Geoarchaeological reconnaissance of the Banja Luka and Doboj area of northern Bosnia and Herzegovina

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Introduction

The application of geological and physical geographical techniques in archaeology is widely established and can provide fruitful and exciting results in the form of geoarchaeology. This report describes the use of geoarchaeological techniques to investigate and interrogate landscape use and change in northern Bosnia and Herzegovina during the late glacial and early Holocene focusing on the Vrbas valley, the Ukrina valley and the surrounding landscape. It examines evidence from archaeological site locations such as limestone caves and river gravel terraces in order to understand human impact on the landscape in the past. In addition it will assess the preservation potential and examine the formation processes at the sites visited in order to fully place the archaeological artefacts in their context.

Primarily the research has two main aims:

1. To develop a geoarchaeological methodology for the rapid assessment of past landscapes in the Banja Luka and Doboj area of northern Bosnia and Herzegovina.

2. To investigate human interaction with the landscape in the late glacial-early Holocene.

Bosnia and Herzegovina is in a unique archaeological position at the beginning of the 21st century. Whilst much research has been undertaken in the Balkan peninsular, Bosnia and Herzegovina has been largely ignored. It is not only ripe for fresh investigation, but it can contribute serious, original and unique evidence to questions about all periods in the past. Key to instigating research of a virgin landscape is the development of an effective methodology for the initial investigation of a large number of sites. By using geoarchaeological techniques in Bosnia and Herzegovina it is hoped that it will also raise the profile of the use of archaeological science in the country.

The country comprises of a complex assemblage of geological units composed mostly of secondary and tertiary sedimentary rocks but also including igneous and metamorphic rocks ranging in age from the Palaeozoic to the Cainozoic.[1] Specifically, in northern Bosnia and Herzegovina Mesozoic limestone is the predominant bedrock parent material, often overlaid with later tertiary and quaternary sediments. The existence of windblown loess sediments in the county is still debateable and this dissertation can hopefully contribute evidence of the presence and contribution of loess to subsoils and soils in Bosnia and Herzegovina. The geological framework of the county comprises three geo-tectonic zones namely the Outer, Central and Inner Dinarides. The focus on northern Bosnia and Herzegovina in this paper means that it primarily deals with the Inner Dinarides, which consist of "Palaeozoic and Mesozoic clastic rocks and carbonate, Jurassic ophiolitic rock and melange, Cretaceous and Palaeogene flysch and granite, Neogene andesite dacite, and lacustrine, lacustrine-lagoonal and marine molasse."[2]

A key component of this research is the creation and application of a quick and effective methodology for examining sites within their landscape. Geoarchaeology is the ideal discipline within which to do this. For example, hand au-

[1] Mulić *et al.* 2006
[2] Mulić *et al.* 2006

gering allows a large area to be studied in a reasonably short time frame and with comparatively low fiscal outlay. When this type of landscape reconnaissance has been done, targeted sample excavation can then take place. This allows a combination of geochemical, multi-elemental and micromorphological data will be used to identify, classify and describe buried soils.

In addition to the theoretical and academic aims, the project also has at its core the promotion of international cooperation and the sharing of knowledge, resources and experiences with colleagues from our host country, as well as learning from them. The research is intended to very much be a two way process.

This research forms part of a wider project which has been running since 2007: 'The Forming of Europe: the dynamism of prehistoric population and the roots of sociocultural diversity.' The overall aim of the wider project is to better understand the nature and development of the transition to agriculture in the Neolithic.

Literature review

The Neolithic transition should be one of the most important and exciting parts of prehistory for study.[3] Instead in the last two decades it has become bogged down in a seemingly ceaseless battle between the dichotomy of migration verses acculturation.[4] Where new work is being published it either looks at ideational verses economic change[5] or it gathers new evidence to track the movement of agriculture.[6] In recent years however there has been some movement towards reopening the debates. Rather than looking for evidence to support an entrenched position, some archaeologists are now beginning to enact the change they wish to see. Miracle and Robb (2007) have proposed reopening the debates surrounding the Neolithic transition in an attempt to reignite critical thought in this area. The concept of an either/or debate seems now outdated and too awkward to truly explain the complexities of human interaction. As archaeology navigates through the post-modern paradigm, with its incredulity towards meta narratives, it is inevitable that an all inclusive continent wide theory, be it acculturationist or migrationalists, will be replaced with more critical assessments of the evidence. Alongside this movement to re-theorize the Neolithic, there has also been a push to reinterpret more critically already published data.

Sherratt (1997) reintroduced the concept of climate and ecology into the debate and his work is being followed up by others who are attempting to reassess the radiocarbon dating of Neolithic sites, to better explain the Neolithic Transition.[7] This movement towards a multi-faceted theorized Neolithic, it is hoped, will allow the discipline to move forward. Key in doing this is to build on the work of Sherratt[8] in determining the environment and landscape of Europe in the past. Whilst avoiding environmental determinism, it is still necessary and helpful to recreate past environments as the effect the world around us has on decision making is undeniable. This research follows in the footsteps of Sherratt, with its aims to look at the interaction between humans and their environment.

To date, published archaeological and palaeoenvironmental research work in Bosnia has been limited. That said, some important work has been produced with regard to the lithics of the area.[9] Other work that has been written has yet to be translated into English or published in international journals, making it difficult to access unless Serbo-Croat is spoken. In terms of more recent work on the Balkans, Bosnia and Herzegovina consistently seems to be missed out altogether.[10] The geoarchaeological approach of this research will build on a combination of methodological approaches used in other landscape investigative projects elsewhere in Europe, such as those of Chapman and Shiel[11], Ayala and French[12], Bintliff[13], Brown[14] and French and Lewis.[15]

[3] Miracle and Robb 2007
[4] e.g. Ammerman and Cavalli-Sforza 1984; Whittle 1996
[5] Rowley-Conwy 2004; Thomas 2003
[6] Colledge *et al.* 2004; Price *et al.* 2001

[7] Vander Linden, in press
[8] *ibid*.
[9] Baumler 1987; Montet-White and Johnson 1976; Rajkovaca 2004
[10] e.g. Willis and Bennett 1994; van Andel & Runnels 1995; van Andel and Tzedakis 1996; Bailey *et al.* 2002; Bailey 2000), for example in Hungary and Bulgaria (Chapman and Shiel 1987
[11] Chapman / Shiel 1987
[12] Ayala /French 2005
[13] Bintliff 2005
[14] Brown 1999, 2008
[15] French and Lewis 2005

Methodology

This research utilised both field and laboratory based techniques, which aim to be completely reproducible. In the field, hand-augered boreholes and hand-dug test pits were used to generate data on the stratigraphic sequences of both the archaeological sites and the wider landscape. In the laboratory, geochemical/elemental testing and soil micromorphological analysis have been used to generate data with which to analyse, describe and interpret the landscape with greater depth and to search for the existence of buried soils (see Appendices 1-3). The data was gathered in the field during three fieldwork seasons in northern Bosnia and Herzegovina over five weeks in 2009-10, with sites examined from the Vrbas valley and the Ukrina valley as well as the mountains in-between the two valleys, and also along river tributaries. Sites were chosen where previous work had suggested the possibility of *in situ* archaeology, and in order to investigate as many different zones of the landscape as possible, including floodplains, river terraces and foothills. In total, 10 open sites, one cave site and their immediate surroundings were investigated.

The main geoarchaeological survey methodology comprised the following:

– assembly of background geology, soil and topographical map data

– gridded fieldwalking and artefact collection; study by Vander Linden and Pandzic in Museum

– borehole survey using a hand auger; generally at 20m intervals in transects placed at right angles to the slope topography and across the densest area of artefacts[16]

– sampling for physical (pH, loss-on-ignition or LoI, electrical conductivity or EC, magnetic susceptibility or MS, calcium carbonate or CaCO3) and multi-element analyses (ICP-AES) from the boreholes[17]

– targeted/judgemental test pits ($1m^2$ square) placed on hill-top, valley side, valley bottom as appropriate, and in densest area of artefact recovery; with finds and faunal remains recovery

– GIS plotting, height above sea level and stratigraphic/photographic recording of each test pit

– sampling of stratigraphy in each test pit for physical (pH, LoI, EC, MS, CaCO3) and geochemical analyses (ICP-AES), and soil micromorphological analysis where buried soils were believed to have been recognised[18]

– appropriate processing of soil/sediment samples in appropriate laboratories in Cambridge and Seville, Spain.

Every site or area that was visited had at least three boreholes excavated, although most had many more than this, and where time and manpower permitted, and where it was deemed necessary; $1m^2$ test pits were also excavated. The boreholes were made by hand using a soil auger primarily with a Dutch auger head, and where the sediments were of a softer nature with a gouge auger head. All were done either by the author or under direct supervision of a trained assistant using where possible local archaeologists. All boreholes aimed to be augered until the natural underlying geology or primary parent material was reached. Sediment and soil samples were taken directly from the auger head, from the sections of test pits, from exposed sections at the sites (where available). For physical, geochemical and multi-elemental testing approximately 100g of sediment was taken using a trowel and placed in a sealed plastic bag. For micromorphology, intact block samples were cut from sections using a knife and trowel, before being wrapped in plastic and sealed using masking tape to form a tight seal and support the sample to prevent damage to its structure

Samples were taken from sites for two main reasons. Firstly, samples were taken in order to classify the major sediments present at the various sites and to examine their preservation potential. Secondly samples were taken at regular intervals at certain sites to aid with the discovery and description of any buried soils by comparative analysis. All samples were subject to the following tests; pH, organic content via loss-on-ignition (LoI or % organic), magnetic susceptibility (MS) and electrical conductivity (EC). In addition certain samples were selected for digital colour analysis, multi elemental analysis and calcium carbonate content using loss-on-ignition (using LoI, or % $CaCO_3$). Block samples for mi-

[16] French 2003

[17] Allen and Macphail 1987; Boreham 2007; Dearing 1999; Walden 1998; Wilson *et al.* 2008

[18] Bullock *et al.* 1985; Murphy 1986; Courty *et al.* 1989; French 2003

cromorphological analysis were taken from exposed sections and test pit sections, targeted at specific areas of interest such as transitions between sediment horizons.

Results

Due to the variety of sites, visited the results gathered varied greatly from site to site. Before looking at site specific results, geochemical data from across the country can be used to generate an average for all readings (Table 1; App. 1).

The average data presented above shows that the soil/sediment complex is generally circumneutral to weakly acidic with a reasonable organic and calcium carbonate content, positive electrical conductivity and little sign of burning. This indicates that faunal (and possibly molluscan) remains should survive, but that the good preservation of uncharred organic remains may be affected by oxidation. Additionally this provides background results for EC and MS, from which elevations can be recognised. However the use of averages as background readings must be used with caution as a single site with naturally elevated µS/cm or SI Units can easily bias the average.

Results will be presented on a site by site basis (Fig. 1), with the sites categorised into five broad groups. First the floodplain group of sites will be presented, which consists of the site of Kočićevo. Following this will be the sites that sit in the foothills surrounding the Vrbas valley; Pecine, Pejčinovića Brdo, Jelića Brdo, Čardar Čardačani, Luka and Stari Martinac. Next a single site in the mountains to the east of Banja Luka was investigated, Tomasovo Brdo. A number of sites in the valley of the Ukrina river were also investigated; Luščić, Kremna-Njiva Tome Milankovića, Miljevic and Area 55. Finally a single cave site was investigated at Ratstuśa.

Only one floodplain site was examined during this project primarily due to the lack of identified sites within the basin of the Vrbas, most probably as a result of either being buried under later flood sediments or denuded or truncated as a consequence of erosion. All sites used in this research were discovered as a result of farming and slope processes, with artefacts being brought to the surface from ploughing and localised hillwash processes. Where there are thinner soils and greater erosional processes at work, such as at the top of hills/mountains, artefacts are brought to the surface more frequently and therefore there is a bias towards these sites. In the valley bottom however, where sediments are redeposited, ploughing is less likely to disturb the better buried archaeology. Caution must be used when examining floodplains however; just as sediments are eroded up slope and redeposited,

Site	pH	µS/cm	SI Units	% Organic	% $CaCO_3$
Total	6.70	627.3	60.10	4.51	5.71
Kočićevo	7.34	1378.0	108.70	4.20	32.58
Pecine	5.40	130.6	34.17	4.95	
Pejčinovića Brdo	5.46	69.0	25.99	3.56	
Jelića Brdo	6.20	306.0	19.15	3.63	3.78
Čardar Čardačani	5.65	77.1	22.28	2.84	2.81
Luka	6.83	187.5	50.45	3.62	2.95
Stari Martinac	5.64	250.8	23.06	2.72	2.81
Tomasovo Brdo	5.65	80.4	59.08	3.66	
Kremna-Njiva Tome Milankovića	7.51	274.5	10.74	6.10	5.78
Area 55	7.27	256.7	58.98	4.62	3.90
Rastuśa Pecine	7.59	2080.7	82.46	4.96	7.01

Table 1. *Average physical results from soils across the area and at each site*

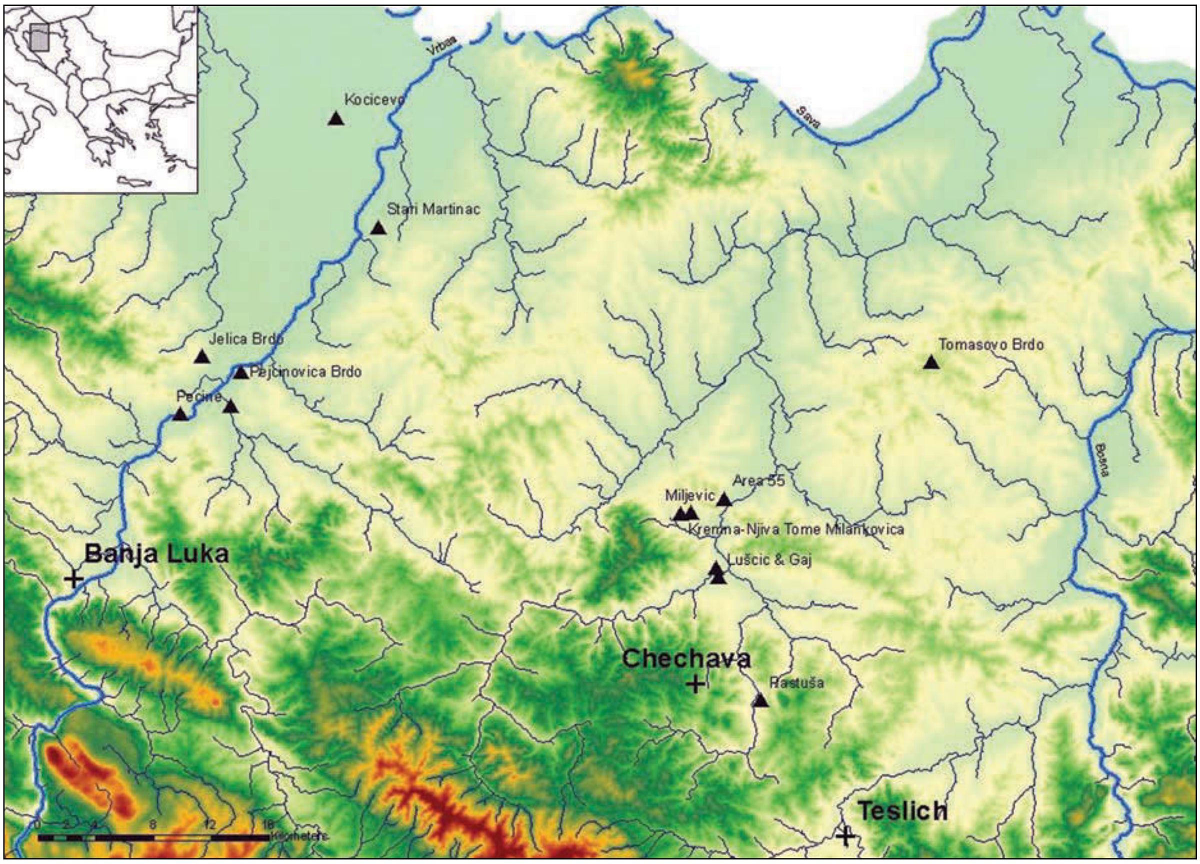


Fig. 1. *Map of the sites investigated within northern Bosnia and Herzegovina*

so archaeological artefacts can be also, especially when dealing with sites close to foothills.

Kočićevo

Kočićevo is located on the floodplain edge of the River Vrbas (Figs. 1 & 2). The site sits on a gentle east-facing slope at about 98m above sea level. It has a seasonal stream running *c.* 10m from its eastern edge, which was dry when visited in November 2009 but which was flowing gently when the site was revisited in March 2010. An auger transect was made on a northeast to southwest alignment (Fig. 3) to target the highest concentration of finds recovered in the fieldwalking and to work upslope from the seasonal stream. Boreholes were spaced at 10m and later 20m intervals during the initial survey. In addition to this auger transect, an exposed well section was examined and sampled to the north of the transect.

From the well profile it was possible to record the complete soil/sediment/geological sequence and take samples for thin section analysis from the possible buried soil. Whilst the auger failed to show any recognizable buried soil in the lower eastern half of the transect, the well profile and auger transect did show a possible archaeological feature and a possible thickened area of buried soil profile in the upper/western half of the transect. This initial work was followed in the March 2010 field season by further augering and the excavation of two 1m^2 test pits (Fig. 3).

The rectilinear archaeological feature observed in test pit 1 coincided with the highest concentrations of Neolithic pottery and lithics. The nearby exposed well section showed the following short sequence: an Ap horizon or ploughsoil (0-40 cm), an artefact-rich silty, clay loam B horizon (40-90 cm), a pale brown sandy silty B/C horizon (90-110 cm), all developed on gravel terrace drift geology. Test pit 2 was excavated to a depth of approximately 1.5m. The pit showed a similar profile to that found in the well profile and archaeological material, appearing to be of Neolithic date, developed on a pale brown sandy

Fig. 2. *Kočićevo from the east looking westward across the area examined. The hay pile in the centre of the photograph is the approximate location of the well profile.*

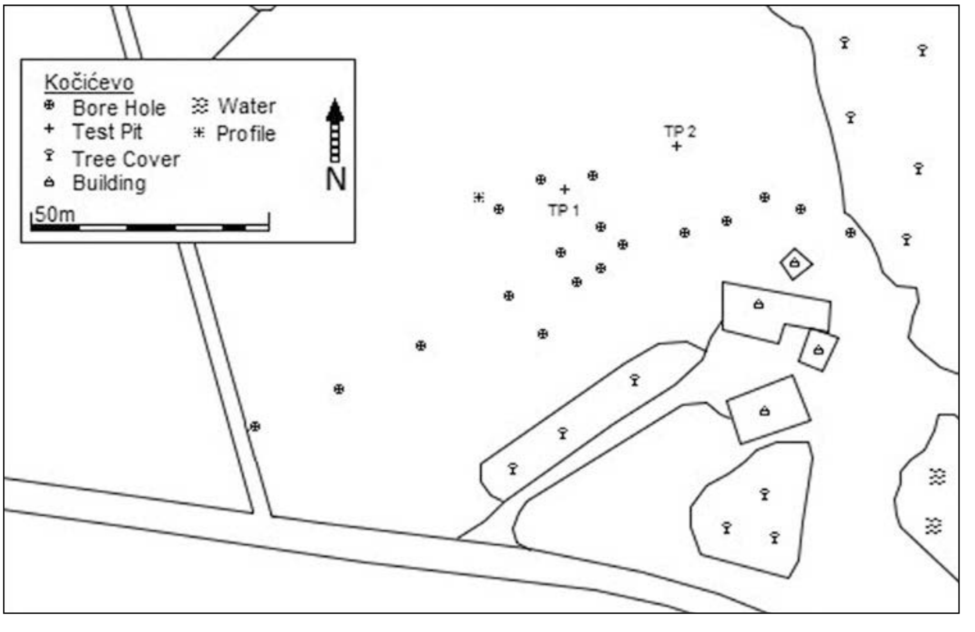


Fig. 3. *Plan of Kočićevo showing the locations of test pits and boreholes*

silt substrate. Test Pit 1 was excavated in the area highlighted as the potential feature during the augering survey. It was excavated to a depth of approximately 1.5m and archaeology was found throughout, again of probable Neolithic date. The finds included a fine example of a jadeite polished hand axe. Samples were taken for physical and geochemical analysis from across the site to investigate the soil/sediment type ranges at this site, to see if any anthropogenic disturbance could be detected, and to assess the preservation potential of the site.

From the analysis, it is possible to say that the silty loam topsoil is slightly acidic (pH 5.53-6.20) with the site tending towards more alkaline sediments down-profile (App. 1). The deepest sample at 1.46m had a pH of 8.78, reflecting the calcareous terrace deposits and groundwater system beneath. The organic content of the soil, as measured via LoI, shows the predictable patterning of decreasing content with depth, with the topsoil having between 8.7-6.28% organic, compared with consistent results of less than 6% below 40 cm. The nutrient content and magnetic susceptibility both show more interesting results. As you would expect both have high results in the topsoil, but both feature a peak in results around 60-70 cm, consistently across the site, but the sediments within the feature have a more alkaline pH and also have a lower nutrient content than the topsoil. Indeed there were some fragments of deer bone recovered (D. Orton, pers. comm.) during the test excavations. Whilst the difference in nutrient content (measured in µS/cm by Electrical Conductivity) could be caused by natural pedogenesis, it is possible that these lower readings are found because the sediment present is a fill. This, combined with the large amounts of finds from this area seems to suggest that the feature could be a large ditch or pit or even a house structure of probable Neolithic date. It is intended that these possibilities will be further investigated in the future through larger scale test excavation.

The micromorphological sample taken from the buried B horizon in the well profile showed the horizon consisted of a porous (*c.* 30% voids), calcitic sandy clay loam with a large amount of humified organic matter (Table 2; App. 2).

This soil is a mixture of organic sandy loam and clay-rich loams (Fig. 4) which appear to correspond to a mixed organic buried Ah horizon

Unit	Structure	Fabric	Features	Horizon	Interpretation
KOC 09 Well Profile					
Lower B horizon					
	granular partial	organic	poorly sorted	Ab	calcareous, alluviated
	accommodated	mixed sandy/clay	dusty clay	Bw	brown earth on river
		loams	micro-charcoal		terrace deposit

Table 2. *The key micromorphological features from Kočićevo*

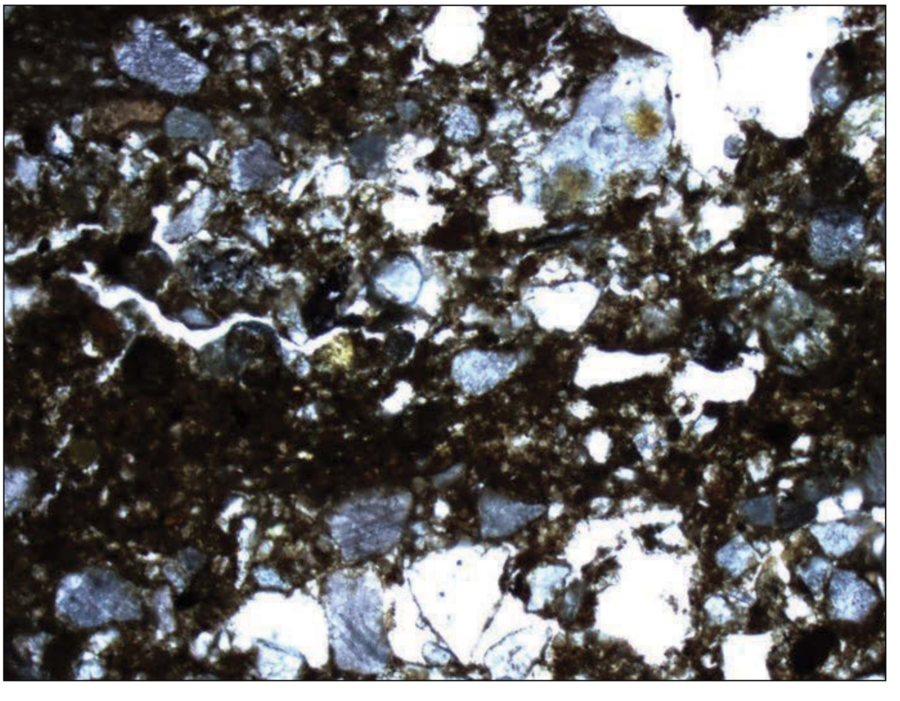


Fig. 4: *Photomicrograph at* 1:10 *showing the mixing of the sands, silts and clays at Kočićevo*

and a more clay-rich B horizon. However both horizons are deeply disturbed by physical mixing, likely to be as a result of deep ploughing. The common incorporation of poorly organised dusty (or silty) clay, which is likely to alluvially derived material from overbank flooding, suggests that this site consists of an aluviated, calcareous brown earth developed on river terrace deposits.

The second type of site visited were those on the foothills along the Vrbas valley. They were all selected for geoarchaeological investigation as they had shown interesting artefacts and some had been previously investigated.

Pecine

The area of sites known as Pecine is approximately 15km northeast of Banja Luka, 300m from the western bank of the Vrbas (Fig. 1), *c*. 171m above sea level. It was one of the few sites along the river which has been previously investigated. A survey in 1979 was conducted prior to the construction of the new Banja Luka to Bosanska Gradiška motorway.[19] Due to the construction and subsequent widening of the new road, these caves, and the open air areas around them have now been destroyed. The site had two separate transects augered (Figs. 5 & 6), the first, in the southwestern corner of the site area. Four boreholes were made at 20m intervals across the area of the site deemed least affected by road construction. The second, eastern, transect utilised a partially exposed section alongside the track towards the western edge of the site area alongside a wooded area. Initially the exposed section was cleaned up, examined and sampled in four places, spaced 10m apart. Once complete, the auger was used to continue the down-profile.

The first transect showed very complicated stratigraphy with a combination of grey and orange silts overlying hard red clays but without any consistent horizons. The pH ranged between 5.45-6.52 (App. 1), or weakly acidic to circumneutral, and the nutrient and organic levels where consistently low. The lack of logical patterning to the results, combined with the unusual stratigraphy, suggests that the soil profile has been heavily modified during the construction of the motorway and various ploughing events in the past. The second transect showed a more standard stratigraphy with a reddish orange silty clay layer over laying a red sterile clay layer, on a weathered B/C horizon, shown by the inclusion of increasing amounts of parent material. The pH increased slightly down the profile, with values ranging from 5.19 at the surface to 5.62 at a depth of 2m, but remained acidic. This corresponded with a decrease in organic content and nutrient levels. These results suggest that, whilst the profile is more intact than at the western transect, more recent ploughing events have truncated any palaeosol beyond the point of recognition, and there is some acidification, presumably derived from the influence of the weathering geological substrate. Overall Pecine presents two examples of the problems working in the Vrbas valley, archaeological destruction through the construction of a new road and the absence of any identifiable old land surface and palaeosol, primarily caused by erosion in the past.

Pejčinovića Brdo

The area of Pejčinovića Brdo is sited on the valley top of the eastern bank of the Vrbas 500m from the modern river and approximately 19.5km northeast of Banja Luka with views of both the floodplain to the north and the higher mountains to the south (Fig. 1). Two separate sites have been identified in the area, one of which was chosen for intensive study with two transects of 19 boreholes and four test pits excavated in the area (Fig. 7). The site was first identified in 2007 from fieldwalking and showed concentrations of stone tools from both the Neolithic and Palaeolithic (P. Miracle and T. Rajkovaca, pers. comms.). The first transect was located down-slope towards the river starting from the highest point of the site (Tr.1) and the second, across the hump of the main hill (Tr.2) at 20m intervals. Two further transects were augered, the first parallel with Tr.1 to the north and starting from the lowest point of the field (Tr.3) and the final transect parallel with Tr.2 to the east and extending south eastward to the edge of the landowners property (Tr.4). In addition to the four transects, four 1m^2 test pits were excavated by hand to examine the depositional relationship of the material recovered. The test pits were located at the highest point of the site, another towards the lowest point of the site, and a third mid-slope.

[19] Graljuk 1983; 1988a, 53; 1988b, 5

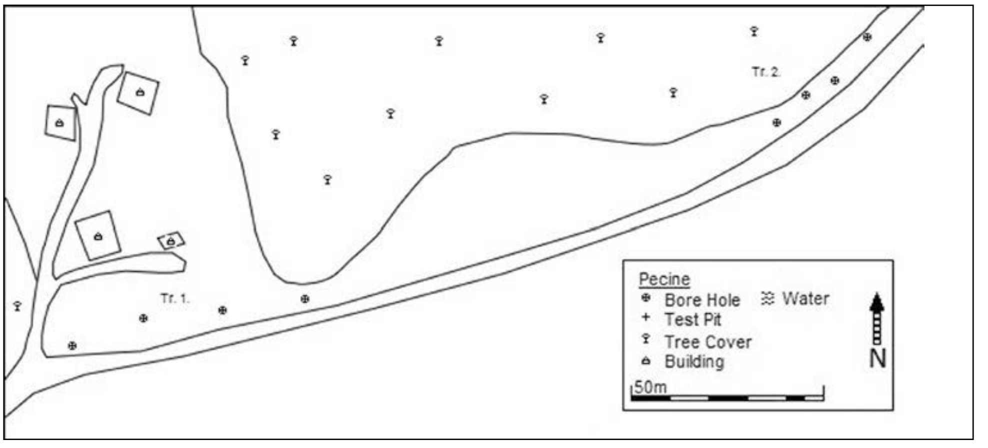


Fig. 5. *Plan of Pecine showing the locations of the two auger transects*

Fig. 6. *Location of transect one at Pecine looking west*

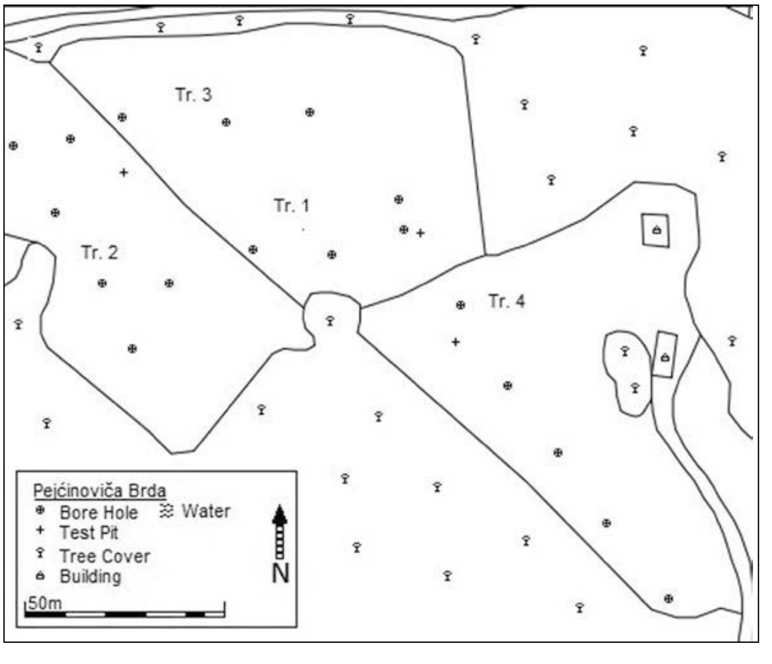


Fig. 7. *Site plan of Pejčinovića Brdo showing the locations of test pits and auger transects*

Fig. 8. *Pejčinovića Brdo looking west along transect* 1, *towards the Vrbas*

When the site was visited in 2009, the majority of the area was in use as pasture and therefore fieldwalking of the site was severely limited. In 2010, the situation was slightly better as the southeastern area recently ploughed. Limited fieldwalking recovered an array of Palaeolithic artefacts (P. Miracle and T. Rajkovaca, pers. comms). From the borehole survey the stratigraphy of the site area appears to be fairly uniform with varying amounts of brown silty A horizon topsoil (24-55 cm thick over an *in situ* B horizon, *c.* 10 to 30 cm in thickness. It is characterised by pale, fine silts. The exception to this is in the southeastern end of the site where the modern ploughsoil directly overlays a degraded B/C horizon. Apart from in this area, the rest of the site has a bed of gravel and pea grit, in the size range of 1-5mm beneath the B horizon. As the angle of the slope increases towards the river, the stony layer becomes more weakly expressed and where it was possible to auger through the gravel layer overlies compact sterile clays. This is suggestive of erosion events in the past which deposited and/or exposed the stony layer. There is no obvious old land surface present at the site, although it may have been truncated. Micromorphological samples were taken from the Ah/B horizon transition and from the base of the B horizon, in order to check for the presence and nature of any buried soil.

Geo-chemical work from the site shows that the sediments have a consistent weakly acidic pH of between 5.05 and 5.84 with no patterning to the results (App. 1). This means that the preservation of faunal remains is likely to be poor. Certainly, none of the test pits recovered any bone. There appears to be a correlation at the site between high organic content and low magnetic susceptibility. This is caused by processes associated with alternating oxidation/reduction conditions causing organic material to be replaced by amorphous iron oxides. This is further supported by decreases in electrical conductivity where magnetic susceptibility is high, meaning that the magnetic substance in the sediment is not conductive.[20] Maghemite (Fe_2O_3) being an iron oxide which is not conductive but is highly magnetic. The correlation is found at various depths across the site, being found in the topsoil, at a depth of 40 cm, in BH 21 and in the sterile clays, at a depth of 196 cm, in BH17. The clays beneath the stony layer were examined for organic con-

[20] Boreham 2007

Unit	Structure	Fabric	Features	Horizon	Interpretation
PEJ 10 – TP 1					
Ah/B transition					
	wedge shaped peds	organic and	bioturbated; ,	Bwt	Disturbed woodland
		silty clay	dusty clay void infills		soil
	weakly developed		and fine dusty clay in		with loessic
			groundmass with high		component to
	unaccommodated		biofringence and		groundmass
			reticulate striations		

Table 3. *The key micromorphological features from the upper slide from Pejčinovića Brdo*

tent and although it had consistently less than 5% organic content, the electrical conductivity and magnetic susceptibility readings were relatively high. Here the perched water table above the clay could lead to good preservation of organic remains.

The micromorphology of the Ah/B horizon transition showed that it consists of a highly bioturbated yellow/orange clayey silt, but with a strong very fine sand component (Figs. 9 & 10; App. 2).

The birefringent, striated to weakly reticulate silty clay forms much of the b-fabric of the groundmass. This is suggestive of dusty or silty clay illuviation that has become well integrated with the groundmass. There are also some weakly organised dusty clays in the pore spaces, some of which are completely infilled. These later textual pedofeatures suggest disturbance of the upper part of the profile leading to the redeposition of finer sediments further down-profile.

The second slide taken from the base of the B horizon showed a few large voids in an otherwise dark yellowish brown, homogenous but stoney, silt loam (Table 4; App. 2).

Together these features are indicative of an illuvial clay-enriched argillic brown earth soil with a strong loessic-like very fine quartz sand and silt component. This once woodland soil appears to have developed in a loess derived substrate. It has been successively disturbed in the past, initially through disturbance of its upper horizon, perhaps through tree clearance, and subsequently through physical mixing, and then bioturbation, no doubt associated with modern ploughing and cropping. The upper half of the modern profile is severely disturbed by physical mixing, reflecting modern deep ploughing.

Unit	Structure	Fabric	Features	Horizon	Interpretation
PEJ 10 – TP1					
Base of B horizon					
	sub-angular blocky	silty clay loam	bioturbated;	Bt	illuvial clay soil with loessic derived component
	peds	with very fine	striated illuvial		enriched B
	moderately well developed	quartz sand	silty clay		horizon

Table 4. *The key micromorphological features from the lower slide at Pejčinovića Brdo*

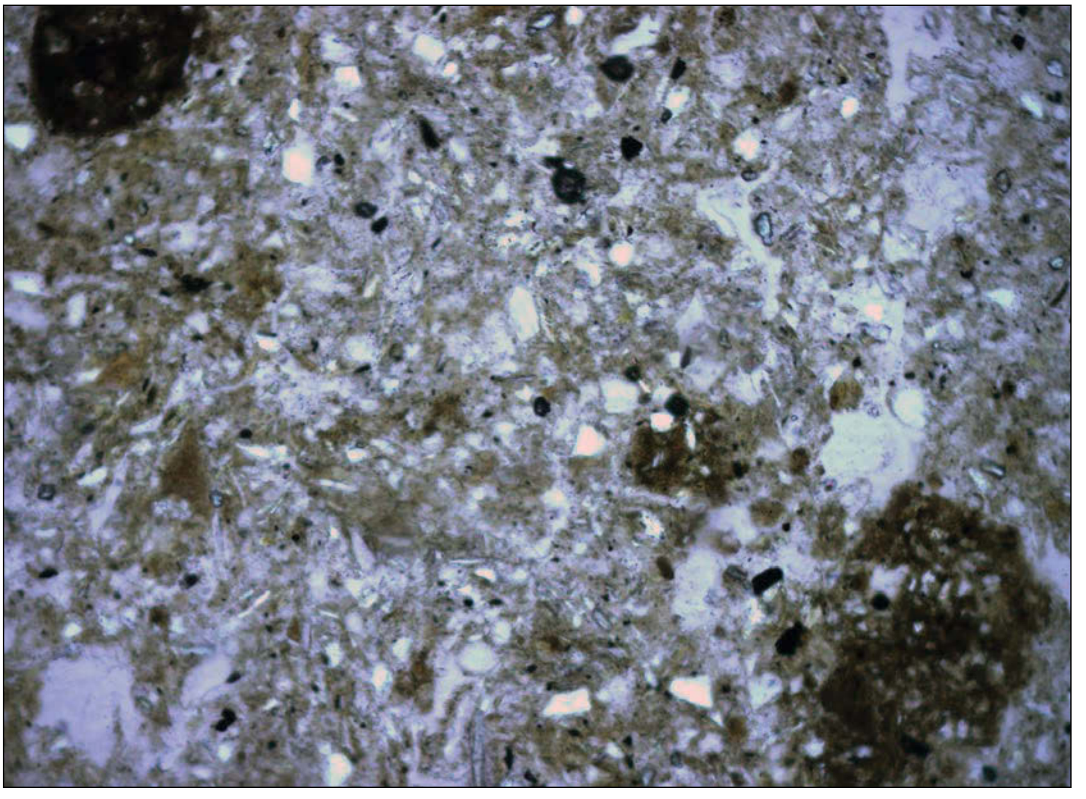


Fig. 9. *Photomicrograph from Pejčinovića Brdo at* 1:25 *showing the loess-like nature of the groundmass*

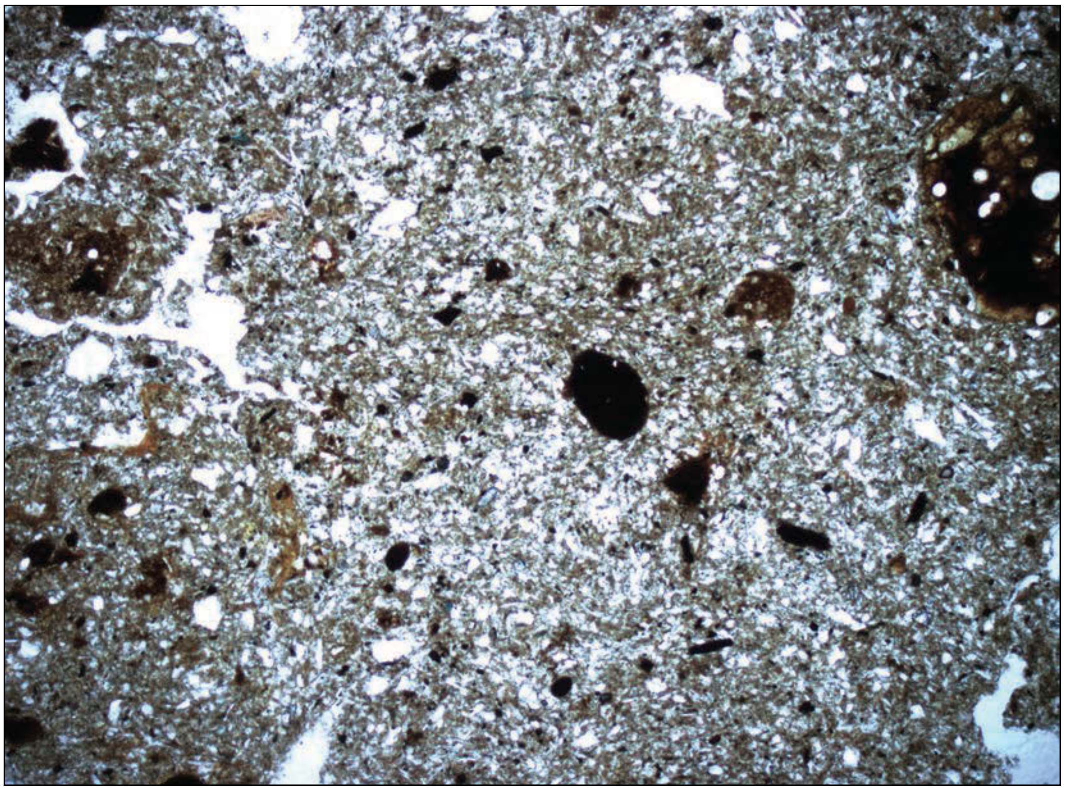


Fig. 10. *Photomicrograph from Pejčinovića Brdo at* 1:10 *showing the evidence of bioturbation*

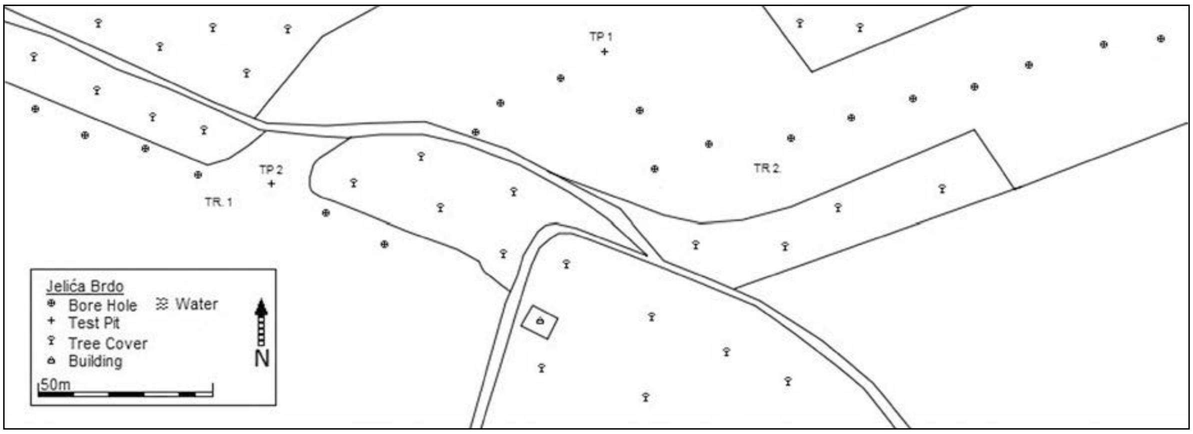


Fig. 11. *Site plan of Jelića Brdo showing the locations of test pits and auger transects*

Jelića Brdo

Jelića Brdo is approximately 19km north of Banja Luka, 500m west of the town of Laktaši in the foothills to the west of the Vrbas River, 2.5km away (Fig. 1). The area contains four separate sites numbered 1-4 but for the purposes of the geoarchaeological survey the area was treated as a single site. Material recovered from the area during the 2006-2007 field survey was predominantly Palaeolithic in age, but there was also a small amount of possible Neolithic pottery and stone finds recovered from the area (P. Miracle and T. Rajkovaca, pers. comms.). Two long transects with 19 boreholes were augered in order to maximise coverage across the large site area (Fig. 11). In addition to the auger survey two 1m^2 test pits were excavated. Transect 1 ran along a northwest-southeast alignment with a test pit (TP2) in the centre of the transect. Transect 2 ran roughly west to east with a 'dog leg' in the middle due to tree coverage at the site with test pit 1 located on the first corner of the transect, at the highest point at the site.

As for the other sites in the area the stratigraphy was fairly uniform. The modern ploughsoil (Ap horizon) of 35-55 cm in thickness was developed directly on top of the weathered natural bedrock (B/C horizon). The only exceptions to this were two boreholes which had a weakly formed subsoil (B horizon) of around 15 cm in thickness. The Ap horizon consists of a brown clayey silt and where it was present, a B horizon of a mottled yellow/grey/brown silty clay loam. The B/C horizon across the site consists of an orange grey, pebble gravel rich, sandy clayey silt loam.

Samples were taken from test pit 1 for geochemical analysis from the Ap and the B/C horizons in order to assess the preservation potential of the site. Analysis showed acidic soil conditions with decreasing acidity with depth. The organic content of the samples is consistently low around 3.5% and there are relatively low readings of magnetic susceptibility (at 18-20 SI Units) and electrical conductivity (at 81-123 μS/cm) (Table 1; App. 1).

Čardar Čardačani

Čardar Čardačani is situated 13km northwest of Banja Luka and 3.5km east of the modern Vrbas River (Fig. 1). The site investigated is *c.* 300m north of Čardak 1 and 2, investigated during the 2006-2007 field survey. During the field survey a large number of ceramic and stone artefacts were found including ceramic sherds believed to date from the Bronze or Iron Age. Due to the large number of finds discovered in the area and its location on a gentle slope in a dry valley it was selected for further investigation. A total of 24 boreholes and three test pits excavated, and in addition an exposed profile 400m to the west of the site area was examined (Fig. 12). Transect 1 was aligned northwest to southeast alignment ran across the main hillock in the centre of the site. Transect 2 was aligned downslope from the northeast to the southwest.

The auger showed two different types of profile at the site. On the lower ground in the northeast and southwest of the site there was *c.* 20-40 cm of modern ploughsoil present directly on the weathered natural. Elsewhere on the site beneath the ploughsoil there was layer of loess-like sedi-

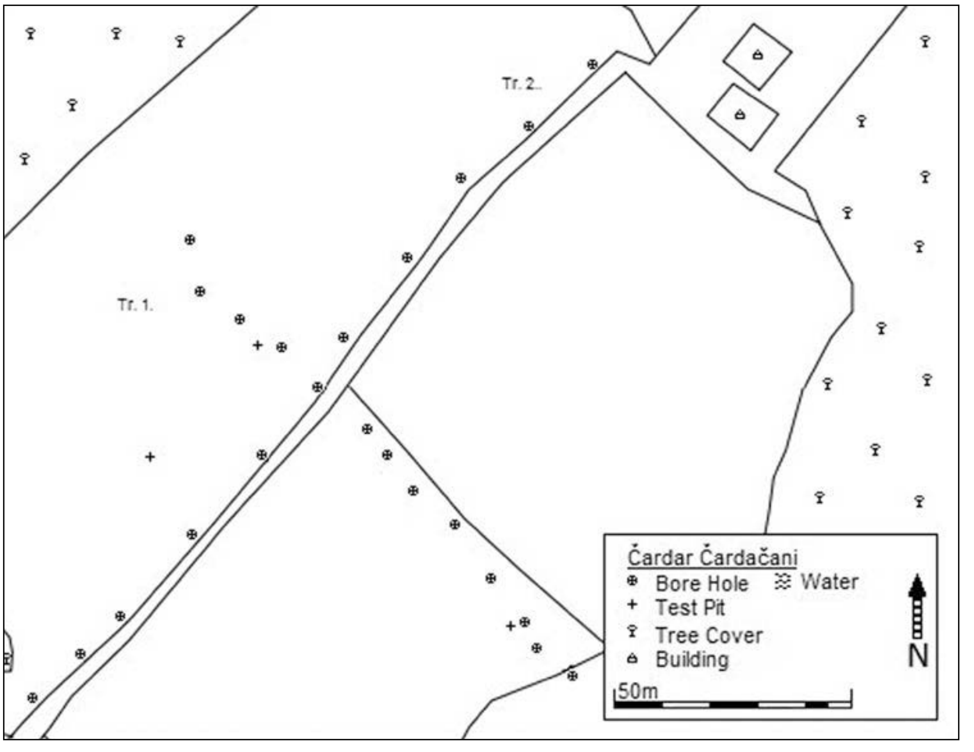


Fig. 12. *Site map of Čardar Čardačani showing the location of test pits and auger transects*

ment between 10-35 cm in thickness, found directly on the weathered bedrock. The only exceptions to this were at the far southeast of the site where a 45-65 cm thick layer of alluvial material was beneath the ploughsoil and above the natural sediments. The ploughsoil (Ap horizon) at the site was a dark brown silt and the subsoil (B horizon) was a fine grained lighter brown silt. The weathered natural (B/C horizon) appeared as a clayey silt with a mottled grey and orange colour. The alluvial deposits appeared as a lighter brown silt with small amounts of charcoal and flecks of unfired ceramic.

Samples were taken from test pits 2 and 3, from the Ap, B and B/C horizons in order to assess their preservation potential and discover if any indications of human occupation could be detected at the site. The sediments at the site were weakly acidic with values ranging from a pH of 6.05 to 5.48 (Table 1; App. 1) meaning that the preservation of faunal and other (uncharred) organic remains is unlikely. The organic content of the sediment consistently fell from the topsoil downwards, as did the magnetic susceptibility and electrical conductivity, suggesting that few, if any, old land surfaces or other occupation features will remain preserved at the site. The exception to this was the sample of the B/C horizon from test pit 3 which did exhibit an elevated organic content, conductivity and magnetic susceptibility; however this is more likely to be anomalous than indicative of any archaeological feature and is likely due to natural variance in the sediments. In addition to the geo-chemical samples, a large block sample was taken from test pit 1 for micromorphological analysis covering the Ah/b transition and much of the B horizon.

The micromorphology from 17-28 cm in depth showed a combination of very fine sand, silt and clay, yellow brown in colour, with a homogenous fabric and a large amount of organic staining (Fig. 13; Table 5; App. 2).

The sediment is loess-like but the presence of some angular particles (Fig. 13) means that not all of the material is aeolian in origin. The slide shows an incredibly dense stable environment as there are no clay lined voids or other pedofeatures associated with bioturbation. The density of the sample and abundance of sand suggests a reworked loessic derived sediment, which could

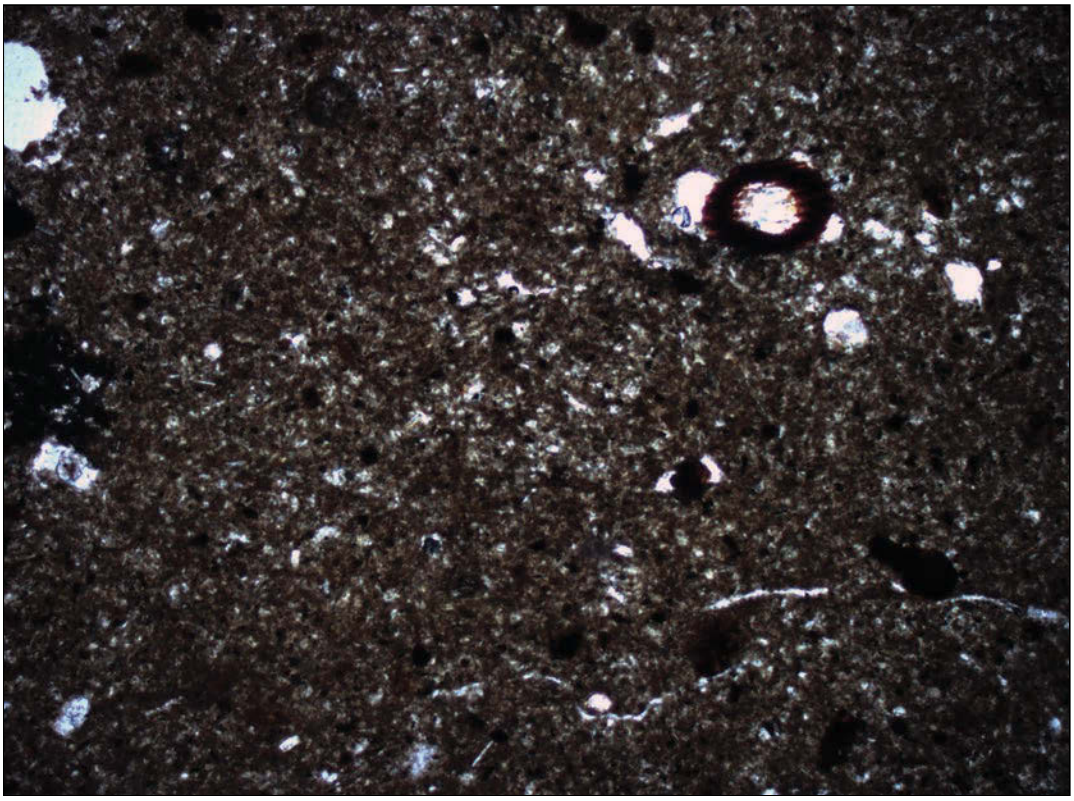


Fig. 13. *Photomicrograph from Čardar Čardačani at* 1:10 *showing the dense loess-like groundmass*

Unit	Structure	Fabric	Features	Horizon	Interpretation
CHA 10 – TP1					
17 – 28cm					
	subrounded to	very fine sand,	dusty clay; amorphous	Bw	well structured, disturbed, illuvial Bw horizon with loess
	subangular	silt and clay loam	organic		derived component
	some angular		vegetal voids		

Table 5. *The key micromorphological features from the upper slide at Čardar Čardačani*

have been inherent in the subsoil rather than transported.

The second slide from the site was taken from a depth of 27 to 38 cm. It showed a relatively homogenous, yellow brown sandy clayey silt, the same as in the other slide but with a lower amount of organic staining (Fig. 14; Table 6; App. 2).

This shows an *in situ* argillic Bt horizon of a once wooded soil with a weathered loessic component. Again the presence of angular sand in the groundmass suggests that aeolian deposition is not the only factor contributing to the very fine sand component of this soil.

Luka

The twin sites of Luka 1 and 2 are two natural ridges of higher ground, aligned north-south. The area is 500m to the west of Čardar Čardačani, 2.75km east of the modern Vrbas River and 15km northeast of Banja Luka (Fig. 1). When investigated as part of the survey in 2006 Luka 1, the eastern ridge, showed a large number of ceramic and stone finds believed to be Neolithic (P. Miracle and T. Rajkovaca, pers. comms.). The western ridge, showed much less pottery but a moderate high number of stone finds. Nineteen boreholes and three test pits were excavated at

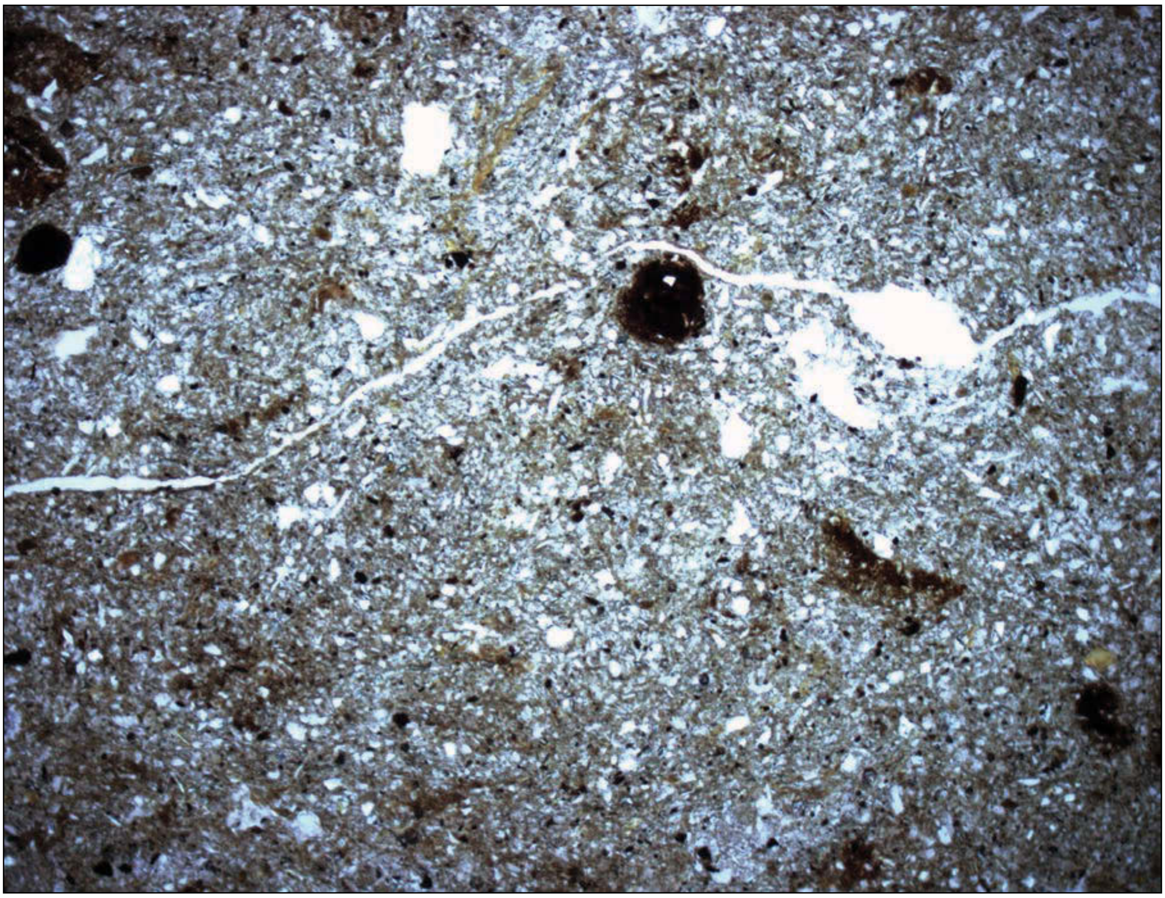


Fig. 14. *Photomicrograph from Čardar Čardačani at* 1:10 *showing clean clay (golden streaks) and amorphous organic material (dark patches)*

Unit	Structure	Fabric	Features	Horizon	Interpretation
CHA 10 – TP1					
27-38cm					
	subrounded to subangular	very fine sand, silt and clay loam	clean clay linings some amorphous organic	Bt	in situ argillic
					brown earth under woodland; with loessic
	some angular				component

Table 6. *The key features from the micromorphology of the lower slide at Čardar Čardačani*

the site. The initial transect from west to east, with the boreholes spaced every 20m, and was laid out in order to investigate both ridges and the low ground in between (Fig. 15). Two further transects were augered, one along the eastern ridge of Luka one to investigate the highest concentrations of finds, and the second in the area of lower ground between the two ridges of higher ground to test for the presence of buried soils. In addition to the boreholes, test pits 1 and 2 were excavated at the northern and southern ends of the eastern transect and test pit 3 was excavated on the western ridge of Luka 2 to examine both sites.

Across the site there was between 15 and 40 cm of modern ploughsoil (Ap horizon). Along the eastern transect on Luka 1 and on its western slope, there is only the modern ploughsoil

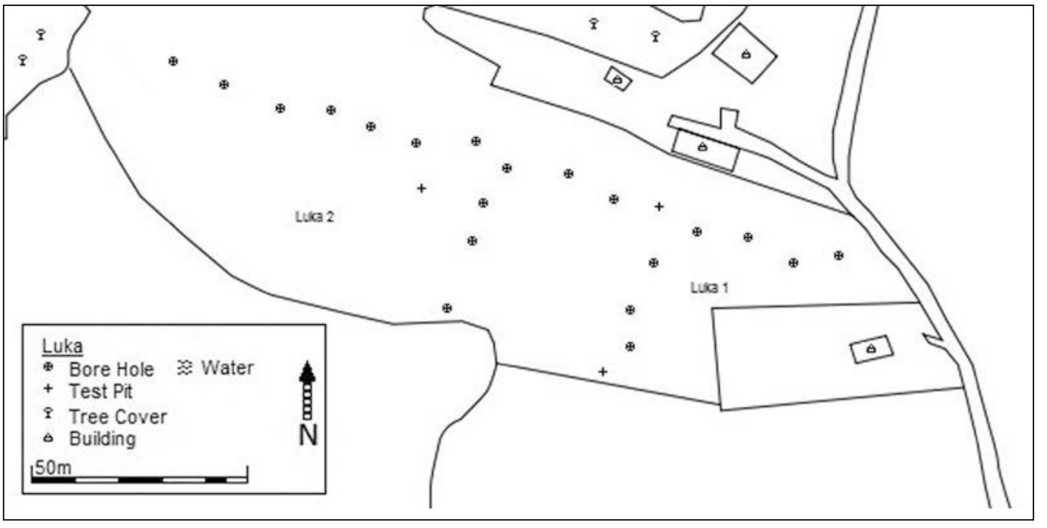


Fig. 15. *Site plan of Luka showing the locations of test pits and auger transects*

directly on top of the weathered natural bedrock (B/C horizon). Elsewhere on the site, a subsoil of between 20 and 60 cm in thickness was present. The Ap horizon composed of a brown silt; the B horizon was a lighter brown finer silt, and the B/C horizon composed of a grey and orange clayey silt with fine stones/gravel. Due to its similarity and geographical proximity to Čardar Čardačani only two sediment samples were taken from the site. The results were very similar to those at Čardar Čardačani, with weakly acidic sediments throughout and low electrical conductivity, magnetic susceptibility and organic content (Table 1; App. 1).

Stari Martinac

Stari Martinac refers to two sites, first identified during the field survey in 2006-2007 (P. Miracle and T. Rajkovaca, pers. comms.). It is approximately 32km northeast of Banja Luka and 300m east of the Vrbas (Fig. 1), sitting upon hill overlooking a meander in the river. During the field survey of the two sites, a reasonable number of lithic finds were found (72 and 49) but only two prehistoric ceramic sherds were recovered. Both sherds were well worn and many of the lithics were indicative of core based technologies suggesting that the site is more likely Palaeolithic with some small scale later used during the Holocene. A 'T'-shaped transect was augered at the site along with four test pits. The test pits were excavated at the top of the 'T,' the northern and southern tips and mid way down the longer line of the transect (Fig. 16). In addition to this an exposed section in the middle of the site was recorded.

Across the site the modern ploughsoil (Ap horizon) was between 20-35 cm in thickness and consisted of dark brown silts. At the centre of the site, in the area around the exposed profile, test pit 2 and the two boreholes to either side of test pit two, beneath the topsoil was a 25 cm thick grey silt soil horizon (or B horizon). Beneath this and everywhere else on the site, the weathered natural bedrock was present directly beneath the topsoil. This is a yellowish white sandy silt loam with small, granular dark patches, probably of manganese.

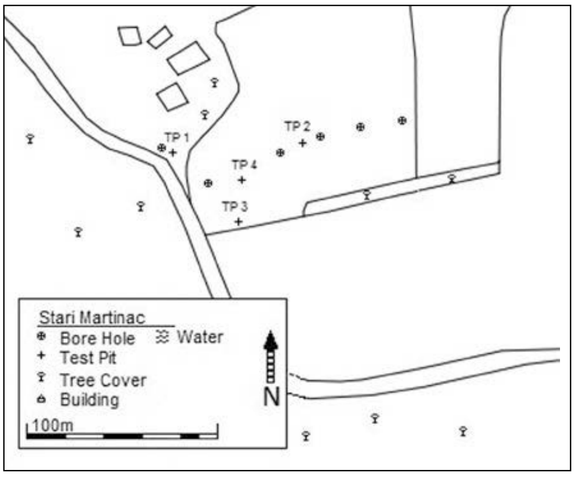


Fig. 16. *Plan of Stari Martinac showing the location of test pits and auger transects*

Samples of the three different horizons were taken for geo-chemical analysis from the exposed profile and test pit 2 (App. 1). In addition samples of the B/C horizon were taken in order to establish background readings. The sediments and soils at the site are all acidic to circum-neutral with the lowest values around a pH of 5 and the highest values around a pH of 6.32. The organic content of the site was consistently low between 2.5-3.5% and the electrical conductivity and magnetic susceptibility results were also consistently low.

Tomasovo Brdo

Tomasovo Brdo was the final area of sites to be visited during the spring field season in 2010 and is a considerable distance from the Vrbas River valley, *c.* 60km east from Banja Luka (Fig. 1). The site is situated on a gentle north-south slope of a high hill. The area was selected as part of it had been previously excavated between 1959 and 1979[21] with both Palaeolithic and Eneolithic finds present.

The area chosen to be investigated was approximately 400m west of the previously excavated areas, as these were no longer accessible. From the field survey in 2006-2007 a large number of finds were recovered (P. Miracle and T. Rajkovaca, pers. Comms). From site one, 216 lithics believed to date from the Palaeolithic and Neolithic, and 92 prehistoric ceramic sherds. In addition to the lithics and ceramic burnt daub was discovered at the site. Together this artefact assemblage suggests the presence of an early Holocene occupation site. Seven boreholes were excavated at the site on a northeast to southwest alignment (Fig. 17). Supplementing this transect, two test pits were excavated close to the boreholes which showed the best signs of finding *in situ* archaeology and a buried soil.

Across the site the modern ploughsoil (Ap horizon) was between 20 and 46 cm thick and was composed of a brown silt. Beneath this horizon was a *c.* 28-85 cm thick, dark brown silt with black manganese flecks (B horizon). Beneath this was between 15 to 40 cm of a dark grey very fine silty clay (or a Bt horizon), developed on a yellow grey pure clay weathered natural (B/C horizon).

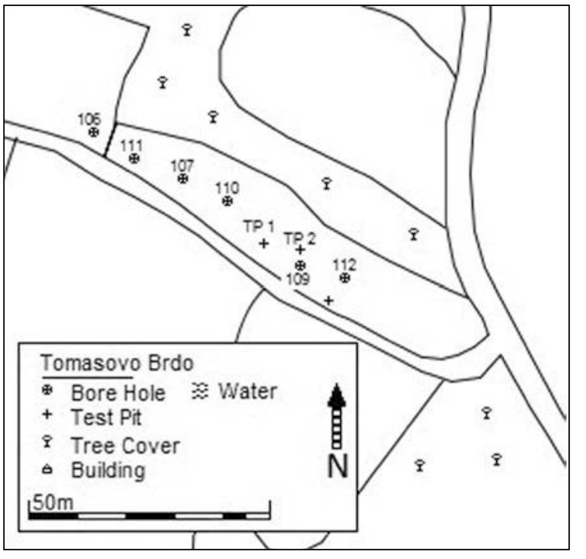


Fig. 17. *Site plan of Tomasovo Brdo showing the locations of test pits and auger transects*

Soil samples were taken every 10 cm from test pit 1 and approximately every 30 cm from the borehole immediately to the east (BH 109). Additional samples were taken from each horizon at further three boreholes (BH 110-112). The sediments at the site are all acidic with values ranging from a pH of 5.29 to 6.41 (Table 1; App. 1). The pH of the sediments becomes less acidic down-profile, shown in both test pit 1 and borehole 109. The electrical conductivity was generally low across the site with the highest levels coming from the modern topsoil and decreasing with depth. The degree of magnetic susceptibility featured peaks at around 70 cm deep and again at around a meter in depth. This corresponds to the top and bottom of the Bt horizon. There is also an elevated organic component to the sediments in these areas. Block samples for micromorphological analysis were taken from test pit 1 at a depth of 50 to 70 cm, which had hints of being a buried soil on site.

The micromorphology shows the sediment is a homogenous yellow brown clay silt with little structure in the upper half of the slide and a sub-angular blocky structure in the lower half (Table 7; App. 2).

The predominance of very fine quartz sand and coarse silt is suggestive of a loessic origins. But the void channel dusty clay and coatings are indicative of later disturbance of this soil.

[21] Basler 1979

Unit	Structure	Fabric	Features	Horizon	Interpretation
TOM 10 – TP 1					
50-60cm					
	subrounded to subangular	organized silt and clay	void infills with dusty clay amorphous iron	Bwt	woodland soil, formed
					in loessic deposit, with episodic phases of disturbance

Table *7: The key features from the micromorphology of the upper slide at Tomasovo Brdo*

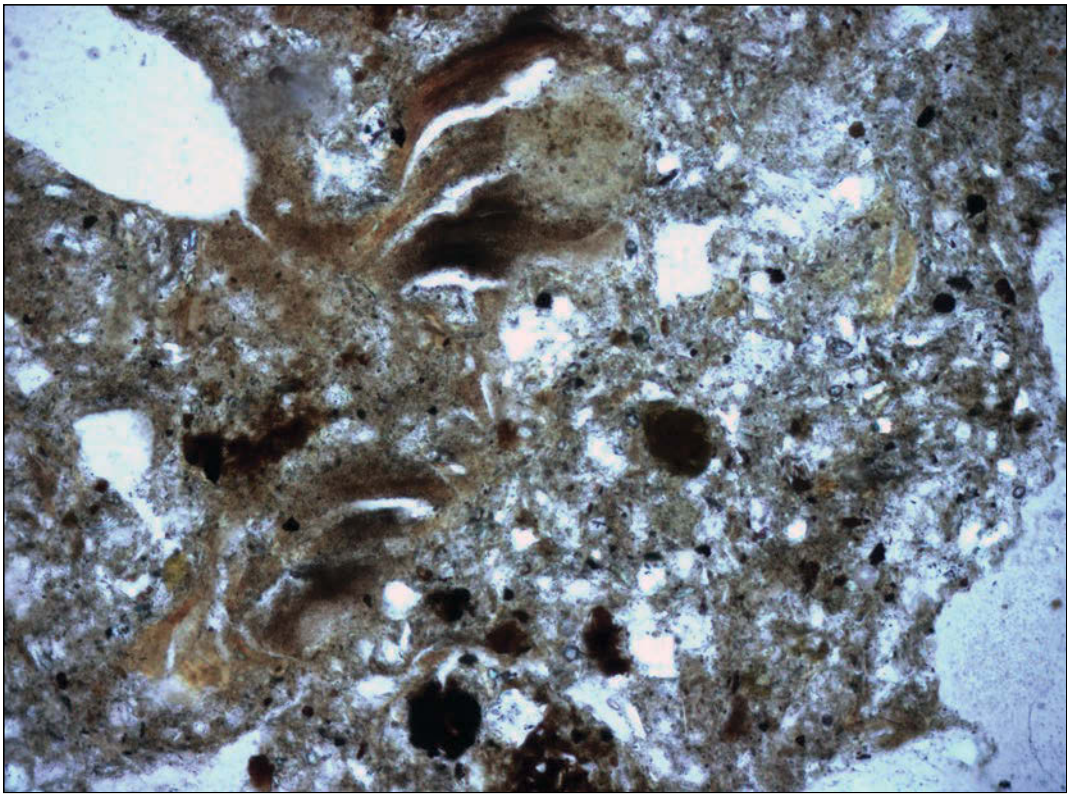


Fig. 18. *Photomicrograph at* 1:20 *showing the dusty clay infills*

The amorphous iron is evidence of groundwater fluctuation and alternating wet to dry conditions. The primary, pure or clean illuvial clays (Fig. 19), indicate slow illuviation in the past, whereas the presence of dirty clay suggests more modern disturbance. The golden streaks of pure clay are former coatings on the outside of peds that have been subsequently incorporated in the groundmass through soil mixing processes. The finer, purer, reticulate clays in the groundmass are indicative of soil formation under stable, well drained, probably wooded conditions.[22]

[22] Bullock and Murphy 1979; Fedoroff 1968; Goldberg and Macphail 2006

The dusty clays are indicative of subsequent illuviation associated with disturbance of the upper part of the soil profile, and the channel/void infills of dirty clay are probably the result of recent disturbance.[23] Thus this is probably the weathered and clay-enriched (or Bwt horizon) of a former woodland soil, or argillic brown earth, formed in loess, which has been much disturbed in the past and more recent times.

The second micromorphological sample forms the lower half of the horizon described above. It is also characterised by a homogenous

[23] Macphail *et al.* 1990; Goldberg and Macphail 2006

Unit	Structure	Fabric	Features	Horizon	Interpretation
TOM 10 – TP 1					
60-70cm					
	subrounded with	organised silt clay	void infills with	Bwt	woodland soil, formed
	slight subangular		dusty clay		in loess, with phases of later
			amorphous iron		disturbance

Table 8. *The key features from the micromorphology of the lower slide at Tomasovo Brdo*

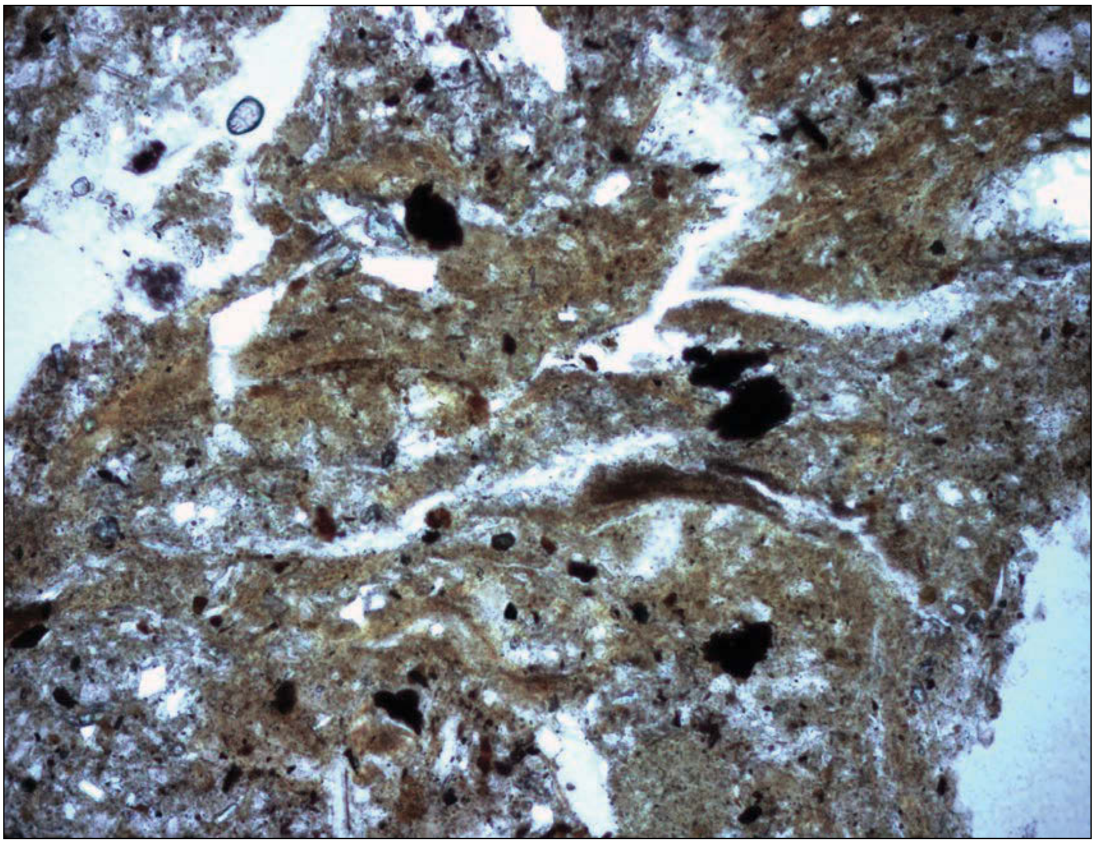


Fig. 19. *Photomicrograph at* 1:20 *showing clean clay coatings and amorphous organic inclusions*

groundmass of yellow brown silt and sand with patches of reddish clay (Table 8; App. 2). This evidence suggests it is also an *in situ* argillic Bt of a woodland soil, but obviously the eluvial Eb and organic Ah horizons above are missing, truncated by more recent agricultural activities.

With a large number of sites investigated in the Vrbas valley and only a few glimpses of buried soils, the decision was made to widen the area in focus. The Ukrina River, to the east of the Vrbas was chosen due to the large concentration of sites in its valley and the possible existence of a river terrace, which could contain buried soils. Sites were again selected to represent a variety of different parts of the valley so that the maximum amount of information could be gained. As with the Vrbas valley, certain sites had been recorded during the investigations of Basler in the 1970s. Many sites in the area had also been visited during the 2006-07 field survey.

Luščić

The site of Luščić is approximately 43km east of Banja Luka, 170m south of a meander in the Ukrina River on the valley bottom, 168m above sea level (Figs. 1 & 20). The site is one of the more

Fig. 20. *Luščić, as viewed from the south looking towards the Ukrina river*

well known in the area having been an early example of rescue archaeology in Bosnia and Herzegovina. It was first located during the construction of the new Banja Luka – Doboj railway line in the 1950s and was systematically excavated between 1958 and 1980 with *c*. 250m^2 excavated.[24] The most recent work at the site was by Kansas University which revealed a single Palaeolithic layer, rich in Aurignacian artefacts, found around 90 cm beneath the surface (*ibid*.). The site was visited during the 2006-07 field survey but due to poor visibility no finds were recovered. Due to the small area of the site remaining, only four boreholes were excavated in a square pattern. The sediment pattern was the same for all four boreholes with between 5-50 cm of silty brown modern ploughsoil (Ap horizon) over a weathered natural (B/C horizon). The Palaeolithic archaeology found at previous excavations was within the weathered natural and is therefore outside the scope of this thesis, although it would be ideal for future investigation. No geochemical samples were taken from the site as it appeared that the sediments explored were no longer *in situ*.

Kremna-Njiva Tome Milankovića

The area around the site of Kremna-Njiva Tome Milankovića was first identified and investigated during the 2006-07 field survey. The area is approximately 44.5km east of Banja Luka, 2.5km west of the Ukrina River on a small rise next to a small stream (Fig. 1). During the field survey a variety of sites were investigated with a large number of lithic finds, but the site boundaries were unclear. A transect of eight boreholes, spaced 20m apart, were excavated on an east-west alignment up-slope with two additional boreholes located in a dip between two hill-tops and at the highest point of the site (Fig. 21). This was to maximise the area covered and to see the effect erosion may have played in the site formation. A well preserved polished hand axe was recovered from the surface in the area around the easternmost borehole.

The transect showed a familiar soil profile. The modern surface consisted of between 7 and 27 cm of organic rich brown modern humic silty

[24] Montet-White and Johnson 1976

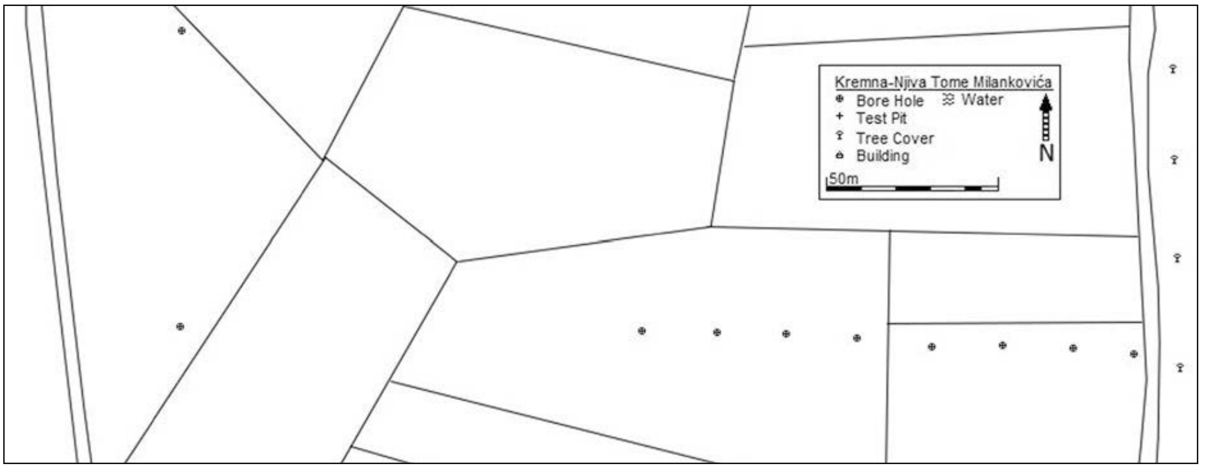


Fig. 21. *Site plan of Kremna-Njiva Tome Milankovića showing the location of the boreholes excavated at the site*

soil (or Ah horizon). Under this was *c*. 15 cm of dark brown silt soil (or B horizon), developed on the weathered natural (B/C horizon). The only exception to this was at borehole 38 where the B horizon was missing. It is not surprising that there is a general trend towards thinner sediments on the hillside, compared to the valley bottom, most likely caused by hillwash erosion. The two boreholes separate from the main transect showed interesting results. Borehole 46, at the highest point of the site, had only 5 cm of modern soil present on the weathered natural. Borehole 45, in the dip between the two hill-tops, had an 80 cm thick B horizon indicative of some colluvial accumulation. Geo-chemical samples were not taken, however the site would benefit from further sampling and analysis.

Miljević

The site of Miljević is approximately 42km east of Banja Luka and 1.5km west of the Ukrina river (Fig. 1). The site was first recorded during the 2006-07 field survey, where 102 lithic finds were recovered (P. Miracle and T. Rajkovaca, pers. comms.). The area searched was a small garden vegetable patch on the top of a steep slope leading down to a small stream. Two boreholes were excavated to the east of the field-walked area (Fig. 22), and due to what appeared to be a palaeosol in the section, a trench was excavated instead. This enabled block samples for micromorphology to be taken.

The western borehole showed a thick, compact organic-rich topsoil (or Ah horizon) of *c*. 20 cm in thickness above a lighter brown organic silty clay (or B horizon). At a depth of 109 cm the sediment changed to a stony dark yellow sand mixed with the silty matrix. The borehole bottomed at 163 cm where the sediment was a yellowish brown gravelly sand (or C horizon). The test trench showed a similar stratigraphy with 15 cm Ah, 40 cm B, and then a mixture of orange, brown and yellow stony sand silt clay loam to a depth of at least 1.05m. The same profile was found 20m to the east at borehole 49. Geochemical samples were taken from borehole 49 and the test trench at every 10 cm (App. 1). In addition to the standard testing, small bulk samples from the trench were sent for multi-elemental analysis (App. 1).

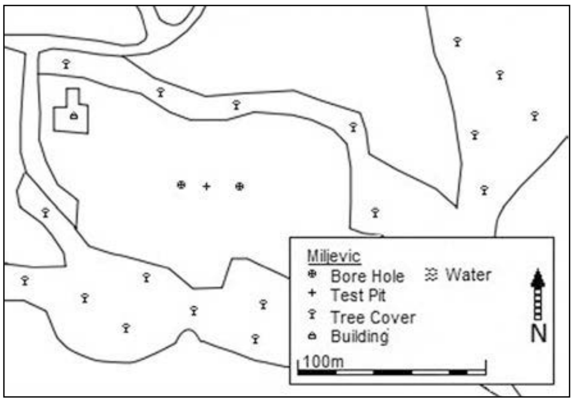
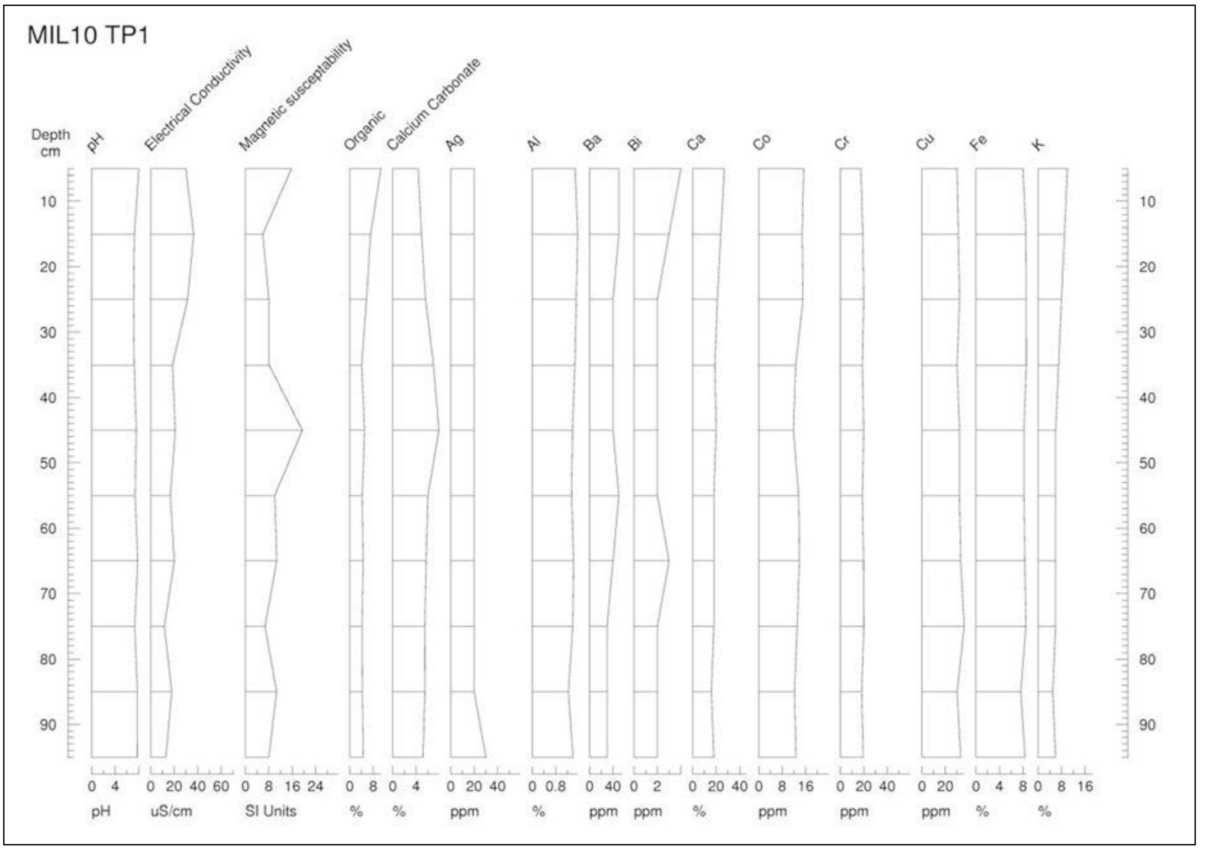


Fig. 22. *Plan of Miljevic showing the locations of the boreholes and test pit*



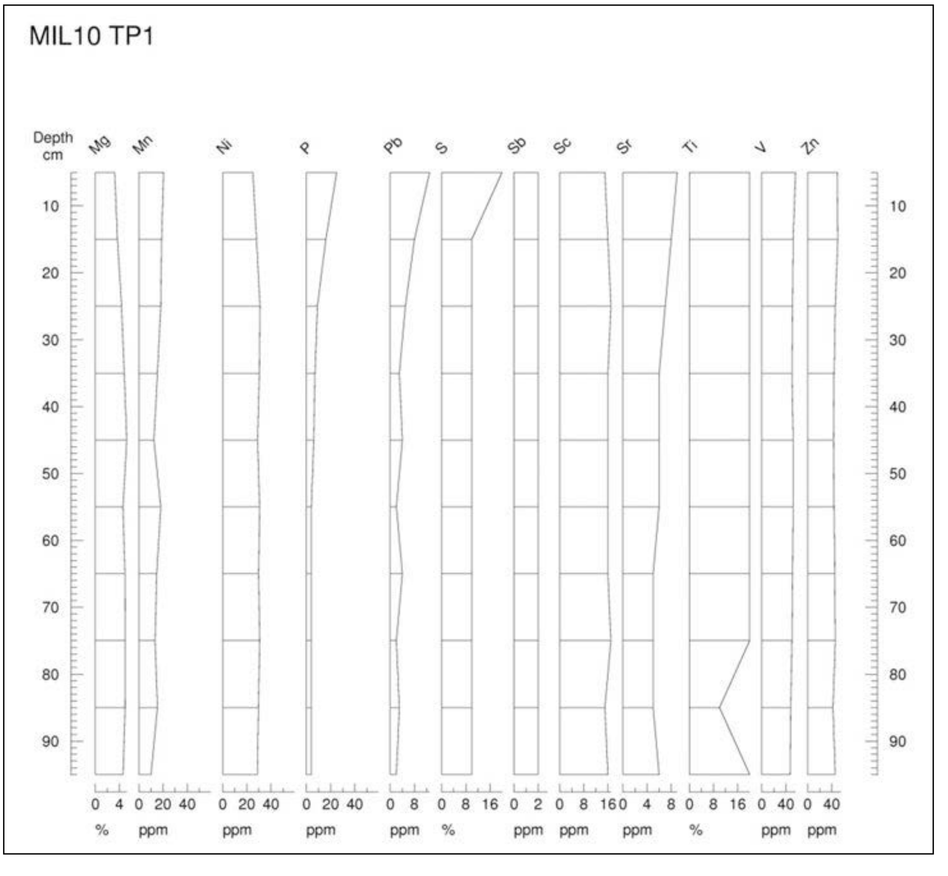


Fig. *23: Multi-elemental data from Miljevic*

The soils and sediments at the site are all slightly alkaline with pH values ranging from 8.03 through to 7.12 (Table 1; App. 1) suggesting a high potential for preservation of faunal material and charred organic remains. There is a peak in both magnetic susceptibility and electrical conductivity at a depth of around 55-75 cm in the trench which corresponds to the transition between the B horizon and the gravels beneath. This may reflect both settlement activity and/or a concentration at this level at the base of the modern ploughsoil. The organic content is also high, suggesting the presence of a remnant buried soil. The multi-element analysis shows no significantly elevated elements in the profile, aside from the expected elevations close to the modern land surface for elements such as phosphorus (Fig. 27).

Brijeg, Brdo and Grabovac (Area 55)

The final site investigated in the hills around the Ukrina Valley is in the area around the known sites of Brijeg, Brdo and Grabovac (Fig. 1). Due to a confusion in the field as to the exact location of the site, it is referred to as Area 55, in order not to clash with the 2006-07 field survey. The area is approximately 46km east of Banja Luka and runs from the western bank of the Ukrina, along the floodplain for 140m before coming to a steep slope upon which there is a plateau. The sites around the area studied showed a variety of finds, largely Palaeolithic in date (P. Miracle and T. Rajkovaca, pers. Comms.). However there were also lithics that are believed to be Neolithic/Eneolithic in date, suggesting some Holocene activity in the area. The site appears to be a river terrace with a wide floodplain. It was therefore decided that it would be intensively augered in order to assess the preservation potential of geoarchaeological features. A transect of 10 boreholes and three 1m test pits were excavated on a northeast to southwest alignment from the top of the terrace, down-slope and into the floodplain (Fig. 24). The test pits were located at the bottom of the terrace to check the sedimentary profile, the middle of the slope to get an idea of the erosional processes, and on the floodplain edge to search for buried soil.

The investigations at the site show a complicated, but logical stratigraphy. Across the site there is a modern organic rich silty humic topsoil (Ah horizon) of between 16 and 49 cm in thickness. It is thinnest along the floodplain and thickest on the top of the terrace. At the top of the terrace and down the bank, beneath the topsoil is between 15 and 45 cm of lighter brown sandy silt soil (or B horizon). On the floodplain part of the site the subsoil is a light brown sand silt loam. On the top of the terrace and along the slope beneath the upper B horizon is a lower Bw horizon consisting of a light grey/brown clayey silt, except at borehole 55 where the upper B is directly on the weathered natural. On the lower half of the site beneath the upper B there is a lower B consisting of a light brown/orange sandy silt. The natural (B/C horizon) consists of an orange grey clayey silt. On the slope and lower part of the site the natural is gravelly sands, assumed to be the old river levee deposits.

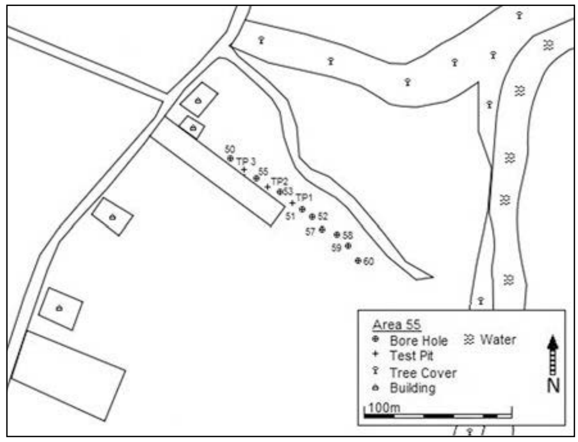


Fig. 24. *Plan of the auger transect and test pits from Area* 55

Samples were taken for thin section analysis, geo-chemical samples were taken from every borehole and test pit at 10 cm intervals where possible, and for multi-elemental analysis. The soil pH at the site is consistently around neutral to calcareous with the extremes at 6.07 and 8.36, respectively (Table 1; App. 1). There is a general trend at the site of an increase in pH with depth, which indicates that the preservation of faunal remains is likely to be good.

Multi-elemental analysis from the top of the terrace shows no elevations in the elements normally used to recognise human interference with

Fig. 25. *View of Area 55 from a hill behind the river, the auger transect extended towards the river from the orange house in the mid-ground*

the landscape,[25] except for elevated levels of Hg. This is most likely due to the presence of raw sewage west of the transect, which could of been washed down-slope. Test pit 2, excavated at the midpoint of the slope showed elevated amounts of many elements at a depth of 70 cm (Fig. 26). Of the elements generally used to infer human interaction (i.e. Ba, Ca, P, Pb, Sr and Zn) all had elevated levels at this depth. Borehole 53, on the lower half of the slope, showed to areas of elevation of certain elements. But between 70 and 80 cm elevated levels of Al, As, Co, Cr, Cu, Fe, Mg, Mn, Ni and Sc are found. Between 1m and 110 cm elevated levels of Ba, Cu, Ca, Mg, Mn, Sc, Ti, Sr and Zn are found. At Test Pit one, at the base of the terrace and layer of elevations is present at a depth of 110-120 cm, although the degree of elevation is less here than elsewhere. The elements with elevated levels are Al, Ba, Ca, Co, Cu, K, P, S, Sc, V and Zn. At borehole 52 on the floodplain almost all elements tested showed elevations at a depth of 40-50 cm. The majority of those that were not elevated had a noticeable decrease in their volume (Cr, Mg and Na). Results from further into the floodplain (BH 58) failed to show any significant increase in the amount of elements present.

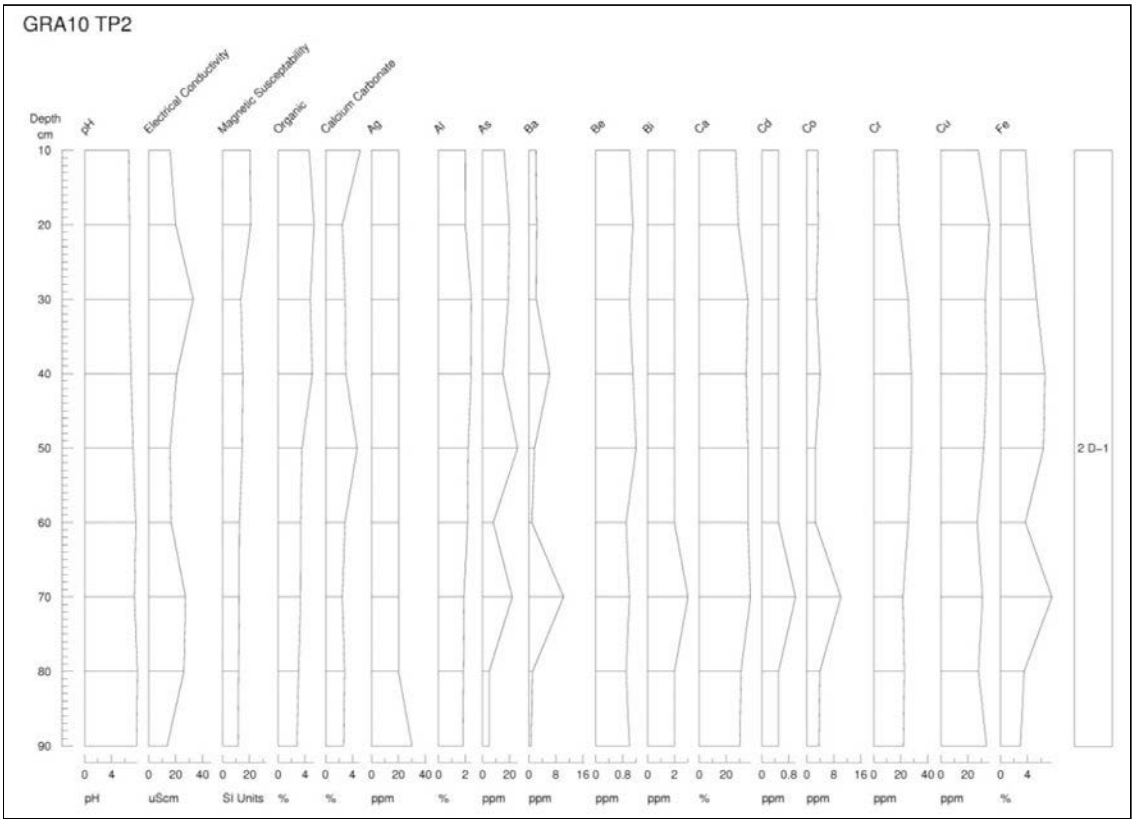
Rastuśa Pecine

The final site investigated for this research was the cave site of Rastuśa Pecine, located *c.* 50km southeast of Banja Luka (Fig. 1). This limestone cave is a combination of tunnels and caverns cut into a steep hillside. The cave was visited during excavations under the directorship of Dr. P.T. Miracle. Three trenches were opened at the site; one immediately in the cave entrance, a second approximately 40m into the cave, and a third in a small chamber in the rear of the cave. All were excavated from the modern surface to the natural limestone. In addition to the trenches, 17 boreholes were excavated at 10m intervals from the cave entrance heading inside. Both previous[26] and current excavations exhibited a thin Holocene deposit above much deeper glacial and Pleistocene deposits with little evidence for human interaction at the site.

The boreholes were excavated with the purpose of locating the extent of the previous excavations at the cave, which was completed with no

[25] Entwistle *et al.* 2000; Wilson *et al.* 2008

[26] Malez *et al.* 1978



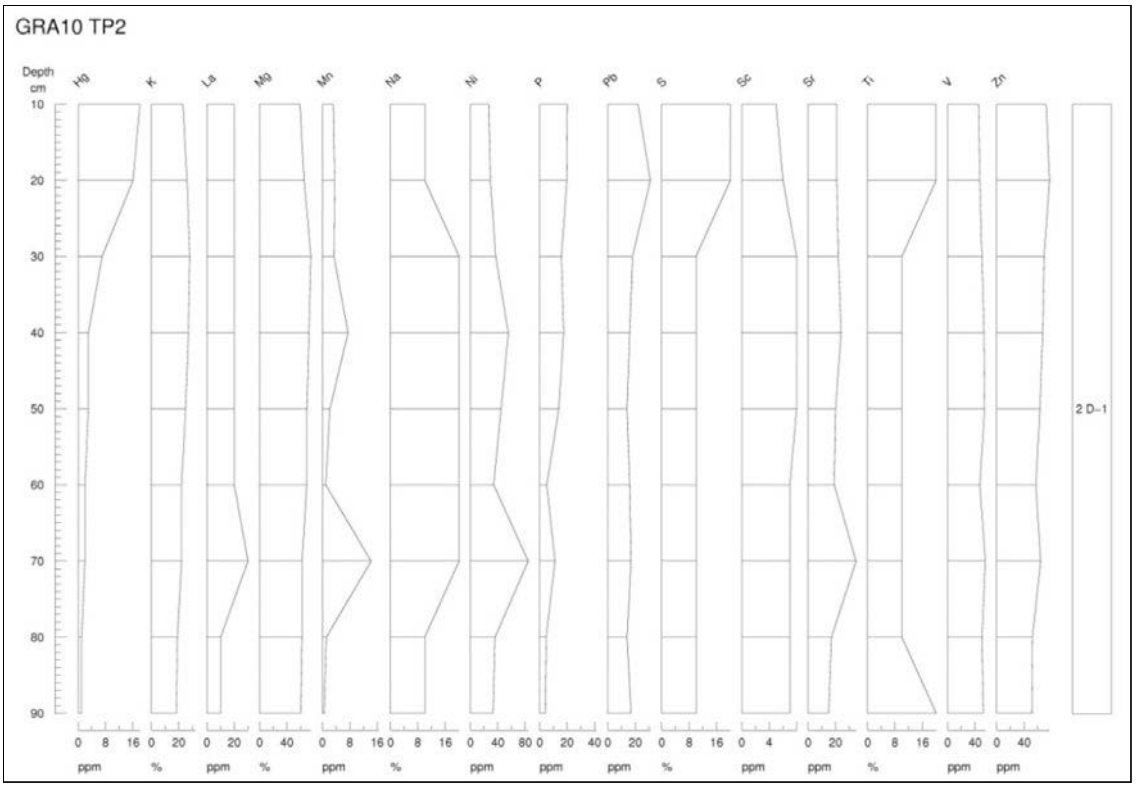


Fig. 26. *Multi-elemental data from the Area* 55 *test pit showing the elevated levels of certain elements at a depth of* 70cm

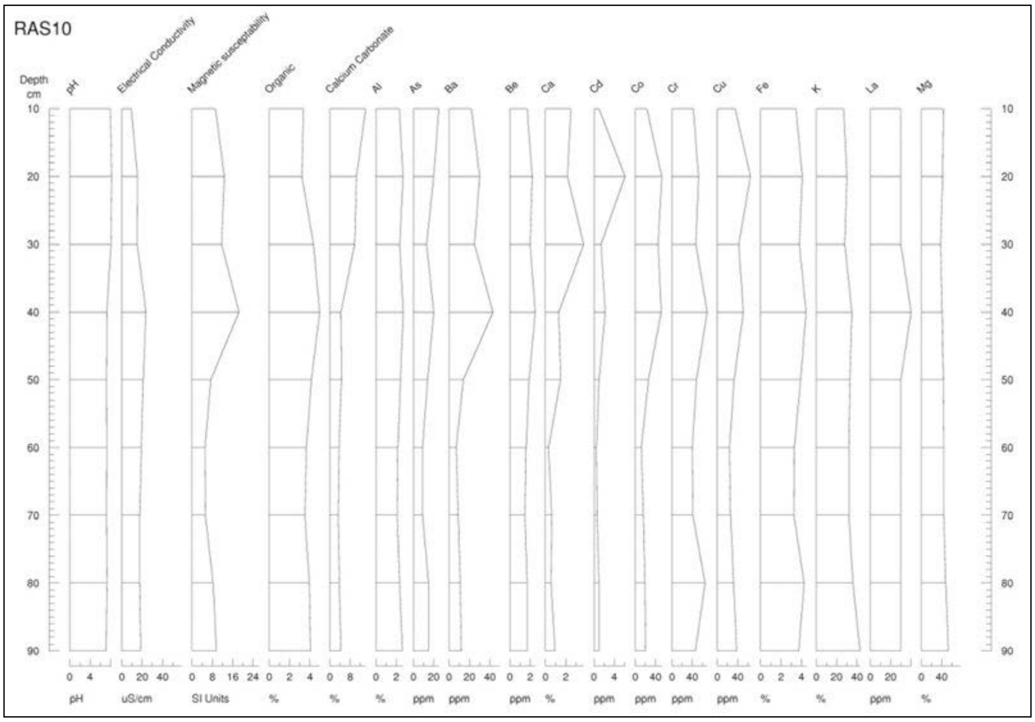


Fig. 27. *Multi-elemental data from trench* 2 *showing an elevated level of elements around* 40cm

problems and also to highlight the best areas for future excavations. The three excavation trenches were all sampled at 10 cm intervals and the top 90 cm of samples were subject to elemental, as well as physical and geo-chemical analysis. The pH of the sediments is all consistently alkaline or circum neutral with the exception of borehole 12 which was on the margin of the previous excavation, possibly within the previous backfill. This would explain the unusual readings (pH of 4.71-6.81) (Table 1; App. 1). With the exception of borehole 12, pH values at the site ranged from 6.64 to 8.48 (Table 1; App. 1). The site consistently showed the highest elevated levels of magnetic susceptibility, electrical conductivity, organic and calcium carbonate content, which is most likely to the great periods of stability experienced inside the cave, the introduction of guano and the damp percolating conditions. Within the generally high readings, there are areas of specific higher readings, at 40 cm depth in Trench 2 for example, the organic content, electrical conductivity and magnetic susceptibility are all elevated. Multi-elemental analysis was performed on the sediments from trenches 1 and 2. Trench 1 shows a general trend of increasing amounts of most elements from 50 cm downwards. The exceptions were As, La and Mg which all decrease around the same point (Fig. 26). Trench 2 showed a peak in many elements (Al, As, Ba, Be, Co, Cr, Fe, K, La, Mn, P, Pb, Sr, Ti, V and Zn) (Fig. 27), which corresponds to the peaks in conductivity, susceptibility and organic content at 40 cm, and possibly being indicative of occupation levels.

Discussion

The central theme of this research is the development of a geoarchaeological approach to investigate the interaction between humans and their environment in the Holocene in the Vrbas and Ukrina River valleys of northern Bosnia and Herzegovina. The earlier Holocene was a time in which humans' lifestyle change from a hunter-gatherer existence to a more sedentary one. By about 5000BC, a settled agricultural way of life was becoming predominant in the Balkan Peninsular, beginning in Greece and moving northwards. Invariably there would have been both wider and longer-term environmental change, but also people and their activities would have had an effect on the environment surrounding them. In order to live a sedentary life it was necessary for people in the past to adopt farming, as otherwise they were largely dependent on movement for the procurement of food.

In order to farm, land must be reasonably clear of other vegetation and have soil conditions suitable for the growth of domestic crops. Therefore deforestation must have taken place in the area, as must a degree of trial and error in terms of determining the best locations for crop growth. Deforestation would have had a huge impact on the development of the soil profile. But the largest effect Neolithic people had on their landscape, aside from tree clearance, was arable agriculture and its associated disruptive effects. These generally loessic-derived soils in the Banja Luka area would have been free-draining, nutrient-rich and easily turned, all attributes that would have been desirable for easy exploitation by the first farmers once cleared. On the other hand, these 'ease of use' features would have made these silt-rich soils susceptible to detrimental hill-slope erosion processes such as overland flow and colluviation.[27] From the earliest evidence of the growth of domestic crops, there is evidence of ploughing. However difficulties arise when similar effects and resultant soil features can also be caused by natural processes (equifinality). It is important to remember that not all buried soils are archaeological and not all processes are induced by human interaction. Human interaction on the landscape can be confirmed, however, if enough lines of evidence are drawn together. For example, if a buried soil is found at four different locations and one location shows elevated nutrient content and higher magnetic susceptibility, it may be inferred that human activities have partly caused these elevated results, but only when other possible causes have been investigated and disproven. Changes in landscape and environment cannot be considered only as a result of human impact unless there is a confluence of corroborative evidence in support.

The first buried soil found during the fieldwork was at the floodplain site of Kočićevo. By combining micromorphological and geo-chemical analyses a buried but partly truncated brown earth soil was discovered which exhibited elevated levels of magnetic susceptibility and electrical conductivity when compared to the surrounding sediments. The sandy loam component is indicative of the weathering of underlying river terrace gravels and the formation of a brown earth, with its disorganised dusty clay component derived from overbank flooding as alluvial deposits. In addition, the presence of micro-charcoal and punctuated organic components within a sandy (clay) loam matrix present suggestions of anthropogenic activity. This soil has been subject to oscillating wet to dry conditions which is shown by the high levels of calcium carbonate and the replacement of organic material with amorphous iron and manganese. Thus the site provides a glimpse into the past landscape present here that was associated with a Neolithic presence and possible settlement on the river's edge. Its partial burial by river flood deposits accounts for its better preservation. However, the geoarchaeological evidence is partly disturbed and truncated by modern ploughing which is typical of the problems faced in working in northern Bosnia and Herzegovina.

The hill-top sites Pecine, Pejčinovića Brdo, Jelića Brdo, Čardar Čardačani, Luka and Stari Martinac all share a similar stratigraphy. At Pecine the geo-chemical results and the stratigraphy are jumbled with no patterning of chemical signatures and poor stratigraphy. This is likely due to a combination of natural erosion and modern disturbance, with the construction of the motorway. It is a recurrent problem when examining a number of sites, that some will have been so heavily modified that no traces of past landscape remains. Other hill-top sites have been better preserved, however, where combining stratigraphy with micromorphological and geo-chemical analyses creates glimpses into the nature of the past landscapes to be found.

At Pejčinovića Brdo the initial stratigraphy suggested that there was no preservation of archaeological deposits. The Ah-B-BC profile, combined with the large number of surface finds suggests that any former old land surfaces are now incorporated with the modern soil profile. The micromorphology however, showed that the B horizon present at the site was in fact both the remains of an *in situ* soil and an archaeological sediment. The loess-like composition of the horizon suggest that this soil has a considerable aeolian component, likely derived from wind blow in cold dry climate of the last glacial period. In

[27] Kirkby 1969

the Holocene, this same soil has been both subject to episodic illuviation with the incorporation of fines (silt and clay), and then was heavily truncated more recently. These events are no doubt associated with clearance and agricultural activities, and perhaps some hillwash action, but it is impossible at this stage to accurately phase/date these events. The *in situ* illuvial clay component at the base of the B horizon indicates that this soil had once supported a stable woodland or argillic soil.

All the hill-top sites displayed weakly acidic soils and sediments, which suggest that the preservation of faunal remains is unlikely in many cases. The most common feature of these sites however is the relatively shallowness of the stratigraphy. None of the sites had much more than 1m of soil/sediment above the weathered natural, and often one-half to two-thirds of this profile was much disturbed. The removal of vegetation is one of the major causes of erosion, and when coupled with a deliberate ploughing of a soil, conditions are perfect for deep soil mixing processes and localised colluvial erosion to occur. This is truly a double-edged sword when it comes to this part of Bosnia and Herzegovina. With no political protection for archaeological sites and limited funds for research investigations, sites are often discovered by the presence of assemblages of finds, brought to the surface by modern ploughing. It is in that sense an invaluable tool for discovering new sites, but it is however incredibly destructive and has consistently removed/destroyed any buried A horizon and often the old land surfaces. At Čardar Čardačani for example, the micromorphology showed a loess-like B horizon which was incredibly dense, without clay-lined voids. This suggests that the environment has been relatively stable for a long period of time. The density and abundance of very fine sand suggests a reworked loessic-derived sediment, which could have been inherently present in the subsoil complex from previous late glacial times. The presence of both subrounded and angular very fine sands suggests that whilst a degree of aeolian deposition has occurred at the site, there is also some *in situ* weathering and soil development, and then changes consequent on long-term agricultural use of the landscape. The medium sand sized amorphous iron/organic aggregates at the site suggest a replacement of organic material by iron, likely caused by oscillating wet/dry conditions which imply that some groundwater fluctuation and colluvial erosion may have occurred at the site, possible a consequence of ploughing and poor soil conservation measures.

The story coming from the hilltop sites in the Vrbas valley tells us that whilst remnants of the past landscape do remain are hard to identify. Indeed, the erosion processes consequent upon ploughing and the weathering of exposed sediments have removed much of the evidence of past landscape use. But, that is not to say they have not been able to provide useful archaeological information. One of the great achievements of the investigations of these sites, some of which were featured during the initial pilot study, is that the methodology is sound. For example, if only the surface finds were used as indicators of sites then no knowledge of the former woodland soil type present at Pejčinovića Brdo would have come to light.

Tomasovo Brdo in the mountains was the only site which has a well developed soil profile that featured two distinct B horizons. The upper B horizon appears to be associated with base of the modern ploughsoil. The lower B or Bt horizon, however, appears to be archaeologically significant. The micromorphology showed that it has a loess-like, aeolian composition suggests that it has an aeolian component from the last glaciation. Although it is highly truncated and mixed, it would have originally been part of a woodland soil, as shown by its well structured and oriented clay component and abundant illuvial silty clay features. This means that at some point in the past Tomasovo Brdo was a wooded landscape with a thick well developed soil. The clean clays in the lower B horizon are evidence of illuviation under stable, well drained wooded conditions first, and then subsequent illuviation of less well organised dusty or silty clays in both the groundmass and voids is indicative of successive phases of soil disturbance, perhaps associated with clearance, bare surface soil and other forms of physical disturbance of the upper part of the soil profile associated with human agency. The heterogeneous mixture of Ah and Bt sediments separated by dusty clay infills and with a degree of vughy porosity, indicates that the whole soil profile has been highly disturbed more recently. In addition, the amorphous iron nodules suggest alternating wet and dry conditions, and the dirty clay void coatings suggest much surface disturbance, probably associated with recent agriculture and localised soil erosion. The peak in magnetic susceptibility, associated with the Bt horizon suggests that there has been a degree of organic replacement around this level. Tomasovo Brdo is one of the best examples of *in situ* soil profiles found anywhere in Bosnia and Herzegovina during this research and it is clear that the landscape contains a soil development sequence indicating that this landscape was heavily modified in the past.

The sites in the Ukrina valley share a lot of the features with the sites in the Vrbas valley. In both areas, the sites exhibited relatively shallow stratigraphic sequences and the nature of the parent material is very similar and is associated with shallow relief river valley and gravel terraces. At Miljevic and Area 55 there was good preservation of the river terrace sequences, although the site did not have clear evidence of buried soil. However, the application of micromorphological analysis may still be able to tease out some soil and therefore landscape history at these sites. Examining the river terraces themselves can also provide useful information when it comes to identifying past landscape change, including patterns of erosion and wider site formation processes. Thus sites such as this one are good candidates for future research.

In particular at Area 55, the highly elevated levels of barium (Ba), carbon (Ca), strontium (Sr) and zinc (Zn) and the slight elevations in the levels of phosphorus (P) and lead (Pb) at 40 cm points to some sort of human interaction with this landscape. The presence of calcium (Ca) and strontium (Sr) may suggest some sort of agricultural use, and the barium (Ba), phosphorus (P) and manganese (Mn) all point to some sort of organic waste disposal, possibly manuring. The site fits well into the idea of early farmers exploiting river floodplains.

Central to the theme of this research is the interaction between humans and their landscape and environment. But, before it is possible to examine the relationships that existed in the past, it is necessary to see how much evidence of human interaction exists and explain why it is lacking in some areas. All the sites examined for this research were initially located and recorded through the discovery of surface assemblages of finds; conventional wisdom would be that at some point in the past humans were utilising these landscapes. However, through erosion events and other processes, artefact assemblages can be exposed, transported, buried and redeposited.

Conclusions

Overall this project had two main aims:

1. To develop a geoarchaeological methodology for the rapid assessment of past landscapes in the Banja Luka and Doboj area of northern Bosnia and Herzegovina.
2. To investigate human interaction with the landscape in the late glacial-early Holocene.

And three subsidiary aims:

3. To develop an understanding and explanation of the occurrence of Upper Palaeolithic and Neolithic sites in the Vrbas and Ukrina River valleys as recovered in the 2006-7 survey of Miracle and Rajkovaca.
4. To explain the preservation factors affecting these sites.
5. To promote and develop new collaborative approaches to the investigation of archaeological landscapes in Bosnia and Herzegovina.

The methodology developed for use in this research has relied on a combination of hand augered borehole transects and test pits to investigate archaeological sites across a landscape to sample these sites for physical, geochemical and multi-elemental attributes and micromorphological analysis, and use this data to discover information about past landscapes development and infer human interactions within their environment. The underlying principle of this approach was that it would have limited fiscal and physical expenditure, be relatively quick in terms of processing results, but still provide useful information and be adaptable to a variety of local environments within a wider landscape. It has been possible to examine 11 sites across an area of 90km^2 in 19 fieldwork days, at every site the stratigraphy was explored and recorded. The post-excavation work has taken substantially longer, however it still took only a relatively small length of time when compared to the length of time it would taken to have excavated large trenches and done the post-excavation analyses. Crucially the information gathered in terms of boreholes, test pits and the suite of laboratory techniques has allowed each site and its associated landscape to be successfully interrogated and explored with fruitful results.

Each aspect of the methodology has been successful in different ways. As well as providing samples, the augering and test pitting has provided previously unknown stratigraphic information for all sites. It has enabled an assessment of the preservation of buried soils and has shown which sites have *in situ* archaeology and old land surfaces. The geo-chemical analysis has enabled an assessment of the preservation potential of sites across the region and has contributed to the hunt for buried soils. The multi-elemental analysis has enabled the recognition of potential human impact on the landscape. The micromorphological analyses have provided information on the existence and nature of buried soils where they have been found, in particular identifying former woodland soil types that would have formed in this landscape in the earlier Holocene. It has confirmed the presence of loessic sediments contributing to the composition of the subsoils, and highlighted the effect modern ploughing has had on the *in situ* palaeosols.

Despite the success of the methodology it has been very difficult to look directly at human interaction with the landscape, not due to a lack of results but due to the lack of appropriately secure evidence from the results. Even with the problems of erosion, plough damage and weathering present across the research area, some startling results have come up and certain preliminary conclusions can be drawn with regards human interaction with the landscape. The buried soil at Kočićevo has shown that a brown earth soil that would have covered the site in prehistory. If we accept the idea that early farmers would have moved onto the most fertile and cleared lands first, then the absence of a woodland soil and the organic rich nature of the buried soil, the seasonal alluvial replenishment and a high local groundwater table, makes the site seem like an obvious choice for early farmers. The potential buried soil shown from the multi-elemental analysis at Area 55 has elevated levels of elements indicative of human interaction and this site would also be an obvious choice for early farmers. This fits with Van Andel *et al.* (1986) theory that floodplain sites would be the first to be exploited during the early Holocene due to the easily tilled, highly fertile soils and a regular flooding pattern, and the river zone providing access, transport, raw materials, game and fish resources.

Debate as to why people decided to abandon a hunter-gather lifestyle for a sedentary farming one will hopefully rage on for decades as only through honest, open and powerful debate can the reasons become clearer. Whilst no definitive evidence for either lifestyle was found during this research, there is a wealth of evidence to suggest that northern Bosnia and Herzegovina would be an ideal place for agricultural settlement and exploitation. The area is characterised by well-drained, silt-rich organic soils with moderate pH which would be ideally suited to early prehistoric farming practices. Even at sites where no archaeological horizons were found due to their use as modern arable fields, the area is still fertile and supports agriculture today. The climate would have been ideal with temperate summers and only occasionally fierce winters. At last glacial maximum when much of northern Europe was under ice cap, the area around northern Bosnia and Herzegovina would have been the first semi-habitable area, likely consisting of woodland steppe. It is possible that as the Palaeolithic people of northern Europe retreated southwards, away from the ice, they would have settled in what we now think of as Bosnia and Herzegovina.

Another way in which this research can reopen debates is in terms of what evidence can be realistically recovered from certain areas of Europe. At the majority of sites investigated, no *in situ* archaeological artefacts were found despite large amounts appearing during fieldwalking. When so much destruction of archaeological sediments and stratigraphy can occur in such a small area, how can we be sure that other areas have not been subject to similar processes? This has major implications for migrationalist debates, as sites which have be eradicated, could be key mid-points between major migrations. Whether this is due to deep ploughing and/or erosion associated with landscape denudation, the impact of modern humans on the landscape of northern Bosnia and Herzegovina is remarkable.

The interaction of people and the landscape during the early Holocene however is still less clear. Whilst certain processes have been recorded and presented here, it is impossible to say with any certainty if these processes are naturally occurring or as a result of human interaction. If we assume that humans have caused everything we find then, the turbation found at Kočićevo and the woodland clearance found at Pejčinovića Brdo would have been a result of early farmers stripping back the landscape and putting it to use under the plough. It is not yet possible without further investigation for this to be more than a suggestion at this stage.

The preservation potential for organic and faunal remains archaeological remains in this part of Bosnia and Herzegovina is generally good. Although the soils are weakly acidic, this tendency is counter-balanced by the slightly calcareous groundwater system, such as at Kočićevo. The best preservation of faunal remains came from Rastuśa, where huge numbers of cave bear bones were found there in the Pleistocene sediments. Where buried soils have been found they are often quite heavily truncated, especially in their upper horizons. When dealing with a landscape as transformed as northern Bosnia and Herzegovina, it is always important to bear in mind the possibility of erosional and weathering processes, and as sites such as Area 55 show, the redeposition of sediments can be problematic. The thin stratigraphic sequences at sites on the hill-tops should serve as a warning, especially when combined with large surface scatters. The likelihood is that the ancient land surface is also the current land surface and either due to a lack of soil formation or more likely due to hillwash erosion we are seeing only surface survival in many areas of the late-glacial-Holocene landscape.

In terms of international cooperation between Bosnia and Herzegovina and the UK, the project has been a resounding success. The public lectures hosted by the Museum of the Republika Srpska in Banja Luka were well attended and the flow of information between the two countries has been excellent. Press reports in both newspapers and on television have served to raise the profile of the project and the interest of politicians and heritage officers was a welcome addition to the project. The introduction of geoarchaeology into the country has been embraced warmly and the archaeological team at the Museum plan to use field based geoarchaeological techniques in all future excavations. Moves are also underway, within the wider project, to press politicians into adopting some sort of compulsory archaeological protection and prospection.

Future work

Future work is a necessity in the area investigated in order that the glimpses of information provided by this research are explored further. Sites such as Kočićevo and Tomasovo Brdo would all benefit from larger scale excavations in order to explore them further as they have provided the most detailed information, in terms of past landscapes. Area 55 would be particularly useful to investigate further as the floodplain at the bottom of the slope/upper part of the valley terrace has only been looked at briefly. It would be necessary in future work to take a more targeted approach to sites. Now that sites from hill-tops, terraces and floodplains have all been investigated, it is possible to say with some confidence that the best chances of finding *in situ* buried soils are in floodplain margin and lower slope areas and possibly under colluvial deposits in small tributary valleys. Augering and test pitting provides good indicators of what is beneath the ground, but other investigative methods also need to be applied. The use of geophysical survey, such as magnetometry and topographical studies would be of great benefit to the investigation. The application of other archaeological science fields would also be of great use, especially pollen analysis and other botanical techniques. This could provide information on the flora assemblage and vegetational sequences and therefore contribute much to environmental reconstructions.

Equally useful, and indeed necessary, is the need for good dating evidence. Whilst various impacts and changes on the landscape have been found during this research, such as woodland clearance, it is impossible to put it down to human interaction without artefacts and crucially dates. Radiocarbon dating of charcoal, buried wood and bone, found *in situ* would provide good site chronologies. Additionally the use of optically stimulated luminescence dating methods could provide dates for sites where the carbon and other suitable organic material have not been preserved, or in valley deposit sequences without included organic or other anthropogenic/cultural material. The combination of these two dating approaches would allow archaeologists to firmly date deposits at the sites, build a secure chronology and place humans within it.

Future archaeological research needs to draw together these additional techniques to create a complete methodology in order to discover settlements and field systems of both prehistoric and historic date. Complementary to this, long-term land-use change can be analysed and human impacts can be identified through time. It is difficult to look at human impact as a snapshot as human use of the landscape invariably changes its nature. If changes in landscape use can be proven to be a direct or indirect result of human impact then this research can move further on. Judging by the results found during this research, the best places to look in the landscape for well sealed and preserved new evidence is probably at the floodplain margins, lower river terraces and foot slopes of the immediate hinterland. It is in these areas that conventional wisdom would suggest there should be the best preservation of buried soils. Therefore, as well as revisiting previously examined sites, new sites will need to be identified, investigated thoroughly and well dated. The more sites that are examined, the more lines of evidence can be drawn together, and the stronger the interpretations we make can be.

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Rezime

Geoarheološko istraživanje Banja Luke i Doboja, severne oblasti Bosne i Hercegovine

Ovaj članak opisuje geoarheološko istraživanje sprovedeno u oblasti oko Banja Luke i Doboja na severu Bosne i Hercegovine. Projekat je zasnovan na velikom broju paleolitskih i neolitskih lokaliteta, koji su smešteni na niskim rečnim terasama i padinama iznad plavnih oboda Vrbasa i Ukrine, pritoka Save. Iako je većina lokaliteta bila izložena raznim erozivnim procesima, kao što su priobalne poplave pri čemu se nanose rečne naslage (aluvijum) i spiranje geoloških slojeva (koluvijum), procesi koji su uticali na mnoge lokalitete, razaznata su '*in situ*' paleosol zemljišta karakteristična za rani razvoj Holocenskog pejzaža. Ova studija je ukazala na naučni potencijal ovog dela Bosne za istraživanje perioda upotrebe zemljišta i uticaj ljudi na prirodnu sredinu u toku praistorije.

Primena geoloških i fizičko-geografskih metoda u arheologiji široko je ustanovljena i može obezbediti plodonosne i uzbudljive rezultate u obliku geoarheologije. Naš izveštaj istraživanja opisuje upotrebu geoarheoloških tehnika u istraživanju i pretraživanju prirodne sredine, kao i promene u severnoj Bosni i Hercegovini u toku kasnog glacijala i ranog Holocena fokusirajući se na doline Vrbasa, Ukrine dolinu i okolnu sredinu. Studija ima za cilj da ispita kvalitet dokaza sa arheoloških lokaliteta, kao što su krečnjačke pećine i rečne šljunkovite terase kako bi se razumeo ljudski uticaj na ovu oblast u prošlosti. Šta više, studija takođe ima za cilj da oceni potencijal očuvanosti slojeva, kao i da istraži procese formiranja istih na istraženim lokalitetima kako bi se arheološki material mogao smestiti u kulturni i prirodni kontekst.

Projekat ima dva glavna cilja:

– Razvoj geoarheološke metodologije za brzu evaluaciju prirodne okoline iz prošlosti u oblasti Banja Luke i Doboja na severu Bosne i Hercegovine.

– Istraživanje ljudske interakcije sa pejzažom u periodu kasnog glacijala – ranog Holocena

I tri dopunska cilja:

– Okarakterisati i objasniti prisustvo gornjepaleolitskih i neolitskih lokaliteta u dolini Vrbas i Ukrine, zabeleženih od strane Miracle i Rajkovača u toku istraživanja sprovedenih 2006-7

– Razjašnjenje faktora koji utiču na prezervaciju arheoloških slojeva i materijala na istraženim lokalitetima.

– Promocija i razvoj novih kolaborativnih pristupa istraživanju arheoloških lokaliteta i prirodne sredine koji su zajednice koristile u prošlosti u okviru Bosne i Hercegovine.

Metodologija razvijena za korišćenje u ovom istraživanju oslanja se na kombinaciju bušotina rađenim uz pomoć geološkog svrdla-bušilice (*auger*) i test sondi da se istraže arheološki lokaliteti u celoj oblasti. Svi lokaliteti su uzorkovani za fizičke, geohemijske, multi-elementarne, i mikromorfološke analize, a podaci dobijeni ovom analizom biće upotrebljeni u rekonstrukciji prošlih pejzaža i ukazivanju na ljudske interakcije unutar prirodnog okruženja koje su okupirali. Osnovni princip iza ovakvog pristupa bili su ograničeni fiskalni i fizički troškovi, relativna brzina u dobijanju rezultata, dok su isto vreme dobijene informacije prilagodljive za druga područja unutar šire oblasti. Na kraju, bilo je moguće istražiti nekih 15 lokaliteta površine 90 km² u toku 19 terenski dana, pri čemu je na svakom lokalitetu stratigrafija detaljno istražena i zabeležena. Rad na post-terenskim istraživanjima bio je znatno duži, ali ipak manje vremena u poređenju sa vremenom koje bi se moralo uložiti u iskopavanje sondi velike površine i analize rezultata.

Informacije sakupljene iz bušotina, test sondi, kao i na osnovu odgovarajućih laboratorijskih tehnika omogućile su da se svaki lokalitet i okolna prirodna sredina uspešno istraže uz plodne rezultate.

Svaki aspekt metodologije pokazao se uspešnim na različite načine. Pored toga što su omogućile prikupljanje uzoraka, iskopavanje bušotina i test sondi otkrilo je do sada nepoznatu stratigrafsku sekvencu za svaki od ispitanih lokaliteta. Ovaj segment metodologije omogućio je ispitivanje očuvanosti geološki pohranjenih slojeva zemljišta (*buried soil*) i pokazao je koji od lokaliteta ima "*in situ*" arheologiju i očuvane slojeve. Geohemijske analize omogućile su ispitivanje potencijala prezervacije lokaliteta unutar oblasti i doprinele su potrazi očuvanim geološki pohranjenim slojevima. Multi-elementarne analize mogu omogućiti da se ispita uticaj ljudskih zajednica na prirodnu sredinu. Mikromorfološke analize pružaju informaciju o postojanju i prirodi geološki pohranjenih slojeva zemljišta (*buried soil*) tamo gde su zabeležena, kao i da se posebno identifikuju zemljišta šumskih pejzaža iz prošlosti koja su se formirala na ovom području u ranom Holocenskom periodu. Analize su takođe potvrile prisustvo lesnih naslaga kao sastavni deo tipova zemljišta ispod gornjeg pokrivača (subsoils) i pokazale su koliki uticaj moderno oranje ima na tipove zemljišta formirana u prošlosti " *in situ*".

Uprkos uspešnoj metodologiji, bilo je izuzetno teško direktno analizirati ljudsku interakciju sa prirodnom okolinom, ne toliko zbog nedostatka rezultata, već zbog nedostatka sigurnih dokaza. Ako se uzmu u obzir problem erozije, štete nanesene oranjem i loša preservazija, moguće je izneti čitavu serija preliminarnih zaključaka o interakciji ljudskih zajednica sa prirodnom okolinom.

Analize zemljišta na Kočićevu pokazale su da je zemljište pohranjeno u praistoriji bilo slično današnjoj crnici. Ako se uzme u obzir da bi se praistorijski farmeri prvo preselili na najplodniju i zemlju očišćenu od rastinja, onda nepostojanje šumskog zemljišta i organski bogate prirode pohranjenog zemljišta, sezonska aluvijalni nanosi i lokalno visoki vodostaj podzemnih vode, može se doći do zaključka da je lokalitet bio očigledan izbor za rane farmere. Zemljište pohranjeno u praistoriji otkriveno kroz multi-elementalne analize na području 55 podiglo je nivoe elemenata koji bi ukazali na ljudsku interakciju i ovaj lokalitet bi takođe bio očigledan izbor za rane farmere. Ovo se slaže sa teorijom publikovanom od strane Van Andel *et al.* (1986) da su lokaliteti na plavnom području bili prvi koji su korišćeni u vreme ranog Holocenskog perioda zbog lakog obrađivanja (oranja), plodnog zemljišta i redovnog plavljenja, kao i zbog blizine obale koja omogućava pristup, transport, sirovine i izvore divljači i raznih vrsta riba.

Diskusija o tome zašto su ljudi odlučili da odbace način života u kojem su lovili za onaj u kojem su se bavili poljoprivredom sa manje kretanja, vekovima će vladati i samo kroz poštenu, otvorenu i dokazima podupretu raspravu razlozi mogu postati jasniji. Iako nisu pronađeni definitivni dokazi za ijedan od gorenavedenih načina života, dokazi koji nagoveštavaju da je severna Bosna i Hercegovina bila idealno mesto za poljoprivredno naseljavanje i eksploataciju su brojni. Područje se karakteriše dobro-isušenom, muljevito bogatom organskim zemljištem sa umerenom pH vrednošću koje bi bilo pogodno za ranu preistorijsku poljoprivredu. Čak i na lokalitetima gde nije pronađena arheologija u vezi sa upotrebom modernih obradivih polja, područje je još uvek plodno i služi za poljoprivredu i danas. Klima je idealna sa umerenim letom i samo povremeno žestokom zimom. U toku poslednje glacijalnog maksimuma, kada je veći deo severne Evrope bio pod ledom, područje oko severne Bosne i Hercegovine bilo bi prvo područje koje bi bilo donekle-prikladno za naseljavanja, i verovatno je bilo pokriveno šumskih stepa. Moguć je scenario po kome bi se paleolitske zajednice severne Evrope povlačile južno, bežeći od ledenog pokrivača, nastanili na područje današnje Bosne i Hercegovine.

Drugi način na koji ovo istraživanje može da ponovo započne debatu tiče se toga koji dokazi se mogu realno dobiti iz izvesnih oblasti Evrope. Na većini istraženih lokaliteta, nijedan arheološki nalaz nije *in situ* pronađen uprkos velikom broju koji je pronađen u toku rekognosciranja. Kada je zabeležena destrukcija arheoloških sedimenata i stratigrafije na tako malom području, kako možemo biti sigurni da druga područja nisu bila predmet sličnih procesa? Ovo ima značajne implikacije za debate o migraciji, jer, lokaliteti koji su 'izbrisani' mogli su biti mesta okupirana između velikih migracija. Bilo da je ovo zbog dubokog oranja i/ili erozije povezane sa ogoljavanjem pejzaža, uticaj modernih ljudi na pejzaž severne Bosne i Hercegovine je značajan.

Interakcija ljudi i prirodne okoline za vreme ranog Holocena međutim još uvek je manje jasna. Iako su izvesni procesi zabeleženi i prezentovani ovde, nemoguće je reći sa bilo kojom sigurnošću da li su ovi procesi prirodna pojava ili su rezultat ljudske interakcije. Ako pretpostavimo da su ljudi prouzrukovali sve procese, mešanje sedimenata zabeleženo na Kočićevu i čišćenje šume zabeleženo na Pejčinovića Brdu mogu se interpretirati kao rad ranih farmera koji su očistili pejzaž i počeli da ga koriste za oranje. U ovom trenutku, bez daljih istraživanja još uvek nije moguće tvrditi za sigurno.

Prezervacija organskih i životinjskih ostataka, kao i drugih arheoloških ostataka na ovom delu Bosne i Hercegovine je generalno dobra. Iako je zemljište blago kiselo, to je gotovo poništeno činjenicom da su podzemne vode blago krečnjačkog sastava, kao što je na slučaj na Kočićevu. Najbolja očuvanost životinjskih ostataka zabeležena je na Rastuši, gde je pronađen veliki broj kostiju pećinskog medveda u Pleistocenskim slojevima. Na lokalitetima na kojima je zabeleženo pohranjeno zemljište, ono je često poremećeno, posebno u njihovim gornjim horizontima. Kada se bavimo prirodnom okolinom koja je transformisana kao što je slučak sa Bosnom i Hercegovinom, uvek je važno imati na umu mogućnost procesa erozije, i lokaliteti kao što Area 55 pokazuje, ponovno taloženje sedimenta može biti problematično.

Tanke stratiografske sekvence na lokalitetima na vrhovima brda mogu poslužiti kao upozorenje, posebno ako se uzmu u obzir velike površine sa kojih su prikupljene kremene alatke. Pretpostavka je da se praistorijske površine zemljišta poklapaju sa današnjim, bilo da je to zbog nedostatka formiranja novih zemljišta ili zbog erozije na strmim padinama, i vidljiv je samo izvestan broj praistorijskih površina na mnogim područjima Holocenskog pejzaža u kasnom glacijalu.

Kada je u pitanju međunarodne saradnje između Bosne i Hercegovine i Ujedinjenog Kraljevstva, projekat ima izuzetan uspeh. Javna predavanja u Banja Luci, a organizovana od strane Muzeja Republike Srpske, domaćina ovog projekta, bila su veoma dobro posećena, a protok i razmena informacija između ovih dveju zemalja su izuzetni. Izveštavanje novinara u štampi i na televiziji poslužilo je da podigne profil ovog projekta, a zainteresovanost političara i onih koji se bave nasleđem pridodala je još veću važnost ovom projektu. Uvođenje geoarheologije u zemlju prihvaćeno je veoma toplo, a arheološki tim u Muzeju planira da koristi polje bazirano na geoarheološkim tehnikama u svojim budućim iskopavanjima. Takođe se planira, u sklopu šireg projekta, uključivanje i političara u cilju dobijanja obavezne arheološke zaštite i drugih istraživanja.

Neophodno je nastaviti sa budućim radom na istraženom području kako bi se dobio što veći broj daljih rezultata, samo neki od kojih su izneseni u ovom istraživanju. Iskopavanja širih razmera na lokalitetima kao što su Kočićevo i Tomašovo Brdo bi bila od velikog značaja, iz razloga što su ova dva lokaliteta dala najdetaljnije rezultate o prirodnoj okolini u prošlost. Posebno je korisno istražiti dalje Area 55, jer su plavno područje na dnu padine i gornji deo terase doline samo površno ispitani. Bilo bi neophodno u budućnosti imati detaljno razrađene ciljeve u pristupu lokalitetima. Sada kada su lokaliteti sa vrha brda, terase i plavnog područja svi istraženi, moguće je reći sa nekom sigurnošću da su najbolje šanse za nalaženje pohranjenih zemljišta *in situ* na obodima plavnog područja, na području niže padine i moguće ispod koluvijalnih naslaga na malim dolinama oko pritoka. Bušotine i test sonde pružaju dovoljne indikacije za to šta se nalazi ispod zemlje, ali potrebno je primeniti i druge istraživačke metode. Upotreba geofizičkog istraživanja, kao što su magnetometrija i topografske studije bi bile od velike koristi za istraživanje. Upotreba drugih naučnih polja unutar arheologije bi takođe bila od velike koristi, posebno polen analize i druge botaničke tehnike. Ovo bi dalo značajne rezultate o flori i vegetacije što bi umnogome doprinelo rekonsrukciji prirodne okoline.

Jednako korisna, i zaista neophodna, je potreba za dobrim datovanjem arheoloških nalaza. Iako su promene u prirodnoj sredini i uticaj čoveka zabeleženi u toku ovog istraživanja, kao što su krčenje šume, nemoguće je to pripisati ljudskoj interakciji bez artefakata i, još značajnije – datuma. Datovanje putem radioaktivnog ugljenika, uglja i kosti pronađene *in situ* mogu da pruže hronologiju lokaliteta. Upotreba metoda termoluminescencije za utvrđivanje starosti obezbedila bi datume za lokalitete na kojima ugljenik i drugi organski materijali nisu prisutni, ili u prirodnim slojevima u rečnoj dolini bez tragova organskih ili drugih materijala ljudskog porekla. Kombinacija ovih pristupa za određivanje starosti omogućila bi arheolozima da sa sigurnošću odrede starost slojeva na lokalitetima.

Buduće arheološko istraživanje treba da sjedini ove dodatne naučne metode kako bi stvorio kompletnu metodologiju i na taj način izgradio sistem za istraživanje naselja i prirodnu okolinu, kako praistorijskog tako i istorijskog datuma. Kao dopuna ovome I kao što je ova studija pokazala, promene koja nastaju unutar zemljišta kao rezultat dugotrajne upotrebe zemlje mogu se analizirati i time se ljudski uticaj može identifikovati kroz vreme. Nemoguće je ljudski uticaj posmatrati kao fotografiju, pošto ljudska upotreba prirodne okoline konstantno menja njegovu prirodu. Ako se promene u prirodnoj okolini mogu dokazati kao direktan ili indirektan rezultat ljudskog uticaja, onda ovo istraživanje može da donese nove rezultate. Sudeći po rezultatima dobijenim u toku ovog istraživanja, najbolja mesta na pejzažu za traženje dobro očuvanih novih dokaza je verovatno na obodima plavnog područja, nižim rečnim terasama i podnožju sadašnjeg zaleđa. Međutim, kao što treba ponovo posetiti već istražene lokalitete, tako je potrebno identifikovati i nove lokalitete, istražiti potpuno i sigurno datovati. Sa rastom broja istraženih lokaliteta, rastu i jačaju naše interprentacije o prošlosti Bosne i Hercegovine.

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This paper describes the geoarchaeological reconnaissance conducted in the area around Banja Luka and Doboj of northern Bosnia and Herzegovina. The project focused on a large number of Palaeolithic and Neolithic sites situated on low promontories and hillsides above the floodplain margins of the Sava tributaries of the Vrbas and Ukrina rivers. Although many sites have been affected by various erosion processes such as overbank flooding or alluviation and hillwash or colluviation, a number of *in situ* palaeosols were discerned which have yielded some clues as to the nature of early Holocene landscape development. This research has indicated the rich potential in this part of Bosnia for the discovery of land-use sequences and human impact in prehistoric times.

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