Archaeology of Death
7 GIS & Spatial analysis of funerary areas: An Introduction

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GIS in Archaeology

GIS or Geographic Information Systems has been an important tool in archaeology since the early 1990s. Indeed, archaeologists were early adopters, users, and developers of GIS and GIScience, Geographic Information Science. The combination of GIS and archaeology has been considered a perfect match, since archaeology often involves the study of the spatial dimension of human behaviour over time, and all archaeology carries a spatial component.

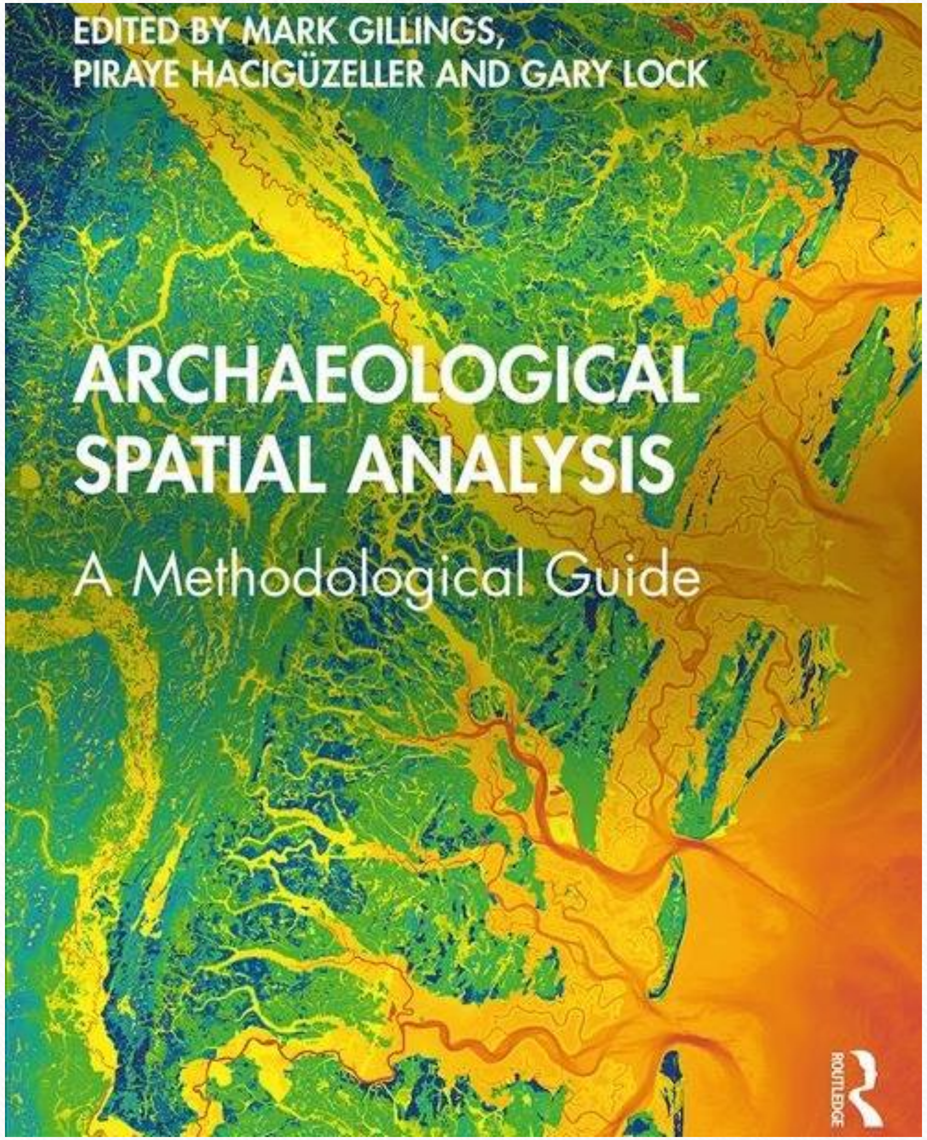
Since archaeology looks at the unfolding of historical events through geography, time and culture, the results of archaeological studies are rich in spatial information. GIS is adept at processing these large volumes of data, especially that which is geographically referenced. It is a cost-effective, accurate and fast tool. The tools made available through GIS help in data collection, its storage and retrieval, its manipulation for customized circumstances and, finally, the display of the data so that it is visually comprehensible by the user. The most important aspect of GIS in archaeology lies, however, not in its use as a pure map-making tool, but in its capability to merge and analyse different types of data in order to create new information. The use of GIS in archaeology has changed not only the way archaeologists acquire and visualise data, but also the way in which archaeologists think about space itself. GIS has therefore become more of a science than an objective tool.

GIS are able to store, manipulate and combine multiple data sets, making complex analyses of the landscape possible. Catchment analysis is the analysis of catchment areas, the region surrounding the site accessible with a given expenditure of time or effort. Viewshed analysis is the study of what regions surrounding the site are visible from that site. This has been used to interpret the relationship of sites to their social landscape. Simulation is a simplified representation of reality, attempting to model phenomena by identifying key variables and their interactions. This is used to think through problem formulation, as a means of testing hypothetical predictions, and also as a means to generate data.

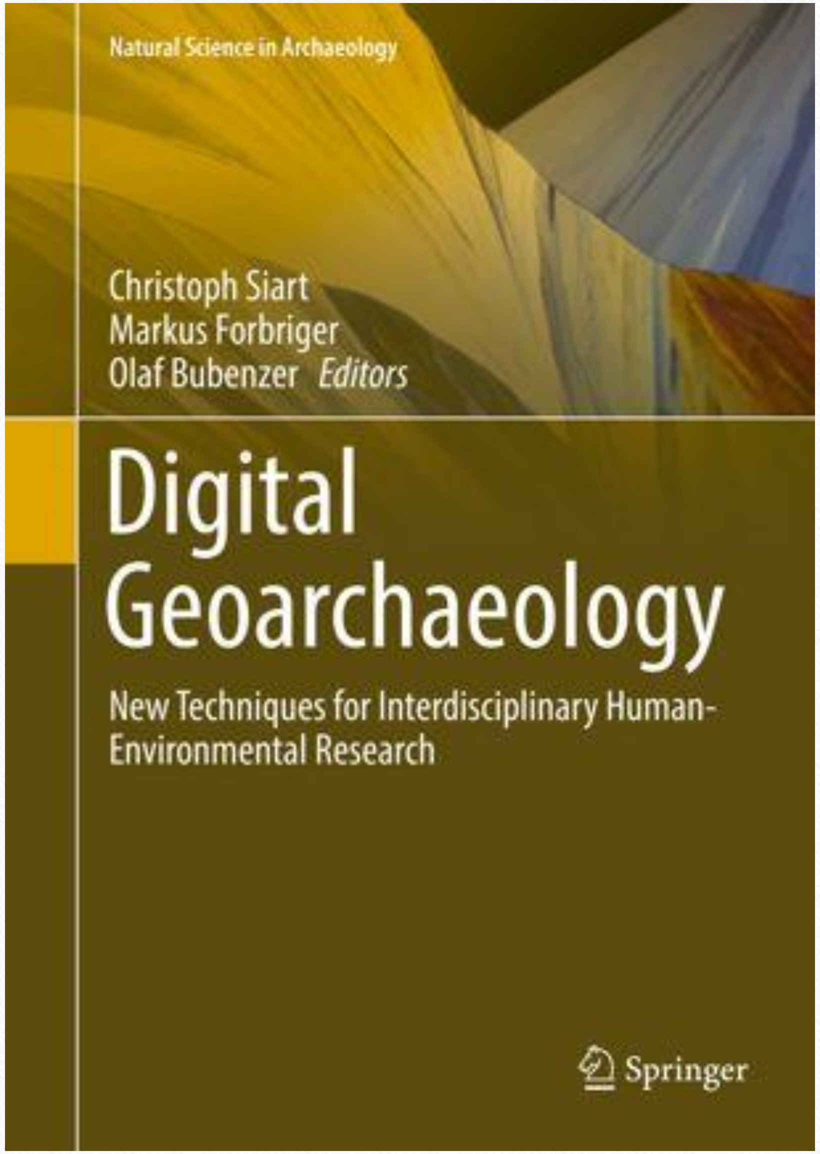
In recent years, it has become clear that archaeologists will only be able to harvest the full potential of GIS or any other spatial technology if they become aware of the specific pitfalls and potentials inherent in the archaeological data and research process. Archaeoinformation Science attempts to uncover and explore spatial and temporal patterns and properties in archaeology. Research towards a uniquely archaeological approach to information processing produces quantitative methods and computer software specifically geared towards archaeological problem solving and understanding.

Mark Gillings, Piraye Hacigüzeller & Gary Lock 2020: *Archaeological Spatial Analysis: A Methodological Guide*, Routledge, London, ISBN: 9780815373230

Effective spatial analysis is an essential element of archaeological research; this book is a unique guide to choosing the appropriate technique, applying it correctly and understanding its implications both theoretically and practically. Focusing upon the key techniques used in archaeological spatial analysis, this book provides the authoritative, yet accessible, methodological guide to the subject which has thus far been missing from the corpus. It can be consulted by undergraduate and post-graduate level students as well as instructors, researchers and professionals in archaeology. Each chapter tackles a specific technique or application area and follows a clear and coherent structure. First, is a richly referenced introduction to the particular technique, followed by a detailed description of the methodology, then an archaeological case-study to illustrate the application of the technique, and conclusions that point to the implications and potential of the technique within archaeology. The book is designed to function as the main textbook for archaeological spatial analysis courses at undergraduate and post-graduate level, while its user friendly structure makes it also suitable for self-learning by archaeology students as well as researchers and professionals.



Verhagen P. (2018): Spatial Analysis in Archaeology: Moving into New Territories. In: Siart C., Forbriger M., Bubenzer O. (eds) *Digital Geoarchaeology. Natural Science in Archaeology.* Springer, Cham, https://doi.org/10.1007/978-3-319-25316-9_2



GIS in Archaeological Research

If we would have to describe the history of the use of GIS in archaeology in a nutshell, it could be summarized as a cycle of initial enthusiasm and proliferation in the 1980s and early 1990s, followed by severe criticism and (partial) disillusionment in the late 1990s, only to be reappraised again and rapidly gaining momentum in the late 2000s, leading to its current status as an almost indispensable research tool—or rather methodology—for dealing with spatial archaeological data. The main trends in this development have been described by, e.g. Kvamme (1999), Verhagen (2007: 13–25), McCoy and Ladefoged (2009), Wagtendonk et al. (2009) and Verhagen (2012) and need not be repeated here. However, when reading the academic literature on the subject (which has the tendency of being a rather slow detector of longer-term trends), we could be under the impression that archaeologists are still reluctant and hesitant in their appreciation and adoption of GIS-based spatial analysis. This is because of its association with the theoretical school of processual archaeology, with its underlying, naive support of scientism, and with its emphasis on environmental determinism (see Hacıgüzeller 2012). Theoretically oriented archaeologists were seriously concerned about these issues in the 1990s and early 2000s when thinking about how to deal with digital technologies in general. However, archaeological practice has certainly moved on since then, and currently archaeologists have generally embraced geographical database management, digital cartography and spatial analysis, if only for reasons of efficiency. To a lesser extent, they have also gradually adopted computer-based modelling as a research tool, although acceptance here has been a lot slower, due to the fact that it has stood in the middle of the processual versus post-processual controversy (see also Verhagen and Whitley 2012). This is part of a larger debate about computing applications in archaeology that has been described as an 'anxiety discourse' by Huggett (2013) and which is a general characteristic of emerging fields trying to establish their scientific identity.

One of the reasons why the debate on GIS has been quite tense is highlighted by Hacıgüzeller (2012). She distinguishes between two views of understanding the past, the representational and non-representational. In the representational view, the past is supposed to have an objective reality. This is a reality, however, that we cannot touch. For this reason we can only use representations to understand the past. This leads to a dualistic approach to research, separating, e.g. past and present and material and meaning. It also implies that there is a constant search for the right medium to construct representations that are as faithful to 'reality' as possible—and this is exactly where GIS filled a huge gap when it came to the scene in the 1980s. Digital cartography suddenly allowed researchers (not just in archaeology) to take mapping to a much higher level and to collect and manipulate geographical data in a much more sophisticated way.

The critique of this representational viewpoint is very prominent in the post-processual rejection of 'processualist' methods such as GIS (Thomas 1993, 2001, 2004; Tilley 2004, 2008). The preoccupation of post-processual researchers with bodily understanding as the preferred way to study the past, and in this way to come closer to the mindset of human beings long dead, shows that they were looking for new ways of representation, albeit in a different form than what cartography and other techniques of data complexity reduction could achieve (see, e.g. Tilley 2004). It has however been noted before (Fleming 2006; Verhagen and Whitley 2012) that the rejection of the 'scientific method' by post-processualism contradicts one of its own tenets, i.e. the exploration of multiple and equivalent views of the past. As such, 'scientific' approaches can and should have their place in archaeological research practice, and the predominance given to narrative by post-processualists is not necessarily the best way to represent the past either

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What the early practitioners of GIS and their critics did not perceive is that GIS and other computer-based methods enable pluralism, rather than enforce reductionism. Using these tools, a multitude of representations can be created with little effort, in which there is no longer an easy way to distinguish between right and wrong and between more and less plausible. Because of this, cartography has been effectively democratized, and mapping these days is, more than ever, an exercise in (scientific) rhetoric. Following Hacıgüzeller's (2012) view, we can gain much more by adopting a non-representational approach to the study of the past, and thus to GIS. In this view, the past is not something that can be understood in a static and definitive way, but rather something that continually changes and is repeatedly reconstructed in the present. It is therefore a plea for eclecticism in using GIS and to consider it more as a constantly changing research practice than as a technology-driven instant solution that can be applied to all forms of spatial data and all archaeological research questions. It also follows that GIS-based spatial analysis and modelling can never be a stand-alone approach, but should be an integral part of what we might call 'hybrid' archaeological research—which of course echoes the strong call for interdisciplinarity in modern science.

We might even go one step further and ask ourselves whether spatial analysis and modelling could not be just one of many approaches, but perhaps constitute a *leitmotiv* for doing archaeological research in the twenty-first century. An important characteristic of computer-based techniques that sets them apart from all other approaches is their ability to deal with data sets that are too big and complex to handle by human minds. Therefore, they can be applied to all situations where we have 'big data'. GIS can deal with big data that also have a spatial dimension and in this way help to discern patterns and to simulate theories of human behaviour over large areas. It is therefore, in all probability, the next frontier for spatial technology in archaeology: to move beyond the boundaries of individual, site-based or micro-regional projects and to have a look at the 'big picture'.

Visibility Analysis

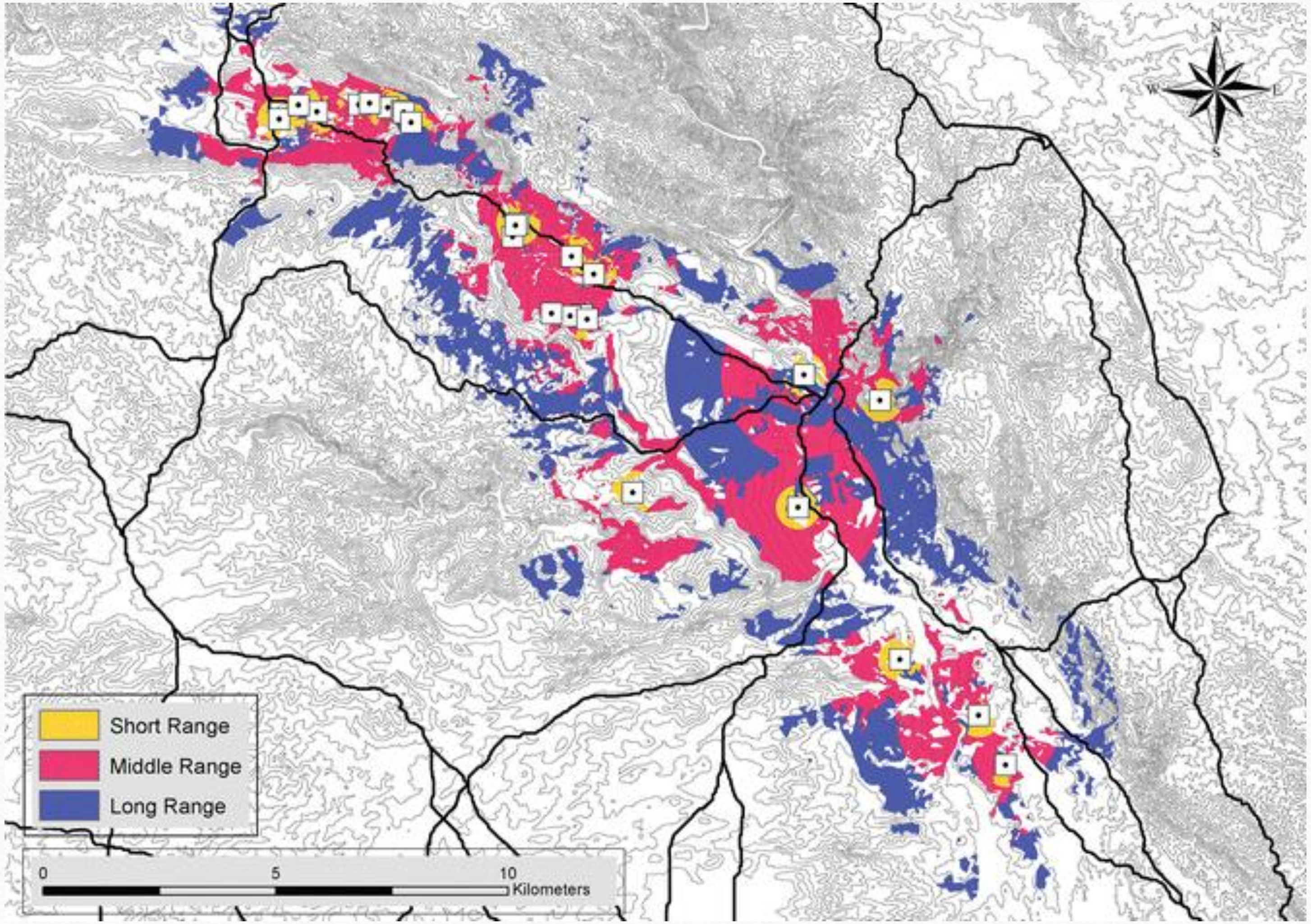
The third major branch of GIS methods that made its way into archaeology is the calculation of lines of sight and viewsheds. It is a technique that originated outside archaeology, where it is used in particular for siting military and telecommunications facilities. Archaeology however is quite unique in how it has used visibility analysis—and it is probably the nearest that GIS can come to representing bodily experience, by determining what places and objects can be seen from a particular vantage point (Tschan et al. 2000; Llobera 2003; Fitzjohn 2007).

In essence, visibility analysis starts by determining the line of sight between two locations, by comparing the elevation of location A to the elevations encountered on a straight line to location B. If there is no higher elevation obstructing the view, then B can be seen from A. In this way, it is possible to calculate, for each and every grid cell in a region, which cells within a certain neighbourhood can be seen: this is the cell's *viewshed.* These viewsheds can then be combined to obtain *cumulative* (Wheatley 1995) or even *total viewsheds* (see Llobera 2003), which show the number of cells from which a location can be seen. Importantly, these viewsheds not only provide information on which locations are most visible but also on those which are hidden from view. Obviously, viewsheds can be calculated for different ranges of view (Wheatley and Gillings 2000; Llobera 2007a), and in this way multiple measures of visibility can be obtained to characterize landscapes and site locations.

Llobera (2003) introduced the concept of visualscape as '*a spatial representation of a visual property generated by or associated with a spatial configuration*'. Using this concept, Llobera explicitly linked visual prominence and exposure to movement, which both are strongly connected to sensory perception. In practice, however, the application of GIS-based visibility analysis to questions of human perception of the landscape has not become very popular, despite several attempts in this direction (e.g. Llobera 1996; Trifković 2006; Gillings 2009; Lock et al. 2014). 3D modelling and virtual reality approaches would now seem to be more effective tools for this, although these generally lack the analytical capabilities offered by GIS.

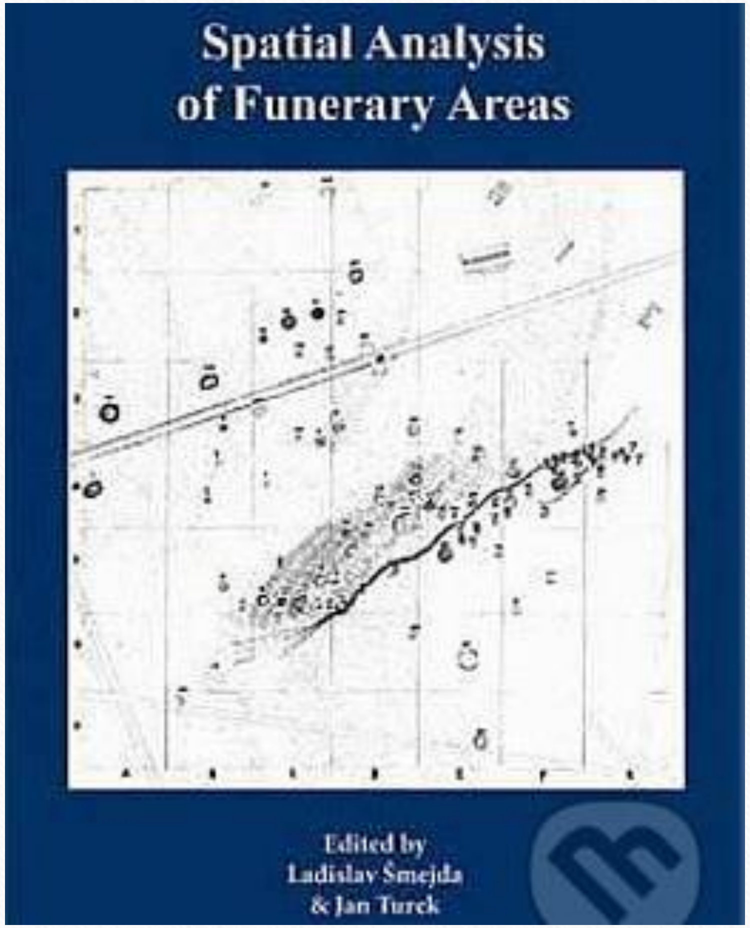
Viewshed analysis has been applied more regularly and successfully in conjunction with site location analysis (e.g. Sevenant and Antrop 2007; De Montis and Caschili 2012) as well as with least-cost path modelling (e.g. Murrieta-Flores 2014; Lock et al. 2014), not just to test whether visibility may have been a factor influencing site location but more importantly to understand how archaeological sites are visually related. This has been especially of interest for analysing the placement of megalithic monuments, burial mounds, hillforts, castles and other monumental and defensive sites (e.g. Gaffney and Stančič 1991; Wheatley 1995; Ruggles and Medyckyj-Scott 1996; Loots et al. 1999; Lake and Woodman 2003; Bourgeois 2013: 105–158; Čučković 2015).

However, it is also a technique that is fraught with difficulties, since its results highly depend on the quality of the digital elevation models used, both in terms of vertical accuracy (Fisher 1992; Loots et al. 1999; Ruestes Bitrià 2007) and in terms of how well a DEM, which is stripped of vegetation, represents a prehistoric landscape (Llobera 2007b). Viewshed analysis is also highly sensitive to edge effects and can therefore only be applied to large areas, which even today might lead to problems with computing power. Furthermore, the question of what specific elements in the landscape would be important to see is not always addressed, resulting in maps of cumulative viewsheds that only provide information on the proportion of the landscape that is visible from a vantage point. Even though there has been some research done on the level of detail of objects that can be discerned at various distances (e.g. Ogburn 2006), GIS would not seem the best suited tool for this, and many studies interested in understanding visibility of objects, especially in built-up spaces, now tend to use 3D modelling instead.



Visual ranges of megaliths along the Viar Valley (Sierra Morena, Andalusia, Spain) and their correspondence with natural corridors. Source: Murrieta-Flores (2014)

Šmejda, L.- Turek, J. (eds.): *Spatial Analysis of Funerary Areas*. UWB in Pilsen, Vydavatelství a nakladatelství Aleš Čeněk, Plzeň, ISBN: 80-86898-07-5.



Funerary areas and burial monuments represent an important source for archaeological chronology as well as for reconstructing social relations and cultural norms of past societies, and their variability in time and space. In the last few decades archaeologists have gradually become aware of the spatial significance of their data, including those originating from cemeteries and burial contexts. Funerary data is currently analysed in its spatial circumstances and in its relationship to other components of the prehistoric community areas, residential and ritual areas for example. Spatial relationships within funerary areas also illuminate continuity and change in the perception of sacred space and provide valuable insight into the question of monuments' re-use.

The growing interest in the spatial studies is also reflected in the wide range of papers presented during the session "Spatial Analysis of Funerary Areas" at the 8th Annual Meeting of the European Association of Archaeologists in Thessaloniki 2002. Most of them are included in this volume as well as several other papers which could not be given in the Thessaloniki session. Sixteen contributions written by scholars from thirteen different countries approached the spatial structure of funerary areas from the level of landscape down to the spatial relations within particular cemeteries and even within individual burial contexts.

The book covers a wide range of theoretical and methodological issues, such as: locating cemeteries in the landscape; age; gender and social relations derived from mortuary evidence, and also the chronological and spatial development of sites and the question of their continuity. We regard as very important that spatial distribution of both artefactual and biological variables are treated in the current debate. Future projects will of necessity have to interconnect all these aspects of burial more closely. The chronological span of topics is wide: from the Palaeolithic to Iron Age and the geographical scope includes vast regions of Europe from Belgium to Estonia and from Italy to Scandinavia. A further aspect which should be stressed here is application of new analytical methods. The introduction into archaeology of ancient DNA analysis, advanced databases and Geographic Information Systems created a new dimension in the analysis of past human activities. New methods and approaches are progressively being implemented into the inter and intra-site investigations and their impact will be dramatically felt in the near future. That so many scholars with very different geographical and scientific backgrounds joined in the discussion of methods and approaches to spatial studies of funerary areas is extremely satisfying. This lively discussion promises to establish a forum for continued future co-operation and comment concerning new trends and topics in this field of archaeological research. We hope that this inspiring volume will be soon joined by further spatial studies of human mortuary behaviour.

Contents:

Bronze Age tumuli in Denmark and the Skelhøj project *(Henrik Thrane)*.

Evolution of burial places in western Flanders in the Bronze and Iron Age *(Jean Bourgeois & Bart Cherretté)*.

Stone-cist graves, landscape and people *(Gurly Vedru)*.

Funeral plant offerings from Greek historical sites: a preliminary study *(Fragkiska Megaloudi)*.

Tumuli in the Hallstatt landscape: continuity and transformation *(Hrvoje Potrebica)*.

Wechselseitige Beziehungen im Nekropolen- und Bestattungskonzept im Laufe der mehrmaligen Belegung des zentralen Funeralareals in Murska Sobota/Nova tabla (Slowenien) *(Georg Tiefengraber)*.

The use of space in the Etruscan cemeteries of Pontecagnano (Salerno - Italy) in the Orientalising period (8th–7th century BC) *(Mariassunta Cuozzo, Andrea D'Andrea & Carmine Pellegrino)*.

Early Iron Age mortuary ritual in southwest Germany: the Heuneburg and the "Landscape of ancestors" project *(Bettina Arnold)*.

Ladislav Šmejda 2004: Potential of GIS for analysis of funerary areas: prehistoric cemetery at Holešov, distr. Kroměříž, Czech Republic, In: Šmejda, L.- Turek, J. (eds.): *Spatial Analysis of Funerary Areas*. University of West Bohemia in Pilsen, Vydavatelství a nakladatelství Aleš Čeněk, Plzeň, ISBN: 80-86898-07-5.

Intra-site spatial analysis can significantly benefit from the application of Geographic Information Systems (GIS). This case-study investigates spatial relations within a large late Eneolithic-early Bronze Age cemetery in east Moravia. Several methods of data exploration are introduced and their potential is discussed. Mapping of individual variables, use of spatial filters and working with results of factor analysis provide important clues to the study of the chronological development and social aspects of the site. Also it is argued that some of these results would be hardly available if only traditional approaches of archaeological inquiry were employed.

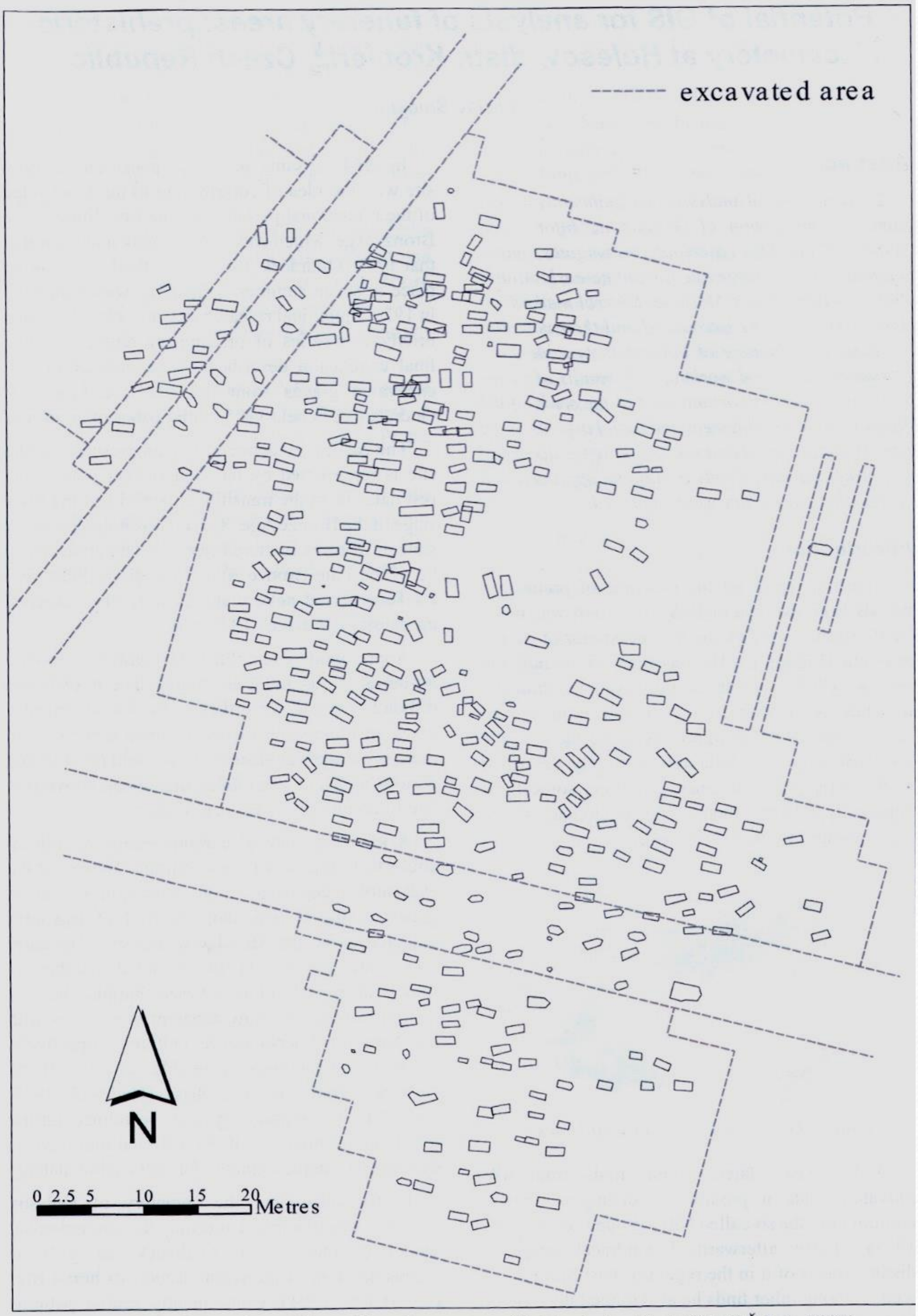
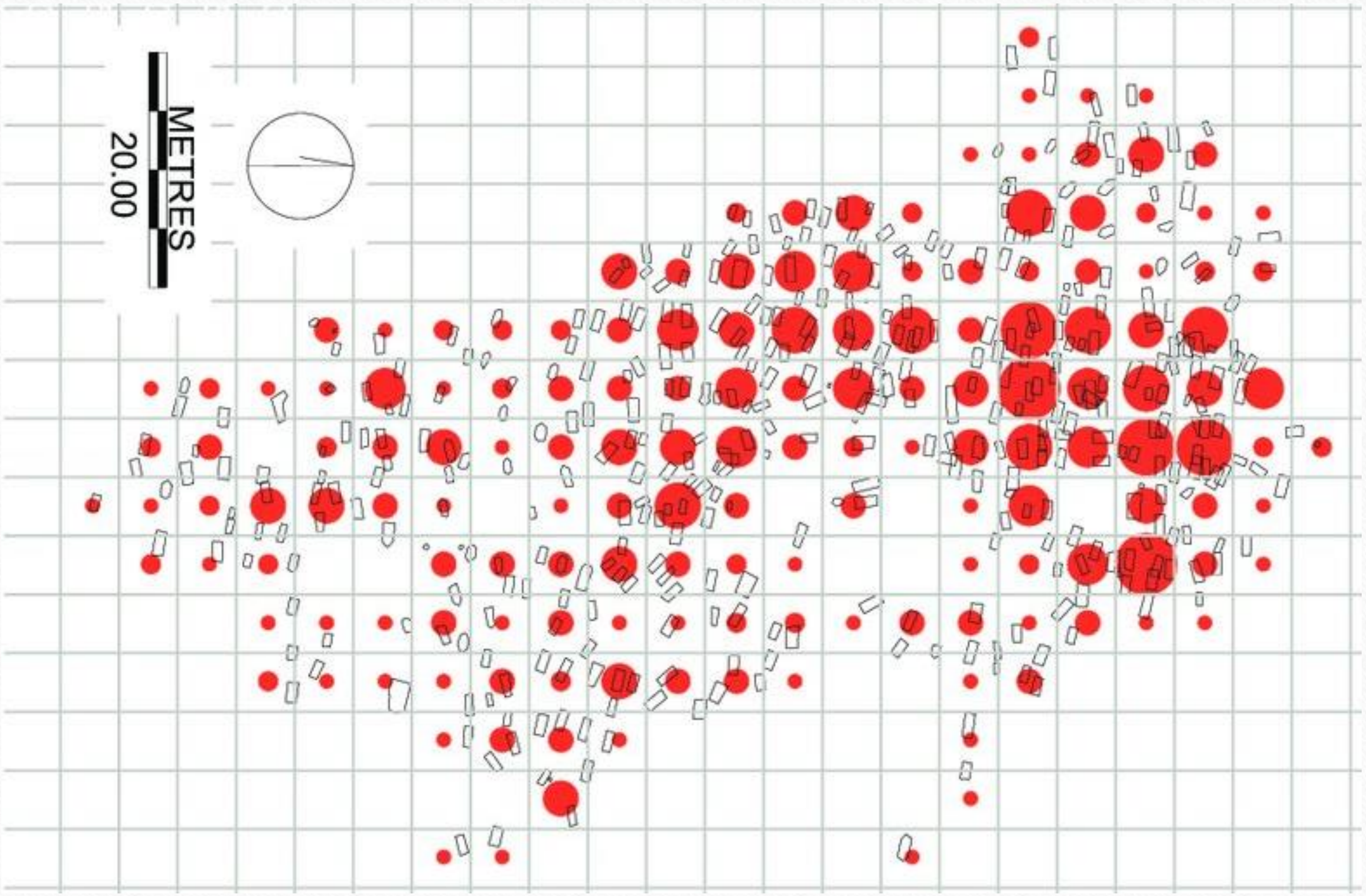
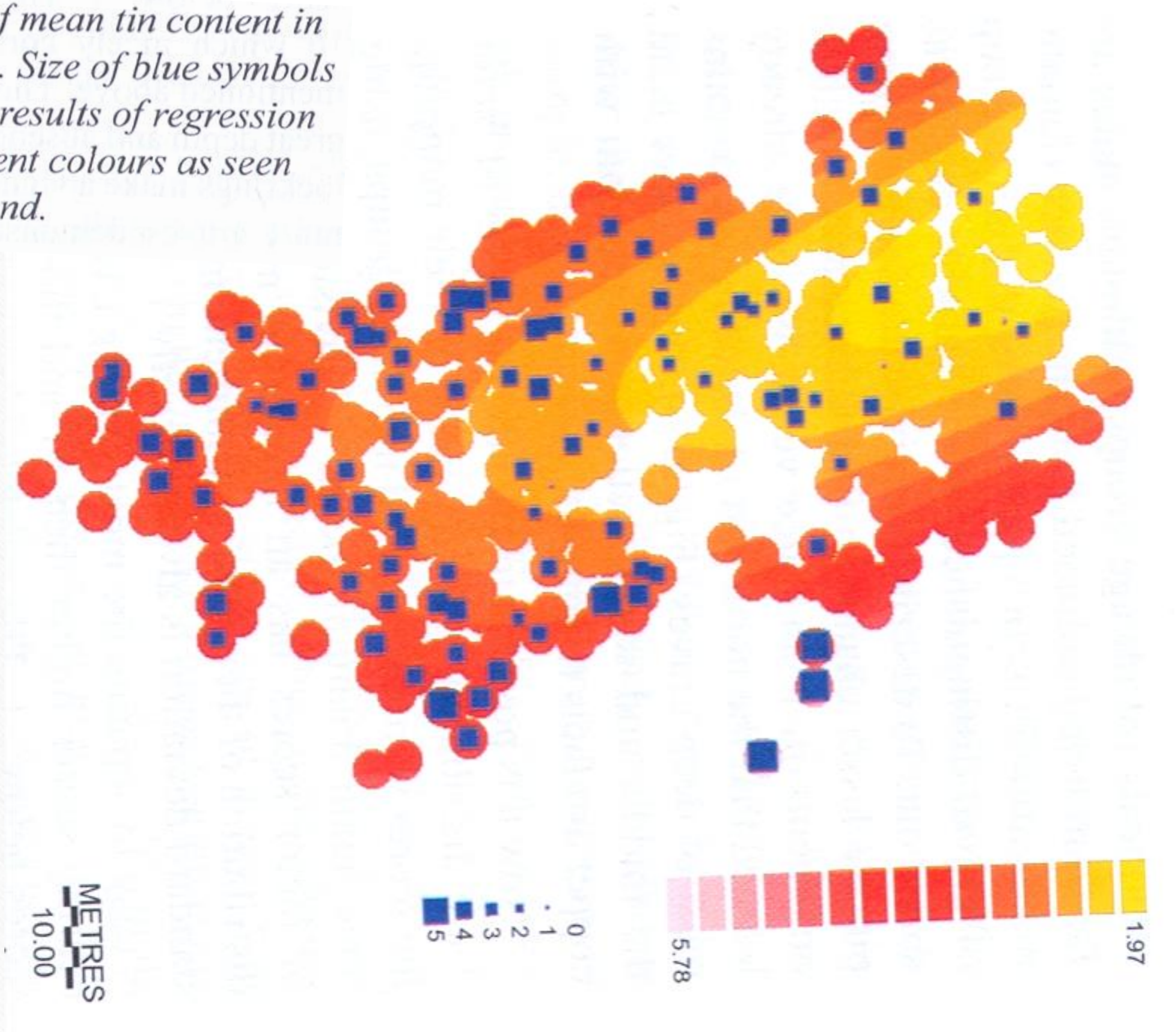


Figure 2. Holešov, plan of the prehistoric cemetery (digitized after Ondráček & Šebela 1985).

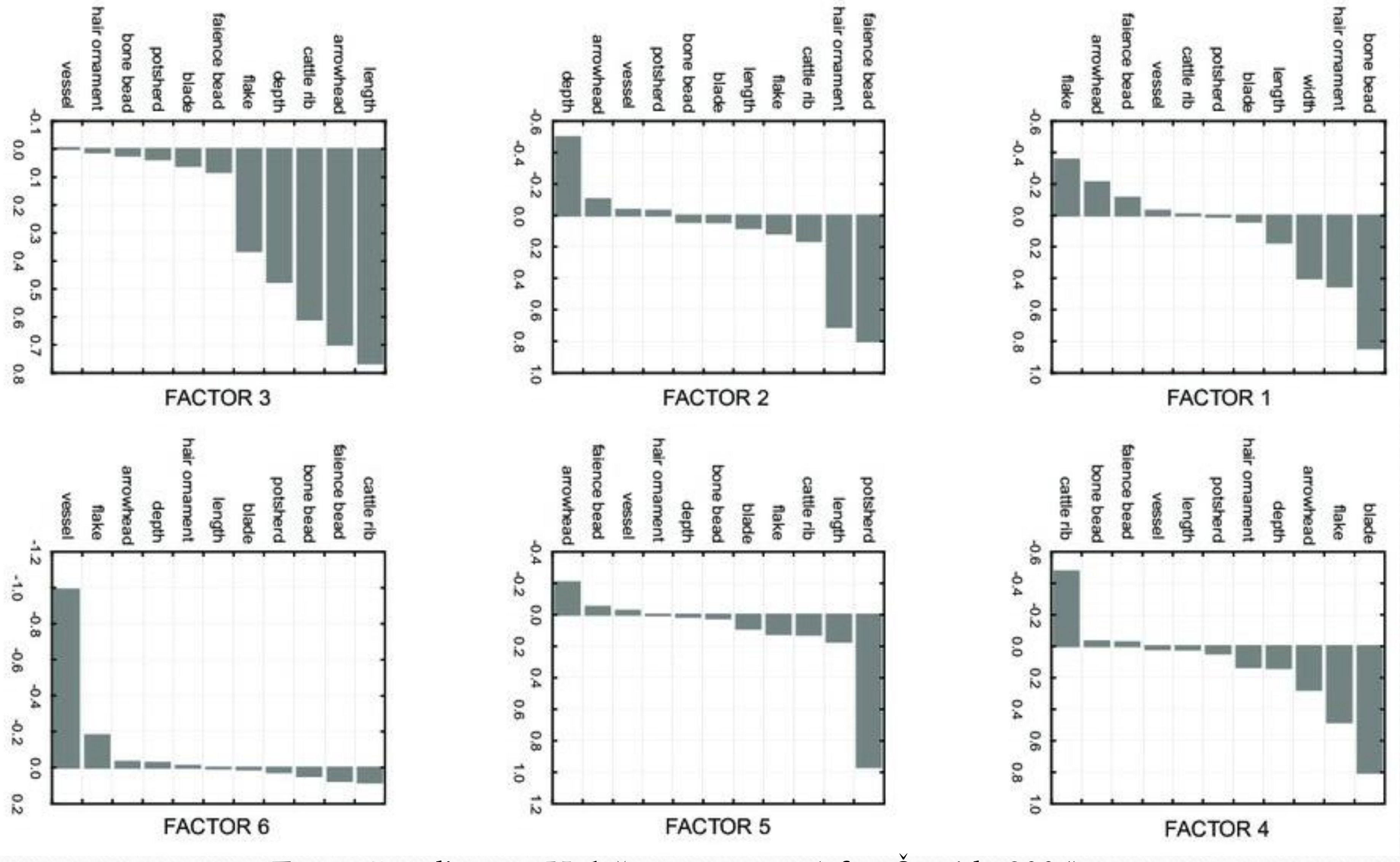


Holešov (Kroměříž District)– Nitra Culture & Bell Beaker cemetery. Density of burial events across the cemetery area.

Figure 13. Trend analysis of mean tin content in sampled burial assemblages. Size of blue symbols represents the mean value, results of regression fitting are coded by different colours as seen in the legend.



After Šmejda 2004

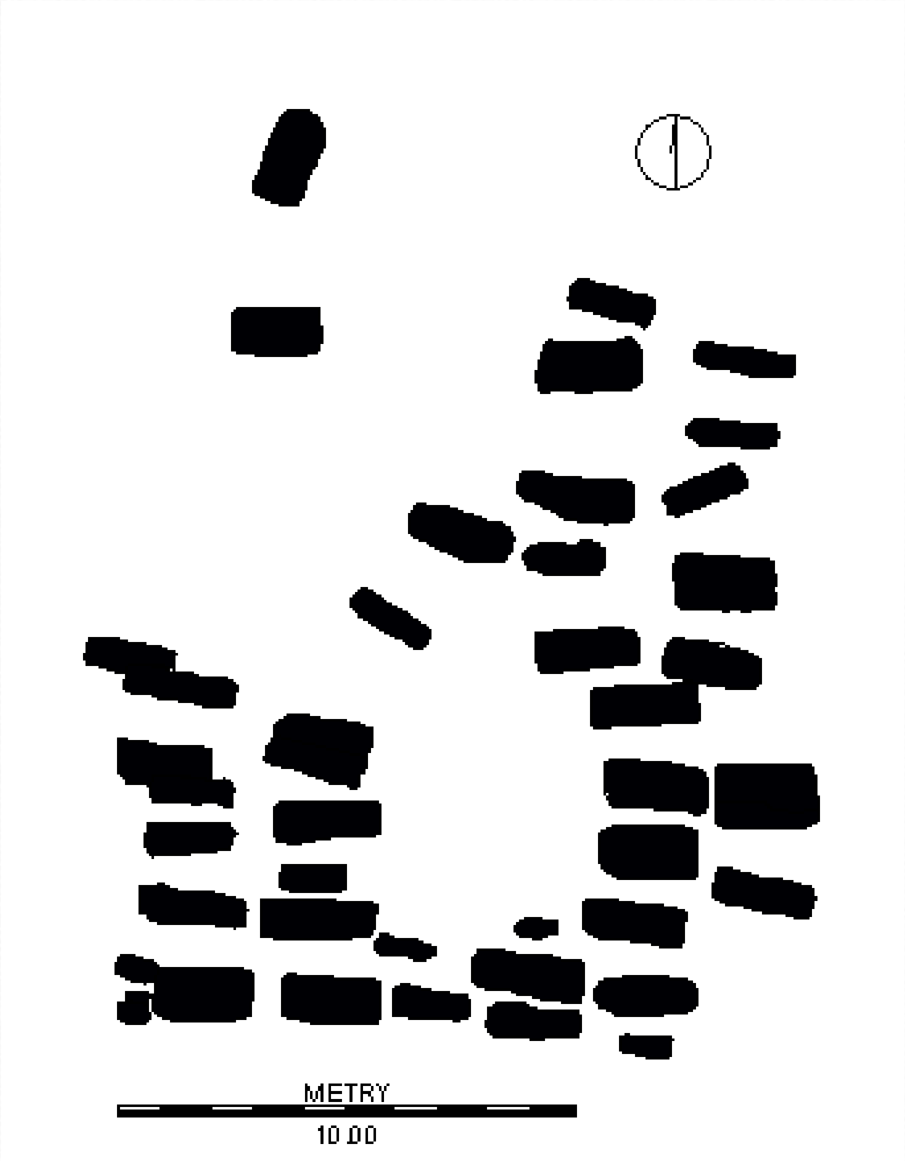


Factor Loadings at Holešov cemetery (after Šmejda 2004)

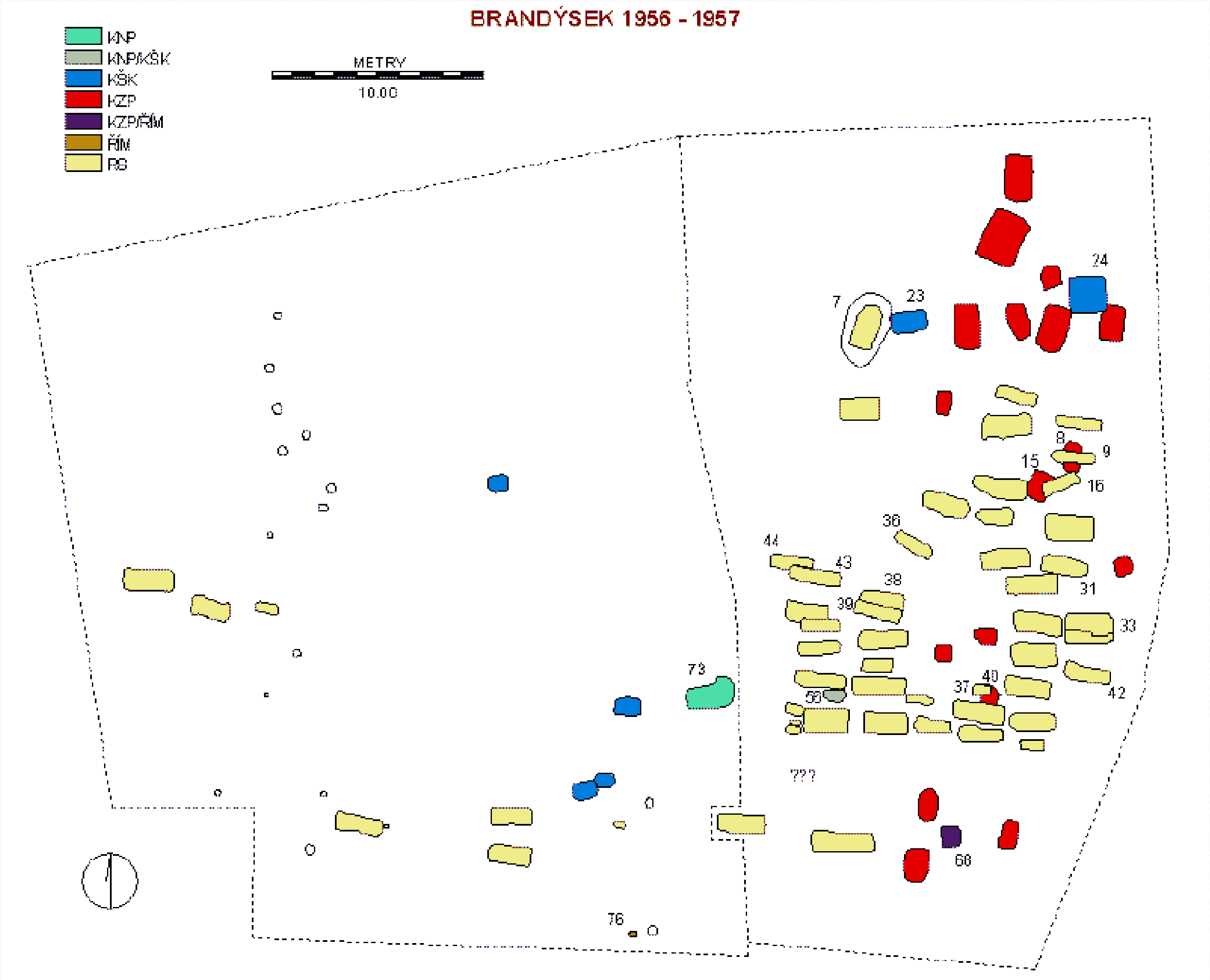
Šmejda, L. 2001: **CHURCH OR TUMULUS? ACONTRIBUTION TO THE STUDYOF BURIAL AREAS**, Archeologické rozhledy 53, 499-514

This article considers the question of the secondary use of prehistoric monuments in the Early Medieval period, taking as an example a burial area. Between 1955 and 1958 archaeological investigations were conducted on an elongated rise between Brandýsek and Třebusice in Kladno district, with the aim of documenting features disturbed over along period by sand extraction works (*Kytli-cová 1957*). Modest evidence of Neolithic settlement was identified, along with a sequence of graves from the Eneolithic, Roman Period and Early Middle Ages (*Kytlicová 1960*; *1968*).The original interpretation of the site, in accordance with the approach of contemporary work, divided the prehistoric and Medieval finds, and these were thus further processed separately. In the area of the greatest concentration of graves, the plan of the enclosure cemetery revealed a conspicuously empty area, which was interpreted (with some reservations) as the former site of a wooden church (Fig. 2). On the basis of the data available, however, an alternative interpretation is possible. The earliest datable grave was sunk during the Funnel Beaker culture period. It can be assumed that, in accordance with contemporary cultural norms, a tumulus with an elongated shape covered it. Another grave, too, can hypothetically be assumed to be of the same age. The same tumulus may have covered both graves; an analogous situation is known from nearby Březno (*Pleinerová 1980*) .The later components of the site include Corded Ware culture and Bell Beaker culture graves; in these cultures, too, common custom was to bury beneath (round) tumuli, often within the frame-work of a single cemetery (*Buchvaldek – Koutecký 1970*); *Neustupný – Smrž 1989*). This is an ex-ample of a tumulus field used for along period, containing burials of various periods. The excavated area also contained an isolated example of a cremation burial from the later Roman Period(grave 76), while the cultural affiliation of another cremation (grave 68) remains open to question. The latest graves date to the Early Middle Ages (9th–10th centuries AD). The simple fact that the enclosure burials are found within the very area of the prehistoric cemetery is fundamental to the new interpretation.

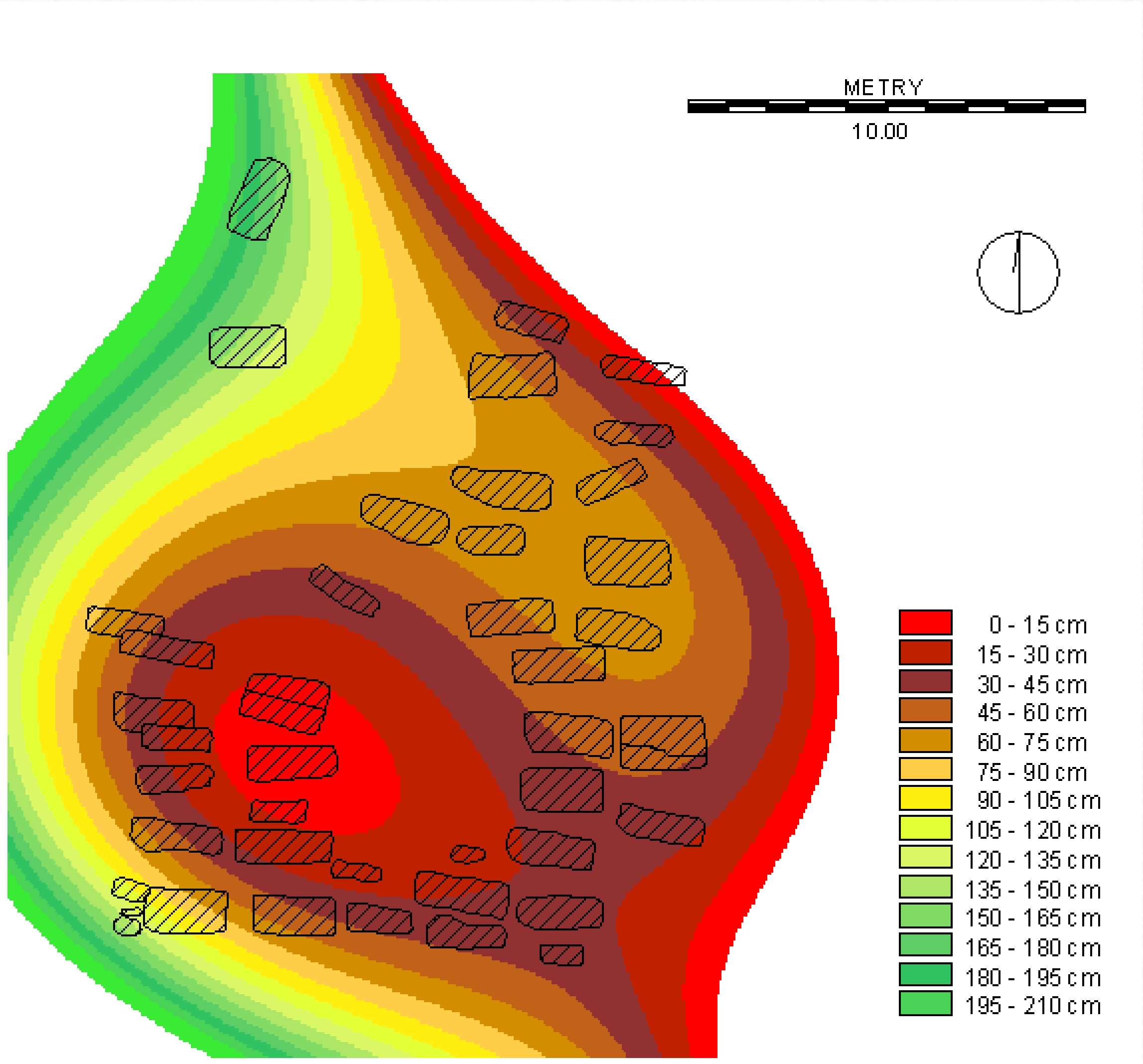
The Early Medieval graves are arranged in such way as almost without exception to respect the prehistoric graves – only two neighbouring Bell Beaker culture graves are noticeably disturbed, which given the great density of burial is a remark-ably small number. It could therefore be surmised that even in the 9th–10thcenturies, surface traces of the Eneolithic tumuli were still visible on the surface. An ideal reconstruction of such a situations given in Fig. 5; the illustration shows medium–sized tumuli of the same size, which obviously does not reflect the reality. It is obvious that a series of neighbouring mounds cumulatively created a single large tumulus (see clusters A–F). The majority of the Medieval burials could have been sunk into the facing represented by cluster C, or in its immediate surroundings. Theoretically, the burial at the center of the mound need not have been sunk into the original ground surface at all, and could later have been destroyed along with the tumulus itself. Towards the edge of the mound, on the other hand, secondary burials could have remained. The actual situation was almost certainly more complex, but the general plan of the depths of the grave pits closely matched this hypothesis (Fig. 4 was generated using the TREND module of IDRISI 32 software). A series of archaeological projects have shown the depth of the structure of the cultural landscape (e.g. *Neustupný 1986* ; *Vařeka 1994*; *Bradley 2000*). In a number of cases, burial areas have remained fixed points of settlement areas over extended periods. Several may have been used for the burial of the dead as late as the Early Medieval period, but similar customs gradually gave way before the pressure of Christianity. Cemeteries symbolically bound to the past and to mythical ancestors probably influenced the siting of communities or their placing on the social ladder, underpinning particular claims to land, raw material resources etc. (*Chapman – Randsborg 1981*). As examples from Medieval written sources show, however, prehistoric monuments had a variety of secondary uses.



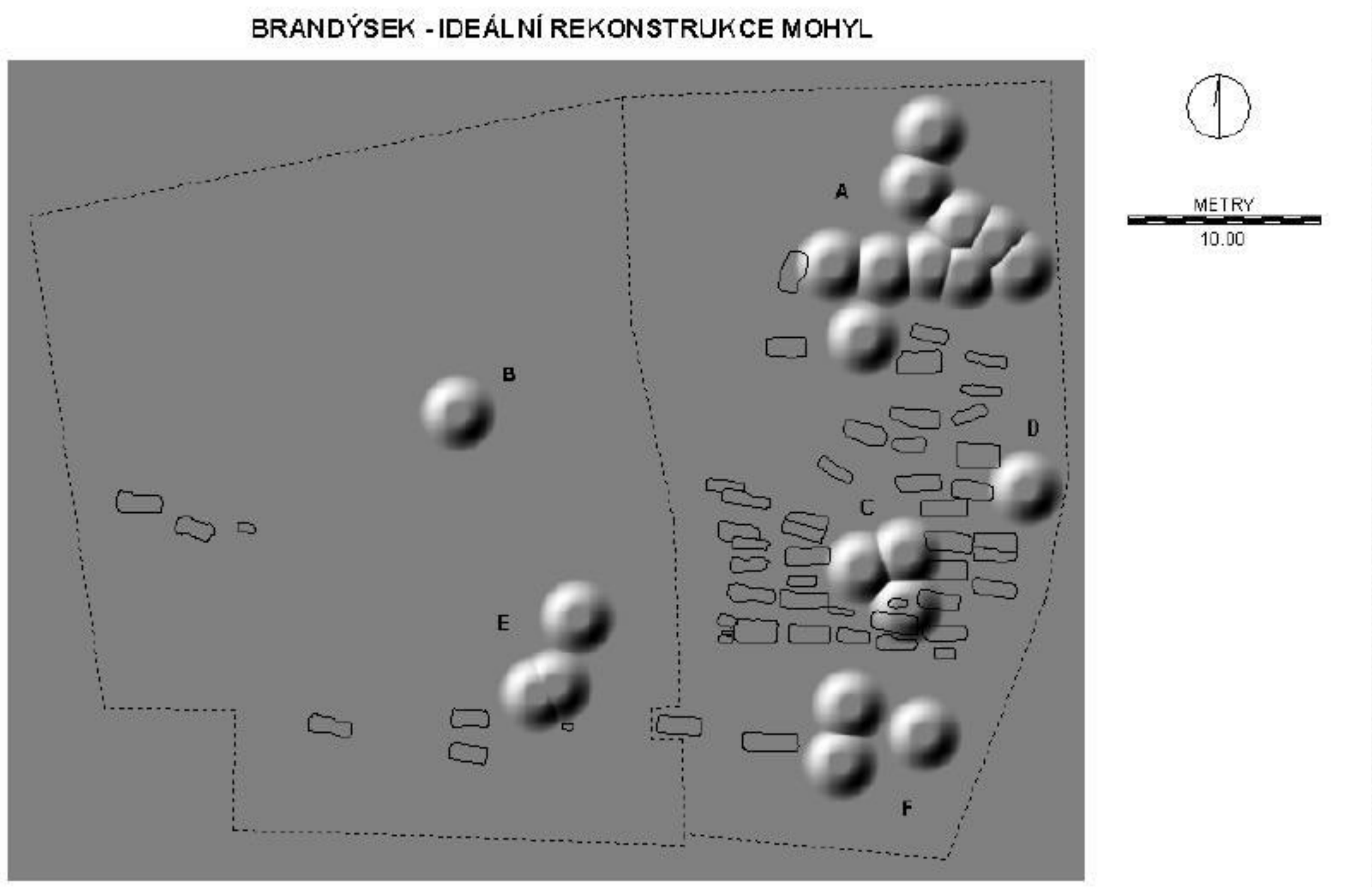
Brandýsek. Central part of the EarlyMedieval cemetery with the empty area in the centre (suspected location of a church). This example shows the danger of isolated analysis of only one chronological component.



Digitised overall plan of the excavations conducted in Brandýsek 1956–57, with the chronological phases represented by colours: KNP – Funnel Beaker culture; KŠK – Corded Ware culture (blue); KZP – Bell Beaker culture (red), ŘÍM – Roman Period; RS – Early Middle Ages (yellow)



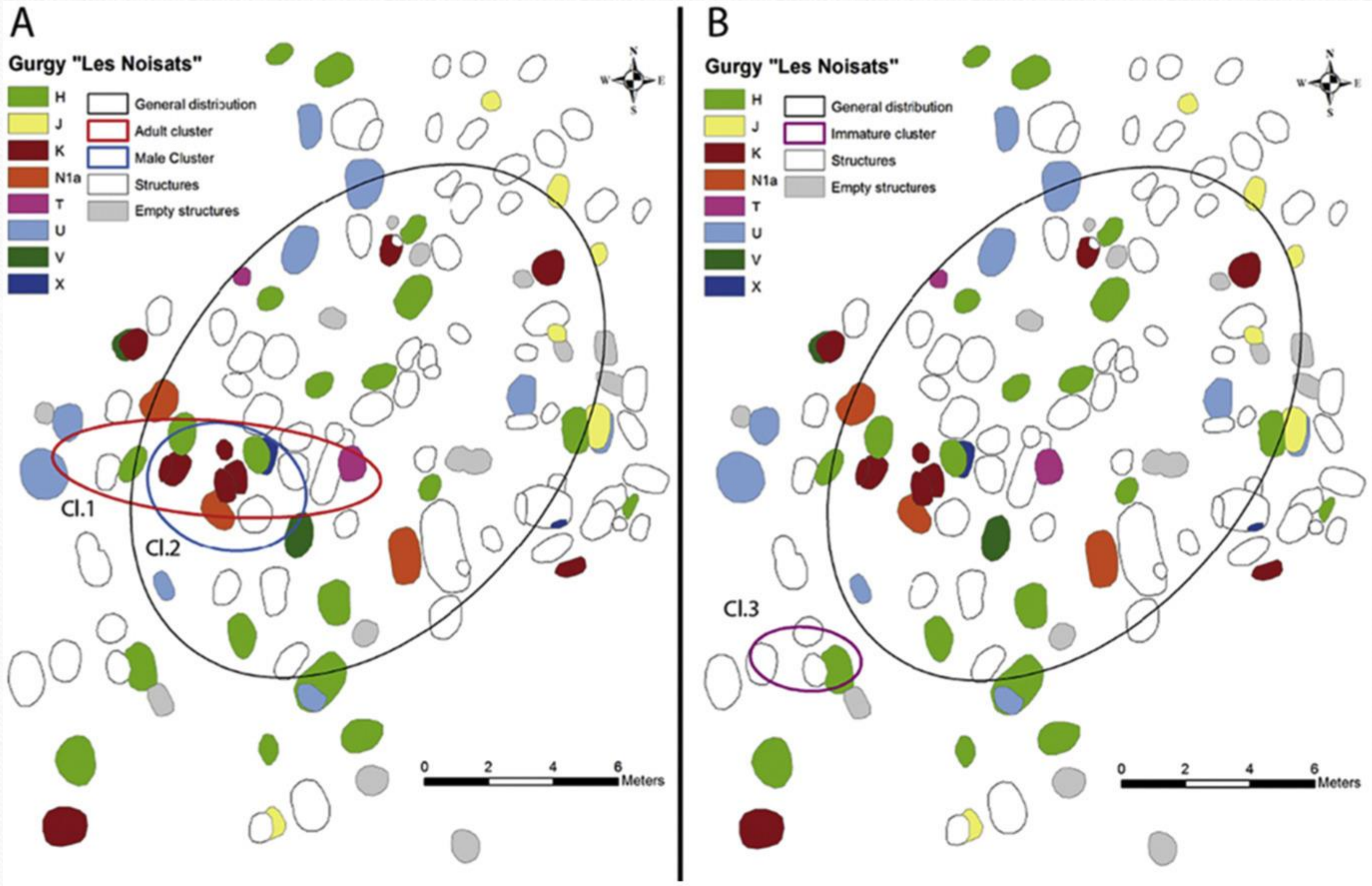
Brandýsek - Spatial trends in the depths of grave pits



Ideal reconstruction of the Late Eneolithic burial mounds; the configuration of the Early Medieval graves is shown in outline

Mélie Le Roy et al: Distinct ancestries for similar funerary practices? A GIS analysis comparing funerary, osteological and aDNA data from the Middle Neolithic necropolis Gurgy "Les Noisats" (Yonne, France), Journal of Archaeological Science, Volume 73, September 2016, Pages 45-54, https://doi.org/10.1016/j.jas.2016.07.003

The French Paris Basin is well known as a complex cultural area of the Early/Middle Neolithic, particularly with respect to funerary practices. Gurgy "Les Noisats", which is an important necropolis in the southern Paris basin, is a burial site (N = 128) associated with the first Neolithic groups established in that area. The understanding of the necropolis composition and organization is complicated given the substantial homogeneity of the site's spatial organization in relation to a great diversity of characterized funerary traits. The unprecedented quantity of genetic (mitochondrial DNA), osteological (sex, age), and archaeological (funerary) data obtained for the Gurgy necropolis facilitates the search for potential correlations between cultural and biological (i.e. genetic and osteological) diversity at the site level. Despite the application of the powerful geographic information system, no correlation could be detected (i) between individual maternal lineages and specific bioarchaeological profiles (ii) or between maternal lineages and spatially identified bio-archaeological clusters. Therefore, analyses were performed to test for a correlation between the maternal ancestries of the individuals (i.e., hunter-gatherer/Central European farmer and Southern European farmer ancestries) and specific funerary traits. Again, the homogeneity of the funerary treatment of all of the individuals regardless of their potential maternal ancestries is striking. Taken together, our results regarding the way in which the Gurgy necropolis functioned provide strong evidence for the acculturation of all maternal ancestries groups, at least in terms of funerary practice. In addition, the demonstration of a recurrent association of adult men and immature individuals suggests a patrilocal system, which could be consistent with the detected acculturation of women who present a hunter-gatherer ancestry.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Burials and Graphs: Relational Approach to Mortuary Analysis

Daniel Sosna[1], Patrik Galeta[1], Ladislav Šmejda[1], Vladimír Sladek[2], and Jaroslav Bruzek[3]

Abstract

This article demonstrates the analytical potential of graph theory for understanding mortuary practices in past societies. We take advantage of social network analysis software PAJEK to model relationships among burials. The case study of the Early Bronze Age cemetery Rebešovice (Czech Republic) is used to explore the potential of the network approach to explain the contrast between the center and the periphery of the cemetery. Two hypotheses are proposed to explain this contrast: Chronological and social. The first hypothesis explains the difference between the center and the periphery as an effect of social standing, while the latter as an effect of time. The data set includes archaeological and biological data from 72 burials. We calculate simple matching distance matrices as a measure of dissimilarity among the burials based on socially and chronologically significant variables and Euclidean matrix as a measure of spatial proximity among pairs of graves. We project the results into geographic space and compare the patterns with the expectations derived from the two research hypotheses. The evaluation of results allows us to reject both hypotheses and formulate a new model of spatial organization based on a few contemporary subsections of the cemetery used by different corporate groups. Finally, the potential of computer-aided modeling of matrices and graphs is discussed in context of other analytical techniques used for the investigation of intracemetery mortuary variability.

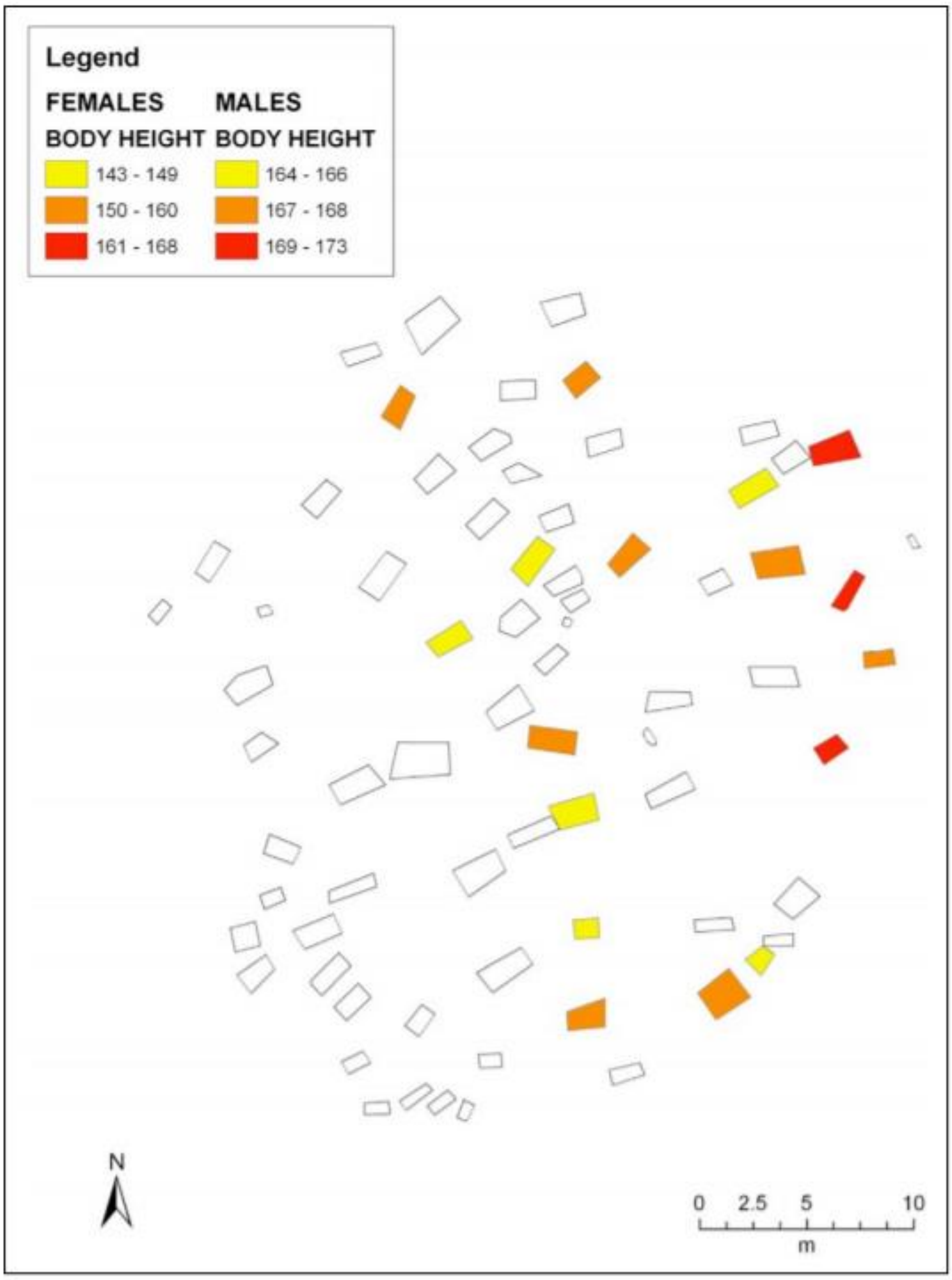

Figure 4. Spatial distribution of individuals with estimated stature ($N = 17$) for females and males. Values in cm.

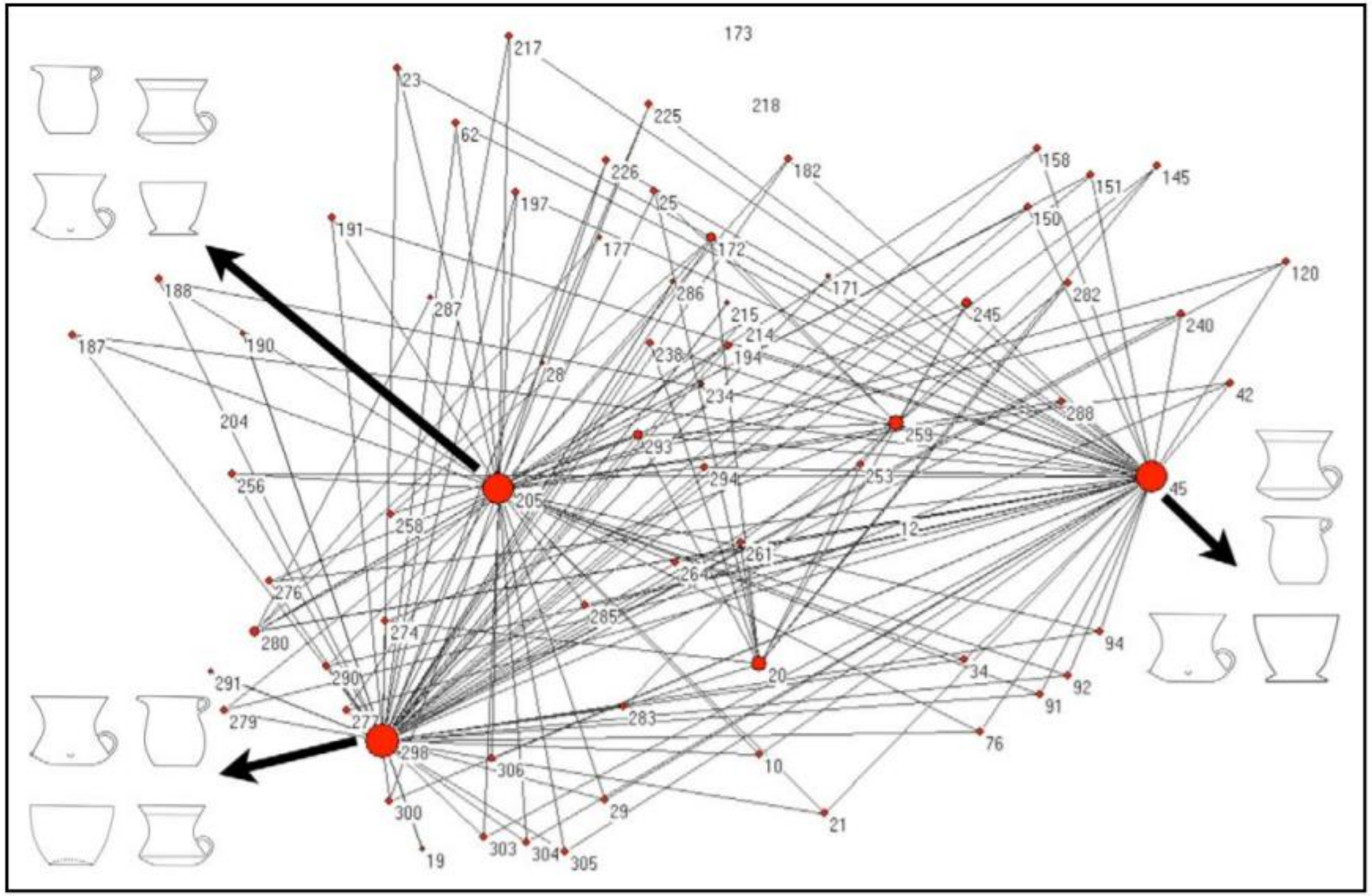

Figure 5. Network of burials in geographic space based on five variables associated with chronology. Edges—only 7% of edges with the highest values of simple matching distance (edges among highly dissimilar burials). The size of vertices reflects the degree of vertices. The artifacts depicted show selected attributes of ceramics such as bulges on vessel's belly, incised horizontal decoration, indented base, concave bottom, and prominent lip. Numbers designate burial IDs.

Thank you
for your attention!

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