KABIYUK PROJECT: EXPLORATION AND CONSERVATION OF ARCHAEOLOGICAL SITE USING REMOTE SENSING METHODS AND GIS TECHNOLOGIES

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ABSTRACT — *This paper reveals the achievements in a project implementation focused on the application of non-destructive methods for study of the National Historical and Archaeological Reserve "Kabiyuk" in Bulgaria. The purpose of the paper is to present the application of remote sensing methods and GIS technologies as a tool for digital documentation of the survey and conservation of Kabiyuk archaeological reserve.*

Keywords: *Remote Sensing, GIS, Archaeology, Conservation, Cultural Heritage*

INTRODUCTION

The purpose of the paper is to present the application of remote sensing methods and GIS technologies as a tool for digital documentation of the survey and conservation of Kabiyuk archaeological reserve in Bulgaria. The paper reveals the achievements in the implementation of a project for multidisciplinary study and the development of geodatabase which serves for conservation planning of the territory. It presents an integrated method for investigation of archaeological sites based on geoformation technologies.

STUDY AREA

The method is developed and applied in the investigation of two of the most significant archaeological sites in Bulgaria, The Outer Town of Medieval Pliska and National Historical and Archaeological Reserve "Kabiyuk" (NHAR "Kabiyuk"). National Historical and Archaeological Reserve Kabiyuk is located in Northeast Bulgaria, 12 km northeast from the town of Shoumen (Fig. 1).

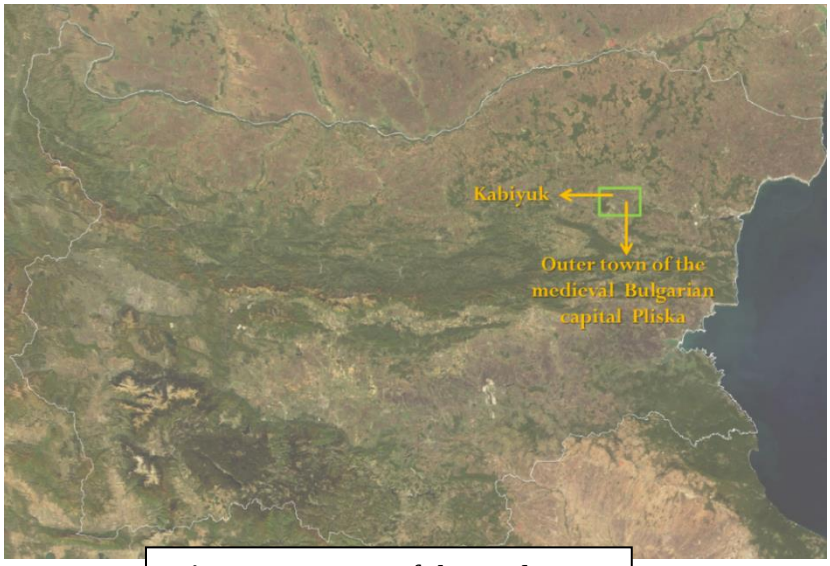

Fig. 1. Location of the study area

It was announced as a National Historical and Archaeological Reserve in 2011. With the amendment to the Law on Cultural Heritage, in its appendix, Kabiyuk was added under No. 32 with the name "Early Medieval Village of Kabiyuk" as an archaeological reserve situated on the territory of two municipalities

- Shumen and Hitrino (State Gazette, issue 54 of July 15, 2011) [1]. It is one of the main archaeological early medieval sites connected with the First Bulgarian Kingdom, whose earthen rampart is the second biggest after the fortification of the First Bulgarian Capital – Pliska. (Fig.2). It covers an area of 5.7 sq. km.

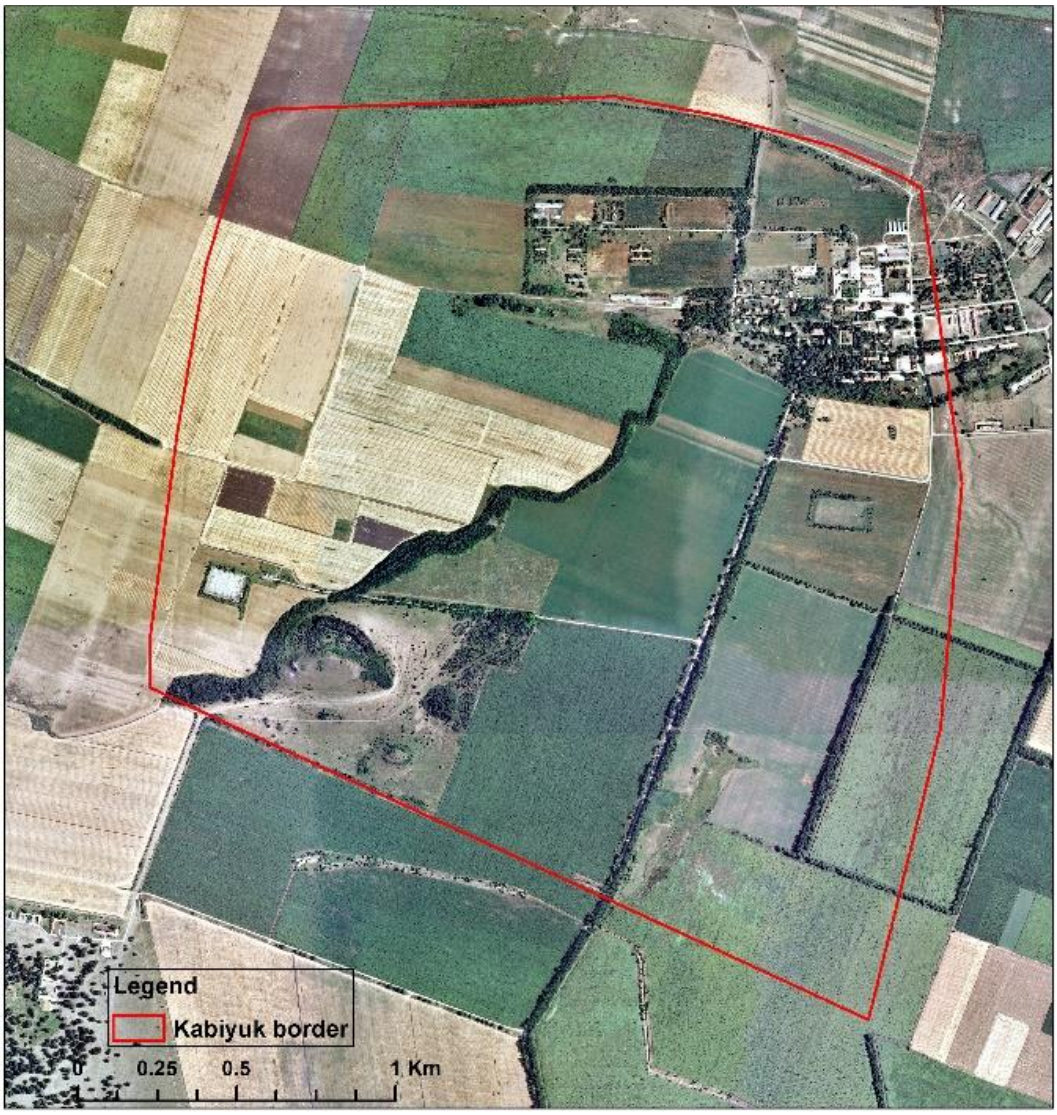

Fig. 2. National historical and archaeological reserve "Kabiyuk"

On its territory is situated also the earliest stud farm in Bulgaria – Kabiyuk, started in 1864 by Midhat Pasha, the Governor of the Danube Province, as a military stud farm for the Turkish army. The stud farm is located on 13 km northeast of Shumen and the average altitude is 194 m. Even in the first years of its operation, the number of horses reached about 1000. Later, in the course of the 1877-78 Russian-Turkish War, all horses were transported to Anadola by the withdrawing Turkish army. The newly liberated Bulgarian state found the stud farm empty. In 1883, an attempt was made to revive its operation as the newly formed Bulgarian army severely needed horses. However, that was a wasted effort: the breeding horses were of poor quality and there was no qualified staff. That was the reason why the stud farm had to close down four years later. The actual revival of its activities was in the autumn of 1894 and the farm was called Kabiyuk National Stud Farm, Stallion and Stud Depot. Since then, it has always been active [2].

There are two museums at the Kabiyuk stud farm. The Museum of Battenberg – first ruler of liberated Bulgaria. Alexander of Battenberg, was the first prince (*knyaz*) of modern Bulgaria from 1879 until his abdication in 1886. There is also the only on the Balkan Peninsula Museum of Horse [2].

The study area is a great example of a combination of cultural and natural heritage, and it includes three protected areas – archaeological reserve, protected site, and Natura 2000 site (Fig. 3).

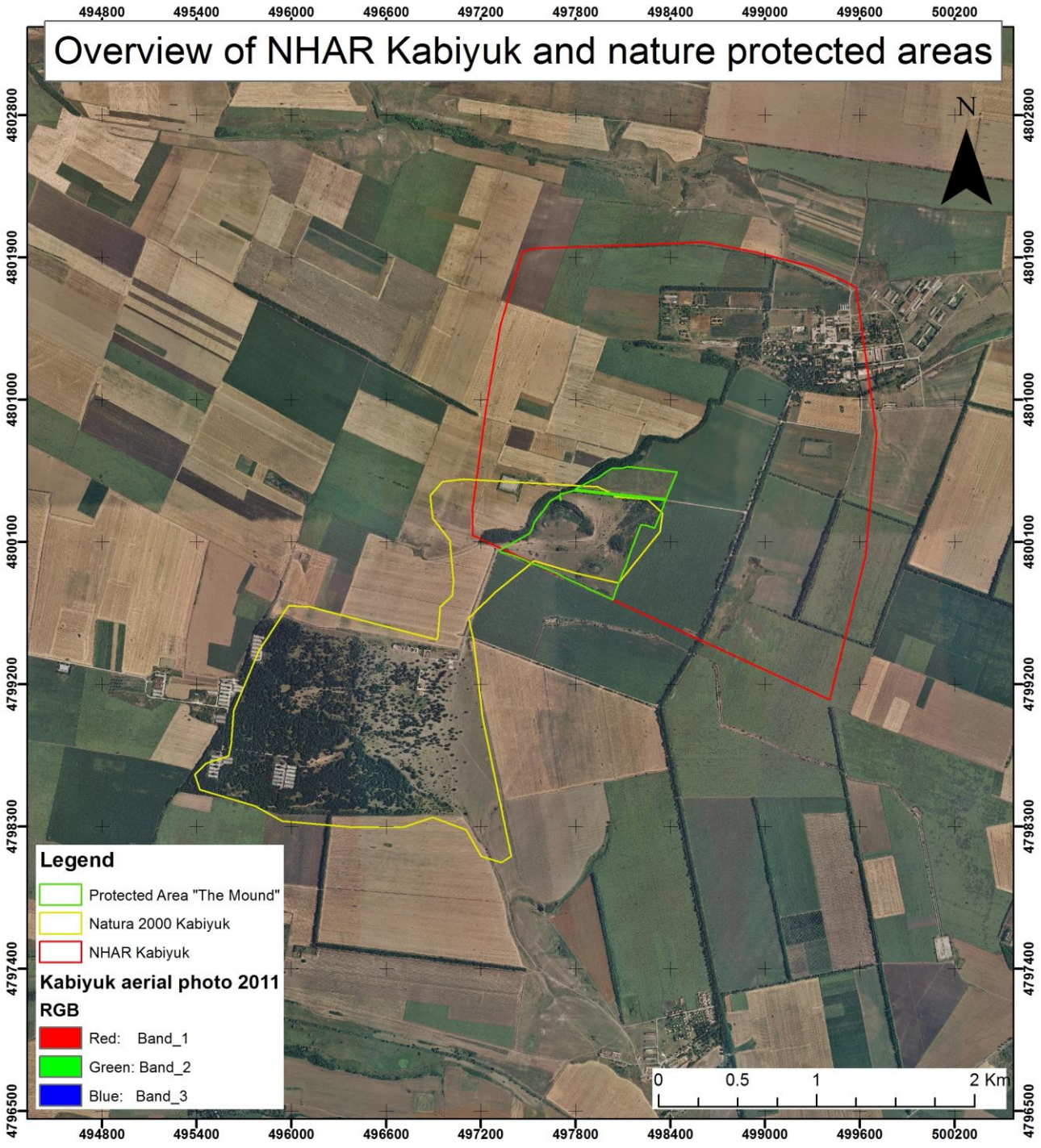

Fig. 3. Protected areas of the region Kabiyuk

The protected territory of the mound Kabiyuk (Fig. 4) is proclaimed as Natural Monument in 29.12.1973 and reclassified as Protected Site in 25.07.2003. It has area is 47.5 ha and is a home of over 200 herbaceous and shrub species [3]. "The Mound" is the best preserved area with steppe vegetation in Bulgaria, more typical are *Adonis vernalis* (Fig. 5), *Stipa sp. div., Pulsatilla vernalis, Peucedanum ruthenicum* and others.

Fig. 5. *Adonis vernalis*

Fig. 4. The mound "Kabiyuk"

The mound Kabiyuk fall in Natura 2000 protected sites under Habitats Directive 92/43/EEC [4] on conservation of natural habitats and of wild fauna and flora (Site Code BG0000602) with an area 286.87 ha, adopted by the Council of Ministers by Decision №122/02.03.2007 [5], [6], [7]. The site is the one of the most important territories for the preservation of the steppe bushes - species (Caragana frutex, Amygdalus nana) and habitats - 40A0 (Subcontinental peri-Pannonic scrub) and 40C0 (Ponto – sarmatic deciduous tickets). There are many rare species - Anemone sylvestris, Peucedanum ruthenicum, Centaurea marshaliana and the population of Echium russicum is one of the biggest in Bulgaria. There are an old thin oak forest on the territory of the site as well [6], [7].

The investigation of the early medieval Bulgarian culture in Northeastern Bulgaria began in the end of XIX century and the beginning of the XX century when the first field observations and excavations are made by K. Shkorpil [8]. As a result several important archaeological sites are found, among them is Kabiyuk. After its discovery, the site was explored sporadically and only separate structures were explored through the years [9], [10], [11], [12] and [13].

The project "NHAR Kabiyuk: Complex interdisciplinary study of one of the non-capital royal residences (Aul) of the First Bulgarian Kingdom" is the first archaeological project aimed to explore the whole area of Kabiyuk and the first project in Bulgaria focused entirely on the leading role of methods for non-destructive survey.

METHODS AND DATA

The developed integrated approach includes:

- processing and interpretation of satellite images and aerial photos;
- terrain GNSS measurements;
- geophysical prospection;
- GIS spatial analysis and data processing;
- UAV aerial surveying, analysis of the aerial photography and DEM creation.

The project applies a complex multidisciplinary approach, combining the expertise and knowledge of archaeologists, remote sensing and GIS specialists and geophysicists for exploring archaeological objects covering large areas. The accent on the non-destructive methods (aerospace methods and technologies, geophysics and GIS), combined with conventional archaeological methods of exploration aiming not only to discover and mapping the archaeological sites before excavation, but to plan ahead the measures of their conservation and usage as tourists sites. Essential part of the project is the improvement of the methodology for archeological field survey, which was developed during the first stage of the project implementation and during a previous project for exploration of the Outer Town of Pliska and was partially presented at the Digital Heritage 2013 congress in Marseille [14], [15]. The methodology for archaeological field survey combines the usage of GIS technology, aerospace data with very high resolution, aerial survey by UAV and GNSS measurements.

The remote sensing methods include application of satellite images and aerial photos with very high spatial resolution, georeferenced topographic maps and digital terrain modeling derived from UAV scanning. The used remote sensing data include archive satellite images from the sensors of Worldview-1, Ikonos, Orbview and color orthophotos. They were combined to cover a 10-year period, required for registering the changes of the land cover/land use. The remote sensing data were used for computer-aided visual interpretation and deciphering of the main land cover/land use types, required for planning and conductance of the archaeological field survey and for localization of potential sites.

The application of remote sensing methods is complemented by the use of UAV. For implementing a detailed mapping and documentation of the archaeological excavations within the project two aerial surveys with a resolution of 5 cm were planned and one conducted so far. The main criteria for the aerial surveys are minimal vegetation cover and lack of snow cover, which limits the time interval for acquisition to two short periods in spring and autumn. The combination of satellite images and aerial photos was made to provide an increasing spatial resolution from 0.5-1 m of some images and aerial photos to 5 cm of the aerial photos obtained by UAV.

Geodatabase of Kabiyuk

All remote sensing and ground-based data acquired during the project will be imported into a geodatabase and used for spatial analysis and modeling. The geodatabase model for NHAR

"Kabiyuk" was designed during the first year of the project and the available data (including remote sensing data for various years – 2002, 2006, 2009, 2011, data from the archaeological field survey, aerial photos with 5 cm resolution, digital terrain model, point clouds, land cover / land use types, plus auxiliary working files) were imported (Fig. 7). The primary goal of the geodatabase is facilitation of the non-destructive study of archaeological sites, documenting and storing the results of the archaeological surveys and excavations, and its use in planning of future studies.

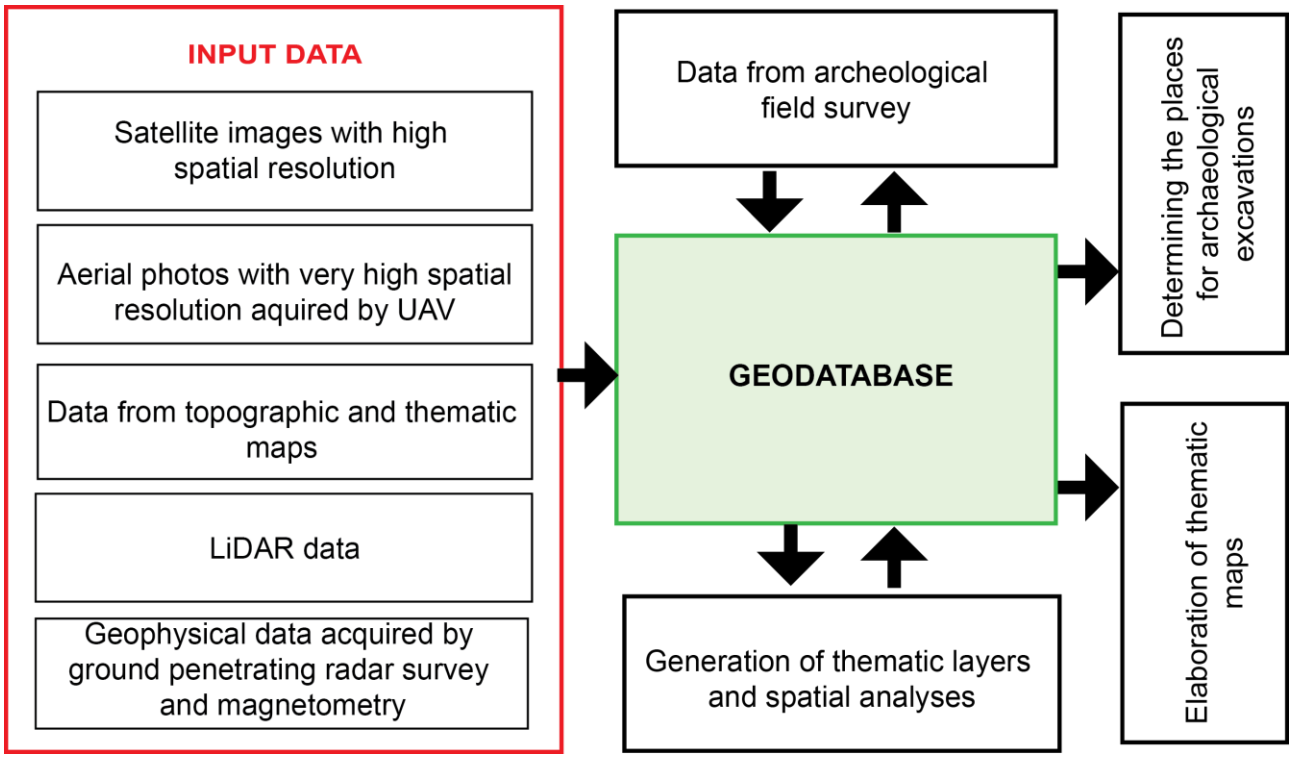

Fig. 7. Structure and interconnection of the data used in applying the integrated approach for non-destructive survey of archaeological sites.

RESULTS AND EXPECTED IMPACT

The main results of the project implementation could be summarized in improvement of the methodology for archaeological field survey through applying modern geoinformation technologies. The integration of the information and data, obtained by the various remote sensing methods and archaeological field surveys, into GIS will allow a series of spatial analysis to be applied, thematic maps and digital terrain model to be generated and a detailed archaeological map of the NHAR "Kabiyuk" to be elaborated (Fig. 8, Fig. 9 and Fig. 10).

The created integrated geodatabase of NHAR "Kabiyuk" could be updated with new information and will serve for more precise planning of archaeological research in Kabiyuk for the next decades.

As a long-term effect of the project implementation it is foreseen a team of highly qualified scientists, including young scientists with multidisciplinary knowledge in the application of remote sensing and GIS technologies for the study of archaeological sites to be formed.

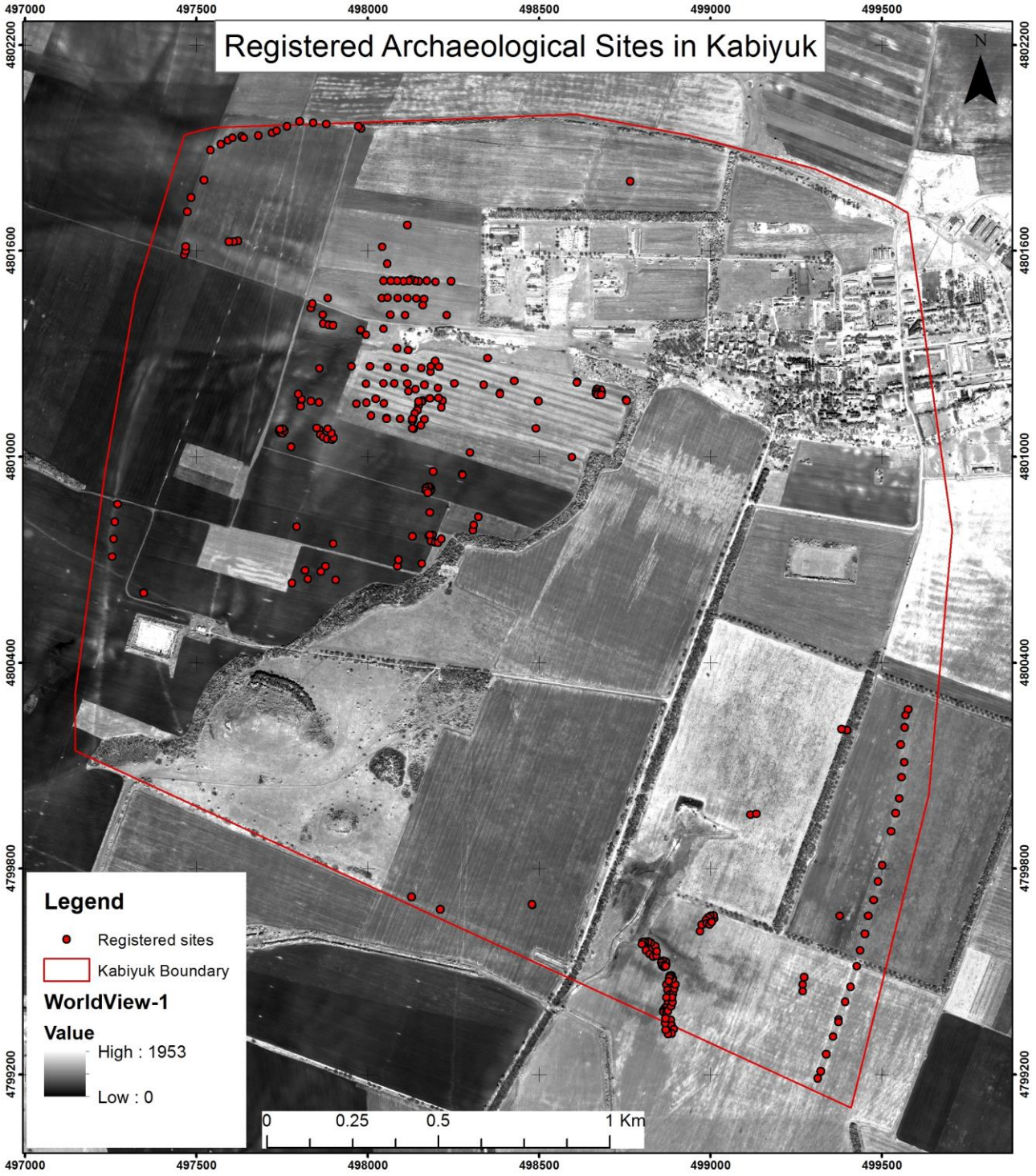

Fig. 8. Registered archaeological sites in NHAR Kabiyuk

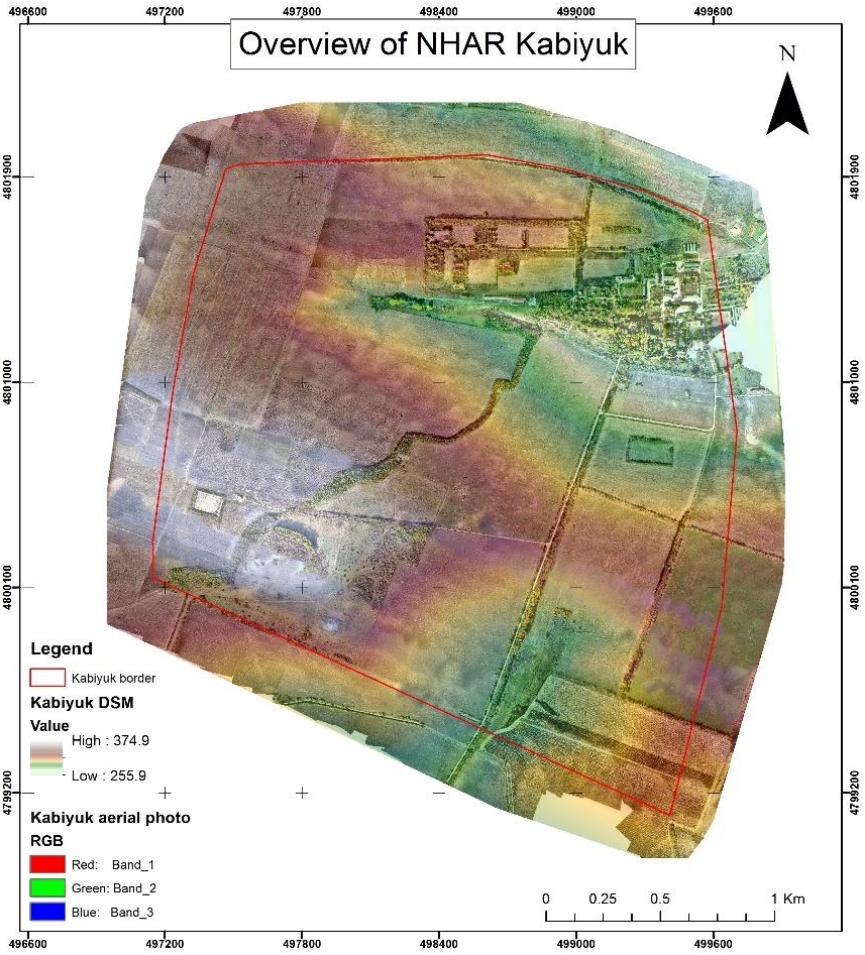

Fig. 9. Digital elevation model overlaid over aerial photos of NHAR "Kabiyuk"

Fig. 10. Aerial view of the archaeological structures during the excavation

CONCLUSIONS

The presented method was created and applied throughout the archaeological survey of the Outer Town of medieval Bulgarian capital Pliska, conducted as part of the PhD thesis of Stefan Stamenov. The method was improved and applied in the scientific research project ДФНИ К01/5/2012, funded by National Science Fund of Ministry of Science and Education for NHAR Kabiyuk. The presented method was the reason for winning the project funding. The method can be successfully applied for archaeological sites from different ages, up to modernity.

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