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The Murghab Delta in Central Asia 1990-2001: GIS from a Research Resource to a Reasoning Tool for the Study of Settlement Change in Long-Term Fluctuations

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Abstract. Intensive field surveys across the Murghab Delta in Southern Turkmenistan have detected pastoral campsites of Andronovo culture intruding the local Late Bronze Age settlement structure. Their distribution indicates convergence of economic specialization and political integration of cultural diversity. By using GIS as a tool for the systematic testing of alternative explanations and simulation models we may direct archaeological data to enhance historical interpretations for the formative stages of Central Asian civilisations.

Keywords. GIS, Central Asia, Murghab, Settlement Archaeology, Andronovo Culture

1 Introduction

The Murghab River drains the northernmost corrugations of the Hindu Kush along the southern borders of Central Asia, forming a medium-sized land-locked fertile corridor between the highlands of Afghanistan and the Kara Kum desert in Turkmenistan. Once out of the narrow mountain valleys the Murghab receives the last tributary waters and its course runs northwards for other 150 km encased in the limestone basement and a series of Pleistocene gravel conoids. As the gradients lower themselves into the shallow lowlands, the river breaks into a delta fan irrigating a flood plain of some 35,000 sqkm divided by the elongated shallow waters of the Jar swamp in two distinctive subsystems: the Aravalli delta to the west and the Merv oasis to the east (fig. 1). Similar in its layout to an open hand, the system is divided into a lower or 'palm' section to the south where continuous cultivations form a true "Mesopotamia", and an upper one with the lower channels radiating like 'fingers' to the north, flowing across dry sediments and desert sands. At present these branches form sequels of oases that may extend the cultivated lands further 30-40 km. The fluctuations of the delta landscape during the Holocene can be analysed from the dimensions and relative proportions of these four divisions.

Water and silt have turned the Murghab Delta in one of largest farmlands of Central Asia, and a propulsive area in the formation of the early Iranian civilisation. Known to the Greeks as *Margianaē* or Margiana in Latin, the country is first mentioned as *Margush* in the lists of provinces ruled by the Achaemenid king of kings since the end of the 6th century BC. After Alexander's conquest in 332 BC and the opening of direct trade relations with China, Margiana developed as a nodal point along the Silk Road. Trade and industry made its capital Merv, founded around 500 BC, legendary, but it was not until the Arab conquest, that the city gave its name to the whole region. Its ruins form to day an impressive compound of different cities, the size of several hundred hectares, that in 1997 the UNESCO has added to the World Heritage List (HERRMANN 2001).

Initiated in the fifties, archaeological surveys and excavation work have focused along the upper and lower sections of the eastern Murghab delta (MASSON 1959; MASIMOV 1979; SARIANIDI 1990; GUBAEV ET AL. 1998). Not surprisingly, explorations have uncovered that the history of agriculture and settlement in the Murghab Delta begins in later prehistoric time, long before the foundation of Merv. The earliest evidence dates to the beginning of the third millennium BC, in the Early Bronze Age (SARIANIDI 1990). Like all other alluvial floodplains across the arid lands between the Aral Sea and the Indian Ocean, the Murghab Delta was an area of convergence of complex political and cultural developments that culminated in the emergence of early states and urban societies of the eastern Mesopotamian Plain and the Iranian Plateau (TOSI ET AL. 1992; SARIANIDI 1993; HIEBERT AND LAMBERG-KARLOVSKY 1992).

The consolidated assumption among archaeologists and historians is that in dry alluvial lowlands settlement population is almost exclusively related to irrigation and agricultural productivity. Since beside water, irrigation requires the organisation of human labour, the expectation is that the scale of irrigation works would be related to levels of political complexity. Settlement hierarchies and the projected sizes of the available farmlands are considered to be directly related to the political systems. The contained expansion and relative isolation of the Murghab Delta provide ideal conditions for testing these theoretical assumptions. Large-scale irrigation works have altered several times the layout of the delta area during the Late Holocene, from the emergence of early states at around 3000 BC to the present date. The most radical transformation occurred in the 1960s with the construction of the Kara Kum canal by the Soviet Power.

What has distinguished the Murghab Delta from other land-locked alluvial lands in Middle Asia is its relative stability during the Holocene. Its branching water courses have been far less erratic than those of the Helmand or the Tarim and as a result we have none of the vast fossil landscapes pinpointed by still standing ghost towns, like in Sistan or the in Xingjian. The

result has been that over the past 5000 years the sediments have built up a stair-like sequence of descending platforms in NNW direction from a maximum height of 250 m asl at the breaking point in Yolatan to a minimum of 170 m asl at the end of the water flows near the caravanserai of Sheikh Mansur, 200 km downstream. The Murghab has buried hundreds of sites under several meters of silt. The only reliable window of observation over some consistent sections of fossil landscapes has been left behind by a southward retreat of the delta presumably after 1000 BC, probably in connection with the Sultan-ab water collector and the vast irrigation schemes around Merv (fig. 1). This area of higher visibility extends for some 140 km E-W and 200 km N-S across the eastern delta, between latitudes 37°20' - 38°40' N and 61°20' - 62°20' E, ca. 200 m asl. The exposed surfaces are fine alluvial sediments that were farmed during most of the 2nd millennium BC, occupied by mounds and shallow sites of the Late Bronze Age, while earlier ones of the Middle Bronze Age are mostly buried under the silt.

Immediately to the south of this area only the Iron Age sites become visible, while Bronze Age ones are found two to four meter below the present ground level. Further to the south, Parthian and Sasanian mounds dominate the skyline and neither Iron Age nor Bronze Age can be detected, even from the exposed sections of irrigation canals, suggesting that the early levels are buried more than five meters below.

To the north the situation does not improve. Between and beyond the present channels of the open fan, visibility of the ancient irrigated farmlands is almost totally hindered by the sands of the Kara Kum moving southwards that deck with a continuous carpet all sign of prehistoric occupation.

2 The Archaeological Map of the Murghab Delta

In its original formulation the 'The Archaeological Map of the Murghab Delta' (hereafter AMMD) [1] was designed to carry out the systematic recording of sites and palaeochannels across the Merv Oasis Delta, before most of them would disappear as a result of the continued expansion of irrigation works at the Kara Kum Canal. The primary aim was to reconstruct landscape and settlement variations along the traditional research lines established by R.McC. Adams in the Mesopotamian lowlands (ADAMS 1965) and by J.-C. Gardin in Northern Afghanistan (GARDIN 1980). After the very first season it became evident that to the north a very large number of earlier sites were buried under sand or silt, while among the later Partho-Sasanian and Medieval ones to the south only the higher mounds had survived agricultural intensification. There was no possibility to develop any reliable reconstruction of the agricultural landscape or to draw from the settlement data any estimate of population. However, despite the fact that visibility was critically constrained, the technical means for surveying work were radically improved by "the geonomics revolution" that hit archaeology in the early nineties. GPS were available to us from the third fieldwork season, together with Total Stations directly linked to computers using a variety of software to record and handle very large volumes of data. A second wave of technical improvements came from new developments in the satellite imagery made available to the public: on one side higher resolution images allowed direct visibility of large-to-medium sites, on the other the US Government released the CORONA images dating to the sixties, before the transformations brought by the Kara Kum Canal.

Quite obviously the project had to be radically re-organised: from a systematic documentation work and a quite linear historical reconstruction, it was turned into a braided pigtail of methodological questions.

This was not the only motivation for changing the first framework of the project. The complexity faced by the working teams was exponentially increased by the archaeological aspects of the survey from the best-exposed sections of the delta region. Rules and parameters had to be redefined. First of all the fact that at various degrees of density artefacts are ubiquitous across the floodplain, whenever even a small patch of alluvial soil is exposed among the sands, site/non-site became a question of discriminatory sills, to be arbitrarily determined after context evaluation.

The fact is that the stability of the delta has made possible the preservation of the least conspicuous settlement remains: most of them, 70-80% of the surfaces identified as sites, were shallow scatters of artefacts with deposits less than one meter high. Mounds still signal the remains of central or important settlements ranking degrees of centrality, because their mass derived from brick platforms or other monumental remains. They can be used as nodal points in Thiessen polygons or any other representation of Central Place Theory (CPT), but no population estimates could be made beyond the narrow limits of the micro-regional dimension, left exposed between the sand and the silt. We wonder to what extent we can rely on earlier survey works in other alluvial lowlands in SW Asia if they were based on counting people from mounds.

Systematic walking transects were run across the exposed section of the Merv delta between couples of main sites, counting sherds per standard units of surface (fig. 2). The resulting lattice of intersection has allowed the definition of settlement spaces and their functional repartitions according to different classes of indicators, along the lines developed for the Middle East by T. Wilkinson (1982; 1989).

In the best-detailed area, between Togolok and south of Takhirbaj-3, five different transects connect central points in settlement lattice. From Togolok-1 to site 126 through 148, sherd counting allows us to disarticulate the complex aggregations forming the MBA-LBA centre of Togolok (site 190) and to identify secondary small sites for a better reconstruction of the rural landscape. They also made possible to view the edge of alluvial deposits that hide Bronze Age settlements towards the south. Between sites 148 and 126 increasing density of potsherds correspond to the first settlement complexes of Achaemenid period. Similar evidence with exclusive presence of Iron Age pottery is attested in the transect run between sites 148 and 64 (Takhirbaj-1). More transects have been carried out to evaluate the impact of aeolian sands in the LBA pointing to the lack of settlements (transect between 638 and 172), or to the presence of Andronovo sites in desert zones (transect between 64 and 972). Furthermore transect between sites 172 and 215 indicate a

[1] The Archaeological Map of the Murghab Delta' (AMMD) was originally designed as a joint research project by the Institute of Archaeology of the Russian Academy of Sciences (IARAN) in Moscow, the State University of Turkmenistan (TSU) in Ashgabat, the Italian Institute for Africa and the Orient (IsIAO) in Rome and the Istituto Universitario Orientale in Naples (IUON)].

continuous but poor presence of Late Iron Age pottery, suggesting more manuring than actual settlement remains.

In general our survey work across Margiana indicates three main categories of sites:

1) *Mounds,* made by the massive remains of superimposed architecture volumes that represent central sites of long-duration;

2) *Low Elevations* from artefact concentration and shallow architectural remains representing medium-to-short duration dwelling and industrial areas of permanent settlements;

3) *Scatters of Artefacts* with almost no surviving sediment representing seasonal occupation.

There are intermediate situations between these three categories but the lack of natural elevations from terraces or rocky outcrops create a single uniformitarian situation across the whole delta landscape. Many more sites are buried under the silt of later alluviation, only exposed by occasional archaeological excavations, and they cannot be considered within a classification strictly related to survey work. We assume that the expected rate of preservation is directly related to the volume of building and the density of artefacts per square unit of surface. Natural erosion, and, to a greater extent, ancient and modern agricultural works, would destroy all sites of Category 3, over 90 % of Category 2 and only a fraction of the higher mounds of Category 1 (KIRKBY AND KIRKBY 1976; MILLER ROSEN 1986).

The exceptional preservation of few campsites in Margiana, as well as that of very large number of the shallow settlement areas, has been made possible by the retreat of irrigation and the advance of the desert. It has to be said that once aimed for in walking transects a higher proportion of campsites can be recovered on top of settled sand dunes. This is the result of two different conditions: the fact that the nomads had camped in the desert or on the sand patches advancing over the farmlands, or that the potsherds scattered on the surface are the result of eruptions from topsoil underlying the alluvial silt. The two situations can be easily distinct by closer scrutiny and small test excavations. Since both situations often concur on the same site, to detect and study campsite remains requires targeted research procedures. In general statistical analysis of quantitative data spreadsheets would be rarely meaningful from direct incorporation of the surviving evidence. One needs to project the restricted patches of surviving evidence on reconstructing models. Ethnographic data on patterns of mobility, heard composition and camp architecture become the essential tool for any future theoretical construction, to overcome the limitations of a record made of mounds (NECHAEVA, MORDVINOV, MOSOLOV 1943; PLETNEVA 1981).

3 Intrusive Campsite Scatters of Alien Pastoralists

In the course of every archaeological project there is a degree of unexpected discovery and the AMMD has been no exception to the rule. The closer scrutiny of the ground surface from a multiplication of walking transects has produced the unexpected identification of dozens of seasonal campsites scattered across the alluvial plain. (fig. 3). They indicate in a developed stage of the Late Bronze Age around 1700 BC a significant space across the delta was allocated to seasonal animal breeders. The important aspect is that the ceramic assemblage associated to these campsite remains bears no relation to the local tradition of fine-tempered wheel-made pottery. The majority of the sherds are of a coarse ware with incised or impressed decoration (ICW), considered the most characteristic signature of the Andronovo Culture Complex that spread across the Eurasian steppes during the Bronze Age for most of the 2nd mill BC (TEPLOUKHOV 1927; GRYAZNOV 1966). With minor typological variations its material culture covered a greater part of the steppe grasslands to the east of the Ural till the gates of China. For many of the specialists Andronovo marks the beginning of pastoral nomadism and represents the formative stages for the civilisation of Scythian and Saka in the first mill BC (KUZ'MINA 1994; for a recent critical review of the whole question see LAMBERG-KARLOVSKY 2002). Vast barren deserts cross the continent landmass divide the Eurasian steppes from the agriculture farmlands along the mountains that make the northern borders of Iran and India. The rivers that drain into Central Asia from the northern watershed of the Hindu Kush, and the Murghab among them, form fertile corridors deeply cutting the desert wastelands and connecting those outposts of agriculture civilisation to the sea of grasses in the northern steppe, home of different evolutionary pathways. The discovery of Andronovo ceramics intruding with specialised campsites among the established agricultural communities in the Murghab Delta has given direct indications for the beginning of this process of interchange.

This exceptional preservation of nomadic campsites, as well as that of very large number of the shallow settlements areas, has been made possible by the retreat of irrigation and the advance of the desert. It has to be said that once aimed for in walking transects a higher proportion of campsites can be recovered on top of settled sand dunes. Sites with materials of steppe-like tradition, including ICW potsherds, fired clay or stones, are frequently located in playas (*takyr*) free from the sand cover. Several sites are located on top of stabilized sand dunes, confirming the co-occurrence of sand invasion and nomadic campsites. This is the result of two different situations: the fact that pastoralists had camped in the desert or on the patches of sand already invading the farmlands, or that the potsherds scattered on the surface are the result of an eruption from the silt topsoil buried underneath. The two situations can easily be made distinct by closer scrutiny and small test excavations, while often both situations concur on the same site.

In few other instances campsites with ICW are located within areas of cultivated fields and canals, around LBA towns and villages. Especially during the final phases of the Late Bronze Age these occurrences increase in density and frequency. Vessels or potsherds are sometimes located above the floors of main buildings of the farmers' central towns (e.g. Togolok-1) or abundantly spread on the surface of several sites (e.g. Takhirbaj-3). Andronovo sites are particularly abundant along radial axes next departing from site 67 (Takhirbaj-4), where more intensive and systematic survey has been carried out (fig. 4). In this case we can assume complementary pastoral activities integrating the farming production of sedentary peoples. In particular it is evident that pastoral campsites are prevalently distributed across deserted zones, along transverse direction of irrigation canals flowing from northwards. The Togolok area is one with a significant presence of steppe-like

pottery when compared with other LBA sites, suggesting an increasing density in its final phases. According to the evidence from Takhirbaj-3 (MASSON 1959), during the Final Bronze Age a higher level of integration between nomadic and sedentary peoples was attained. However the presence of an Andronovo graveyard is still indicating a degree ethno-cultural diversity.

The intrusive phase of campsites, dated between 1700 and 1400 BC, is concurrent with significant changes of the landscape. A detailed geomorphologic survey of the eastern delta carried out by M. Cremaschi (1998) indicates that a direct correspondence may have developed between the establishment of nomadic campsites and the advance of aeolian sands over the alluvial farmlands. Undoubtedly, no conflicts but synergies can better explain the fine-grained tapestry of intersecting farmers and pastoralists, resulting from a compensating strategy devised by the local farming communities to meet the diminishing returns from irrigation farming across a territory invaded by sand and salt. The small seasonal campsites would represent not an "invasion" event, but a convergence process that might have lasted two hundred years through the middle of the 2nd millennium BC. Around 1300 BC with the emergence of the new Yaz-1 culture characterized by painted pottery, there is no more evidence of material culture related to the steppe. The ceramic types of this period from both settlement and campsites are consistently the same.

To evaluate also in quantitative terms the impact of the northern pastoralists on the local population of established farmers we need to analyse the evidence against the environmental settlements and cultural changes in the long period, covering over one thousand years between Middle Bronze Age to Early Iron Age, before and after the Andronovo intrusion. At present we can divide this period of time in five-six phases (table 1), probably still too coarse repartition to derive the appropriate profile of variability across the supra-regional dimension of Delta.

B.C.	PERIOD	MARGIANA	BACTRIA	PIEDMONT
2400	Middle Bronze Age	Kelleli Phase (Gonur North)	Dashly 3 (test trench) & looted graves	Namazga V
2300				
2200				
2100				
2000	Late Bronze Age	Taip Phase	Sapalli Phase	Namazga VI
1900				
1800		Gonur Phase	Dzarkutan Phase	
1700			Kuzali Phase	
1600		Togolok Phase	Molali Phase	
1500				
1400	Final Bronze Age	Takhirbai 3 Phase	Bustan Phase	Late Namazga VI
1300				

Table 1*. Chronological Scheme of Bronze Age in Margiana and their Relationships with Surrounding Areas.*

The widespread distribution of campsites across the exposed surfaces indicates the original scale of the phenomenon can only be established on the basis of a detailed re-visitation by survey. More walking transects will be necessary to detail the extent and duration of the campsite from the density of the small potsherds scatters, since the scale is to small for air photographs or other means can support the evidence. Although very few of the sites found so far have any archaeological deposit left, excavations might provide interesting clues to reconstruct the particular societal and economic conditions.

4 GIS as a Tool for Model Building and Research Planning

The presence of encampments and other seasonal installations of animal breeders was a common feature across the rural landscape of the Ancient Orient (HOLE 1974; CRIBB 1991). The exceptional conditions of preservation offered by the Murghab Delta open a new perspective for the modelisation of past economies from survey data. Any future quantitative elaboration will have to begin from considering that whatever the number of campsites found they would always remain a fraction of the total number.

In order to direct these further explorations to the historical dimensions of the problem, GIS might provide us with the most appropriate analytical tools to visualise the concurrent variability across the archaeological record. Standard methods of site ranking, mostly organised along classifications per type and size, have proved totally inadequate to organise the complexity and discontinuity of the sites identified across the Murghab lowlands. In pastoral campsite there are elements of functionality not directly related to the size and number of households (KHAZANOV 1994). Measure of wealth and power are the animal herds, and their size is only loosely connected to the number of people. This is particularly evident when we have no clue for the techniques used to control animal and pastures, as it is still the case for Andronovo. Also if we plot the Andronovo sites according classes of size, the results are deceptive since it is highly possible that many of them are not just seasonal campsites. Table 2 indicates the frequency per sizes, distributed according four main classes of sites. Highest values are around 1000 sqm, equivalent to an area of approximately of 30 x 30 m, This may correspond to small campsites with one or few dwellings and other small features related to pastoral or related processing activities. In calculating the size we must consider that remains of herding sheds are hardly recognizable on field research. The other dimensional classes can indicate both larger campsites with industrial activity or settlements incorporating integration between herding and farming peoples.

Some of the largest ones found so far like 1211 are large enough and contain indications for permanent habitations and multiple industrial activities.

Thus to develop within a GIS frame (ArcView) an appropriate analytical tool, we need to establish an intense interplay between the field and the computer, almost on a day by day basis, in order to incorporate the different options for classification categories, developing the measure of scale. The optional definition has to be tested in parallel procedures at best by simulations to contrast both cultural and functional data from the archaeological record against the environmental variables relative to both alluvial regression and sand infiltration. The fact is that we have to establish to what extent the success of the nomads was determined by political decisions or environmental adaptations. One is a function of the other.

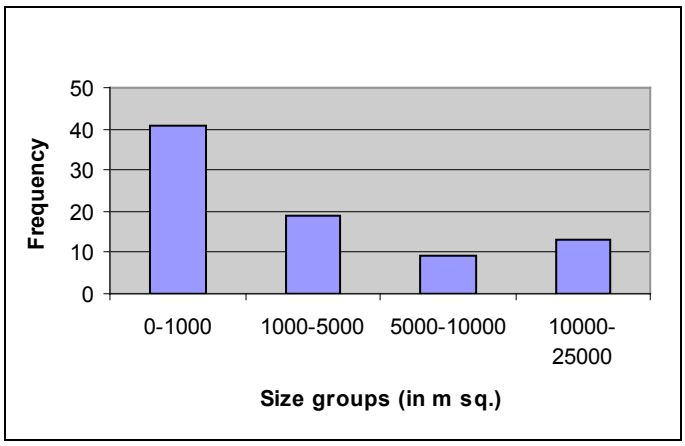

Table 2. *Frequency of ICW site surface.*

The cultural integration, reached around 1300 BC with the Yaz 1 culture, makes the Andronovo infiltration an episode of convergence that might have lasted from 100-300 years. We need to define its occurrence in the greatest detail to transfer the archaeological data to a level of historical interpretation. For this reason the study of the Andronovo in Murghab is a great opportunity to test the value of GIS for future investments in archaeology.

Finally, a most significant aspect where GIS can be developed in a research tool is the application in reconstructing ancient landscape. Present-time geo-morphological analyses are often off the right path for the scientific research and can be used only if no changes from ancient landscape are demonstrated. GIS as reasoning tool appears largely useful combining archaeological and geo-morphological records (fig. 5). Areas lacking data do not correspond to lack of ancient settlements. Some geo-morphological evidences like buried Bronze Age remains (cross symbol with depth indications) suggest that alluvial deposit created by some of the ancient rivers branches can hide the location of several settlements in the same area. A presumable area of alluvial sediments deposited progressively during the first part of Iron Age (horizontal lines) has been located combining points of depth of the Bronze Age soils and the absence of contemporary sites on the surface. Reasoning with selected data in the GIS, we can direct future research to exclude or to determine the position of ancient remains. For this purpose test trenches and more exposed sections observations together with bore-drillings will allow to estimate the thickness of alluvial deposit in the same area.

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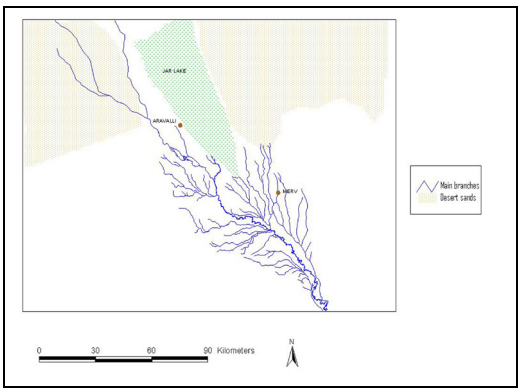

Fig. 1. *The Murghab Delta: simplified general map of natural channels and ancient irrigation networks. Note the irrigation subsystem around Merv fed by the Sultan-ab water collector, probably built in Iron Age times.*

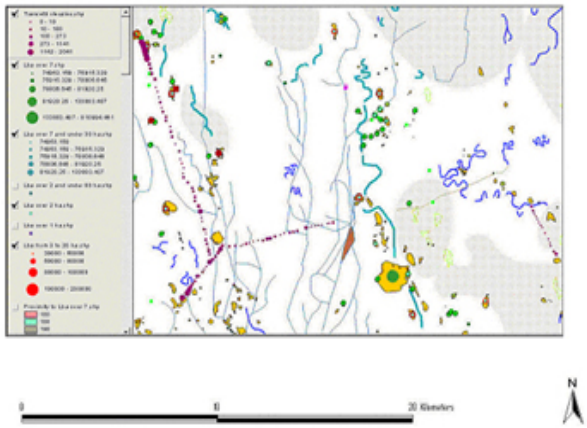

Fig. 2. *The Archaeological Map of Murghab Delta. Transects carried in Togolok and Takhirbaj areas*

Legend: graduated size circles according number of sherds; symbols and polygons = Late Bronze Age sites; dotted area = massive aeolian sands; meander lines = ancient riverbeds recognized from aerial photographs; enclosed green areas = takyr playas; straight lines = modern canals.

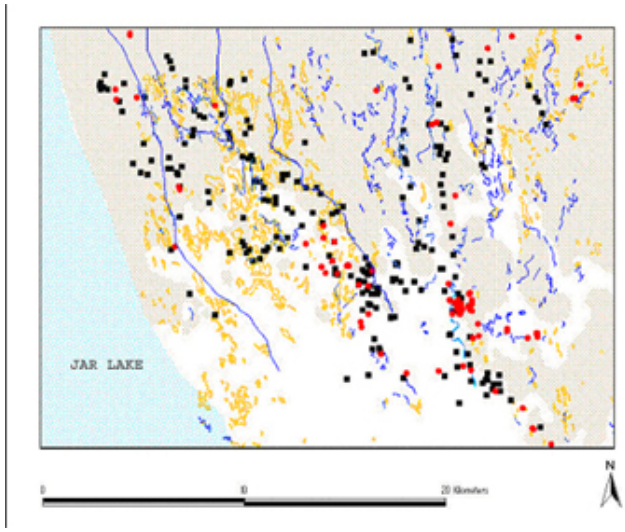

Fig. 3. *Distribution of Andronovo type campsites (red circles) and Late Bronze Age sedentary settlements (black squares)*

Legend: dotted area = massive aeolian sands; meander lines = ancient riverbeds recognized from aerial photographs; enclosed yellow areas = takyr playas.

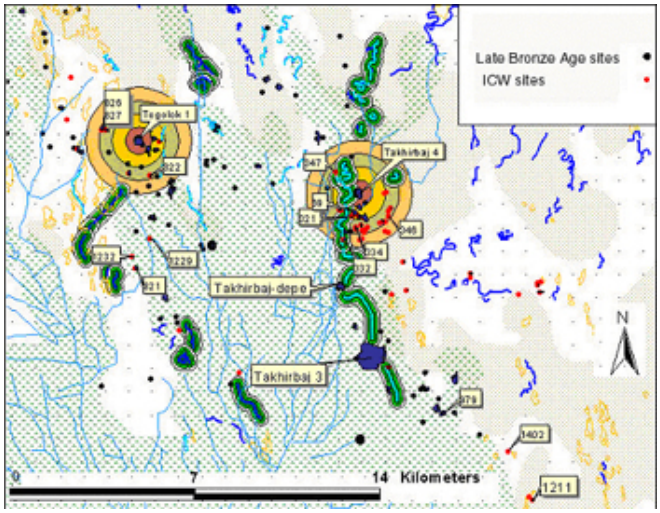

Fig. 4. *Relationship between campsites and main farmers' centres during the Late Bronze Age.*

Legend: black squares = Late Bronze Age sites; red circles = Andronovo type campsites; dotted brown areas = massive aeolian sands; meander lines = ancient riverbeds recognized from aerial photographs; enclosed yellow areas = takyr playas; buffers are centred at Late Bronze Age river beds.

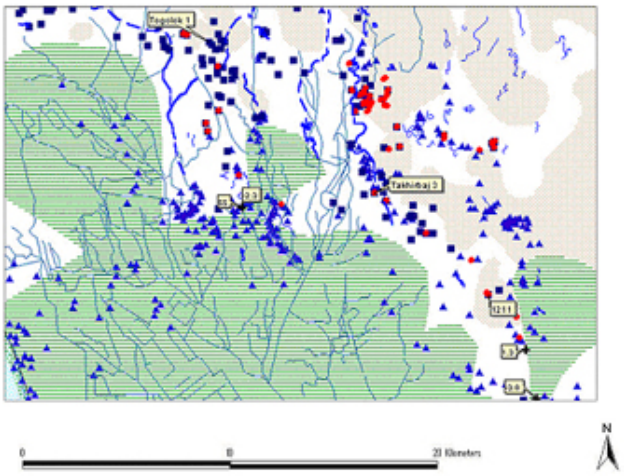

Fig. 5. *Alluvium deposits (horizontal green lines) set with absence of Bronze Age sites and palaeosoil spots (cross symbol with indicated depth). Legend: black squares = Late Bronze Age sites; red circles = Andronovo type campsites; blue triangles = Iron Age sites; dotted brown areas = massive aeolian sands; meander lines = ancient riverbeds recognized from aerial photographs.*