Potentiality of intra-site spatial analysis and post-depositional processes: a Slovenian case study Resnikov prekop

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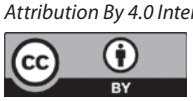

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This paper is dedicated to proving the relevance of intra-site spatial analysis as a means of testing the integrity of the archaeological record, even in "unfamiliar", post-depositionally affected contexts. When, as in the case discussed in this paper, the nature, strength and potential effects of such processes have been reconstructed through a preliminary multidisciplinary approach, spatial analysis identifying patterns in concrete and decisive categories of evidence, corroborates assessments of whether and to what extent post-depositional disturbances have changed their original spatial distribution. Comparison between the results of both such approaches contributes to the current debate regarding the formation and deformation processes which took place at Resnikov Prekop and will shed more light on the interpretation of the spatial patterns observed.

Keywords: intra-site spatial analysis, multidisciplinary approach, post-depositional processes, pile-dwelling, Slovenia

Članek obravnava pomen znotrajnajdiščnih prostorskih analiz pri ocenjevanju obsega motenj arheološkega zapisa v okrnjenih kontekstih, izpostavljenih poodložitvenim procesom. Kjer je mogoče naravo, jakost in potencialni učinek takšnih procesov zadovoljivo rekonstruirati, kot je bilo to s preliminarnimi multidisciplinarnimi raziskavami doseženo v tukaj predstavljenem primeru koliščarske naselbine Resnikov prekop, lahko analiza prostorske razpršenosti posameznih kategorij najdb pomembno prispeva k oceni razkoraka med njihovim izvirnim in poznejšim, z izkopavanji dokumentiranim vzorcem porazdelitve. Primerjava rezultatov obeh omenjenih analitičnih pristopov je namreč zagotovila nova spoznanja o nastajanju arheološkega zapisa na omenjenem kolišču in obenem ponudila nekatere nove možnosti razlage ugotovljene prostorske razpršenosti arheoloških najdb.

Ključne besede: znotrajnajdiščna prostorska analiza, multidisciplinarni pristop, poodložitveni procesi, kolišče, Slovenija

1. INTRODUCTION

Archaeological contexts affected strongly by post-depositional processes have for a long time been considered unpredictable and inexplicable. However, there has been increasing consciousness of the importance of establishing the degree of disturbance in archaeological deposits in order to fully comprehend the archaeological record (Schiffer 1972; 1983; 1987; Wood, Johnson 1978; Nash, Petraglia 1987; Dibble et al. 1997; Djindjian 1999; Hilton 2003), as well as advances in archaeological researches during recent decades enabling us to overcome this theoretical barrier. This has opened up ongoing cooperation with the natural sciences, and through fruitful multidisciplinary approaches archaeologists are now able to answer concrete questions, particularly concerning the formation and deformation of archaeological contexts. Although spatial statistics have been predominantly applied to reconstructing the behaviour of past populations from the preserved traces (material culture) in the archaeological record, recent studies have started to acknowledge post-depositional processes (Orton 2004; Bevan, Conolly 2006; 2009; Bevan et al. 2013; Bevan, Wilson 2013; Crema et al. 2010; Crema 2015; Eve, Crema 2014; Carrer 2015; Achino 2016; Achino et al. 2016; Giusti, Arzarello 2016). In this study we propose the application of intra-site spatial analysis as a worthwhile tool in reassessing the degree of post-depositional reworking of the archaeo-

1. UVOD

Arheološki konteksti, ki so bili v pomembni meri izpostavljeni delovanju različnih poodložitvenih dejavnikov, so bili v preteklosti pogosto opredeljeni kot nerazložljivi in torej raziskovalno neperspektivni. V zadnjem času se zavedanje o koristnosti poznavanja stopnje okrnjenosti posameznih plasti za celovitejše razumevanje arheološkega zapisa vendarle krepi (Schiffer 1972; 1983; 1987; Wood, Johnson 1978; Nash, Petraglia 1987; Dibble et al. 1997; Djindjian 1999; Hilton 2003), k čemur je ključno prispeval napredek v arheološkem raziskovanju. Zelo pomembna je bila predvsem vzpostavitev sodelovanja z naravoslovnimi vedami, kar danes omogoča obravnavo zelo konkretnih vprašanj o načinu formiranja in deformiranja preučevanih arheoloških zapisov. Med drugim se je začela učinkovito uporabljati prostorska statistika, ki je v preteklosti večinoma služila za rekonstrukcijo načina življenja nekdanjih skupnosti (Orton 2004; Bevan, Conolly 2006; 2009; Bevan et al. 2013; Bevan, Wilson 2013; Crema et al. 2010; Crema 2015; Eve, Crema 2014; Carrer 2015; Achino 2016; Achino et al. 2016; Giusti, Arzarello 2016). V tem prispevku želimo poudariti učinkovitost navedenega statističnega orodja pri preučevanju poodložitvenih sprememb v razpršenosti arheoloških najdb na primeru kolišča Resnikov prekop z Ljubljanskega barja (Slovenija). Ta je v preteklosti že bil predmet multidisciplinarno zasnovane ra-

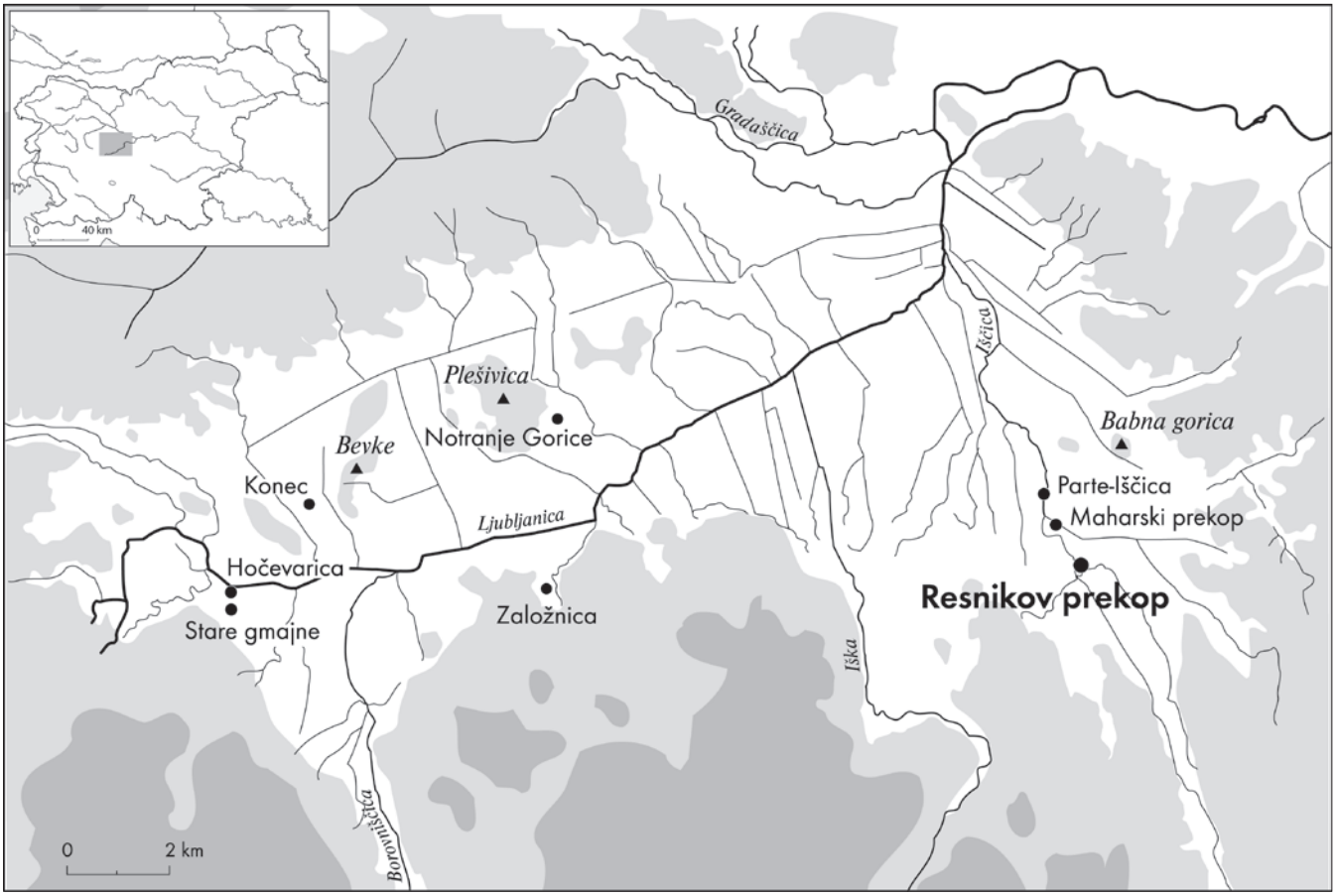

Fig. 1 Spatial location of Resnikov Prekop in Slovenia (top on left) and within the more important pile-dwelling settlements in the Ljubljansko barje (after Velušček 2006: 20, Fig. 1)

Sl. 1 Geografska lega Resnikovega prekopa v Sloveniji (zgoraj levo) in na območju Ljubljanskega barja z označbo še drugih pomembnejših tamkajšnjih kolišč (po Velušček 2006: 29, sl. 1)

logical remains in controlled conditions. Where, as at Resnikov prekop, a previous multidisciplinary approach (allowed archaeologists to reconstruct the formation of the archaeological record, the comparison of such data with the spatial distribution of concrete categories of evidence within the settlement, as well their spatial association (or segregation), offers a remarkable overview, useful to evaluate the integrity of the deposit.

2. BACKGROUND

2.1 Research at Resnikov prekop

The pile-dwelling of Resnikov prekop lies in the south-eastern part of the Ljubljansko barje (Ger. das Laibacher Moor), situated in central Slovenia, near the capital Ljubljana (Fig. 1). It was discovered during the excavation of the new Resnikov prekop/canal in September 1953 and investigated through small trenches until 1962, when J. Korošec conducted systematic excavations encompassing 160 m^2, in ten 4 x 4 m^2 (Korošec 1962; 1964a; Bregant 1964; Velušček 1997). In 1963, T. Bregant excavated 13 sample trenches in the area of the pile-dwelling and ten years later, during mechanized cleaning of the canal in 1974, workers came upon piles driven vertically into the ground and a large number of pottery fragments (Harej 1975: 145). Finally, the Institute of Archaeology of ZRC SAZU excavated 3 sample trenches in 2002 (totalling 33 m^2) which spatially related to the previous sample through trench 1, which was excavated about 6 m south of Korošec's excavation (Velušček 2006: 55) (Fig. 2). Three verziskave, ki je med drugim poglobljeno obravnavala potek formiranja arheološkega zapisa (Velušček 2006). Primerjava rezultatov z ugotovitvami znotrajnajdiščne prostorske analize različnih kategorij najdb, kakor tudi njihovega prostorskega združevanja (ali razdruževanja), je ponudila pomembna nova dognanja o obsegu okrnjenosti preučevanega arheološkega konteksta.

2. OZADJE

2.1 Raziskave na Resnikovem prekopu

Ostanki koliščarske naselbine Resnikov prekop ležijo na jugovzhodnem delu Ljubljanskega barja, južno od prestolnice Ljubljana (sl. 1). Najdišče je bilo odkrito septembra leta 1953 med izkopom novega Resnikovega kanala in do leta 1962 v manjšem obsegu tudi sondirano. Tega leta je nato J. Korošec izvedel večja sistematična izkopavanja na skupni površini 160 m^2 po kvadrantih velikosti 4 x 4 m^2 (Korošec 1962; 1964a; Bregant 1964; Velušček 1997). Leta 1963 je T. Bregant na območju kolišča izkopala 13 poskusnih sond, desetletje pozneje so delavci pri strojnem čiščenju kanala 1974. naleteli na navpično zabite kole in številne odlomke lončenine (Harej 1975: 145). Zadnje arheološke aktivnosti na najdišču so povezane s sondiranji Inštituta za arheologijo ZRC SAZU iz leta 2002, ko je bila raziskana površina u 3 sonde (ukupno 33 m^2) koje su prostorno povezane s predhodnom površinom kroz sondu 1, koja je bila iskopavana oko 6m južno tik ob izkopnem polju J. Korošca (Velušček 2006: 55) (sl. 2). Trije navpični koli, ki so bili datirani dendro-

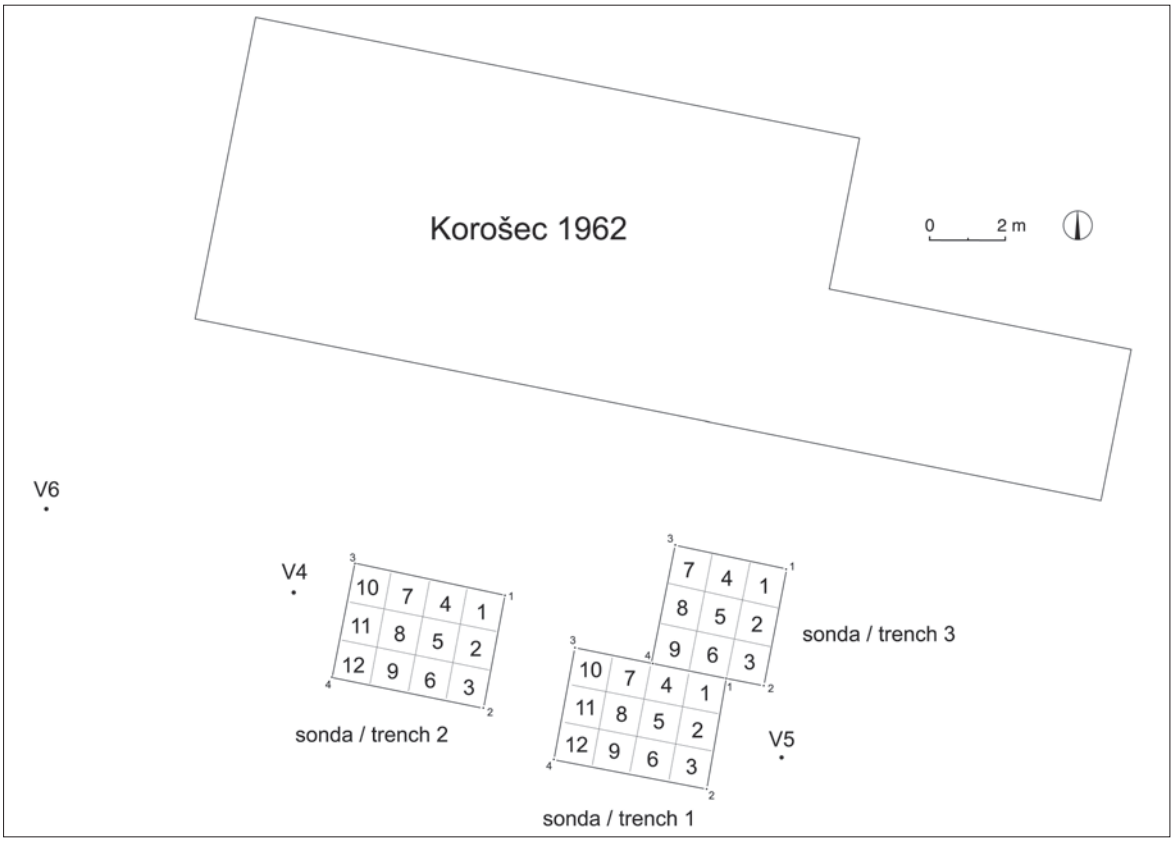

Fig. 2 Excavation site of J. Korošec (1962) and investigations in 2002: trenches 1–3 with a square grid and boreholes 4–6 (after Velušček 2006: 22, Fig. 3)

Sl. 2 Izkopna polja J. Korošca (1962) in raziskav iz leta 2002 s sondami 1–3 in označbami mreže kvadrantov ter vrtin 4–6 (po Velušček 2006: 22, sl. 3)

tical piles from trench 3 were dated by both ^{14}C and dendrochronology, placing the site in the second quarter of the 5th millennium BC (for more details see Velušček 2006; Čufar, Korenčič 2006). This paper is focused on the geo-referenced spatial data provided by the excavation of 2002.

2.2 Results provided by multidisciplinary approach

The finds recovered from Resnikov prekop during this last excavation comprised several categories of prehistoric material: pottery, animal bones, seeds, stones, lithic artefacts, and wooden remains (both vertical and horizontal piles); furthermore some more recent finds, including Roman pottery, iron artefacts (an arrowhead and a possible fish-hook) and a fragmented amber ringlet have been found. While most of these later finds originated from the upper level of the sediment with prehistoric finds, others were collected from deeper contexts (as the arrowhead) (Velušček 2006: 54–61). This condition, together with the peculiar stratigraphy observed, and the results provided by sedimentological and palynological analyses, forces us to question the integrity of archaeological record. These analyses indeed demonstrated an interruption in sediment deposit at the site; the sedimentary core collected for pollen analysis (from grid square 12 of trench 1) showed that the profile was divided into two portions, R1 and R2, respectively deposited before 6000 cal BC (R1) and after 200 cal BC (R2) (Fig. 3). An interruption in the sedimentary sequence is thus observed and it was concluded that during a period ranging from 6000 cal BC to before the end of the 1st millennium BC, an unknown watercourse traversed the site, and this running water probably both removed and deposited material (Andrič 2006; Golyeva 2006; Turk 2006: 98; Velušček 2006: 57, 113). According to this premise, sediment overlying the calcareous lake marl is assumed to be alluvial and the finds from various periods should therefore be mixed together, as was proved for the sectors investigated so far (Jesse 1954; 1955; Bregant 1964: 15; 1964/65; Korošec 1964b: 57; Turk 2006: 111; Velušček 2006: 55). Furthermore, an interesting remark was made by researchers on the low quantity of vertical piles observed within the trenches excavated during 2002; there are ten in total, comprising 2 in trench 1 (nos. 8 and 11), three in trench 2 (nos. 13 to 15) and five more (nos. 21, 22, 24, 32 and 33) in trench 3 (Fig. 4). Although the average diameter is comparable with other pile-dwellings in the Ljubljansko barje (Velušček 2006: 56), their scarceness suggested a short-lived settlement, matching the conclusion reached by researchers that carried out previous excavations (Bregant 1964: 13).

Taken together, these premises enable researchers to propose that heavier artefacts, such as pottery, stones, larger bones and vertical piles have remained in their initial positions at the site, despite the washing-out action of an unknown watercourse. This assumption is reinforced, and their association to the pile-dwelling settlement proved, by the discovery of such finds above the lake marl at the lower end of the alluvium (Velušček 2006: 25, Fig. 5B); the chrono-typological analyses of pottery places these finds into the

kronološko in z metodo radioaktivnega ogljika, so kolišče časovno umestili v drugo četrtino 5. tisočletja pr. n. št. (za podrobnosti glej Velušček 2006; Čufar, Korenčič 2006). Ta prispevek obravnava georeferencirane prostorske podatke, pridobljene med sondiranji leta 2002.

2.2 Rezultati multidisciplinarnih raziskav

Arheološko gradivo, ki je bilo na Resnikovem prekopu pridobljeno med sondiranjem leta 2002, vključuje lončenino, živalske kosti, semena, kamenje, kamnite izdelke in les (vertikalne in horizontalne kole). Ob tem je bilo odkritih tudi nekaj najdb iz mlajših obdobij, npr. rimskodobna lončenina, posamezni železni predmeti (puščična ost, morda trnek) in fragment jantarnega obročka. Te najdbe so ležale v različnih višinah stratigrafskega stolpca (Velušček 2006: 54–61), kar – skupaj z rezultati sedimentoloških in palinoloških analiz

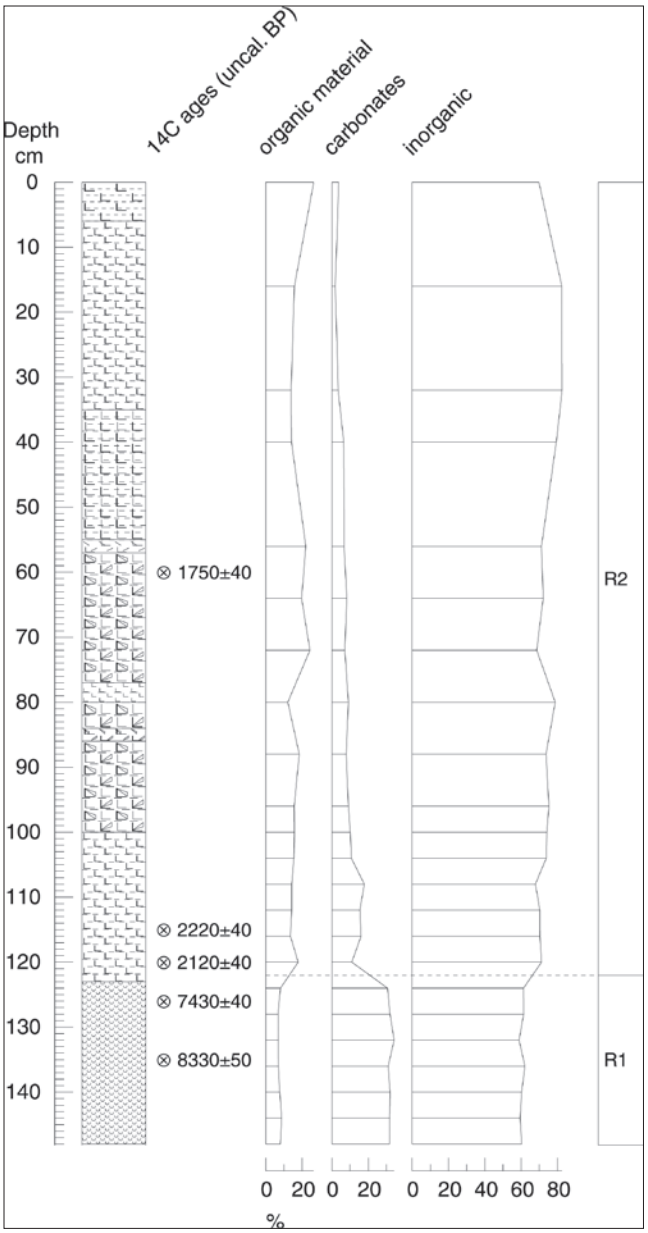

Fig. 3 Results of loss-on-ignition for Resnikov prekop (after Andrič 2006: 104, Fig. 1)

Sl. 3 Rezultati analize 'loss-on-ignition' z Resnikovega prekopa (po Andrič 2006: 104, sl. 1)

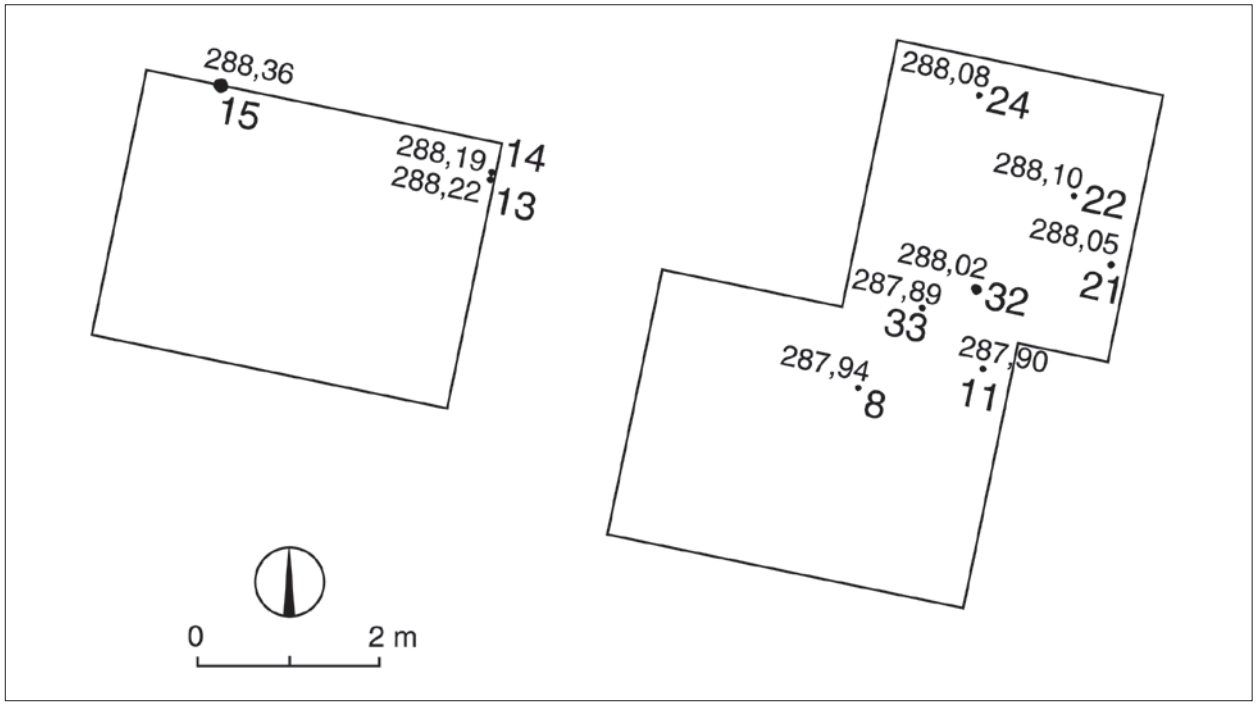

Fig. 4 Vertical posts from excavations in 2002 (after Velušček 2006: 25, Fig. 5B; Čufar, Korenčič 2006)
Sl. 4 Vertikalni koli izkopavanja iz leta 2002 (po Velušček 2006: 25, sl. 5B; Čufar, Korenčič 2006)

same time-span (Velušček 2006: 45–49, 57–61).

Starting from this assumption regarding the heavier artefacts, the analysis of their spatial patterns and their potential spatial association will enable us to evaluate and stress the correspondence to their original "spatiality".

3. MATERIALS AND METHODS

3.1 Heavier artefacts from Resnikov Prekop: a reviewed interpretation

Among the category of the heavier – and least mobile – artefacts, previous research included pottery, stones, larger bones, and vertical piles; in the framework of this analysis aiming to question the preservation of original spatial patterns, a reassessment of this categorisation was required. It was particularly important for macro-fauna, for instance, since the sample of 477 remains was predominantly composed of slivers, mostly ranging between 1–5 centimetres[1] (Toškan, Dirjec 2006: 151–154). We can then hypothesise, on the basis of some archaeological comparisons, that they are more likely to be related to particular consumption and/or culinary practices which involve intensive systematic crushing of the stated skeletal elements, with the purpose of marrow extraction and fat accumulation (the so-called "succo di ossa", Rowley-Conwy 1996: 75–78; after Binford 1978). Similar action, quite common in the Mesolithic period (Pohar 1984; 1986; Rowley-Conwy 1996; Miracle et al. 2000; Toškan, Dirjec 2004; Turk et al. 2004; Miracle 2007: 220–227; Odar 2008: 9), is also attested at the site of Spaha, contem-

1 Within a total sample of 477 remains, 91 items do not overcome 1 cm, 317 fragments range from 1–5 cm, 51 between 5–10 cm, 15 between 10–15 cm and only 3 overcome 15 cm (Toškan, Dirjec 2006: 145).

– zbuja dvome o neokrnjenosti arheološkega zapisa. Vrtina za palinološko raziskavo na območju kvadranta 12 sonde 1 je, denimo, pokazala, da je bil spodnji del profila (t. i. R1) odložen pred več kot šestimi tisočletji, zgornji (t. i. R2) pa po letu 200 pr. Kr. (sl. 3). Uočen je prekid v sedimentološkoj sekvenci v obdobju od 6000. god. pr. Kr. do pred koncem 1. tisočletja pr. Kr. čez je kroz najdišče tekel neznan vodni tok ter je odnašal in prinašal material (glej Andrič 2006; Golyeva 2006; Turk 2006: 98; Velušček 2006: 57, 113). Sediment nad jezersko kredo naj bi bil torej aluvialen, arheološke najdbe iz posameznih obdobij pa so v njem premešane (Jesse 1954; 1955; Bregant 1964: 15; 1964/65; Korošec 1964b: 57; Turk 2006: 111; Velušček 2006: 55). Na območju treh sond iz leta 2002 je bilo odkritih le deset navpičnih kolov: dva v sondi 1 (št. 8 in 11), trije v sondi 2 (št. 13 do 15) in pet v sondi 3 (št. 21, 22, 24, 32 in 33) (sl. 4). Njihovi premeri ne odstopajo od vrednosti za kole z drugih kolišč na Ljubljanskem barju (Velušček 2006: 56), njihova pičlost pa naj bi kazala na kratkotrajnost obravnavane naselbine (cf. Bregant 1964: 13).

Na podlagi predstavljenih ugotovitev je bila ponujena razlaga, po kateri neznani vodni tok ni pomembneje vplival na lego težjih najdb (npr. lončenine, kamenja, večjih kosti, navpičnih kolov); te naj bi torej večinoma ostale na območju najdišča, kamor so bile tudi odložene. Skladni s takšno tezo sta lega omenjenih najdb v spodnjem delu naplavinskega sedimenta tik nad jezersko kredo (Velušček 2006: 25, sl. 5B) in tipokronološka slika lončenine, ki ne odstopa od časovnega okvirja trajanja naselbine (Velušček 2006: 45–49, 57–61).

porary to Resnikov prekop and spatially located at 50 km south-east from the latter (Toškan 2011: 277). The bones from Resnikov prekop were also largely eroded and many of them were well rounded. All these conditions, as well as their low frequency compared with assemblages at other pile-dwellings (Toškan, Dirjec 2006: Tab. 6), suggest that they cannot be considered as a complete depiction of the macro-fauna from the site.[2] In light of these assumptions, macro-faunal remains cannot be included *tout court* among the heavier artefacts, as stones (intentionally brought to this area by pile-dwellers)[3] and pottery (chronologically well-framed[4] and in most cases of considerable dimensions) can. As light material remains, they might instead be moved more easily by post-depositional washing out process, as might avifaunal and micro-faunal remains and seeds. These categories of more movable archaeological markers are thus considered comparatively in this study,[5] in order to verify whether their spatial distribution, more affected by disturbances, is similar to that displayed by supposed more stable artefacts. It would help to clarify the dynamic of their formation (and potential deformation).

Zaradi domneve o statičnosti težjih arheoloških najdb (tj. lončenine, odlomkov kosti in kamenja) bi z analizo vzorcev njihove razpršenosti lahko dobili uvid v stopnjo ujemanja najdiščne lege posameznih najdb z njihovo izhodiščno lego (tj. lego ob odložitvi).

3. GRADIVO IN METODE

3.1 Težje najdbe z Resnikovega prekopa: posodobljena interpretacija

Dosedanje raziskave težjih – in torej manj mobilnih – najdb z Resnikovega prekopa so bile osredotočene na lončenino, kamenje, večje kosti in vertikalne kole. V okviru aktualne študije je bila razpršenost teh najdb v prostoru analizirana znova, kar je bilo še posebej pomembno pri živalskih kosteh. Med 477 izkopanimi primerki močno prevladujejo med 1 in 5 cm veliki odlomki[1] (Toškan, Dirjec 2006: 151–154). Na podlagi nekaterih arheoloških primerjav je mogoče domnevati, da bi takšno stanje utegnilo odražati specifične prehranske prakse, ki bi stremele k intenzivnemu razbijanju kosti z namenom izkoriščanja kostnega mozga in drugih maščob (t. i. succo di ossa, Rowley-Conwy 1996: 75–78; povzeto

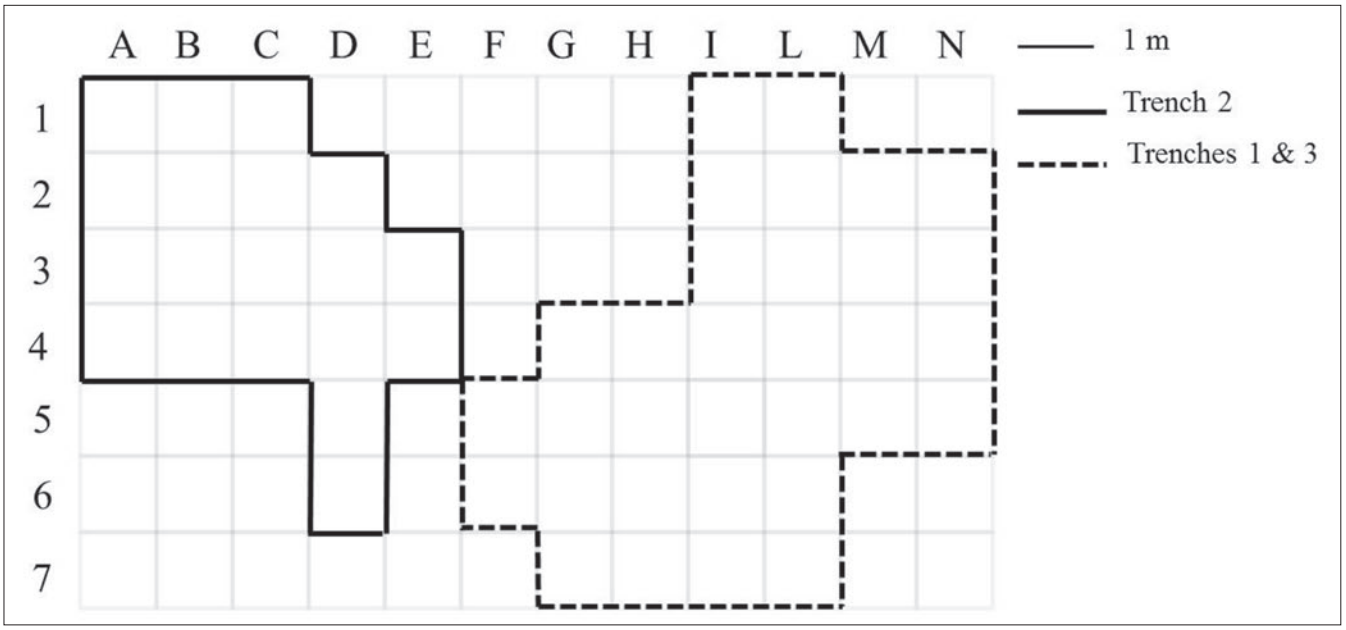

Fig. 5 Subdivision of these three trenches from 2002 for performing intra-site spatial analysis
Sl. 5 Razdelitev območja treh sond iz leta 2002 za potrebe znotrajnajdiščne prostorske analize

3.2 Spatial data collection and sampling

During 2002 three trenches, respectively subdivided into twelve (trenches 1 and 2) and nine (trench 3) 1 x 1 m squares were excavated (Fig. 2). All the sediments resulting from excavation were wet-sieved through both 3 mm and

po Binford 1978). O podobnem početju, ki je bilo lokalno razmeroma pogosto dokumentirano predvsem v paleolitskih in mezolitskih kontekstih (Pohar 1984; 1986; Rowley-Conwy 1996; Miracle et al. 2000; Toškan, Dirjec 2004; Turk et al. 2004; Miracle 2007: 220–227; Odar 2008: 9), je mogoče govoriti tudi pri Resnikovemu prekopu sočasnih najdiščih. Tak primer je, denimo, Spaha nad Brezovico pri Predgradu

2 As above mentioned, we have also to take into account that the site is interpreted as a short-lived settlement.

3 As pointed out by previous researches they are not easily find out in the natural environment.

4 More details are provided in Velušček 2006.

5 And the results of intra-site spatial analyses presented therein.

1 Izmed 477 živalskih najdb jih 91 ne presega centimetra, velikost 317 primerkov se giblje med enim in petimi centimetri, 51 primerkov meri med pet in deset centimetrov, 15 primerkov med deset in petnajst centimetrov, zgolj trije odlomki pa so večji od 15 cm (Toškan, Dirjec 2006: 145).

1 mm mesh (Velušček 2006: 54–55). X, y, and z co-ordinates were determined for the more important finds, while the remainder were spatially defined by a 1 square metre grid and recorded on hand-drawn maps. Therefore, a centroid-system was calculated, characterised by x-y centroid coordinates of 0.50 square metres within each square metre, in order to capture the finds spatially. Within each sampling unit the associated total frequency of each material category was counted. Trench 2 comprised 19 sampling units named from A to E and from 1 to 6, while trenches 1 and 3 included 32 sampling units named from F to N from 1 to 7 (Fig. 5). Such trenches are spatially almost continuous, despite the presence of empty space between trenches 1 and 3 and trench 2. Avoiding possible sampling issues in spatial data analysis related to such conditions[6] we considered the former together and the latter alone. The dataset included the two macro-categories of heavier artefacts (pottery, stones and vertical piles) and more movable finds (macro-fauna, avifauna, micro-fauna, seeds and horizontal piles); they were spatially distributed in the same alluvial deposit and sub-divided within trenches according to Table 1.

na Kočevskem (tj. pribl. 50 km JV; Toškan 2011: 277). V zvezi s kostnimi ostanki z Resnikovega prekopa je pomembno omeniti tudi pogostnost močno obrušenih primerkov, ki jo kaže pripisati izpostavljenosti vodnemu toku. Analizirani nabor živalskih najdb torej najbrž ne predstavlja celovitega arheozooloških inventarja z obravnavanega najdišča, kar ne nazadnje dokazuje tudi bistveno manjše število tovrstnih najdb v primerjavi z drugimi kolišči na območju Ljubljanskega barja[2] (glej npr. Toškan, Dirjec 2006: Tab. 6). Ostankov velikih sesalcev z Resnikovega prekopa posledično ni mogoče *tout court* vključiti med težje najdbe, kot to velja za lončenino (kronološko dobro umeščena[3] ter večinoma znatnih dimenzij) in kamenje (namerno prineseno v vas s strani koliščarjev),[4] temveč med bolj mobilne ostanke malih sesalcev, ptičev in semen. Tovrstne (tj. lažje) najdbe so v okviru analize prostorske razpršenosti[5] zato obravnavane ločeno od težjega in bolj statičnega gradiva, saj naj bi eventualne razlike v vzorcu razpršenosti pomembno prispevale k razumevanju dinamike odlaganja posameznih kategorij najdb in vrednotenju intenzivnosti morebitnih kasnejših presedimentiranj.

categories of archaeological evidence / kategorije arheoloških najdb	frequencies TRENCH 2 / pojavnost SONDA 2	frequencies TRENCHES 1 and 3 / pojavnost SONDE 1 in 3
pottery / lončenina	53	169
macro-faunal remains / ostanki velikih živali	107	337
micro-faunal remains / ostanki malih živali	17	73
avifaunal remains / ostanki ptičev	0	44
seeds / semena	3242	11309
stones / kamenje	518	579

Tab. 1 Frequencies of material evidence considered in this study within the corresponding trenches
Tab. 1 Število primerkov različnih kategorij najdb, obravnavanih v tem prispevku, po posameznih sondah

3.3 Intra-site spatial analyses: density analysis and geostatistics

Intra-site spatial analysis performed in this study with the aim of reconstructing whether the original placement of heavier artefacts is, at least partially, preserved in the archaeological record, despite the presence of the unknown watercourse. In achieving this goal, the spatial patterns of such categories were compared with those displayed by more movable artefacts, supposedly more strongly affected by this post-depositional disturbance due to their intrinsic features, such as lightness. As a null hypothesis we postulated that the absolute counts of archaeological observations, which include all identified materials together as a palimpsest, fit a Poisson distribution, as result of a reduction of entropy, the consequence of this disturbance process. To test the uniformity, irregularity or concentration of patterns in the spatial distribution of each category, we use the Kolmogorov-Smirnov test, as well as *Nearest Neighbour analysis* (Clark, Evans 1954; Hodder, Orton 1976; Hammer, Harper 2006). Furthermore, both area-wide "trends" (first-order va-

6 For a more detailed explanation and references therein see Achino 2016.

3.2 Zbiranje podatkov o prostorski razkropljenosti najdb in vzorčenje

Leta 2002 so bile izkopane tri sonde, od katerih sta prvi dve (sonde 1 in 2) merili 12 m^2, tretja (sonda 3) pa 9 m^2 (sl. 2). Ves izkopani sediment je bil presejan na sitih s premerom 3 oziroma 1 mm (Velušček 2006: 54–55). Pri pomembnejših najdbah so bile natančno izmerjene koordinata x, y in z, pri drugih je na voljo zgolj podatek o kvadrantu (površina: 1 x 1 m^2) in režnju, iz katerega posamezna najdba izvira. Da bi pri prostorski analizi lahko zajeli lego vseh ostalin, je bil postavljen sistem središčnih točk (centroidov) s po eno točko v sredini neodvisno opredeljenih 1 m^2 velikih kvadrantov. Za vsako takšno osnovno vzorčno enoto je bilo ugotovljeno natančno število primerkov posameznih kategorij najdb (tj. lončenine, kamenja, semen, kosti, kolov). Sonda 2 je obsegala 19 vzorčnih enot, poimenovanih od A do E in od 1 do

2 Pri tem je treba upoštevati tudi vpliv kratkega trajanja naselbine na Resnikovem prekopu.

3 Za podrobnejše podatke glej Velušček (2006).

4 Gre za najdbe, ki v lokalnem naravnem okolju niso zlahka dobavljive.

5 Kakor tudi v okviru predstavitve rezultatov znotrajnajdiščne prostorske analize.

riation) and correlation structures (second-order variation) of categories within the trenches were analysed. First order properties of a spatial pattern of variation are indicative of the intensity of the process at particular locations (Cressie 1993; Bailey, Gatrell 1995); since for this study the available dataset is composed of spatial frequencies counted per sampling unit for each category of material evidence, we perform density-distributional analysis. This are among the most common methods used in archaeology to spatially represent data, since it enables easy graphical detection of areas where major accumulations of remains are located; they are usually calculated using a grid that divides the area being analysed, plotting and counting the objects situated within each grid cell (Baxter et al. 1997), in this case by a centroid coordinate. This kind of study, more widespread at the inter-site scale, is now also used for small intra-site interpretations of spatial patterns (Oron, Goron Inbar 2014; Sánchez-Romero et al. 2016). First-order variations are statistically described and visualised by a plot of spatial frequencies and Kernel Density Estimates; this latter method can be used to convert spatially distributed single observations (counts) into spatial frequencies, by estimating the amplitude of cells. Thus, *z* is an estimate of the local intensity of the spatial process, in terms of the greater or lower density of locations (Ahsanullah 1985; Kotz et al. 2000). Furthermore, the spatial pattern of archaeological observations at a particular place and in its immediate area can be described using a variation of standard statistical parameters suitable for spatial distribution, as provided by centrographic statistics. Second-order variations were also taken into account in this study: by analysing the relationships between the different frequencies of archaeological features within the sampled area, the spatial dependence attested was calculated. To estimate autocorrelation, two of the most important second-order properties characterising a spatial process, Moran's I Correlogram and semivariogram, were calculated (Bailey, Gatrell 1995; Cressie 1993; Fotheringham et al. 2000; Houding 2000; Diggle 2003; Hanning 2003; Lloyd, Atkinson 2004). These are widespread in archaeological research (Kvamme 1990; Lloyd, Atkinson 2004; Premo 2004; Wells 2010; Rondelli et al. 2014; Carrer 2015). Such mathematical tools explore whether repeated spatial patterns are present; the occurrence of positive spatial autocorrelation suggests that neighbouring sampling units have similar frequencies of evidence, which implies the presence of a certain degree of uniformity over a specific delimited area. Negative spatial autocorrelation indicates the presence of very different frequency values between neighbouring locations, suggesting the concentration of evidence at distinct places within the site. As suggested elsewhere (Achino et al. 2016), by using the analysis of second order variations we can predict the most probable location of the original social action in the site; hence, change in the frequency of evidence at different locations is a measure of the probability that associated activities were performed in certain locations.

6, sondi 1 in 3 pa 32 vzorčnih enot, poimenovanih od F do N in od 1 do 7 (sl. 5). Sonde su bile skori povezane, samo je prazen prostor bil med sondi 1 in 3 in sonde 2. Da navedena okoliščina ne bi negativno vplivala na rezultat prostorske analize,[6] je bila sonda 2 obravnavana ločeno. Končna podatkovna baza vstopnih podatkov je tako vključevala informacijo o frekvenci pojavljanja posameznih kategorij težjih najdb (lončenina, kamenje, vertikalni koli), pa tudi lažjih, bolj mobilnih ostalin (ostanki velikih in malih sesalcev, ptičev, semen in horizontalnih kolov). Vse gradivo izvira iz istega naplavljenega sedimenta. Razpršenost najdb znotraj posameznih sond je prikazana v tabeli 1.

3.3 Znotrajnajdiščna prostorska analiza: analiza gostote in geostatistika

Z znotrajnajdiščno prostorsko analizo smo se nadejali ugotoviti, ali dokumentirani vzorec razpršenosti težjih najdb v kakršni koli meri odseva njihovo izhodiščno lego iz časa obstoja naselbine, kljub poznejši izpostavljenosti delovanju neznanega vodnega toka. Pri tem so bili za primerjavo upoštevani podatki o najdiščnih lokacijah lažjih najdb, kjer je bil učinek vodnega transporta domnevno še izrazitejši. V izhodišče smo postavili ničelno hipotezo, po kateri naj bi razpršenost arheoloških ostankov na raziskanem območju ustrezala Poissonovi porazdelitvi; vodni transport naj bi namreč pripomogel k zmanjšanju entropije. Stopnjo odstopanja od enakomerne razpršenosti posameznih kategorij najdb smo ugotavljali z uporabo testa Kolmogorova in Smirnova in z analizo razdalje do najbližjega soseda (*Nearest Neighbour Analysis*; Clark, Evans 1954; Hodder, Orton 1976; Hammer, Harper 2006). Ob tem smo analizirali tudi "trende" na širšem območju (*area-wide "trends"*; variacija prvega reda) in korelacijske strukture (variacija drugega reda). Ker so bili v tukaj predstavljenem primeru v izhodišče raziskave postavljeni podatki o številu primerkov posameznih kategorij najdb na prostorsko opredeljeno vzorčno enoto, je bila med drugim izvedena analiza njihovih zgostitev v prostoru (*density-distributional analysis*). Našteta analitična orodja sodijo med najpogosteje uporabljene metode ponazarjanja in analize prostorske razpršenosti predmetov v arheologiji, saj omogočajo enostavno prepoznavo območij z izrazitejšimi koncentracijami ostalin. Praviloma temeljijo na razdelitvi preučevanega območja na kvadrante (v tukajšnjem primeru so to koordinate središčnih točk oziroma centroidov) in ugotavljanju števila primerkov posameznih kategorij najdb v vsakem izmed njih (Baxter et al. 1997). Tovrstne analize, sicer pogoste pri mednajdiščnih primerjavah, so na tem mestu uporabljene pri raziskavi vzorcev razpršenosti gradiva znotraj razmeroma omejene površine enega samega najdišča (cf. Oron, Goron Inbar 2014; Sánchez-Romero et al. 2016). Variacije prvega reda, ki pričajo o intenzivnosti procesa na nekem območju (Cressie 1993; Bailey, Gatrell 1995), smo statistično opisali. Ponazorjene so z grafičnim prikazom števila najdb na prostorsko enoto in z ocenami Kernelove gostote (*Kernel Density Estimates*). Slednje omogočajo pretvorbo enostavnih podatkov o številu najdb na

6 Za podrobnejšo predstavitev problematike glej Achino (2016) in tam navedeno literaturo.

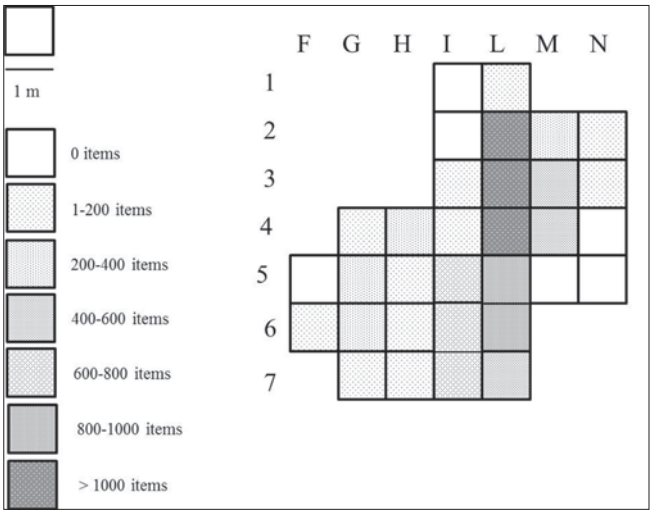

Fig. 6 2D histogram of palimpsest frequencies distributed within trenches 1 and 3

Sl. 6 Dvodimenzionalni histogram pojavnosti celotnega nabora arheoloških najdb na območju sond 1 in 3

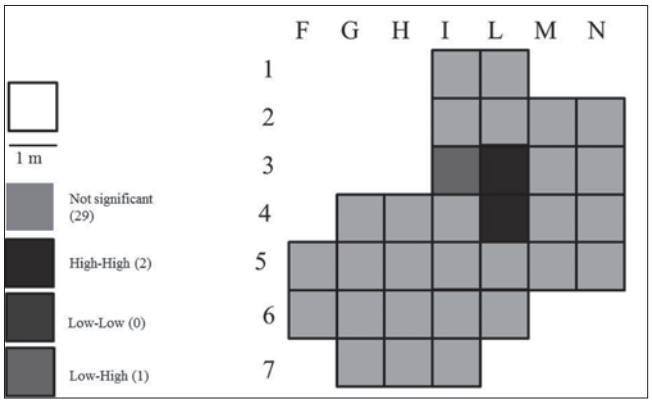

Fig. 7 Graphical result of Local Moran I for palimpsest, within trenches 1 and 3

Sl. 7 Grafični prikaz rezultatov lokalnega testa Moran I za celoten nabor arheoloških najdb na območju sond 1 in 3

4. RESULTS

4.1 Distributional analysis of archaeological data and spatial variability: trenches 1 and 3

In exploring the spatial patterns followed by material evidence and their density variability within these trenches, we began by analysing the absolute counts of archaeological observations. This was used to form a null hypothesis for the separated analysis of the two main archaeological categories, heavier and more movable artefacts. In general terms, we defined a random – Poisson – distribution as the null hypothesis, i.e. the absence of recognisable concentrations. If this hypothesis fitted our data, evidence of a random spatial distribution for all evidence would be identified. In this case, it would mean that each spatial location should have similar frequency values of archaeological remains, indicating the absence of any preserved trace of the original spatial pattern, completely obscured by post-depositional processes for all categories of evidence. The results obtained from the Kolmogorov-Smirnov test refuted this hypothesis, enabling us to carry out spatial analysis for the palimpsest, as well as for the main categories above reported separately. According to the distributional analysis (as graphically portrayed by Fig. 6), the majority of the evidence is homogeneous and linearly concentrated within sampling units L2, L3, L4, L5 and L6. Global Moran's I autocorrelation results are indicative of a predominant spatial heterogeneity; for instance, the semivariogram shows a non-linear model that does not fit the Poisson distribution. Graphical results of the interpolation[7] and Local Moran were more informative, underlining the presence of two spatially concentrated sampling units with high-high values of autocorrelation (L3 and L4) (Fig. 7). The same step-by-step procedure was applied to single classes of evidence included within the two main categories considered in this study.

7 Used in this context as a "predictive" model which enables to visualise the spatial concentration of material evidence (for more details see Achino 2016).

prostorsko enoto v podatke o prostorskih frekvencah (*spatial frequencies*) na podlagi amplitude celic oziroma osnovnih prostorskih enot. Pri tem oceno intenzivnosti prostorskega procesa na nekem območju v smislu večje ali manjše gostote lokacij izražamo z vrednostjo 'z' (Ahsanullah 1985; Kotz et al. 2000). Vzorec razpršenosti najdb v okviru izbrane točke in njene neposredne soseščine je lahko prikazan tudi z uporabo standardnih statističnih parametrov prostorske analize v okviru centrografske statistike.

Pri analizi variacije drugega reda smo primerjali vzorce razpršenosti različnih kategorij arheoloških ostalin. Avtokorelacijo smo ocenili s pomočjo Moranovega korelograma in semivariograma, sicer dveh osrednjih lastnosti drugega reda, ki označujejo prostorski proces (Bailey, Gatrell 1995; Cressie 1993; Fotheringham et al. 2000; Houding 2000; Diggle 2003; Hanning 2003; Lloyd, Atkinson 2004). Gre za pogosto uporabljeni analitični orodji v arheologiji (Kvamme 1990; Lloyd, Atkinson 2004; Premo 2004; Wells 2010; Rondelli et al. 2014; Carrer 2015), ki omogočata zaznavo eventualnih ponavljajočih se vzorcev prostorske razpršenosti gradiva. Pozitivna prostorska avtokorelacija nakazuje, da so bile znotraj sosednjih kvadrantov odkrite primerljive količine posameznih kategorij najdb in da so te razpršene podobno. Negativna prostorska avtokorelacija izpostavlja ravno nasprotno, tj. obstoj bistvenih razlik v količini lončenine, kosti, kamenja in kolov med sosednjimi kvadranti. Koncentracija različnih kategorij najdb se v takšnih primerih torej znotraj preučevanega prostora pojavlja na različnih mestih. Kot že pokazano drugod (Achino et al. 2016), lahko z uporabo analiz variacije drugega reda opredelimo najverjetnejša območja izvajanja posameznih aktivnosti znotraj nekdanje naselbine.

4. REZULTATI

4.1 Analiza razkropljenosti arheoloških najdb in variabilnost v prostoru: sondi 1 in 3

Pri raziskovanju vzorcev razpršenosti posameznih kategorij arheoloških najdb in variabilnosti v pojavljanju njihovih zgostitev na območju navedenih dveh sond smo najprej zbrali podatke o številu odkritih primerkov na kvadrant. Na

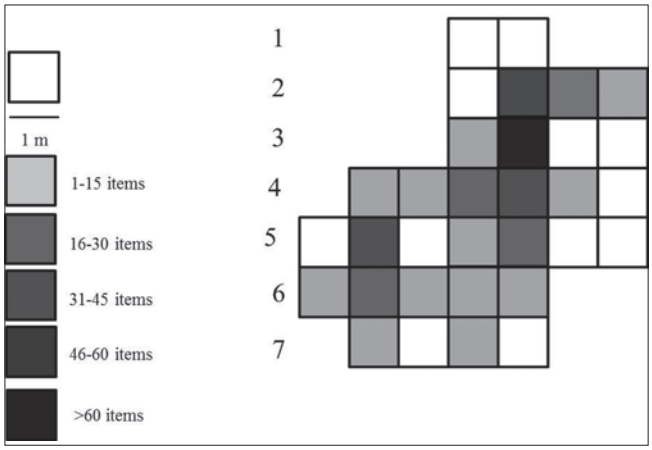

Fig. 8A 2D histogram of macro-faunal frequencies distributed within trenches 1 and 3

Sl. 8A Dvodimenzionalni histogram pojavnosti ostankov velikih sesalcev na območju sond 1 in 3

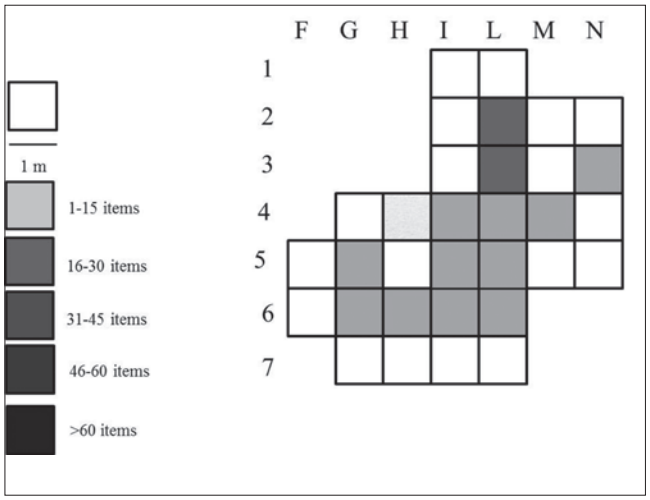

Fig. 8B 2D histogram of micro-faunal frequencies distributed within trenches 1 and 3

Sl. 8B Dvodimenzionalni histogram pojavnosti ostankov malih sesalcev na območju sond 1 in 3

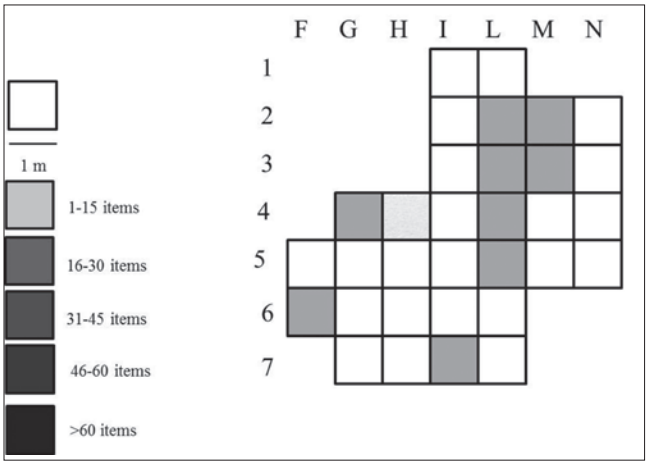

Fig. 8C 2D histogram of avifaunal frequencies distributed within trenches 1 and 3

Sl. 8C Dvodimenzionalni histogram pojavnosti ostankov ptičev na območju sond 1 in 3

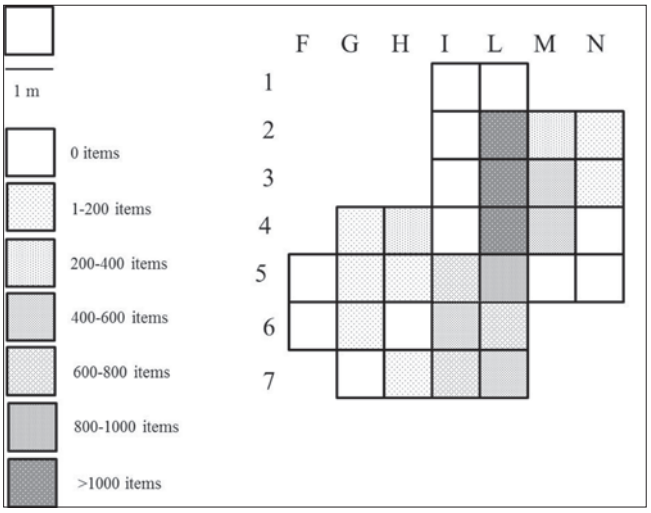

Fig. 8D 2D histogram of seed frequencies distributed within trenches 1 and 3

Sl. 8D Dvodimenzionalni histogram pojavnosti semen na območju sond 1 in 3

dy. Surprisingly, the major contribution to the formation of the concentration in sampling units L3 and L4, noted above, is the movable objects (avifauna, micro- and macro-fauna, and seeds) (Figs. 8a, b, c and d). Their spatial distribution did not fit a Poisson distribution (macro- as well as micro-fauna fitted a Binomial negative distribution)[8] and they were mainly distributed according to an overdispersal spatial pattern. Furthermore, in this area of concentration the majority of both vertical piles and horizontal wooden remains recovered were also preserved.

In contrast, the other categories of evidence included among the heavier artefacts, stones and pottery, were spatially differently distributed. The former fit an overdispersal spatial pattern, with the highest frequencies concentrated

8 Macro-fauna: K-S Test for Binomial Negative distribution=0.99 with k=0.273 and p=0.025; micro-fauna: K-S Test for Binomial Negative distribution=1 for k=0.211 and p=0.086.

tej podlagi smo v nadaljevanju oblikovali ničelno hipotezo o naključni razpršenosti posameznih kategorij ostalin v prostoru skladno s Poissonovim modelom porazdelitve. Odsotnost kakršnih koli prepoznavnih koncentracij bi pričala o tem, da je delovanje poodložitvenih procesov zabrisalo vsakršne sledi izhodiščne prostorske razpršenosti najdb. Vendar pa so rezultati testa Kolmogorova in Smirnova pokazali, da je treba ničelno hipotezo ovreči. S tem so osmislili izvedbo dodatnih analiz na celotnem palimpsestu razpoložljivih najdb ter tudi za vsako od obeh omenjenih skupin posebej. Analiza razpršenosti (sl. 6) je pri tem pokazala, da so bile pri večini različnih kategorij najdb največje koncentracije ugotovljene na območju vzorčnih enot L2, L3, L4, L5 in L6. O poudarjeni prostorski heterogenosti pričajo tudi rezultati avtokorelacijskega testa Moran I; semivariogram, denimo, izkazuje nelinearni model, ki značilno odstopa od Poissonovega modela porazdelitve. Grafični rezultati in-

within cells I5 and L7, while sampling units with medium to high frequencies of evidence were observed close to these (Figs. 9a and b). However, both Global and Local Moran I results, as well as a Moran I Correlogram and semivariogram, demonstrated the absence of autocorrelation between different spatial locations within these trenches. The latter category, pottery, approximated a Binomial Negative distribution[9] and it was also spatially overdispersed. According to the 2D histogram, pottery was predominantly attested at medium frequencies in sampling units G6, H6 and I6, while higher counts were mainly concentrated in G5 (Fig. 9a). Local Moran results, as well as a Moran I Correlogram, indicated spatial autocorrelation between neighbouring sampling units within trenches 1 and 3. A Moran I Correlogram highlighted positive spatial autocorrelation at distances ranging between 0.50 and 1.2 metres, while Local Moran marked out three neighbouring sampling units (F6, G5 and G6) which showed high-high values of autocorrelation. They corresponded to concentrations, even underlined by interpolation (Fig. 10); a further continuity in the count of frequencies was observed in the surrounding low-high values in cells G7, H4 and H5. Four low-low sampling units (L2, M2, N2 and N4) are defined as centres of absence, since observations are scarcely attested in these cells.

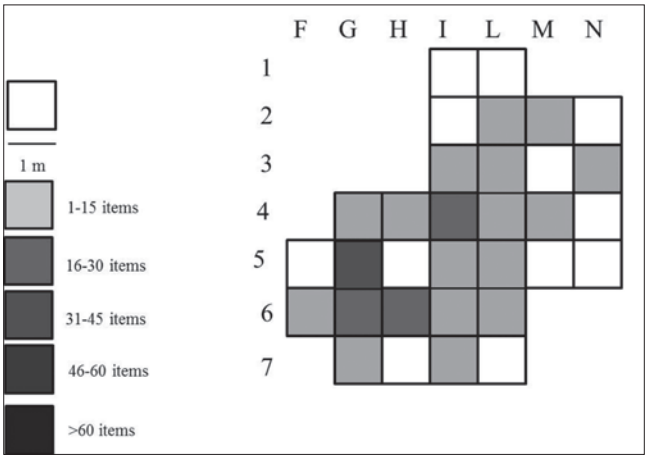

Fig. 9A 2D histogram of pottery frequencies distributed within trenches 1 and 3

Sl. 9A Dvodimenzionalni histogram pojavnosti lončenine na območju sond 1 in 3

In general terms, the data provided by spatial analysis shows the different concentrations of evidence ascribable to heavier artefacts (mostly stones and pottery), compared to that of more movable remains (macro- and microfauna, avifauna and seeds). Their spatial association with the highest frequencies of vertical and horizontal piles[10] attested within the trenches suggests a hypothetical reconstruction of their pattern, based on comparisons with modern observations of the river Ljubljanica (Fig. 11). As can be presumed, these portable archaeological remains have suffered the effects of the unknown watercourse which traversed the investigated area in the past. Although its

9 P-values with a only sufficient value for k=0.428 and p=0.075.

10 Their modest number, however, does not allow the interpretation of the purpose of the structures of which they were part.

terpolacije[7] in vrednosti lokalnega testa Moran I so v tem smislu še pomenljivejši, saj kažejo na obstoj dveh različnih območij s kombinacijo visokih avtokorelacijskih vrednosti (L3 in L4) (sl. 7). Enak analitični pristop je bil uporabljen za posamezno kategorijo najdb znotraj skupine težjih oziroma lažjih ostalin. V nasprotju s pričakovanji smo ugotovili, da k prej omenjeni izraziti koncentraciji najdb v vzorčnih enotah L3 in L4 ključno prispevajo mobilnejši predmeti (ptičje kosti, ostanki malih in velikih sesalcev, semena) (sl. 8a, b, c in d). Vzorec njihove razpršenosti odstopa od Poissonovega modela porazdelitve (ostanki malih in velikih sesalcev so izkazovali negativno binomsko porazdelitev),[8] na območju njihovega najizrazitejšega pojavljanja pa so bile ugotovljene tudi izstopajoče koncentracije vertikalnih kolov in horizontalno orientiranih lesenih ostankov.

Ostale težje najdbe, tj. kamenje in lončenina, so razpršene drugače. Podatki za kamenje izkazujejo nadrazpršenost (*overdispersion*), pri čemer vzorčne enote z najizrazitejšo koncentracijo najdb (tj. I5 in L7) mejijo na enote s srednje visokimi in visokimi frekvencami pojavljanja te kategorije ostalin (sl. 9a in b). Vendar pa rezultati lokalnega in globalnega testa Moran I, pa tudi Moranovega korelograma in semivariograma, zavračajo možnost obstoja avtokorelacije

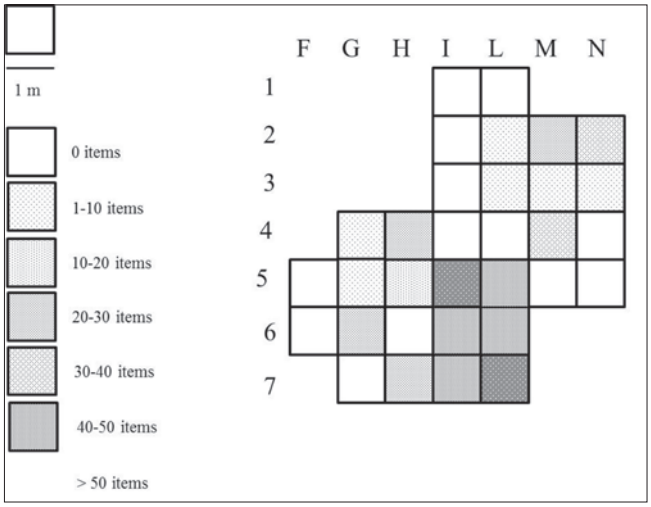

Fig. 9B 2D histogram of stone frequencies distributed within trenches 1 and 3

Sl. 9B Dvodimenzionalni histogram pojavnosti kamenja na območju sond 1 in 3

med posameznimi območji znotraj obeh sond. Prostorska razpršenost lončenine ustreza negativni binomski porazdelitvi.[9] Število teh najdb, ki so v prostoru nadrazpršene, je največje v vzorčni enoti G5, v enotah G6, H6 in I6 pa so ugotovljene vrednosti srednje visoke (sl. 9a). Rezultati lokalnega testa Moran I ter tudi Moranov korelogram so pokazali na avtokorelacijo med sosednjimi vzorčnimi enotami znotraj

7 V tem primeru uporabljeno kot "napovedni" model, ki omogoča prikaz razkropljenosti ostalin v prostoru (za podrobnosti glej Achino 2016).

8 Ostanki velikih sesalcev: K-S test negativne binomske porazdelitve = 0,99, pri k = 0,273 in p = 0,025; ostanki malih sesalcev: K-S test negativne binomske porazdelitve = 1, pri k = 0.211 in p = 0.086.

9 Kot zadostna je bila ugotovljena le ena P-vrednost, in sicer pri k = 0,428 in p = 0,075.

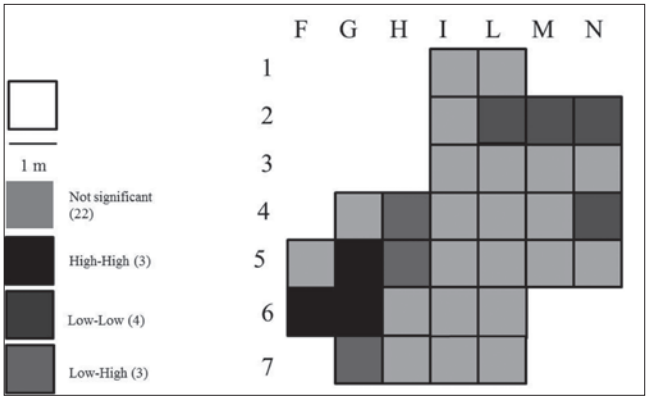

Fig. 10 Graphical result of Local Moran I for pottery, within trenches 1 and 3

Sl. 10 Grafični prikaz rezultatov lokalnega testa Moran I za lončenino na območju sond 1 in 3

strength was not particularly strong, as reconstructed from archaeological observations (Toškan 2006; Velušček 2006; Gaspari 2009: 38)[11] and experiments performed in comparable conditions to measure the flow of the current Ljubljanica river (Gaspari 2002: 55–58)[12], it was probably able to substantially shift objects of smaller specific weights (Gaspari 2002: 55–58). For this reason their concentration in the

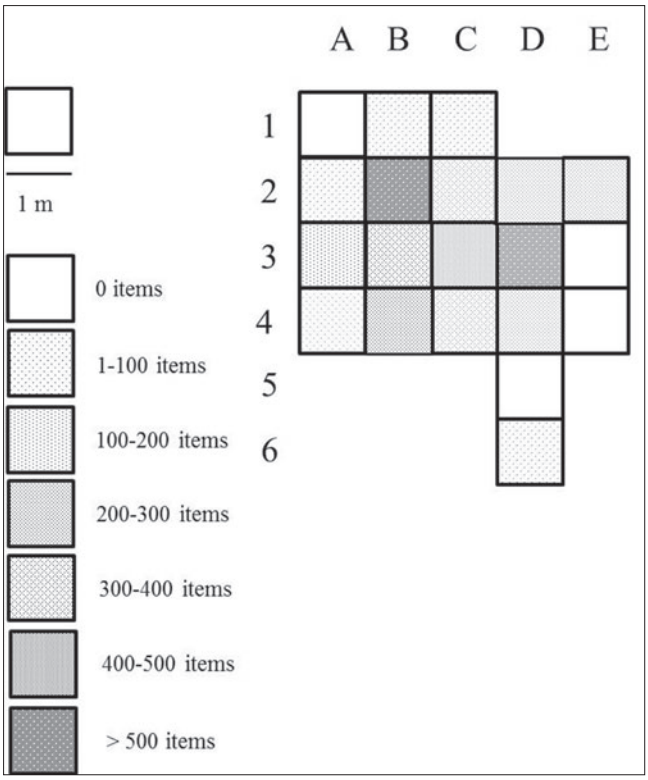

Fig. 12 2D histogram of palimpsest frequencies distributed within trench 2

Sl. 12 Dvodimenzionalni histogram pojavnosti celotnega nabora arheoloških najdb na območju sonde 2

Fig. 11 The accumulation of organic material at the metallic piles of the riverine port at Špica in Ljubljana (photo: D. Valoh)

Sl. 11 Akumuliran organski material ob kovinskih pilotih rečnega pristanišča na Špici v Ljubljani (foto: D. Valoh)

obeh obravnavanih sond. Na podlagi Moranovega korelograma je bilo mogoče ta fenomen zaznati na razdaljah med 0,5 in 1,2 metra, lokalni test Moran I pa je pokazal na obstoj koncentracije najdb na območju sosednjih referenčnih točk F6, G5 in G6. Slednje je potrdila tudi interpolacija (sl. 10), pri čemer nižje vrednosti v okoliških enotah G7, H4 in H5 razumemo kot robni efekt obravnavanega območja koncentracije lončenih najdb. Omeniti je treba še skupino sosednjih vzorčnih enot L2, M2, N2 in N4, ki izstopajo po pičlosti lončenine in jih zato opredeljujemo kot središče odsotnosti te kategorije arheoloških ostalin.

Ugotovimo lahko, da so rezultati prostorske analize nedvoumno dokazali obstoj razlik v vzorcu razpršenosti težjih (tj. predvsem kamenja in lončenine) in lažjih (tj. ostanki malih in velikih sesalcev, ptičjih kosti in semen) arheoloških najdb. Pri tem je zanimivo, da je bila na območju z najvišjimi koncentracijami lažjih najdb ugotovljena tudi največja pojavnost kolov.[10] Zdi se, da z razlogom. Ko je namreč čez najdišče tekel neznani vodni tok in pri tem odplavljal (tudi) kosti in semena, jih je na tem mestu utegnil zadržati preplet vejevja, ujetega med posameznimi vertikalnimi koli. Podoben fenomen lahko ob vertikalnih ovirah na reki Ljubljanici opazujemo tudi danes (sl. 11). Čeprav naj moč nekdanjega vodnega toka na območju Resnikovega prekopa ne bi bila velika – o čemer pričajo tako izsledki arheoloških raziskav (Toškan 2006; Velušček 2006; Gaspari 2009: 38)[11] kot tudi eksperimentalne študije učinkov vodnega transporta reke Ljubljanice v sedanjosti (Gaspari 2009: 55–58)[12] – je ta domnevno torej še vseeno zadoščala za prerazporejanje lažjih

11 Preservation of hoards with clearly recognisable connections and parts of the same found together nearby, along with the good preservation and the limited degree of broken surfaces of pottery vessels (Gaspari 2009: 38).

12 Objects experimentally deposed have been retrieved in an almost unchanged position for several years.

10 Njihovo skromno število sicer ne dovoljuje interpretacije namembnosti struktur, katerih del so bili.

11 O tem pričajo, denimo, zakladne najdbe z jasno prepoznavno povezavo med posameznimi blizu najdenimi sestavnimi deli, pa tudi visoka stopnja ohranjenosti in majhna fragmentiranost lončenih posod (Gaspari 2009: 38).

12 V strugo namerno odloženi predmeti se med nekajletnim opazovanjem skoraj niso premaknili.

sampling units where wooden remains are attested is not so surprising; in fact, as part of a prehistoric structure, these timbers could represent the first barriers large enough to interrupt the movement of artefacts, as attraction points for almost all of these one centimetre remains. Among these portable remains are some which provide C^{14} evidence dating them to different time periods, as observed for two seeds (Culiberg 2006: 131) yielding an age of 1250 ± 40 BP (seed of *Staphylea pinnata*) and 1587 ±3 0 BP (nut of *Corylus avellana*). The latter confirms, on one hand, the portability of such light evidence and, on the other, the role of wooden remains as a "pull factor" during the past.

4.2 Distributional analysis of archaeological data and spatial variability: trench 2

The null hypothesis was tested that the palimpsest, i.e. the absolute counts of archaeological observations identified within trench 2, fitted a Poisson distribution; the results provided by a Kolmogorov-Smirnov test refuted this hypothesis, and enabled the analysis of the main categories of evidence already defined. According to density-distributional analysis, as graphically portrayed by 2D histogram, Fig. 12 a spatially non-homogeneous distribution of observations was attested, with the highest frequencies concentrated in sampling units B2, C3 and D3, with neighbouring cells also displaying high counts. The Global Moran I autocorrelation results are indicative of a predominant spatial heterogeneity; for instance, the semivariogram shows a

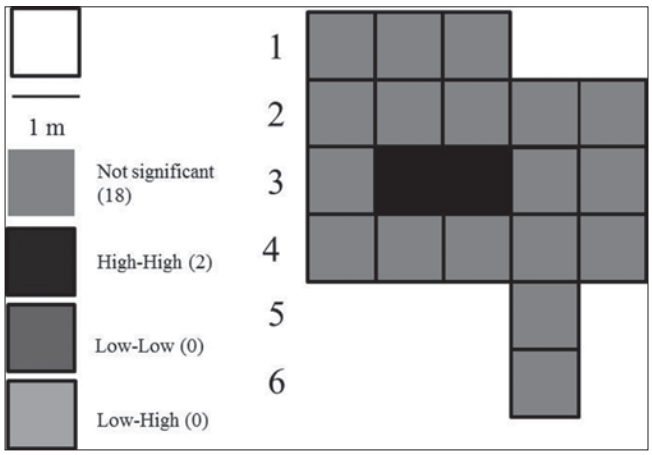

Fig. 13 Graphical result of Local Moran I for palimpsest, within trench 2

Sl. 13 Grafični prikaz rezultatov lokalnega testa Moran I za celoten nabor arheoloških najdb na območju sonde 2

non-linear model that does not fit the Poisson distribution. Graphical results of interpolation and Local Moran identify respectively the presence of these two concentrations, and the occurrence of two neighbouring sampling units with high-high values of autocorrelation (B3 and C3) (Fig. 13); the same result is provided by a Moran I Correlogram.

Concerning the two sub-categories, the heavier artefacts (stones and pottery)[13] showed very similar spatial distributions within trench 2. Stones were quite homogepredmetov (Gaspari 2002: 55–58). Med obravnavanimi lažjimi najdbami je bilo nekaj primerkov analiziranih z metodo radioaktivnega ogljika. Rezultati so pokazali, da najdbe izvirajo iz različnih obdobij in ne zgolj iz časa trajanja koliščarske naselbine (glej npr. semeni vrst *Staphylea pinnata* in *Corylus avellana*, katerih starost je bila ocenjena na 1250 ± 40 BP oziroma 1587 ± 30 BP; Culiberg 2006: 131). Predstavljene ugotovitve torej v celoti podkrepljujejo tezi o vodnem transportu lažjih arheoloških najdb in o skupkih vertikalnih kolov kot potencialni oviri pri takšnem transportu.

4.2 Analiza razpršenosti arheoloških najdb in variabilnosti v prostoru: sonda 2

Ničelna hipoteza, po kateri naj bi vzorec razpršenosti arheoloških ostalin na območju sonde 2 ustrezal Poissonovemu modelu porazdelitve, smo na podlagi rezultatov testa Kolmogorova in Smirnovega ovrgli. Sledila je analiza horizontalne porazdelitve posameznih kategorij najdb, kot so bile opredeljene že zgoraj. S slike 12 je razvidno, da je bila njihova razpršenost v prostoru nehomogena. Najvišje koncentracije najdb smo ugotovili v vzorčnih enotah B2, C3 in D3, nadpovprečno visoke vrednosti smo dokumentirali tudi v sosednjih enotah. Skladni s tem so rezultati globalnega testa Moran I. Nazoren primer predstavlja semivariogram, ki izkazuje nelinearen model in torej odstopa od Poissonove porazdelitve. Grafični prikaz rezultatov interpolacije in lokalnega testa Moran I potrjuje obstoj obeh omenjenih koncentracij najdb, pri čemer visoke vrednosti izkazujeta tudi dve sosednji vzorčni enoti (B3 in C3) (sl. 13). Enako izhaja iz Moranovega korelograma.

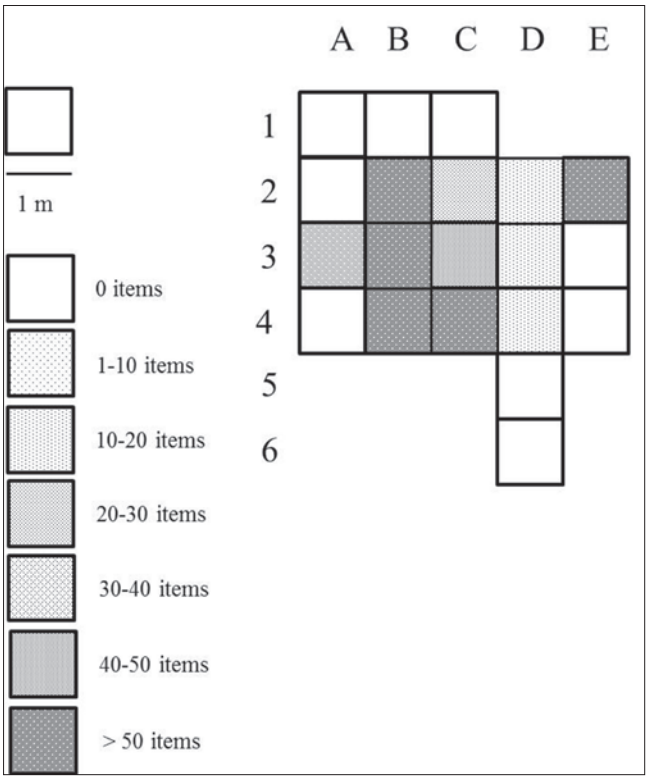

Fig. 14 2D histogram of stone frequencies distributed within trench 2

Sl. 14 Dvodimenzionalni histogram pojavnosti kamenja na območju sonde 2

13 Only three vertical piles have been recovered during excavations.

neous, and distributed with the highest frequencies in sampling units B2, B3, B4, C4 and E2; while neighbouring cells also had medium counts (Fig. 14). An absence of spatial autocorrelation is underlined by Global Moran and a Moran I Correlogram. Local Moran suggests the presence of a high-high value corresponding to cell B3, while a low-high value distinguished sampling unit A2. The latter marker, pottery, was distributed according to an overdispersal pattern, in almost the same low values across the majority of non-empty cells, with higher frequencies concentrated in sampling unit B2 (Fig. 15). Results provided by Global and Local Moran that underlined the reduced spatial autocorrelation between neighbouring sampling units were less informative. However, it is interesting to note that both such variables were closely associated in their highest frequencies. In contrast, the majority of more portable remains, macro- and micro-faunal remains, were both differently spatially distributed; although it was not possible to carry out deeper analysis for both categories, due to their infrequency within the trench, as shown by Fig. 16, 17 micro-faunal remains were distributed in similar counts within three sampling units (B1, B3 and D3), while macro-faunal evidence was concentrated in the highest frequencies in A3, with neighbouring cells again showing medium counts (A2, B2 and B3); some spatial autocorrelation was indeed confirmed by Local Moran I, which marked out high-high values within cells A3 and B3. Despite the scarcity of samples and the consequent effects on the applicability of spatial analysis, the goal of the study to compare the spatial pattern observed for the two main categories was achieved, underlining their difference.

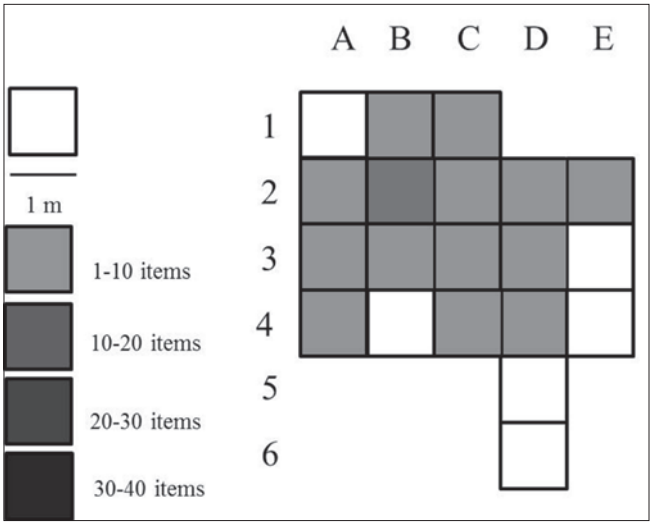

Fig. 15 2D histogram of pottery frequencies distributed within trench 2

Sl. 15 Dvodimenzionalni histogram pojavnosti lončenine na območju sonde 2

5. DISCUSSION AND CONCLUSION

The aim of this study, focused on proving the relevance of intra-site spatial analysis as a means of testing the integrity of the archaeological record in controlled conditions, can be considered to have been achieved. First of all, intra-site spatial analysis enabled the underlining of the different spatial patterns fitted by the two main categories examined (heavier artefacts vs. more portable evidence), proving that they have not been affected by post-depositional disturban-

Vzorca razpršenosti obeh kategorij težjih najdb (tj. kamenja in lončenine)[13] sta zelo podobna. Kamenje izkazuje najvišje vrednosti v vzorčnih enotah B2, B3, B4, C4 in E2, srednje visoke vrednosti so bile ugotovljene tudi v sosednjih kvadrantih (sl. 14). Rezultati globalnega testa Moran I in Moranovega korelograma kažejo na odsotnost avtokorelacije. Na podlagi izsledkov lokalnega testa Moran I smo kot območje z visoko pojavnostjo kamenja izpostavili vzorčno enoto B3 in njeno neposredno soseščino. V nasprotju s tem v okolici enote A2, ki prav tako izstopa po količini najdenega kamenja, tega materiala ni veliko. Vzorec prostorske porazdelitve lončenine izraža nadrazpršenost. V vzorčnih enotah, kjer so bile tovrstne najdbe sploh dokumentirane, je njihova pojavnost skoraj povsod skromna. Nekoliko višje vrednosti so bile ugotovljene le v vzorčni enoti B2 (sl. 15). Rezultati lokalnega in globalnega testa Moran I, ki so pokazali na majhno avtokorelacijo med sosednjimi vzorčnimi enotami, so manj povedni. Je pa zanimivo, da je vzorec razpršenosti lončenine in kamenja enak, pri ostankih malih in velikih sesalcev pa različen. Žal zaradi skromnega števila kostnih najdb v sondi 2 poglobljena prostorska analiza tega gradiva ni bila mogoča (sl. 16). Zgolj 17 ostankov malih sesalcev je sicer razmeroma enakomerno porazdeljenih med vzorčne enote B1, B3 in D3, najdbe velikih sesalcev pa največjo pojavnost izkazujejo v vzorčni enoti A3 in – z nekoliko nižjimi vrednostmi – v sosednjih enotah A2 in B2. Obstoj sicer omejene avtokorelacije med enotama A3 in B3 je bil potrjen tudi z rezultati lokalnega testa Moran I. Kljub skromnosti razpoložljivega gradiva se zdi torej sklep o različni prostorski razpršenosti težjih in lažjih najdb smiseln tudi za območje sonde 2.

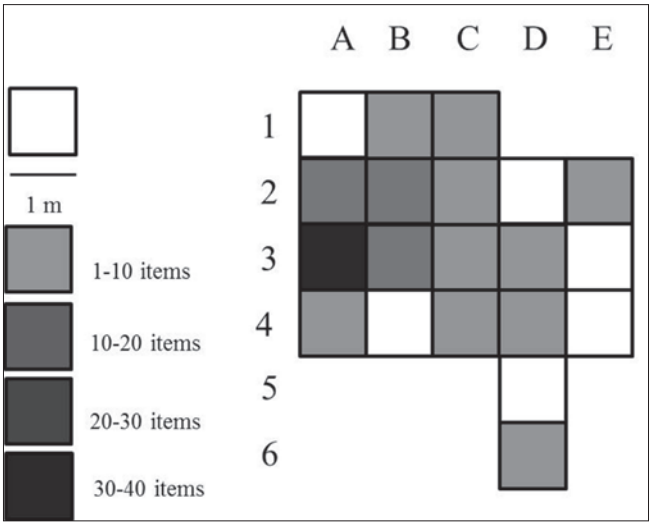

Fig. 16 2D histogram of macro-faunal frequencies distributed within trench 2

Sl. 16 Dvodimenzionalni histogram pojavnosti ostankov velikih sesalcev na območju sonde 2

5. RAZPRAVA IN SKLEP

Cilj raziskave je bil pokazati uporabnost znotrajnajdiščnih prostorskih analiz pri testiranju neokrnjenosti arheološkega zapisa v nadzorovanih razmerah, in zdi se, da je

13 Na območju sonde 2 so bili odkriti le trije vertikalni koli.

ce in the same way. Indeed, if it had been the case that the unknown watercourse had completely re-arranged the original spatial pattern for all evidence, we should expect two potential spatial patterns: 1) all material evidence would fit a Poisson distribution; 2) similar spatial concentrations would characterise classes ascribable to both main categories. In contrast, the capability to recognise the different spatial patterns also enables us to propose an interesting new reconstructive hypothesis for the observed distribution of the lightest remains within the trenches (1 and 3) with suitable frequencies of evidence (as explained in Section 4.1).

Furthermore, the re-evaluation of archaeological inferences provided by a multidisciplinary approach allows us to question whether this sector of the site can be considered the central nucleus of the settlement; taking into consideration the scarcity of macro-faunal remains, in comparison with the high frequencies generally recovered at pile-dwellings, it does not seem to completely fit this category within such a site. As noted above, the distribution could be caused by the use of particular culinary practices, as well as clean-up practices carried out after the daily butchery and consumption activities. Thus, broken bones would accumulate in a spatial location different to the potential primary activity area, as proved by archaeological and ethnoarchaeological case studies (among others Schiffer 1972; 1977; 1987; South 1977; 1979; Hayden, Cannon 1983; Rathje, Murphy 1992; Rossignol, Wandsnider 1992; Kuna 2015). Such a hypothesis which interprets the trenches excavated during 2002 as a "secondary" sector of the site is also supported by the few vertical and horizontal piles observed within this area, compared with the higher frequencies from previously investigated trenches.[14]

Based on current data and previous inferences, it appears that spatial distribution of evidence reflects well the complex history of formation and deformation at the site of Resnikov Prekop. In an attempt to corroborate the identified spatial processes, a multidisciplinary approach was singled out and the overlapping use of approaches has proved its effectiveness in providing archaeological insights that improve our understanding of the site.

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14 However, as it was previously highlighted and emphasised in Velušček 2006: 56, Fig. 5, vertical piles are not so widespread at Resnikov Prekop as in majority of Slovenian pile-dwellings.

bil dosežen. Rezultati so namreč prepričljivo potrdili razlike v vzorcu razpršenosti težjih in lažjih arheoloških najdb ter s tem pokazali, da so poodložitveni dejavniki na ti dve kategoriji ostalin delovali različno. Če bi namreč nepoznan vodni tok prerazporedil vse gradivo na območju nekdanje koliščarske naselbine, bi to privedlo do (1) ujemanja vzorca razpršenosti posameznih kategorij najdb s Poissonovo porazdelitvijo in (2) sovpadanja območij z največjo pojavnostjo lažjih in težjih ostalin. V resnici pa je bil vzorec prostorske razpršenosti obeh skupin najdb različen, kar nam je omogočilo oblikovanje nove zanimive razlage za ugotovljeno porazdelitev lažjih ostankov na območju sond 1 in 3 (glej poglavje 4.1).

Ob tem je multidisciplinarno zastavljena analiza arheološkega zapisa omogočila preverjanje možnosti, ali je na raziskano območje mogoče gledati kot na osrednji del obravnavane koliščarske naselbine. Na podlagi skromnega števila živalskih ostankov, ki se na drugih koliščih praviloma pojavljajo v bistveno večjem številu, se zdi to malo verjetno. Vzorec razpršenosti tovrstnih najdb bi prej lahko pripisali specifičnim kulinaričnim praksam ter tudi rednemu čiščenju organskih odpadkov vsled priprave in zaužitja mesne hrane znotraj naselbine. Po tej razlagi so koliščarji neuporabne odlomke razbitih kosti zavrgli izven osrednjega območja aktivnosti, kar se ujema z izsledki številnih arheoloških in etnoarheoloških primerov študij (glej npr. Schiffer 1972; 1977; 1987; South 1977; 1979; Hayden, Cannon 1983; Rathje, Murphy 1992; Rossignol, Wandsnider 1992; Kuna 2015). S takšno tezo, ki v letu 2002 raziskano površino razlaga kot območje drugotnega pomena v življenju kolišča, je skladna tudi ugotovitev o skromnem številu tam odkritih vertikalnih in horizontalnih kolov. To število namreč bistveno zaostaja za podatki z drugih raziskanih kolišč.[14]

Na podlagi tukaj predstavljenih in nekaterih predhodno objavljenih dognanj je mogoče trditi, da se v vzorcu prostorske razkropljenosti arheoloških najdb na Resnikovem prekopu v pomembni meri odraža zapletena zgodovina formiranja in deformiranja tamkajšnjega arheološkega zapisa. Uporaba multidisciplinarnega pristopa pri prostorski analizi zbranih ostalin je zato ponudila ugotovitve, ki so izboljšale naše poznavanje obravnavanega najdišča.

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14 Pri tem je sicer treba opozoriti na že izpostavljeno dejstvo, da za vrednostmi z večine drugih lokalnih kolišč zaostaja tudi gostota vertikalnih kolov na preostalih terensko raziskanih delih Resnikovega prekopa (Velušček 2006: 56, sl. 5).

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