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WEB-PORTAL "COUNTRY OF CITIES" – COMPREHENSIVE STUDY OF THE VOLGA BULGARIAN FORTIFIED SETTLEMENTS

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Abstract

The article presents the results of research aimed at collecting and systematizing information about the settlements of the Volga Bulgaria period (10th - early 13th centuries). For the first time in Russia, field studies of 88 medieval settlements of different size were carried out using UAVs and GNSS equipment. The collected information was compiled into a geoinformation database with 36 qualitative and quantitative parameters for 95 objects (medieval settlements). Based on the obtained data, for the first time for the study area, "Country of Cities" web resource was created, which allows access to analytical and generalizing information about each studied fortified settlement of the Volga Bulgaria period. The combination of the descriptive component and the cartographic module makes it possible to assess not only the regularities of the hillfort's placement in the studied territory, but also to study individual archaeological objects in detail by interactive textured three-dimensional models. The analysis made it possible to specify the location and boundaries of the fortified settlements, to assess the current state and the risks of destruction under the influence of natural and anthropogenic factors.

***Keywords**: Archaeological heritage; Fortifications; Natural hazards; Anthropogenic impact; GIS; Geoportal*

Introduction

The study of the Volga Bulgaria fortified settlements occupies a special page in the history of the study of archaeological sites of the Middle Ages in the territory of the Volga-Kama region. Because of the absolute absence of the Bulgarian written sources of the 10-13th centuries, the settlements provide unique evidence of the urban life of the Volga Bulgaria, the spatial distribution of military, administrative, fortification architecture, trading points, and their interconnections, etc. [1]. To date, in the archaeological literature, these monuments are considered according to outdated and inaccurate plans and descriptions. Using modern methods and approaches, a complete study is not carried out. Also, their transformation (the destruction of defensive structures, which are a unique feature of fortified settlements, under the influence

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of natural hazards and anthropogenic impact, that reduces the area of monuments, which leads to the loss of their shape and cultural layer) is not considered [2-5]. Under these conditions, researchers work with incorrect information, which leads to errors in typology. Unique evidence of the past may entirely disappear. For example, over the past 60 years, the defensive systems of the Hulash and Deushevskoe sites have been destroyed before they were properly documented [6].

In this situation, to improve the methods of studying the archaeological heritage, the authors propose using an integrated (multidisciplinary) approach based on modern non-destructive field research methods [7]. It includes the application of the latest technical achievements in geosciences and archaeology, based on the principle of studying and preserving archaeological sites using remote sensing data [8, 9]. This approach allows obtaining information about archaeological objects' location, shape, size, and condition without archaeological excavations, which also leads to the destruction of the site.

The rapid development of digital technologies in the late 20 - early 21st centuries led to their widespread use in various branches of science, including archaeology. They allow a new interpretation of archaeological material due to the quick and efficient processing of large amounts of information [10]. The following tools that are widely used in modern archaeology can be distinguished: GIS, spatial analysis, processing and interpretation of remote sensing data, the use of unmanned aerial vehicles [11], 3D modeling [12]. As world practice shows, the combination of these methods makes it possible to implement complex (multidisciplinary) projects to study archaeological heritage [7, 13]. The multidisciplinary approach became a commonplace for modern archaeological work and gives the most significant results in research [14, 15]. Revision of already identified sites, their additional examination, obtaining accurate information on the location, and integrating the data in GIS make it possible to study and interpret archaeological materials by historical modeling processes, spatial and historical analysis of cultural landscapes [1, 16].

Recently, to solve the issues of integrated archeological research, the concept of geoportal is increasingly being used - interactive maps that allow displaying a series of thematic spatial data in the form of vector objects and raster images. Existing experience proves the demand for such geoinformation solutions. Examples include the web GIS “Atlas of Hillforts of Britain and Ireland” [17]; geoportal of the National Monuments Service of Ireland [18]; the geoportal of the Castello di Alceste Museum (Italy), which allows to “visit” it in augmented reality [19]; an information system with an image-based modelling (IBM) reconstruction of the Basilica of St. Ambrose in Milan [20]; geoportal of Australian cultural heritage sites [21]; web GIS “Archaeological monuments of Crimea” [22, 23], cultural heritage sites from Romania [24-26] and many others.

This article reflects the study carried out within the framework of the RFBR project №18-09-40114 "Country of Cities" - a complex study of the fortified settlements of the Volga Bulgaria using modern methods. The work aims to develop an archaeological geoportal that provides access to the results of assessing the current state of the medieval hillforts of the Volga Bulgaria period based on a set of non-destructive methods.

Experimental part

Study Area

The objects under study are the fortified settlements (hillforts) of the Volga Bulgaria and the subsequent Golden Horde period (10-15th centuries) – archaeological objects that has preserved traces (remains) of an ancient settlement, fortified with defensive structures. The study area is the historical territory of Volga Bulgaria, determined by archaeological research. Volga Bulgaria was in the Middle Volga and Trans-Volga regions (including the territory of the lower Kama region). The territory is located within several geographical zones, in which the

Kazan Volga region occupies a central place. According to the archaeologist's conclusion, the Volga Bulgaria territory extended from the Kazanka River in the north to Samarskaya Luka in the south and from the Sura River in the southwest to the Sheshma and Cheremshan rivers in the east and southeast, respectively [1].

Chronologically, most of the studied archeological sites belong to the two periods of the existence of the Volga Bulgaria. The first one – the pre-Mongolian period of the 10-13th centuries (60%), the second one – the Golden Horde period of the 13-15th centuries (20%). Small sites are 1-5 hectares in size, and the largest – up to 600 hectares. Most of the fortified settlements have 5 to 35ha area [27]. Bulgarian settlements have attracted the attention of researchers since the end of the 18th century.

Through the many years of research in the pre-revolutionary, Soviet, and post-Soviet periods, by the beginning of the XXI century, about 200 Bulgar fortified settlements were identified. Several overviews work (monographs and articles) was published [28]. After analysis of the materials of the 19-20th centuries, presented in the archaeological literature, 125 settlements were chosen for study by the authors. One hundred nineteen of them are located on the territory of the Republic of Tatarstan, 2 in the Republic of Chuvashia, and 4 in the Ulyanovsk region (Fig. 1).

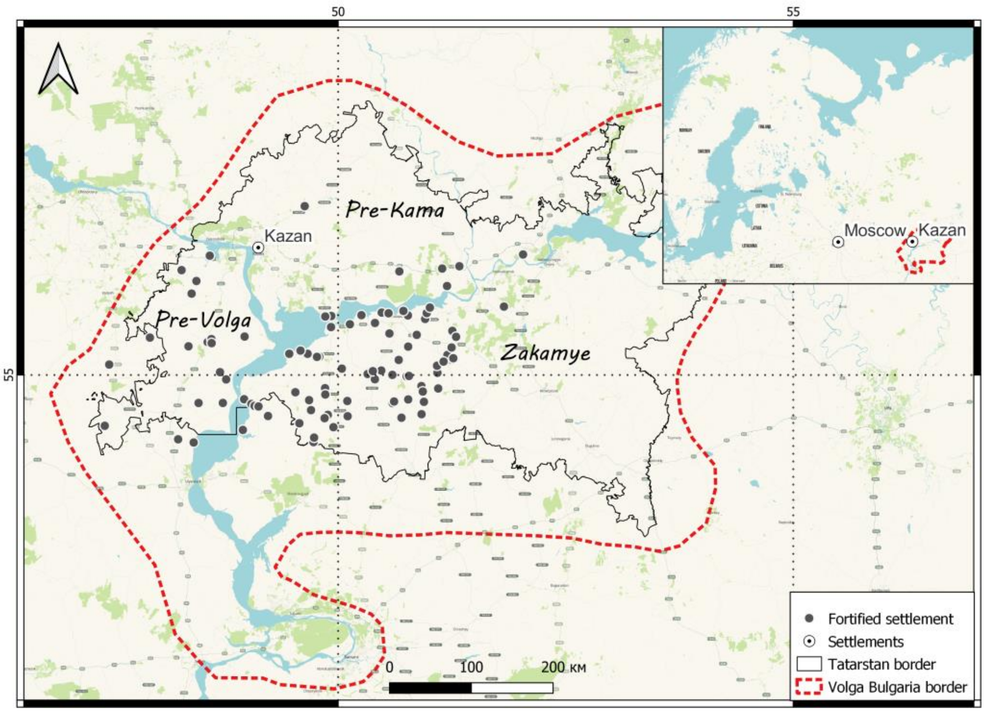

Fig. 1. Boundaries of the Volga Bulgaria and location of studied fortified settlements

Settlements with the remains of earthen fortifications in their current state are natural-anthropogenic complexes, the formation of which is due to the influence of human work and natural processes [29]. Thus, the natural and anthropogenic nature of the studied sites determines the research methods, the basis of which is an integrated approach that involves the study and interpretation of archaeological materials. It also includes the study of the development of natural hazards that destroy archeological sites and the forecast of the development of the studied objects and processes in the future. The approach is based on natural sciences, historical and archaeological fields of study, resulting an interdisciplinary approach.

Methodology

Historical data

The study's data sources were archival materials and reports of archaeological research, which provide data on monuments at the time of their discovery, such as area, characteristics of defensive structures, etc. General land survey plans of the late 18th - early 19th centuries were used as the primary source of cartographic materials. Based on the georeferenced general land surveying plans, an assessment of the land use structure near the hillforts for the late 18th - early 19th centuries were carried out [30].

Remote sensing data

Archival remote sensing data are the most important data source for assessing changes in the state of fortified settlements. Analysis of aerial and satellite images of the 1950s–1980s of the last century makes it possible to determine the exact location of archeological sites, including destroyed ones. It allowed to conduct a more reliable spatial analysis of the location of the settlements of the Volga Bulgaria and assess the dynamics of their destruction over the past 60 years.

Aerial photographs (scale 1:17000, 1:25000) for 50 settlements, including those already destroyed, were found in the special fund of the library of Kazan Federal University. Declassified images of the Corona intelligence space program from the KeyHole-4, KeyHole-4A, KeyHole-9 satellites were downloaded from the open archive of the US Geological Survey (USGS) [31]. Acquisition date 1967 and 1975-1977. Cloud-free multi-season Landsat 8 (Surface Reflectance Level-2 Data Products) images for the snow free period of 2015–2019 were used to analyse the modern land use/land cover structure. The Universal Transverse Mercator (UTM) WGS84 projection, 39 zone of the northern hemisphere, was used for all materials. Archival aerial and KeyHole satellite images were referenced using the Georeferencing tool in the ArcMap. Georeferencing subsequent scenes were taken into account already referenced to achieve maximum accuracy. Both visual and quantitative evaluation of the reference accuracy was evaluated. The RMSE for all scenes does not exceed 5m.

Field surveys

A DJI Phantom 4 PRO v2 drone equipped with a 20-megapixel camera was obtained as part of the project. The quadcopter was modified using the camera shutter synchronization system developed by the TeoDrone company, making it possible to replace the built-in positioning system with a GNSS solution produced by the EMLID company.

The EMLID Reach M+ module with a TOPGNSS TOP508 spiral antenna was used as the GNSS receiver. The changes made allow coordinates to be recorded at a frequency of 1.0Hz, and the camera shutter time was reduced to 0.05 seconds. In the case of using a standard, non-GNSS version of the copter, special landmarks were positioned in the territory of the site, the coordinates of which were determined by E-Survey (Fig. 2a) and Emlid RS+GNSS receivers. The flight and surveying of the sites were entirely performed in an automated mode. For this purpose, a flight task was loaded into the UAV controller using the DroneDeploy mobile software, including the flight altitude over the takeoff point and the longitudinal and transverse overlap between adjacent images. To observe the consistency of the flight methodology, the flight altitude at each site was 150m above the takeoff point. The longitudinal and transverse overlap between adjacent images was 70% [32, 33].

During the cameral processing of the obtained data, the correction was made in the rover log-file concerning the shutter delay time using the UAV Design Tools software. The RINEX file with the changes made was processed by the PPK mode in specialized geodetic software for baseline equalization. We used RTKLIB [34]. Data from the GNSS rover was recalculated based on data from the base station. For this purpose, the SmartNet base station closest to the site was selected. The resulting coordinates of the image projection centers were further compared with the UAV image files and then processed in Agisoft Metashape photogrammetric software. The methodology of GNSS-UAV data processing in this software is not fundamentally different from that using ground control points. Further, the phototriangulation and creation of dense point clouds are performed after the digital elevation model (DEM) and orthophotomap are created.

Methodology for archaeological sites assessment

There are two groups of factors affecting the current state of archaeological sites - natural and anthropogenic. Natural ones include modern natural hazards associated with gravitational movement (gullies, landslides, rockslides, etc.) and the development of fluvial processes (rivers and reservoirs) [10]. Anthropogenic impact includes all types of man-made modification of the territory, accepted as functional use (plowing, haying, grazing, residential, transport, etc.) [35]. Thus, to assess the risks of sites destruction, an approach based on consideration of anthropogenic and natural risks was used. Anthropogenic risks were calculated based on the cumulative score based on land use types on the ancient settlement site. A total of six predominant land-use types were identified, which are presented in Table 1.

Table 1. Evaluation of impact score by land use types at the Volga Bulgaria fortified settlements territory

Type of land use	Parameter	Impact score (*xi*)
Tree and shrub vegetation	a	1
Hayfields	b	2
Grasslands	c	3
Roads	d	3
Cropland	e	4
Development	f	5

The formula calculated the final estimate of the anthropogenic impact:

$$\mathbf{X}_i = (\mathbf{S}_i^a \times x_i^a) + (\mathbf{S}_i^b \times x_i^b) + (\mathbf{S}_i^c \times x_i^c) + (\mathbf{S}_i^d \times x_i^d) + (\mathbf{S}_i^e \times x_i^e) + (\mathbf{S}_i^f \times x_i^f) \quad (1)$$

where: *Si* is the area of the corresponding type of land use.

Creation of a web-based geoportal

A database was created based on the information obtained during the analysis of archival and field data. The web resource "Country of Cities" was created [36]. Historical maps and aerial and space images of different years are presented on the portal as archival data sources. A qualitative description was carried out for the Volga Bulgaria fortified settlements. The field works were accompanied by photo- and video-filming, both ground and airborne. To increase the speed of work of the system and thematic partitioning of the Country of Cities web-resource functionality, it was decided to separate descriptive and cartographic parts, web-portal, and geoportal, respectively. To do this, a separate page was created for each ancient settlement on which thematic blocks were made: a block with the field photographs of the fortified settlement from different angles, taken from UAV, a block with the main descriptive information, a block with a series of thematic maps (a map with the shadow relief, the map of functional zoning, the graph of profiles), a block with the archive materials, and a block with the interactive textured 3D model of the site obtained by UAV survey.

The cartographic part is a classical geoportal implemented using the open-source leaflet library [37]. A distinctive feature of the library is its modularity, which allows adding functionality without changing the main content of the geoportal - the initial geo-information in the prepared geodatabase on the ancient Volga Bulgars settlements.

Results and Discussions

Analysis of archival information

Results of the study of historical description and maps

During the study of the archives, it was discovered a block of documents, which constituted the manuscript "Lists of barrows and settlements, the most remarkable in the Kazan province", compiled and prepared for submission to the Anthropological Exhibition in Moscow in 1879 by the Provincial Statistical Committee, edited by the Chairman of the Committee NN. Vecheslav. The manuscript, which contains unique and detailed descriptions of sites of the ancient settlement of Volga Bulgaria, is accompanied by a rich cartographic material (Fig. 3a) and is one of the most valuable newly discovered sources in the history of the study of archeological heritage in the Russian Empire in the 19th century.

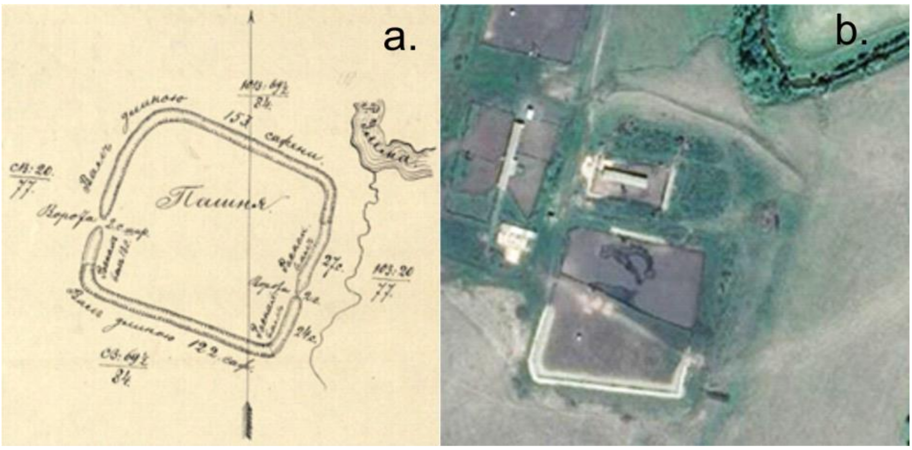

Fig. 3. a) Lyashevskoe ancient settlement plan (1878) with the the initial state of the defensive system; b) The current state on the modern satellite image (2018)

This source turned out to be especially useful for studying the dynamics of natural hazards because for many hillforts it is possible to analyse the preservation from the 70s of the 19th centuries (Fig. 3b).

Analysis of archival remote sensing data

Remote sensing data are useful for studying the dynamics of the sites. Analysis of images also allowed us to detect sites destroyed due to natural processes – "Devichy Gorodok" affected by coastal erosion (Fig. 4a), Bolsheklyarinskoe site affected by plowing (Fig. 4b and c) and as like Lukovskoye site – by river erosion (Fig. 4d, e and f), Dzhuketau site affected by building development (Fig. 4g, h and i). The results of satellite imagery analysis revealed the Yerjapkinskoye fortified settlement, which was still known only by the description in the archives of S.M. Shpilevskiy "Ancient cities and other Bulgaro-Tatar monuments in Kazan province", and not discovered later on.

Results of field surveys

Out of 122 fortified settlements selected for the study, the field survey was conducted at 88 sites. During the analysis of archival materials and modern satellite images, it was determined that 22 hillforts were either destroyed or were identified in the 19-20th centuries. However, their location is unknown. The UAV surveys found that 12 objects were entirely or partially forested and inaccessible. Out of the investigated sites, 19 are located in the Pre-Volga region, 10 in the Pre-Kama region, and 59 in the Zakamye region.

As a result of first studies of sites located in the Pre-Kama and Pre-Volga regions, the field survey methodology of the ancient medieval settlements of different types and sizes by UAVs was developed, a universal set of recommendations that can be used both for the studies of the fortified settlements and other archaeological objects. The order and parameters of the survey are determined, and the optimal software is selected.

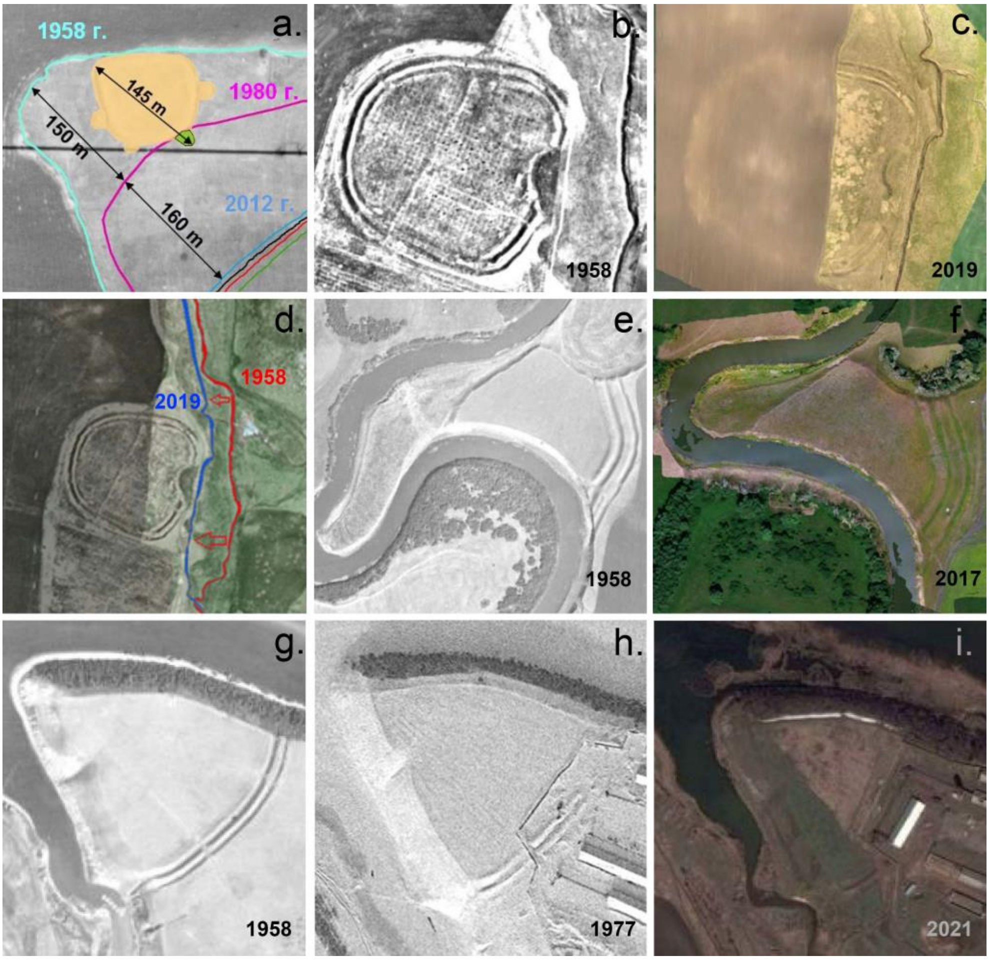

Fig. 4. Study of the fortified settlement territories changes by archival aerial images:
a) Identifying the boundaries of the eroded Devichy Gorodok site; b, c) Ploughed Bolsheklyarinskoe site;
d-f) Destruction of Bolsheklyarinskoe site (d) and Lukovskoye site (e, f) by river erosion;
g-i) Building development at the Dzhuketau site territory

Besides the main tasks performed with the use of UAVs – establishing of the precise borders of archaeological sites, evaluation of the state of defensive systems, etc., the analysis of the DEM obtained during the field survey. For example, traces of the secondary use of the Narat-Yelginskoe fortified settlement were revealed – defensive structures (bastions), built presumably in the 17-18 centuries (Fig. 5a); or the traces of the original defensive structures and the ancient road were indentified on the territory of the Churu-Baryshevskoye site (Fig. 5b).

Archaeological sites assessment

The assessment of exogenous processes was carried out based on the risk model of exogenous processes of the Republic of Tatarstan. The corresponding map was calculated based on the regression of support vectors using the indicators presented in Table 1, which were integrated into equation 1. The values in the corresponding model vary from 0 to 1 according to the probability of the natural hazards risk (Fig. 6).

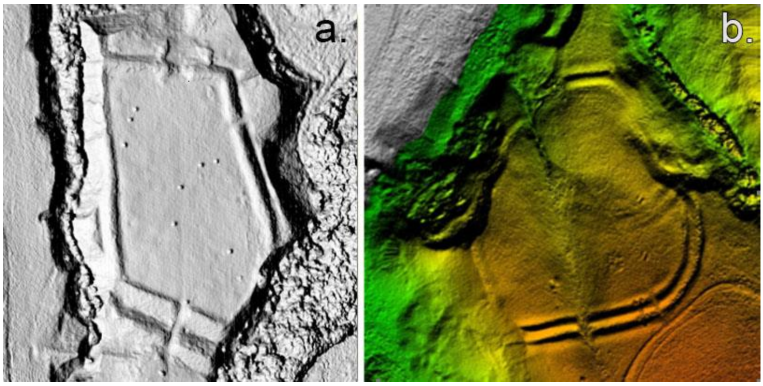

Fig. 5. a) Identified remains of bastions (17-18 centuries) at the Narat-Yelginskoe site; b) Identified traces of the original fortifications of the Churu-Baryshevskoye site

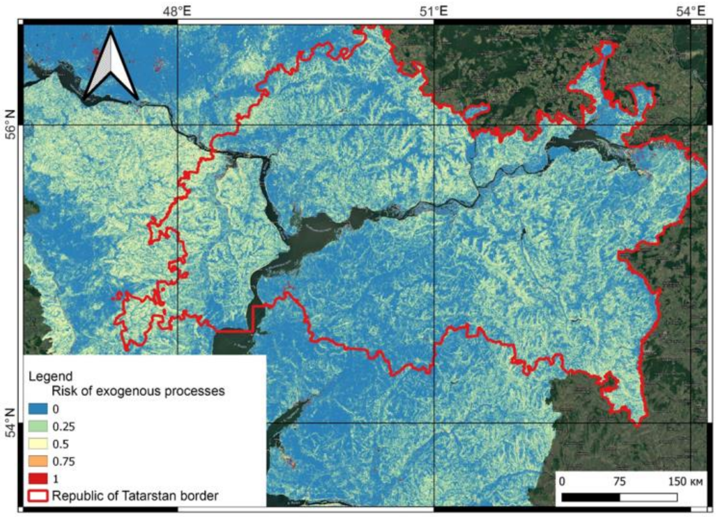

Fig. 6. Map of natural hazards risk assessment

The database

The main result of field observations was the data obtained from the UAV, which was used for the ultra-high resolution digital elevation models (DEM) construction and orthophotomaps projected on them. After cleaning artifacts, forests, buildings, it is used for various morphometric and statistical indicators – steepness, exposure, profile and plan curvature, average, maximum, and minimum heights relief of the town – calculation.

Orthophoto interpretation makes it possible to assess the current state of a particular fortified settlement [7, 38, 39]. Based on the orthophotomaps analysis, the database includes the site area, centroids coordinates, degree of destruction, land use, and anthropogenic impacts. Additionally, historiographic data is embedded, such as the type according to Rappoport (1961) [40], date of the study, territorial features (a reference to the province, county, and volost), as well as data from landscape and geographical analysis – confinement to geographical and administrative regions, assignment to the prevailing types of landscape, soils and parent rocks, assessment of the natural hazards risk development [41]. Obtained data were further used to assess the risk of fortified settlement destruction, entered into the database (Table 2).

Analysis of the fortified settlements state. Ramparts and ditches are the main features of the fortified settlements and the surrounding relief. Therefore, we select the undamaged defensive structures as the primary criterion for preserving this type of site. The visual signs of the hillfort – its shape and appearance – will be lost with the destruction of the fortifications. Therefore, the preserved area will still be an archeological site, because of the existent cultural layer(s); without a defensive system, it can no longer be considered as a settlement (Fig. 4d and e).

Table 2. “Country of Cities” database structure

Field	Field type	Parameter
Id	Integer	Fortified settlement ID
Name	Text	Fortified settlement Name
HistDate	Text	Dating
HistYear	Integer	Description Year
X	Integer	Centroid coordinate X
Y	Integer	Centroid coordinate Y
region	Text	Geographical region
municip	Text	Municipal region
Hmean	Decimal	Average Heights
Hmax	Decimal	Maximum Heights
Hmin	Decimal	Minimum Heights
Hdelta	Decimal	Height range
SLOPEmean	Decimal	Average slopes
Aspect	Decimal	Dominant exposure
Soil	Integer	Predominant soil subtype
Geol	Integer	Predominant type of Quaternary deposits
landscape	Integer	Landscape areas
morphocomp	Integer	Morphogenetic complexes
morphogr	Integer	Morphogenetic groups
Rappoport	Integer	Settlement type, according to Rappoport (1961)
TypeImpact	Integer	Impact type
domAntr	Integer	Dominant land use type
AreaTotal	Decimal	Fortified settlement area (m^2)
AreaCrop	Decimal	Arable land area (%)
AreaPastur	Decimal	Pastures area (%)
AreaGrass	Decimal	Hayfields area (%)
AreaForest	Decimal	Forest area (%)
AreaDev	Decimal	Built-up area (%)
AreaRoad	Decimal	Road’s area (%)
Status	Integer	Fortified settlement state
preserv	Integer	Fortified settlement destruction degree
Exogen	Decimal	The risk of exogenous processes
impact	Decimal	Degree of anthropogenic impact
Risk	Integer	The risk of fortified settlement destruction

The following gradation of preservation was used (Fig. 7), which was calculated based on the total length of defensive structures (rampart-ditch system) to consider the destruction of complex 2-3 row fortification systems. As shown in figure 8, half of the studied hillforts have a good and complete degree of preservation, 30% have an average degree of preservation, 19% are destroyed or almost disappeared.

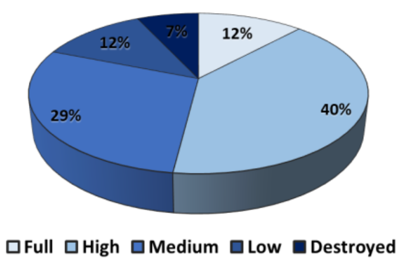

Fig. 7. Percentage of the Volga Bulgaria fortified settlements with different state of preservation

An important factor determining fortified settlements risk to natural hazards is their confinement to certain landscapes, namely, to morphogenetic groups. According to the landscape zoning of the Republic of Tatarstan [42], the location of most of the studied sites belong to the morphogenetic groups "Middle" and "Lower parts of the slopes" – 21 and 30, respectively (Fig. 8).

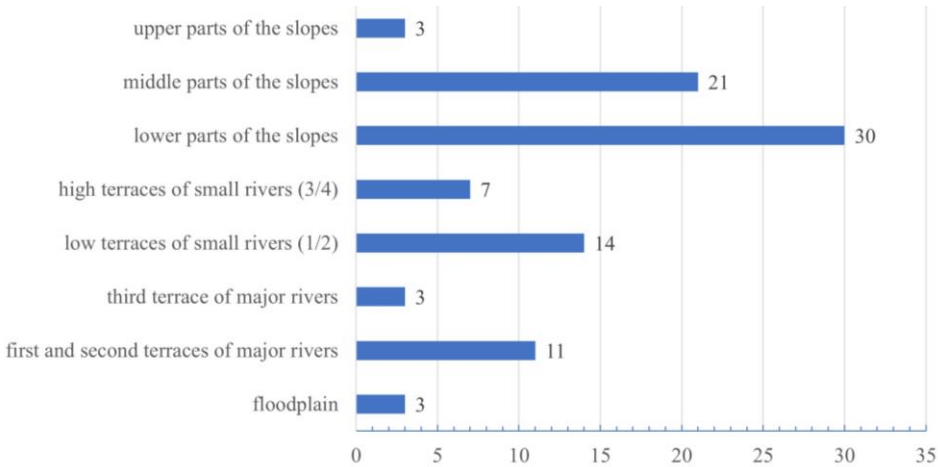

Fig. 8. Bulgarian fortified settlements allocation on different landscapes

The location of 6 fortified settlements is defined as the highest-altitude – "The watershed parts of the slopes" (Balynguzskoe, Ekaterino-Slobodkinskoe II, Utyashkinskoe sites) and "The third terrace of large rivers" (Balymerskoe, Maklasheevskoe I, Tankeevskoe II sites). Among the studied sites, there is no site belonging to the highest morphogenetic groups – "Watersheds" and "The Fourth Terrace of Large Rivers". At the same time, according to the same zoning, the location of the 24 fortified settlements was assigned to the "Floodplain" group, which is not logically correct and can be explained by the significant generalization of the used electronic landscape map. In this case, based on an expert assessment, the location of most settlements was revised: 3 settlements (Bolsheklyarinskoye, Nizhnekacheevskoye, Chuvashsko-Brodskoye) remained in the "Floodplain" group, the location of 13 fortified settlements was confined to the "Low terraces of small rivers", seven– to the “High terraces of small rivers”, one site (Dzhuketausskoye) – is confined to the “First and second terraces of large rivers”. As a result, we got the following distribution of hillfort locations (see Fig. 8): the most common type (32.6%) is “Lower parts of the slopes”, 22.8% of the hillforts are confined to the middle parts of the slopes, 15.2% of fortified settlements belong to the “Low terraces of small rivers” and 7.6% to the “High terraces of small rivers”, 12% – belong to the “First and second terraces of large rivers” and 3.3% – to the other three types – "Dividing parts of the slopes", "Third terrace of large rivers" and "Floodplain".

The location of the site on the relief is reflected in the typological division of the settlements, compiled by Rappoport [40] for ancient Russian fortified settlements, which is also commonly used for the Volga Bulgaria period: Type I – hillforts with a fortification subordinate to the surrounding terrain; in their large majority, these are cape monuments; Type II – hillforts with defensive structures, only partially using the protective properties of the terrain; Type III – hillforts not subject to relief; located on a flat area or with one side adjacent to a cliff, the edge of the terrace, usually have a relatively regular geometric shape; Type IV – hillforts with a complex plan; occupy several capes or sites, which are sometimes united together by a common line of defense or have independent fortifications, but represent a single fortified settlement in chronological and cultural terms.

Hillforts of type I are confined to relief (cape monuments) and, logically, should be more exposed to natural hazards due to the proximity of slopes and scarps that serve as natural fortifications. Type III –not subordinated to the relief, located on flat terrain, and only on one side with a scarp (Table 3 and Fig. 9a). Given the easy accessibility for economic activities, this type may be more likely to be subject to anthropogenic impact. II and IV types of classification suggest a complex, mixed location options and, consequently, different types of impact.

To identify this relationship, we determined the number of fortified settlements destroyed by one or another type of impact by four categories (Fig. 9b):

1) natural hazards;
2) anthropogenic processes;
3) mixed type – natural + anthropogenic;
4) there are no traces of impact.

Tab. 3. Distribution of the fortified settlements according to Rappoport typology [37] and by the type of negative impact

Types by Rappoport	Negative impact				
	1 – natural hazards	2 - anthropogenic	3 - mixed	4 - none	Total
I	17	4	26	4	51
II	1	1	8	0	10
III	4	10	16	1	31
IV	0	0	3	0	3
Total	22	15	53	5	95

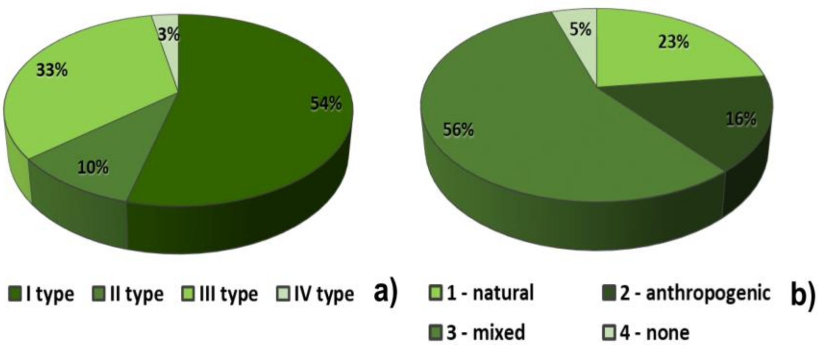

Fig. 9. Proportion of the Bolgar hillforts: a – according to Rappoport typology [37]; b – by the type of impact

It was found that 51% of the fortified settlements belong to the subordinate relief type, and 32% belong to the non-subordinate relief type. The proposed assumption about the relationship between the type of settlement and specific nature of the impact was confirmed by the results of the analysis – on the fortified settlements of type I, the influence of natural (17 versus 4) factors is more often noted, and on fortified settlements of type III – anthropogenic (10 versus 4) factors. 23% of hillforts are impacted by natural hazards, and only 15% by anthropogenic interventions. However, a mixed type of impact prevails – half of all settlements, both in general and for each category, are under destruction due to both natural and anthropogenic impact. This indicates a high level of danger of destruction of the archaeological sites. This is also evidenced by the fact that only 5% of the fortified settlements are not impacted by the destruction of the site and defensive structures.

An assessment of the risks of destruction by natural hazards revealed that most of the fortified settlements are characterized by an average risk – 63% (Fig. 10a), and 37% by low risk. As for the risk of destruction due to anthropogenic impact, the situation is worse – a third of the settlements (29%) are at high risk, 64% – at medium level. Only 7% have a low risk of destruction. As a result, the risk assessment shows more serious risks of fortified settlements destruction under the influence of anthropogenic impact factors. The final assessment, determined by the sum of exogenous and anthropogenic risks of destruction, indicates an average degree of risk in 56% of the studied sites; 43% have a low value. This is explained because hazardous natural processes do not significantly impact hillforts under solid anthropogenic pressure.

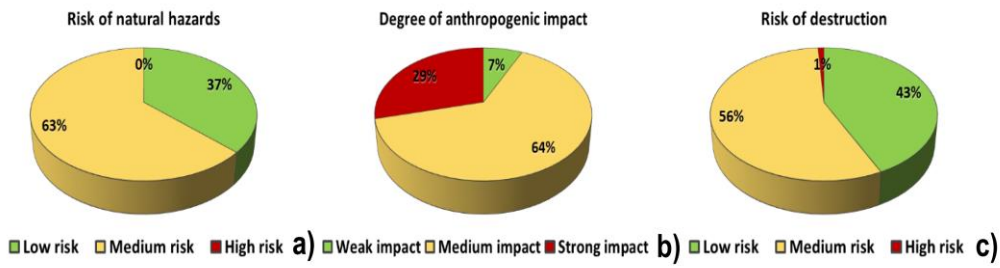

Fig. 10. Risk of destruction of the Volga Bulgaria fortified settlements as a result of: a) natural hazards; b) anthropogenic impact; c) cumulative impact

The resulting risks are presented on the cartographic part of the "Country of Cities" Web resource (web-drevnosti.archeogeo.ru) in the form of thematic maps, where each settlement is marked with a color corresponding to a certain type of natural, anthropogenic, and mixed risk of destruction.

Conclusions

Systematisation was carried out based on the research results and information for 95 fortified settlements of the Volga Bulgaria period. The analysis allowed us to clarify and update the location and boundaries of the sites to assess the current state and the risks of destruction under the influence of natural hazards and anthropogenic impact. Based on the obtained data, for the first time for the study area, an open web resource "Country of Cities" was created, complemented with analytical and generalized information about the settlements of the Volga Bulgaria period. Following this, cultural heritage managers, local stakeholders and researchers can make spatial analyses at different generalization levels (from regional to local). The combination of the descriptive component and the cartographic materials allows not only to assess the regularities in the placement of sites in the study area, but also to study individual sites in detail using interactive textured 3D models. The interactivity of the models and the presenting information in a popular science style could induce interest to a wide range of users – from schoolchildren and students of history faculties to people interested in the archeology of the Middle Ages and the history of their native land. The results have practical application for the interested scientific community, specialists in protecting historical and cultural heritage, and territorial management at the regional level.

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