



HAL
open science

The Iron Age in Serakhs Oasis (Turkmenistan). The Preliminary Results of the Application of Geographic Information System in the Study of the Settlement Pattern of the Earliest Confirmed Occupation of the Oasis

Nazarij Bulawka, Barbara Kaim

► To cite this version:

Nazarij Bulawka, Barbara Kaim. The Iron Age in Serakhs Oasis (Turkmenistan). The Preliminary Results of the Application of Geographic Information System in the Study of the Settlement Pattern of the Earliest Confirmed Occupation of the Oasis. Campana, Stefano; Scopigno, Roberto; Carpentiero, Gabriella; Cirillo, Marianna. CAA2015. Keep The Revolution Going Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Volume 1, Archaeopress, pp.791-801, 2016. hal-03371042

HAL Id: hal-03371042

<https://hal.science/hal-03371042v1>

Submitted on 8 Oct 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

CAA2015

KEEP THE REVOLUTION GOING >>>

PROCEEDINGS OF THE 43RD ANNUAL CONFERENCE
ON COMPUTER APPLICATIONS AND QUANTITATIVE
METHODS IN ARCHAEOLOGY

edited by

**Stefano Campana, Roberto Scopigno,
Gabriella Carpentiero and Marianna Cirillo**

Volume 1

ARCHAEOPRESS ARCHAEOLOGY

The Iron Age in Serakhs Oasis (Turkmenistan). The Preliminary Results of the Application of Geographic Information System in the Study of the Settlement Pattern of the Earliest Confirmed Occupation of the Oasis

Nazarij Buławka

nazar.bulawka@gmail.com

Institute of Archaeology, University of Warsaw, Poland

Barbara Kaim

barbara.kaim@uw.edu.pl

Department of the Near Eastern Archaeology, Institute of Archaeology, University of Warsaw, Poland

Abstract: For almost twenty years the Serakhs Oasis in southern Turkmenistan has been studied by the Polish-Turkmen Archaeological Mission headed by Barbara Kaim. The intensive field survey, conducted since 2007, resulted not only in a discovery of almost 150 sites of different periods, but it also sheds light on the Yaz period and the earliest confirmed occupation of the oasis.

The ArcGIS database created, which includes satellite imagery, digital elevation data, topographic maps, vector data related to hydrology, ancient and recent occupation, is used as a tool to discuss some important questions relating to the settlement pattern of the oasis. The main issue of this contribution is an evaluation of the current state of research regarding the oldest settlement pattern (Iron Age), water management and the landscape taphonomy of the Serakhs Oasis. The possibility of the detection of the oldest sites will be also discussed.

Keywords: Central Asia, Landscape taphonomy, Iron Age, Irrigation, Settlement pattern

Introduction

Change within ancient settlement patterns, as detected by field survey techniques, is one of the main preoccupations of archaeologists today (Willey 1953; Schiffer *et al.* 1978: 1; Banning 1996: 26; Wheatley and Gillings 2002: 4–7). The collected data, however, is open to misinterpretation, especially when scholars treat it as a final picture. In fact, most of the archaeological landscapes have been and are constantly transformed, which often has negative influences on archaeological sites (Gaffney and Stančič 1991: 68-9; Wells 2001: 108; Wilkinson 2003: 41, 107). The aim of this paper is to evaluate how much of the ancient landscape of the Serakhs Oasis is available for archaeological study and what the present-day results may reveal in terms of the oldest settlement pattern.

1 The local conditions and the availability of archaeological sites.

Similar to the Near East, vast archaeological landscapes within southern regions of Central Asia consist of multi-stratified mound sites and palimpsests of dry levees or ravines that speak of the water-courses or irrigation networks that once existed here in the remote past. To some degree most of these areas were changed by recent human activities. Especially in Turkmenistan, the construction of the Karakum Canal led to a rapid urban sprawl and an intensive cotton cultivation program (Efremov *et al.* 1970). The Serakhs Oasis is one of such landscapes, but due its location the large investments were never conducted in the area. In fact, the shift of settlement to the territory irrigated by the Karakum Canal in the 1960s and the political transformation after the collapse of Soviet Union extended the existence of many archaeological sites located

here. However, study in this area has never been easy in terms of the oldest settlement pattern, which seems to be drastically unrepresented.

The state of recognition of settlement patterns in a given place depends on the fortunate combination of field survey techniques, applied chronology and the nature of the area itself. Beyond doubt, the problem of ‘visibility’ and ‘obtrusiveness’ of sites, as mentioned by M.B. Schiffer (Schiffer *et al.* 1978: 6-8) and F.P. McManamon (1984: 223), is one of the crucial issues for Near Eastern archaeology (Banning 1996: 30). In the context of Central Asia this matter is also very topical. The efficiency of different survey techniques, however, has been discussed many times and their selection depends on the character of the sites and the archaeological landscape (Schiffer *et al.* 1978; McManamon, 1984: 223; Banning 1996). Thus, this paper will address the other aspects of surface survey which have been introduced to archaeology from environmental studies as ‘landscape taphonomy’ (Zvelebil *et al.* 1992: 204-7; Green 1997: 17; Barton 2002: 166; Wilkinson 2003: 41-3; Niknami 2007; Burger *et al.* 2008).

Following the ideas of M. B. Schiffer, we can agree that archaeological sites have ‘undergone successive transformations’ (1975: 838) and that this affects the whole of their surroundings as well. The non-cultural transformations (n-transforms) distinguished by Schiffer (1975: 839-40) are the subject of study by geomorphologists, whereas cultural ones (Schiffer 1975: 840-1), with regard to whole settlement patterns cannot be formalized into a set of laws because they are poorly understood and dependent on the specific area and form of land-use performed there. The cultural transformation of any site after its abandonment can be very different, for example it may imply the use of its layers to manure the agricultural fields



(Wilkinson 1994: 491-2; Wilkinson 2003: 56, 119) or vineyards (Brookes *et al.* 1982, p. 295), to level the ground before the construction of a new house, or to produce construction material, etc. (Boyer *et al.* 2006: 676). T. J. Wilkinson has argued that cultural transformations might cause the 'selective loss of landscape features' and they must be included in the analysis (Wilkinson 2003: 8); here we can add an example from our place of study. In the Serakhs Oasis, and possibly in other areas of Central Asia, the pastoral communities build their pit-houses on archaeological sites, sometimes even digging into the hard surface of the floor (Wagner 2011), possibly in order to gain better visibility from the top of the mound. This, however, could be also a coincidence, since pastoral communities locate their camps near wells, where archaeological sites are sometimes present.

Even though these issues are crucial to settlement pattern analysis they were often ignored in many early settlement pattern studies. Especially in the context of Central Asian archaeology there are examples showing that the lack of understanding of 'landscape taphonomy' can result in wrong assumptions about the development of settlement in specific areas (Masson 1959: 90-2; Hlopin 1964: 137-41). It should be noted that the absence of sites, which means the lack of archaeological record, cannot be easily explained with the methods traditionally used by archaeologists. Thus, explanations should be derived from other disciplines. In fact, especially in light of processual archaeology, those issues were put into equations in order to produce significant scientific laws (Schiffer *et al.* 1978). This practice was often criticized by later scholars. Fortunately, the study of this complex issue is now much easier due to the widespread development of spatial analysis available within Geographic Information Systems (GIS) in archaeology (Wheatley and Gillings 2002). Moreover, the scientific literature that published over several decades has produced an immense body of evidence.

The processes involved within 'landscape taphonomy' of dry environments of the Near East and Central Asia fall within two main categories – natural processes and human activity – which can result in the destruction or masking of possible sites. And beyond doubt most of these processes can occur together as well.

The largest impact on the preservation of sites is present-day agriculture, which, with contemporary machinery, can obliterate most low elevated sites. There are many examples of the impact of agriculture on the preservation of archaeological sites in Near Eastern archaeology (Adams 1981: 35, 47; Banning 1996: 27; Hritz 2010: 189; 2013: 1978.). Modern agriculture, however, often occurs in the form of orthogonal fields, which often require the construction of modern irrigation networks, and as result many of the archaeological sites can be destroyed. In fact, especially in Turkmenistan, this issue has been emphasized on many occasions (Bondioli and Tosi 1998: IX; Cremaschi 1998: 16; Cattani *et al.* 2008: 42). On the other hand, the agricultural transformation of the landscape can occur together with urban sprawl, which impedes access to archaeological features by masking them (Wilkinson 1994: 487) or resulting in their destruction (Pilipko 2005: 57). This applies to the construction of roads and other infrastructure elements as well.

The impact of agriculture and layers of occupation, however, should not be restricted to contemporary human activities: landscape transformation is also caused of course by previous and dense population and agriculture (Wilkinson 2003: 18, 219). The presence of layers of later occupation is an especially difficult issue for investigating the oldest settlement patterns (Adams 1981: 39-40, 63; Wilkinson 1990b: 55-6; 1994: 487). Since many mound sites often reflect the persistent presence of human occupation, the area of the oldest settlements is difficult to delineate without concerted studies, for examples with use of drilling and systematic sampling (Wilkinson *et al.* 2007: 225).

The natural processes that could influence the preservation of individual sites or their visibility are numerous and are strongly dependent on the character of an area. Some of them, however, influence the shape and height of individual sites, but in terms of preservation of the entire landscape they have less importance for the study of dry environments. A good example is hill slope erosion (Brookes *et al.* 1982: 295), which, together with wind erosion, can influence the shape of the site, even if the actual destruction of a medium size site is rather doubtful (Adams 1981: 31, 50). Even in the extremely dry environment of a desert, where wind erosion is usually greater, the stability of processes might form the best environment for the preservation of the archaeological sites. On the other hand, especially in the desert, the winds cause the sand dunes to move, which can cover the archaeological sites (Hritz 2006: 396). The other type of site coverage, such as by vegetation, and which is characteristic of European landscapes, can also occur in dry environments, especially near water courses (Banning 1996: 31-2).

Importantly, specific parts of the Near East, Egypt, Iran and Central Asia differentiate in their ratios between sedimentation and erosion, which is mainly caused by distances to available water courses (rivers/streams) and their character, soil and the gradient of terrain. Due to river activity the associated sites are endangered by water erosion (Wilkinson 1998: 73, 82; Challis *et al.* 2004: 145; Boyer *et al.* 2006: 676; Hritz 2013: 1976, 1978.); this also implies to episodes of flooding (Hassan 1997: 63; Wilkinson: 2003: 195). It should, however, be emphasized that in the upper parts of water courses rapid water erosion occurs, while in lower parts, specifically near the desert's edge, sedimentation prevails. Since most of the rivers in arid continental conditions frequently do not reach any open water or reservoir and end in the desert, they often form alluvial landscapes in their deltas or crevasse splays. The visibility of sites located in such areas is drastically influenced by the process of alluviation; this phenomenon has been much discussed in the scientific literature related to the archaeology of Mesopotamia and Syria.

2.1 The area of study

The Serakhs Oasis, the sub-delta of the Tedjen River, is located in southern Turkmenistan near the border with Iran and Afghanistan (Fig. 1). The gradient of the oasis falls from 300 to 225m.a.s.l. in its northern part, marked by the range of present-day irrigation. The southern and eastern edges of the oasis touch the Badkhyz uplands and Karakum desert (Orazov 1973: 3; Kaim 2008: 129; Buławka 2015: 12). The Serakhs Oasis is the subject of study by the Polish-Turkmen mission for almost twenty years. Intensive field surveys conducted since 2007 have revealed over 150 sites of different periods in the



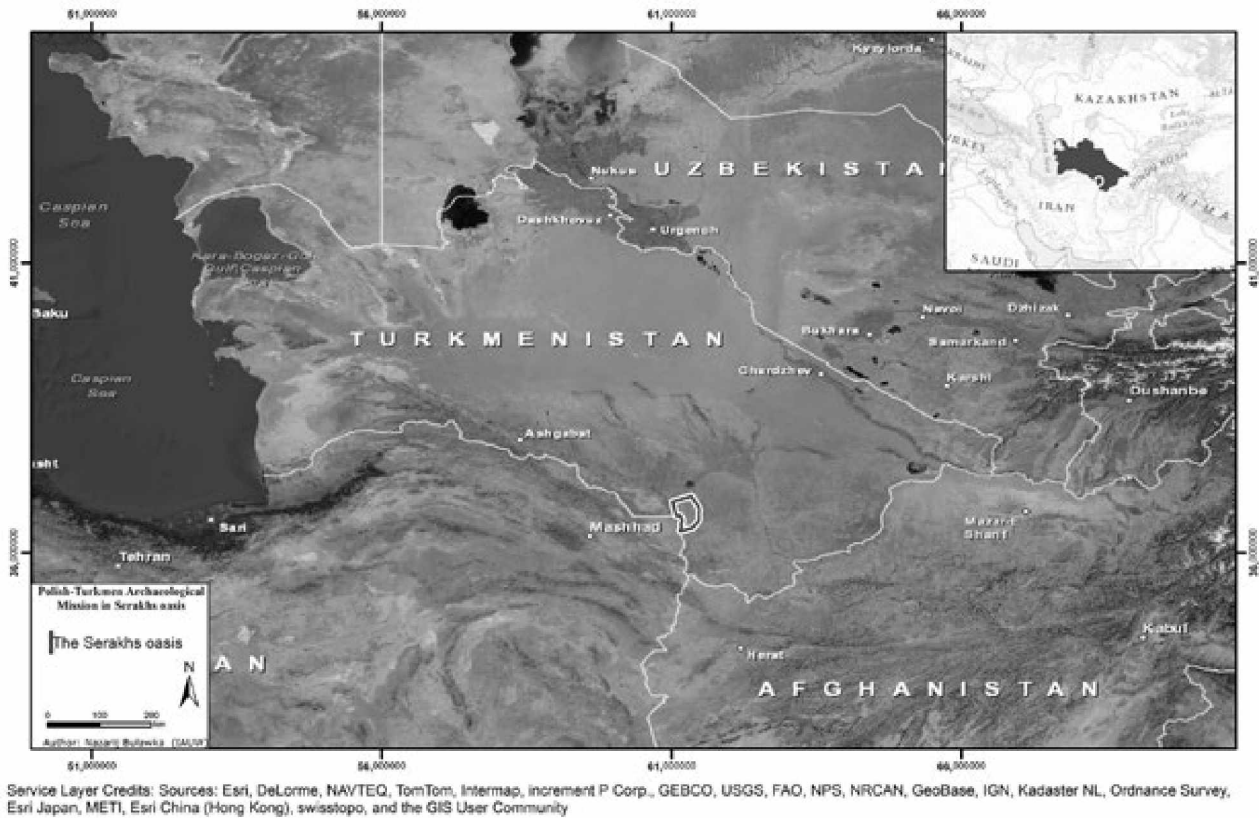


FIG. 1. THE LOCATION OF THE SERAKHS OASIS.

oasis. The current state of research suggests that 20 of these represent the oldest known period – the Iron Age (Yaz I-III periods – 1400-300 BC) (Buławka 2015-2016b).

Since agriculture is one of the main aspects of the traditional Central Asian economy, the time of the emergence of artificial irrigation, which is crucial to existence of sedentary life in the region, is very important. The second aspect of both ancient and present-day economies, is, of course, pastoralism, which must have thrived here, especially when water resources were scarce.

Contrary to other regions in Turkmenistan, the Serakhs Oasis is not irrigated by the Karakum canal. All the water available for irrigation here comes from the Tedjen River or wells. The present-day network is based on one main canal (the Salyr-yap), which is derived from the river near the mountains of Kizil Koi at about 310m.a.s.l. It is then divided into several branches, which are named after Turkmen tribes – Kichi-aga-yap, Atayap, Han-yap, and so on (Orazov 1973: 30; Kaim 2008: 130-1). It is obvious that this is the contemporary irrigation network and it is different from the ancient one.

According to the current state of research in the oasis, the locations of all the Iron Age sites (Yaz culture) are all very close to the present-day irrigation network. The average distance between sites and canals is 123m, which indicates that most of the sites follow the location of today’s irrigation systems. It should be noted, however, that some sites here are located further away and others are ringed by canals. Taking the measured distances it is possible to assume that the irrigation network might date to the Iron Age. This assumption,

however, could be wrong, since the canals are dated only by ‘association’. More recent studies conducted in Central Asia suggest that the existence of monumental irrigation networks in the Iron Age is more and more questionable (Košelenko *et al.* 1994: 78-91; Stride *et al.* 2009: 77-8; Malatesta *et al.* 2012: 91, 103). Thus, the emergence of irrigation in the studied area is problematic when studied in depth.

The subject of the oldest settlement pattern is also very challenging as there is no direct evidence of settlement predating the Iron Age, in contrast to surroundings areas. The only example of an older site, *Serakhske Poselenie* (dated to Aeneolithic - Early Bronze Age) (Adykov and Masson 1960: 62; Orazov 1973: 53-4; Kohl 1984: 67) is located at the edge of a river terrace and could not be taken as an argument that the entire oasis was settled during the mentioned period. It is assumed, however, that access to the oldest sites in the Serakhs Oasis could somehow be impeded by the processes included in the ‘landscape taphonomy’ of the oasis.

The distribution of presently known Yaz sites in the oasis also points to the fragmentary recognition of the oldest settlement pattern. The largest cluster of sites is located in the northern part of the oasis, about 40km from the town of Serakhs. The average distance between the sites of Yaz culture here is about 879m, but some settlements are located much closer to each other. The Yaz sites are known in the central part of the oasis as well. They are, however, more dispersed, with an average distance of 2982m between their nearest neighbours (Buławka 2015-2016a, Fig. 3). This can also be observed in cases of sites of specific phases of the Iron Age and the occurrence of sites dated to other periods. However most of the Iron Age sites can



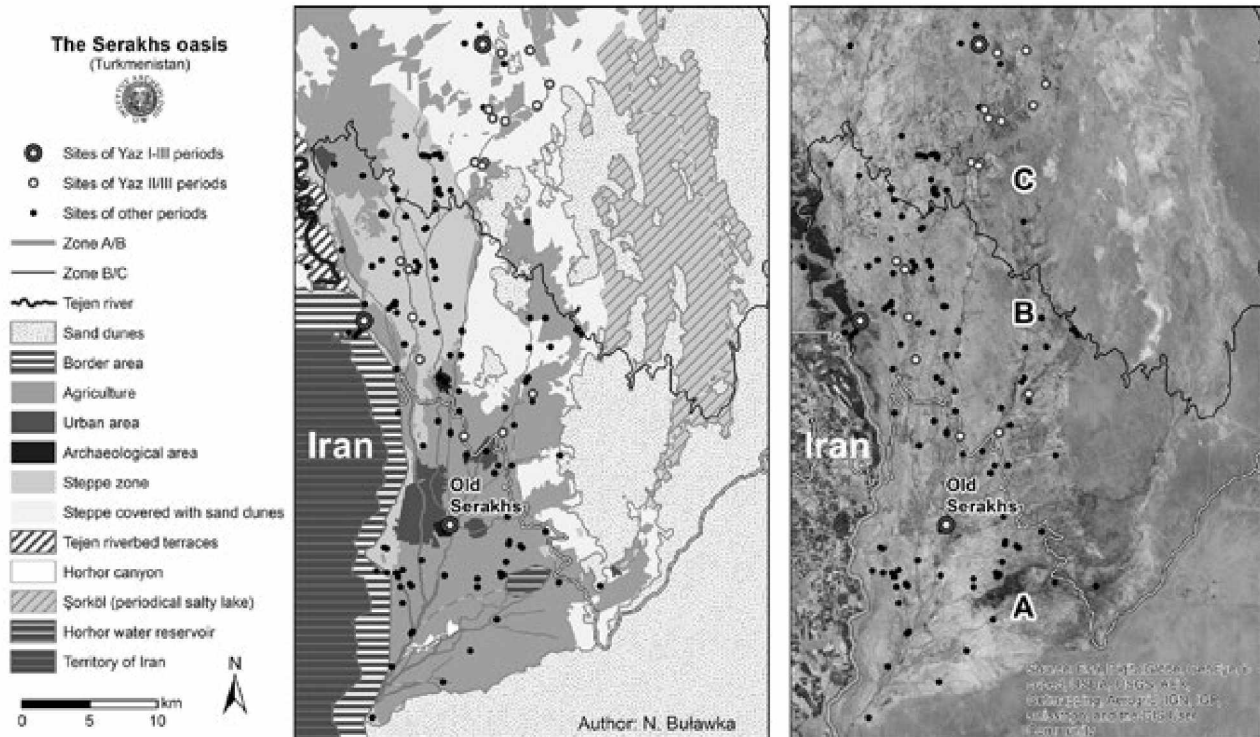


FIG. 2. THE ANALYSIS OF 'LANDSCAPE TAPHONOMY' OF THE SERAKHS OASIS.

be dated to Yaz II-III periods. The painted pottery of the Yaz I period accidentally found in 2014 at Goşa-depe (about 50km from Serakhs) was not identified elsewhere in the oasis during our surface survey (Buławka, 2015-2016a; 2015-2016b) (Fig. 5). It should be mentioned, however, that it was found during the excavation of A.A. Marushchenko at Old Serakhs, but the layers are covered there by 9m of later occupation (Maruşenko 1956: 174-5) (Fig. 2, 4). What is more, apart from the Iron Age, there are no clear traces of later occupation in the northern cluster of the sites, with exception of rare glazed Muslim pottery sherds (dated to 12th century AD) and two sites clearly dated to Muslim periods (Gala Burun and Atamyrat gala) (Fig. 5). This could indicate that most of the sites here were abandoned after the Iron Age (Buławka 2015-2016a; 2015-2016b). On the contrary, in the southern part of the oasis all the remaining sites were settled during later periods. It is unclear whether the large-scale irrigation also functioned during Mediaeval times, this has not yet been confirmed by historical data.

In the 9th century Al-Ya'qubi noted that there were no canals or streams in Serakhs and city dwellers had to draw water from wells (BGA VIII: 279). It is to Ibn Rusta, a 10th-century Persian explorer and geographer, that we owe our first information about irrigation in the oasis. He wrote that a canal that irrigated Serakhs flows from the river to a distance of two farasakhs (ca 12km) above the town (BGA VII: 173). The same information is provided by al-Maqdīsī as well (BGA III: 329, 333). In 10th century, despite the presence of irrigation canals, the region of Serakhs was rich in pastures, but its cultivated fields were limited by the lack of a constant water supply (Le Strange 1905: 396). Evidence about irrigation in the region disappears in 13th century AD, to return only in the early 19th century in the period when the Serakhs Oasis was an area of political tension between the British and Russian Empires (Alihanov 1883: 90-1; Geier 1901: 82; Logofet 1909: 195-214).

The situation described by early Islamic authors is therefore quite different from what is suggested by Iron Age settlement patterns identified some 40km north of Old Serakhs. It is not clear, however, whether large-scale canals were used already during the early Iron Age, or if the fields were irrigated by ditches carrying water from smaller natural streams forming the ancient sub-delta of the Tedjen River, which dried out in the following periods because of climatic changes and then their former beds and features were transformed into irrigation canals. Hence it was clear that without deeper study of the landscape taphonomy and topography it is not possible to undermine the previous hypothesis.

2.2 Research strategy

In order to address different issues that appeared in the studies, a GIS database was created. The database consisted of different vector and raster data, which were analysed with ArcGIS. Some data, such as SRTM, were also processed in SAGA GIS. The vector data represented the archaeological sites, irrigation network, agricultural fields, urban areas, roads, etc. About 25 thousand kilometres of irrigation canals and other watercourses were mapped in the oasis. The archaeological sites were documented both as points (the geographic coordinates taken with GPS receiver) and polygons, which represent their contours. All the data comes from vectorization of available raster data or our survey. A very important part of the raster data are the digital elevation models (DEM) that are available through the US Geological Survey (SRTM v2) or METI and NASA (Aster GDEM v2). Besides these mentioned, specially produced digital elevation models on the basis of large scale topographic maps were also prepared. The collection of topographic maps represented the oasis from the late 18th to the early 1990s. The most useful are the large-scale military maps (1:10000m). A variety of satellite imagery is available for

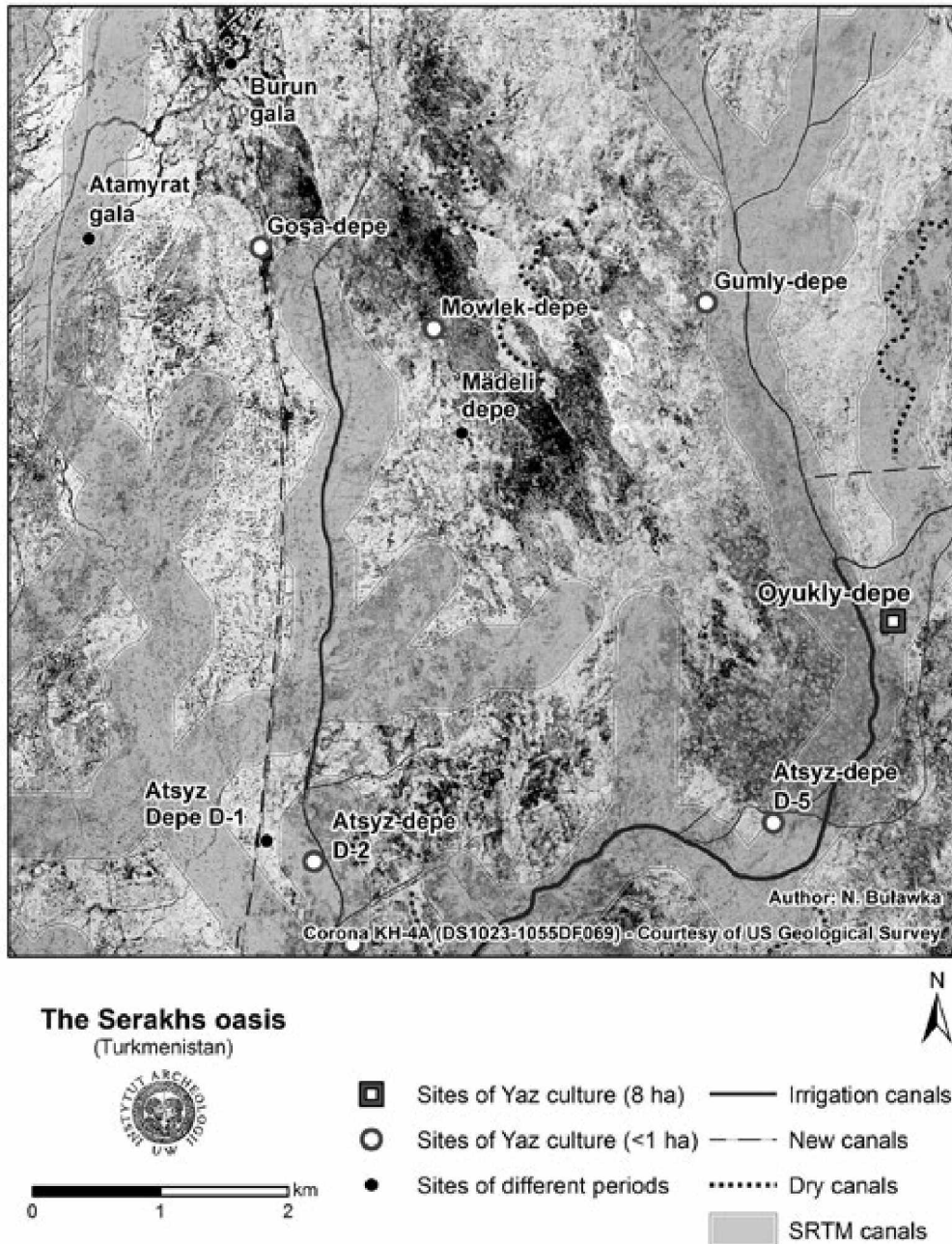


FIG. 5. THE COMPARISON OF PRESENT-DAY IRRIGATION AND LOCATION OF MAIN LEVEES DERIVED FROM SRTM DATA NEAR THE NORTHERN CLUSTER OF SITES.

the basis of SRTM data. It is difficult to estimate the precise data loss related to river activity, but even in the last 50 years the river meanders changed have their locations several times.

The most important non-cultural transformation process in the Serakhs Oasis is alluviation. This phenomenon could be easily observed on the basis of available Digital Elevation Models. The use of shaded relief maps, profile graphs and the simple approach of visualizing the maximum and minimum values for specific areas, with the use of a choropleth representation of elevation data, clearly show the differences in topography. These include the palimpsest of levees corresponding to the irrigation network (Buławka 2015: 18-9) and large areas

covered by sand dunes located in the eastern part of the oasis. Also, at the eastern edge a salty perennial lake called Shor Kel is located, which is also well recognizable on the shaded relief (Fig. 2). The detailed analysis of the alluviation phenomenon required the automatic extraction of linear feature related to the ridges (levees) visible at SRTM and their comparison with the present-day irrigation network. This implied the removal of characteristic stripes (Oimonen 2000; Perego 2009) and then ‘despeckling’ the SRTM data (Sun *et al.* 2007; Stevenson *et al.* 2010). The elevation data was further processed in order to extract the features mentioned. This approach revealed that the modern irrigation system generally follows the location of the levees, but some of the canals are clearly beyond their



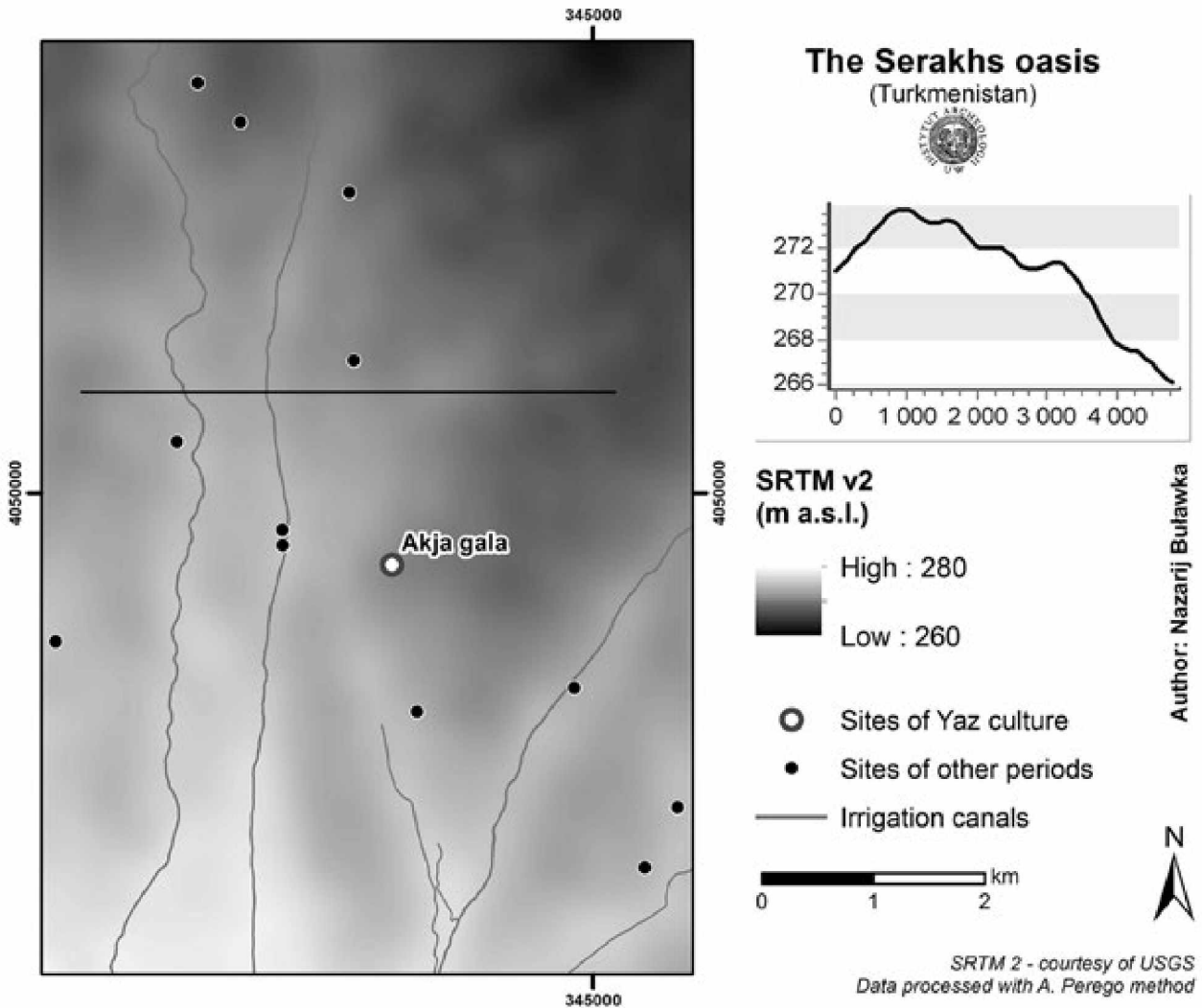


FIG. 3. ANALYSES OF THE HEIGHT OF THE LEVEES AND LOCATION OF PRESENT-DAY IRRIGATION.

the Serakhs Oasis, which included the freely available Landsat 1-8, Orbview-3 and Corona images. All the mentioned raster data are courtesy of the US Geological Survey. The coverage of panchromatic Orbview-3 imagery, publicly released by GeoEye, and with a resolution of 1m, gives the area near to the border with Iran. Taking in to account their resolution and the time of acquisition, they provide a good tool to locate most of the sites in the area near the border. Besides these mentioned, the Serakhs Oasis at the moment has very good coverage by Bing Maps and Google Earth as well. The high resolution Bing Maps of the Serakhs Oasis are provided by Digital Globe (27 November 2010, Worldview-2, resolution 0.5m, accuracy 10.2m).

With respect to the scale of the topographic maps, they give some insights into the location of archaeological sites and changes within the overall irrigation network. The latter could be supplemented by historical data. The combination of all the above-mentioned data makes it possible not only to plan and document the archaeological surface survey, locate new sites and analyse the collected data in ArcGIS environment, but also in some degree to evaluate and study the landscape taphonomy of the Serakhs Oasis.

2.3 The Serakhs Oasis as a test area

The landscape taphonomy of the Serakhs Oasis was studied in much detail. First of all, this implied the use of different available raster data. One of the most important goals of this study was to find ‘taphonomic windows’ that could reveal sites of the oldest periods in the region; this first of all required the analysis of main cultural and non-cultural processes involved here.

One of the most evident human activities in the area is agriculture. In order to evaluate the extent of the agricultural fields, four sets of satellite imagery were compared. This implied the use of Bing Maps imagery (WorldView 2 - 27 November 2010), available in ArcGIS, the georeferenced scenes taken from Google Earth Pro (1 February 2013), Corona images (17 August 1965 - DS1023 mission) and Landsat 8 (18 April 2014 - LC81580352014108). The main aim of the study was to document the changes between 1960s and contemporary land use. While the Corona and Bing Maps images clearly indicated the shift within size, shape of fields and the scale of agricultural use of terrain between mentioned periods, the use of other sources produced a rather disturbing result. The use of



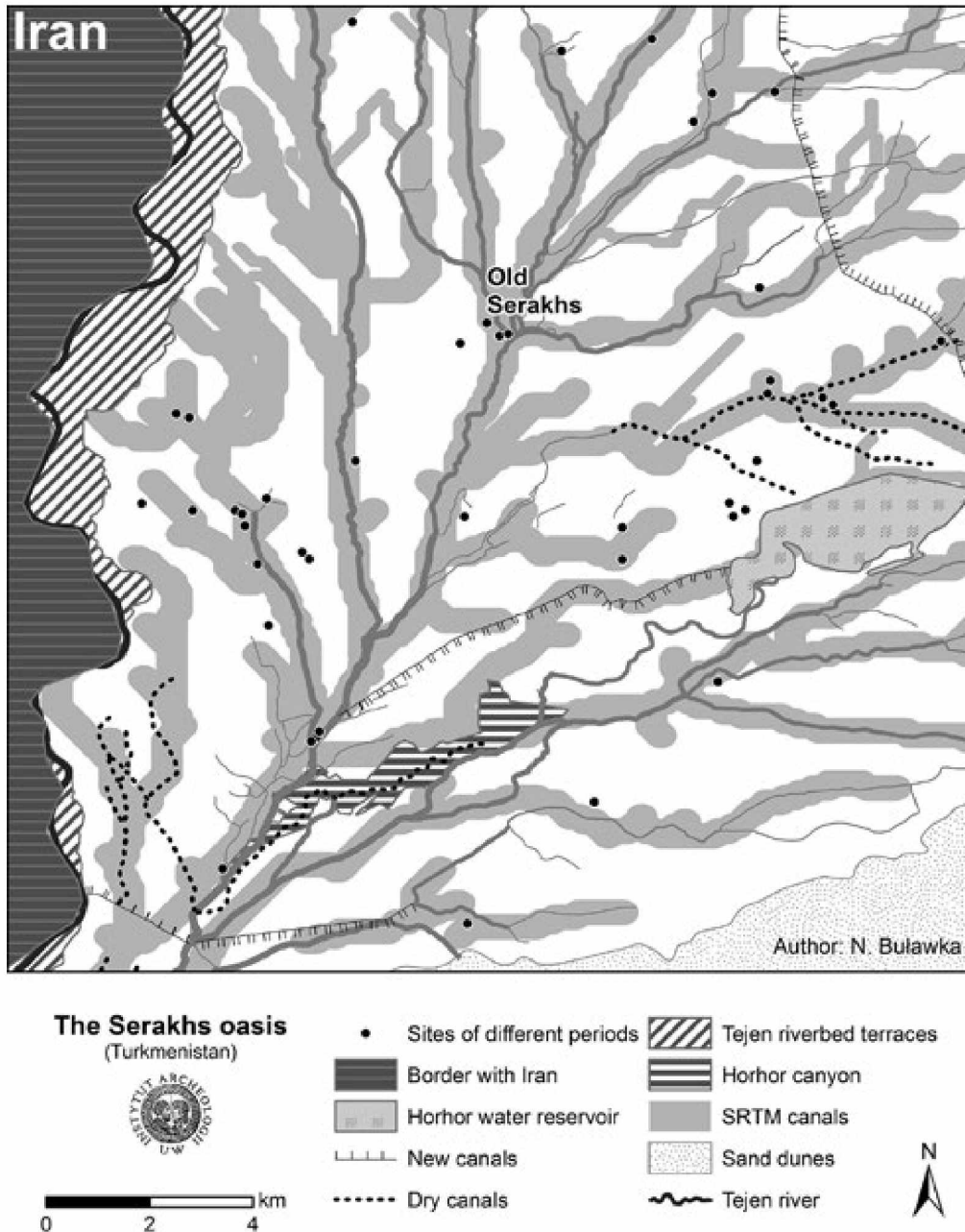


FIG. 4. THE COMPARISON OF PRESENT-DAY IRRIGATION AND LOCATION OF MAIN LEVEES DERIVED FROM RTM DATA.

a combination of SWIR 2, NIR and Green bands of Landsat 8 (753) and historical Google Earth images (1 February 2013) revealed that the area changed by agriculture is even larger than was shown by previous raster data (Fig. 2).

A similar set of imagery was used in order to estimate the boundaries of urban areas. The comparison of historic Corona images and the recently acquired ones, revealed the enlargement of some urban areas, such as the town of Serakhs, which occupied space between two adjacent villages located in its vicinity. The abandonment of a few small villages was also observed (Fig. 2).

The other recent human activities could also be analysed, i.e. the construction of modern irrigation canals and the Hor

reservoir, which apparently was built before 1965 and destroyed the possible sites in its range. A further peculiar cultural transformation of the landscape is the zone that is constantly ploughed to improve protection of the large fence near the border with Iran. Behind this fence lies a further large protected border zone, which our mission was unable to study. This, however, in some degree preserved the landscape in the mentioned region (Fig. 2).

The non-cultural aspects of landscape transformation are more complicated to study on the basis of raster data only. Several aspects, however, can be discussed here. The largest impact in this category is the Tedjen River activity itself. The area affected by the river was mapped with the use of satellite imagery and large-scale topographic maps, and confirmed on



range, which indicates that they are recent. Surprisingly, the comparison of the results with Corona images exposed the presence of relict meander-shaped water courses that are located separately or could be partly covered by present day irrigation. Moreover, one of the examples also corresponds to the location of data derived from SRTM results (Fig. 4, 5).

Analysis of the occurrence of the above-mentioned phenomena indicates that the Serakhs Oasis could be divided into three zones that represent different landscape taphonomies. Those zones are named here as zones A, B and C. The actual borders are arbitrary, but they are based on the location of specific contour lines derived from SRTM.

The most southerly zone (A) is a landscape completely changed by agriculture and urban areas. Here only the high multiperiod sites protrude, while the rest of the medium-elevated ones have been possibly deleted by modern human activity. There are, however, few 'taphonomic windows' such as the Old Serakhs archaeological park. As mentioned above, it is only at Old Serakhs that Yaz pottery was found in the southern part of the oasis, and the layers of this period are covered by 9m of later occupation (Fig. 2, 4).

To the north, zone B is also changed by agriculture to some degree, but the presence of a vast landscape used by pastoralists should be noted. Here eight sites containing Yaz pottery were found, which were settled during later periods as well. Both mentioned zones of landscape taphonomy are deeply influenced by the alluviation process. In fact the differences between the areas where the main canals are located and their surroundings are the largest here (Fig. 3). A significant difference between zones A and B is visible in the presence of sand coverage in the eastern part of the oasis, which could mask any possible sites or watercourses (Fig. 2).

The most northern taphonomy zone (C) was also changed by present day agriculture. But the agricultural activities seems to be less important here, since the presence of ploughing could be recognised only on the basis of satellite images made in winter, when the sun is very low (Google Earth - 1 February 2013). This zone is also affected by alluviation, but considering the low contrast between the areas where the watercourses are located, the actual impact could be minimal. It should be noted that, contrary to previous areas, the number of sites dated to Yaz culture is also larger. The sites of later periods are very unrepresented here. Since the sites are clustered in a particular area more surface surveys in the region should be conducted. It is assumed that the circumstances mentioned enable 'taphonomic windows' to be found, where the low elevated sites could be present. It should be emphasized, however, that the most significant impediment to the surface survey is the presence of low- to medium-size sand dunes that are difficult to distinguish from the archaeological sites on the satellite imagery (Fig. 2).

3 Conclusions

The range of the above-mentioned taphonomic processes is clearly related to the distribution of the sites of the Iron Age. It seems that they not only create a large impediment to the study of the sites of the oldest periods, but also disturb the character of previous water management systems. It should be noted that the presence of the taphonomic processes mentioned not only

disturb the state of recognition of the settlement patterns of the Iron Age, but also explain the lack of sites of older periods in the oasis.

The correspondence between the sites of the oldest periods in the northern part of the oasis and the dry meander-shaped features mentioned could indicate the existence of a different water management system during the Iron Age. In order to confirm or reject this hypothesis, a thorough geomorphological study should be conducted. It should be noted that usually in Central Asia all Iron Age canals are dated only by 'association'. The results from the Serakhs Oasis could significantly undermine the existing hypothesis of the construction of a large-scale irrigation network during the Iron Age. Recently this issue was also questioned by Sebastian Stride, who proved that the valley near Samarkand could have been irrigated during the Iron Age by a network of natural streams (Stride *et al.* 2009: 77-8).

Taking into account the historical records it is assumed that the present-day irrigation network could be explained merely by the activity of the pre-modern occupation of the oasis, which began in the 19th century AD. The layout of the canals, however, follows the variation within the topography formed by the previous water management systems.

4 Discussion

The taphonomic zone A in the Serakhs oasis could be easily linked with the 4th zone distinguished by T. J. Wilkinson (2003: 41-3). It should be noted, however, that the character of the Serakhs alluvial plain, with the addition of past and recent taphonomic processes, made it possible to distinguish two intermediate zones here. Zone B, to some degree, also could be treated as the zone of attrition for the oldest settlement pattern (the 4th zone in T. J. Wilkinson 2003: 41-3), but it became inhospitable for sedentary economy when the irrigation of this region stopped. Since then the area has been used by pastoral communities for several hundred years. This caused the preservation of a large amount of sites dated to the Partho-Sasanian and Islamic periods. On the other hand, the concentration of settlement in the above-mentioned periods masked or destroyed all the possible Iron Age sites that could be located here. It assumed, however, that the visibility of the sites was decreased mainly by alluvial layers. Nevertheless, the quantity of known Yaz culture sites located here is surprisingly large, but all of them are very distant from each other. Taking this into account, it is assumed that the area between the known sites could have been settled in the Iron Age as well. Zone C clearly represents a large taphonomic window for the oldest settlements. The favourable conditions for further studies were confirmed by the results of the recent season of surface surveys (2014), which revealed a large cluster of sites at the southern edge of zone C. It is assumed that following this approach the entire intermediate area between zones B and C should be studied. It should be noted, however, that the presence of sand dunes and the lack of roads makes the archaeological study very difficult here.

Credits

Maps throughout this paper were created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ material is the intellectual property of Esri and are used herein under licence.



Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.

Acknowledgements

The research was funded through grants by the National Science Centre, Poland - Grant 2012/07/B/HS3/00908 (Narodowe Centrum Nauki, OPUS) and Ministry of Science and Higher Education (Poland) (N109 007 31/0426, 2006-2009).

I would like to sincerely thank the Fundacja na Rzecz Studentów i Absolwentów Uniwersytetu Warszawskiego 'Universitatis Varsoviensis', CAA2015 Bursary Committee, and the Department of Near Eastern Archaeology (IAUW) for their support in attending the CAA2015 Conference (NB).

Bibliography

- Abay, E. 2003. The Neolithic Figurines from Ulucak Höyük: Reconsideration of the Figurine Issue by Contextual Evidence. *Neo-Lithics*. 2/03. p. 16–22. Available at: <http://www.exoriente.org/docs/00046.pdf> [Accessed: 4 February 2015].
- Adams, R.M. 1981. *Heartland of Cities. Surveys of ancient settlement and land use on the central floodplain of the Euphrates*. Chicago and London, The University of Chicago Press.
- Adykov, K. A. and Masson, V. M. 1960. Drevnosti Tedžen-Murgabskogo meždureč'â (k izučeniû arheologičeskikh pamâtnikov v zone 2-oj očeredi Karakumskogo kanala). *Izvestiâ Akademii Nauk TSSR. Seriiâ obšestvennyh nauk* 2: 58–66.
- Alihanov' 1883. Mervskij oazis' i dorogi vedušiâ k' nemu. S.-Peterburg': Tipografiâ i hromolitografiâ A. Travšela, Stremânaâ 12.
- Andrianov, B. V. 1958. Arheologo-topografičeskie issledovaniâ drevnej irrigacionnoj seti kanala Čermen-Âb. Arheologičeskie i ètnografičeskie Raboty Horezmskoj Èkspedicii 1949-1953 gg. II: 311-29. Moskva
- Al-Ya'Qūbī, *Kitāb al-Buldān*, M. J. de Goeje (ed.) 1860. *Bibliotheca Geographorum Arabicorum VII*. Leiden, Brill.
- Al-Mas'ūdī, *Kitāb al-Tanbīh wa al-ishrāf*. M.J. de Goeje (ed.) 1893-4. *Bibliotheca Geographorum Arabicorum VIII*. Leiden, Brill.
- Al-Maqdīsī, *Kitāb Aḥsan al-taqāsīm fī ma'rifat al-'aqlām*. M. J. de Goeje (ed.) 1906. *Bibliotheca Geographorum Arabicorum III*. Leiden, Brill.
- Andrianov, B. V. 1969. Drevnie orositel'nye sistemy Priaral'â, Moskva: Izdatel'stvo «Nauka».
- Andrianov, B. V. and Muhamedžanov, A. R. 1986. Rol' irrigacii v social'noj istorii drevnej Srednej Azii. In V. M. Masson (ed.), *Drevnee civilizacii vostoka (Materialy II Sovetsko-amerikanskogo simpoziuma)*, Taškent: Izdatel'stvo Fan: 34-44.
- Banning, E. B. 1996. Highlands and Lowlands: Problems and Survey Frameworks for Rural Archaeology in the near East. *Bulletin of the American Schools of Oriental Research* 301. Available at: <http://www.jstor.org/stable/10.2307/1357294?origin=crossref> [Accessed: 4 August 2014].
- Barton, C. M., Bernabeu, J., Aura, J. E., Garcia, O., La Roca, N. 2002. Dynamic Landscapes, Artifact Taphonomy, and Landuse Modeling in the Western Mediterranean. *Geoarchaeology - An International Journal* 17 (2): 155–90. DOI:10.1002/gea.10008.
- Bondioli, L. and Tosi, M. 1998. Introduction. In A. Gubaev, G. Koshelenko, M. Tosi (eds.), *The Archaeological Map of the Murghab delta. Preliminary reports 1990–95, Centro Scavi e Ricerche Archeologiche, Reports and Memoirs, Series Minor 3, Istituto Italiano per l'Africa e l'Oriente: IX-XIX*. Rome, La Nuova Poligrafica.
- Boyer, P., Roberts, N., Baird, D. 2006. Holocene environment and settlement on the Çarşamba alluvial fan, south-central Turkey: Integrating geoarchaeology and archaeological field survey, *Geoarchaeology* 21 (7): 675–98. DOI:10.1002/gea.20133.
- Brookes, I. A., Levine, L. D., Dennell, R. W. 1982. Alluvial Sequence in Central West Iran and Implications for Archaeological Survey. *Journal of Field Archaeology* 9 (3): 285–99. DOI:10.1179/009346982791504544.
- Buławka, N. 2015. Przykłady zastosowania programu ArcGIS w badaniu osadnictwa kultury Jaz w oazie Serachs (Turkmenistan). In J. Lechnio (ed), *GIS w UW. Pierwsze forum użytkowników licencji edukacyjnej SITE oprogramowania ArcGIS na Uniwersytecie Warszawskim. Materiały pokonferencyjne. WGiSR UW*: 11-25. Warszawa, Uniwersytet Warszawski, Wydział Geografii i Studiów Regionalnych
- Buławka, N. 2015-2016a. Settlement pattern of the Yaz culture in the deltas of Tejen River in Turkmenistan. In *Proceedings of the Conference: A millennium of history: The Iron Age in Central Asia (2nd and 1st millennia BC)*, Archäologie in Iran und Turan (submitted).
- Buławka, N. 2015-2016b. Yaz II-III settlement pattern in Serakhs Oasis, southern Turkmenistan. *Iran. Journal of the British Institute of Persian Studies* (submitted).
- Burger, O., Todd, L., Burnett, P. 2008. The Behavior of Surface Artifacts: Building a Landscape Taphonomy on the High Plains. In L. L. Scheiber and B. J. Clark (eds.), *Archaeological Landscapes on the High Plains*: 203-36. Boulder, Colorado, University Press of Colorado.
- Cattani, M., Cerasetti, B., Salvatori, S., Tosi, M. 2008. The Murghab Delta in Central Asia 1990-2001: the GIS from research resource to a reasoning tool for the study of settlement change in long-term fluctuations. In S. Salvatori, M. Tosi, B. Cerasetti (eds.), *Volume II. The Bronze Age and Early Iron Age in the Margiana lowlands: facts and methodological proposal for a redefinition of the research strategies, The Archaeological Map of the Murghab Delta. Studies and Reports*. British Archaeological Reports International Series 1806: 39-45. Oxford, Archaeopress.
- Cerasetti, B. 2008. A GIS for the archaeology of the Murghab Delta. In S. Salvatori, M. Tosi, B. Cerasetti (eds.), *Volume II. The Bronze Age and Early Iron Age in the Margiana lowlands: facts and methodological proposal for a redefinition of the research strategies, The Archaeological Map of the Murghab Delta. Studies and Reports*. British Archaeological Reports International Series 1806: 29-37. Oxford, Archaeopress.
- Challis, K., Priestnall, G., Gardner, A., Henderson, J., O'Hara, S. 2004. Corona Remotely-Sensed Imagery in Dryland Archaeology: The Islamic City of al-Raqqā, Syria. *Journal of Field Archaeology* 29 (1-2): 139–53. DOI:10.1179/jfa.2004.29.1-2.139.
- Cremschi, M. 1998. Palaeohydrography and middle holocene desertification in the northern fridge of the Murghab delta. In A. Gubaev, G. A. Koshelenko, M. Tosi (eds.), *The*



- Archaeological Map of the Murghab Delta. Preliminary Reports 1990-95*: 15-26. Rome, La Nuova Poligrafica.
- French, D. H. 1970. Notes on Site Distribution in the Cumra Area. *Anatolian Studies* 20: 139-48. DOI:10.2307/3642592.
- Gaffney, V. and Stančič, Z. 1991. *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar*. Ljubljana, Znanstveni Inštitut Filozofske Fakultete.
- Gejer, I. I. 1901. *Putevoditel' po Turkiestanu, Taškent'*. Tipoligrafija V.M. Il'ina.
- Green, S. W. 1997. Reuniting the truth: integrating anthropology, geography, and history through landscape archaeology. In L. F. Stine (ed.), *Carolina's historical landscapes: archaeological perspectives*: 17-22. Knoxville, University of Tennessee Press.
- Hassan, F. A. 1997. The Dynamics of a Riverine Civilization: A Geoarchaeological Perspective on the Nile Valley, Egypt. *World Archaeology* 29 (1): 51-74. DOI:10.2307/124996.
- Hlopin, I. N. 1964. *Geoksúrskaa gruppa poselenij èpohi èneolita*. Leningrad, Izdatel'stvo «Nauka».
- Hritz, C. 2006. The changing Mesopotamian landscape as seen from Spot and Corona images. In M. W. Mehrer and K. L. Wescott (eds.), *GIS and archaeological site location modelling*: 380-402. Boca Raton, London and New York, Taylor & Francis.
- Hritz, C. 2010. Tracing Settlement Patterns and Channel Systems in Southern Mesopotamia Using Remote Sensing. *Journal of Field Archaeology* 35 (2): 184-203.
- Hritz, C. 2013. A malarial-ridden swamp: using Google Earth Pro and Corona to access the southern Balikh valley, Syria. *Journal of Archaeological Science* 40 (4): 1975-87.
- Jeffreys, D. 2008. Settlements in Egypt: Alluvial Settlements in the Nile Valley (and Delta), in H. Selin (ed.), *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures SE - 8427*: 1994-8. Springer Netherlands.
- Johnston, K. 2002. Protrusion, Bioturbation, and Settlement Detection during Surface Survey: The Lowland Maya Case. *Journal of Archaeological Method and Theory* 9 (1): 1-67.
- Kaim, B. 2008. The Parthian settlements in the Serakhs Oasis. *Parthica* 10: 129-34.
- Kohl, P. L. 1981. Introduction. In P. L. Kohl (ed.), *The Bronze Age Civilization of Central Asia. Recent Soviet Discoveries: I-XXXIX*. New York, M.E. Sharpe
- Kohl, P. L. 1984. *Central Asia. Palaeolithic beginnings to the Iron Age*. Paris, Editions Recherche sur les civilisations.
- Košelenko, G. A., Gubaev, A. G., Gaibov, A. V., Bader, A. 1994. Mervskij oasis: dinamika sistem rasseleniâ i irrigacii. *Vestnik Drevnej Istorii* 4: 78-91.
- Le Strange, G. 1905 *The Lands of the Eastern Caliphate: Mesopotamia, Persia, and Central Asia from the Moslem Conquest to the Time of Timur*. Cambridge, University Press.
- Lisicyna, G. N. 1978. *Stanovlenie i razvitie orošaemogo zemledeliâ v ũznoj Turkmenii*, Moskva, Izdatel'stvo «Nauka».
- Lisitsina, G. N. 1981. The History of Irrigation Agriculture in Southern Turkmenia, In P. L. Kohl (ed.), *The Bronze Age Civilization of Central Asia. Recent Soviet Discoveries*: 350-9. New York, M. E. Sharpe.
- Logofet', D. N. 1909. *Na granicah Srednej Azii. Putevye očerki v' 3-h' knigah'. Kniga 1. Persidskaâ granica*, S.-Peterburg', V. Berezovskij.
- Malatesta, L. C., Castellort, S., Mantellini, S., Picotti, V., Hajdas, I., Simpson, G., Berdimuradov, A.E., Tosi, M., Willett, S. D. 2012. Dating the Irrigation System of the Samarkand Oasis: A Geoarchaeological Study. *Radiocarbon* 54 (1): 91-105.
- Markofsky, S. 2010. *Illuminating the Black Sands: survey and settlement in the Bronze Age Murghab Delta, Turkmenistan*. Unpublished PhD thesis, University College London. Available from: <http://discovery.ucl.ac.uk/770433/>
- Marušenko, A. A. 1956. Staryj Serahs (Otčët o raskopkah 1953 g.). *Trudy Instituta Istorii, Arheologii i Ètnografii Akademii Nauk Turkmenskoj SSR* 2: 161-205.
- Mcmanamon, F. P. 1984. Discovering Sites Unseen. In M. B. Schiffer (ed.), *Advances in Archaeological Method and Theory* 7: 223-92. Orlando, Academic Press.
- Niknami, K. A. 2007. A stochastic model to simulate and predict archaeological landscape taphonomy: monitoring cultural landscape values based on an Iranian survey project. *Archeologia e Calcolatori* 18: 101-20.
- Oimoen, M. 2000. An effective filter for removal of production artifacts in US Geological Survey 7.5-minute digital elevation models. In *Proceedings of the Fourteenth International Conference on Applied Geologic Remote Sensing*: 6-8. Las Vegas. Available at: <http://edna.usgs.gov/Edna/pubs/artifacts.pdf> [Accessed: 3 June 2015]
- Orazov, O. 1973. *Arheologičeskie i arhitekturnye pamâtniki Serahskogo oazisa*, Ašhabad, Izdatel'stvo «Turkmenistan».
- Perego, A. 2009. SRTM DEM destripping with SAGA GIS: consequences on drainage network extraction, Available from: <http://www.webalice.it/alper78/> [Accessed: 3 June 2015]
- Pilipko, V. N. 2005. Raskopki na Hyrly-depe. *Problemy Istorii, Filologii, Kul'tury. Journal of Historical, Philological and Cultural Studies* 15: 57-80.
- Salvatori, S. 2008. The Margiana settlement pattern from the Middle Bronze Age to the Parthian-Sasanian: a contribution to the study of complexity. In S. Salvatori, M. Tosi, B. Cerasetti (eds.), *Volume II. The Bronze Age and Early Iron Age in the Margiana lowlands: facts and methodological proposal for a redefinition of the research strategies. The Archaeological Map of the Murghab Delta. Studies and Reports*. British Archaeological Reports International Series 1806: 57-74. Oxford, Archaeopress.
- Schiffer, M. B., Sullivan, A. P., Klinger, T. C. 1978. The Design of Archaeological Surveys, *World Archaeology* 10 (1): 1-28. Available from: <http://www.jstor.org/stable/124409> [Accessed: 4 May 2015]
- Schmidt, A. and Fazeli, H. 2007. Tepe Ghabristan: a Chalcolithic tell buried in alluvium. *Archaeological Prospection* 14 (1): 38-46. Available at: DOI:10.1002/arp.291.
- Stevenson, J. A., Sun, X., Mitchell, N. C. 2010. Despeckling SRTM and other topographic data with a denoising algorithm. *Geomorphology* 114: 238-52. Available at: doi:10.1016/j.geomorph.2009.07.006.
- Stride, S., Rondelli, B., Mantellini, S. 2009. Canals versus horses: political power in the oasis of Samarkand. *World Archaeology* 41 (1): 73-87. Available at: <http://www.tandfonline.com/doi/abs/10.1080/00438240802655302> [Accessed: 9 February 2015].
- Sullivan, A. P. III (ed.) 1998. *Surface Archaeology*. Albuquerque, University of New Mexico Press.
- Sun, X., Rosin, P. L., Martin, R. R., Langbein, F. C. 2007. Fast and effective feature-preserving mesh denoising. *IEEE*



- Transactions on Visualisation and Computer Graphics* 13: 925–38.
- Tolstov, S. P. 1948. *Drevnij Horezm. Opyt istoriko-arheologičeskogo issledovaniâ*, Moskva, Izdanie MGU.
- Wagner, M. 2011. The first season of excavations at Topaz Gala Depe in the Sarakhs oasis, southern Turkmenistan. *Światowit* Vol. VII (XLIX)/A 2009–2010: 209–11.
- Wells, L. E. 2001. A geomorphological approach to reconstructing archaeological settlement patterns based on surficial artifact distribution: replacing humans on the landscape. In P. Goldberg, V. Holliday, C. R. Ferring (eds.), *Earth Sciences and Archaeology SE – 5*: 107–41. Springer US. Available at: http://link.springer.com/chapter/10.1007/978-1-4615-1183-0_5 [Accessed: 16 May 2015]
- Wheatley, D., Gillings, M. 2002. *Spatial technology and archaeology: a guide to the archaeological applications of GIS*. London and New York, Taylor & Francis.
- Wilkinson, T. J. 1990a. Early Channels and Landscape Development around Abu Salabikh, a Preliminary Report. *Iraq* 52: 75–83.
- Wilkinson, T. J. 1990b. The Development of Settlement in the North Jazira between the 7th and 1st Millennia BC. *Iraq* 52: 49–62.
- Wilkinson, T. J. 1994. The Structure and Dynamics of Dry-Farming States in Upper Mesopotamia [and Comments and Reply]. *Current Anthropology* 35 (5): 483–520. Available at: <http://www.jstor.org/stable/2744079>.
- Wilkinson, T. J. 1998. Water and Human Settlement in the Balikh Valley, Syria: Investigations from 1992–1995, *Journal of Field Archaeology* 25 (1): 63–87. Available from: <http://www.jstor.org/stable/530458> [Accessed: 17 May 2015]
- Wilkinson, T. J. 1999. Holocene valley fills of southern Turkey and northwestern Syria: Recent geoarchaeological contributions. *Quaternary Science Reviews* 18 (4–5): 555–71. Available at: DOI:10.1016/S0277-3791(98)00097-3.
- Wilkinson, T. J. 2003. *Archaeological landscapes of the Near East*. Tucson, University of Arizona Press.
- Wilkinson, T. J., Boucharlat, R., Ertsen, M. W., Gillmore, G., Kennet, D., Magee, P., Rezakhani, K., De Schacht, T. 2012. From human niche construction to imperial power: long-term trends in ancient Iranian water systems. *Water History* 4 (2): 155–76. Available at: DOI:10.1007/s12685-012-0056-9.
- Wilkinson, T. J., Peltenburg, E., McCarthy, A., Wilkinson, E. B., Brown, M. 2007. Archaeology in the land of Carchemish: landscape surveys in the area of Jerablus Tahtani, 2006. *Levant* 39: 213–47.
- Wilkinson, T. J., Philip, G., Bradbury, J., Dunford, R., Donoghue, D., Galiatsatos, N., Lawrence, D., Ricci, A., Smith, S. L. 2014. Contextualizing Early Urbanization: Settlement Cores, Early States and Agro-pastoral Strategies in the Fertile Crescent During the Fourth and Third Millennia BC. *Journal of World Prehistory* 27: 43–109. Available at: DOI:10.1007/s10963-014-9072-2.
- Willey, G. R. 1953. Prehistoric Settlement Patterns in the Virú Valley, Perú. *Bureau of American Ethnology Bulletin* 155. Washington D. C., Government Printing Office.
- Zvelebil, M., Green S. W., Macklin, M. G. 1992. Archaeological landscapes, lithic scatters, and human behavior. In J. Rossignol and L. Wandsnider (eds.), *Space, Time, and Archaeological Landscapes*: 193–226. Boston, MA, Springer US. Available at: DOI:10.1007/978-1-4899-2450-6.

