected by enclosures. This fact can be explained by more arid climatic conditions with less annual precipitation and thus less risk of flooding (Tairov 2003). Finally, while military affairs could have had a place in the Late Bronze Age, there are not many facts supporting intense warfare—human remains do not demonstrate any conflict-related trauma, and no evidence of assaults on the Sintashta-Petrovka settlements has been found. Presumably, if military conflict took place, it was limited in scale and did not influence the local communities.

4.2 ANSWERING THE RESEARCH QUESTIONS

In Chapter 1 of this, five research questions were stated as the primary heuristic tool for assessing the social and political processes that took place in the Late Bronze Age. Answering

these research questions helps to develop the bigger picture and address broader theoretical issues related to the chiefdomization process.

1. To what extent do the remains outside the walls indicate actual residence there? The combined methodology of sub-surface testing and laboratory analysis revealed Late Bronze Age cultural deposits outside the walls at all three sites. At Kamennyi Ambar this takes the form of a layer of depleted humus ("A1" soil horizon), which contains ceramic sherds, faunal and plant remains, as well as higher proportions of phosphorus, molybdenum, calcium, and lower proportions of iron and other metals. The area of cultural deposits outside Kamennyi Ambar is about 2 ha, although the cultural layer is uneven and patchy, which allows the conclusion that the whole 2 ha were not used with the same intensity. Due to post-depositional plowing, it is difficult to estimate the area at the two other sites, however, cultural layers evidently exist there too.

At Kamennyi Ambar, 78% of identifiable ceramic sherds are of the Sintashta-Petrovka period, suggesting that the deposition primarily happened during this period. Even though no actual residential structures were registered, it can be proposed that the cultural deposits were accumulated by people who lived outside in temporary structures and did not form as a result of garbage or dung disposal from inside the walls of the nucleated village. This is supported by the the less diverse artifact assemblage outside the walls (meaning that only sleected garbage was disposed of outside) and the moderate level of phosphorus in soil outside Kamennyi Ambar (meaning that no animal dung was placed adjacent to the wall areas). The magnetic plan of the area of rich cultural deposits located north of the settlement revealed a circular structure with a radius of about 5.5 m that might be interpreted as evidence for a yurt-like structure standing at that spot. Further, the existence of such structures can be supported by the significant presence of burnt clay, and tiny calcined pieces of bone that are interpreted as the remains of fires stoked with animal bones.

Late Bronze Age ceramics occurred outside the walls at Konoplyanka and Zhurumbay as well, although intense post-depositional plowing destroyed the soil horizon that had contained the cultural layer at Kamennyi Ambar. At Konoplyanka, 95% of the sherds are not diagnostic. At Zhurumbay, about 3% are of the Sintashta-Petrovka period, about 12% are of the Srubnaya-Alakul' period, and about 84% are not diagnostic.

2. Were any residences outside the walls those of year-round occupants or were they instead of people who moved seasonally between the fortified settlements and a more distant

hinterland? Since no remains of permanent structures were found and any people living outside the walls must have stayed in temporary shelters. If this was the case, then the outside part of the population consisted of a semi-mobile group of people who moved to live near the fortified settlement during the winter. The pattern of animal slaughtering supports this conclusion. Animal teeth found near Kamennyi Ambar and Konoplyanka demonstrate a tendency for animal butchering during the fall, throughout the winter and spring, with less evidence of summer meat consumption. Moreover, since the Bronze Age subsistence strategy relied heavily on pastoralism, herds had to be grazed during the summer and kept safe during the winter. This strongly suggests that the part of the population responsible for management of animals spent their time in the summer pastures with the livestock. During the winter the animals had to be kept in the warm and safe environment of the walled settlements (as suggested by the highest level of phosphorus on the house floors) while the herders stayed in portable shelters in close to the walls.

3. If real residence is present, did the residents have less wealth or prestige than occupants of houses inside the walls? The composition of the artifact assemblage from outside the walls at Kamennyi Ambar demonstrates less wealth and diversity in comparison with the material complex from the permanent houses inside the walls. This observation suggests that the outsiders used a less diverse set of tools, as well as less durable materials (for example, wooden instead of metal) in their everyday life and did not accumulate much in the way of archaeologically visible possessions. On the other hand, a few stone and lithic artifacts demonstrate that craft activities were carried out using cheap and abundant raw materials. The artefact assemblages also point out that the people inside accumulated wealth in the form of material belongings and luxury goods, especially, things like metal artifacts and symbolic or military-related stone artifacts, while people outside did not do that. However, the presence of semi-precious stones could signify some kind of wealth accumulation by the segment of population outside the walls. Since there are limits to our ability to assess social relationships from material remains, it is difficult to say if the people who lived outside the walls were oppressed or less respected. Their possible concentration on herding-related activities and livestock keeping might suggest less prestigious social status. The most prominent members of the society were, nonetheless, buried with the attributes of warriors or craft specialists, not those of shepherds, suggesting that those involved in livestock management had less social prestige.

4. Irrespective of actual residence, what kinds of activities took place outside the walls, and how do they differ from activities inside the walls, as shown by previous excavations as well as by the disposal of garbage from inside the walls?

According to the phosphorus content of soils, animals appear to have been kept inside the walls, at least in some houses, while outside the phosphorus level is lower and could have been produced solely by human activity. At the same time, the molybdenum content of soil is higher in the cultural layer outside the walls, supporting that these locations were settled. The macro-botanical remains suggest that hay was stored outside the walls. Metallurgical slag of the Sintashta-Petrovka type found outside the Kamennyi Ambar and Konoplyanka walls supports Rüdiger Krause's (Krause and Koryakova 2013:222–223) idea that initial smelting of copper could have taken place outside the walls of the settlement, although, the cultural layer outside does not show higher levels of copper in comparison to natural values, or the values inside the settlement. In this case, copper smelting was likely a summer activity on the part of the population that did not move somewhere else for summer pastures. The postulated semi-mobile population demonstrates less engagement in craft activities, although some evidence for ceramic production was also found outside the walls of Kamennyi Ambar. Presumably, the household mode of production was typical for inhabitants of both walled and unwalled parts of the settlement, with possessions of daily use created by members of a family for their own use. In this case, the pastoralists made their every-day possessions from locally available raw materials, since lithic artifacts are also relatively abundant. At the same time, more specialized crafts, like wood-working and bone-carving could be concentrated in the hands of the inhabitants of the nucleated houses, and the products of craftsmen might have been distributed among herders by the local elites to maintain their network of supporters.

5. How do Konoplyanka and Zhurumbay differ from Kamennyi Ambar in the balance of productive activities indicated by artifacts and ecofacts deposited in the area around their walls? The artefact assemblages from outside the walls of all three walled communities demonstrate high similarities in terms of their composition. In all three cases, ceramic sherds and metallurgical slag predominate in the collections, even though fewer categories of artefacts were recorded for Zhurumbay and Konoplyanka. However, these two sites are heavily disturbed by post-depositional plowing and received less intensive archaeological study, which raises the possibility that

this difference could be attributable to less intensive sampling. The collections of animal bones demonstrate identical proportional composition in terms of domestic species. The collected materials demonstrate a high degree of homogeneity and indicate no significant difference in the balance of productive activities between the three settlements. This supports the idea that all three settlements might have been built by the same community moving sequentially along the river valley with their livestock to prevent over-grazing.

6. How were the locations of the settlements in the landscape chosen? All three settlements, as well as other Sintashta-Petrovka communities, werelocated at relatively low points on the landscape near sources of fresh water. Obviously, the need to water livestock played a crucial role for prehistoric pastoral societies. The GIS analysis of the surrounding landscapes shows that people chose to locate settlements in zones with moderate risk of flooding, but the settlements were surrounded by ditches that could be used to to drain water away during seasonal floods. In such locations, they are sheltered from high winds, which would decrease the heat loss and the risk of frostbite in the cold winters. Local visibility did not play any significant role in locating the settlements, unless they had tall watching towers that are unknown from the archaeological record. The spots with the best visibility on the surrounding hills do not show any evidence for cultural layers, and it is concluded that they were not inhabited even on an impermanent basis for protective functions.

4.3 THE SINTASHTA-PETROVKA LOCAL COMMUNITY: ALL PIECES COME TOGETHER

4.3.1 Outside and Inside the Walls

While it cannot be said that this field research found certain evidence for habitation outside the walled villages, the most pluasible interpretation of the cultural layers it revealed is a complicated palimpsest of craft activities, garbage deposition from the inside, and remains

of seasonal living in impermanent shelters. The population outside the walls, then, followed a significantly different lifestyle than that of the people who stayed year-round inside the walls.

A skeptic may argue that the architectural patterns of the early Indo-European traditional societies are characterized by post and beam structures, while other types of houses are not known for these groups (Kuzmina 1994:67). However, this idea contradicts cross-cultural observations that dwellings vary depending on climatic conditions, socio-political environment and subsistence practices. For example, in the settlements of the Early Bronze Age Pit-Grave archaeological culture are seasonal camps with dispersed cultural layers and no permanent houses in the Volga-Don region (Merpert 1974:101–109) and fortified settlements like Mikhailovskoye in the Black Sea region, where two distinct contemporaneous types of houses are recorded within the walls (Korobkova, Shaposhnikova 2005:38–45). Furthermore, Kuzmina (1994:72) cites linguistic studies demonstrating that the Sanskrit word for a permanent village earlier meant a circle of mobile wagon homes, situated together for defensive purposes for an overnight camp (Kuzmina 1994:72). An ethnographic example of the same kind is highland society in Western Tibet, where the pastoral *drokpas* reside in tents made of yak wool, while their farming counterparts (*shigpas*) live in permanent villages. Both groups belong to the same Tibetan culture, speak the same language, and practice the same religion (Bellezza 2014). In other words, traditional societies do have variety types of housing and it is possible that economic rationality governed the life-styles of the different parts of Sintashta-Petrovka communities.

The likely population of semi-mobile herders represented some 30%–60% of the entire local community, while the other of 40%–70% were inhabitants of the walled settlement. The almost completely excavated kurgan cemetery of Kamennyi Ambar-5 (only two kurgans remain unstudied) yielded about 100 individuals, or about 2%–5% of the total of 4,896±1,960 individuals in four generations who lived at the nearby settlement for 100 years. In other words, no more than 10% of the population was entitled to be buried under the kurgan mound and this proportion can be taken as an estimate of those with elevated social status. Perhaps, these elites were kin, since analysis of the burial patterns suggests sex/age rather than wealth/prestige differentiation between buried individuals within this elite group (Epimakhov and Berseneva 2011; Ventresca Miller 2013). The remaining non-elite members of the permanently resident community, then, represent-

ed some 30%–60% of the complete local community, but did not show evidence of standards of living particularly lower than the elites eventually interred in the kurgan.

The settlement of Sintashta had approximately 76 houses in which lived a population of 760±486 people along with another 486±194 people outside the walls. There are no radiocarbon dates for the Sintashta site, but if it was also occupied for about 100 years, then its total population over four generations sums up to 4,984±2,720 individuals. The buried population in the Sintashta Cemetery is about 80 individuals or only about 2%–3% of the total estimated population. However, these few individuals were buried with extremely rich offerings, like complete chariots, decorations made of precious metals or sacrifices of six horses (equal to about 900 kg of meat), etc. With such a low proportion of the population assigned such high prestige, the Sintashta local community can easily be labeled a local chiefdom. In Pitman and Doonan's view (2018) the social structure of the chifeom consisted of a chief and his kin at the highest level; warriors, religious specialists, and craftsmen in the middle; and the pastoral community at the bottom level.

Thus, the difference in social prestige between the social elites on the one hand, who were celebrated in death with elaborate rituals and large quantities of offerings, and commoners on the other hand could be quite significant, even though the standards of living of these elites visible in the burial evidence differed little from the standards of living of the other residents of the permanent settlement.

The semi-mobile herders moved with the livestock on the seasonal basis—as is suggested for the possible ancestors of Sintasha people in the Black Sea region. There, the communities of the Catacomb culture also could be divided into sedentary and pastoral groups (Ivanova 2013:273). Similar practices are noted for the inhabitants of the Pit-Grave culture settlement of Mikhailovksoye (Korobkova, Shaposhnikova 2005:257). Importantly, the stable isotope data from the Karagaily-Ayat valley demonstrate that the animals were grown locally within the same valley (Kiseleva et al. 2017). This suggests that usually people also did not travel far, but remained within the same valley for prolonged periods. A similar economic pattern is still practiced by the villagers of Varshavka, who are involved in the capitalistic production of livestock for the Varshavskoye, Ltd Enterprise with 5,000–6,000 head of cattle (Grebenshikova, 2017, personal communication). During the summertime, several herders move away from the village to live in the summer pastures in small wagons. The majority of the population remains in the village, including political leaders and owners of the

enterprise. Interestingly enough, the house of the enterprise's owner Evdokiya Grebenshikova is not significantly bigger or architecturally different from the homes of the rest of the villagers.

In the Bronze Age, the people who comprised the majority of the permanent population were involved in craft activities, including extraction of copper ores, metallurgy, bone, leather, and woodwork. The most important and labor-intensive part of the economy, however, was haymaking. The evidence of hay found in the cultural layer near Kamennyi Ambar supports the idea that animals were fed during the winter. Nowadays, hay cutting is typically done in July-August, the period of most intensive grazing for animals. Thus, the part of the collective that remained in the settlement had to provide the labor force for haymaking.

In the wintertime, the herders returned to the settlements with the herds, and animals were kept inside the walls—a practice which is known archaeologically (Zakh 1995) and ethnographically (Shahack-Gross et al. 2004)—while herders stayed outside in their tents.

In sum, the Sintashta-Petrovka chiefdoms demonstrate a three-part social order. In Kuzmina's (1994) view, this is similar to the Varna system of ancient India, that consisted of priests (Sansk. Brahmanis), rulers and warriors (Sansk. Kshatriyas), free producers (Sansk. Vaishyas) and laborers and service providers (Sansk. Shudras). In the Sintashta-Petrovka chiefdom, the elite 2%–5% of the population would have consisted of priests and warriors; 48%–55% would have been dependent producers; and 50%–60% would have been herders of lower social rank.

4.3.2 Social Complexity and Social Organization of the Sintashta-Petrovka Chiefdom

Analysis of social realms known for other pastoral societies makes it poosible to characterize further the Sintashta-Petrovka local chiefdoms. Among these realms are relationships of property, political leadership, land tenure and ownership, community and social organization (Dyson-Hudson & Dyson-Hudson 1980; Cribbs 1991; Frachetti 2008).

Regarding property, the most straightforward way to accumulate wealth is to increase the size of herds. Even though we do not know what rules of property Sintashta-Petrovka people had, rich burial offerings of domestic animals in Sintashta-Petrovka cemeteries, along with the

scarcity of luxury goods there, suggest that animals played the most essential role among possessions. It is possible that while the herd as a whole was considered common property, some individual animals could belong to the particular individuals. For example, trained chariot horses might have been owned by charioteers, or a breeding bull could have belonged to the most prominent family (Krupnik 1993:162–172). However, herd capital is perishable, and risk management strategies would be required to safeguard well-being and increase prosperity. Sintashta-Petrovka elites employed such strategies as multi-species herds and hunting, while other families might have diversified their subsistence strategies by gathering wild plants and fishing (Ventresca-Miller 2013). Other forms of wealth and property accumulation, of course, could have included the accumulation of luxury craft goods (like silver decorations) or semi-precious stones.

Regarding land tenure and ownership, the Sintashta-Petrovka local chiefdoms do not demonstrate any solid boundaries, but if three communities in the Karagaily-Ayat valley existed simultaneously, each had a buffer zone with a diameter of about 8-10 km. Within the buffer zone, the land was likely considered common property (Frachetti 2008), since it is most likely that herds were pastured together. If Kamennyi Ambar, Konoplyanka and Zhurumbay represent the same community that moved around the land, access to resources (water and pastures) was not a problem due to their abundance in the valley. Another important issue regarding land ownership is that, despite the arguments of high importance of bronze metallurgy (Vinogradov 2011; Doonan et al. 2013), none of the fortified communities were located near the known sites of copper extraction. For example, Sarym-Sakly is the closest settlement to the biggest mine of Vorovskaya Yama located about 7 km away, while the newly discovered the Novonikolayevka mine is in 10 km from the settlement of Rodniki (Zaikov et al. 2016).

In the case of the Sintashta-Petrovka chiefdoms, the questions of why and how exactly social complexity developed through time and why individuals choose to integrate and give up their independence can be answered as some combination of two necessities: to persist as a larger community in the ecological niche of the newly settled region, and to protect herds from theft. There is general agreement among researchers that the Sintashta phenomenon had no local roots and originated with a large-scale migration of pastoral communities from Eastern Europe to the marginal area of the Southern Urals. This process forced families to stay together and fueled the necessity in the walled villages for ensuring the reproduction of herds in the extreme climatic

conditions of the southern Urals that are colder and dryer than the eastern Black Sea region from which the Sintashta populations are thought to have migrated (Kuzmina 1994, 2007; Anthony 2007; Vinogradov 2011, etc.). At the same time, the herds needed protection from animal and human predators. Probably, the risk of losing animals was a threat to survival that created tensions between neighboring communities, and the Neolithic hunter-gatherers who had populated the Urals before the arrival of Sintashta people could have hunted the domestic animals. Apparently, those who were talented in managing the construction of closely-packed villages surrounded by ditches and walls to protect people and livestock from threats from neighbors, and who otherwise served the community in the newly colonized zone became the most prominent members of society. Theses people formed the core of the Sintashta-Petrovka chiefdom but were not able to accumulate much personal wealth in the form of material possessions. Instead, they acquired high social prestige that could even be transferred to their children (since up to 65% of the buried elite population consists of infants [Razhev and Epimakhov 2005). In this sense, the Sintashta-Petrovka elites were simmilar to their counterparts in the Alto Magdalena of Colombia (Drennan 1995; Gonzalez Fernandez 2007; Drennan and Peterson 2008).

However, this situation did not last longer than 300 years, since after the initial phase of colonization of the Southern Urals was over, the need for social services provided by an elite disappeared and centralized chiefly communities disintegrated into the smaller unfortified villages of the Srubnaya-Alakul' period.

4.4 DIRECTIONS FOR FUTURE RESEARCH

This study has provided a theoretical framework for the future evaluation of the early complex societies of the southern Tran-Urals and adjacent territories. It has demonstrated the necessity of looking outside the walls of the famous sites for fuller depiction of the past society. However, it cannot be considered as an exclamation point at the end of a completed sentence, but rather as a pause for breath before asking further research questions. As one result, this dissertation study has also generated a number of topics for future research.

Continued research is still crucial for better understanding of the Sintashta-Petrovka early complex societies and the ways that social complexity was shaped. A more evenly spread sample of test pits would help to characterize the area around Kamennyi Ambar better and provide a more representative sample of artefactual materials for comparison. Even though the current sample of materials is large enough for the statistical inferences, it was obtaineded from a sample of strategically placed units that tends to over-represent some parts of the land lying outside the walls (the north and west) and under-represent others (the east and northwest). Next, it is vital to excavated a larger area near the Kamennyi Ambar walls with the purpose of more careful study and better understanding of the nature of the cultural deposits. The most promising areas around Kamennyi Ambar are (1) the location north of the wall where magnetometer survey shows a circular anomaly and where nearby excavation discovered a deep cultural layer and (2) the location to the east-southeast of the enclosure where the remains of a fire were recorded. These areas need to receive more detailed study including geochemistry and soil macro- and micro-morphology.

Another valuable line of research would extend the current survey to the Karagaily-Ayat valley in order to look for summer camps of the Sintashta-Petrovka herders. Successful methodology for such survey has been developed by Denis Sharapov in the Zingeyka River valley (Sharapov 2017), but its combination with the strategy of the Krasnosamarskoye project (Anthony et al. 2005) might allow locating previously unknown scatters of Bronze Age materials. Combining full-coverage regional pedestrian survey with intensive sub-surface testing focused on the small tributaries may yield evidence of the social group of herders. In addition, excavation of the un-walled settlements could provide more understanding of their relationship to the walled villages.

Finally, in addition to what is known about local chiefdoms in the Karagaily-Ayat valley, similar research near Sarym-Sakly could provide a good comparison for the understanding of societal relationships in the Bronze Age. Presence of hinterland groups near Sarym-Sakly was established by Denis Sharapov (2017), but the results of both his and this research can be expanded by more intensive study of the area just outside the walls of the Sarym-Sakly walled settlement.

APPENDIX A

ACCESS TO THE ONLINE DATASET

The dataset for the Karagaily-Ayat River valley is available electronically through the University of Pittsburgh's Comparative Archaeology Database. The downloadable dataset contains both spatial and quantitative information about the cores, the cross-sections and test pits that were documented during the fieldwork. Full field reports in the Russian language are available. The database of collected artifacts and values of chemical elements are provided. The data are available in a variety of formats and can be accessed at www.cadb.pitt.edu. General questions regarding the database and its contents should be sent to cadb@pitt.edu.

BIBLIOGRAPHY

1989   *Agricultural Encyclopedic Dictionary.* Moscow: Sov. Enciklopediya.

2008   *Fermerskoye khozyaystvo [Farming].* Belgorod: EKSMO.

Abrams, Elliot M.

1994   *How the Maya Built Their World: Energetics and Ancient Architecture.* Austin: University of Texas Press

Adams, Robert McC.

1981   *Heartland of Cities: Surveys of Ancient Settlement and Land Use on the Central Floodplain of the Euphrates.* Chicago: University of Chicago Press.

Alberti, Gianmarco

2014   Modeling Group Size and Scalar Stress by Logistic Regression from an Archaeological Perspective. *PLoS One* 9 (3):1–15.

Alden, John R.

1979   A Reconstruction of Toltec Period Political Units in the Valley of Mexico. In *Transformations: Mathematical Approaches to Culture Change*, edited by Colin Renfrew and Kenneth L. Cooke, 169–200. New York: Academic Press.

Allard, Francis, and D. Erdenebaatar

2005   Khirigsuurs, Ritual and Mobility in the Bronze Age of Mongolia. *Antiquity* 79 (305):547–563.

American Meteorological Society

2005   *Glossary of Meteorology.* https://www.ametsoc.org/ams/index.cfm/publications/glossary-of-meteorology/.

Anisimov, N. P.

2009   Arkaim – strana kard: empirica prostranstva zaural'skoyi sredy [Arkaim and the Country of Barns: Environments of the Trans–Urals]. *Gradostroitel'stvo* (2):16–21.

Anthony, David W.

2007   *The Horse, the Wheel, and Language: How Bronze-Age Riders from the Eurasian Steppes Shaped the Modern World.* Princeton, N.J.: Princeton University Press.

2009   The Sintashta Genesis: The Roles of Climate Change, Warfare and Long-Distance Trade. In *Social Complexity in Prehistoric Eurasia: Monuments, Metals, and Mobility*, edited by Bryan K. Hanks and Katheryn M. Linduff, pp. 47–73. Cambridge: Cambridge University Press.

Anthony, David W., Dorcas Brown, E. Brown, A. Goodman, A. Kochlov, Pavel A. Kosincev, Pavel F. Kuznetsov, Oleg D. Mochalov, E. M. Murphy, D.L. Peterson, A. Pike-Tay, Laura M. Popova, A. Rosen, N. Russel, and A. Weisskopf

2005   The Samara Valley Project. Late Bronze Age Economy and Ritual in the Russian Steppes. In *Eurasia Antiqua*, edited by Svend Hansen and Mayke Wagner, pp. 395–417. Mainz am Rhein: Deutshes Archaeologishes Insitut.

Anthony, David W., Dorcas R. Brown, Pavel F. Kuznetsov and Oleg D. Mochalov

2016   *A Bronze Age Landscape in the Russian Steppes: The Samara Valley Project.* Los Angeles: UCLA Cotsen Institute of Archaeology Press.

Arkush, Elizabeth N.

2011   *Hillforts of the Ancient Andes.* Gainesville: University Press of Florida

Bachura, O. P.

2013.   Sezony funkcionirovaniya posileniy skotovodov sredney bronzy v Yuzhnom Zauralie [The Seasonality of the Middle Bronze Aga Settlements in the Southern Urals]. In *Etnicheskiye Vzaimodeistviya na Yuzhnom Urale [Ethnic Relationships in the Southern Urals]*, edited by Alexandr D. Tairov and Nadezhda O. Ivanova, pp. 271–276. Chelyabinsk: OOO CIKR "Rifei".

Bachura, O. P., Gennadiy B. Zdanovich, and Pavel A. Kosincev

2011   Sezon i vozrast zaboya domashnikh kopytnykh po registriruyushchim strukturam iz ukreplennogo poseleniya Arkaim [Season and Age of Slaughtering of Domestic Animals from the Fortified Settlement of Arkaim]. In *Ekologiya drevnikh i traditsionnykh obshchestv [Ecology of Ancient and Traditional Societies],* edited by N. P. Matveeva and A. N. Bagashev, pp.11–12. Tyumen: Izd-vo Tumenskogo gosudarstvennogo universiteta

Bahraminova, Ayazan Saghidulovna

2017   *"Ekologicheskiy monitoring sostoyaniya kormovykh ugodiy i effektivnost' priyemov poverkhnostnogo uluchsheniya pastbishch yuzhnykh chernozemov stepnoy zony Akmolinskoy oblasti"* [Ecological Monitoring of the Condition of Fodder Land and Efficiency Methods of Superficial Improvement of Pastures of Southern Chernozems of the Steppe Zone of the Akmola Region], (Ph.D. diss, Kazakhskiy Agrotekhnicheskiy Universitet).

Baker, Jonathan L., Matthew S. Lachniet, Olga Chervyatsova, Yemane Asmerom, and Victor J. Polyak

2017   Holocene Warming in Western Continental Eurasia Driven by Glacial Retreat and Greenhouse Forcing. *Nature Geoscience* 10 (6):430–436.

Bandy, Matthew S.

2004   Fissioning, Scalar Stress, and Social Evolution in Early Village Societies. *American Anthropologist* 106 (2):322–333.

Bandy, Matthew S., and Jake R. Fox

2010   Becoming Villagers: The Evolution of Early Village Societies. In *Becoming Villagers: Comparing Early Village Societies*, edited by Matthew S. Bandy and Jake R. Fox, pp. 1–18. Tucson: The University of Arizona Press.

Batanina, Iya M., and Nadezhda O. Ivanova

1995   Arkheologicheskaya karta zapovednika Arkaim. Istoriya issledovaniya arkheologicheskikh pamyatnikov [The Archaeological Map of the Arkaim Reservation. The History of the Study of the Archaeological Sites].” In *Arkaim: Issledovaniya. Poiski. Otkrytiya,* edited by Gennadiy B. Zdanovich, pp. 159–195. Chelyabinsk: TO “Kammeniiy Poyas”.

Batanina, Iya M., and N. V. Levit

2008   *Otchet ob arkheologicheskom deshifrirovanii reki doliny reki Karagayly-Ayat na Yuzhnom Urale [Report on the Archaeological Interpretation of the Karagaili-Ayat Valley in the Southern Urals].* Chelyabinsk: The Arkaim Reserve. Access: The Scientific Archive of The Arckaim Reserve.

Batanina, Natalya S., and Bryan K. Hanks

2013   Soviet Period Air Photography and Archaeology of the Bronze Age in the Southern Urals of Russia. In *Archaeology from Historical Aerial and Satellite Archives*, edited by W.S. Hanson and I.A. Oltean, pp. 199–219. New York: Springer Science+Business Media.

Bendrey, Robin

2011   Some Like It Hot: Environmental Determinism and the Pastoral Economies of the Later Prehistoric Eurasian Steppe. *Pastoralism: Research, Policy and Practice* 1:8–32.

Bellezze, John Vincent

2014   *The Dawn of Tibet: The Ancient Civilization on the Roof of the World.* Rowman & Littlefield.

Berbekova, N. V., and K. G. Magomedov

2014   Effektivnost’ razlichnykh priyemov uluchsheniya degradirovannykh prisel’skikh pastbishch v Kabardino-Balkarii [Efficiency of Various Methods for Improving Degraded Rural Pastures in Kabardino-Balkaria]. *Agrarnyy vestnik Urala* (9):6–8.

Bersenev, Andrey G., Ludmila N. Koryakova, Igor V. Chechushkov, and Svetlana V. Sharapova

2014   Psalii s poseleniya Kamenniy Ambar [Cheekpieces from the Settlement of Kamennyi Ambar]. *Arkheologiya, etnographiya i antropologiya Evrazii [Archaeology, Ethnology and Anthropology of Eurasia]* 3 (59):60–68.

Berseneva, Nataliya A.

2011   *Otchet ob arkheologicheskikh raskopkakh ukreplennogo poseleniya Kamennyy Ambar v 2010 g. [Report on Archaeological Excavations of the fortified Settlement of Kamennyi Ambar in 2010]*. Chelyabinsk: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences, the South Ural Branch. Access: The Scientific Archive of the Institute of History and Archaeology.

2014   *Otchet ob arkheologicheskikh raskopkakh ukreplennogo poseleniya Kamennyy Ambar v 2012 g. [Report on Archaeological Excavations of the fortified Settlement of Kamennyi Ambar in 2012]*. Vol. 1. Chelyabinsk: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences, the South Ural Branch. Access: The Scientific Archive of the Institute of History and Archaeology.

Berseneva, Nataliya A., Andrey V. Epimakhov, Vladislav V. Noskevich, and Nataliya V. Fedorova

2015   Vozmozhnosti sinteza geofizicheskoy i arkheologicheskoy informatsii pri interpretatsii rezul'tatov raskopok (na primere poseleniya bronzovogo veka Kamennyy Ambar) [Towards Synthesis of Geophysical and Archaeological Information in Interpreting the Results of Excavations (the Example of the Bronze Age Settlement of Kamenny Ambar)]. *Vestnik arkheologii, antropologii i etnografii [Bulletin of Archaeology, Anthropology and Ethnology]* 1 (28):4–14.

Bikmulina, L. R., A. S. Yakimov, V. S. Mosin, and A. I. Bazhenov

2017   Geokhimicheskiye osobennosti pochv i kul'turnykh sloyev poseleniya neolita-eneolita Kochegarovo-1 v lesostepnoy zone Zapadnoy Sibiri i ikh paleoekologicheskaya interpretatsiya [Geochemical Features of Soils and Cultural Layers of the Neolithic-Eneolithic Settlement of Kochegarovo-1 in the Forest-Steppe Zone of Western Siberia and Their Paleoecological Interpretation]. *Arkheologiya, etnografiya i antropologiya Yevrazii [Archeology, ethnography and anthropology of Eurasia]* 45 (2):35–44.

Bishop, Ruth

2005   *The Horse Nutrition Bible: The Comprehensive Guide to the Correct Feeding of Your Horse*: David & Charles.

Blanton, Richard E.

1994   *Houses and Households: A Comparative Study*, *Interdisciplinary Contributions to Archaeology*. New York: Plenum Press.

Brown, Barton McCaul

1987   Population Estimation from Floor Area: A Restudy of "Naroll's Constant. *Behavior Science Research* 21 (1–4):1–49.

Carneiro, Robert L.

1981   Chiefdom: Precursor of the State. In *The Transition to Statehood in the New World* edited by G. D. Jones and R. R. Kautz, pp. 37–79. Cambridge, UK – New York, NY: Cambridge University Press.

1998   What Happened at Flashpoint? Conjectures on Chiefdom Formation at the Very Moment of Conception. In *Chiefdoms and Chieftaincy in the Americas*, edited by Elsa M. Redman, pp.18–42. Gainesville: University Press of Florida.

Cashdan, Elizabeth A.

1990   *Risk and Uncertainty in Tribal and Peasant Economies*: Westview Press.

Chang, Claudia

2012   Cycles of Iron Age Mobility and Sedentism: Climate, Landscape, and Material Culture in Southeastern Kazakhstan. In *Nomads and Networks: The Ancient Art and Culture of Kazakhstan*, edited by Sören Stark, Karen Sydney Rubinson, Z. S. Samashev and Jennifer Chi, pp. 12–22. Princeton: Institute for the Study of the Ancient World, Princeton University Press.

Chang, Claudia, and Harold A. Koster

1986   Beyond Bones: Toward an Archaeology of Pastoralism. *Advances in Archaeological Method and Theory* 9:97–148.

Chechushkov, Igor V.

2011   Kolesnitsy Evraziyskikh stepey epokhi bronzy [The Bronze Age Chariots of the Eurasian Steppes]. *Vestnik arkheologii, antropologii i etnografii [Bulletin of Archaeology, Anthropology and Ethnology]* 2 (15):57–65.

2012   *Otchet ob arkheologicheskoy razvedke na territorii ob'yekta kul'turnogo naslediya regional'nogo znacheniya «Poseleniye Ust'ye» v Varnenskom rayone Chelyabinskoy oblasti v 2011–2012 godakh* [Report on the Archaeological Investigation at the Site of the Cultural Heritage of Regional Importance "The Settlement of Ust'ye" in the Varna District of Chelyabinsk Region, 2011–2012]. Chelyabinsk: Chelyabinsk State Pedagogical University. Access: The Scientific Archive of the Institute of Archaeology.

Chernykh, Evgeny N.

1978   Mettalurgicheskiye provintsiyi I periodizatsiya epokhi rannego metalla na territoriyi SSSR (The Mellurgical Regions and the Periodization of the Early Bronze Age on the teritorry of the USSR]. *Sovetskaya Arkheologiya [Soviet Archaeology]* 4:53–81.

1992   *Ancient Metallurgy in the USSR: The Early Metal Age*. New York: Cambridge University Press.

2008   The «Steppe Belt» of Stockbreeding Cultures in Eurasia During the Early Metal Age. *Trabajos de Prehistoria* 65 (2):79–93.

Chifeng International Collaborative Archaeological Research Project

2011   *Settlement Patterns in the Chifeng Region*. Pittsburgh: Center for Comparative Archeology at the University of Pittsburgh

Clark, John E., and Michael Blake

1994   The Power of Prestige: Competitive Generosity and the Emergence of Rank Societies in Lowland Mesoamerica." In *Factional Competition and Political Development in the New World*, edited by Elizabeth M. Brumfiel and John W. Fox, pp. 17–30. Cambridge: Cambridge University Press.

Coles, John M.

2006. Ancient Wood, Woodworking and Wooden Houses (Contribution to the ESF Workshop on the Reconstruction of Wooden Buildings from the Prehistoric and Early Historic Period in Århus, Denmark in 1987), euroREA. *Journal for (Re)construction and Experiment in Archaeology* (3):50–57.

Costin, Cathy Lynne

1991   Craft Specialization: Issues in Defining, Documenting, and Explaining the Organization of Production. *Archaeological Method and Theory* (5):1–56.

Costin, Cathy Lynne, and Timothy Earle

1989   Status Distinction and Legitimation of Power as Reflected in Changing Patterns of Consumption in Late Prehispanic Peru. *American Antiquity* 54 (4):691–714.

Cribb, Roger

1991   *Nomads in Archaeology*. Cambridge: Cambridge University Press.

Degtyareva, Anna D., Sergey V. Kuzminykh, and Lubov B. Orlovskaya

2001   Metalloproizvodstvo petrovskikh plemen (po materialam poseleniya kulevchi 3) [The Metallurgy of the Petrovka People]. *Vestnik arkheologii, antropologii i etnografii [Bulletin of Archaeology, Anthropology and Ethnology]* 3:23–54.

Dergacheva, M. I.

1997   *Arkheologicheskoye pochvovedeniye [Archaeological pedology]*. Novosibirsk: Nauchno-izdatel'skiy tsentr OIGGM.

Doonan, Roger K., Bryan K. Hanks, Dmitriy G. Zdanovich, Elena V. Kupriyanova, Derek Pitman, Natalya Batanina, and James Johnson

2014   Metals, Society, and Economy in the Late Prehistoric Eurasian Steppe. In *Archaeometallurgy in Global Perspective*, edited by Benjamin W. Roberts and Christopher P. Thornton, pp. 755–784. New York: Springer.

Doonan, Roger K., Derek Pitman, Bryan K. Hanks, Dmitriy G. Zdanovich, and Elena V. Kupriyanova

2013 Die Organization der Merallurgie de Sintashta-Kultur. In *Underannted Kasachstan. Archaologie Im Herzen Asiens*, edited by Thomas Stolner and Zaynolla Samasev, pp. 211–219. Bochum: Deutsches Bergbau-Museum Bochum.

Drennan, Robert D

1995 Mortuary Practices in the Alto Magdalena: The Social Context of the "San Agustin Culture. In *Tombs for the living: Andean Mortuary Practices*, edited by Tom D. Dillehay, pp. 79–110. Washington, D.C.: Dumbarton Oaks Research Library and Collection.

Drennan, Robert D., C. Adam Berrey, and Christian E. Peterson

2015 *Regional Settlement Demography in Archaeology*. New York: Eliot Werner Publications

Drennan, Robert D., Bryan K. Hanks, and Christian E. Peterson.

2011 The Comparative Study of Chiefly Communities in the Eurasian Steppe Region *Social Evolution & History* 10 (1):149–186.

Drennan, Robert D., Teng Mingyu, Christian E. Peterson, Gideon Shelach, G. G. Indrisano, Z. Yanping, Kathryn M. Linduff, G. Zhizhong, and Manuel A. Roman-Lacayo

2003 Methods for Archaeological Settlement Study. In *Regional Archaeology in Eastern Inner Mongolia: A Methodological Exploration*, edited by The Chifeng International Collaborative Archaeological Research Project, pp. 122–162. Beijing: Science Press.

Drennan, Robert D., and Christian E. Peterson

2006 Patterned Variation in Prehistoric Chiefdoms. *Proceedings of the National Academy of Sciences of the United States of America* 103 (11):3960–3967.

2008 Centralized Communities, Population, and Social Complexity after Sedentarization. In *The Neolithic Demographic Transition and Its Consequences*, edited by Jean-Pierre Bocquet-Appel and Ofer Bar-Yosef, pp. 359–386. Dordrecht: Springer.

2012 Challenges for Comparative Study of Early Complex Societies. In *The Comparative Archaeology of Complex Societies*, edited by Michael E. Smith, pp. 62–87. Cambridge: Cambridge University Press.

Drennan, Robert D., Christian E. Peterson., and Jake R. Fox

2010 Degrees and Kinds of Inequality. In *Pathways to Power, Fundamental Issues in Archaeology*, edited by T. Douglas Price and Garry M. Feinman, pp. 45–76. Springer Science+Business Media.

Dubovtseva, E. N., D. V. Kiseleva, and S. E. Panteleyeva

2016 Tekhnologicheskoye issledovaniye keramiki sintashtinskogo tipa iz poseleniya Kamennyi

Ambar [The Technological Study of Sintashta Type Ceramics from the Kamennyi Ambar Settlement]. *Ural'skiy Istoricheskiy Vestnik [The Urals Historical Herald]* 4 (53):99–110.

Dwyer, Mark J., and Kirill V. Istomin

2008 Theories of Nomadic Movement: A New Theoretical Approach for Understanding the Movement Decisions of Nenets and Komi Reindeer Herders. *Human Ecology* 36 (4):521–533.

Dyson-Hudson, Rada, and Neville Dyson-Hudson

1980 Nomadic Pastoralism. *Annual Review of Anthropology* 9:15–61.

Earle, Timothy K.

1987 Chiefdoms in Archaeological and Ethnohistorical Perspective. *Annual Review of Anthropology* 16:279–308.

1997 *How Chiefs Come to Power: The Political Economy in Prehistory*. Stanford, CA: Stanford University Press.

2002 *Bronze Age Economics: The Beginnings of Political Economies*. Boulder, Westview Press

2011 Chiefs, Chieftaincies, Chiefdoms, and Chiefly Confederacies: Power in the Evolution of Political Systems. *Social Evolution & History* 10 (1):27–54.

Eerkens, Jelmer W.

2009 Privatization of Resources and the Evolution of Prehistoric Leadership Strategies. In *The Evolution of Leadership: Transitions in Decision Making from Small-Scale to Middle-Range Societies*, edited by Kevin J. Vaughn, Jelmer W. Eerkens and John Kantner, pp. 73–94. Santa Fe, NM: SAR Press.

Engels, Friedrich, Lewis Henry Morgan, and K. Marx

1972 *The Origin of the Family, Private Property, and the State*. New York: Pathfinder Press.

Epimakhov, Andrey V.

1996 Demograficheskiye aspekty sotsiologicheskikh rekonstruktsiy (po materialam sintashtinsko–petrovskikh pamyatnikov) [Demographic Aspects of Sociological Reconstructions (Based on the Materials of Sintashta-Petrovka Sites)]. In *XIII Ural'skoye arkheologicheskoye soveshchaniye [Proceedings of the XIII Ural Archaeological Meeting]*, pp. 58–60. Ufa: Vostochnyi universitet

2002 *Yuzhnoye Zaural'ye v epokhu sredney bronzy [The Southern Trans-Urals in the Middle Bronze Age]*. Chelyabinsk: South Ural State University.

2005 *Ranniye kompleksnyye obshchestva severa Tsentral'noy Yevrazii: po materialam mogil'nika Kamenniy Ambar-5 [The Early Complex Societies of the Northern Part of Central Eurasia: Materials of the Cemetery of Kamennyy Ambar-5]*. Chelyabinsk: Chelyabinskiy Dom Pechati.

2007a Otnositel'naya i absolyutnaya khronologiya sintashtinskikh pamyatnikov v svete radiokar-bonnykh datirovok [The Relative and Absolute Chronologies of the Sintashta Sites in the Light of Radiocarbon Dates]. *Problemy istorii, filologii, kul'tury [Problems of History, Philology, Culture]* (17):402–421.

2007b *Otchet ob arkheologicheskikh raskopkakh ukreplennogo poseleniya Kamennyy Ambar v 2005 g.* [Report on the Archaeological Excavations of the Fortified Settlement of Kamennyi Ambar in 205]. Ekaterinburg: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences. Access: The Scientific Archive of the Institute of History and Archeology.

2010a *Bronzoviy vek Yuzhnogo Urala (ekonomicheskiye i sotsial'nyye aspekty): Afroreferat dissertatsii na soiskaniye uchenoy stepeni doktora istoricheskikh nauk [The Bronze Age of the Southern Urals (Economic and Social Aspects): The Author's Abstract of the Dissertation for Degree of a Doctor of Science].* Novosibirsk: Institut arkheologii i etnografii Sibirskogo otdeleniya RAN.

2010b *Otchet ob arkheologicheskikh raskopkakh ukreplennogo poseleniya Kamennyy Ambar v 2008 g.* [Report on the Archaeological Excavations of the Fortified Settlement of Kamennyi Ambar in 2008]. Ekaterinburg: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences. Access: The Scientific Archive of the Institute of History and Archeology.

2012 *Otchet ob arkheologicheskikh raskopkakh ukreplennogo poseleniya Kamennyy Ambar v 2008 g.* [Report on the Archaeological Excavations of the Fortified Settlement of Kamennyi Ambar in 2011]. Chelyabinsk: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences, the South Ural Branch. Access: The Scientific Archive of the Institute of History and Archeology.

Epimakhov, Andrey V., and Nataliya A. Berseneva

2012 Variativnost' pogrebal'noy praktiki sintashtinskogo naseleniya (poisk ob"yasnitel'nykh modeley) [Variability of Burial Practices Among Sintashta People (Searching for Explanatory models]. *Vestnik Novosibirskogo Gosudarstvennogo Universiteta [Bulletin of Novosibirsk State University]* 11 (3):148–170.

Erasmus, Charles J.

1965 Monument Building: Some Field Experiments. *Southwestern Journal of Anthropology* 21 (4):277–301.

Erdniyev, U. E.

1985 *Kalmyki: Istoriko-etnograficheskiye ocherki [The Kalmyks: historical and ethnographical reviews].* Elista: Kalm. kn. izd-vo.

Evdokimov, V. V., and V. V. Varfolomeev

2002 *Epokha bronzy central'nogo Kazakhstana [The Bronze Age of central Kazakhstan].* Karaganda: KarGU

Fedorova, Nataliya V., and Vladislav V. Noskevich

2012 Rekosntrukciya planirovki ukreplennykh poseleniy epokhi bronzy na Uzhnom Urale (Ol'gino i Konoplyanka) po rezultatam detal'noy magnitnoy semki [To the Reconstruction of of the Planigraphy of the Bronze Age Fortified Satllements (Ol'gino and Konoplyanka) According to the Magnetometry Survey]. *Ural'skij geofiziceskij vestnik (The Ural Bulettin of Geophysics)* 1 (19):52–59.

Feklin, Ivan

2012 Zasukha na Yuzhnom Urale uzhe obernulas' problemami dlya agrariyev [Drought in the Southern Urals has Already Turned into Problems for Farmers]. Chelyabinsk: Vecherniy Chelyabinsk. November 7, https://vecherka.su/articles/news/2154/.

Flannery, Kent V.

1972 The Cultural Evolution of Civilizations. *Annual Review of Ecology and Systematics* 3:399–426.

Forthofer, Jason, Kyle Shannon, and Bret Butler

2009 Simulating Diurnally Driven Slope Winds with WindNinja. *Proceedings of 8th Symposium on Fire and Forest Meteorological Society, 13-15 October 2009,* pp. 1–13. Kalispell, Montanta.

Frachetti, Michael D.

2008 *Pastoralist Landscapes and Social Interaction in Bronze Age Eurasia*. Los Angeles: University of California Press.

2009 Differentiated Landscapes and Non-Uniform Complexity among Bronze Age Societies of the Eurasian Steppe. In *Social Complexities in Prehistoric Eurasia: Monuments, Metals, and Mobility*, edited by Bryan K. Hanks and Katheryn M. Linduff, pp. 19–46. Cambridge: Cambridge University Press.

2012 The Multi-Regional Emergence of Mobile Pastoralism and the Growth of Non-Uniform Institutional Complexity Across Eurasia. *Current Anthropology* 53 (1):2–38.

Fried, Morton H.

1967 *The Evolution of Political Society: An Essay in Political Anthropology*. New York: Random House.

Fujisada, H., G. B. Bailey, Glen G. Kelly, S. Hara, and M. J. Abrams

2005 ASTER DEM Performance. *IEEE Transactions on Geoscience and Remote Sensing* 43 (12):2707–2713.

Gajewski, K.

2015 Quantitative Reconstruction of Holocene Temperatures across the Canadian Arctic and Greenland. *Global and Planetary Change* 128:14–23.

Gening, Vladimir F.

1977   Mogil'nik Sintashta i problema rannikh indoiranskikh plemen [The Cemerery of Sintashta and the Problem of Early Indo-Iranian people]. *Sovietskaya Arckheologiya [Soviet Archaeology]* 4:53–73.

Gening, Vladimir F., Gennadiy B. Zdanovich, and Vladimir V. Gening

1992   *Sintashta: arkheologicheskie pamiatniki ariiskikh plemen Uralo-Kazakhstanskikh stepei [Sintashta: The Archaeological Evidence of Aryans in the Ural-Kazakhstan Steppes]*. Chelyabinsk: Uzhno-Ural'skoe knizhnoe izd-vo.

Gijseghem, Hendrik Van, and Kevin J. Vaughn

2008   Regional Integration and the Built Environment in Middle-Range Societies: Paracas and Early Nasca Houses and Communities. *Journal of Anthropological Archaeology* 27 (1):111–130.

Gonzalez Fernandez, Victor

2007   *Prehispanic Change in the Mesitas Community: Documenting the Development of a Chiefdom's Central Place in San Agustin, Huila, Colombia, University of Pittsburgh Memoirs in Latin American Archaeology No. 18*. Pittsburgh: University of Pittsburgh, Department of Anthropology.

Government of Canada

2017   Canadian Climate Normals 1971–2000. http://climate.weather.gc.ca/climate_normals/index_e.html.

Gower, J. C.

1985   Measures of Similarity, Dissimilarity, and Distance. In *Encyclopedia of Statistical Sciences*, edited by S. Kotz and N.L. Johnson, pp. 397–405. New York: John Wiley and Sons.

Grigoriev, Stanislav A.

2002   *Ancient Indo-Europeans*. Chelyabinsk: Rifei.

Grigoriev, Stanislav A.

2013   *Metallurgicheskoye proizvodstvo v Severnoy Yevrazii v epokhu bronzy [Metallurgical Production in Northern Eurasia in the Bronze Age]*. Chelyabinsk: Cicero.

Hanks, Bryan K.

2009   Late Prehistoric Mining, Metallurgy, and Social Organization in North Central Eurasia. In *Social Complexity in Prehistoric Eurasia: Monuments, Metals, and Mobility*, edited by Bryan K. Hanks and Katheryn M. Linduff, pp. 146–168. Cambridge: Cambridge University Press.

Hanks, Bryan K.

2013   Notes from the Field. *Interdisciplinaria Archaeologia. Natural Sciences in Archaeology* 1 (2013):3–5.

Hanks, Bryan K., Igor V. Chechushkov, Roger K. Doonan, Derek Pitman, Branko Muzic, Igor Meraic, and Matyazh Mori

2013   Noveyshiye rezul'taty i perspektivy issledovaniy mikrorayona drevnego rasseleniya Ust'ye i doliny reki Nizhniy Toguzak [The Latest Results and Prospects of the Study of the Ancient Settlement of Ust'ye and Nizhniy Toguzak River Valley]. In *Drevneye Ust'ye: ukreplennoye poseleniye bronzovogo veka v Yuzhnom Zaural'ye: Kollektivnaya monografiya [The Ancient Ust'ye: A Fortified Settlement of the Bronze Age in Southern Trans-Urals: Collective Monograph],* edited by Nikolaiy B. Vinogradov and Andrey V. Epimakhov, pp. 393–416. Chelyabinsk: Abris.

Hanks, Bryan K., and Roger K. Doonan

2009   From Scale to Practice: A New Agenda for the Study of Early Metallurgy on the Eurasian Steppe. *Journal of World Prehistory* 22:329–356.

Hanks, Bryan K., Andrej V. Epimakhov, and A. Colin Renfrew

2007   Towards a Refined Chronology for the Bronze Age of the Southern Urals, Russia. *Antiquity* 81 (312):352–367.

Hawkins, Rebecca A.

1998   Coming Full Circle: Plowzone Assemblages and the Interpretation of Fort Ancient Settlement Structure. In *Surface Archaeology*, edited by Alan P. Sullivan, pp. 91–109. Albuquerque: University of New Mexico Press.

Hayden, Brian, and Aubrey Cannon

1983   Where the Garbage Goes: Refuse Disposal in the Maya Highlands. *Journal of Anthropological Archaeology* 2 (2):117–163.

Hendon, Julia A.

1996   Archaeological Approaches to the Organization of Domestic Labor: Household Practice and Domestic Relations. *Annual Review of Anthropology* 25(1):45–61.

Holliday, Vance T, Denise Lawrence-Zuniga, and Victor Buchli

2010   Prologue to Uses of Chemical Residues to Make Statements about Human Activities. *Journal of Archaeological Method and Theory* 17 (3):175–182.

Holton, Glyn A.

2004   Defining Risk. *Financial Analysts Journal* 60 (6):19–25.

Honeychurch, William, and Chunag Amartuvshin

2007   Hinterlands, Urban Centers, and Mobile Settings: The "New" Old World Archaeology from the Eurasian Steppe. *Asian Perspectives* 46 (1):36–64.

Houle, Jean-Luc

2009   Socially Integrative Facilities and the Emergence of Societal Complexity on the Mongolian Steppe. In *Social Complexity in Prehistoric Eurasia. Monuments, Metals, and Mobility*, edited by Bryan K. Hanks and Katheryn M. Linduff, pp. 358–377. Cambridge: Cambridge University Press.

2010   "*Emergent Complexity on the Mongolian Steppe: Mobility, Territoriality, and the Development of Early Nomadic Polities*" (PhD diss., University of Pittsburgh), http://d-scholarship.pitt.edu/7441/.

Howard, Philip

2006   *Archaeological Surveying and Mapping: Recording and Depicting the Landscape*. London and New York: Routledge.

Huler, S.

2007   *Defining the Wind: The Beaufort Scale and How a 19th-Century Admiral Turned Science into Poetry*: Crown/Archetype.

Ingold, Tim

1980   *Hunters, Pastoralists, and Ranchers: Reindeer Economies and Their Transformations*. Cambridge: Cambridge University Press.

Ivanova, S. V.

2013   Katakombnyye kul'tury Severo-Zapadnogo Prichernomor'ya [The Catacomb Cultures of the North-Western Black Sea Region]. In *Drevniye kul'tury Severo-zapadnogo Prichernomor'ya,* 255–275. Odessa: SMIL.

Jenson, Susan K., and Julia O. Domingue

1988   Extracting Topographic Structure from Digital Elevation Data for Geographic Information System Analysis. *Photogrammetric Engineering and Remote Sensing* 54 (11):1593–1600.

Johnson, Gregory A.

1982   Organizational Structure and Scalar Stress. In *Theory and Explanation in Archaeology*, edited by Colin Renfrew, Michael J. Rowlands and Barbara A. Seagraves, pp. 389–421. New York: Academic Press.

Johnson, James

2015   "*Community Matters? Investigating Social Complexity through Centralization and Differentiation in Bronze Age Pastoral Societies of the Southern Urals, Russian Federation, 2100 – 900 BC"* (PhD diss., University of Pittsburgh), http://d-scholarship.pitt.edu/23434/.

Johnson, James, and Bryan K. Hanks

2012   Society, Demography and Community: Reassessing Bronze Age Sintashta Populations in the Southern Urals, Russia (2100–1700 BC). In *Beyond Elites: Alternative to Hierarchical Systems in Modeling Social Formations*, edited by T.L. Kienlin and A. Zimmerman, pp. 355–367. Bochum: Ruhr-Universitat.

Kalinin, P. I., A. O. Alekseyeva, and A. D. Savko

2009   *Lossy, paleopochvy i paleogeographiya kvartira Yugo-Vostoka Russkoy ravniny [Loess, Palaeosols and Paleogeographic of Quarter of the Southeast of Russian Plain]*, *Proceedings of the Science and Research Institute of Geology of the Voronezh State University*. Voronezh: Voronezhskiy gosudarstvennyy universitet.

Keeley, Lawrence H., Marisa Fontana, and Russell Quick

2007   Baffles and Bastions: The Universal Features of Fortifications. *Journal of Archaeological Research* 15 (1):55–95.

Kelly, R. C.

2000   *Warless Societies and the Origin of War*. Ann Arbor: University of Michigan Press.

Khazanov, A.

1984   *Nomads and the Outer World.* Cambridge: Cambridge University Press.

Khokhlova, O. S., A. A. Khokhlov, A. A. Gol'eva, Gennadiy B. Zdanovich, and Tatiana S. Malutina

2008   Yestestvennonauchnyye issledovaniya Bol'shogo Sintashtinskogo kurgana v Chelyabinskoy oblasti [Scientific Research on the Big Sintashta Kurgan in Chelyabinsk Region]. *Vestnik Orenburgskogo gosudarstvennogo universiteta [Bulletin of the Orenburg State University]* 10 (92):150–156.

Killion, Thomas W.

1992   Residential Ethnoarchaeology and Ancient Site Structure: Contemporary Farming and Prehistoric Settlement Agriculture at Matacapan, Veracruz, Mexico. In *Gardens of Prehistory: The Archaeology of Settlement Agriculture in Greater Mesoamerica*, edited by Thomas W. Killion, pp. 119–149. Tuscaloosa: University of Alabama Press.

King, Julia

2004 *The Importance of Plow Zone: A Review and Assessment of Archaeological Investigations at 44RD183,* Virginia, Warsaw https://core.tdar.org/document/6101/the-importance-of-plow-zone-archaeology.

Kintigh, Keith W, and Albert J Ammerman

1982 Heuristic Approaches to Spatial Analysis in Archaeology. *American Antiquity* 47 (1):31–63.

Kiseleva, D. V., L. N. Koryakova, S. V. Sharapova, P. A. Kosintsev, M. V. Zaytseva, M. V. Streletskaya, N. V. Cherednichenko, A. K. Fokina, and E. S. Shagalov

2017 Opredeleniye mikroelementnogo i izotopnogo sostava Sr v obraztsakh kostnoy i zubnoy tkani cheloveka i zhivotnykh iz arkheologicheskikh pamyatnikov Yuzhnogo Urala epokhi bronzy [Determination of the Microelement and Isotopic Composition of Sr in Bone and Dental Tissue Samples of Humans and Animals from the Bronze Age Archaeological sites in the Southern Urals]. In *Geoarchaeology and Archaeological Mineralogy–2017. Proceedings of IV Scientific Youth School*, pp. 41–45. Miass: Institute of Mineralogy UB RAS.

Kislenko, Aleksandr I.

2004 *Letopis' prirody 1998–2003 [Nature's Observations 1998–2003]*. Chelyabinsk: The Scientific Archive of Arkaim Reserve. Access: The Scientific Archive of The Arkaim Reserve.

2005 *Letopis' prirody 2004 [Nature's Observations 2004]*. Chelyabinsk: The Scientific Archive of Arkaim Reserve. Access: The Scientific Archive of The Arkaim Reserve.

2008 *Letopis' prirody 2007 [Nature's Observations 2007]*. Chelyabinsk: The Scientific Archive of Arkaim Reserve. Access: The Scientific Archive of The Arkaim Reserve.

2011 *Letopis' prirody 2010 [Nature's Observations 2010]*. Chelyabinsk: The Scientific Archive of Arkaim Reserve. Access: The Scientific Archive of The Arkaim Reserve.

Kohl, Philip L.

2007 *The Making of Bronze Age Eurasia*, *Cambridge World Archaeology*. Cambridge, UK: Cambridge University Press.

Korkin, S. E., and A. U. Kushanova

2015 Produktyvnist' obs'koyi zaplavnoyi sehmentno-ostrivnoyi landshaftnoyi provintsiyi [Long-Term Productivity of the Ob' Province]]. *Vestnik AMU* 2 (10):57–66.

Koryakova, Ludmila N., and Andrej V. Epimakhov

2007 *The Urals and Western Siberia in the Bronze and Iron Ages.* Cambridge: Cambridge University Press.

Koryakova, Ludmila N., Rüdiger Krause, Andrej V. Epimakhov, Svetlana V. Sharapova, Sofia E. Panteleyeva, Nataliya A. Berseneva, Jochen Fornasier, Elke Kaiser, Ivan V. Molchanov, and Igor V. Chechushkov

2011   Arkheologicheskoye issledovaniye ukreplennogo poseleniya Kamennyy Ambar (Ol'gino) [Archaeological Studies of the Kamennyi Ambar (Ol'gino) Fortified Settlement]. *Arkheologiya, etnographiya iantropologiya Evrazii [Archaeology, Ethnography and Anthropology of Eurasia]* 39 (4):61–74.

Koryakova, Ludmila N., and S. A. Kuzmina

2017   Nekotoryye osobennosti arkhitektury ukreplennogo poseleniya Kamennyy Fmbar v kontekste obraza zhizni naseleniya Yuzhnogo Zaural'ya nachala 2 tys. do n. e. [Some Features of the Architecture of the Fortified Settlement of Kamenniy Ambar in the Context of the Way of Life of the Population of the Southern Trans-Urals in the Begining of the 2nd Millennium BC]. *Ural'skiy Istoricheskiy Vestnik [The Urals Historical Herald]* 1 (54):92–102.

Kostuykov, Vladimir P.

1993   *Otchet o polevykh arkcheologicheskikh issledovaniyakh v Kartalinskov i Kizil'skom rayone Chelyabinskoi oblasti v 1992 g. [The Report for the Field Research in Kartaly and Kizil Districts in 1992]*. Chelyabinsk: Chelyabinsk State Pedagogical University. Access: The Scientific Archive of the Institute of Archaeology.

Kowalewski, Stephen A., Garry M. Feinman, Laura Finsten, Richard E. Blanton, Linda M. Nicholas, Robert D. Drennan, J. Michael Elam, Kent V. Flannery, and Barbara Macnider

1989   *Monte Albán's Hinterland, Part II: Prehispanic Settlement Patterns in Tlacolula, Etla, and Ocotlan, the Valley of Oaxaca, Mexico*. Edited by MI Ann Arbor. Vol. 23, *Memoirs of the Museum of Anthropology, University of Michigan*. Ann Arbor, MI: University of Michigan, Museum of Anthropology.

Kradin, Nikolay N.

2003   Nomadic Empires: Origins, Rise, Decline. In *Nomadic Pathways in Social Evolution*, edited by Nikolay Kradin, Dmitri Bondarenko and T. Barfield, pp. 73–87. Moscow: Center for Civilizational Studies, Russian Academy of Science.

2014   *Nomads of Inner Asia in transition*. Moscow: URSS.

Kramarenko, V. Ya.

2009   Produktivnost' mnogoletnikh trav i travosemey pri razlichnykh urovnyakh mineral'nogo pitaniya i sposoba poseva v usloviyakh lesostepnykh agrolandshaftov Yuzhnogo Urala: Afroreferat dissertatsii na soiskaniye uchenoy stepeni doktora kandidata sel'skohozyistvennykh nauk [Productivity of Perennial Grasses and Grass Families at Various Levels of Mineral Nutrition and the Method of Sowing in Conditions of Forest-Steppe Agrolandscapes of the Southern Urals: Author's Abstract of the Dissertation]. (Ph.D. diss, Kurgan State Agricultural Academy named after T.S. Maltsev). http://www.dissercat.com/content/produktivnost-mnogoletnikh-trav-i-travosmesei-pri-razlichnykh-urovnyakh-mineralnogo-pitaniya.

Krause, Rüdiger, and Ludmila N. Koryakova, eds.

2013   *Multidisciplinary Investigations of the Bronze Age Settlements in the Southern Trans-Urals (Russia).* Frankfurt Am Main: Habelt.

Krupnik, Igor I.

1993   *Arctic Adaptations.* Hannover: University Press of New England.

Kuijt, Ian

2008   The Regeneration of Life: Neolithic Structures of Symbolic Remembering and Forgetting. *Current Anthropology* 49 (2):171–197.

Kuzmina, Elena E.

1994   *Otkuda prishli indoarii? [Whence the Indo-Aryans Came From?].* Moscow: Vostochnaya Literatura.

2007   *The Origin of the Indo-Iranians*, *Leiden Indo-European Etymological Dictionary Series.* Leiden: Brill.

2008 *Klassifikatsiya i periodizatsiya pamyatnikov Andronovskoy kul'turnoy obshchnosti [Classification and Periodization of Andronovo Archaeological Culture].* Aktobe: PrintA.

Kyzlasov, Igor L.

2011   *Kol'tsevyye gorodishcha Khakasii. K istorii monumental'noy arkhitektury na Yeniseye (Khramovaya arkhitektura drevnosti) [Circular Settlements of Khakassia. To the History of Monumental Architecture on the Yenisey (Temple Architecture in Antiquity)].* Moscow: TAUS.

Lavrushin, Yu. A., and E. A. Spiridonova

1995   Geologicheskaya istoriya zony yevraziyskikh stepey v posledniye 10 000 let [Geological History of the Zone of the Eurasian Steppes in the last 10,000 years]. In *Rossiya i Vostok: problemy vzaimodeystviya. Materialy 3-y mezhdunarodnoy nauchnoy konferentsii: Rossiya i Vostok: problemy vzaimodeystviya*, pp. 165–171. Chelyabinsk: Rifei.

Lebedeva, E. Yu.

2005   Arkheobotanika i Izuchenie Zemeledeliya Epokhi Bronzy v Vostochnoi Evrope. [Paleobotany and study of the Bronze Age Agriculture in Eastern Europe]. *OPUS: Mezhdistsiplinarnye Issledovaniya v Arkheologii [OPUS: Interdisciplinary Studies in Archaeology]* 4:50–68.

Levit, Aleksandr I.

2005   *Yuzhnyy Ural: geografiya, ekologiya i prirodopol'zovanie [The Southern Urals: Geography, Ecology, and Environment Management].* Chelyabinsk: Yuzhno-Ural'skoe knizhnoe izdatel'stvo.

Lightfoot, E., G. Motuzaite-Matuzeviciute, T. C. O'Connell, I. A. Kukushkin, V. Loman, V. Varfolo-
meev, X. Liu, and M. K. Jones

2015   How 'Pastoral' is Pastoralism? Dietary Diversity in Bronze Age Communities in the Central
        Kazakhstan Steppes. *Archaeometry* 57:232–249.

Llobera, Marcos

2006   What You See is What You Get? Visualscapes, Visual Genesis and Hierarchy. In *Digital
        Archaeology. Bringing Method and Theory*, edited by Thomas L. Evans and Patrick Daly,
        pp. 148–168. London and New York: Routledge.

Maliutina, Tatiana S., and Gennadiy B. Zdanovich

2012   Poseleniye Kamennyi Brod – sputnik ukreplennogo tsentra Arkaim: stratigraficheskiye go-
        rizonty i ritmy povtorov zhiznennykh tsiklov v Strane gorodov [The Setllement of Kamennyi
        Brod is the Satellite of the Fortified Center of Arkaim: Stratigraphic Horizons and Cycles of
        The Country of Towns]. In *Arkheologicheskiye pamyatniki Orenburzhiya [Archaeological
        Sites of the Orenburg Region]*, edited by N.L. Morgunova, pp. 50–61. Orenburg: Izd-vo
        OGPU.

Mann, Michael

1986   *The Sources of Social Power*. Cambridge: Cambridge University Press.

Marston, John M.

2011   Archaeological Markers of Agricultural Risk Management. *Journal of Anthropological Ar-
        chaeology* 30 (2):190–205.

Mauvieux, Benoit, Alain Reinberg, and Yvan Touitou

2014   The Yurt: A Mobile Home of Nomadic Populations Dwelling in the Mongolian Steppe is Still
        Used Both as a Sun Clock and a Calendar. *Chronobiology International* 31 (2):151–156.

McMahon, Augusta

2008   From Sedentism to States, 10,000–3,000 BCE. In *A Companion to the Ancient Near East*,
        edited by Daniel C. Snell, pp. 20–33. Malden, MA: Wiley-Blackwell Publishing.

Merpert, N. Ya.

1947   *Drevneyshiye skotovody Volzhsko-Ural'skogo Mezhdurech'ya [The Earliest Cattlemen of
        the Volga-Urals Interfluve]*. Moscow: Nauka.

Merrony, Colin, Bryan K. Hanks, and Roger K. Doonan

2009   Seeking the Process: The Application of Geophysical Survey on some Early Mining and
        Metalworking Sites. In *Metals and Societies: Studies in honour of Barbara S. Ottaway.
        Universitats Forschungen zur Prehistorische Archaologie*, edited by Tobias L. Kienlin and
        Benjamin W. Roberts, 421–430. Bonn: Rudolf Habelt. GMBH.

Navazo, Marta, and Carlos Díez

2008   Redistribution of Archaeological Assemblages in Plowzones. *Geoarchaeology* 23 (3):323–333.

Netting, Robert McC., Richard R. Wilk, and Eric J. Arnould

1984   *Households: Comparative and Historical Studies of the Domestic Group.* Vol. 324. Berkeley: University of California Press.

Noskevich, Vladislav V., and Nataliya V. Fedorova

2012   Kartirovaniye arkheologicheskikh pamyatnikov epokhi sredney bronzy s pomoshch'yu detal'noy magnitnoy syemki [Mapping of Archaeological Sites of the Middle Bronze Age with Detailed Magnetic Survey]. *Kratkiye soobshcheniya Instituta arkheologii [Memoirs of the Institute of Archaeology]* 226:87–93.

Odgaard, U.

2014   Ritual kormleniya ognya v ochagakh tsirkumpolyarnykh kul'tur [The Ritual of Fire Feeding in the Centers of Circumpolar Cultures]. *Ural'skiy Istoricheskiy Vestnik* 2 (43):79–88.

Outram, Alan K., Natalie A. Stear, Robin Bendrey, Sandra Olsen, Alexei Kasparov, Victor Zaibert, Nick Thorpe, and Richard P. Evershed.

2009   The Earliest Horse Harnessing and Milking. *Science* 323 (5919):1332–1335.

Padalko, Yu. A.

2016   Sotsial'no-ekonomicheskaya uyazvimost' naseleniya i khozyaystva regionov rossiyskoy chasti basseyna r. Ural ot navodneniy [The Socio-Economic Vulnerability of the Population and the Economy of the Regions of the Russian Part of the Basin of the Ural River]. *Uspekhi sovremennogo yestestvoznaniya* 12 (2):439–443.

Panteleyeva, Sofia E.

2009   *Otchet o razvedochnom obsledovanii ukreplennogo poseleniya Zhurumbay v Kartalinskom rayone Chelyabinskoy oblasti v 2008 godu [Report on the Survey of the Fortified Settlement of Zhurumbay in the Kartaly Ddistrict of the Chelyabinsk Region in 2008].* Ekaterinburg: Institute of History and Archeology, the Ural Branch of the Russian Academy of Sciences.

2013   Kompleks sintashtinskoy keramiki ukreplennogo poseleniya Kamennyy Ambar: tipologicheskiy analiz [Assemblage of Sintashta Ceramics from the Fortified Settlement of Kamenniy Ambar: Typological Analysis]. *Vestnik archeologii, antropologii i etnografii [Bulletin of Archaeology, Anthropology and Ethnography]* 4 (23):22–31.

Pauketat, Timothy R., Lucretia S. Kelly, Gayle J. Fritz, Neal H. Lopinot, Scott Elias, and Eve Hargrave

2002   The Residues of Feasting and Public Ritual at Early Cahokia. *American Antiquity* 67 (2):257–279.

Peterson, Christian E., and Robert D. Drennan

2005   Communities, Settlements, Sites, and Surveys: Regional-Scale Analysis of Prehistoric Human Interaction. *American Antiquity* 70 (1):5–30.

2012   Patterned Variation in Regional Trajectories of Community Growth. In *The Comparative Archaeology of Complex Societies*, edited by Michael E. Smith, pp. 88–137. Cambridge: Cambridge University Press.

Peterson, Christian E., and Gideon Shelach

2012   Jiangzhai: Social and Economic Organization of a Middle Neolithic Chinese Village. *Journal of Anthropological Archaeology* 31 (3):265–301.

Peterson, David L.

2009   Production and Social Complexity: Bronze Age Metalworking in the Middle Volga. In *Social Complexity in Prehistoric Eurasia: Monuments, Metals, and Mobility*, edited by Bryan K. Hanks and Katheryn M. Linduff, pp. 187–215. Cambridge: Cambridge University Press.

Petrov, Fedor N.

2009   *Poseleniye Arkaim v kul'turnom prostranstve epokhi bronzy [The Arkaim Settlement in the Cultural Space of the Bronze Age]*. Dubna: The Dubna Heritage.

Pitman, Derek and Roger Doonan

2018 Beyound the Grave: Crafting Identities in the Middle Bronze Age Southern Trans Urals. In *Warfare in Bronze Age Society,* edited by Christian Horn and Kristian Kristiansen, pp. 119–135. Cambridge: Cambridge University Press.

Plekhanova, L. N., V. A. Demkin, and Gennadiy B. Zdanovich

2007   *Evolyutsiya pochv rechnykh dolin stepnogo Zaural'ya vo vtoroy polovine golotsena [Evolution of River Valleys' Soils of the Steppe Trans-Urals in the Second Half of the Holocene]*. Moscow: Nauka.

Porčić, Marko

2012   Effects of Residential Mobility on the Ratio of Average House floor Area to Average Household Size: Implications for Demographic Reconstructions in Archaeology. *Cross-Cultural Research* 46 (1):72–86.

Potter, J.

2000   Ritual, Power, and Social Differentiation in Small-Scale Societies. In *Hierarchies in Action: Cui Bono?* edited by Michael W. Diehl, pp. 295–316. Carbondale: Southern Illinois University.

Pozorski, Thomas

1980   The Early Horizon Site of Huaca de Los Reyes: Societal Implications. *American Antiquity* 45 (1):100–110.

Prikhod'ko, V. E., I. V. Ivanov, D. G. Zdanovich, G. B. Zdanovich, D. V. Manakhov, and K. Inubushi

2014 *Arkaim – ukreplennoye poseleniye epokhi bronzy stepnogo Zaural'ya: pochvenno-arkheo-logicheskiye issledovaniya [Arkaim – the Fortified Settlement of the Bronze Age of the Steppe Trans-Urals: Soil and Archaeological Studies].* Moscow: Izdat. dom Tipografiya Rossel'khozakademii.

Privat, Karen L.

2002   Preliminary Report of Palaeodietary Analysis of Human and Faunal Remains from Bolshe-karagansky Kurgan 25. In *Arkaim: Nekropol (po materialam kurgana 25 Bolshekaragansk-ogo mogilnika): Kniga 1 [Arkaim: Necropolis],* edited by D. G. Zdanovich, pp. 166–171. Chelyabinsk: Uzhno-Ural'skoe knishnoe izd-vo.

2004   *"Palaeoeconomy of the Eurasian Steppe: Biomolecular Studies"* (PhD diss. Institute of Archaeology, University of Oxford).

Ramsey, Christopher Bronk

2009   Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51 (1):337–360.

Rappaport, P. A.

1965. *Drevniye russkiye kreposti [Ancient Russian Fortresses].* Moscow: Nauka.

Razhev, D. I., and Andrey V. Epimakhov

2005   Fenomen mnogochislennosti detskikh pogrebeniy v mogil'nikakh epokhi bronzy [Penom-enon of Mutiplicity of Children's Burials inf the Bronze Age]. *Vestnik arkheologii, antro-pologii i etnografii [Herald of Archeology, Anthropology and Ethnography]* (5):107–113.

Redmond, Elsa M.

1994   External Warfare and the Internal Politics of Northern South American Tribes and Chief-doms. In *Factional Competition and Political Development in the New World*, edited by Elizabeth M. Brumfiel and John Fox, pp. 44–54. Cambridge: Cambridge University Press.

Reimer, Paula J, Edouard Bard, Alex Bayliss, J Warren Beck, Paul G. Blackwell, Christopher Bronk Ramsey, Caitlin E Buck, Hai Cheng, R Lawrence Edwards, and Michael Friedrich.

2013   IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 years cal BP. *Radiocarbon* 55 (4):1869–1887.

Renfrew, Colin

1973 Monuments, Mobilization and Social Organization in Neolithic Wessex. In *The Explanation of Culture Change: Models in Prehistory*, edited by Colin Renfrew, pp. 539–558. London: Duckworth.

Rick, John W.

2004 The Evolution of Authority and Power at Chavín de Huántar, Peru. *Archeological Papers of the American Anthropological Association* 14 (1):71–89.

Roscoe, Paul

2008 Settlement Fortification in Village and 'Rribal' Society: Evidence from Contact-Era New Guinea. *Journal of Anthropological Archaeology* (27):507–519.

Rosenswig, Robert M.

2007 Beyond Identifying Elites: Feasting as a Means to Understand Early Middle Formative Society on the Pacific Coast of Mexico. *Journal of Anthropological Archaeology* 26 (1):1–27.

Rühl, Lisa, Christoph Herbig, and Astrid Stobbe

2015 Archaeobotanical Analysis of Plant Use at Kamennyi Ambar, a Bronze Age Fortified Settlement of the Sintashta Culture in the Southern Trans-Urals Steppe, Russia. *Vegetation History and Archaeobotany* 24 (3):413–426.

Ryabinina, Z. N.

2003 *Rastitel'nyy pokrov stepey Yuzhnogo Urala (Orenburgskaya oblast') [Vegetation Cover of the Steppes of the Southern Urals (the Orenburg Region)]*. Orenburg: Izd-vo OGPU.

Ryabogina, N.E., and S.N. Ivanov

2011 Drevneye zemledeliye v Zapadnoy Sibiri: problemy argumentatsii, paleo etnobotanicheskiye metody i analiz faktov [Ancient Agriculture in Western Siberia: Arguments, Paleobotanical Methods and Analysis of the Facts]. *Archaeology, Ethnology and Anthropology of Eurasia* 4 (48):96–106.

Ryndina, Nataliya Vadimovna, and Anna Davydovna Degtyareva

2002 *Eneolit i bronzovyy vek [The Eneolithic and Bronze Age]*. Moscow: Izd-vo MGU.

Sageidet, Barbara M.

2000 Soil Micromorphology and Its Contribution to the Interpretation of Archaeological Sites. *AmS-Varia* (37):21–25.

Sahlins, Marshall David

1958   *Social Stratification in Polynesia*, *Monographs of the American Ethnological Society*. Seattle: University of Washington Press.

1963   Poor Man, Rich Man, Big Man, Chief: Political Types in Melanesia and Polynesia. *Comparative Studies in Society and History* 5:285–303.

Sanders, William T., Jeffrey R. Parsons, and Robert S. Santley

1979   *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization*. New York, San Francisco, London: Academic Press.

Sanders, William T., and David Webster

1978   Unilinealism, Multilinealism, and the Evolution of Complex Societies. In *Social Archeology: Beyond Subsistence and Dating*, edited by Charles L. Redman, Mary Jane Berman, Edward V. Curtin, William T. Langhorne, Nina M. Versaggi and Jeffrey C. Wanser, pp. 249–302. New York: Academic Press.

Sazhinov, G. I.

1941   *Senokosy i Pastbisha Vologodskoy Oblasti i ikh ulucheniye i ispol'zovanyue [Pasturegrounds of the Vologda Region and Their Maintanance]*. Vologda: VOZO.

Seaby, R. M. H., and P. A. Henderson

2007   SDR-IV Help: Measuring and Understanding Biodiversity. *Pisces Conservation Ltd, Lymington, UK.*

Semenov, Sergey A.

1968   *The Development of Technology in the Stone Age*. Leningrad: Nauka.

Service, Elman R.

1962   *Primitive Social Organization an Evolutionary Perspective*. New York: Random House.

Shahack-Gross, Ruth, Fiona Marshall, Kathleen Ryan, and Steve Weiner

2004   Reconstruction of Spatial Organization in Abandoned Maasai Settlements: Implications for Site Structure in the Pastoral Neolithic of East Africa. *Journal of Archaeological Science* 31 (10):1395–1411.

Sharapov, Denis V.

2017   *"Bronze Age Settlement Patterns and The Development of Complex Societies in the Southern Ural Steppes"* (PhD diss., University of Pittsburgh), http://d-scholarship.pitt.edu/32421/.

Sharapova, Svetlana V., Rüdiger Krause, Ivan V. Molchanov, Astrid Shtobbe, and Nikolay V. Soldatkin

2014   Mezhdistsiplinarnyye issledovaniya poseleniya Konoplyanka v Yuzhnom Zaural'ye: predvaritel'nyye rezul'taty [Multidisciplinary Investigations of Konoplyanka Settlement in the Southern Trans-Urals: Preliminary Results]. *Vestnik Novosibirskogo Gosudarstvennogo Universiteta [Bulletin of Novosibirsk State University]* 13 (3):101–109.

Smirnov, Konstantin F., and Elena E. Kuz'mina

1977   *Proiskhozhdeniye indoirantsev v svete noveyshikh arkheologicheskikh otkrytiy [The Origin of the Indo-Iranians in the Light of the Latest Archaeological Discoveries]* Moscow: Nauka.

Smith, Michael E.

1987   Household Possessions and Wealth in Agrarian States: Implications for Archaeology. *Journal of Anthropological Archaeology* 6 (4):297–335.

Spengler, Robert, Michael Frachetti, Paula Doumani, Lynne Rouse, Barbara Cerasetti, Elissa Bullion, and Alexei Mar'yashev

2014   Early Agriculture and Crop Transmission among Bronze Age Mobile Pastoralists of Central Eurasia. *Proceedings of the Royal Society of London B: Biological Sciences* 281 (1783): 20133382, http://rspb.royalsocietypublishing.org/content/281/1783/20133382.

Spengler, Robert N.

2015   Agriculture in the Central Asian Bronze Age. *Journal of World Prehistory* 28 (3):215–253

Stein, Gil J.

1994. Economy, Ritual, and Power in 'Ubaid Mesopotamia. In *Chiefdoms and Early States in the Near East: The Organizational Dynamics of Complexity*, edited by Gil Stein and Mitchell S. Rothman, pp. 35–46. Madison, WI: Prehistory Press.

1996   Producers, Patrons, and Prestige: Craft Specialists and Emergent Elites in Mesopotamia from 5500–3100 BC. In *Craft Specialization and Social Evolution*, edited by B. Wailes, pp. 25–38. Philadelphia, PA: University of Pennsylvania Museum.

Steponaitis, Vincas P.

1991   Contrasting Patterns of Mississippian Development. In *Chiefdoms: Power, Economy, and Ideology*, edited by Timothy Earle, pp. 193–228. Cambridge: Cambridge University Press.

Stobbe, Astrid, Maren Gumnior, Lisa Rühl, and Heike Schneider

2016   Bronze Age Human–Landscape Interactions in the Southern Transural Steppe, Russia – Evidence from High-Resolution Palaeobotanical Studies. *The Holocene* 26 (10):1692–1710.

Tairov, Alexandr D.

1996   *Otchet Issledovaniya pamyatnikov strany gorodov v 1995 g. [The Report Studies of the Country of Towns in 1995]*. Chelyabinsk: Chelyabinsk State University. Access: The Scientific Archive of Chelyabinsk State University.

2003   *Izmeneniya klimata stepey i lesostepey tsentral'noy Evrazii vo 2–1 tys. do n.e.: materialy k istoricheskim rekonstruktsiyam [The Climate Changes in the Steppes and Forest-Steppes of Central Eurasia in the 2nd–1st Millennia B.C.: Materials for Historical Reconstructions]*. Chelyabinsk: Rifei.

Tkachev, Vitalyi V.

2007   *Stepi Yuzhnogo Priural'ya i Zapadnogo Kazakhstana na rubezhe epokh sredney i pozdney bronzy [The Steppes of Southern Urals and Western Kazakhstan in the Middle and Nronze Age]*. Aktobe: Aktyubinskiy oblastnoy tsentr istorii, etnografii i arkheologii.

Tkachev, Vitaliy V., and Alexey I. Khavanskii

2006   *Keramika sintashtinskoy kul'tury [The Sintshta Culture Ceramic Assemblage]*. Orsk-Samara: Izdat. Orskogo Gumanitarno-Tekhnologicheskogo Inst-ta.

Trifonov, Viktor A.

2001   Popravki k absolutnoi khronologii kul'tur epohi eneolita – sredney bronzy Kavkaza, stepnoyi i lesostepnoyi zon Vostochnoy Evropy (po dannem radiouglerodnogo datirovanoya) [Refined chronology of the Eneolithic and Bronze Age culures of the Caucases, steppe and forrest-steppe of Eastern Europe]. In *Bronzovy vek Vostochnoy Evpory: kharakteristika kul'tur, khronologiya i pereodizaciya [The Bronze Age of Eastern Europe: Cultures, Chronology and Periodization]*, pp. 71–82. Samara: Izd-vo Sam. gos-go un-ta.

U.S. Department of Health and Human Services and U.S. Department of Agriculture

2015   Dietary Guideline for Americans in 2015–2020. Access: https://health.gov/dietaryguidelines/2015/guidelines/.

Ventresca Miller, Alicia

2013   *"Social Organization and Interaction in Bronze Age Eurasia: A Bioarchaeological and Statistical Approach to the Study of Communities"* (PhD diss., University of Pittsburgh), http://d-scholarship.pitt.edu/18386/.

Ventresca Miller, Alicia, Katherine Haas, Michael Rosenmeier, Emma Usmanova, Viktor Logvin, Saule Kalieva, Irina Shevnina, Andrei Logvin, Alina Kolbina, Aleksander Suslov, and Karen Privat

2014   Subsistence and Social Change in Central Eurasia: Stable Isotope Analysis of Populations Spanning the Bronze Age Transition. *Journal of Archaeological Science* 42:525–538.

Vinogradov, Nikolaiy B.

1982a "*Yuzhnoye Zaural'ye i Severnyi Kazakhstan v rannealakulskiy period (po pamyatnikam petrovskogo tipa): dissertaciya na soiskaniye uchenoy stepeni kandidata istoricheskikh nauk"* [The Southern Urals and Northern Kazakhstan in the Early-Alakul' Period (the Sites of the Petrovka Type)]. (PhD diss., Institute of Archaeology of the AS of USSR). Access: Archive of Institute of Archaeology.

1982b Kulevchi III – pamyatnik petrovskogo tipa v Yuzhnom Zaural'ye [Kulevchi III, an Archaeological Site of the Petrovka Culture in the Southern Trans-Urals]. *Kratkiye soobshcheniya Instituta arkheologii [Memoirs of the Institute of Archaeology]* 169:94–99.

2011 *Stepi Yuzhnogo Urala i Kazakhstana v pervyye veka II tys. do n.e. (pamyatniki sintashtinskogo i petrovskogo tipa) [Steppes of the Southern Urals and Kazakhstan in the First Centuries of the 2nd Millennium BC. (Sites of the Sintashta and Petrovka Types)]*. Chelyabinsk: Abris.

2017 Problemy sinkhronizatsii, kul'turnoy blizosti pamyatnikov sintashtinskogo i petrovskogo tipov i vozmozhnosti ikh resheniya [Toward the Problem of the Synchronization and Cultural Affinity of the Sintashta and Petrovka sites and Its Possible Solution]. *Vestnik arkheologii, antropologii i etnografii [Bulletin of Archaeology, Anthropology and Ethnology]* 3 (37):38–47.

Vinogradov, Nikolaiy B., ed.

2013 *Drevneye Ust'ye: ukreplennoye poseleniye bronzovogo veka v Yuzhnom Zaural'ye: Kollektivnaya monografiya [The Ancient Ust'ye: Fortified Settlement of the Bronze Age in Southern Trans-Urals: A Collective Monograph]*. Chelyabinsk: Abris.

Wagenbrenner, Natalie S., Jason M. Forthofer, Brian K. Lamb, Kyle S. Shannon, and Bret W. Butler

2016 Downscaling Surface Wind Predictions from Numerical Weather Prediction Models in Complex Terrain with WindNinja. *Atmospheric Chemistry and Physics* 16 (8):5229–5241.

Walter, Heinrich, and Siegmar W. Breckle

1989 *Temperate and Polar Zonobiomes of Northern Eurasia*. Berlin: Springer-Verlag Berlin.

Welch, Paul D.

1991 *Moundville's Economy*. Tuscaloosa, AL, USA: University of Alabama Press.

1996 Control over Goods and the Political Stability of the Moundville Chiefdom. In *Political Structure and Change in the Prehistoric Southeastern United States*, edited by John F. Scarry, pp. 69–91. Gainesville: University Press of Florida.

Wescott, K. L., and R. J. Brandon

2000 *Practical Applications of GIS for Archaeologists: A Predictive Modelling Toolkit*. CRC Press.

Wilk, Richard R., and Robert M. Netting

1984   Households: Changing Forms and Functions. In *Households: Comparative and Historical Studies of the Domestic Group*, edited by Robert M. Netting, Richard R. Wilk and Eric J. Arnould, pp. 1–28. Berkeley, CA: University of California Press.

Wilk, Richard R., and William L. Rathje

1982   Household Archaeology. *The American Behavioral Scientist* 25 (6):617–639.

Wilson, Gregory D.

2007   *Archaeology of Everyday Life at Early Moundville*. Tuscaloosa, AL, USA: University of Alabama Press.

Wilson, Gregory D., Jon Marcoux, and Brad Koldehofi

2006   Square Pegs in Round Holes: Organizational Diversity Between Early Moundville and Cahokia. In *Leadership and Polity in Mississippian Society*, edited by Brian M. Butler and Paul D. Welch, pp. 43–72. Southern Illinois University.

Wittfogel, Karl August

1957   *Oriental Despotism: A Comparative Study of Total Power*. New Haven: Yale University Press.

Zakh, V. A.

1995   *Poselok drevnikh skotovodov na Tobole [The Village of the Ancient Pastoralists on the Tobol River]*. Novosibirsk: Nauka.

Zaykov, V. V., A. M. Yuminov, and M. N. Ankushev

2016   Rudnaya geoarkheologiya medi v Tsentral'noy Yevrazii (obzor) [Geoarchaeology of the Central Eurasia (Review)]. In *Geoarchaeology and Archaeological Mineralogy–2017. Proceedings of III Scientific Youth School*, pp. 7–25. Miass: Institut Mineralogii UrO RAN.

Zdanovich, Dmitrii G.

1997   *Sintashtinskoe obshchestvo: sotsialnye osnovy kvazigorodskoi kul'tury Uzhnogo Zauraliya epokhi srednei bronzy [The Social Organization of the Sintashta Communities of the Bronze Age]*. Chelyabinsk: Chelyabinsk State University Press.

Zdanovich, Gennadiy B.

1988   *Bronzovy vek Uralo-Kazakhstanskikh stepey: osnovy pereodizacii [The Bronze Age of the Ural-Kazakhstan Steppes: The Pereodization Basics]*. Sverdlovsk: Izd-vo Ural'skogo un-ta.

1995   Arkaim. Arii na Urale ili nesosyoyavsheyasya civilizasiya [Arkaim. The Arians in the Urals or Failed Civilization]. In *Arkaim: Issledovaniya. Poiski. Otkrytiya [Arkaim: Research, Ex-*

ploration, and Discoveries], edited by Gennadiy B. Zdanovich, pp. 21–42. Chelyabinsk: TO Kammeniiy Poyas.

2011 Ukrepleniya, krepost' v arkheologii sintashtinsko-arkaimskoy kul'tury i v poeticheskoy tra-ditsii Rigvedy [Fortifications, Fortress in the Archeology of the Sintashta-Arkaim Culture and in the Poetic Tradition of the Rig-Veda]. *Voprosy arkheologii Urala: sbornik nauchnykh trudov* (26):40–63.

Zdanovich, Gennadiy B., and Iya M. Batanina

2007 *Arkaim – strana gorodov. Prostranstvo i obrazy [Arkaim and the Country of Towns. Spatial Dimension and Images]*. Chelyabinsk: Krokus.

Zeder, Melinda A.

2008 Domestication and Early Agriculture in the Mediterranean Basin: Origins, Diffusion, and Impact. *Proceedings of the National Academy of Sciences* 105 (33):11597–11604.