In Search of a New Site of the Abashevo Culture in the Southern Trans-Urals: Remote Sensing and Geophysics Survey on the Zarya I Settlement

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Abstract. The paper is devoted to the results of the complex use of non-destructive methods, including topography mapping, obtaining a digital elevation model (DEM) by photogrammetry of the results of shooting with unmanned aerial vehicle (UAV), surface magnetic mapping, and shallow-depth frequency sounding (dipole electromagnetic profiling) was applied to study of the eastern part of the Zarya I settlement. Here, pottery fragments from two vessels of the Abashevo culture, which were found in a test pit, have caught our attention. It was assumed that there could be features of the Abashevo settlement. The data obtained allowed us only to clarify the structure of the settlement and to choose the area for further archaeological excavations. Thus, the hypothesis that Abashevo houses existed in the Zarya I settlement could be confirmed.

Keywords: Bronze age · Abashevo culture · Settlement · Remote sensing · UAV · Aerial photography · Geophysics survey

1 Introduction

Non-destructive studies such as remote sensing (space photography, aerial photography, and aerial laser scanning) and geophysical methods are effective for the preliminary study of archaeological sites. Joint use of these powerful tools makes it possible to identify new structures and obtain detailed information about the architectural features of known objects without destroying of cultural layer (Knoll and Marzolff 2013; Krause et al. 2014; Novikov 2022, etc.). For instance, a magnetic survey revealed a new line of buildings at the site of the Konoplyanka 2 settlement, which was later confirmed by aerial photography. Archaeological studies have shown that this line is associated with the Abashevo culture (Koryakova et al. 2020; Molchanov et al. 2023), while the previously known line of buildings was attributed with the Srubnaya-Alakul culture. Thus, the new settlement named Konoplyanka 2–2 was added to the list of already known sites of this culture, which include such sites as Malo-Kizilskoe (Salnikov 1967) and Serny Klyuch (Borzunov et al. 2020). They mark the eastern and northeastern boundaries of the distribution of the Abashevo culture. This fact stimulates our efforts to search for new sites of this culture.

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Several test pits carried out by Alaeva in 2015 at the Zarya I settlement has caught our attention. Pottery fragments from two vessels of the Abashevo culture were found in a test pit on the northeastern periphery of the settlement (Alaeva 2016, p. 65–66). It was located on a 35° coastal slope. The surface around the test pit had no features of landscape. Interest in this settlement was aroused by the Abashevo pottery and the place where it was found: on the coastal slope. A similar topographic situation was observed at the Konoplyanka 2–2 settlement. In order to identify a new archaeological site in the eastern part of the site of the Zarya I settlement, a geodetic and geophysical survey were carried out in the summer of 2022 around the test pit with the Abashevo pottery. The results of this work made it possible to identify an anomaly close to the test pit with the Abashevo pottery and proposed a hypothesis that it is associated with the Abashevo culture.

2 Materials and Methods

The Zarya I settlement is located in the Kizilsky district of the Chelyabinsk region, on the left bank of the Zingeyka River, 4 km northeast of the Katsbakh village and 5.2 km southwest of the Zarya village. It is located on the first terrace of the oxbow of the Zingeyka River, 2–3 m height above the water's edge. The settlement was discovered in 1988 by the Ural-Kazakhstan archaeological expedition led by Gutkov. It consists of two groups of house depressions ($n = 6$) attributed to the Alakul culture. The distance between the groups is 100 m. The house depressions in each group are extended in a chain along the coast. The depth of the depressions is 0.3–0.6 m. Dimensions of the western group are 30 × 80 m. It is narrow, elongated along the coast. The eastern group is more compact, 35 × 85 m (Zdanovich et al. 2003, p. 150; Alaeva 2016, p. 62–63) (Fig. 1).

The research territory included the eastern periphery of the settlement with the test pit with ceramics of the Abashevo culture, a house depression, and an area outside of the settlement. This made it possible to compare and interpret the data obtained from different parts of this polygon.

The DJI Phantom 4 Advanced Plus quadcopter was used to obtain the DEM of the polygon. The flight and shooting were carried out in an automatic mode along a zigzag route with 50 m height. The flight time was 40 min. The coordinates were determined using the GPS in WGS-84. Totally 269 frames with 70% overlap were taken to cover an area of 4 ha.

The obtained images were processed by photogrammetric methods using the Agisoft Metashape Professional software on the computing server of the Institute of Geophysics, the Ural Branch of the Russian Academy of Sciences (Dell PowerEdge C4130, 4 NVidia Tesla K80). The DEM was calculated in the resolution of 33468 × 20255 pixels, corresponding to approximately one point per 1 cm^2. The total time spent on processing, from uploading images to obtaining a digital model, was about 1 h.

Since a visual inspection of the area has showed some inconsistencies between the existing topographic map and the modern landscape, a geodetic survey was carried out, and a new topographic map of the settlement area (4.7 ha) was obtained. The measurements were carried out using a Sokkia CX-106 total station with spacing between

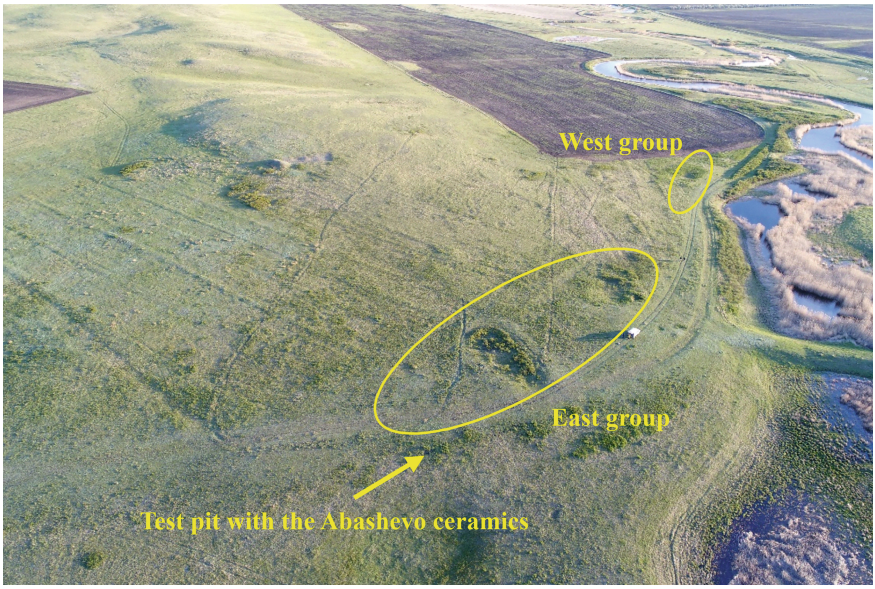

Fig. 1. General view of the groups of house depressions at the Zarya I settlement

survey points of about 0.5–1 m. Outside of the visible structures, it increased up to 3–5 m. The total station data and topographic map were processed in the GIS software by KB "Panorama".

Electromagnetic sounding was performed with the AEMP-14 device—a three-coil probe with a fixed base. The generator loop emits an electromagnetic field at 14 frequencies of 2.5–250 kHz, receiving a signal from different depths from 0.7 to 10 m. Primary data was processed using the iSystem software (Manstein et al. 2015).

The geomagnetic survey was carried out with an Overhauser magnetometer-gradiometer MMPOS-2, which sensors located vertically at heights of 0.3 and 2 m (Narkhov et al. 2017).

3 Results and Discussion

Aerial photography was carried out in the spring and, due to bad weather conditions, was concentrated only on the selected area. A field road, old plow area, scour, mound, and depressions related to houses No. 3 and No. 4, as well as an assumed house No. 5 were clearly distinguished on the DEM (Fig. 2). Unfortunately, it was not possible to identify any new objects here, in contrast to the settlement of Konoplyanka 2–2, where house depressions are clearly visible on the DEM (Molchanov et al. 2023, p. 308).

5 house depressions were identified on the new topographic map of the Zarya I settlement. One house depression was not confirmed. Two house depressions (No. 2 and No. 5) were poorly represented in the landscape, therefore, they were indicated by a dotted line. A possible reason for this is the software weight-average interpolation of values during data processing of the whole area. In addition to the specified location

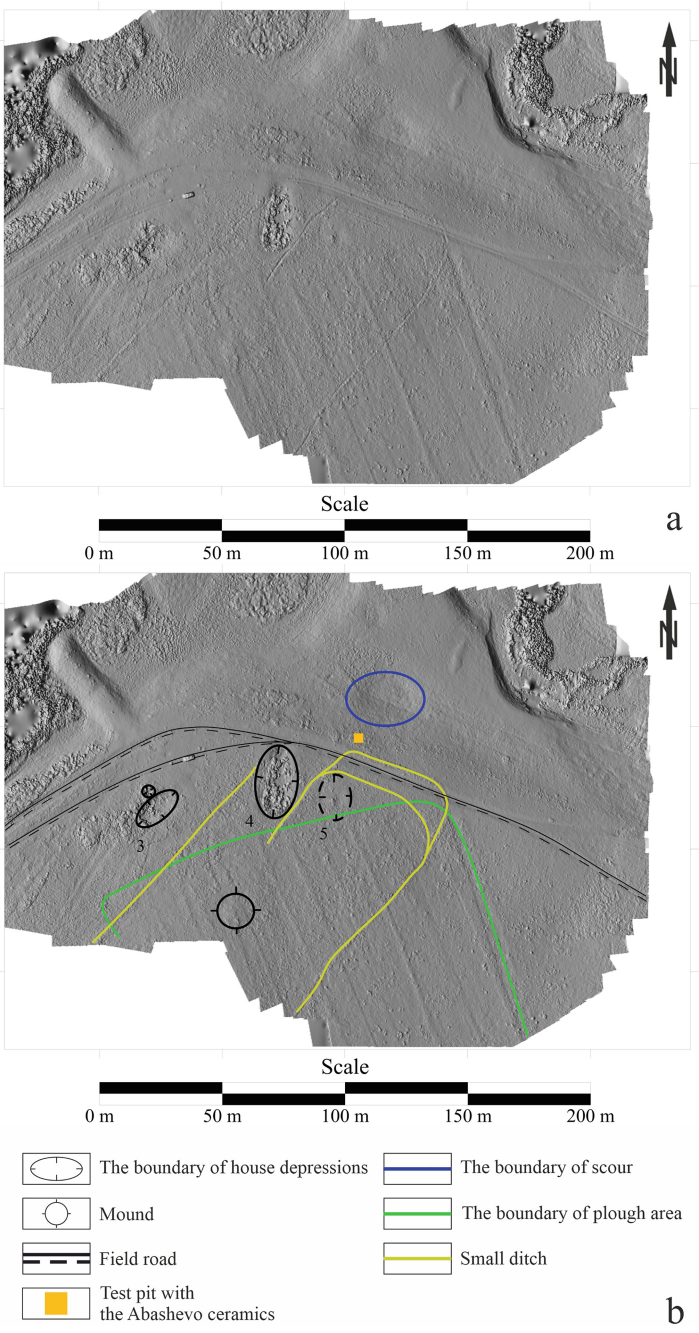

Fig. 2. A digital model of the research area at the Zarya I settlement (**a**) and its interpretation (**b**)

of the house depressions, another object was plotted on the map: modern field road, unknown small ditches, going from the edge of the terrace into its depths, as well as the preserved outlines of 7 test pits (Fig. 3). They were excavated at different times and by different researchers. Unfortunately, the author(s) of 3 of these have not been identified yet. It should be noted that one of these test pits is located on the edge of depression of the assumed house depression No. 5.

A polygon for further geophysical surveys has been defined in accordance with the archaeological and topographical data obtained. An electromagnetic profiling polygon with 1.4 ha area was covered: the area between house depressions No. 3 and No. 5, a large area to the east and south of them, where houses were assumed, and to the north of the pit with pottery (Fig. 4).

Five rounded anomalies with low resistivity are visible on the apparent electrical resistivity map. Positions of two of them correspond almost completely to the house depression No. 4 and the assumed house depression No. 5. To the north of them, an anomaly is located nearly on a large deep scour on the cape. Two low resistivity anomalies to the east and southeast of the assumed house depression No. 5 may not be associated with any structures, but are probably caused by the features of the near-surface geological structure. Relief is flat in this area. An intense complex high resistance anomaly in the southwest is also associated with near-surface geology.

A magnetic survey of a polygon was carried out to check the assumption that anomalies with reduced electrical resistivity are house structures. The polygon of magnetic survey dimensions was 50 × 30 m. It covered the assumed house depression No. 5 and the resistivity anomaly to the east of it. However, the map of magnetic anomalies showed extremely high intensities and did not help in solving the problem (Fig. 5).

It can be explained by the fact that the territory of the settlement is partly located on the eastern flank of a series of ultramafic massifs, which include serpentinites with high magnetic susceptibility (Moseychuk et al. 2013). They also caused an anomaly of high electrical resistance, mentioned above.

4 Conclusions

The results of work on the Zarya I settlement by non-destructive methods allowed us only to clarify the structure of the settlement. The new topographic map, DEM, electromagnetic and magnetic maps of polygons in the eastern part of the settlement was obtained. These data already make it possible to choose an area for further archaeological excavations. Thus, the hypothesis that Abashevo houses existed in the Zarya I settlement could be confirmed. At the same time, new tasks have been set, which solution is required for further development of the work methods and processing of obtaining data.

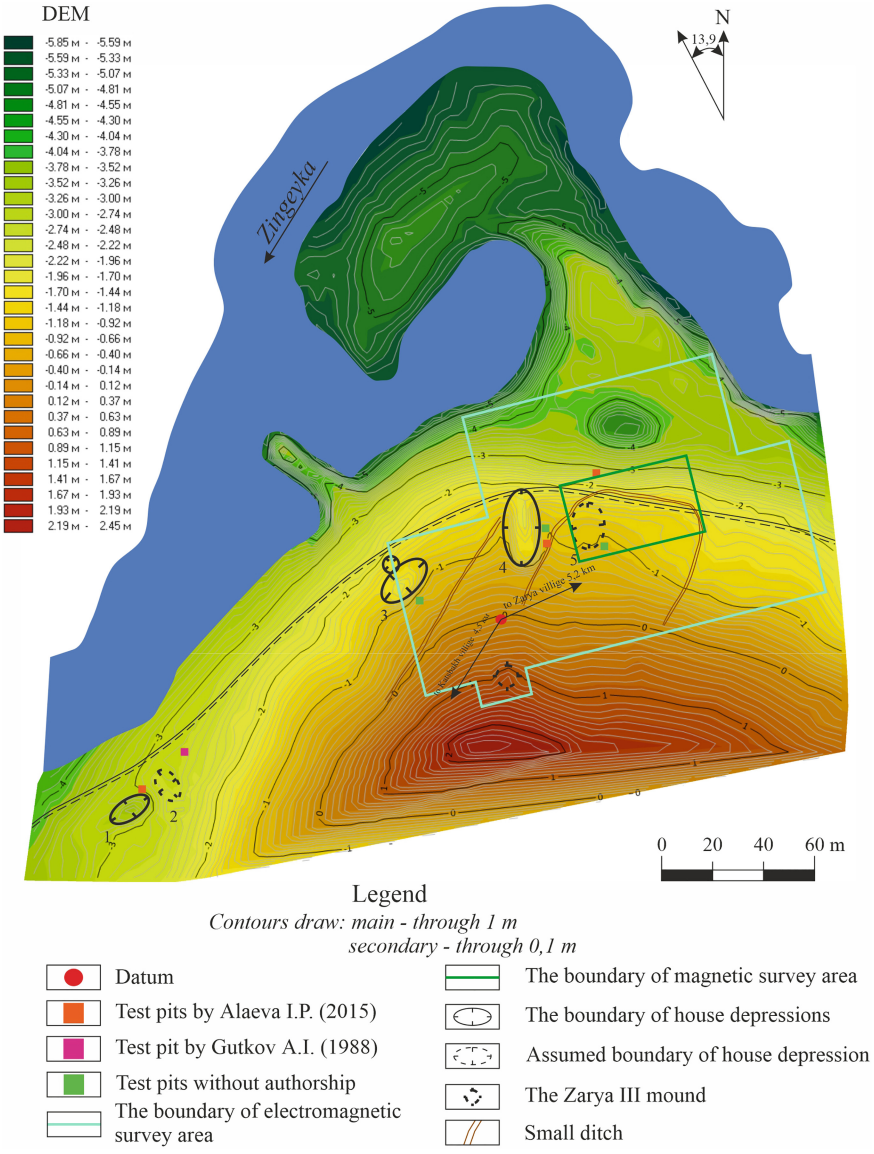

Fig. 3. The Zarya I settlement. Topographic map with plotted objects and areas of geophysical survey

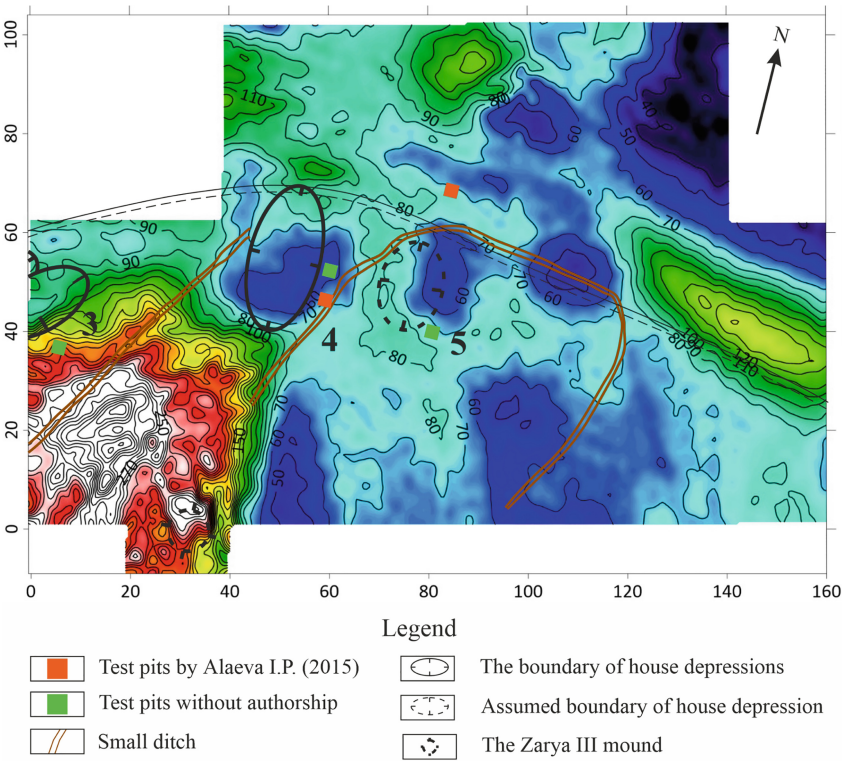

Fig. 4. The Zarya I settlement. Apparent electrical resistivity map

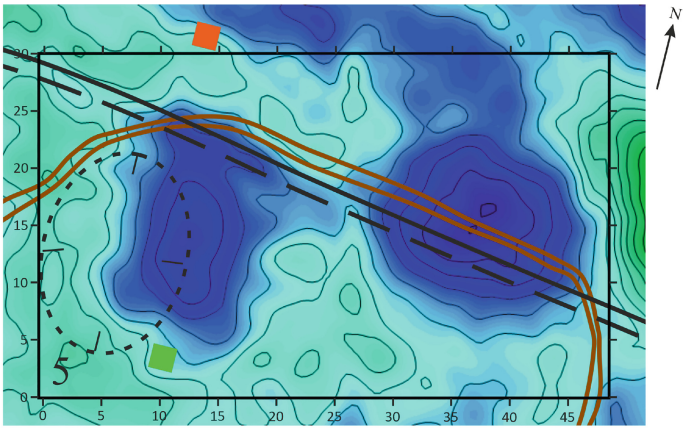

Fig. 5. The Zarya I settlement. Apparent resistivity map (1) with magnetic survey area (2) at the same location

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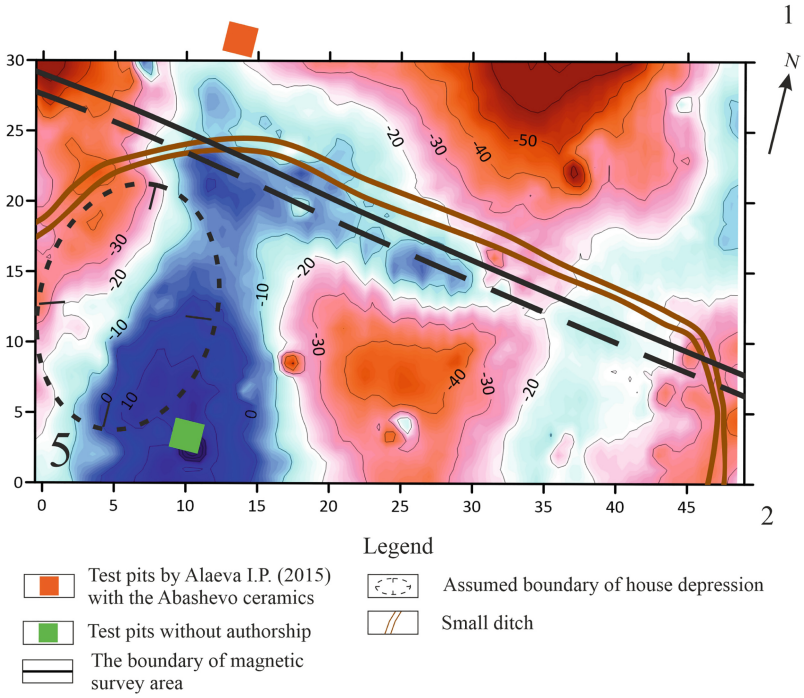

Fig. 5. (*continued*)

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