Römisch-Germanisches Zentralmuseum
Leibniz-Forschungsinstitut für Archäologie

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RGZM – TAGUNGEN Band 40

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# FROM THE ATLANTIC TO BEYOND THE BUG RIVER

## FINDING AND DEFINING THE FEDERMESSER-GRUPPEN / AZILIAN

Proceedings of Session A5b (Commission »The Final Palaeolithic of Northern Eurasia«) of the XVII$^{th}$ UISPP Congress,
Burgos, September 2014

Gedruckt mit Unterstützung des
Zentrums für Baltische und Skandinavische Archäologie
in der Stiftung Schleswig-Holsteinische Landesmuseen
Schloss Gottorf, Schleswig

ZBSA

Römisch-Germanisches
Zentralmuseum
Leibniz-Forschungsinstitut
für Archäologie
RGZM

Redaktion: Gundula Lidke (ZBSA) unter Mitwirkung von Sonja B. Grimm
und Mara-Julia Weber (beide ZBSA); Claudia Nickel (RGZM)
Satz: Claudia Nickel (RGZM)
Umschlaggestaltung: Claudia Nickel (RGZM)

**Bibliografische Information
der Deutschen Nationalbibliothek**

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in
der Deutschen Nationalbibliografie; detaillierte bibliografische
Daten sind im Internet über **http://dnb.d-nb.de** abrufbar.

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Propylaeum
FACHINFORMATIONSDIENST
ALTERTUMSWISSENSCHAFTEN

Publiziert bei Propylaeum, Universitätsbibliothek Heidelberg /
Römisch-Germanisches Zentralmuseum, Mainz 2020.

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Diese Publikation ist auf http://www.propylaeum.de dauerhaft frei
verfügbar (Open Access).
URN: urn:nbn:de:bsz:16-propylaeum-ebook-575-4
DOI: https://doi.org/10.11588/propylaeum.575

**e-ISBN: 978-3-948465-04-9 (PDF)
e-ISSN: 2698-9069
ISBN: 978-3-948465-05-6 (Softcover)
ISSN: 1862-4812**

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SONJA B. GRIMM · MARA-JULIA WEBER · LUDOVIC MEVEL
IWONA SOBKOWIAK-TABAKA

# NOT QUITE AS FAR AS FROM THE ATLANTIC TO BEYOND THE BUG RIVER – AN EDITORIAL

*To Martin Street, our friend and teacher*

The history of this volume begins in September 2012 when three of the editors met at MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution (part of the Römisch-Germanisches Zentralmuseum, Leibniz-Forschungsinstitut für Archäologie, a member of the Leibniz Association). While Sonja B. Grimm has been writing her PhD about the transition from Magdalenian to Federmesser-Gruppen in North-West Europe (Grimm 2019) there, Ludovic Mevel stayed for several months to analyse some of these assemblages technologically to compare them to French inventories within a Post-Doc project (Mevel/Grimm 2019). During this time, Iwona Sobkowiak-Tabaka came to examine some Federmesser-Gruppen material from Central Rhineland sites for comparative reasons within her habilitation project about the Federmesser-Gruppen on the North European Plain (Sobkowiak-Tabaka 2017). She was hosted by Martin Street who also functioned as Sonja's tutor. In this culture clash of English, French, German, and Polish traditions of thoughts on the Federmesser-Gruppen and Azilian, we realised that it could be very fruitful to bring together these different approaches of material culture and spatial studies. In a direct comparison we hoped to find answers to questions such as:

What do we actually know about the groups living in Western and Central Europe during the Weichselian Lateglacial Interstadial? How are they reflected in the archaeologically defined groups that we call Azilian and Federmesser-Gruppen? Do they represent related groups or even a single entity? Or were they formed by many rather different groups of hunter-gatherers with a similar way of life? Were they contemporaries or chronological successors? And how are these related to the Epigravettian industries in Southern and South-eastern Europe?

In order to gather different ways of approaching these questions, Martin Street suggested to organise a session on behalf of the UISPP commission »The Final Palaeolithic of Northern Eurasia« but left the details to us »younger ones«. Yet, Martin's influence as researcher, mentor, host, peer, and friend was always present during the process of organising and holding the session as well as in the production of this volume.

Considering the geographic extent of assemblages attributed to the Azilian and/or Federmesser-Gruppen and the differences therein, we quickly dropped the idea of also including the Epigravettian. Instead, to include directly the Northern European research tradition in the organising team, we turned to Mara-Julia Weber working in Schleswig and together prepared a session for the XVII$^{th}$ UISPP congress. So in September 2014, a session with the title »From the Atlantic to beyond the Bug River – Finding and defining the Federmesser-Gruppen/Azilian on the North European Plain and adjacent areas« was held in Burgos (Spain). It consisted of an introductory talk, nine presentations and a poster covering the area from the United Kingdom, France, Germany, the Czech Republic, and Poland. Hence, from the northern Carpathians to beyond the English Channel would have been the more appropriate title to describe the actual geography covered by our contributions. Three of these presentations were – by the time – on-going PhD projects (W. Mills, M. Monik, F. Sauer) which showed that the questions relate to a topical subject of study and the results will be picked up by a young generation of scientists.

However, the variety of nomenclature already displayed in these talks showed the necessity but also the difficulty of the prospective discussion. Federmesser-Gruppen and Azilian were used almost evenly but also Arch-Backed Point (ABP) groups, Lateglacial, Late Palaeolithic, and Late Upper Palaeolithic were used to describe the material from this period. This plurality might indicate a few different groups but often they rather referred to different scales or appeared rudiments of different scholarly traditions (cf. Sauer/Riede 2019). In general, terms such as Federmesser-Gruppen, Azilian, Penknife Point phase, Tjongerian, Curve-Backed Point groups, or ABP are general representatives for a period when foragers roamed in a boreal environment and, thus, were already different from the classic Upper Palaeolithic hunter-gatherers of the Late Pleistocene steppe landscapes but were not fully Mesolithic yet. The difference to perhaps more local groups such as the Tjonger group, Witowian, or Atzenhof group is often fuzzy. These variable levels reflect different spatial and chronological sections of the hardly distinguishable scale of human social units. It is generally difficult to identify these units based on archaeological material that is then compared over increasingly large areas and timespans. This taxonomic approach becomes particularly difficult if it is applied to periods when only low cost strategies are used (Vaquero/Romagnoli 2018) such as it appears during the here discussed period. The decrease of elaborate and standardised behaviours – compared to the previous Magdalenian technological behaviours – reflected in the material record give only very few possibilities to link differences in the material to group traditions. These few and/or small differences are then likely to be overestimated.

Besides the difficulty of identifying the material, processes during and after the Younger Dryas also affected the *in situ* preservation and visibility of the material. For instance, taphonomic disturbances of the material deposition occurred when deep frozen grounds melted and caused significant *in situ* sediment loss or the material became inaccessible due to cover by sometimes very thick coversands. Finally, the preservation conditions become less favourable for organic material in environments with richer biogenic interactions and reduced mineral coverage. The long bog development that occurred during the Holocene seemed to have no equivalent in the Lateglacial Interstadial. Hence, less diverse remains were preserved to base the studies on.

Furthermore, chronostratigraphic terms such as Meiendorf, Bølling, or Allerød were also used differently (cf. Terberger/Barton/Street 2009, tab. 1). So when trying to at least correlate the archaeological terms spatially and chronologically again quite some confusion can be caused. This also applies to the radiocarbon dates that are sometimes given as raw radiocarbon data (in this volume identified as $^{14}$C-BP) and sometimes calibrated data (in this volume given as cal. BC). The difference is occasionally not visible.

Hence, before being able to explore the inconsistent use of terminology as one of the main aims of the session, we had to find a way between the wide-spread wish to remain within the own frame of traditions and the establishment of a shared frame of references. Although we attempted to unify some general terminology within the different contributions, different concepts remained and the need for a common analysis to come up with a classification we can all work with is still a desideratum. However, single-minded attempts will not solve the problem but rather add yet another new taxonomy that has not grown from a reunification of traditions. Instead of this top-down approach, a bottom-up approach of unifying the recording systems is on its way, for example the work of L. Mevel using one technological approach to describe the assemblages from the Paris Basin and the Rhineland was taken to the north in cooperation with M.-J. Weber and will be continued in a PhD thesis about the Federmesser-Gruppen in northern Germany and Denmark by T. Burau. Anyway, to come to results that can be compared across wider geographic areas, we all have to leave the comfort zone of our national narratives and analytical traditions and see what in a greater framework is possible. In this volume, we assemble contributions from different parts of North-Western and Central Europe (France, UK, Belgium, Germany, Poland, Czech Republic). Lithic industries still remain the main archaeological source (Sobkowiak-Tabaka; Pyżewicz et al.; Valde-Nowak and Kraszewska) but recent research has also been exploring and combining further sources of information such as faunal and spatial data and geo- and environmental archives (Bignon-Lau; Mills; Crombé; Sauer; Monik and Pankowská). With regard to the research topics addressed, one can observe two main perspectives by which the relationship between archaeological entities in the mid-Lateglacial Interstadial is regarded: spatial behaviour on variable scales, from site to landscape, on the one hand and the cultural attribution of single lithic inventories on the other hand.

We may not have come closer in defining the Federmesser-Gruppen and/or Azilian but we hope that this book will keep the discussion about these Final Palaeolithic hunter-gatherer groups on-going, especially as they received some relevance in relation to the Epigravettian in the light of aDNA results (Posth et al. 2016; Fu et al. 2016).

**Acknowledgements**

The authors want to thank the former board of the UISPP commission »The Final Palaeolithic of Northern Eurasia« (Berit Valentin Eriksen, Eelco Rensink, and Martin Street) for their support of the idea of the session and the publication. We also like to thank the RGZM for accepting these proceedings for publication. Furthermore, we wish to express our deep gratitude to the Centre of Baltic and Scandinavian Archaeology (ZBSA) for the generous financial support during the editing and publishing process. This support made the employment of Dr. Gundula Lidke possible to whom we owe a big thank you for her comprehensive text and picture editing and her kind communications with the authors of the different contributions. We also much appreciated the time donated to this project by the peer reviewers and English proof-readers who clearly improved the science presentation in this volume.

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MARTIN MONÍK · ANNA PANKOWSKÁ

# SETTLEMENT PATTERNS OF THE LATE PALAEOLITHIC IN BOHEMIA AND MORAVIA

Similarly to other territories in Central and Western Europe, what is today Bohemia and Moravia (CZ) saw significant cultural change at the beginning of or during the Allerød period when Magdalenian sites disappeared from the archaeological record and typologically less pronounced Late Palaeolithic (LP) assemblages started to appear (Vencl 2013). The task of this study is to statistically evaluate whether, complementary to changing artefact types, areas of a different topographical type were exploited during the LP period, broadly identified with the Allerød and Younger Dryas climatic phases in the Bohemian and Moravian territory (Valoch 2001; Vencl 2013). A similar approach was applied recently in northern Spain where differences in site preferences between distinct Palaeolithic periods were identified (Turrero et al. 2013). The assumption is that selected topographical categories of archaeological sites can be quantified, and that they, responding to a certain settlement pattern, change in time together with changing climate or even archaeological cultures. The principal questions to be answered are whether there is a certain settlement pattern, if this pattern changes between the two analysed periods, and what are the topographical features that most likely influenced Late Pleistocene people.

Bohemia and Moravia are two parts of what is today the Czech Republic (the third one, Silesia, is considered here together with Moravia). They are both well known for their rich Upper Palaeolithic settlement evidence (Oliva 2005; Vencl 2013). Whereas Magdalenian sites, above all caves, were excavated primarily at the end of the 19$^{th}$ and the beginning of the 20$^{th}$ century (Valoch 2001), LP sites were recognised only in the 1960s (Klíma 1962; Vencl 1964). Although nowadays more numerous than Magdalenian sites, LP sites usually consist just of chipped stone assemblages acquired through field-walking. Stratified LP sites are rather exceptional in the area and have not provided a clear stratigraphy as Allerød and Younger Dryas strata are either mixed with (e. g. in Kůlna Cave at Sloup; Nerudová / Neruda 2014), or are difficult to distinguish from (e. g. in Tmaň, Tři voli Cave; Prošek 1958) Holocene soil, or are otherwise disturbed by post-depositional processes (e. g. Voletiny, Plzeň-Roudná; Vencl 1978; 1988). This has also resulted in very few reliable radiocarbon dates from local LP sites.

## MATERIAL AND METHODS

### Mapping and GIS analysis

A characteristic element of Magdalenian settlement in Bohemia and Moravia (Svoboda 2002; Valoch 2001; Vencl 1995a) is the elevated number of cave sites, a situation that changed in the following LP. Cave sites concentrate predominantly in two karst areas – the Bohemian and Moravian Karsts – although Bohemian open-air sites are relatively frequent as well (Vencl 2013). LP sites, on the other hand, are known throughout the country, with clear concentrations in South-West Bohemia and North-East Moravia, i. e. areas of intensive professional or amateur surface prospection. Analysed sites are presented on the map (**fig. 1**) and, in the case of LP sites (n = 152), are practically identical to those mentioned in Moník / Eigner (2019), with the

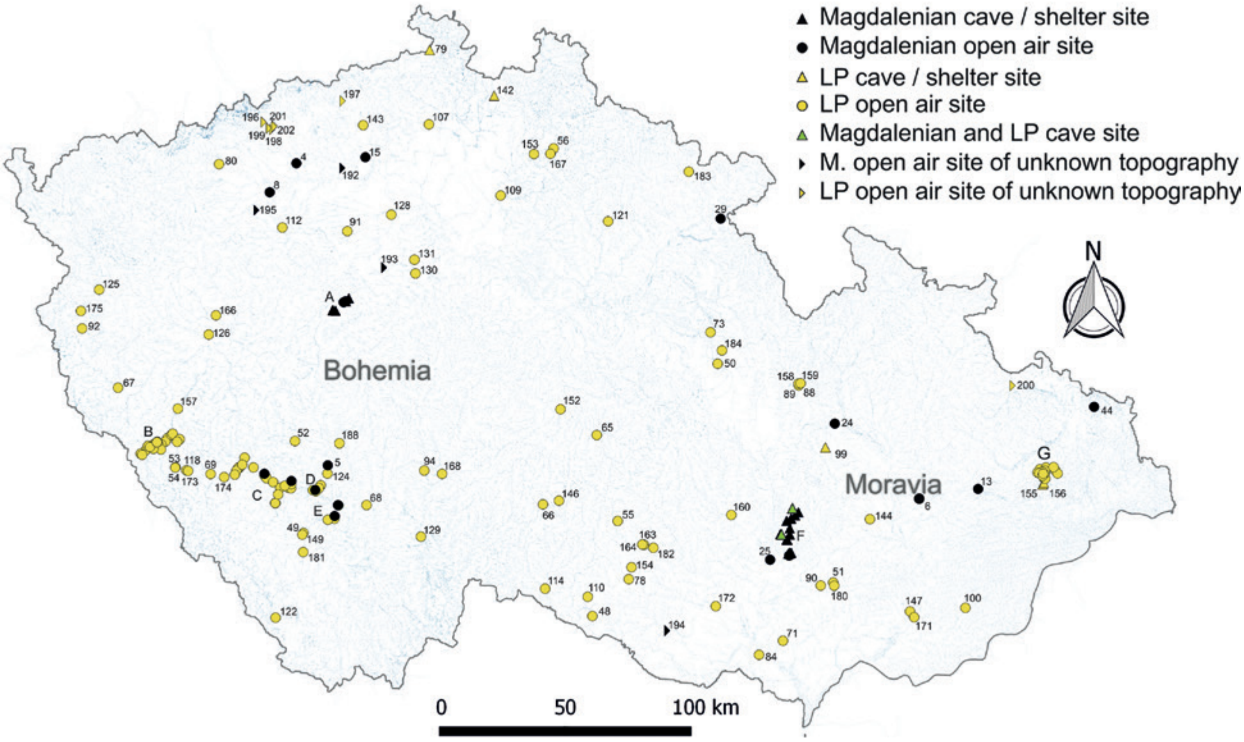


**Fig. 1** Magdalenian and LP settlement in Bohemia and Moravia.
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exception of two cave sites with both LP and Magdalenian settlement (Barová and Kůlna Caves). These were considered separately for each period in all performed statistics (see below), but are presented as one site on the map (**fig. 1**). Seven LP sites could not be precisely located due to their destruction by quarrying (specifically, the Federmesser-Gruppen sites in North-West Bohemia, and the Opava-Kylešovice site; see Klíma 1951; Vencl 1970). Precise topographical data could not be reconstructed here, and these sites were not used for our analysis though we also present them on the map (**fig. 1**). Similarly, 46 Magdalenian sites have been analysed, leaving aside further four sites of uncertain or unknown topographical data mentioned by Vencl (1962; 2013), Woldřich (1900), and Kovárník (2001). As most LP finds in Bohemia and Moravia consist just of chipped stone assemblages acquired through surface prospection, a limit was set at ten artefacts when distinguishing single finds (not considered in this study) from sites *sensu stricto*.
The settlement pattern of archaeological sites is characterised by their altitude, aspect, distance to freshwater source and steepness of slope (cf. Turrero et al. 2013). In this study, moreover, the area visible from each site was considered as a complementary variable, important for example in the tracking of game in the Palaeolithic.
Coordinates of different sites were obtained from literature (Moník 2014; Neruda / Kostrhun 2002; Neruda / Nerudová / Čulíková 2009; Nerudová 2010; Svoboda 2002; Škrdla / Schenk / Zapletal 2008; Valoch 2001; Vencl 1995a; 2006; 2013). If not stated by the authors, the positions of sites were located on mapping servers (Google Earth) on the basis of their description. The coordinates were then used to acquire necessary variables from a Digital Elevation Model (DEM) in the QGIS Desktop 2.4.0 software. As the resolution of the available pixel DEM for the Czech Republic is rather poor (100 m × 100 m), altitude and distance to freshwater were usually copied from the literature or read off the map (mapy.cz 2015) manually. Possible errors in topographical analyses (see below) may have originated here as present-day water courses are often different from those of the Late Pleistocene as is the whole landscape. Aspect, slope and visible area values had to be obtained through interpolation of DEM map and vector data (**fig. 2**). When considering areas visible from every Magdalenian and LP site, the height of the observer was set at 1.6 m, and the range (radius) of vision at 10 km. The reliability of this method is rather restricted by the fact that vegetation cover is not taken into account, and also by the rather poor DEM resolution which affects the slope analysis as well. Nonetheless, the general strategic importance of sites is, in our opinion, discernible.

### Statistics

Principal Component Analysis (PCA) is a statistical technique used to reduce the dimensionality of interrelated variables of a certain dataset (Salkind 2007) and detect their mutual relationships. Similarly to the study of Turrero et al. (2013), it was conducted here for topographical variables of different periods (Magdalenian and LP), first for cave / shelter and open-air sites together, and then for these two site types separately. If any of the variables characterising the sites were correlated (e. g. the higher the position of the settlement, the better the vision range), the correlation would be identified using this technique. If there were significant changes in site preferences, correlation of variables would differ between the Magdalenian and LP.
The Mann-Whitney U test is a non-parametrical test to verify whether there is a difference between two or more populations (Dodge 2008). It was performed here to determine whether the settlement pattern of the two periods in question is significant as regards four of the considered variables (altitude, aspect, slope, distance to freshwater source) or not, i. e. whether sites were chosen randomly or according to specific criteria. For every LP and Magdalenian site the identical amount of »Expected random samples« (points on the map) was created in the QGIS software and compared with the existing sites.

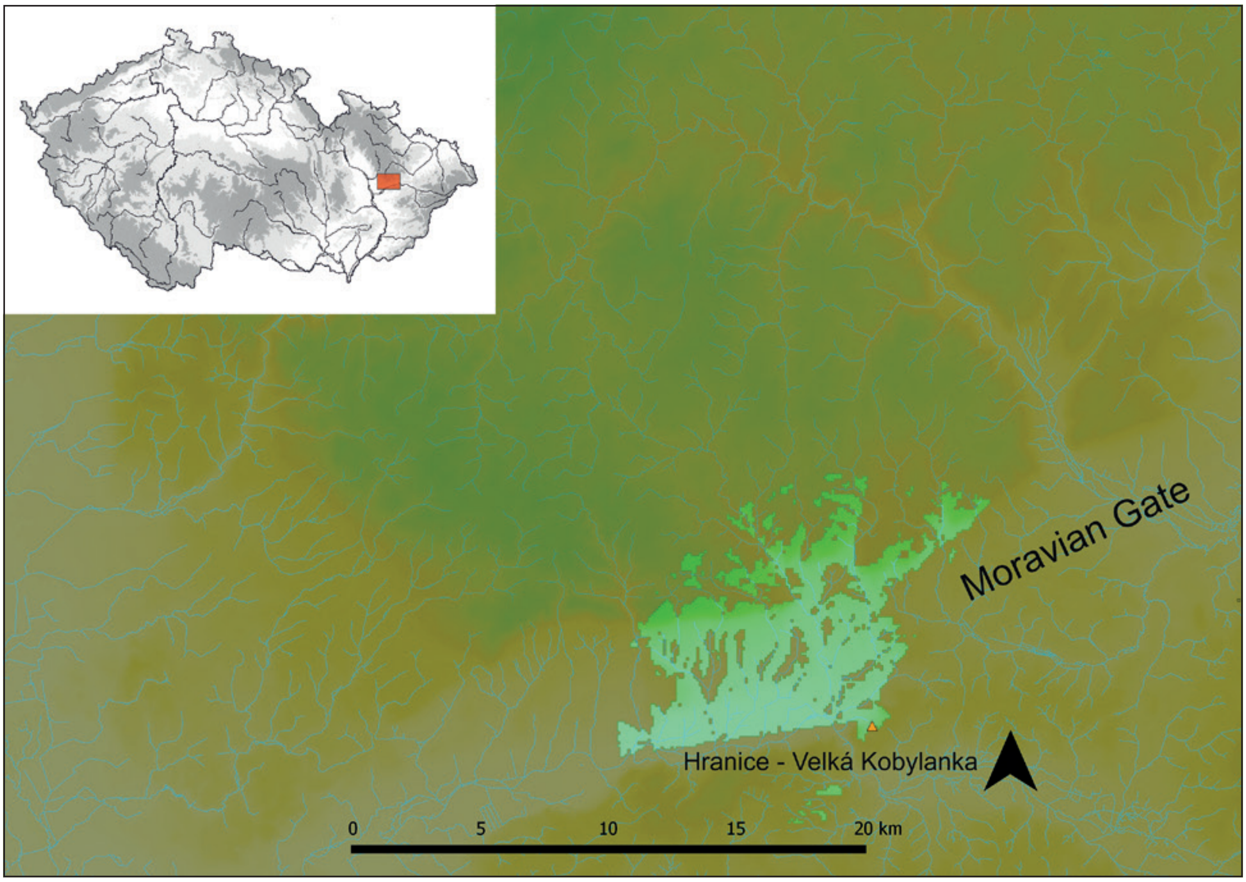


**Fig. 2** Vectorised area (bright green) visible from a selected Magdalenian site and calculated as regards the extent of visibility. Analogous calculations were conducted for all Magdalenian and LP sites.

Secondarily, a Mann-Whitney U test was conducted for testing the significance of topographical differences between Magdalenian and LP sites. In this case, five variables were taken into account (altitude, aspect, slope, distance to freshwater source, visible area).

## RESULTS

### Topography of sites

Variable means and medians of selected topographical variables are summarised in **table 1**. When considering cave/shelter and open-air sites together, a number of trends are observable at the end of the Magdalenian and the onset of the LP, especially the settlement of higher altitudes. Typical altitudes (i.e. the mean 50 % of all altitudes) exploited during the Magdalenian were situated between 315 and 396 m with no maximum outliers and a non-outlying maximum at 476 m. This pattern changed in the LP when mean values increased to 331-450 m, with a non-outlying maximum at 613 m and a maximum outlier at 770 m.
Probably related to this change are larger areas visible from LP sites, increasing from units of square kilometres (when median values are considered) visible from all types of Magdalenian sites to tens of square kilometres visible from LP sites (**tab. 1**). The general aspect of sites does not change much between the two periods, the south-west orientation being preferable, whereas the distance to freshwater sources rises slightly in the LP (**fig. 3**). Magdalenian sites used to be situated on steeper slopes than LP ones, a fact prob-

| Means and medians for | Altitude (m a.s.l.) | Aspect (degrees from N) | Slope (degrees) | Distance to freshwater (meters) | Visible area (km²) | Open-air sites (n) | Cave and shelter sites (n) |
|---|---|---|---|---|---|---|---|
| **Magdalenian sites** | | | | | | **18** | **28** |
| Open-air sites | | | | | | | |
| mean | 314.56 | 187.59 | 5.25 | 342.22 | 27.38 | | |
| median | 325.5 | 202.98 | 4.03 | 140 | 19.4 | | |
| Cave and shelter sites | | | | | | | |
| mean | 373.93 | 196.99 | 11.19 | 210.14 | 4.26 | | |
| median | 367 | 207.05 | 11.68 | 122.5 | 2.03 | | |
| All sites | | | | | | | |
| mean | 353.34 | 193.31 | 8.87 | 256.68 | 13.31 | | |
| median | 361 | 207.05 | 8.12 | 130 | 4.33 | | |
| | | | | | | | |
| **Late Palaeolithic sites** | | | | | | **139** | **8** |
| Open-air sites | | | | | | | |
| mean | 397.9 | 199.6 | 4 | 239.9 | 24.79 | | |
| median | 413.5 | 204 | 3.3 | 165 | 18.25 | | |
| Cave and shelter sites | | | | | | | |
| mean | 396.8 | 203 | 11.1 | 177.2 | 14.75 | | |
| median | 357.0 | 207.5 | 12.1 | 140 | 11.73 | | |
| All sites | | | | | | | |
| mean | 397.86 | 199.78 | 4.46 | 236.11 | 24.25 | | |
| median | 413 | 204.44 | 3.44 | 160 | 16.6 | | |

**Tab. 1** Descriptive statistics of topographical variables of Magdalenian and LP sites in Bohemia and Moravia.

ably influenced by the preference of cave settlements often situated under steep precipices (frequent in the Moravian Karst area) in the former period (**fig. 1**).

The »steepness« of karst areas becomes evident when comparing Magdalenian cave/shelter sites and open-air sites. Magdalenian open-air sites are situated on gentle slopes, similarly to LP ones, and grant a larger visible area than cave/shelter sites. They also tend to be situated in lower altitudes than cave/shelter sites in either period, and slightly closer to streams.

### Principal Component Analysis

Looking at the results for cave/shelter and open-air sites together, both similar and different trends are observable in the Magdalenian and the LP (**tab. 2**). A similar variability is observed in visible area and distance to freshwater. In other words, Magdalenian and LP hunters exploited sites close to water or farther from it, overviewing a large area or just a single valley. The aspect varied little in the two periods, probably in relation to the preferable south or south-west orientation of sites. Slope steepness seems to have been more variable in the Magdalenian, meaning that chipped stone assemblages can be encountered on rather steep slopes as well. Lower loading values for the LP indicate a growing trend for preferring gentle slopes at the sites (the role of karst areas in this matter has been mentioned above). Altitude, again, shows a higher variability in the Magdalenian and a more restricted one in the LP.

When considering cave/shelter and open-air sites separately (**tab. 3**), a slightly higher variability is evident in areas visible from Magdalenian caves when compared to open-air sites. When compared with data in **table 1**, it seems probable that the range of vision was not the most important factor when settling a cave

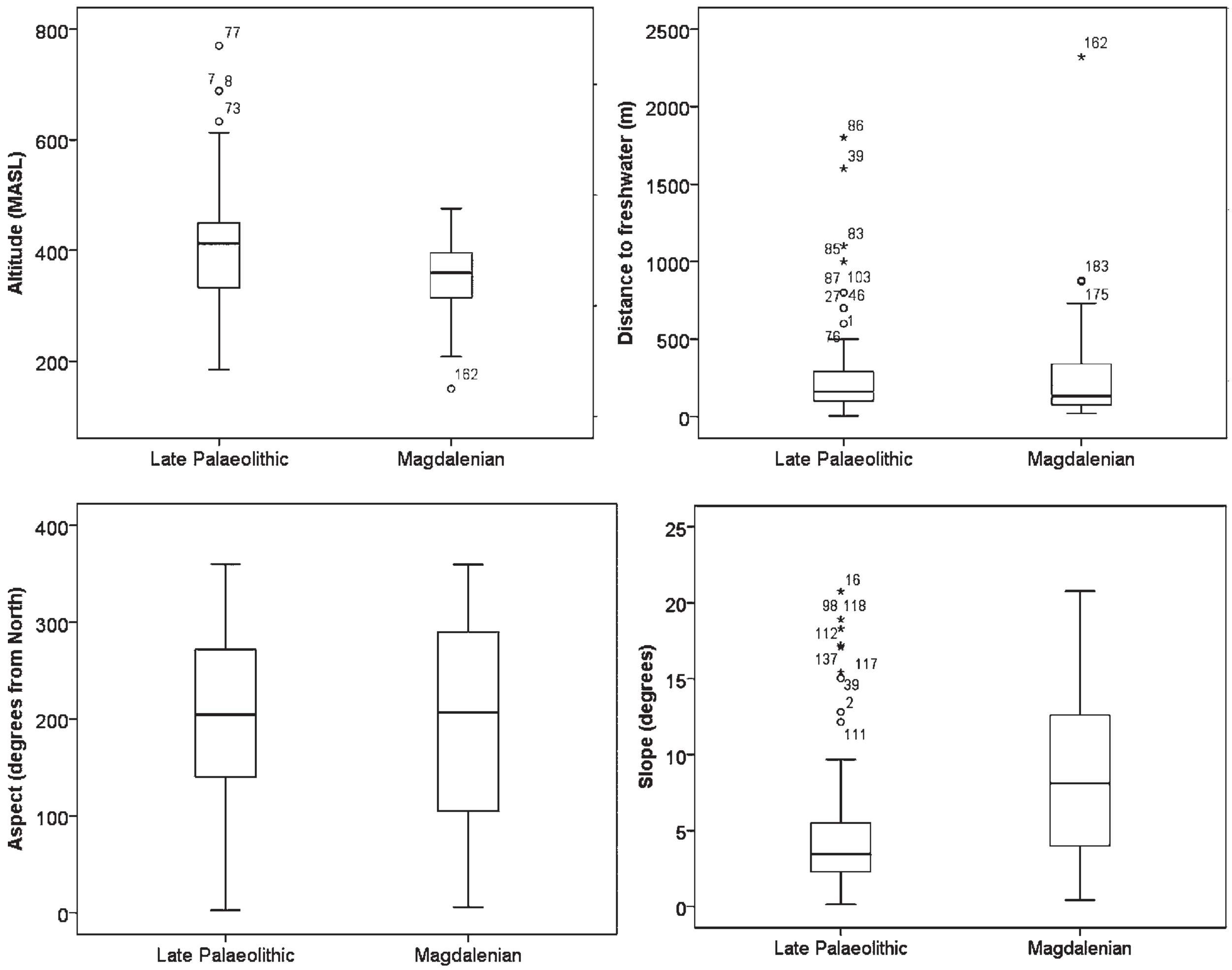


**Fig. 3** Box plots of topographic variable distribution in the Magdalenian and LP. The box plots illustrate the spread and differences of samples, they show a 95 % confidence interval and standard deviation for the mean. Numbers represent sites mapped in **fig. 1**.

in the Magdalenian as the values, apart from being variable, are on average low. Greater variance could be observed in the mean distance to freshwater sources in Magdalenian open-air sites, whereas Magdalenian caves are more uniform in this matter and tend to be situated closer to water (**tab. 1**). A third major difference is the greater variability in slope steepness in Magdalenian caves/shelter sites. This may be due to the rugged relief in karst areas where Magdalenian caves in both Bohemia and Moravia are situated. The aspect of Magdalenian cave/shelter sites was highly varied (as already mentioned by Oliva 2005), and therefore obviously not too important when choosing a cave for settlement. This situation changes in open-air sites, where the southern aspect was more preferable (**tabs 1. 3**).

As for LP cave/shelter sites, the informative value of the statistics is limited by their restricted number. Major uniformity is observed in slope steepness and altitude here (**tab. 3**). Most variable are the aspect of cave sites, distance to freshwater and the area visible from them. LP open-air sites are also highly variable as regards distance to freshwater and visible area, but are more restricted when altitude, aspect and slope are considered.

Comparing Magdalenian and LP cave/shelter sites is difficult due to the restricted number of cave settlements in the latter period, reflected in the high variability in LP cave/shelter sites' topography. As for open-air sites, there is a higher variability in altitude, aspect and slope in the Magdalenian when compared to the LP, with the LP sites situated on flatter grounds, though in higher altitudes (**tab. 1**). Distances to freshwater

| Magdalenian | | | | |
|---|---|---|---|---|
| Principal component | Eigenvalue | % Variance | | Loading (component 1) |
| 1 | 1.877 | 37.540 | altitude | -0.585 |
| 2 | 1.096 | 21.914 | aspect | 0.072 |
| 3 | 0.896 | 17.921 | slope | -0.485 |
| 4 | 0.690 | 13.980 | distance to freshwater | 0.652 |
| | | | visible area | 0.859 |
| | | | | |
| Late Palaeolithic | | | | |
| Principal component | Eigenvalue | % Variance | | Loading (component 1) |
| 1 | 1.454 | 29.085 | altitude | -0.198 |
| 2 | 1.216 | 24.319 | aspect | -0.188 |
| 3 | 1.031 | 20.612 | slope | -0.017 |
| 4 | 0.784 | 15.671 | distance to freshwater | 0.855 |
| | | | visible area | 0.802 |

**Tab. 2** PCA of topographical variables of Magdalenian and LP sites. Cave/shelter and open-air sites are considered together. Most variable during the Magdalenian was the area visible from different sites, followed by distance to freshwater, slope steepness and altitude. Visible area and distance to freshwater were most variable in the LP.

| Magdalenian cave/shelter sites | | | | |
|---|---|---|---|---|
| Principal component | Eigenvalue | % Total variance | | Loading (component 1) |
| 1 | 1.7093 | 34.1854 | altitude | 0.0572 |
| 2 | 1.1728 | 23.4562 | aspect | -0.7986 |
| 3 | 1.0462 | 20.9231 | slope | -0.7194 |
| 4 | 0.6369 | 12.7388 | distance to freshwater | 0.3898 |
| | | | visible area | 0.6314 |
| | | | | |
| Magdalenian open-air sites | | | | |
| Principal component | Eigenvalue | % Total variance | | Loading (component 1) |
| 1 | 1.9066 | 38.1328 | altitude | -0.6991 |
| 2 | 1.3036 | 26.0722 | aspect | -0.4189 |
| 3 | 0.9367 | 18.7330 | slope | -0.4831 |
| 4 | 0.5564 | 11.1275 | distance to freshwater | 0.8993 |
| | | | visible area | 0.4437 |
| | | | | |
| Late Palaeolithic cave/shelter sites | | | | |
| Principal components | Eigenvalue | % Total variance | | Loading (component 1) |
| 1 | 2.782 | 55.632 | altitude | 0.412 |
| 2 | 1.411 | 28.228 | aspect | -0.988 |
| 3 | 0.591 | 11.823 | slope | 0.303 |
| 4 | 0.184 | 3.677 | distance to freshwater | 0.920 |
| | | | visible area | 0.828 |
| | | | | |
| Late Palaeolithic open-air sites | | | | |
| Principal components | Eigenvalue | % Total variance | | Loading (Component 1) |
| 1 | 1.445 | 28.906 | altitude | -0.186 |
| 2 | 1.217 | 24.334 | aspect | -0.158 |
| 3 | 1.045 | 20.896 | slope | -0.018 |
| 4 | 0.795 | 15.888 | distance to freshwater | 0.856 |
| | | | visible area | 0.803 |

**Tab. 3** PCA of topographical variables of Magdalenian and LP sites. Cave/shelter and open-air sites are considered separately. Most variable in Magdalenian cave/shelter sites were aspect, slope steepness and visible area, but altitude and distance to freshwater in Magdalenian open-air sites. LP cave/shelter sites were variable in all categories except slope steepness, whereas LP open-air sites were variable in distance to freshwater and visible area.

| | Magdalenian vs. Late Palaeolithic | | | |
|---|---|---|---|---|
| Topographic variable | n(1) | M-W U test | SE | p value |
| altitude | 193 | 2,323.5 | 330.0 | 0.001* |
| distance to freshwater | 193 | 3,151.0 | 330.4 | 0.486 |
| aspect | 193 | 3,310.0 | 330.6 | 0.831 |
| slope | 193 | 4,983.5 | 330.6 | 0.001* |
| visible area | 193 | 1,845.0 | 330.6 | 0.001* |
| | | | | |
| | Late Palaeolithic vs. Expected random sample | | | |
| Topographic variable | n(2) | M-W U test | SE | p value |
| altitude | 294 | 8,135.0 | 728.8 | 0.001* |
| distance to freshwater | 294 | 9,102.5 | 728.7 | 0.020* |
| aspect | 294 | 11,576.0 | 728.8 | 0.290 |
| slope | 294 | 12,006.5 | 728.8 | 0.099** |
| visible area | | | | |
| | | | | |
| | Magdalenian vs. Expected random sample | | | |
| Topographic variable | n(2) | M-W U test | SE | p value |
| altitude | 193 | 1,935.0 | 330.6 | 0.001* |
| distance to freshwater | 193 | 3,198.5 | 330.6 | 0.581 |
| aspect | 193 | 2,750.5 | 330.6 | 0.057** |
| slope | 193 | 4,960.0 | 330.6 | 0.001* |
| visible area | | | | |

**Tab. 4** Comparison of topographical values between Magdalenian and LP sites, LP sites and »Expected random samples« and Magdalenian sites and »Expected random samples«.
(1) 147 LP sites and 46 Magdalenian sites; (2) 147 LP sites and 147 »Expected random samples«; * observed variable is not the same concerning Magdalenian vs. LP, or LP vs. »Expected random sample«; ** is significant at the 0.10 level (slope differs between LP sites and »Expected random sample«, and aspect differs between Magdalenian sites and »Expected random sample«); n = number of sites; M-W U test = Mann-Whitney U test; SE = standard error; p value = statistical significance; if less than 0.05 (or 0.10**), there is no significant difference between two means; (3) 46 Magdalenian sites and 147 »Expected random samples«.

are comparable between the two considered periods, whereas the area visible from Magdalenian open-air sites is more uniform than that from LP sites. This latter fact, however, may be due to the restricted number of Magdalenian open-air sites as median values of visible areas are comparable in both periods.

### Comparison between Magdalenian, Late Palaeolithic and identical number of »Expected random samples«

Comparing frequency distributions of »Expected random samples« and existing LP sites, significant differences of topographical values were identified in the case of altitude and distance to freshwater on a 0.05 significance level (**tab. 4**). The differences were caused by lower altitudes and lesser distances to freshwater sources in the case of existing sites. The aspect of sites might have predominantly been south (**tab. 1**), but the advantages of this orientation were probably not sufficient to be statistically significant. Slope steepness of existing sites is significantly different from »Expected random values« only on a 0.1 significance level. As for Magdalenian sites, these were preferentially situated in lower altitudes and on steeper slopes than »Expected random samples« on a 0.05 significance level. Preferential aspect (southward) is significant on a 0.1 significance level when open-air sites probably play a major role, as cave/shelter sites do not show a preferred aspect (see above).
When Magdalenian and LP sites were compared topographically, values of altitude and slope were different on a 0.05 significance level. Slope values were higher for the Magdalenian, whereas altitude was higher in

LP sites. Also the area visible from different LP sites was larger than in the Magdalenian period. Aspect of sites and distance to freshwater remained similar in the observed area throughout the Magdalenian and the LP.

## DISCUSSION

Our analysis has shown that Magdalenian sites are not situated randomly in the landscape as regards altitude, aspect and slope steepness. Magdalenian hunters preferred lower altitudes on south-facing slopes (when not living in caves) when the considerable steepness of the slopes was caused by the position of cave / shelter sites in karst areas. LP sites, on the other hand, differ from »Expected random samples« in altitude and distance to freshwater source, and, if 0.1 significance level is considered, in slope steepness. The altitude remained below the »Expected values«, although LP hunters moved slightly off water streams (when median values are considered) compared to Magdalenian ones (**tab. 1**). Exceptionally, LP sites lie over 1 km or even 2 km away from the nearest water source (**fig. 3**). When sites of the two periods are compared, topographical differences are statistically significant in the settlement of higher altitudes on gentler slopes with a greater area visible (disregarding vegetation cover) from sites in the LP. Similarly, the »elevation hypothesis« (Jones 2007) of hunter-gatherers' movements to higher altitudes with a warming climate was tested for the Dordogne area at the Pleistocene / Holocene transition, where, nonetheless, this trend could not be (altogether) demonstrated. Reasons for this changing pattern in Bohemian and Moravian territory are difficult to determine, not least because most LP sites in the area are preserved as mere surface chipped stone assemblages without sufficient information on chronology, season of occupation, game species or surrounding vegetation. Warming during the Allerød period, a possible propagation of tree cover or bogs in the lowlands, with animals and people moving to more open areas, and human population density increase are possible hypotheses, and will remain so until more stratified LP sites are located and excavated to grant us more quantifiable data. Climate change, nonetheless, seems to have played a major role in the abandonment of caves at the beginning of the Allerød.

That being said, we have to stress once again the low quality of data regarding the LP of Bohemia and Moravia. Assemblages of chipped stone artefacts can be termed sites only with a significant amount of uncertainty, whereas the original position of finds is beyond reconstruction due their continuous redeposition or poor preservation conditions (Schiffer 1987; Vencl 1995b). This problem is inherent to LP sites in other parts of Europe as well (e. g. Sorokin 2006; Sulgostowska 2006). Performed statistics are also undoubtedly biased by an uneven prospection intensity in different parts of Bohemian and Moravian territory. LP research in the Czech Republic should thus focus not only on prospection in less explored areas (e. g. Ore Mountains, Slavkov Forest, Hostýn-Vsetín Highlands, High Ash Mountains), but also on the realisation of excavations in places with an increased density of surface finds. Without stratified finds, local LP research will remain a quest for stratified typological analogies in neighbouring countries.

An effort was also made to divide Bohemian and Moravian LP sites into more (106) and less (48) reliable assemblages (Moník / Eigner 2019) on the basis of the amount of preserved chipped stone industries, the presence of »fossiles directeurs«, the reliability of a publishing author or journal, and the quality of the original research. Leaving aside six sites of unknown topography, just 100 reliable LP sites would be at our disposal. The Mann-Whitney U test then comes out differently in the non-random aspect of LP sites, being of 190º, meaning a preferred south-west orientation of most sites. A comparison with Magdalenian sites, however, shows the same results for all 154 sites, i. e. significant differences in altitude, slope steepness and visibility between the sites of the two periods. If predictive analyses were to be conducted in the future,

however, it would be preferable to use just those 100 LP sites to eliminate (if ever possible) a high uncertainty of imbalanced datasets.
So far it looks most promising to look for LP sites on gentle slopes or in flat areas in higher altitudes, relatively close to water and with good control of the surrounding area. In a certain sense, this partially corroborates the often stated (though not statistically evaluated) presumption (e. g. Vencl 2013) that LP sites were situated in elevated places above valleys and confluences. As many Magdalenian cave sites in the region were (completely) excavated in the past, prospection for Magdalenian open-air sites seems more promising. These should be situated close to streams in low altitudes (about 315 m above sea level) as indicated by our analysis. Though open-air areas might seem to have been all but ignored during the Magdalenian of Moravia (Oliva 2005), recent intensive prospection identified Magdalenian sites in areas (e. g. southern Bohemia; Vencl 2013) traditionally considered empty during most of the Pleistocene (Pleiner / Rybová 1978).
The settlement of higher altitudes and a major density of sites in the LP were perhaps responsible for a more intensive exploitation of the landscape and raw material sources. That is probably why a more variable scale of chipped stone materials was now used when compared to the previous Magdalenian (Valoch 2001; Vencl 2013), and why territories (»provinces«) with a specific raw material preference appeared (Moník / Eigner 2019). A different perception of the landscape, on the other hand, led to the scarcity of long-range raw material imports in the LP (Moník / Eigner 2019).

## CONCLUSIONS

A quantification of topographical variables of Magdalenian and LP sites in Bohemia and Moravia along with GIS analyses and a statistical evaluation of the data have indicated the following:

1) There was a specialised settlement pattern in both periods. This involved altitude, slope steepness, and aspect of sites in the Magdalenian, and distance to freshwater sources, slope steepness, and altitude of sites in the LP. These patterns differentiate existing sites from randomly chosen points on the map.
2) LP sites differed from Magdalenian ones not only in the almost complete abandonment of caves, but were also preferably established higher up in the landscape. This was possibly driven by the movement of game to more open areas, and the need for greater visible areas from sites, controlling surrounding landscape. The difference in altitude is evident even when just open-air sites are considered.
3) Distance to freshwater and aspect of sites did not change much in the two considered periods, although a greater variability can be observed in the LP.

At least part of the mentioned topographical differences was probably caused by changing climate during the Allerød and Younger Dryas. The significance of this change in Bohemian and Moravian territory is yet to be quantified and correlated with archaeological finds as reliable stratified LP sites are all but missing here. Although the quality of LP data from the territory in question is relatively low, the used method is promising as shown by past research (e. g. Turrero et al. 2013). We thus suggest comparing our data with topographical data of other Upper Palaeolithic cultures in the region, especially the Pavlovian and the Aurignacian.

**Acknowledgements**

The authors would like to thank V. Pechanec from the Department of Geoinformatics (Palacky University, Olomouc, Czech Republic) for his help regarding the GIS analyses.

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*Summary*

A quantification of topographical data of Magdalenian and Late Palaeolithic (LP) sites in the Bohemian and Moravian territory (Czech Republic) was conducted in order to analyse settlement patterns in the two periods. To achieve this, GIS analyses along with descriptive statistics, Principal Component Analysis and Mann-Whitney U test were conducted. The results have shown that there were non-random settlement patterns in both periods, different from each other. Apart from the almost complete abandonment of caves in the Bohemian and Moravian LP, the major difference of LP sites from those of the local Magdalenian is the settlement of gentler slopes in higher altitudes, and larger areas visible from LP sites. Aspect of sites and their distance to freshwater did not change significantly in the two periods.

*Keywords*

Magdalenian, Late Palaeolithic, Bohemia, Moravia, topography