# Late Pleistocene Hunter-Gatherer Settlement and Ecology of the Romanian Carpathians and Adjacent Areas

by

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# ABSTRACT

Despite nearly five decades of archaeological research in the Romanian Carpathian basin and adjacent areas, how human foragers organized their stone artifact technologies under varying environmental conditions remains poorly understood.

Some broad generalizations have been made, most work in the region is concerned primarily with descriptive and definitional issues rather than efforts to explain past human behavior or human-environmental interactions. Modern research directed towards understanding human adaptation to different environments remains in its infancy. Grounded in the powerful conceptual framework of evolutionary ecology and utilizing recent methodological advances, this work has shown that shifts in land-use strategies changes the opportunities for social and biological interaction among Late Pleistocene hominins in western Eurasia, bringing with it a plethora of important consequences for cultural and biological evolution.

I employ, in my Dissertation, theoretical and methodological advances derived from human behavioral ecology (HBE) and lithic technology organization to show how variability in lithic technology can explain differences in technoeconomic choices and land-use strategies of Late Pleistocene foragers in Romanian Carpathians Basin and adjacent areas. Set against the backdrop of paleoenvironmental change, the principal questions I addressed are whether or not technological variation at the beginning of the Upper Paleolithic can account for fundamental changes at its end.

The analysis of the Middle and Upper Paleolithic strata from six archaeological sites show that the lithic industries were different *not* because of biocultural differences in technological organization, landuse strategies, and organizational flexibility. Instead the evidence suggests that technoeconomic strategies, the intensity of artifact curation and how foragers used the land appear to have been more closely related to changing environmental conditions, task-specific activities, and duration of occupation. This agrees well with the results of studies conducted in other areas and with those predicted from theoretically-derived models based on evolutionary ecology. My results lead to the conclusion that human landuse effectively changes the environment of selection for hominins and their lithic technologies, an important component of the interface between humans and the natural world. Foragers move across the landscape in comparable ways in very different ecological settings, cross-cutting both biological morphotypes and prehistorian-defined analytical units.

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# CHAPTER 1

# Introduction

The early Upper Pleistocene (ca. 130 ka) sees intensified occupation of parts of Central and Eastern Europe including Poland (Raj, Zwolen, Zwierzyniec), Moravia (Kulna, Predmosti), Slovakia (Ganovce), Hungary (Büdospest, Soloyomkuti, Subalyuk) and possibly Romania (Ripiceni-Izvor) (Dobоș and Trinkaus, 2012; Kozłowski, 1996; Mester, 1995; Moncel, 2003; Svoboda et al., 1996). The earliest sites in the Upper Danube date to approximately the same time (end of OIS 5) (i.e., Schambach, Sesselfelsgrotte, and Bokstein). Whether the lowest archaeological levels at the Sesselfelsgrotte are Eemian or early Würm is debated (Muller-Beck, 1988; Richter, 1997). A human presence in Belgium's Meuse Basin (Scladina) (Demarsin, et al. 2006) and in Romania (Boroșteni) (Mertens 1996; but see Doboș and Trinkaus 2012; Tuffreau et al. 2009 for probable earlier dates of occupation) dates no earlier than the last Interglacial. Neanderthals appear in the Levant from the beginning of the first Würm-Weichsel pleniglacial at 74 ka (but see Klein, 2009, for earlier claims of Neanderthals in the Levant). By about 40 ka Neanderthals had colonized the cold, dry steppes of Central Asia (Uzbekistan – (Vishnyatsky and Nehoroshev, 2004).

Based on techno-typological characteristics several Middle Paleolithic groups have been defined that pertain to the early Upper Pleistocene in Central Europe. The archaeological thinking behind the establishment of these groups relies heavily on French Paleolithic systematics, either Bordesian (Bordes, 1972) or in some cases, the *chaîne opératoire* approach (Boëda, 1991).

So far as the archaeology is concerned, much of the study of Middle Paleolithic variability is concerned with the hotly-debated issue of modern human origins, when and how they replaced the Neanderthals, and the nature and timing of the 'transition' between the Middle and the Upper Paleolithic (see chapters in Hovers and Kuhn 2006). Because this research is often based on data classified according to the conventional systematics and explained in terms of the implicit assumptions about process that underlie what is essentially a culture-historical approach (Binford & Sabloff 1982, Clark 1993), it cannot fail to limit our capacity as paleoanthropologists to understand the evolutionary mechanisms involved and how they are expressed in space and time. Kuhn (1995, p. 5) has pointed out that an exclusive focus on the transition as if it were an isolated phenomenon might give the impression the only thing that was important about it was that it happened, and that the Middle Paleolithic, however defined, came to an end. There is no doubt that the Middle Paleolithic was more than just a phase in human evolution during which some prehistoric societies were "waiting to become modern" (Kuhn, 1995, p. 5). New approaches developed during the past 30 years have led to the emergence of powerful explanatory models grounded in human behavioral ecology (HBE) (Barton and Clark, 1997; Winterhalder and Smith, 2000) that indicate that Late Pleistocene hominins in general possessed a range of flexible adaptive behaviors that would not necessarily lead to the transformation of *H. sapiens neandertalensis into H. sapiens sapiens,* nor to the transformation of the Middle into the Upper Paleolithic (Clark 2007). These processes cannot be understood by the *en bloc* comparisons of the two analytical units favored by cultural historians. The research must be diachronic, regional, and comprehensive and take into account a longer temporal sequence than the more restricted transition interval

(50-30 ka). It is my intention here to assess the utility of this approach using data from sites in the Carpathian Basin and focused on the long sequence at Ripiceni-Izvor (Păunescu, 1993).

One of the most enduring aspects of the modern human origins debate is the fate of the Neanderthals (Conard, 2006; Finlayson, 2004; Mellars, 2000; Zilhão and d'Errico, 2003). At present, researchers involved in this debate tend to be somewhat polarized between those advocating the evidence of a gradually evolving mosaic of behavioral continuity (Clark, 2002, 2005; Straus, 2003; Marks, 2003) and those advocating an abrupt change between the Middle and Upper Paleolithic manifest in a range of archaeological monitors of behavioral modernity (Bar-Yosef, 2002; Clark, 2002, 2005; Marks, 2003; Mellars, 1996, 2005). The evidence for such a punctuated change in the archaeology is usually predicated on the fossil evidence – replacement of Neanderthals by modern humans – despite a paucity of diagnostic hominin remains dating to the transition (Barton and Riel-Salvatore, 2012; Churchill and Smith, 2000; Trinkaus, 2007). However, more and more evidence recently published suggest that there was more interbreeding between archaic and modern hominins than thought before (Fu et al., 2015). There is also a third position known as the 'indigenist' model whose proponents claim the Neanderthals had achieved an 'Upper Paleolithic' level of cultural development earlier than, and independent of, modern humans (Harold and Otte, 2001; Zilhão and d'Errico, 1999, 2000, 2003). However, no testable hypothesis has been proposed to explain this accelerated development on the part of the Neanderthals. Because it posits that the Neanderthals disappeared subsequent to the appearance of the Aurignacian in western Eurasia, this model can be considered a variant of the replacement position. As Wolpoff and colleagues (2004) have noted, all these models agree on the fact that Neanderthals had disappeared from the European record by sometime around 30-25 ka, and at issue is *how* they had disappeared.

Since the early 1990s central and eastern Europe have become of critical importance in ongoing discussions of the Middle to Upper Paleolithic transition. The region lies astride the 'Danube Corridor', includes the Carpathian Basin, and constitutes the major inland passageway between Europe and Asia. It could be considered a kind of refugium, especially during the last Glaciation, when the European Plain to the north and east was a much harsher environment for human occupation than it is today (Conard and Bolus, 2003; Mellars, 2005). Dated to 36-34 ka BP, an AMH mandible and a partial cranium in the Peştera cu Oase cave, southwestern Romania, are the oldest unequivocal evidence for an early modern human presence in Europe. Argued to present a mosaic of archaic, early modern human and possibly Neanderthal morphological features, the specimens underscore the complex population dynamics of the modern human dispersal in this poorly-known region (Doboş et al., 2010; Fu et al., 2015; Soficaru et al., 2006; Trinkaus and Zilhão, 2007; Trinkaus et al., 2003b).

Although Paleolithic archaeology in the Carpathians dates back to the latter half of the 19th century, most earlier work was conducted under an implicit, descriptive, culture-history conceptual framework (see discussion in Anghelinu 2004; Anghelinu and Nita 2012). That said, the archaeological record still contains enough untapped information to address so far unexploited research questions involving one or another of the complex relationships between technology and behavioral dynamics of the Late Pleistocene foragers in the region (Barton et al. 2011; Cârciumaru, et al. 2000; Dobrescu

2008; Moncel, et al. 2002; Riel-Salvatore et al. 2008). These research questions are examined here using the powerful conceptual framework of human behavioral ecology.

I propose to evaluate models of raw material acquisition and management, identify distinct technological characteristics in the stone industries of Late Pleistocene foragers and determine how their technological systems were organized. The data available to do this are mostly from old collections stored in museums and from published and unpublished site reports but, if research questions are properly framed and appropriate methodologies adopted, new behavioral information can be extracted from them and interpreted using an eclectic approach guided by HBE (Adams 1998; Adams 2007; Féblot-Augustins 1993; Féblot-Augustins 1997; Kuhn 1994; Kuhn 1995; Nejman 2006; Nejman 2008; Nejman et al. 2011; Riel-Salvatore și Barton 2004; Riel-Salvatore, et al. 2008; Roth și Dibble 1998; Tostevin 2000, 2003).

Explicit theory-based approaches employing mathematical and computational modeling have called into question long-held assumptions about the relationship between Neanderthals and modern humans. This research has shown that changes in land-use strategies also changed the opportunities available for social interaction among Late Pleistocene hominins in western Eurasia, bringing along a plethora of consequences for biological and cultural evolution (Brantingham and Kuhn, 2001; Brantingham, 2003; Surovell, 2009; Barton et al., 2011; Barton and Riel-Salvatore, 2014). Despite the ‘coarse-grained’ nature of the data, these models can be tested against the empirical paleoanthropological record. In this dissertation I will employ HBE theoretical and methodological advances to study the organization of lithic technologies and to show how they vary across space and time. Set against the backdrop of climate change, variability in lithic technology can be used to explain differences in technoeconomic choices and land-use strategies between the Middle (MP) and Early Upper Paleolithic (EUP) in Romania, and within the broader context of Central-Eastern Europe. My intention is to evaluate whether or not technological differences at the beginning of the EUP can account for the fundamental change and re-conceptualization of hominin behavior often thought to coincide with the MP-UP transition.

Explicit theoretical models derived from HBE and novel methodologies developed over the past decade are ideally suited to the aspects of prehistoric behavior that I hope to monitor, and to the time span under scrutiny here. Of the various aspects of the Middle and Upper Paleolithic variability, those concerned with land-use have perhaps remained less emphasized, mostly because of the lack of adequate methods with which to directly compare sites and assemblages from different periods. Several researchers have used retouch intensity as a proxy for studying the models of land-use and mobility in the Middle Paleolithic (Barton 1988, 1998; Dibble 1995; Kuhn 1995) and the EUP (most often the Aurignacian) (Blades 2001, 2003). Although there are differences among researchers in respect of how to measure retouch intensity, blank size and shape, and in sample quality and representativeness, direct regional comparisons between Middle and Upper Paleolithic assemblages are still possible provided that test implications of null and alternative hypotheses are worked out beforehand and are well understood (Dibble, 1995b). In addition to being underemphasized, the interpretive potential of territorial behavior is often under acknowledged. Despite sharing a common set of behavioral rules, hunter-gatherers can act and discard different traces of material culture, as a result of contextual factors (climate, hydrology, resource abundance or scarcity) which can lead to different expressions of the same behavioral system (Neeley and Barton, 1994; Barton and Neeley, 1996; Goring-Morris, 1996). We can therefore expect within the same time period and physical environment a suite of behavioral stasis and change, rather than a single monolithic one that corresponds to the MP/UP transition (Clark, 2002, p. 63).

The research design adopted here falls squarely within the conceptual framework of human biogeography (Harcourt 2012, Clark 2013 – Harcourt cit. in Clark 2013, AJPA). It addresses the socioecological meaning of lithic technological variability during the Late Pleistocene of the Carpathian Basin (I still like 'Carpathia', even if I made it up!). The data used here consists of 40 archaeological assemblages from six Middle and Early Upper Paleolithic (both cave and open air) in Romania (Figure 1, Appendix 3 Table 1). The information relative to these sites comes from my own study of lithic collections, where possible (Bordu Mare, Ripiceni-Izvor), and from the available literature pertaining to the study area (Mitoc-Malu Galben, Poiana Cireşului, Buda-Dealu Viilor, and Lespezi-Lutărie). Data from these assemblages include 161,332 lithic artifacts, 9 bone artifacts, and 11,623 identifiable animal bones (Appendix 3, Tables 3-8).

I employ a methodology that can be applied to collections from previously excavated sites regardless of any typological label assigned to the assemblages. This approach had been used effectively to analyze Middle Paleolithic, 'Transitional' M/UP, Upper and Epipaleolithic assemblages from the Mediterranean coasts of Europe and the Levant, as well as Continental Europe (Barton and Riel-Salvatore, 2012; Barton et al., 1999, 2013; Clark, 2015; Kuhn, 2004; Kuhn and Clark, 2015; Villaverde et al., 1998). The six sites that provide the database were excavated using relatively modern techniques, systematic recovery of artifacts and fauna, adequate data recording and quantification

(Figure 1, Appendix 3 Tables 1-8). Two of them have both Middle and Upper Paleolithic assemblages (Bordu Mare cave and Ripiceni-Izvor), while the other four (Mitoc-Malu Galben, Poiana Cireşului, Buda-Dealu Viilor, and Lespezi-Lutărie) have only Upper Paleolithic assemblages assigned typologically to techno-complexes that span most of the Early Upper Paleolithic (EUP), Aurignacian, Gravettian and Epigravettian.

Although the title of my dissertation refers to the Carpathian Basin in general, it does not mean that I have analyzed the totality of the Middle and Early Upper Paleolithic assemblages from that area, nor those that lie entirely within the strictly defined boundaries of the Basin. I have chosen only those sites I consider to be amongst the most representative in respect of lithic and faunal assemblages, adequately curated museum collections, relatively well-documented and published in sufficient detail to fulfill the requirements of the analysis. The Carpathian Basin is defined by its generally recognized geographical limits, which are of interest for this work. Throughout the dissertation data from other MP and EUP sites in areas adjacent to the basin are taken into account and comparisons made between them and those directly studied by me.

A single analytical format is used throughout. Aware of the circular reasoning implicit in the conventional systematics, I adopt novel methodologies that seek to eliminate the typological barrier between the MP and the EUP imposed in earlier works, which although went beyond the comparative barrier of former typological approaches between the MP and EUP, have focused mainly on the artifact morphologies to establish cultural antecedents (Tostevin 2000; Tostevin 2003; but see Marks 2003). This dissertation goes beyond culture history approaches and underscores the behavioral dimensions of lithic technology in order to achieve a better understanding of the adaptive problems faced by Pleistocene foragers at both the local and the regional scales.

The primary null *($H_o$)* and alternative *($H_1$)* hypotheses that guide this research are given below, together with their respective test implications *($T_n$).* Test implications are expectations about pattern generated before an analysis is undertaken that are compared with empirical patterns once the analysis has been completed (Clark 1982). Keep in mind that one cannot 'prove' $H_o$ to be true but only attempt to falsify it. If $H_o$ is in fact falsified, the case for accepting $H_1$ is correspondingly strengthened.

$H_o$: *The archaeological monitors of human adaptation specified in here show significant differences that correspond to the MP/EUP transition, as conventionally defined, at 40±5 ka.*

- $T_1$: *Changes in lithic technology correspond to the transition interval at 40±5ka.*
- $T_2$: *Changes in lithic typology correspond to the transition interval at 40±5ka.*
- $T_3$: *Changes in the relative frequencies of raw material procurement, package size, and sources correspond to the transition interval at 40±5ka.*
- $T_4$: *Changes in the faunal inventories correspond to the transition interval at 40±5ka.*
- $T_5$: *The MP/EUP transition interval is strongly correlated with episodes of significant climate change resulting in changes in resource distributions and, consequently, how humans distributed themselves over the landscape.*
- $T_6$: *There are autocorrelations across at least 60% (3 of 5) of these changes, suggesting a broader pattern that marks significant behavioral change over the transition interval and relatively little change during the MP and the EUP.*

$H_1$: *The archaeological monitors of human adaptation specified here vary independently from correlated differences that correspond to the MP/EUP transition, as conventionally defined, at 40±5 ka.*

- $T_1$: *Changes in lithic technology are not correlated with the transition interval at 40±5ka.*
- $T_2$: *Changes in lithic typology are not correlated with the transition interval at 40±5ka.*
- $T_3$: *Changes in the relative frequencies of raw material sources and mobility patterns implied by raw material source distributions are not correlated with the transition interval at 40±5ka.*

*$T_4$: Changes in the faunal inventories are not correlated with the transition interval at 40±5ka.*

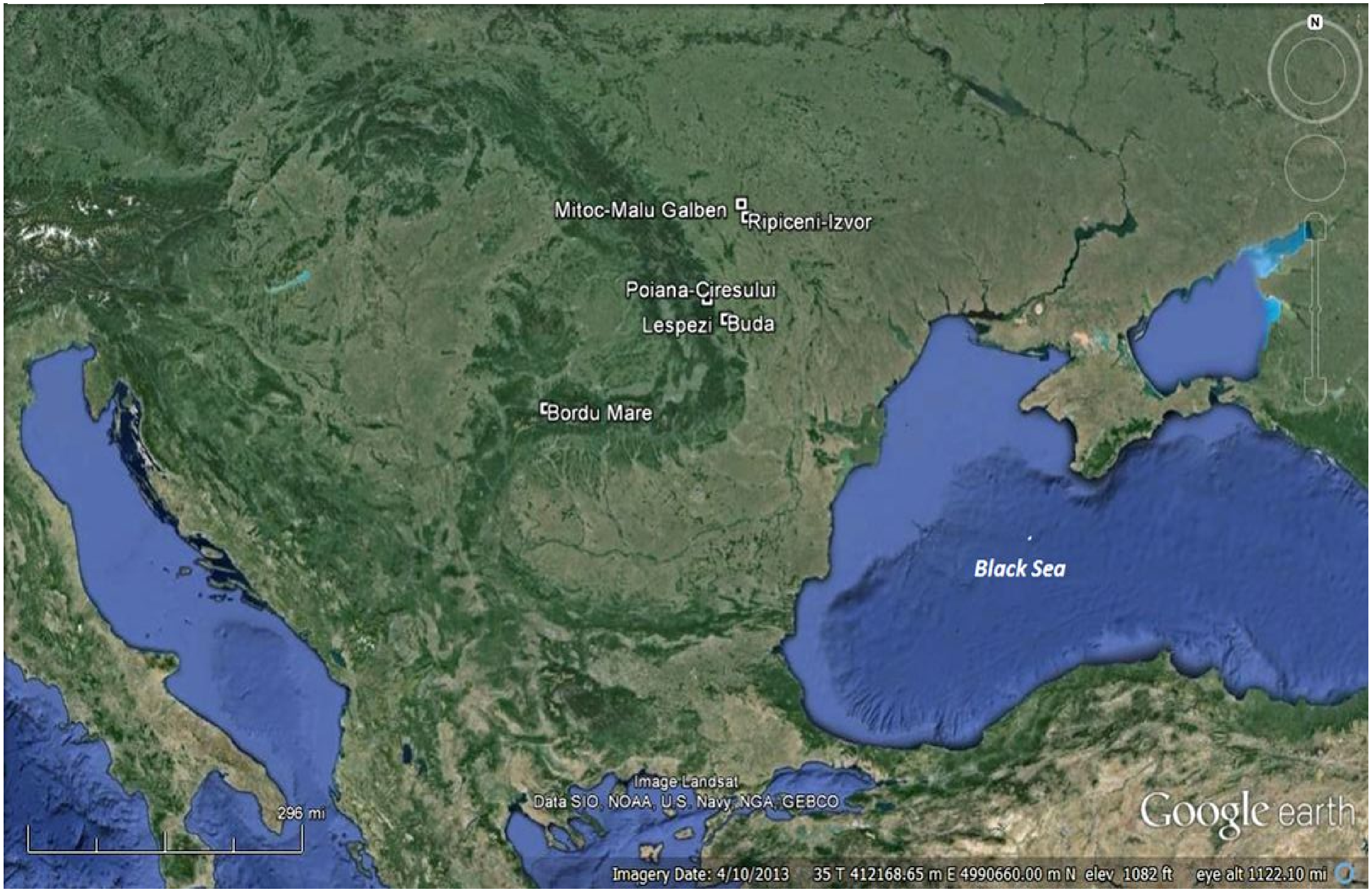
*$T_5$: The MP/EUP transition interval is not correlated with episodes of significant climate change resulting in changes in resource distributions and, consequently, how humans distributed themselves on the landscape.*

*$T_6$: There are few (≤ 40%) (2 of 5) correlations across these changes, suggesting that significant behavioral change, while it doubtless occurred, did not take place exclusively over the transition interval.*

Although there are, as yet, no sites of comparable antiquity on Romania, just to the south in Bulgaria a Lower Pleistocene hominin presence is recorded at Kozarnika cave in the northwestern part of the country (Sirakov et al., 2010). Thought to date to around 1.5 ma, the lower levels in Kozarnika contain a series of non-Acheulean core-and-flake industries associated with a large (69 taxa) and well-preserved Middle Villafranchian fauna comprised mainly of large mammals, many of them long extinct. Although not dated radiometrically, the mammal assemblage indicates that the lower levels fall between MNQ 17 and MNQ 19 (MIS 53-45), These layers produced several bones showing anthropic traces, arguably the oldest known in Europe (Sirakov et al. 2010). The earliest modern human remains in Romania (in fact, in Europe) are dated to about 37.8 ka at Peştera cu Oase, a cave near the Iron Gates in the southeastern part of the country (Soficaru et al., 2006; Trinkaus, 2007). Modern-era research in the Balkans is still in its earliest stages, however, and shows great promise for future work. The Middle and Early Upper Paleolithic of the Carpathian Basin is particularly rich and diverse when compared with other areas (e.g. the Levant) and constitutes a very important piece in the complex, and as yet incomplete, geographic puzzle of Late Pleistocene human adaptations in Continental Europe. Given its rich archaeological record and its topographical and environmental diversity, an accurate understating of this region's

Middle and Early Upper Paleolithic systems of lithic reduction, mobility and land-use is of crucial importance.

Figure 1. Geographical position of the sites discussed in text.



# CHAPTER 2
## Theoretical Background

### Introduction

The study of human ecological dynamics during the Late Pleistocene is critical for understanding the evolutionary fate of the Neanderthals, their interaction with Anatomically Modern Humans (AMH), the spread of the latter throughout Eurasia, and their apparently successful capacity to respond to the rapid and dramatic changes of OIS 5 (Clark, 2002, 2009; Shea, 2011).

To better understand these dynamics we not only need to understand similarities and differences we see in the archaeological record. We also need to try to determine whether those similarities and differences are rooted in the conventional systematics used to assign sites and industries to the Middle and Upper Paleolithic, or whether we are seeing a shift in human adaptation that may or may not correspond to those sites and industries.

Among the most important research questions are (1) to what extent did the cultural and biogeographical responses of Middle and Upper Paleolithic hominins to the changing environments of Late Pleistocene Europe vary across space and environmental context? (2) How was variation through time in techno-economic choices, landuse patterns and resource exploitation related to Middle and Upper Paleolithic industries across the Late Pleistocene? (3) What kinds of relationships are evident between variation in hominin ecological and cultural behaviors? Answering these questions will help us determine to what extent studying archaeological materials such as lithic assemblages will allow us also to comprehend human ecology and whether, because of co-variation of technological indices with environmental change, ecological behaviors can serve as an alternative more powerful explanation than that proposed by the typo-technological systematics.

Over the last two decades the sites in the Middle and Lower Danube have become more important in the modern human origins (MHO) debate and the 'Transition' from the Middle to the Upper Paleolithic. This is because they lie astride the Danube corridor, long regarded as one of the major routes between Europe and Asia (Conard and Bolus, 2003; Mellars, 2006). Large parts of eastern Europe have been the focus of long-term archaeological investigations that produced large chipped stone assemblages that can provide data for a diachronic analysis of Late Pleistocene hominin land-use strategies, settlement organizational flexibility and consequently lithic technological organization (Adams, 1998; Anghelinu and Niță, 2012; Anghelinu et al., 2012; Cârciumaru et al., 2010; Păunescu, 1993; Nejman, 2006; Tostevin, 2000). The assemblages from these sites span the time period from at least MIS 6 through about 30 ka (MIS 3), encompassing the Middle-Upper Paleolithic transition, within an east-west geographic distribution of radiometric dates for regional Early Upper Paleolithic (EUP) industries (Conard and Bolus, 2003; Nejman et al., 2011; Roebroeks and Gamble, 1999; Svoboda et al., 1996). There is considerable documentation for these sites and they have also benefited from modern field research and dating programs (both AMS and OSL) and have been reported in a variety of publications (Nejman, 2006; Nejman et al., 2011; Neruda and Nerudová, 2011; Richter et al., 2009; Tostevin and Skrdla, 2006). Nevertheless, the causes invoked to explain morphological similarities and differences between several of the ‘transitional’ industries in this region are not well understood (Brantingham et al., 2004).

What we know of Paleolithic archaeology in Europe has largely been built on the study of lithics, and central-eastern Europe is no exception. Interpretation of (usually retouched) stone artifacts has been based on a descriptive, typological, culture-history approach that does not explicitly incorporate many factors now known to give rise to assemblage variation. The initial objective of this approach was to classify lithic assemblages in time and space rather than identify the behavior that worked behind it and responsible for patterned change. The classification of retouched stone artifacts and their attribution to particular kinds of hominins has been the major focus of Paleolithic archaeologists since the later part of the 19th century. This is true even today in most of the central eastern European research tradition, heavily influenced and largely derived from French Paleolithic archaeology (Barton, 1991; Clark, 2005; Riel-Salvatore and Barton, 2007). This trait list oriented approach of culture history is wholly *inductive* and lacking an hypothesis testing component, making it a weak form of explanation, essentially in the archaeology of deep time (Clark, 2003).

However, many theoretical, conceptual, and empirical issues for the region’s prehistory that are of interest today can best be addressed by a science-oriented approach explicitly grounded in detailed regional and interregional studies of stone technology and subsistence strategies from multiple sites spanning the time period of interest (Clark, 1993). For example, during the last 25 years or so, new developments based mostly on the *chaîne opératoire* approach, have improved this situation by generating more objective models of raw material acquisition and distribution, by recognizing the specific technological features of different technological systems, and by focusing on technological organization as a whole (Tostevin, 2000; Mester and Moncel, 2006; Tostevin and Skrdla, 2006; Adams, 2007, 2009)(Anghelinu and Niță, 2012; Anghelinu et al., 2012; Nejman, 2008; Riel-Salvatore et al., 2008; Steguweit et al., 2009). In central-eastern Europe, this kind of research is still in its infancy, and has not, so far, been directed toward the Late Middle and early Upper Pleistocene. It also should be kept in mind that, so far as interpretation concerned, the *Chaîne opératoire* approach has sometimes been applied in ways as rigid, inflexible and atheoretical as the traditional Bordesian classification (see Bar-Yosef and Van Peer, 2009; Bleed, 2001; Boeda, 2005; Shott, 2003 for more details).

## Human behavioral ecology and Paleolithic archaeology

The logic of inference underlying the trait-oriented conventional systematics has recently been summarized by Hiscock (2007), who notes that the culture history approach is based on implicit theory that assumes that: (1) classification is revealing natural, real divisions inherent in the material. One implication of this proposition is that only one classificatory system is valid. (2) Descriptions geared toward comparisons between classes effectively prevent or at least discourage evaluation of variation within a class. This is partly achieved through (3) a focus on describing the central tendency (often the mode) of population distributions. (4) There is an overemphasis on retouched artifacts, only a portion of 5-10 % of an artifact assemblage. This focus is largely explained by (5) a near universal reference to intentional design criteria to account for the form and frequency of retouch. This principle reveals (6) preconception that examines artifact form only in terms of the presumed purposes for which it was created (Hiscock, 2007, p. 199).

In archaeology in general, and in Paleolithic archaeology in particular, typology is ‘essentially essentialist’ yet continues to play a major role in defining and explaining Paleolithic analytical units (Clark, 1993, 2002, 2005, 2009; Dunnell, 1992; Shea, 2011; Lyman et al., 1997; O’Brien and Lyman, 2002; Shea, 2014).

Conceptual problems with the traditional culture history approaches have been summarized by a number of workers. They include (1) the absence of an overarching conceptual framework specific to paleoanthropological inquiry that might allow us to choose amongst null and alternative hypotheses; (2) many of the European archaeological tradition still tend to implicitly view prehistory as history-like, with analytical units analogous to those of tribes, nations and peoples of history (Barton, 2013; Barton and Clark, 1997; Barton and Riel-Salvatore, 2014; Holdaway and Wandsnider, 2008; Kuhn, 2004a; Kuhn and Clark, 2015). Such a culture history conceptual framework might be viable if it were consistent with the major tenets of an evolutionary approach. But there has not been any effort to reconcile culture history and evolutionary ecology (or human behavioral ecology), and such consilience may not be possible at least in the archaeology of deep time (Clark, 2003). Conceptual frameworks better suited to Paleolithic archaeology have recently been outlined and compared by Bettinger et al (2009) (Bettinger et al., 2006; Powell et al., 2009; Richerson et al., 2009). All are grounded in modern human behavioral ecology, focus on adaptation, and in aggregate address questions and problems that are central to a genuinely interdisciplinary Paleolithic archaeology (e.g. demography, life history, reproductive ecology, resource transfer, division of labor, etc.) (See also Barton, 2008). In short a focus on the requirements of evolutionary ecology at both the theoretical and methodological levels shows promise to give rise to a more coherent framework for explaining different kinds of variation in the archaeological record (Clark, 1993, 1994).

Recent studies integrating the organization of lithic technology and human behavioral ecology (HBE) from a population perspective have shown that lithic technology is a good proxy with which to explore these aspects of human behavior (Bird and O'Connell, 2006; Nelson, 1991; Bradbury and Carr, 1999; Carr and Bradbury, 2011; Marwick, 2008a; Riel-Salvatore, 2007; Smith, 1992; Winterhalder and Smith, 1992, 2000; Surovell, 2009).

Such analytical and explanatory approaches that combine foraging theory and lithic technology have rarely been employed by central-eastern European archaeologists. When applied to the "transition" interval, however, they have revealed interesting and important results suggesting that major changes in technology and territoriality are correlated and occurred as a reaction to increased subsistence risk connected with a decline in the resource abundance and predictability (Moncel, 2001, 2003; Nejman, 2008; Nejman et al., 2013; Riel-Salvatore et al., 2008). It is therefore legitimate to expect that similar processes might have been active and of great importance during the entire course of the Late Pleistocene and even for earlier episodes of accelerated climate instability. This underscores the potential value of untangling the links between technology and the socio-ecologies of Pleistocene foragers using models drawn from human behavioral ecology (Brantingham and Perreault, 2010; Burger et al., 2005; Hamilton et al., 2007; Smith and Winterhalder, 1992; Surovell, 2009; Winterhalder and Smith, 1992, 2000).

Recent advances in theoretical and methodological approaches to lithic studies have led to new perspectives on past human behavioral systems. These emphasize technology as an integral aspect of cultural variability, adaptation, and change; the symbolic role of stone in communicating social, political, and ideological relationships; the social and evolutionary mechanisms that give rise and transmit to technological innovation; and the behavioral and physical factors affecting variability in both individual artifacts and whole assemblages (Bleed, 1997; Bamforth and Bleed, 1997; Kuhn, 1995; Shott, 2003). To a large extent, these new approaches can be lumped under the rubric of evolutionary archaeology (EA). They see change as the product of a complex interplay of exogenous and endogenous Darwinian forces that include natural selection, various transmission mechanisms, and adaptive problem solving in relation to proximate goals (Powell et al., 2009; Richerson et al., 2009).

Integrating ideas about technology generated within cultural evolutionary theory involves framing adaptive strategies in terms of human behavioral ecology, identifying and evaluating the selective advantages offered by technological performance characteristics through examination of trait frequencies over time. Optimality models, widely used in human behavioral ecology, provide a valuable tool for explaining why certain technologies offered fitness advantages and hence why they proliferated at the expense of others (Brantingham and Perreault, 2010; Clarkson, 2007; Grove, 2010; Kuhn, 2004b; Perreault and Brantingham, 2011). This approach to technological variability assumes that natural selection, operating within culturally mediated social learning, optimizes technical systems to cope with physical, environmental and social constraints over time for the benefits they bestow on individual and group fitness. Mean returns for effort expended thus becomes an important concept in evolutionary formulations of technological change, and some archaeologists have begun to explore the role of ‘risk’, the probability or cost of failing to reach a specific objective, as an important selective force acting on technological variation (Bamforth and Bleed, 1997). Others have investigated energetic efficiency and technological investment in tool design and the reduction of handling costs as important strategies likely to have come under selection in various situations in the past (Ugan et al., 2003). Additional behavioral and contextual factors that have been studied in relation to lithic technology within this evolutionary framework include variation in residential mobility, prey density and prey quality, as well as risk and uncertainty in resource availability and scheduling (Bleed, 2008; Kelly, 1988; Kuhn, 1995; Nelson, 1991; Riel-Salvatore and Barton, 2004; Stiner, 2002). Strategies for manufacturing and implementing technical systems to emphasize performance characteristics have been labeled ‘provisioning systems’ by Kuhn (1995). Characterizing distinctive provisioning systems and identifying their various signals in the archaeological record holds the promise of enabling archaeologists to not only investigate changing stone artifact manufacturing patterns across space and time but also to explore changing land use and mobility, intensity of occupation and changing levels of familiarity with the landscape and its resources, each of which will have consequences for social and ideological constructions of landscape and world views (Chippindale et al., 2000).

The view of lithic technology that has emerged from this body of research defines it as a flexible variable, and responsive aspect of culture. This view has reshaped and expanded concepts of earlier decades that were primarily focused on simpler stylistic and functional explanations of assemblage diversity. It offers new opportunities for archaeologists to incorporate information derived from stone artifacts into theoretically informed interpretations of the past and explore the nature of long-term cultural change.

## Connecting lithic assemblages and models

A number of optimal foraging models consider risk as an important factor contributing to variation in prehistoric technology, including lithic assemblages. From an archaeological perspective, it is thus important to determine how risk minimizing strategies can be identified in the discarded lithic assemblages found in deposits at sites. There has already been considerable work done on identifying risk minimizing strategies in stone artifact technology. This work is based on the assumption that the palimpsest nature of most assemblages in archaeological deposits does not obscure the signal of short time scale activities repeated over long time periods (as long as these formation processes are reasonably constant). One well known example is Bleed's (1986) categorization of tools as 'maintainable' (readily repairable) and 'reliable' (unlikely to break while in use). Maintainable tools are described as relatively simple, generalized, light and portable, being suitable for quick and easy repair during use. Reliable tools are more complex and specialized, with redundant design elements to minimize unscheduled repair time and requiring more effort and time to produce and repair (and thus more costly when they fail). Assemblages that are relatively abundant in both reliable and maintainable tools reflect an investment to minimize a relatively high exposure to risk.

Bleed's approach has proven productive in a variety of archaeological studies (Myers, 1989; Hiscock, 1994, 2005; Neeley and Barton, 1994; Bleed, 2001) but is limited by its dependence on visually distinctive and relatively complex tools as the objects of analysis and the reality that reliable and maintainable tools are not mutually exclusive. The conventional idea of a tool is a specimen that has at least one of the four attributes identified by Hiscock (2007) to hypothesize implement design (repeated shaped, regular form, morphological features in excess of performance requirements and extensive retouch). This becomes problematic, however, when assemblages almost entirely consist of unretouched flakes and cores, and lack retouched pieces as conventionally defined. Therefore discussions of toolkit complexity and diversity are not really suitable for assemblages constituted in the majority of unretouched stone artifacts (Torrence, 1989; Marwick, 2008a). This is not to say that unretouched flakes were not used - (they probably were – and frequently (Young and Bamforth, 1990) - only that utilized pieces cannot be unambiguously distinguished from tool-making debris. Similarly, the stone component that remains in archaeological sites may often represent only part of the whole implement, so analysis of tool design is limited to one small, often simple and cheap component. While Bleed (1986) and Torrence (1989) have proposed special cases of a theory for connecting risk to stone artifacts, there is also a need for general theory that connects risk to the largest part of stone artifact assemblages in most archaeological sites – the unretouched flakes and cores (see also Braun, 2005; Douglas et al., 2008; Lin et al., 2013; Mackay, 2005; Surovell, 2009; Ugan et al., 2003).

One way to derive such theory is to make an appeal to the patch choice model of human behavioral ecology. The patch choice model simply states that a forager will remain in a patch on the landscape, until ‘energy returns from the patch fall below the mean of all patches’, whereupon forager will move on to a more productive patch with a lower cost to benefit ratio (MacArthur and Pianka, 1966; Charnov, 1976; Marwick, 2013; Smith, 1983). To the extent that a higher density of archaeological materials is indicative of longer or recurrent hunter-gatherer occupations, more sites and/or larger sites with higher artifact densities could indicate higher value resource patches. Of course, it is necessary to ensure that technological differences alone are not responsible for higher artifact densities by analyzing artifact technologies and by examining discard rates of other cultural materials.

Other useful behavioral ecological models for lithic assemblage variation are those that express relationships between the extent that a resource is used and the time spent obtaining and transporting that resource in central place foraging (Bettinger et al., 1997; Orians and Pearson, 1979; Bird and O'Connell, 2006; Metcalfe and Barlow, 1992). These relationships can be evaluated by measuring the relative degrees of pre-processing of lithic raw material prior to entering the site. The methodological challenge here is distinguishing pre-processing from on-site processing. This can be done by analyzing core and flake ratios and metrics in assemblages recovered from archaeological sites and identifying pieces that appear to be missing from the assemblage. For example, if cores are present in the assemblage but certain size classes of flakes appear to be absent then it is possible that those flakes were detached from the core off-site during a pre-processing event. More complicated is testing the predictions of optimal dispersion models, which describes the circumstances under which people will adopt logistical or residential foraging patterns (Horn, 1968; Smith, 1983). For the lithic technology, is important to understand how foragers solved the problems of maintaining an adequate supply of stone artifacts at different points across a spectrum of high to low residential mobility. Numerous studies have shown that core reduction and flake production will be more frequent at logistic sites, whereas blank selection and retouch frequency will be more intensive at residential sites (Binford, 1980; Marks and Freidel, 1977; Marwick, 2008a; Parry and Kelly, 1987; Surovell, 2009; Wallace and Shea, 2006). Hence, core reduction and retouch frequency / intensity can be used as proxies to connect technological organization to land-use strategies and mobility, and to differentiate between logistical to residential patterns.

Related to this, a productive approach to making the connection between lithic assemblages and residential mobility are the two ‘provisioning strategies’ described by Kuhn (1992, 1995; see also Kuhn and Clark, 2015). Individual provisioning describes a strategy of keeping individual foragers supplied with the artifacts and raw materials they need as they move through the landscape. Place provisioning refers to strategies that involve accumulating artifacts and raw materials at particular places in the landscape where activities are likely to be carried out. Similar to Bleed’s scheme, Kuhn’s system has been most commonly employed in the analysis of tools rather than unretouched pieces. However, several studies have successfully shown that Kuhn’s system can be adapted for assemblages yielding both retouched pieces and unretouched flakes and cores (Clarkson, 2007, 2008; Mackay, 2005, 2009; Holdaway, 2004; Shiner et al., 2005).

### ***Individual Provisioning***

A key limiting factor in provisioning mobile individuals with lithic technology is transport cost, so artifacts should be designed to supply a satisfactory amount of potential utility given these transport costs (Kuhn, 2004b, p. 432). The method for obtaining the utility to transport cost ratio varies across different lithic technologies and is contingent on other factors such as raw material quality, and package size etc. (Goodyear, 1989; Morrow, 1995; Kuhn, 1994; Nelson, 1991; Roth and Dibble, 1998; Shott, 1986). A general trend is for mobile individuals to provision themselves with artifacts that have undergone some processing and are ready for use rather than less- or un-processed raw material nodules, which would involve carrying mass that is not contributing to the artifact's function. When foragers have to travel further to obtain resources, the field processing models for central place foraging predicts that pre-processing of resources should increase to optimize the delivery of sufficient quantities of useful material given travel and transport costs. In the case of lithic assemblages, the correlate of increased travel and transport costs is increased individual provisioning (Barton and Riel-Salvatore, 2014; Kuhn, 1994; Marwick, 2008a, 2013).

In particular, the expected characteristics of an assemblage resulting from individual provisioning are pieces that initially have greater potential for extended use through rejuvenation (i.e. retouch) and, more importantly, pieces in archaeological assemblages (i.e., discarded) that display the morphological results of this extended use through greater amounts of more intensive retouch. Such rejuvenation inherently reduces the sizes of lithic artifacts. Reduction potential refers to the degree that an artifact can be modified and repaired to prolong its useful life prior to discard, making a given quantity of raw material do more work (Shott, 1989; Macgregor, 2005). Identifying reduction potential of tools is difficult and problematic, but several effective methods have been developed for retouched artifacts, and provided they take into account contextual factors, and can be ranked relative to one another, can be quite successful (Clarkson, 2002; Eren et al., 2005; Kuhn, 1990; Marwick, 2008b). For assemblages with no retouched pieces a different approach is required. Hiscock (2006) has suggested that instead of looking for reduction potential, assemblages can be examined to identify technological decisions that reduced the rate at which artifacts need to be supplied, thus reducing procurement and transport costs. Hiscock (2006, p. 81) calls these decisions to reduce procurement and transport costs an ‘extension strategy’ and notes that it is characterized by fewer and smaller artifacts that have attributes suitable for extended flaking, use and resharpening. Examples of these attributes include higher quality raw materials (Goodyear 1989) and cores with multiple platforms (Macgregor 2005). When employing this strategy foragers are investing relatively more energy in a smaller number of artifacts for a higher use return over an extended period. Perhaps the most useful link provided by the concept of individual provisioning is between lithic assemblages and optimal dispersion models. The paradigmatic mobile individual is one who makes lengthy logistical foraging trips from a base camp, but foragers as a group are all mobile individuals when the residential unit is a small, frequently relocating camp. Thus a ‘signal’ of individual foraging in an assemblage can reflect high logistical mobility during conditions of mobile and clumped resources or high residential mobility in stable/evenly dispersed environments, when foraging activities are out of phase with raw material provisioning opportunities. Local factors like raw material and availability and the nature of particular target resources are the key to disentangling the two possibilities. For example if a residentially mobile group is foraging in an area of relative raw material abundance then the signal of individual provisioning in the assemblage should be weak.

### *Place Provisioning*

Place provisioning occurs when transport costs do not strongly constrain technological choices. The relaxation of these constraints means that people can accumulate quantities of raw material at more permanently or more frequently occupied locations in anticipation of future use. These locations will tend to be provisioned with raw material in various states of manufacture including un-worked nodules and minimally shaped cores (Parry and Kelly, 1987). This strategy is optimal under three conditions: abundant raw material, low residential mobility or short range logistical movements.

The identification of place provisioning as opposed to individual provisioning provides a more robust link between optimal foraging models and the characteristics of lithic assemblages. In reality, of course, the two strategies are not polar opposites but will both be present in an assemblage or a sequence of assemblages to different degrees depending on particular habitat characteristics. Place provisioning strategies also can be examined from the perspective of patch choice model, which predicts that potential foraging locales will be exploited in order of the return rates expected from searching and handling resources within each, adjusted for the coast of traveling. The key here is that the optimal forager should leave any patch when it is depleted to the point where foraging elsewhere will yield higher returns, travel coasts considered. Archaeologically these predictions suggest that areas or periods of higher patch yields will have evidence of more intensive human occupation, such as place-provisioned logistical base camps, as people exploit a reliable and abundant resource (MacArthur and Pianka, 1966; Charnov, 1976; Clarkson, 2007; Marwick, 2013; Smith, 1983; Hawkes and O’Connell, 1992). Similarly, some characteristics of stone assemblages stockpiled in place provisioning strategies can be accounted for by the relationship that can exist between the extent that a resource is used and the time spent obtaining and transporting that resource in central place foraging models (Orians and Pearson, 1979). Following Beck and colleagues (Beck et al., 2002) one can predict that the further a piece of stone has been transported, the more work is extracted from that piece to justify the effort invested in transport.

Therefore the outcome of the investment in time and transport is the increased return of work done by the stone. As an example one may think of assemblages with pieces showing signs of extensive cortex removal and less than expected with cortex might represent in-field detachment of unwanted material to reduce weight and increase the artifact's utility prior to transport (Clarkson, 2006; Marwick, 2008a). Finally, the locations of logistical base camps with place provisioning can be evaluated from the perspective of the optimal dispersion model, which predicts optimum forager settlement patterns under different environmental conditions, assuming foragers are minimizing round-trip travel costs from resource to to settlement location. When the resources become more mobile and clumped, foragers are predicted to increasingly aggregate into larger groups: when resources are more stable and evenly distributed, foragers will increasingly disperse into smaller groups (Horn, 1968). Anthropological speaking the model predicts that foragers will increasingly adopt a residential settlement pattern in stable or evenly dispersed environments because small frequency relocating settlements will always be near resources (Cashdan, 1992; Smith, 1983). A logistical settlement pattern is preferred in clumped environments, with larger settlements from which groups of people venture out to collect resources at distant or constantly shifting patches (Binford, 1980; Harpending and Davis, 1977). Archaeologically speaking a logistical organization will show signs of higher investment in efficiency because the group cannot easily relocate and the availability of stone sources is less predictable. Determining the mix of factors influencing technological provisioning choices requires knowledge of the local habitat (Barton et al., 2013; Barton and Riel-Salvatore, 2014; Clarkson, 2007, 2008; Mackay, 2005; Marwick, 2008c, 2013; Riel-Salvatore and Barton, 2004).

These two provisioning strategies, when linked with the optimal foraging models described can be ultimately regarded as responses to varying degrees of exposure to risk. There are two specific kinds of risk that these provisioning strategies should be most effective in reducing. First is *subsistence risk*, or the risks associated with procuring food. It is to this type of risk that Torrence's work refers, and is likely to be relevant in the discussion of any technology of mobile human foragers. Elston and Raven (*apud* Clarkson 2007) describe this as contingency risk, which is the probability of not having enough tool stone to meet subsistence needs. This risk increases as tool stone supply diminishes compelling people to invest more effort in monitoring and managing stone consumption to avoid insufficiency. However, many of the flake and core assemblages are likely to have been used for tasks other than food procurement, such as processing wood for making shelters and repairing hafts, wooden, bone and antler tools.

A second type of risk, *technological risk*, may be more important for assemblages from sites that cannot be exclusively linked to food procurement. Technological risk refers to the risk of running out of usable tools or raw material and being unable to perform key activities. This kind of risk does not require knowledge of how the artifacts were used. Instead it depends on the assumption that making and maintaining stone artifacts incurs an opportunity cost by diverting time and effort from time sensitive activities like pursuing mobile resources or traveling between patches. Elston and Raven (1992: 33-34, *apud* Clarkson 2007) describe this as *venture risk*, which is the probability that the procurement and opportunity costs of seeking stone resources will exceed the benefits of any stone resources acquired.

This taxonomy of risk illustrates the sorts of risks that stone artifact technology can minimize through the choice of an individual or place provisioning strategy. Measuring the "degree" of risk can be realized, for example, through the analysis of the impact of climate variability on human populations. Burke and colleagues (Burke et al., 2014) studied the impact of climate variability with the help of downscaled high resolution numerical climate experiments. Human sensitivity to short time scale climate variability was tested through the spatial distribution of archaeological sites. Their results indicated that climate variability at sub-millennial scale was an important component of ecological risk, which played a major role in standardizing prehistoric human spatial behavior and affected their social networks. That being said, an individual's technological decisions are likely to be influenced by risk on a variety of scales and levels from personal momentary risk to population-level generational risk. Lithic production is not simply a technical act, but a process of supplying functional tools at the same time as solving problems related to risk, cost, and efficiency in systems of time budgeting, mobility and land-use (Barton et al., 2013); (Kelly, 1988, 1992; Kuhn, 1995). This means that a lithic assemblage will include a combination of individual and place provisioning strategies, and analysis of provisioning strategies will only reflect a response that is an average of several different responses conflated together during the formation of the archaeological deposits. Embedding technology in other systems can help us to understand the distribution of assemblages at different stages of reduction over space and time as a reflection of variation in planning, land-use and settlement and subsistence patterns of hunter-gatherers (Binford 1979; Kuhn 1995; Nelson 1991).

In the next section I present two examples to illustrate how HBE and the organization of technology can be used to test models of prehistoric social dynamics through landuse and mobility.

### Example 1: Human eco-dynamics in late Pleistocene Mediterranean Iberia

Barton and colleagues (2013) used a number of proxies to decipher late glacial eco-dynamics that were derived from a series of excavated, stratified archaeological sites spanning all of the Mediterranean Spain, and from a series of several surface assemblages located in the central part of the region (Barton et al. 2013, fig 1, table 1). The archaeological material recovered from the area included both lithics and faunal remains. In order to make this record meaningful, the authors calculated a set of quantitative indices from the raw lithic and faunal data, based in HBE principles and middle-range theory and designed to provide information about prehistoric ecological behavior at regional scales. These indices were calculated at the level of landuse strategies, specialization in hunting weapons, and general hunting strategies. The authors also analyzed some important information about site locations and survey collections. Climate, plant and animal communities vary both with altitude and latitude along the Mediterranean coastal façade, and were affected by sea level transgressions/regressions and by the distance from glacial terrain north of the Pyrenees (Barton et al., 2013; Villaverde et al., 1998).

This study differs from the more traditional approaches in that a set of theory based quantitative indices were devised to monitor several important dimensions of hunter-gatherer ecology: landuse strategies, hunting strategies, and technology. The results showed that the indices covaried according to the expectations based on ecological theory, providing statistical support for their reliability as proxies for ancient forager ecological strategies. This approach offers new opportunities to examine the relationships between ancient ecological behavior and environmental variation in space and time, while also offering a novel holistic perspective on the organization of Paleolithic hunter-gatherers societies, supported by robust quantitative data.

Spatial and temporal variation as shown by the proxies used for landuse, hunting strategies, and technological specialization, suggested that Upper Paleolithic settlement and subsistence systems were attached to base camps at inland locations varying from 50 to 100 km from the Pleistocene coastline, and elevations intermediate between the coast and central Meseta (Barton et al. 2013, figs. 6-11). The phases of occupation and reoccupation at those sites took place for sufficient duration to produce both lithic and faunal assemblages that encouraged place provisioning. In terms of hunting this is reflected at base camps by faunal assemblages dominated by local, small game (e.g. rabbits, hare, etc.), and that larger game was processed in the field at distant butchering sites, most of bones being left behind. Overexploitation of leporids might also account for the large number of rabbit bones in the basecamps and could even signal the depletion of large game in the immediate vicinity of those sites. As acknowledged by the authors this is an aspect that is yet difficult to disentangle on the basis of the available evidence.

The scenario that arises from this approach is that the large area between the coast and the Meseta, where the base camps were located, was used by small groups of foragers who hunted and butchered those animals and maintained their specialized hunting weapons in short terms sites. This scenario can be tested if new Upper Paleolithic sites are discovered between the coast and the highlands that are characterized by relatively high values of retouch, a high herbivore index, and an index of technological specialization as described above (Barton et al. 2013).

The most important conclusion generated by this kind of analysis is that a resilient pattern in landscape and resource use was maintained throughout Mediterranean Iberia until the end of the Pleistocene, and more that it extends in time across the traditional classifications of Upper Paleolithic industries. Change over time here is mostly apparent in the increasing importance of specialized hunting weapons, that could have been the driver for the changes in archaeological materials that we normally think of as 'Aurignacian', 'Gravettian', etc. It remains to be demonstrated whether this vectored change, which does not seem to covary with climate-driven environmental change, may be responsive to anthropogenic eco-dynamics.

### Example 2: Human behavior and biogeography in the Southern Carpathians during the Late Pleistocene

A series of caves and rockshelters in the Romanian Southern Carpathians have a long history of human use. They were the focus of very early archaeological investigations, mostly for antiquarian reasons, beginning in the latter half of the 18th Century and aimed at recovering prehistoric artifacts and faunal remains (Jungbert, 1978, 1979, 1982; Păunescu, 1987, 2001). More recent, systematic research in these caves was carried out mostly in the 1960s and 1970s when caves Curată at Nandru, Bordu Mare at Ohaba Ponor, Muierii at Baia de Fier, Cioclovina, Cioarei at Boroșteni, etc., have been excavated by various teams of archaeologists and biological anthropologists (Nicolăescu-Plopșor, 1957, 1956; Mogoșanu, 1978; Păunescu, 2000, 2001).

The lithic assemblages recovered from nearly two centuries of excavations have been published in varying degrees of detail, and classified following French Paleolithic systematics (Cârciumaru, 1999; Dobrescu, 2008; Mogoșanu, 1978; Moncel et al., 2002; Păunescu, 2001). This work was largely culture-historical in nature and sought to assign these assemblages to different technocomplexes and/or facies of the Middle and Upper Paleolithic. With a few exceptions, aimed at describing certain aspects of the operational sequences of the most important cave and open air sites in the region and based mostly on the *chaîne opératoire* approach, not much else has been published on the human biogeography of the area (Dobrescu, 2008; Moncel et al., 2002; Popescu et al., 2007; Riel-Salvatore et al., 2008).

To examine spatial and temporal dimensions of prehistoric human ecological behavior, Popescu and colleagues (2007; see also Riel-Salvatore et al., 2008) undertook a diachronic study of Late Pleistocene landuse patterns based on a series of 44 assemblages from 14 Middle and Upper Paleolithic sites extending across this region of central Romania (Popescu et al., 2007, fig. 1, table 1; Riel-Salvatore et al., 2008). This work employed a methodology (i.e. Whole Assemblage Behavioral Indicator [WABI]) that can be applied to collections from previously excavated sites and classified according to traditional typotechnological systematics, but irrespective of any typological label assigned to assemblages. In several other publications this methodology has been successfully deployed to analyze Middle, 'transitional' and Upper Paleolithic assemblages from the Mediterranean coasts of Europe, and elsewhere (Barton et al., 2013; Clark, 2015; Kuhn and Clark, 2015; Riel-Salvatore and Barton, 2004; Sandgathe, 2005). The approach offers a means to compare landuse strategies, and thus gain a better insight into ecological behaviors more generally, across the typologically defined transition between the Middle to Upper Paleolithic.

This method combines the information relative to the retouch frequency in an assemblage and the density of total lithics in the deposit from which they are derived. It is based on middle range theory and human behavioral ecology and integrates the organization of lithic technology with the relationship between the frequency of retouch and artifact curation. It postulates a strong negative correlation between the discarded retouched pieces in an assemblage and the volumetric density of all lithics in that assemblage. In a given depositional environment, assemblages with low lithic volumetric densities are predicted to show relatively higher frequencies of retouched pieces compared to high-density assemblages where the frequency of retouch is expected to be comparatively low. Artifact accumulations pattern are captured by these predictions along a continuum between ‘mostly curated’ to ‘mostly expedient’ assemblages. The terms *expedient* and *curated* refer rather to time-averaged suites of strategies resulting from a palimpsest of occupations, the predominant character of which will dominate the signature of a given archaeological assemblage (Barton and Riel-Salvatore, 2014; Clark, 2015; Kuhn, 1995; Kuhn and Clark, 2015).

The results obtained from this study confirmed the expectations from the model based on WABI (Riel-Salvatore et al., 2008). Although the results were strong and significant at the regional level, they were even stronger when separated on geographical, contextual (caves vs. open sites) and environmental grounds.

A particularly significant finding was the high degree of overlap in the range of technological organization strategies and associated landuse patterns displayed by Middle and Upper Paleolithic assemblages evidenced by a continuum of provisioning strategies from individual to place provisioning (Popescu et al., 2007, pp. 2–6; Riel-Salvatore et al., 2008, fig. 2–6). The variation that was evident in the range of landuse strategies employed by the hominin groups responsible for manufacturing and accumulating the assemblages analyzed in the study was not related to the typotechnological classification of assemblages into Middle and Upper Paleolithic, Transition included, in the Southern Carpathians throughout the Late Pleistocene,.

The most important aspect of the work was that it reinforced the role played by environmental conditions in structuring both local site occupation and broader landuse strategies. It showed clearly that besides varying geographically, environmental parameters varied temporally with global climatic change during the Late Pleistocene. Based on the micro mammal assemblages available for some of the sites, the occupational layers can be separated into “cold/continental” and “temperate” groups to allow us to assess the potential influence of climatic conditions on landuse strategies. Retouch frequencies was used as a proxy measure for provisioning and mobility: low frequencies indicating place provisioning and a prevalently logistical landuse strategy, and high frequencies indicating individual provisioning and a dominance of residential mobility (Riel-Salvatore and Barton, 2004, 2007). Comparison of climate indicators and retouch frequency across assemblages showed that landuse strategies clearly vary under different climatic conditions, with temperate conditions associated mainly with place provisioning and lower residential mobility, and colder conditions displaying both evidence of more individual provisioning and higher mobility as well as greater variance in both (Riel-Salvatore et al., 2008, pp. 15–16, fig. 9). In other words these results indicated that in continental Eastern Europe as in the western Mediterranean, large-scale climatic fluctuations and human ecological responses in landuse strategies better account for variation in lithic assemblages than more traditional typotechnological classifications.

## Discussion

As with any other works that try to synthesize the theoretical thinking behind a domain of research, this is only a short review of the state of the art of current Paleolithic research, addressed mainly in the central eastern part of the European continent. Although the record for Early Upper Pleistocene discovered in central-eastern Europe is not as well studied as that from Western Europe or the Near East, it has the potential to offer important insights about prehistoric life ways, as well as, maybe more importantly, the potential for continuing and opening new avenues of research dedicated to the human evolution during Paleolithic.

The more intensive research that has taken place in the post Iron-Curtain era brought about an increased interest in central-eastern Europe with respect to several central issues of the Paleolithic research overall. They include the meaning of variability in the archaeological record, the analytical usefulness of different discrete “cultural” entities, their defining grounds and significance, and the overarching ideas that can be inferred relative to human socio-ecodynamics (Adams, 1998; Anghelinu, 2006; Anghelinu and Niță, 2012; Dobrescu, 2008; Nejman, 2008; Neruda and Nerudová, 2011; Nigst, 2012; Popescu, 2009; Riel-Salvatore et al., 2008; Tostevin, 2007).

The two examples presented here analyze large, albeit imperfect data sets, quite differently than much Paleolithic research and resulted in new insights into regional scale socio-ecodynamics. They also underscore the fact that provided the right questions are asked and the appropriate methodology is applied, there is still much information to be gleaned from older collections and used to compare with new ones to obtain an integrated body of knowledge relative to prehistoric human behavior.

## Conclusion

Along with other workers who have used different methodological and theoretical approaches (Bettinger, 2009; Bettinger et al., 2006; Brantingham, 2006; Brantingham and Kuhn, 2001; Kuhn, 1995, 2004a; Stiner and Kuhn, 1992; Surovell, 2009), this review also shows how principles derived from human behavioral ecology can be used together with technological organization to provide better answers to the very important questions related to human behavior during the Pleistocene, its dynamics, and how diachronic comparisons can be made within and between sites and regions, employing a powerful and unique integrated methodology. This approach crosscuts the archaeological assignments based on traditional prehistorians' defined Paleolithic systematics.

Although new data systematically recovered with modern techniques are very important, it is equally important that theory driven, quantitative analyses of existing collections already stored in museums and universities be carried out. Unearthing new collections of stones, bones, and ceramics cannot by themselves resolve the important issues with which prehistoric archaeologists must contend, unless they are theory driven and methodologically appropriate. Put another way, 'data' in and of themselves cannot be understood independent of the conceptual frameworks that define and contextualize them (Clark, 1993, 1999, 2003).

That said, just as any scenario derived from theory based analyses of archaeological data must be tested with new data, the models presented above, must also be tested against new data sets, because an empirically derived model, cannot be tested with data upon which it is based. One can hope for the future that more projects will develop along these lines and that new study of both older and new collections will shed even more light on the understanding of long term variation of human behavior in ‘deep time’.

# CHAPTER 3

## Methodology

### Introduction

The study of human ecological dynamics during the Late Pleistocene is critical for understanding the interaction between Neanderthals and morphologically modern humans (MMH), the spread of the latter throughout Eurasia, and their apparently successful capacity to respond to the rapid and dramatic changes of Late Pleistocene environments (Bolus and Conard, 2001; Conard and Bolus, 2003; Clark, 2002, 2009; Shea, 2011; Smith et al., 2005). Studies integrating the organization of lithic technology and human behavioral ecology (HBE) have shown that lithic technology is a good proxy with which to explore these aspects of human behavior (Bradbury and Carr, 1999; Carr and Bradbury, 2011; Kuhn, 1995; Lyman and O'Brien, 2000; Nelson, 1991; Stiner and Kuhn, 2006; Surovell, 2009; Winterhalder, 1981, 2002; Winterhalder and Smith, 1981, 2000).

The research reported here presents a study of formation processes and ecological behavioral based analyses of Middle (MP) and Upper Paleolithic (UP) lithic assemblages from the site of Ripiceni-Izvor in northeast Romania (Păunescu, 1993). This work has implications for several important issues in Paleolithic archaeology. First, it is important to better understand the discard behavior of the hominins responsible for the production and accumulation of Paleolithic artifacts at the site. Second, Ripiceni-Izvor offers the opportunity to examine the technological behavior that created these assemblages by focusing on different rates of deposition rather than only on relative frequencies of types. This allows me to explore relationships between technological organization and landuse.

To achieve these goals we need to understand whether the differences in these industries are rooted partly or mostly in their assignment to the Middle and Upper Paleolithic, or whether we are seeing a shift in their adaptive circumstances partly or mostly unrelated to these assignments. Doing this should allow us to determine to what extent studying lithic assemblages will help us understand human ecology and whether, because of covariation of technological indices with environmental change, the former can serve as an alternative and more powerful explanation of past human ecology than more normative technotypological systematics currently used in Romania. The kind of the collections and the long archaeological sequence at R-I are well-suited to a diachronic study of assemblage formation processes, technological organization and landuse practices throughout the Middle and Upper Paleolithic, and over the transition between them. The results contribute to ongoing efforts to integrate an HBE perspective with other Paleolithic research in central-eastern Europe and to put it into the broader conceptual framework of paleoanthropology (Tostevin, 2000; Nejman, 2008; Richter et al., 2009; Nejman et al., 2011; Neruda and Nerudová, 2011; Anghelinu and Niță, 2012; Clark, 2002, 2009; Shea, 2011). As pointed out in several recent papers, lithic analysis is often divorced from the powerful HBE conceptual framework; in order to improve its logic of inference, it should be reintegrated into this broader evolutionary perspective (Clark, 2009; Barton et al., 2011; Shea, 2011, Barton and Riel-Salvatore, 2014). This chapter is a small step in an attempt to do this, to improve our understanding of the nature and degree of behavioral differences between the Neanderthals and MMH and to help us better understand the *how* and *why* of the spread of MMH throughout Eurasia.

## Assemblage Formation and Variability

### Introduction

The choice of methodology is indissolubly linked to the question of what aspects of prehistoric behavior one wishes to understand and over what period of time. From all the multifaceted aspects of Paleolithic research, studies on landuse strategies and mobility have generally remained secondary, to classification and chronology largely due to a lack of appropriate methods to directly compare sites across space and time. Although ethnographic models have become standard operating procedure among archaeologists interested in more recent time frames, applying this approach to the Paleolithic tends to lead to interpretations of stone artifact assemblages as the material consequences of the past activities of socially-conscious groups (Deetz, 1967; Mace, 2005; see discussion in Kuhn, 2004; Shott, 2010). However reasonable this may be in the very recent past, it should be kept in mind that ethnographic analogy offers only a 'snapshot' of human behavior and is, arguably, inappropriate to the study of human adaptation in 'deep time' where archaeological assemblages often are the accumulations of decades to centuries (Clark and Riel-Salvatore, 2006; Clark, 2009; Holdaway and Douglass, 2011; Shott, 2010). Moreover, sites are not just simple products of activities and social identities, but also of cultural and natural formation processes. Most often, Paleolithic sites are palimpsests – compositional aggregates accumulated over very long time spans –

composed of the material remains of complex combinations of past behavior (artifact manufacture, reworking, loss and discard) and geological processes (deposition, erosion, soil formation, etc.). Hence, the size and composition of assemblages are correlated variables, not fixed properties, and composition varies as sample size increases (Marks and Freidel, 1977, Barton and Clark, 1993, Grayson and Cole, 1998; Shott, 1998, 2010; Kuhn, 2004, Barton and Riel-Salvatore, 2014).

Over the Holocene, lithic technology has essentially become extinct, a fact that makes it difficult to observe directly and evaluate the ways in which lithic assemblages were accumulated by the societies who made and used them (Rosen, 1997). Although efforts have been made to study formation processes among the few human groups who still use stone technology, they remain ethnographic 'snapshots,' with insufficient time-span to identify the long-term accumulation processes that produced the archaeological record (Yellen, 1977, Hiscock, 2004, Holdaway and Douglass 2011, Barton and Riel-Salvatore, 2014). Promising results are given by the experimental approaches that try to overcome the problem of lacking ethnographic models. Nevertheless, although studies of the organization of lithic technology, operational sequences, and assemblage formation processes are increasingly common, the essentialist, culture history approaches are still deeply embedded in Paleolithic research (Ahler, 1989a, 1989b; Boeda, 1995; Bradbury and Carr, 2014; Braun et al., 2008; Brown et al., 2009; McPherron et al., 2014; Patterson and Sollberger, 1978; Schick, 1986; Toth, 1987).

Most comparisons of sites and especially archaeological deposits within sites assume a fairly direct, 'fine-grained' association between the material remains and the past behavior and identities of the people who made and used them. In order to understand inter-assemblage variation it is often assumed that the co-occurrence of artifacts within assemblages is primarily meaningful in terms of human behavior or identity. There is also a tendency to assume that the differences between assemblages are more significant that the variation within them (Kuhn, 2004; Barton and Riel-Salvatore, 2014).

However, this perspective is less appropriate for the study of Pleistocene assemblage composition than it is for ethnographic studies of lithic technology mentioned above. Workers like Kuhn, Clark, Barton, Holdaway, Shott, Riel-Salvatore and others would argue that the accumulation of lithic assemblages at archaeological localities is more likely tied to general contextual or situational factors with which all Stone Age foragers had to contend – factors that constrained choice among a range of options. Such factors include the distribution of tool stone in the landscape, raw material 'package size' and quality, manufacturing techniques, discard contexts and rates, anticipated tasks, group size and composition (which change seasonally, annually, generationally, over the evolutionary long-term), structural pose of the site occupants in an annual round and duration of site occupation, especially as these constrained by forager mobility (Clark, 2002; Clark and Riel-Salvatore, 2006; Andrefsky, 2009; McCall, 2012; Barton and Riel-Salvatore 2014). In the study reported here, I examine the relationships between some of these factors and the Paleolithic lithic assemblages from Ripiceni-Izvor.

## *Materials and Methods*

### *Site Setting*

Ripiceni-Izvor is located on the right bank of the river Prut in the region of the Middle Prut Valley (Figure 3.1). It lies atop the lower terrace of the river about 1.2 km north of the village of Ripiceni. Its significance for Quaternary human and natural ecology was first highlighted by geologists who, at the beginning of the 20th century, reported the presence of fossil fauna and, stone tools. The first test excavations were carried out in 1929 and 1930 by N. N.Moroșan who reported the existence of MP and UP artifact assemblages (Moroșan, 1938). Subsequently, A. Păunescu conducted major excavations there between 1961 and 1981. During that time, three areas (Sections I-III) were excavated totaling approximately 4000 $m^2$ (Păunescu, 1993: 1-25, Fig. 1-2; see also Noiret 2009, Figs. 93-94). In 1982 the site was covered by the reservoir created for the hydroelectric power plant at Stânca-Ripiceni (Păunescu, 1993). Of the 16 layers defined during Paunescu's excavations, the lowest yielded a few lithics in reworked sediments and was assigned to the Lower Paleolithic. Six levels were assigned to the Middle Paleolithic (MP I-VI bottom to top), and eight to the Upper Paleolithic "Aurignacian" (Ia, Ib, IIa, IIb) and "Gravettian" (Ia, Ib, IIa, IIb) (Păunescu, 1993, Fig. 3-4).

Given the many contradictory discussions over the meaning of the Aurignacian (Straus, 2003, 2005; Clark and Riel-Salvatore, 2009) and whether or not it is present at Ripiceni-Izvor based on comparisons with other sites in the Carpathian Basin and east of the Carpathinas it is perhaps better to consider those layers as pertaining to an undifferentiated Early Upper Paleolithic (EUP) as is the practice in neighboring areas (Noiret, 2004; Anghelinu and Niță, 2012). I use the term “Gravettian” to refer to the four upper layers but only as a *descriptor* for what appears to be Last Glacial Maximum (LGM) occupation at the site, to which the EUP IV might also belong, based on its characteristics (SI-II). Above the Pleistocene deposits, there was also a Mesolithic level assigned to the Tardenoisian (Păunescu, 1993, figs. 3-4).

The research reported here focuses on the six Middle and eight Upper Paleolithic layers. Within the Middle Paleolithic sequence, the oldest three layers (MP I-III) were assigned typologically to a Typical Mousterian of Levallois facies, the following two (MP IV-V) to the Mousterian of Acheulean Tradition (MTA), and the uppermost layer (MP VI) to the Denticulate Mousterian (Păunescu, 1989, 1993; see (Culley et al., 2013 for a discussion of the nature of Bordes’ facies). Because of the relatively high percentage of Micoquian bifaces and ‘prodniks’ (bifacially retouched backed knives), the MP IV and V appear to belong typologically to the Micoquian rather than the MTA, as was the case for the MP layer at Mitoc-Valea Izvorului (Bocquet-Appel and Tuffreau, 2009). Those two layers were also the richest of the sequence totaling more than 50,000 lithics accounting for 92 % of the entire Middle Paleolithic sequence and about a half of the total of the entire Middle and Upper Paleolithic sequence combined. Numerous combustion features and traces of fire are reported, as well as what appear to have been some sort of dwelling structures interpreted as wind breaks (Păunescu, 1993: 31-171). More detailed information on techno-typological characteristics of the site can be found in Păunescu (1989, 1993; Noiret 2004, 2009).

Along with the lithics several thousand faunal remains were recovered (Appendix A, table 2). However, except for species lists and estimates of relative frequency they remain unanalyzed (Păunescu, 1993). Although most of the MP occupations (except M VI) have provided fairly large faunal collections, along with combustion structures ('hearths') and possible shelters made from bones and mammoth tusks, most of the fauna and features are found in the uppermost MP occupations. Given the nature of the assemblages and features, it is likely that repeated occupations created the kind of record that we see here.

The faunal sequence is dominated by large herbivores, principally mammoth *(Mammuthus primigenius)* followed by bison *(Bison priscus),* Irish elk *(Megaloceros* sp.), reindeer *(Rangifer tarandus),* and red deer *(Cervus elaphus).* Various species of land snails *(Helix spp.)* were also recovered from most of the levels (Păunescu 1993). Fauna from the Upper Paleolithic layers are scarce and poorly preserved except for a few remains from the "Gravettian" IIb.

Păunescu (1965, 1993) concluded that the large bone assemblages found at Ripiceni-Izvor were the direct result of intentional hunting and has never considered other possibilities for their accumulation. The possibility that such a dominance of large herbivores might have been created by excavation techniques biased against the recovery of small animal bones cannot be ruled out without further investigation. It is therefore very difficult to assess accurately the nature of Middle and Upper Paleolithic subsistence strategies at Ripiceni-Izvor with such sparse data. As stated above, except for species lists, there is little information that would provide some insights in respect to subsistence at Ripiceni-Izvor.

Although not particularly straightforward, sedimentological, pedologic, macrofaunal (no micro-mammals were recovered) and palynological lines of evidence converge to create a tentative image of the environment and climate and its relationship to assemblage accumulation at the site (Păunescu et al., 1976; Cârciumaru, 1989). The earliest MP occupations (I-III) took place during more favorable, temperate climatic conditions (Cârciumaru 1976, 1989; Conea, 1976, Codarcea, 1976, Grossu, 1976) followed by harsher continental/cold and dry conditions toward the end of these early occupations as suggested by reindeer *(Rangifer tarandus),* woolly rhino *(Coelodonta antiquitatis),* and wooly mammoth *(Mammuthus* spp.) The second part of the MP sequence (M IV-V) matches this kind of tundra-steppe environment. The UP occupations followed after a hiatus of unknown duration and apparently began with a second episode of more favorable climate, whereas the rest of the UP sequence took place under a second interval characterized by cold and dry conditions. The geo-stratigraphic and technological characteristics of R-I are similar to those of neighboring sites, suggesting that the later UP ('Gravettian IV') assemblages may belong or even post-date the LGM and pertained to the Tardiglacial (Păunescu et al., 1976; Cârciumaru, 1989, Chirica et al., 1996, Noiret, 2009).

The integration of the site within a regional context is hampered by the lack of precise radiometric dates for both the MP and UP levels. Most of the existing dates (especially for the MP) appear to be too young, in comparison with other nearby sites, possibly because they were originally dated using conventional radiocarbon assays of bulk charcoal (Păunescu 1988a, 1988b). As shown by Higham (2011, p. 245), because of the tendency of radiocarbon dates to cleave asymptotically to the dating limit means that a large number of European 'late' MP and EUP results produced over the last 50 years are underestimates of their real age, that could sometime be severe. More accurate dating for the site would be desirable to better assess the context in which the MP evolved within and outside of the Carpathian basin, and whether or not it was contemporaneous with the earlier phases of the UP at other sites (Cârciumaru et al. 2007; Doboș and Trinkaus, 2012, Popescu et al., 2007).

In eastern Romania, the MP is best represented by Ripiceni-Izvor and Mitoc-Valea Izvorului along with some small open sites with only a few lithics (Păunescu, 1998, 1999). Early UP sites are more common with the oldest securely dated well before 30 ka $^{14}$C BP. The earliest layer at Dârțu in the BistrițaValley has a date of 35,775 ± 408 $^{14}$ C BP (Erl-12165) and the earliest UP level at Mitoc-Malu Galben has a determination of 32,720 ± 220 $^{14}$ C BP (GrA-1357) (Noiret, 2009; Steguweit et al. 2009; Anghelinu and Niță, 2012; Anghelinu et al., 2012). Only one conventional radiocarbon date, from the EUP Ib at Ripiceni-Izvor, is available and provided a disputed, relatively old age of 28,420 ± 400 $^{14}$ C BP (Bln-809) (Păunescu, 1984, 1993; Noiret, 2009).

A recent dating program has changed the chronological landmarks for the MP in the Prut valley region. This is the case for the site of Mitoc-Valea Izvorului in northeast Romania (~ 20 km south of Ripiceni-Izvor). The Micoquian level there was considered to be contemporaneous with the MP layers IV and V at Ripiceni-Izvor based on technotypological similarities and similar sedimentary contexts and thus estimated at ~ 43 ka $^{14}$C BP. However, an IRSL date for the Micoquian at

Mitoc-Valea Izvorului has yielded an age of 160,000 ± 17,000 cal BP (Tuffreau et al., 2009), which places the MP there in MIS 6. Given these conflicting determinations it is apparent that new dates are needed to establish the age of the MP levels at Ripiceni-Izvor. Unfortunately, this is impossible now because the site is no longer accessible. Seven conventional radiocarbon dates on bone (burnt or not), charcoal, and sediment samples fell within MIS 3 but most of them are infinite, indicate ages greater than 40,000 $^{14}$C BP and/or have large standard deviations (Doboș and Trinkaus, 2012: 8; Păunescu, 1993: 185-186). A new AMS date with ultrafiltration for layer IV yielded an age of > 45,000 BP. In aggregate, however, both the old and new dates indicate that the age of the Middle Paleolithic here is beyond the radiocarbon range and probably much earlier than the Upper Paleolithic in the region (Doboș and Trinkaus, 2012: 9; Păunescu 1993: 185-186). As suggested by Doboș and Trinkaus (2012) the dates should be taken only as an indication of *minimum* age but they are not consistent with an MIS 3 age for MP IV and V.

### ***Assemblage Formation Processes***

Although there are inherent problems with many of the collections from the old excavations, behavioral information can still be gleaned from them provided that the right questions are asked and appropriate methodologies are applied. Although the original publications treat the stratigraphic sequence at R-I as though it represented a series of discrete events, current thinking on site formation processes clearly shows that this is unwarranted. Again, the levels do not constitute 'snapshots' from the daily lives of the hominins who created them. That this is so is not, of course, an insurmountable obstacle. Although occasional ‘little Paleolithic Pompeiis’ do exist, they are extremely rare (see Shott et al. [2011] for an example). The overwhelming majority of Pleistocene archaeological sites are time-averaged palimpsests – composites of many events and processes – unrelated to the activities of any single group of contemporary individuals (Schick, 1986, Barton and Clark, 1993, Goldberg et al., 1993, 2001; Holdaway and Wandsnider, 2008; Barton and Riel-Salvatore 2014).

Because of the way it was excavated, Ripiceni-Izvor offers us the opportunity to study variability both between and within assemblages. To achieve these ends I adopt a methodology that has proven useful in several recent contexts – that of *whole assemblage behavioral indicators* (WABI) for both landuse and assemblage formation. WABI is a flexible method that can be adapted to the analysis of both caves and open sites within extensive geographic areas (Barton 1998; Riel-Salvatore and Barton 2004, 2007; Barton et al., 2013; Popescu et al., 2007; Riel-Salvatore et al. 2008; Kuhn, 2004). To this I add a number of other analyses that expand on the general protocols of WABI methods.

In order to calculate the volumetric data for the purpose of this analysis, I used site documentation that is available for Ripiceni from the site monograph as well as from the earlier reports and papers (Păunescu, 1965, 1978, 1993). The volume was estimated based upon the information regarding the excavation area from which the artifacts were recovered and layers average thickness of each layer (i.e. Volume = Area * Layers Thickness). The volumetric densities for all lithics as well as for the various artifact categories used in this analysis, have been calculated by dividing the number of artifacts by the volume of sediment.

The analysis begins with observations about the relative rates of discard (volumetric densities of artifact categories) in the Middle and Upper Paleolithic sequence grounded in and anchored to observations of the actual archaeological sequence at Ripiceni-Izvor. If we accept that assemblages defined on the basis of sedimentological criteria or by natural or arbitrary levels are largely artificial subdivisions of time-transgressive accumulations of discarded artifacts, then variations in the rate at which different kinds and quantities of discarded artifacts accumulate are important elements for understanding how the accumulation formed. The proxy measures for the rates of accumulation are artifact densities scaled to unit volume (usually the number of artifacts per cubic meter). When sedimentation rates are fairly constant throughout a sequence, or when a site is excavated by arbitrary levels, studying the covariation in artifact densities may obviate problems imposed by changes in rates of sediment accumulation as these must have affected all artifact classes in the same manner. Essentially, this approach examines differential discard rates for various kinds of lithic artifacts on the surface of the site over time. As shown by Kuhn (2004) focusing on rates of deposition provides an image of the aggregated results of the many small-scale behavioral events that led directly to the accumulation of aggregates of artifacts that are generally known as assemblages. However, when sedimentation rates are not constant throughout the sequence, or when layers are excavated by natural stratigraphy, and not arbitrary levels, differences in discard rates may be mostly the result of differences in sediment deposition rates, thus allowing for a better understanding of both natural and cultural formation processes.

### ***Results***

Following Kuhn (2004) I begin with the examination of the overall artifact volumetric densities in the Paleolithic sequence at Ripiceni-Izvor. Figures 3.2 and 3.3 show volumetric densities for the major artifact classes of the MP and UP layers at the site. The first thing that is readily apparent is the overall low volumetric densities for most of the artifact classes, especially within the MP sequence, except for 'shatter/debris' and 'unretouched pieces' (for UP) when scaled to the impressive area and volume of sediment excavated (Appendix A, table 1). The low densities of *Unretouched* and *Debris* categories and their fluctuating values are particularly important in `the early Middle Paleolithic sequence (I- III) and may be typical of most open sites on terraces where higher sedimentation rates are more common than in caves and rockshelters. There is also the likelihood of greater artifact dispersion due to horizontal and vertical post-depositional displacement. Open sites are also less constrained spatially than those in caves. Another factor that might affect volumetric density is the extent to which sediments were screened. Although several types and sizes of sieves were used, some of the very small debris may have been lost. An alternative explanation is that, except for layers MP IV and V and some of the later UP layers, relatively shorter episodes of occupation occurred repeatedly at the site. The densities of major artifact classes, while not particularly high (especially for the EUP) seem to significantly change and fluctuate (mainly the *'unretouched'* and *'debris'* categories) between the EUP and LUP occupations.

The volumetric densities of the major retouched classes are shown in Figure 3.3. Although densities are overall low they fluctuate for most of the Middle and Upper Paleolithic sequences. The most obvious density fluctuations are for 'scrapers' and 'notches/denticulates', followed by 'bifaces' and 'UP types.' As they are present only toward the end of the UP sequence, 'backed artifacts' increase in frequency from the EUP IV through the GR IV. The most stable category and the one that most clearly separates the MP and UP, are the 'UP types.' But here too a clear cut difference can easily be seen that separates both MP and EUP altogether, from the later UP sequence. As I will show below, most of this variability within and between the MP and UP can be explained by variation in deposition rates that created quite important differences in sediment volume and, therefore, in artifact densities.

To evaluate whether and how different sediment deposition rates affected the densities of artifacts discarded at Ripiceni-Izvor, I used layer thickness as a proxy. Admittedly, layer thickness is only a rough approximation of sediment deposition rate, but it is the only one available here. Despite the crude nature of the measurement instrument, it proved to be very insightful for the purposes of this research. Figure 3.4 shows the relationship between layer thickness and major artifact categories, all lithics volumetric density included, and the way in which layer thickness, a proxy for the variation in sediment deposition rate, determines the overall density for the artifacts discarded at the site (see also Appendix A-II).

The reasoning behind this is as follows. If sediment deposition rates do not significantly affect artifact densities, there should be either no correlation whatsoever between layer thickness and artifact density or a positive correlation. If this were the case, the variation in artifact densities would be mostly related to various behavioral factors including (1) the frequency and duration of occupation at the site, (2) artifact discard rates, and (3) the intensity with which various tasks/activities were conducted. On the other hand, if variation in sedimentation rates is mostly responsible for low or fluctuating artifact density, there could be significant (non-random) negative relationships between artifact density and the proxy for sedimentation rate. That is the greater the thickness (proxy for deposition rate), the lower the artifact density.

It is obvious from Figure 3.4 that variation in sediment deposition rates mostly determines artifact densities in most of the Middle Paleolithic sequence, and less so during the Upper Paleolithic. It is important to note that while the sedimentation rates do affect most of the MP sequence, a clear cut pattern is also observed within it, especially for MP IV and V, the ‘all lithics’ and ‘debris’ categories. Some parts of the UP sequence also have low artifact densities, mostly in the EUP, but in this case layer thickness does not seem to have played such a major role. Average layer thickness is more constant for the UP assemblages and fluctuates more between the early and late parts of it. Clear-cut differences in densities do appear between the EUP and the LUP (’Gravettian’), especially regarding the *‘all lithics’, ‘unretouched’,* and *‘debris’* categories (see also Appendix A Table 1 for both MP and UP). If one also looks at the raw counts and frequencies of the various artifact categories in both MP and UP assemblages, it becomes clearer that variability in UP discard rates for the sequence as a whole, and differences in discard rates within it are more closely related to different kinds of occupations and the intensity with which different tasks were performed at the site.

It is possible to look at other dimensions of variation in artifact density data at Ripiceni-Izvor. For one thing it is not surprising to find that both sediment accumulation rates and the frequency of occupation at the site varied. If these were the main factors affecting the rate of artifact accumulation, then the density of different artifact classes should all vary in the same way from layer to layer. Differences in the variation through time in the densities of different artifact classes would indicate that the rates of artifact accumulation were more complexely determined. Those artifact classes with the most consistent densities should represent the material remains of the activities most commonly performed at the site. On the other hand, artifact classes exhibiting highly variable densities should indicate a more sporadic occupation and therefore were more likely to have been affected by variable sedimentation rates or changes in activities that were not always represented (Figure 3.2-3.4).

Major classes of discard can also be assumed to have entered the archaeological record in somewhat different ways as a result of different spectra of activities. Cores and debris should be mostly the by-products of local artifact production, and much of the debris from such activities is expected to be left in place (Figure 3.5). Although cores themselves may have been transported for appreciable distances, core reduction products are more portable, hence more easily and more frequently transported between sites and/or quarry areas (Andrefsky, 1994, Kuhn 1994, 1996; Surovell, 2009).

Retouched pieces might have found their way into a site through manufacture, use, but they might also have been deposited as a consequence of resharpening whereby exhausted artifacts produced at some other location were reworked, perhaps from lost or discarded pieces, and/or where new tools are made to replace them. Refitting studies have documented tool resharpening activities at prehistoric sites in both hemispheres (Frison, 1968; Conard and Adler, 1997). Artifacts abandoned in the context of resharpening activities should show evidence of different degrees of reduction. Given the ratio of retouched pieces weighted by volumetric density, the ratio of retouched pieces to all lithics, and that of scrapers to notches and denticulates combined for most of the Paleolithic (Figures 3.6-3.9), as well as the statistics for both the modification of retouched pieces and the degree of core reduction, a certain amount of variation is to be expected. Therefore, resharpening seems to have been important at Ripiceni-Izvor, at least at various times during the Middle Paleolithic (Popescu i.p.)[i]. It is possible that the *'unretouched'* category (all flakes >20 mm) might follow at least two of these pathways: (1) some flakes might have been used expediently as tools, or (2) others might represent the by-products of manufacture.

## Landuse Strategies

Ripiceni-Izvor did not exist in isolation; it was part of a settlement-subsistence system tightly linked to the changing regional ecology. Landuse strategies must be reconstructed to situate the site in its larger social and natural context. The methodology used here was originally proposed by Barton (Barton, 1998; Villaverde et al., 1998) and subsequently refined in other recent studies (Kuhn, 2004; Riel- Salvatore and Barton, 2004, 2007; Sandgathe, 2005; Popescu et al., 2007; Clark, 2008; Riel-Salvatore et al., 2008, Barton et al., 2013). These studies have shown that retouch frequency is a robust proxy for landuse because it can be used to monitor the duration of site use or occupation and to assess the relative importance of individual versus place provisioning *(sensu* Kuhn 1992). Modes of provisioning have in turn been linked to variation between residential mobility (moving people to resources) and logistical mobility (moving resources to people) (Marks and Freidel, 1977; Binford, 1980; Kelly, 1992, 1995; Grove, 2009). Since the approach has been described at length in previous works, I will only summarize it here to underscore its heuristic potential for situating Ripiceni-Izvor in the context of Late Pleistocene landuse patterns.

The method uses what has been called a *whole assemblage behavioral indicator* (WABI) that combines information about the total number of retouched pieces in an assemblage and the volumetric density of lithic accumulation in the deposit from which they are derived (as above) (Barton, 1998; Barton et al., 2004; Clark, 2008; Kuhn and Clark, 2015; Riel-Salvatore et al., 2008; Sandgathe, 2005). It is based on middle range theory and human behavioral ecology. It integrates the organization of lithic technology with the relationship between the incidence of retouch and artifact curation, and it postulates a strong negative correlation between the relative frequency of discarded retouched pieces in an assemblage and the volumetric density of all lithics (including cores and *débitage)* in that assemblage. This means that for a given depositional environment, assemblages with low lithic volumetric densities are predicted to show relatively higher frequencies of retouched pieces compared to high-density assemblages where the frequency of retouch is expected to be comparatively low. These predictions capture artifact accumulation patterns along a continuum between 'mostly curated' to 'mostly expedient' assemblages. Differences are best distinguished when all the assemblages from a site or a series of sites are plotted on the same graph, and both axes are expressed as log scales (Figures 3.11a, 3.11b). It is important to note that the terms *expedient* and *curated* do not necessarily reflect individual site-occupation events, but rather refer to time-averaged suites of strategies resulting from a palimpsest of occupations, the predominant character of which will dominate the signature of a given archaeological assemblage.

Assemblage characteristics can also be linked to the prevalent landuse strategies adopted by the Pleistocene foragers responsible for their manufacture, use, maintenance and discard (Binford 1979, 1980; see also Nelson [1991]). Expedient assemblages are often the consequence of logistical mobility in which a central residential base is occupied for relatively long periods of time while task-groups are deployed from it to procure various non-local resources. In contrast, curated assemblages are expected in cases of residential mobility when hunter-gatherer bands moved their camps frequently to exploit sometimes-distant resource patches and where artifact portability was important. In other words, 'expedient' and 'curated' assemblages track relative mobility along a continuum in which there is considerable variation, the same kind of variation seen in forager movement in ethnographic contexts (Bettinger, 1991; Kelly, 1995; Riel-Salvatore and Barton, 2004). That said, there are important differences in the organization of activities in time and space, use of technology, resource patch exploitation, cycles of fission and fusion in group size and composition and social institutions among foragers who primarily engage in logistical as opposed to residential mobility (Binford, 1980; Kelly, 1983, 1992, 1995; Grove, 2009, 2010). Premo (2012, see also Barton and Riel-Salvatore [2014: 337]) that suggests that it might be more realistic to divide the continuum situations in which (1) some groups are mostly residentially mobile but occasionally logistical and vice versa, and (2) those that are mainly logistical but occasionally residential, rather than combining the duration of occupation and the site catchment's (the distance from the camp traveled to procure resources (Higgs, 1975)].

It is important to note that, because this method does not depend on typologies specific to either Middle or Upper Paleolithic assemblages, it allows for the comparison of behavioral modalities across time and space without the necessity to invoke the presence of identity-conscious social units or the archaeological index types that supposedly identify them. The approach allows the direct comparison of assemblages argued on techno-typological grounds to be different and offers us a powerful methodological instrument to assess whether the makers of different industries appear to have exploited their landscapes differently, or whether they display comparable ranges of behavioral flexibility. The dominance of one or the other mode in given technocomplexes may also have significant implications about how 'behavioral modernity' might appear in the characteristics of lithic assemblages.

Different sedimentation rates and diagenesis can, of course, influence the results obtained by the approach and these factors must be controlled to the extent it is possible to do so (Barton 1998; Riel-Salvatore and Barton, 2004). Fine-grained radiometric dates can provide good estimates of the time elapsed in assemblage formation while sediment analysis can indicate the effects of post-depositional forces on artifact counts and sediment volume, underscoring the need for credible geoarchaeological information in general. By the same token, deviation from expected patterns can also serve to identify various depositional and post-depositional processes (Riel-Salvatore and Barton, 2007; Riel-Salvatore et al., 2008).

***Results***

For all the assemblages in the sample, there is an overall strong negative correlation between artifact volumetric density (AVD) and frequency of retouched pieces (Figure 3.11a) as predicted by the theory that underpins the WABI approach ($R = -0.91$, $p < 0.001$). From the regression plot it is clear that three patterns are evident from the analysis of formation processes above at Ripiceni-Izvor. Variation in artifact volumetric density accounts for almost 88 % of the variability observed in the frequency of retouched pieces. In Figure 3.11b assemblages are divided first into those assigned to the Middle and Upper Paleolithic respectively, and then into early and late UP sequences (EUP and 'Gravettian'). The negative correlation between AVD and retouch frequency remains equally strong and statistically significant when assemblages are divided into the three groups (Figure 3.11b) and, again, AVD accounts for 88-99 % of the variability observed in the frequency of retouched pieces. As noted in previous research the strong negative correlation between artifact density and retouch frequency indicates that these data can serve as proxies for prehistoric forager landuse, especially as it relates to mobility strategies and the nature of site occupancy.

In order to assess whether excavation strategies (differences in stratigraphic resolution in this particular case) might have biased the results, I have also compared retouch frequency with area excavated and excavated layers thickness (Figures 3.12-

3.14). In neither case are there significant correlations. The results support one another and indicate that the relationship identified through WABI is not conditioned by any of these factors.

It is worth mentioning that there is a considerable amount of overlap in regard to technological organization strategies across the Middle-Upper Paleolithic. Some differences are also evident, of course, but they are linked more to temporal and environmental variation than to assignment to MP or UP industries. As in the previous section it is mainly LUP sequence ('Gravettian') that stands out as quite different from both the MP and the EUP, falling at the very expedient end of the landuse continuum, whereas curated and expedient assemblages are found in both the MP and EUP, along with some that fall somewhere in between those two extremes. This is shown very clearly in Figures 3.15 and 3.16, which compare retouch frequency and artifact volumetric density for Middle and Upper Paleolithic assemblages. An analysis of variance shows Middle and Upper assemblages to be quite similar in terms of retouch frequency. The significant differences show up – again – when both MP and EUP together and separately are compared with the 'Gravettian' (Figure 3.15). Figure 3.16 shows a significant difference between MP and UP overall, but a closer look shows that the difference is determined by the LUP assemblages which are highly expedient and with low frequencies of retouched pieces. Within assemblage analyses show no significant differences between the MP and the EUP and again significant differences between MP and EUP separately and together when compared to the 'Gravettian.' Other lines of evidence extracted from WABI also revealed very interesting results.

Following the reasoning from the previous sections, if the main activity at R-I were flake production then there should be an overall negative relationship between frequencies of cores densities and of flakes and debris. This is because higher debris densities would have tended to decrease the core frequencies abandoned on the site, just like the relationship between artifact volumetric density and the frequency of retouched pieces. Consequently, if the main focus at the site was only flake production, then there could be no correlation between the overall debitage densities and the combined frequencies of cores and retouched pieces.

Figures 3.17 and 3.19 show the regression correlations between densities of unretouched flakes and debris combined and core frequencies (Fig. 3.17), and densities of unretouched flakes and debris combined and the combined frequencies of retouched pieces and cores (Fig. 3.19). As the results of these analysis show, there is a significant correlation at the site level between these two components of the R-I lithic sample. Moreover, quite a bit of variation exists both within and between the MP and UP sequences. While a negative correlation exists within the MP and UP assemblages, others are somewhere in the middle of the continuum while still others fall at the upper end. ‘Gravettian’ assemblages stand out as different and closely follow the same general pattern. The foregoing is clearly expressed in Figure 3.18. Here, too, a negative correlation is expected within the site and at the assemblage level. While for the whole site the results are strong and significant statistically, assemblages cluster together in three different ways, showing a high degree of variation. (1) Some of the MP and EUP levels fall at the negative end of the continuum pattern closely, (2) others fall somewhere in the middle (MP IV) while others, (3) mostly the earliest MP assemblages fall at the upper end, in which tool production and resharpening are indicated by discarding. Later UP assemblages, as in all the analyses so far, fall at the expedient end of the continuum.

Amongst the retouched categories, sidescrapers and endscrapers are the artifact classes with the longest life histories in Paleolithic assemblages, and the classes found in high numbers both in frequencies and densities at R-I. Given that there is evidence that some assemblages show a moderate-to-high degree of reduction (Popescu *In Preparation*), sidescrapers and endscrapers are analyzed here, first separately and then together with cores, compared to the combined unretouched and debris densities. The reasoning behind this is as follows. If scraper frequencies do not reflect local production and resharpening, and thus exhibit a low degree of tool reduction, then there should be no correlation or a strong negative correlation between scraper frequency and the densities of unretouched pieces and debris. If there is a focus on both blank production and tool reduction, then there should be a clear positive pattern for those assemblages that follow this path, and a correspondingly negative one for those that do not. That is, if the goal of flake production was the manufacture of scrapers, the quantities of those artifacts should be positively correlated; if the manufacture of flakes was intended for their expedient use and discard, instead of long-term maintenance and resharpening which resulted in the discard of scrapers, these artifact categories should not be correlated or should display a negative correlation.

Figure 3.18 shows an overall negative correlation pattern at the site level, as well as within each sequence (except for the ‘Gravettian’, where scrapers are very rare). Here again, the variation between assemblage groups (MP, EUP, LUP) is informative. Both the Middle and Early Upper Paleolithic are clumped either more or less midway in the regression continuum and also more toward the curated end. Earlier MP occupations and M VI follow the positive pattern toward the curated end. Figure 3.20 is conclusive in the fairly good overlap between the MP and the EUP and thus agrees with expectations. Assemblages from both MP and EUP assemblage groups exhibit the same range of variation between place provisioning and individual provisioning.

When we consider the analyses presented here together it underscores the importance of environmental conditions in structuring both local site occupation and broader landuse strategies. Generally, human foragers responded to environmental change through an integrated suite of organized landuse strategies, including shifts between logistical and residential mobility, varying the frequency and distance of moves, changing group size and composition, and perhaps adopting a more specialized diet (Grove 2010, Stiner and Kuhn 1992). Organizational shifts similar to the above have been documented in Late Pleistocene contexts elsewhere (Marks and Freidel 1977, Wallace and Shea 2006, Riel- Salvatore et al. 2008, Grove 2010) and this paper shows that it is possible to track such changes at Ripiceni-Izvor as well. Landuse strategies vary under different climatic conditions (Figure 3.21). In this particular site, temperate conditions are associated predominantly with higher residential mobility and greater variance in mobility (mean retouch frequency = 12.05 %); colder conditions are correlated with higher logistical mobility (mean retouch frequency = 3.9 %). The higher variance in retouch frequency under temperate climatic regimes also suggests that residential mobility (= individual provisioning) is associated with greater diversity in occupation patterns. It is interesting to note that the MP IV and V were characterized by similar behavioral suites as their later EUP counterparts and are quite similar to the ‘Gravettian’ ones. As shown above, these adaptations vary by shifting back and forth between residential and logistical strategies. This suggests that large-scale climatic fluctuations are a much better predictor of landuse strategies than the techno-typological classifications of lithic industries.

## Discussion

Although tool production and resharpening were not the dominant activities at R-I, especially during the LUP, both the condition of retouched pieces (Popescu i.p.) and the fact that cores, debris and tools were deposited at more or less the same rates (especially during the MP), all indicate that some degree of resharpening and tool production took place at the site. It should be kept in mind that the greater variability for cores and debris throughout the sequence is related to a much higher density of these two categories at various intervals of occupation at the site.

That being said, the degree of variation across layers for these two categories indicates that at certain points in time the site was primarily used as a production locale. At he same time, the site could be viewed more as a locus of lithic consumption where tool production, use, and resharpening took place. These characteristics are not mutually exclusive, of course. Significant variation in site use can be seen both between assemblages and within assemblage groups (MP, EUP, and LUP), mostly for the MP IV and V but also for the EUP layers. LUP layers appear to be quite distinct in most of their characteristics both between the MP and the EUP and altogether. This suggests that episodes of more intense occupation and artifact production as well as some replacement of exhausted tools and cores occurred over time. Their material consequences are likely represented in certain levels. Figure 3.5 shows core and debris frequencies as a proportion of the entire lithic assemblage within each occupation layer, representing a rough index of the amount of basic stoneworking that took place at the site. Distinct cycles of increase and decline in the relative frequencies of core reduction and its by-products indicate where in the sequence these activities might fit best with the notions of production or provisioning areas (Kuhn 1992, 1995; Stiner and Kuhn 1992). There is a continuous increase in the proportion of cores and debris for which reaches its maximum in MP IV and V, followed by a sharp decline at the beginning of the EUP but fluctuating and decreasing afterwards. Cores and debris deposition rates, although varying to a greater or lesser degree at times were more constant at other times. It is therefore evident that there is site functional variation over time between the MP and the UP, but more variation within each of these typological industries than between them.

If, in the MP case, core and debris densities vis à vis those of retouched pieces and unretouched flakes have different ranges of variation, it might have implication for how tools found their way into the archaeological context. If tools were produced whenever it was necessary, and if use and discard co-occurred with manufacture, then we would expect to find a fairly constant proportion of both products and by-products of toolmaking. Overall, it seems that in situ tool manufacture took place, albeit with various degrees of variability. Some of the retouched pieces may have been made by recycling flakes that had previously been discarded. Because the source of raw material – good quality flint – was terrace gravels in the immediate vicinity of the site, the likelihood that retouched pieces were brought to the site from somewhere else is not really tenable. However, this does not mean that a medium to high degree of reduction is not evident on some of the retouched pieces. This is particularly true of the MP levels (Popescu i.p.).

These MP assemblages are characterized by high artifact densities despite thicknesses almost twice as high as those of the UP layers, and fall midway within the range of artifact densities variation of the UP sequence. It is also true that MP IV-V are less thick then MP I-III probably because of a more constant rate of loess deposition as opposed to the more alluvial early MP sequence when the low terrace seems to have been frequently flooded by the nearby river, thus creating a higher and more variable depositional environment (Conea, 1976; Grossu, 1976). When site occupation was really intense (MP IV-V) sedimentation did not affect the rate of artifact accumulation so much. That is, a complex combination of both behavioral and natural interactions generated the variability we see in discard rates and their fluctuations within the MP sequence.

If many or most of the tools were the result of recycling, then dense accumulations of debitage products would have provided more opportunities to recycle, and more intense occupations and tasks would have provided more impetus to do so. If most of the retouched pieces resulted from recycling of things previously discarded, then the frequency of retouch should increase with the density of flakes and tools in the underlying sediments. Studies that were conducted in settings similar to Ripiceni-Izvor, where raw material sources were available nearby, have shown a fairly high incidence of tool reduction/recycling (Marks et al., 1991).

The correlations between the proportion of usable blanks that were retouched[ii], artifact density, and the comparison of this ratio across the entire Paleolithic sequence at Ripiceni-Izvor are shown in Figures 3.6 and 3.7. Overall the proportion of usable blanks that were retouched is negatively correlated with overall artifact density *(R* = - 0.91, *p* < 0.001). Three patterns are clearly discernible from the regression plots. First, the LUP (i.e.,'Gravettian'), is quite different from the rest and follows a totally different pattern (Figure 3.7), falling at the extreme corner of the 'expedient' part of the graph. EUP IV falls in more or less the same place. LUP core and debris densities, and blank discard, are less variable than in the MP and EUP, as noted in LUP assemblages elsewhere (Riel-Salvatore, 2007; Barton and Riel-Salvatore, 2012, 2014).

A closer examination of the MP and EUP shows that there is quite a bit of flexibility in the amount of variation in these lithic assemblages. In respect of the MP, the lowermost occupation (I-III, as well as M VI) shows the highest frequency of tools per useable flakes, while the MP IV and V and the EUP II and III are about midway along that continuum of variation, whereas EUP I tends to group with MP I-III and VI. These occupations appear to focus on core reduction and flake production, but also on the manufacture and resharpening thereof (i.e., frequently switching back and forth from provisioning to consumption and vice versa (Kuhn, 1995; Barton, et al., 2013; Barton and Riel-Salvatore, 2014). These results show that while tool production and resharpening activities might not have been the main activities site wise, there is a reasonable degree of variation within and between levels for some of the MP (I-III) and EUP (I-III) assemblages, and that some tool production and resharpening also took place throughout the sequence.

At first glance the characteristics of the latest MP occupations (see above) might appear seem to contradict expectations under the models used here (Barton and Riel-Salvatore 2014; Popescu et al., 2007; Riel-Salvatore and Barton, 2004; Kuhn, 2004). However, given variation between logistical and residential mobility, they actually fit quite well the expectations for formation processes, landuse strategies and mobility. Unfortunately, detailed analyses of the faunal collections from the MP levels at the site are not yet available at the level of detail needed for a better understanding of the processes that governed the entire set of behaviors at R-I (See Appendix A, Table 1-3). They might also offer the prospect of insights into the more general hominin behavior of the whole Middle Prut valley area overall. Overall, the results presented here suggest that even though landuse varies from assemblage to assemblage, there is no apparent qualitative difference in the range of landuse strategies employed by the hominin groups responsible for the production and discard of the assemblages assigned to either MP or EUP. Obvious changes are apparent in the organization of technology and mobility strategies in the Middle Prut between both the MP and EUP on one hand and LUP on the other, with the advent of the LGM and LUP occupations (Noiret, 2009; Riel-Salvatore, 2007; Stiner and Kuhn, 2006; and this study).

The results from this study clearly show that changes in land-use strategies are linked to human ecological responses to environmental change rather than to prehistorian-defined archaeological constructs. It is important to emphasize that, while other aspects of technology and typology might have changed over this long interval, fundamental aspects of the hunter-gatherer way of life – mobility and landuse – varied continuously over time within all these assemblages and not just between them.

Analysis of the Middle and Upper Paleolithic strata from Ripiceni-Izvor shows that the two lithic industries were different *not* because biocultural differences in assemblage formation behaviors, lithic technological organization, landuse strategies, and organizational flexibility. Rather the data observed here suggest that technoeconomic strategies, artifact curation intensity and landuse appear to have been more closely related to changing environmental conditions, task-specific activities, and duration of occupation. This agrees well with the results of studies conducted in other areas using similar variables and methods (Sandgathe, 2005; Clark, 2008; Barton et al., 2013) and with those predicted from theoretically-derived models based on evolutionary ecology (Barton and Riel-Salvatore, 2014). Given that human-environment interactions are mediated by technology, which conditions behavioral responses to ecological conditions as well as to resource abundance and availability, this is perhaps unsurprising and is, in fact, expected under those models. This translates into the fact that human landuse behavior effectively changes the environment of selection for hominins and their lithic technology, as a component of the interface between humans and the natural world. In other words, foragers move across the landscape in comparable ways in very different ecological settings, cross-cutting both biological morphotypes and prehistorian-defined analytical units (Clark and Riel-Salvatore, 2006).

## Conclusion

The overall pattern for both the MP and most of the EUP sequence is not that different so far as general aspects of discarding behavior are concerned (e.g., tool and flake production by level, retouch frequency and intensity of reduction as shown in Figures 3.8-3.10). All these data are statistically similar to one another, and the fundamental shift in assemblage formation behavior at the site is most evident when either the MP or EUP separately, or the MP and EUP combined, are compared with the 'Gravettian' occupation. This marked difference is, in fact, documented by most of the analyses in this study. In other words, the big difference is not between the MP and UP, nor between the MP and the EUP, but rather between the LUP (= Gravettian) and everything else. Importantly, the LUP is coterminous with the most dramatic environmental changes if the Late Pleistocene, the Last Glacial Maximum and the time immediately following the LGM. Although there is significant variation in formation processes within the MP and the UP sequences, there is no evidence of differences between these prehistorian-defined analytical units. Instead the variation in these measures and indexes is due to the complex formation processes characteristic of time-averaged palimpsests.

I have shown in this chapter that the use of artifact volumetric density overall and by various artifact categories, and retouch frequency are useful as proxies for studying the linked relationships between formation processes, technological organization, and flexibility in techno-economic choices, mobility and landuse. The method itself (WABI) has also been validated and shown to be a useful tool in many quite different archaeological contexts. It can be applied to many different data sets, collections of variable quality and resolution, and it is not restricted to particular geographical, ecological, topographic and/or cultural circumstances.

This study also underscores the use of artifact volumetric density and retouch frequency as proxies for studying the linked relationships between formation processes, technological organization, and flexibility in techno-economic choices, mobility and landuse. The method itself (WABI) has also been validated and shown to be a useful tool in many quite different archaeological contexts. It can be applied to many different data sets, collections of variable quality and resolution, and it is not restricted to particular geographical, ecological, topographic and/or cultural circumstances.

I do not claim that there are no behavioral differences in human adaptation in Eastern-Central Europe over the late Pleistocene but those differences do not seem to match the analytical units defined by conventional systematics (see also discussions in Riel-Salvatore et al., 2008; Nejman, 2008, 2011; Shea, 2011). This is because traditional technotypological groupings were not developed to provide information about fundamental behavioral differences in how technology articulated with landuse and mobility. Pretty clearly, forager adaptations in some areas of Pleistocene Eastern Europe appear to have varied independently from the analytical units defined by the conventional techno-typological systematics used in the region for almost a century. If we consider the data presented here in their broader ecological and climatic contexts, they allow us to rethink the typological dichotomy between MP and UP as only a segment in a longer and more complex sequence of events that lead to the fundamental shift in technological organization that took place during the LGM and the Tardiglacial. This fundamental shift is documented by the record at Ripiceni-Izvor.

One can hope that in the future more projects grounded in these methods and using these variables will develop along these lines of evidence and that new studies of both old and new collections will help to advance our understanding of long-term variation in hunter-gatherer adaptation.

Figure 3.1 Geographic placement of the site discussed in text.

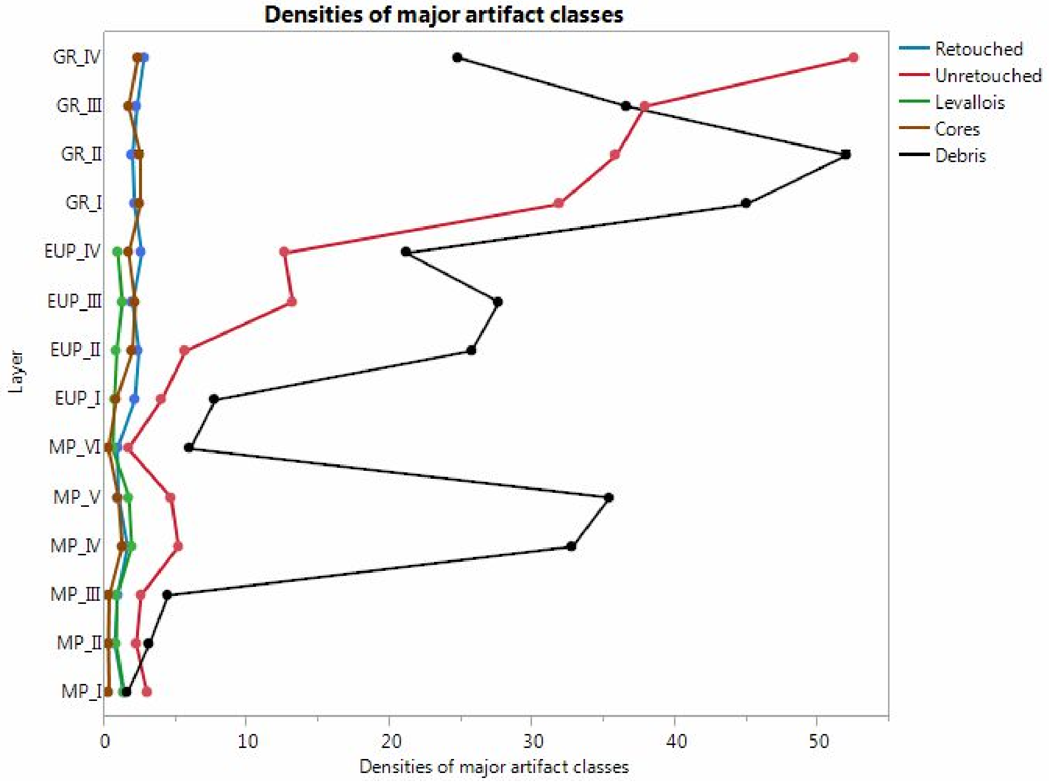


Figure 3.2. Volumetric densities of major artifact classes within the Middle and Upper Paleolithic layers at Ripiceni-Izvor.

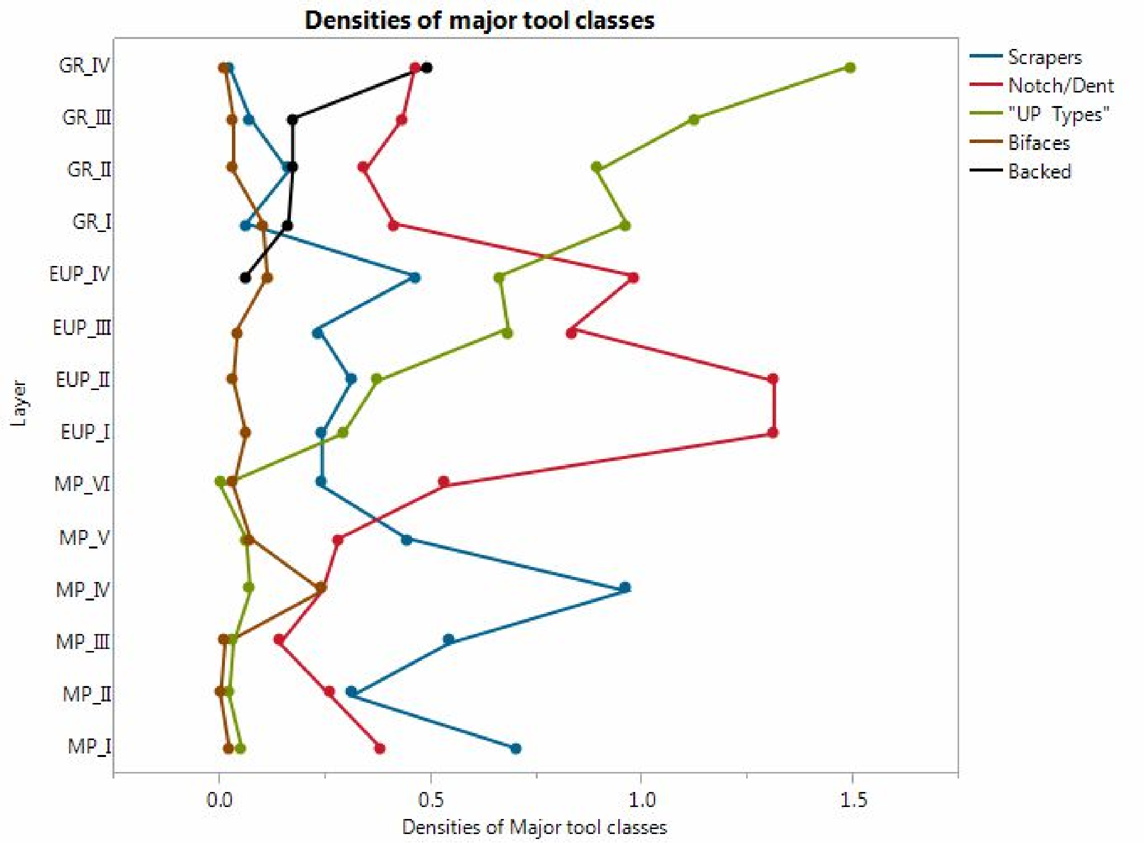


Figure 3.3 Volumetric densities of major tool classes within the Middle and Upper Paleolithic payers at Ripiceni-Izvor.

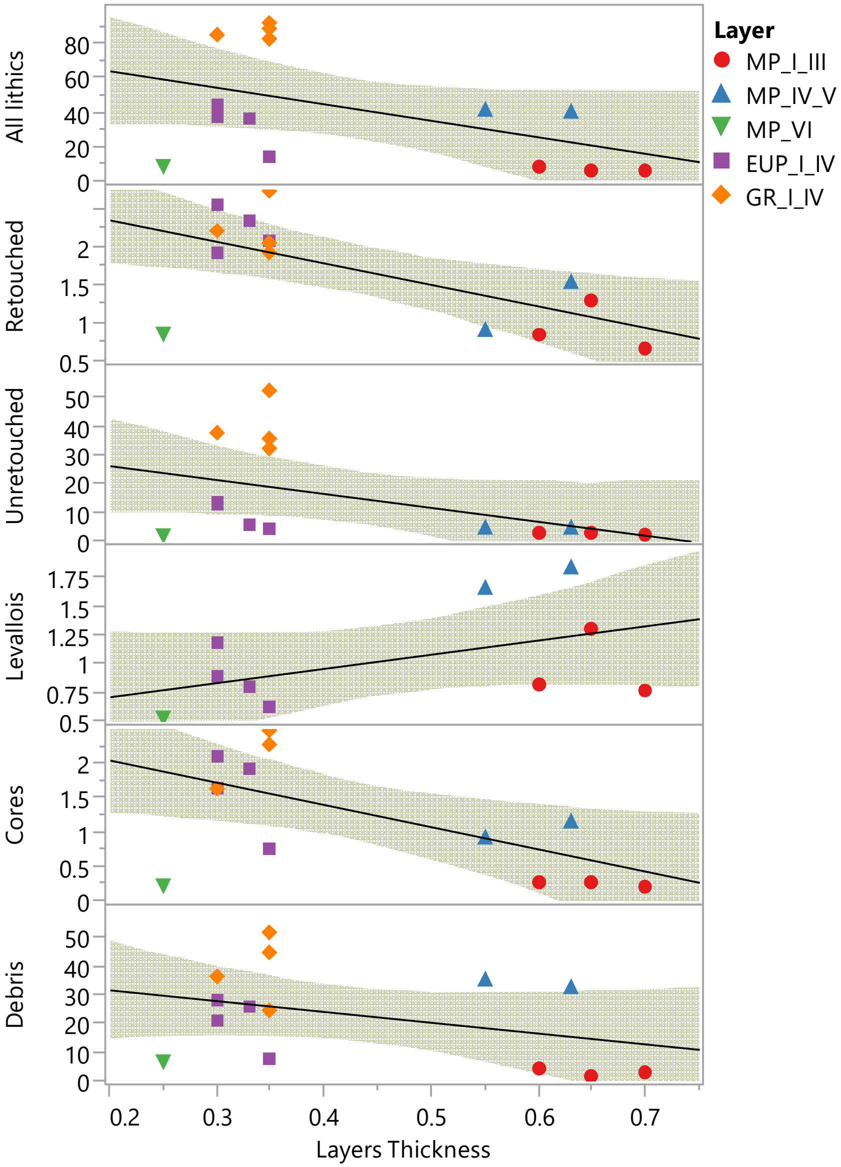


Figure 3.4. Major artifact categories by layers thickness at Ripiceni-Izvor. $R^2 = 0.22$, $p = 0.09$, for 'All lithics'; $R^2 = 0.41$, $p = 0.01$, for 'Retouched'; $R^2 = 0.20$, $p = 0.10$, for 'Unretouched'; $R^2 = 0.23$, $p = 0.16$, for 'Levallois"; $R^2 = 0.34$, $p = 0.03$, for 'Cores'; $R^2 = 0.12$, $p = 0.20$, for 'Debris'.

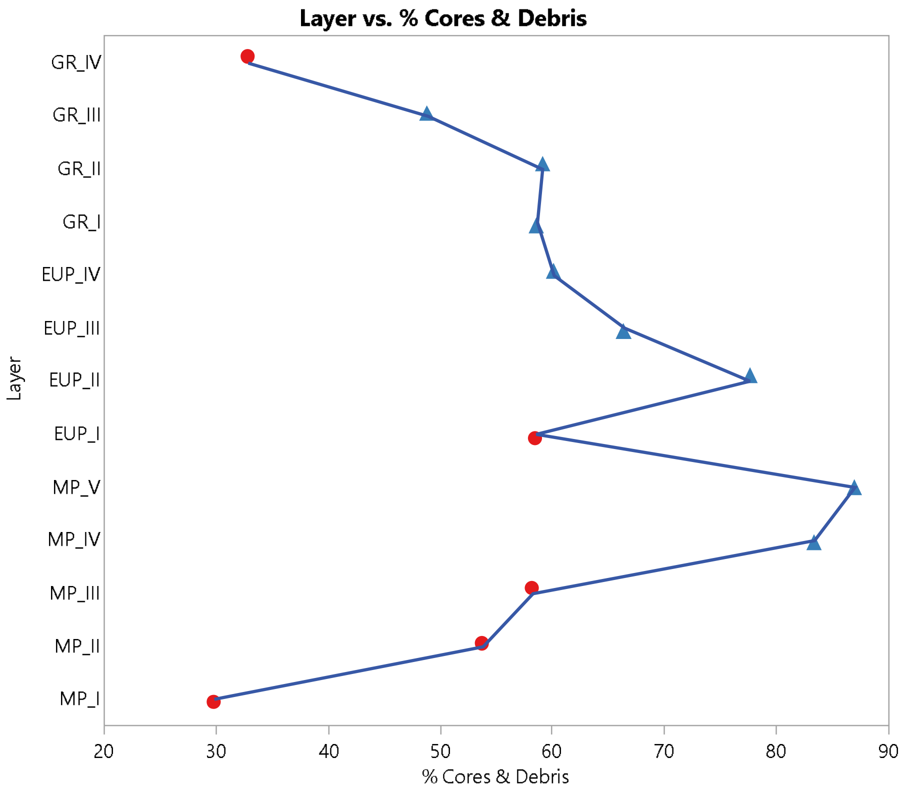


Figure 3.5. Proportions of cores and debris within Middle and Upper Paleolithic deposits at Ripiceni-Izvor. Red dots: Temperate climate; Blue triangle: Cold/Continental climate.

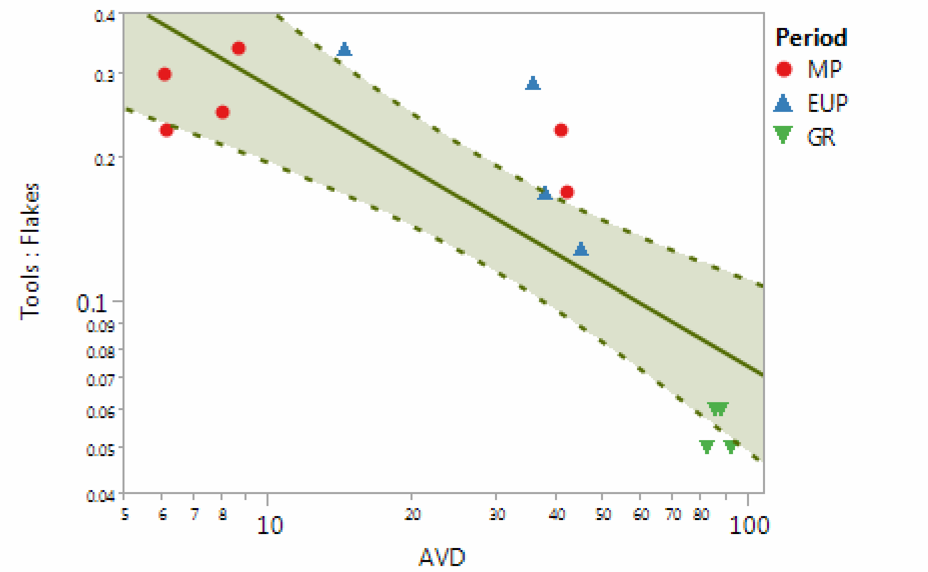


Figure 3.6. Tools to flakes ratio by Artifact volumetric density (AVD) of all lithics at Ripiceni-Izvor. $R = -0.91$, $p < 0.001$.

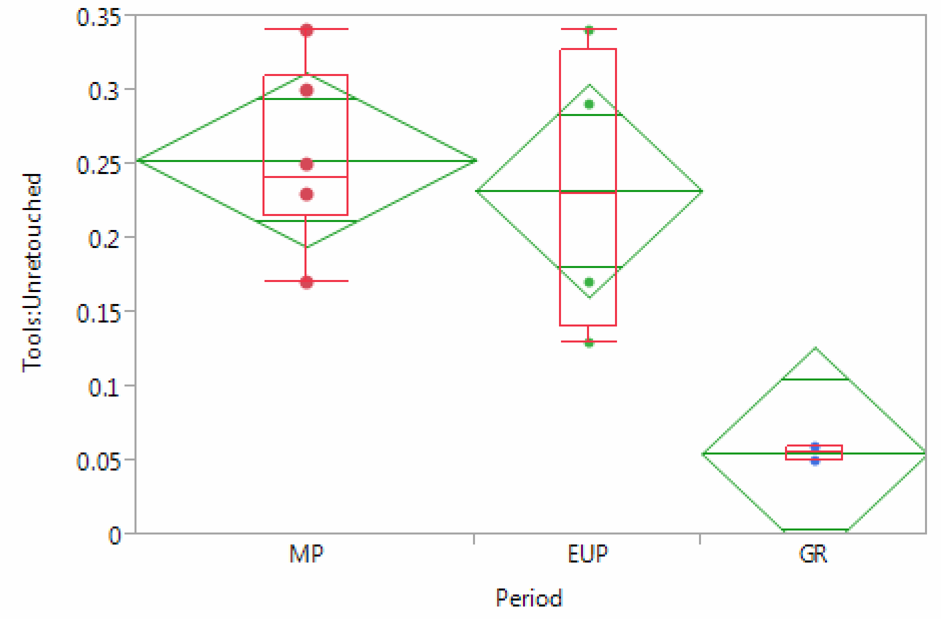


Figure 3.7. Comparison of retouched frequencies by age, within the Paleolithic sequence at Ripiceni-Izvor. ANOVA all site $F = 12.16$, df = 13, $p = 0.002$; ANOVA MP & EUP vs GR $F = 7.824$, df= 13, $p = 0.007$. ANOVA MP vs. EUP $F = 0.07$, df = 9, $p = 0.794$. Boxplots show median, midspread, and range. Mean diamonds show mean (center horizontal line), 95% confidence intervals (upper and lower horizontal lines), and standard deviations (upper and lower points of the diamond). Widths of boxes and diamonds are proportional to sample size.

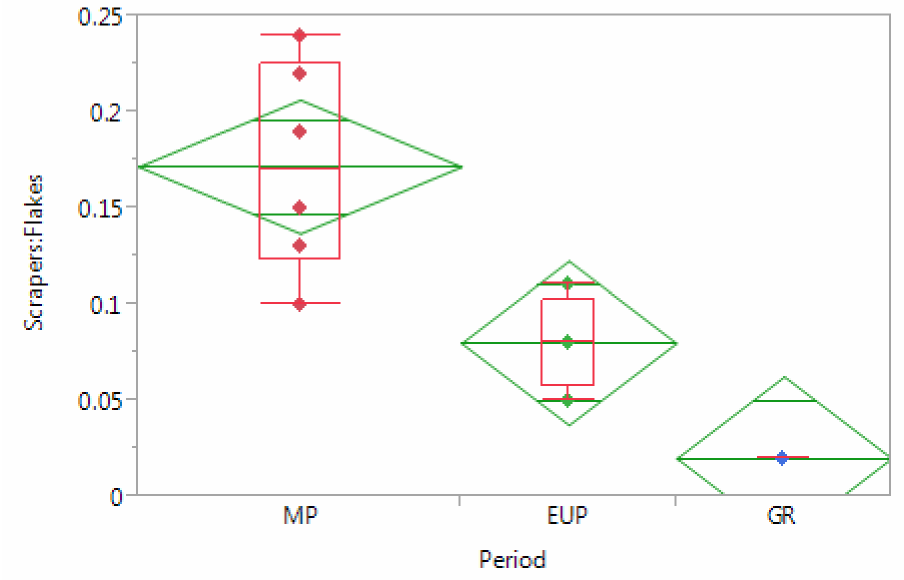


Figure 3.8. Comparison of MP and UP assemblages for frequencies of scrapers-endscrapers category. ANOVA for the entire sequence $F = 19.337$, df=13, $p < 0.001$. Comparisons of MP vs EUP and GR are also significant $p < 0.001$, and $p = 0.01$.

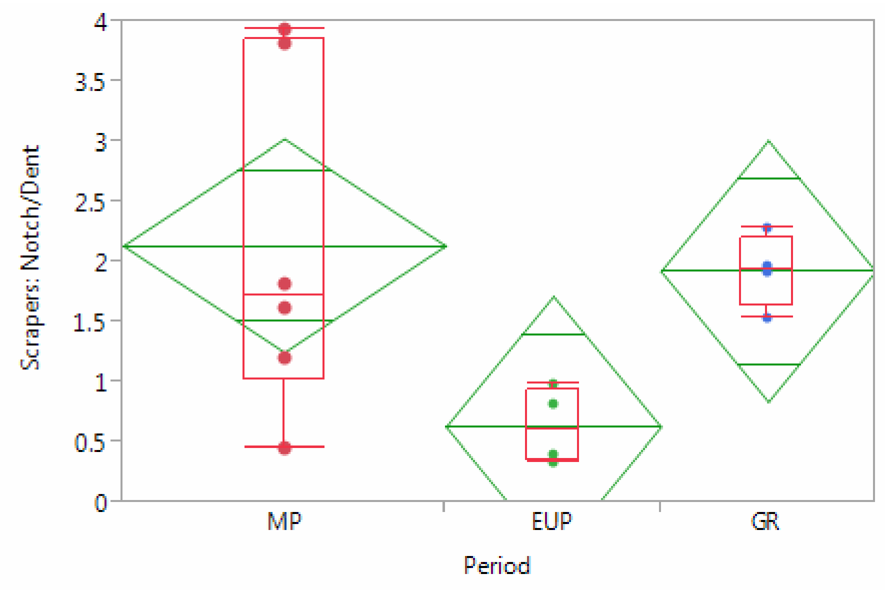


Figure 3.9. Comparison of MP and UP assemblages for Scrapers: Notchs/Denticulates (N&D) ratio. ANOVA for the whole sequence *F*= 2.40, df=13, *p*= 0.148. ANOVA MP vs EUP *F*= 4.281, df= 9, *p*= 0.07. A comparison of each pair's means using student's *t* test provided *p*= 0.03 between MP and EUP assemblages.

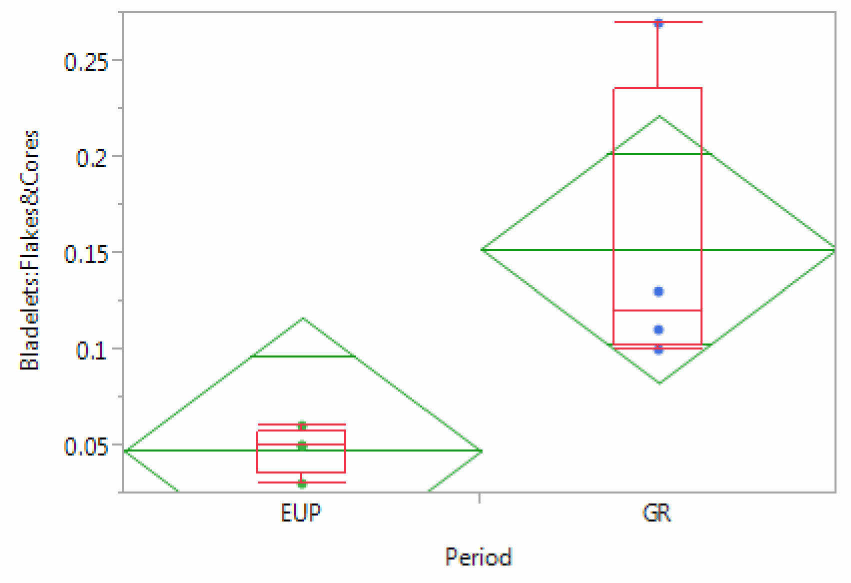


Figure 3.10. Comparison within UP assemblages for Bladelets: Unretouched and Debris ratio. ANOVA *F*= 9.330, df= 7, *p* =0.02.

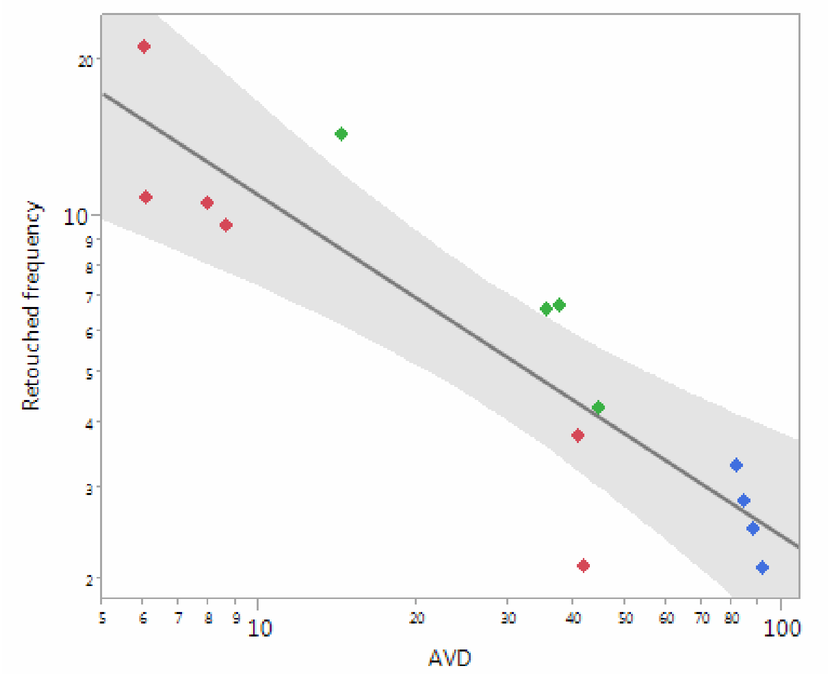


Figure 3.11a. Regression plot of the AVD of all lithics and Retouched frequency for the entire Paleolithic sequence at Ripiceni-Izvor. $R = -0.91$, $p < 0.001$. Red diamond is Middle Paleolithic (MP); green diamond is Early Upper Paleolithic (EUP), blue diamond is Gravettian (GR). Shaded area represent 95% confidence fit.

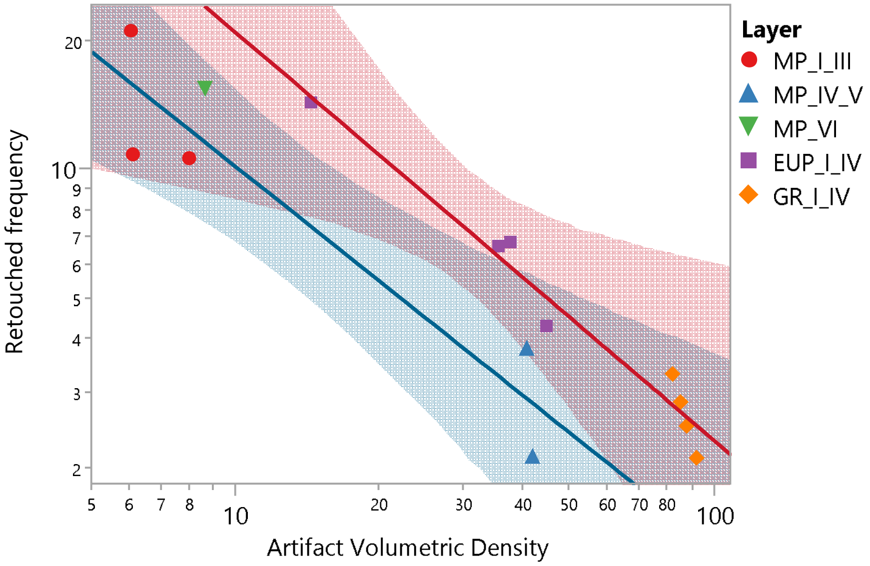


Figure 3.11b. Regression plot of the AVD of all lithics and Retouched frequency for the major Paleolithic subdivisions at Ripiceni-Izvor. MP $R = -0.935$, $p < 0.001$; EUP $R = -0.97$, $p = 0.03$; GR $R = -0.998$, $p = 0.001$.

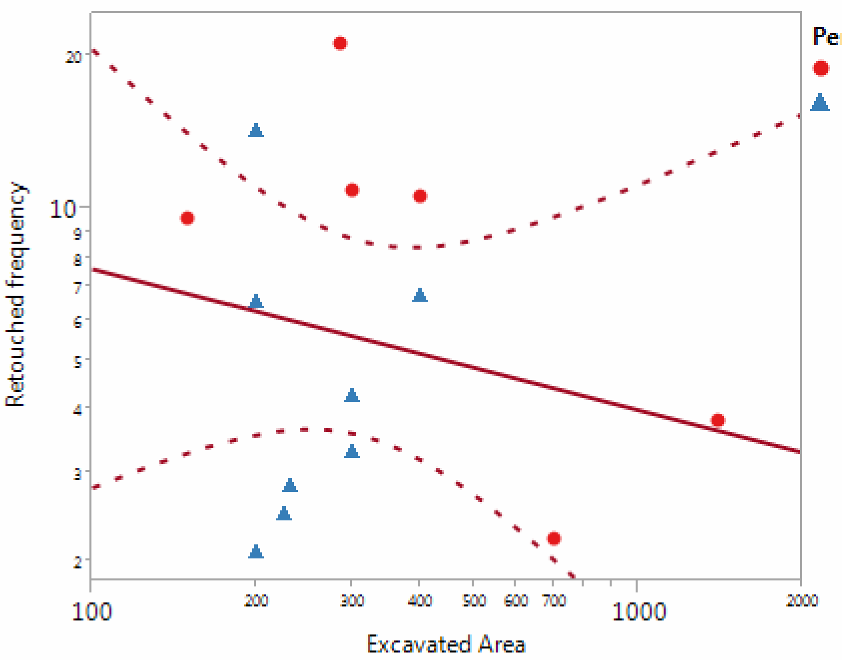


Figure 3.12. The relationship between excavations estimated area and retouched frequency within the Paleolithic sequence at Ripiceni-Izvor. *R* = -0. 270, *p*= 0.35.

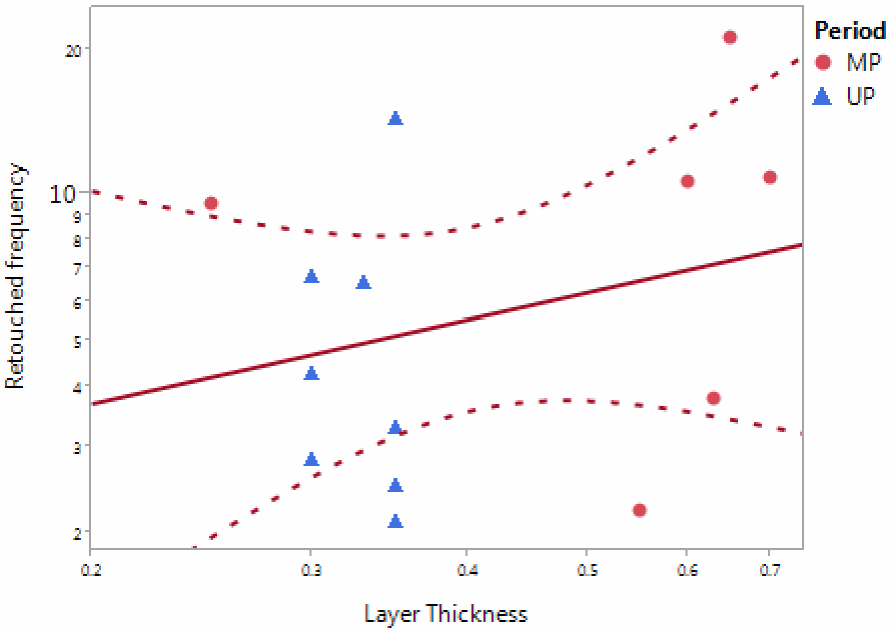


Figure 3.13. The relationship between layers average thickness and retouched frequency within the Paleolithic sequence at Ripiceni-Izvor. *R* = -0.190, *p*= 0.51.

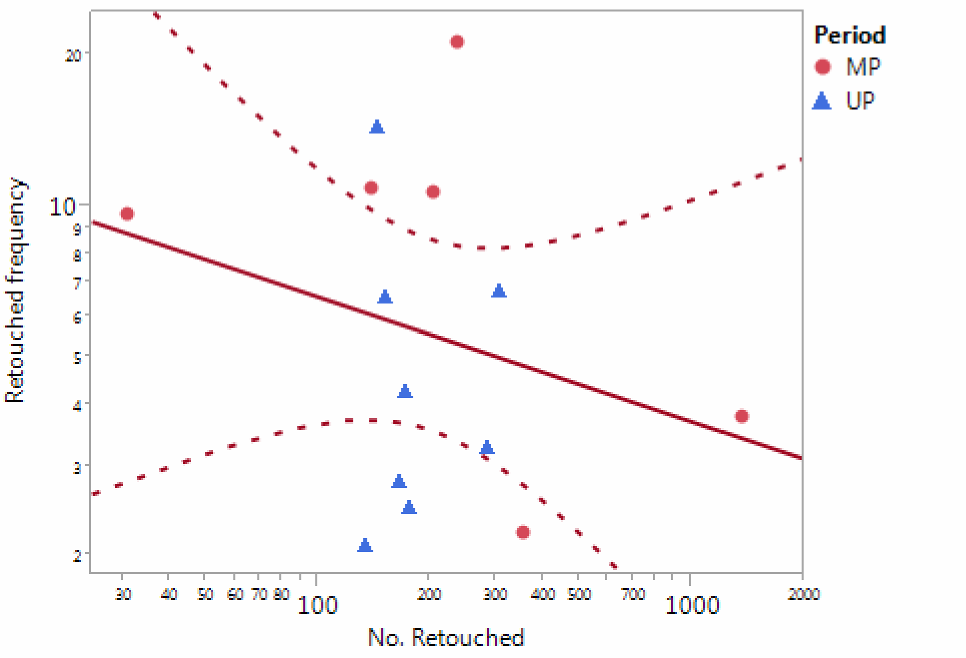


Figure 3.14. The relationship between counts of retouched artifacts and % retouched artifacts within the Paleolithic sequence at Ripiceni-Izvor. *R* = -0.33, *p*= 0.24

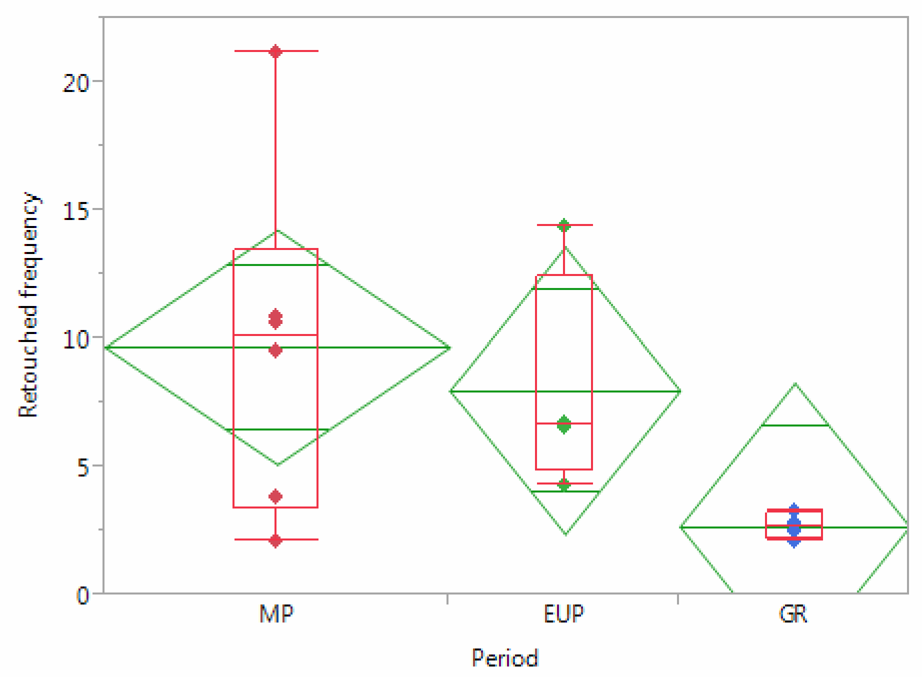


Figure 3.15. Comparison of retouch frequency for MP and UP subdivisions. ANOVA MP vs UP *F* = 3.16, df = 13, *p* = 0.11. ANOVA for MP vs. EUP *p*= 0.143, ANOVA for MP & EUP vs. GR. *F*= 7.824, df=9, *p*= 0.007; MP vs GR *p*= 0.07, EUP vs GR *p*= 0.05.

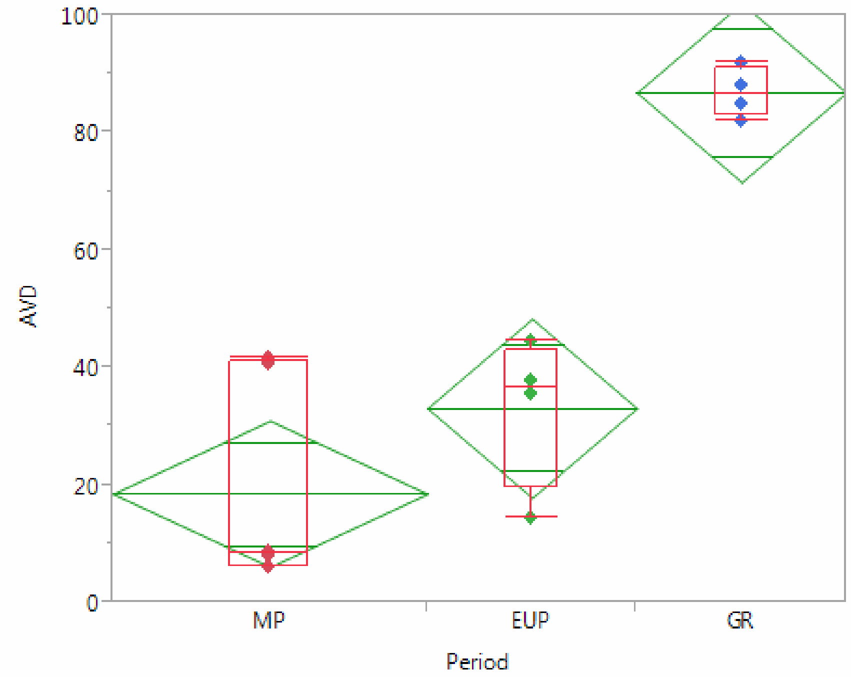


Figure 3.16. Comparison of Artifact volumetric density for MP and UP assemblages as a whole and subdivided into EUP and GR. ANOVA for MP vs UP assemblages $F = 30.395$, df= 13, $p < 0.001$. ANOVA for MP vs. EUP $F= 1.98$, $p= 0.1972$. ANOVA for MP vs. GR $F= 55.945$, df= 9, $p < 0.001$. ANOVA for EUP vs. GR $F= 61.552$, df= 7, $p < 0.001$.

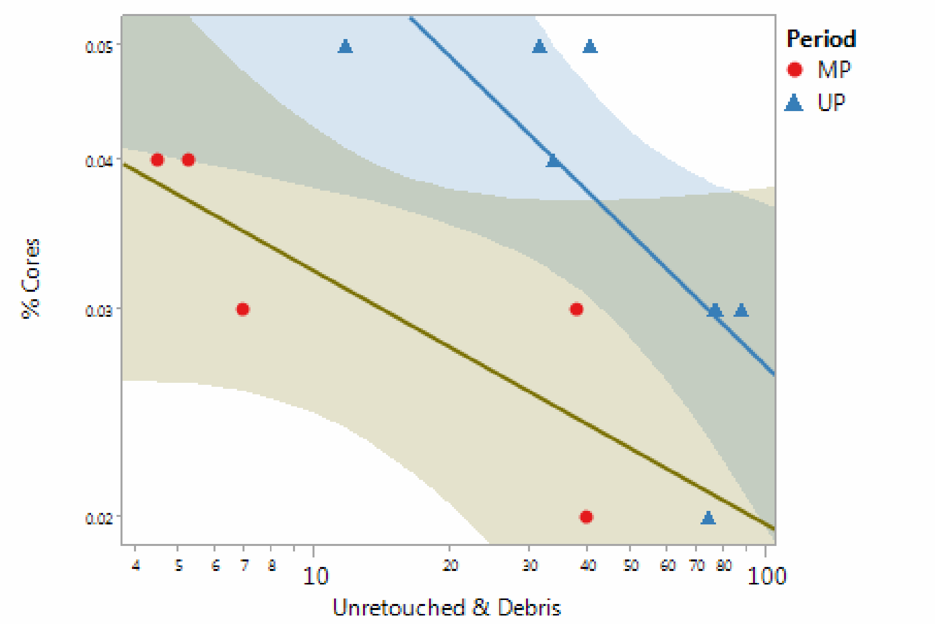


Figure 3.17. Regression plot of Unretouched & Debris volumetric density and Cores frequency for MP and UP assemblages and whole site. $R^2$ (whole site) = 0.224, $p= 0.142$. MP $R^2= 0.685$, $p = 0.08$. UP $R^2= 0.65$, $p= 0.016$. Shaded area represent 95% confidence fit.

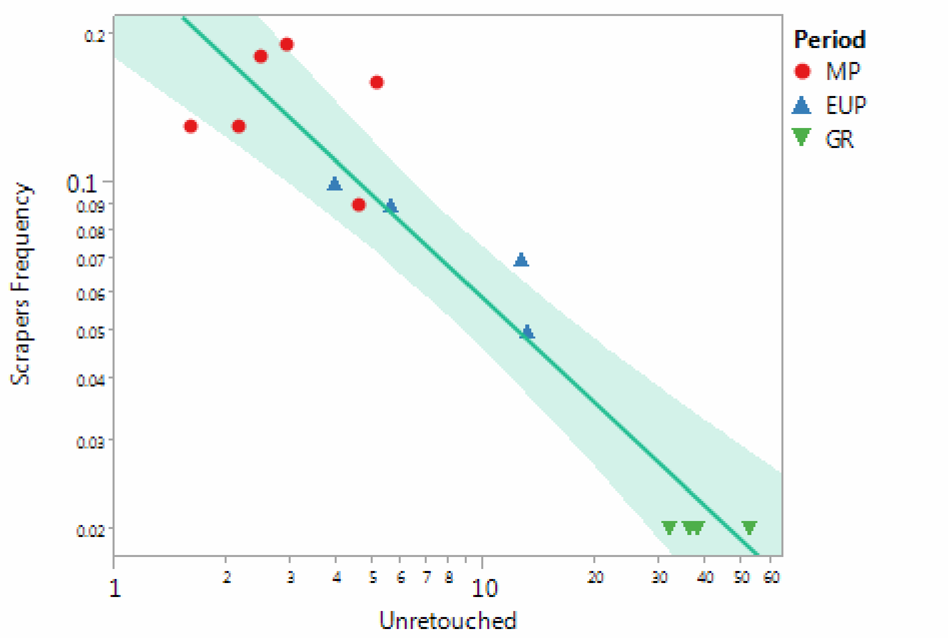


Figure 3.18. Regression plot of Unretouched & Debris volumetric density and Scrapers – Endscrapers category frequency within the Paleolithic sequence at Ripiceni-Izvor. $R^2 = 0.68$, ANOVA $F = 25.24$, df= 13, $p < 0.001$ for the whole site. MP $R^2 = 0.67$, ANOVA $F = 8.15$, df= 5, $p = 0.046$; EUP $R^2 = 0.93$, ANOVA $F = 30.00$, df = 3, $p = 0.03$. GR $R^2 = 0.28$, $p = 0.47$.

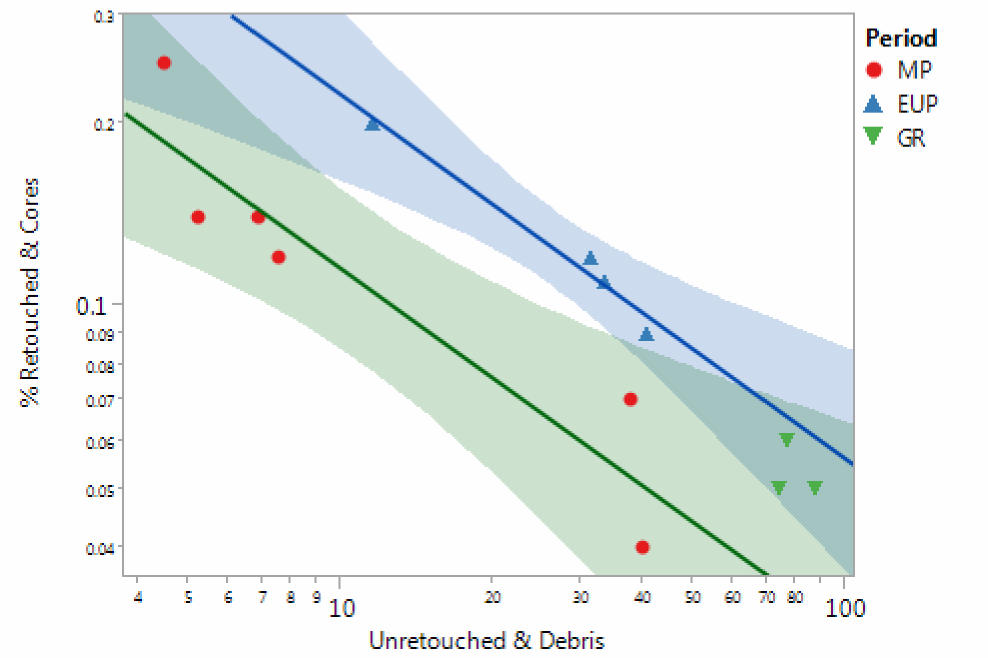


Figure 3.19. Relationship between Unretouched & Debris volumetric density and Retouched & Cores frequency for MP and UP units. $R = -0.782$, $p < 0.001$ (Whole site); MP $R = -0.928$, $p = 0.007$. UP $R = -0.980$, $p < 0.001$. Shaded area represent 95% confidence fit.

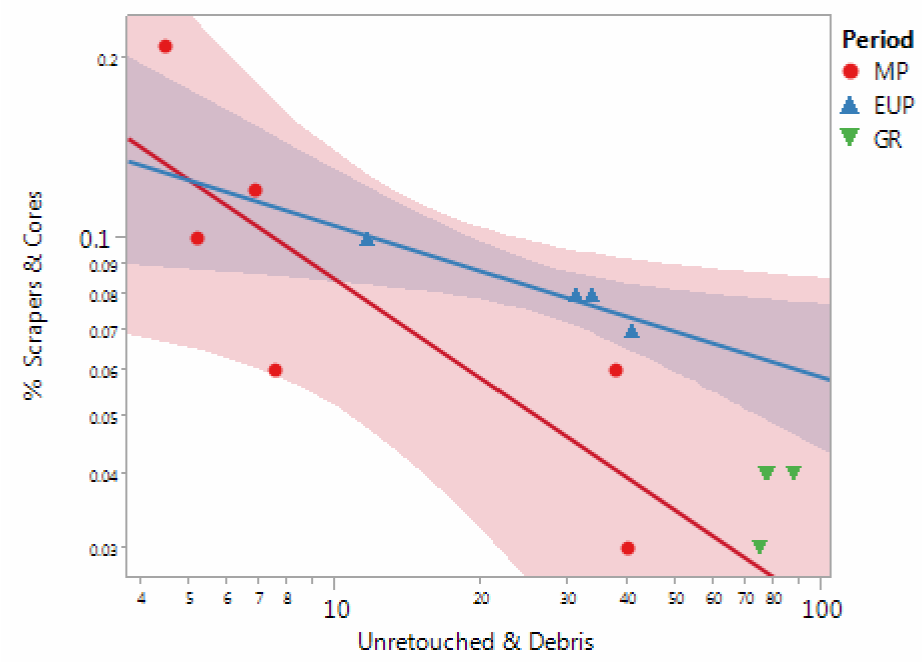


Figure 3.20. Regression plot of the relationship between volumetric densities of Unretouched & Debris category and frequencies of Cores and Scrapers category. Site level $R^2 = 0.68$, ANOVA $F = 25.24$, df = 13, $p < 0.001$. MP $R^2 = 0.67$, ANOVA $F = 8.15$, df = 3, $p = 0.046$. EUP $R^2 = 0.93$, ANOVA $F = 30.0$, df = 3, $p = 0.03$.GR $R^2 = 0.28$, $p = 0.47$.

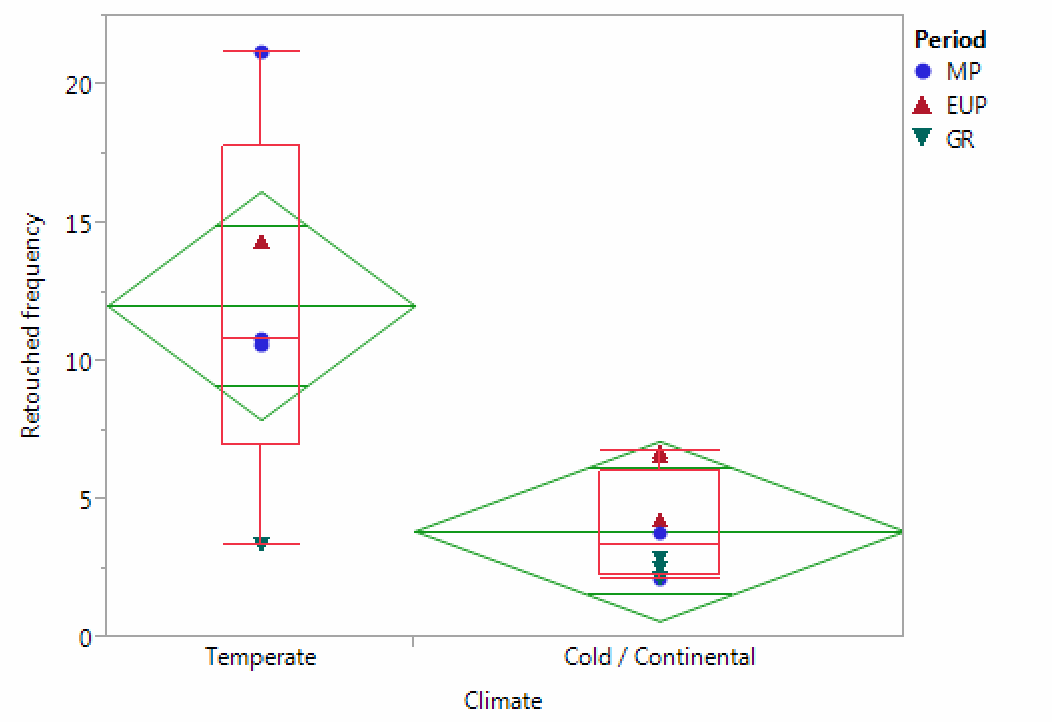


Figure 3.21. Comparison of assemblages associated with cold and temperate regimes. ANOVA $F = 11.70$, df = 12, $p = 0.006$.

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[i] Because of time constraints and collections curated to different locations the study concerning those reduction measures is still preliminary and will make the case for a different publication.

[ii] This proportion is calculated as Tools / (All unretouched flakes + Tools) to avoid autocorrelation that occur when using proportions of a whole.

# CHAPTER 4

## Synthesis

### Introduction

Despite nearly five decades of continuous archaeological research in the Romanian Carpathian basin and adjacent areas, the ways in which human foragers organized their stone artifact technologies under varying environmental conditions remains poorly understood. Most work in the region is concerned primarily with descriptive and definitional issues rather than efforts to explain past human behavior or human-environmental interactions (Anghelinu, 2004; Anghelinu et al., 2012a, 2012b; Cârciumaru, 1999; Dobrescu, 2008; Nițu, 2012; Păunescu, 1998, 1999; Popescu et al., 2007; Riel-Salvatore et al., 2008). Modern-era research directed towards understanding human adaptation to different environments remains in its infancy (Riel-Salvatore et al., 2008; Popescu, 2009). Grounded in the powerful conceptual framework of evolutionary ecology and utilizing recent methodological advances, this latter work has shown that shifts in land-use strategies change the opportunities for social and biological interaction among Late Pleistocene hominins in western Eurasia, bringing a plethora of important consequences for cultural and biological evolution (see also Barton and Riel-Salvatore, 2011; Barton et al., 2011).

The major advantage of these theoretically derived models is that they can be tested empirically against patterns in the paleoanthropological record. In the studypresented here, theoretical and methodological advances derived from human behavioral ecology (HBE) and lithic technology organization are employed to show how variability in lithic technology can explain differences in technoeconomic choices and land-use strategies of Late Pleistocene foragers in northeastern Romania (Appendix B Table 1, 3-4, Figure 1). Set against the backdrop of paleoenvironmental change, the principal question addressed here is whether or not technological variation at the beginning of the Upper Paleolithic can account for fundamental changes at its end.

The environmental record is based on sedimentological, palynological and faunal studies (Appendix B Table 1-8, Figures 1-6). Although of unequal resolution, these studies constitute a foundation upon which to contextualize the human settlements in the region and to help suggest future research directions. Within this ecological framework, I explore changes in technological organization and land-use strategies using an analytical approach based on HBE to analyze stone artifact assemblages from sites in the Carpathian Basin of Romania (Figure 4.1). This study also highlights the opportunities that both old and new collections have for understanding human eco-dynamics, provided appropriate conceptual and methodological frameworks are used.

It has long been known that forager socioecology is responsive to changing environmental conditions, especially with respect to plant and animal resources. This responsiveness occurs at multiple scales, and is driven by the need to fine-tune subsistence strategies to accommodate changes in resource availability in local and regional environmental conditions. Put another way, foragers reconfigure their overall land-use strategies to adapt to spatial and temporal changes in resource distributions (Kelly, 1992a, 1995; Grove, 2009). We cannot, of course, observe prehistoric socio-ecological systems in action and therefore must rely upon theory-driven analysis of proxy data as the empirical source of behavioral information regarding them.

Here, as elsewhere, the primary behavioral proxies for late Pleistocene hunter-gatherers are the stone artifacts they made, used and discarded and the bones of the animals that they killed, butchered and ate. Although mobile foragers were intimately familiar with the time/space distributions of plant and animal resources, the material remains of these resources are unavoidably restricted to the small 'windows' afforded by excavated archaeological sites that provide data. It is important to keep in mind that Pleistocene archaeological sites are only rarely 'little Pompeiis', moments frozen in time and unaltered by its passage (Binford, 1981). Instead, practically all of them are time-averaged palimpsests of items discarded in the course of activities that accumulated over time spans as long as tens of millennia. Hence, pattern in any particular stratum will reflect those activities most prevalent during the accumulation of that stratum rather than a 'snapshot' of the activities of a particular social group during a single occupation. Given the highly flexible behavioral strategies employed by foragers to respond to the variable distribution of different resources across space, we should expect archaeological remains of Paleolithic hunter-gatherers to co-vary with geographically local and short-term environmental conditions. That said, discrepancies in assemblage size and resolution both within and between sites, site distributions in time and space, and the acknowledged palimpsest character of the samples makes it extremely unlikely that any single level or site can be considered representative of the regional-scale foraging systems and adaptations to climate driven changes in late Pleistocene environments that are the target of this research. In spite of these changes daunting sampling problems, theoretically grounded quantitative analyses of stone artifacts and fauna from these sites can still provide valuable insights into the eco-dynamics of late Pleistocene foragers in the

Romanian Carpathians. Thus, the emphasis here is on human ecology at a broadly regional scale rather than on the activities of hunter-gatherers at any particular place and moment in time. In this respect, time itself is regarded as a 'reference variable' used to measure changes attributed to other causes. It is not, in and of itself, a cause of change. The approach used integrates data from multiple sources and allows us to identify spatially and temporally variable adaptive strategies that are not apparent at the individual sites.

### Proxy data for late Pleistocene eco-dynamics

To address these issues of human biogeography in this region of Europe, I undertook a diachronic study of Late Pleistocene land-use patterns based on 40 assemblages from six sites, assigned by their excavators to Middle Paleolithic (MP), Upper Paleolithic (UP). The geographic locations of these sites extend from the Southern Carpathians to the Bistriţa Valley of the Eastern Carpathians, through the Middle Prut valley of northeastern Romania. They are situated in differing physiographic settings that span mountains (Bordu-Mare cave in Southern Carpathians), uplands (Bistrița Valley sites: Poiana Cireșului, Lespezi-Lutărie, Buda-Dealu Viilor) and plains (Ripiceni-Izvor and Mitoc-Malu Galben). Data recovered from these sites include 162,090 lithic artifacts, 9 bone artifacts, and 11,623 identifiable animal bones 758 bifaces and backed elements (see Appendix B, tables 3-8).

As detailed below I employ a methodology that can be applied to collections from previously excavated sites and irrespective of typological label assigned to the assemblages. This makes it possible to apply the same analytical metricvs to all lithic assemblages and assess spatial/temporal variation in human ecodynamics across the entire Late Pleistocene sequence in this region. This approach has been used effectively to analyze Middle Paleolithic, 'Transitional' M/UP, Upper and Epipaleolithic assemblages from the Mediterranean coasts of Europe and the Levant, as well as the European interior (Barton and Riel-Salvatore, 2012; Barton et al., 1999, 2013; Clark, 2008; Kuhn, 2004; Kuhn and Clark, n.d.; Sandgathe, 2005; Villaverde et al., 1998). All sites included in this study have been excavated using relatively modern techniques and data recording with systematic recovery of artifacts and fauna, and have been published in sufficient detaile for quantitative analysis (Appendix B Tables 1-8). Two of them produced assemblages assigned to both Middle and Upper Paleolithic, while the other four have only Upper Paleolithic assemblages, archaeologically assigned to archaeological techno-complexes spanning the Early Upper Paleolithic (EUP), Aurignacian, Gravettian and Epigravettian. Given the many contradictory discussions over the meaning of the various Upper Paleolithic 'techno-complexes' (Straus 2003, 2005; Clark and Riel-Salvatore 2009) and whether or not they are present in this area it is perhaps better to consider those assemblages predating the Last Glacial Maximum (LGM) as Early Upper Paleolithic (EUP) and those from within the LGM as Late Upper Paleolithic (LUP), instead of 'Aurignacian' and 'Gravettian' (Anghelinu and Niță, 2012; Anghelinu et al., 2012a, 2012b; Clark and Riel-Salvatore, 2009; Noiret, 2009; Straus, 2003, 2005).

One of the six sites is a cave and the rest are open air sites. I have chosen these sites because they have large lithic assemblages, detailed documentation, and because four also have detailed information on faunal remains associated with the lithics - information that is lacking from many other sites. Five of them also have reliable radiometric chronologies (see Appendix B, Table 1). Data upon which this research is based have been gathered by me through the study of the collections from Bordu Mare cave and Ripiceni-Izvor and from published sites reports (Anghelinu et al., 2012b; Bitiri and Căpitanu, 1972; Bitiri-Ciortescu et al., 1989; Bolomey, 1989; Căpitanu et al., 1962; Cârciumaru, 1999; Cârciumaru and Nițu, 2008; Dobrescu, 2008; Nicolăescu-Plopşor et al., 1955, 1957c; Nicolăescu-Plopșor et al., 1966; Paul-Bolomey, 1961; Otte et al., 2007; Păunescu, 1998).

It is important to note that these lithic and faunal assemblages, although indicative of human presence, only become meaningful in the context of an explicit conceptual framework, here HBE and middle-range theory derived from its basic premises (Clark, 2009). Following recent research dedicated to similar goals, I calculated a set of quantitative indices from the raw lithic counts to provide information about prehistoric ecological behavior at a geographic scale (Barton et al., 2013; Barton and Riel-Salvatore, 2012, 2014; Kuhn and Clark, n.d.). These indices characterize land-use strategies, specialization in hunting weapons, and general hunting strategies, which are related to topography, elevation and latitude of site locations. Artifact counts and indices for all assemblages are shown in Appendix B, tables 3-8.

### Land-use strategies

Ethnohistoric literature dedicated to recent hunter-gatherers underscores an important relationship between the spatiotemporal distribution of resources, the mobility of human groups, ant the spatiotemporal distribution of campsites in the landscape. Research that first emerged almost twenty years ago showed that retouch frequency is a robust proxy for land-use strategies because it can be used to monitor individual versus place provisioning to assess the relative duration of site use/occupation (*sensu* Kuhn, 1992, 1995). Modes of provisioning have likewise been linked to variation between residential mobility (moving people to resources) and logistical mobility (moving resources to people) (Marks and Freidel, 1977; Binford, 1980; Kelly, 1992a, 1995; Barton, 1998; Kuhn, 2004; Riel-Salvatore and Barton, 2004, 2007; Popescu et al., 2007; Clark, 2008; Sandgathe, 2005; Barton et al., 2013; Kuhn and Clark, n.d.).

In this way, assemblage characteristics can serve as a proxy for prevalent landuse strategies adopted by Pleistocene foragers responsible for artifact manufacture, use, maintenance and discard (Binford, 1979, 1980, 2001; see also Nelson, 1991). Following Binford (1979), assemblages can be characterized as either ‘expedient’ or ‘curated’, two extremes of a continuum of variation in strategies. Expedient assemblages are often a consequence of logistical mobility in which a central residential base is occupied for relatively long periods of time while task-groups are deployed from it to procure various non-local resources. In contrast, curated assemblages are expected in cases of residential mobility when hunter-gatherer bands move their camps frequently to exploit resource patches and where artifact portability is important. I will therefore refer here to the camps of residentially mobile hunter-gatherers as *residential camps*, and to those of logistically organized foragers as *base camps*. In other words, ‘expedient’ and ‘curated’ assemblages track relative mobility along a continuum in which there is considerable variation, the same kind of variation seen in the periodic moves of foragers known from ethnography (Bettinger, 1991; Kelly, 1995; Riel-Salvatore and Barton, 2004). It is important to note that in the context of archaeological assemblages, instead of living foragers, the terms *expedient* and *curated* do not reflect individual site-occupation events, but rather refer to time-averaged suites of strategies resulting from a palimpsest of occupations, the predominant character of which will dominate the signature of a given archaeological assemblages. That said, there are important differences in the organization of activities in time and space, use of technology, resource patch exploitation, cycles of fission and fusion in group size and composition and social institutions among foragers who primarily engage in logistical as opposed to residential mobility (Binford, 1980; Kelly, 1983, 1992b, 1995; Grove, 2009, 2010). Premo (2012; Barton and Riel-Salvatore, 2014, p. 337) suggests that it might be more realistic to divide the continuum situations into (1) groups that are mostly residentially mobile but occasionally logistical and vice versa, and (2) those that are mainly logistical but occasionally residential, rather than combining the duration of occupation and the site catchment (the distance from the camp traveled to procure resources (Higgs, 1975)].

I use *retouch frequency* to indicate the relative importance of curation of lithic utility through reuse and resharpening, as a proxy for these land-use strategies (see also chapter 2 and references above). As shown in chapter 2 as well as in different other studies, the relationship between the extent to which lithic artifacts were curated and the land-use strategy adopted should show a strong negative correlation between retouch frequency and total lithic artifacts per unit volume of sediment for assemblages recovered from stratified deposits (Riel-Salvatore and Barton, 2004, 2007; Popescu et al., 2007). Figures 4.2 and 4.3 show retouch frequency by artifact volumetric density (AVD), for all sites in the study area. For all assemblages in the sample there is an overall strong negative correlation between AVD and frequency of retouched pieces. This relationship is even more evident when assemblages are divided by geographical region (Figure 4.3). This clear negative correlation between the two measures indicates that retouch frequency can serve as a proxy for land-use in the lithic collections under scrutiny for this research (see also Barton et al., 2013). Given that most of Paleolithic lithic collections are likely time averaged palimpsests of multiple occupations rather than discard assemblages from a single episode of site use, variation in retouch frequency is a proxy for the relative importance of residential versus logistical land-use strategies over some time interval. This does not preclude the possibility that foragers can adopt either mobility pattern during that time interval. The important thing is the dominant pattern.

## Specialized hunting technology

A long research tradition has shown that portability is a very important aspect in the material culture of both residential and logistically organized foragers. Specialized hunting weapons, such as hafted points with microlithic armatures, bone point foreshafts, are highly portable, easily maintainable and reliable in the field (Torrence, 1989; van der Leeuw and Torrence, 1989). Bifaces are also easily maintained and relatively portable, but are also valuable because of their versatility. They can be used either as tools or weapons but also as cores (mostly as flakes cores, but sometimes as bladelet, as it is the case in Japan, for the production of backed microliths, the replaceable component of compound tools) (Clarke, 1979; Andrefsky Jr, 2005, 2009; Bleed, 1986; Bamforth, 2003; Kelly, 1983, 1988, 1992a). Compound complex tools require more effort and time to manufacture, both of which are more likely to be typical of logistically organized foragers who can spend more time at base camps preparing for the anticipated requirements of periodic resource forays. It is important to note that such tools are usually used in long distance forays, where prey may be field processed to bring to the residential basecamps only the anatomical parts of maximum utility (Metcalfe and Barlow, 1992; Barton et al., 2013).

To account for all this I combined the frequency of microlithic backed pieces, bone artifacts and bifaces into a composite index of specialized technology called *technological specialization / portability index* (TSPI), to indicate the importance of logistical resource forays relative to local more expedient resource acquisition. This is calculated as the sum of backed pieces plus bone artifacts plus bifaces divided by the sum of all lithics. While it is acknowledged that both kinds of resource extraction are practiced by many foragers, this index is used here as a proxy for the relative importance of logistical forays (see Barton et al. 2013).

### Relating proxies and ecological behaviors

Production of specialized technologies should also be associated with basecamps, while in-field maintenance of these artifacts would be more common at resource acquisition camps (e.g. bladelet cores, crested blades, core tabs, versus backed bladelets (Neeley, 1997; Neeley and Barton, 1994). It is therefore expected that one should find a correspondence between proxies for higher mobility camps and higher values of the technological specialization / portability index (TSPI) (see also Barton et al., 2013).

As can be seen in figure 4.4, these predictions are supported empirically for retouch frequency and TSPI ($R = 0.50$, $p = 0.007$ for all sites together). However, the pattern is even more interesting when the assemblages are grouped by industry (MP, $R = 0.06$, $p = 0.89$; EUP, $R = 0.72$, $p = 0.08$; LUP, $R = 0.96$, $p < 0.001$). Except for the Middle Paleolithic assemblages where the TSPI is very low in all assemblages, the correlations are strongly positive and highly significant statistically, especially for the LGM assemblages. When sources of sampling error are taken into account (i.e., sample size, variation in data recovery techniques, the simple nature of the indices themselves and the fact that different measures give results that are consistent with one another), a value of $\alpha = 0.10$ is considered sufficient to indicate the level of confidence in the statistical trends noted here (Cowgill, 1977).

An interesting trend can be seen when the land-use and TSPI are grouped by topography (i.e. plains, uplands, and mountains) (Figure 4.4c). There is no covariance between these indices in the plains (i.e. Ripiceni-Izvor and Mitoc-Malu Galben), including both MP and UP assemblages), but the results are highly significant for assemblages in the uplands ($R = 0.87$, $p = 0.0005$) and in the mountains (i.e., a single EUP layer at Bordu Mare), again across cutting MP and UP assemblages.

Keeping in mind that these sites and levels are palimpsests, these statistics show how behavioral and ecological factors can influence the composition of discard assemblages at these Late Pleistocene sites (see also below).

## Geographic variables

It would be ideal to have-‘fine-grained’-paleoenvironmental data at the sites involved in this study that could be used for comparative purposes, given that human foragers’ ecological behaviors are affected by a number of environmental variables. However, modern environmental data cannot be used as proxies for past ones and modeling aspects of past terrain landforms and vegetation have not, yet attempted in the region. However, there are several kinds of geographic data that can provide an indication of spatial variability that are amenable to archaeological analysis (see e.g. Riel-Salvatore et al. 2008 for the Romanian Southern Carpathians). For all the sites I measured elevation above sea level, and grouped the sites by topography: mountains of the southern Carpathians, uplands of the Bistriţa Valley, and plains in the Prut River valley.

## Results

### *Land-use strategies*

Retouch frequency shows a positive correlation with elevation for the UP but not the MP (Figure 4.6a) ($R$= 0.391, $p$= 0.01, for all sites together; $R$= 0.01, $p$= 0.9834, for MP; $R$= 0.4754, $p$= 0.0274 for EUP; $R$= 0.39, $p$= 0.004, for LUP). Signifficant differences in retouch frequencies are also associated with regional topography (figure 4.6b, Anova, $F$= 3.447, $p$= 0.025. Regionally there are clear differences between MP and UP lithic assemblages from the Middle Prut Valley, (plains) on one hand and MP and UP from the Southern Carpathians (mountains) and the Bistrița Valley (uplands), on the other (Figure 4.6b). The variance in retouch frequency increases with altitude for the UP but not for the MP (ANOVA, $F = 5.92$, $p = 0.02$).

This trend indicates that during the UP there are both base camps and residential-like camps at higher elevations but mostly base camps at lower altitudes. MP groups on the other hand seem to be using both low and high elevations in similar ways, that is, mostly logisticaly base camps. In contrast to other regions where the same kind of analysis has been applied (e.g., the Iberian Peninsula [Barton et al., 2013]), sites at lower elevations are increasingly dominated by lower mobility, longer residence times and logistical provisioning. On the other hand when these assemblages are grouped by industry (i.e. MP, EUP or LUP, Figure 4.6c) there are no significant differences among them (ANOVA, $F= 0.6609$, $p= 0.5224$). The regional topographic analysis support this assessment (Figure 4.6b). Plains sites within the Prut Valley region, are dominated by logistical organization, irrespective of assignment to the MP or the UP albeit with some variation in the importance of individual and place provisioning (visible mainly in the MP layers at Ripiceni-Izvor; see also, chapter 2). Localities with short term occupation could be either targeted-resource foray camps *or* evidence for general residential mobility. Importantly, variation in the use of localities for base camps or short temr camps exist not only between sites but also within them (Figure 4.6a). This is especially for the plains sites of Ripiceni-Izvor and Mitoc-Malu Galben, a pattern that again cross-cuts assemblage assignment as MP or UP.

Analysis of variance can help evaluate and visualize these relationships (Figure 4.7). The pattern for increasing retouch frequency in higher elevation sites is clear, but the pattern is not linear, and there is significant variation *within* both MP and UP. Most of the variation at Ripiceni-Izvor (elevation 100 m) is due to the shorter occupations represented in the two earliest MP assemblages (MI and MII and later MVI), and EUP (see also chapter 2). The frequency of retouch increases with elevation (of 400 meters) (LUP assemblages from the Bistrița Valley Lespezi, Buda, Poiana Cireşului), only to decrease again with the MP assemblages from Bordu Mare cave in the mountains (elevation 685 m), where the retouch frequency declines to the level of the lowland MP assemblages from Ripiceni and Mitoc.

*Specialized technologies*

The index of specialized technologies is positively correlated with evidence of short-term camps and also significantly co-varies with both elevation and topography (Figure 4.5a-b, 4.8a-b), but it does not co-vary with lithic industry (Figure 4.8b). This index exhibits a peak in its values in the uplands at around 400 m with the LUP assemblages from Poiana Cireşului and Lespezi (Figure 4.5a-b), suggesting that both land-use strategies and weapons' maintenance are more associated with particular ecological contexts and the landscape itself, than with different archaeologicall defined lithic industries. Neither land-use atrategies nor specialized / portable technologies show any trends that differentiate the Upper Paleolithic as a whole from the Middle Paleolithic, but rather co-vary with geographical and landscape factors (Figure 4.8a; ANOVA $F$= 7.5938, $p$= 0.0015). The most apparent differences in the discard of the lithic components of specialized

/ portable technologies (indicating maintenance of these weapons), are between plains assemblages (e.g., from Ripieni-Izvor and Mitoc-Malu Galben) on one hand and those from the uplands and mountains on the other hand (Buda-Dealu Viilor, Lespezi-Lutărie, Poiana Cireșului, in Bistrița valley; Bordu Mare in the Southern Carpathians).

*Temporal dynamics*

The lack of significant temporal change in Late Pleistocene eco-dynamics in these regions of Romania is apparent in figure 4.9a-b, although we are dealing with a coarse-grained temporal framework because of few radiocarbon dates (especially if the MP at Ripiceni-Izvor goes back to MIS 6 [see Chaper 2]). Figure 4.9a-b shows the variance of retouch frequency by geochronological framework. No statistically significant time trend in these two proxies is revealed. Variation does exist, as shown in the results shown above and in the previous chapter, but that variation is associated with ecological context rather than chronology or techno-typological assignment of the assemblages.

Even if we take into account the small sample sizes, the amount of vectored temporal change throughout the late Pleistocene seems limited. This apparent stability for long-term in human ecology over a span of tens of thousands of years, noteworthy, considering the amount of environmental change experienced in glaciated landscapes to the north and in mountainous areas. It seems that human socio-ecological systems appear to have been sufficiently flexible and resilient to be sustained with little apparent change. Although the incresased use of specialized / portable technologies seems, to some extent, to correspond with large-scale environmental shifts associated with the LGM, it still appears to a variable extent throughout the Late Pleistocene. It may be that we are dealing here with a combination of responses to changes in the human niche and geographically driven environmental characteristics.

## Discussion

In this study of spatial-temporal change in the socio-ecological systems of late Pleistocene hunter-gatherers in the Carpathian basin writ large, I have synthesized data from 40 Paleolithic assemblages recovered from six archaeological sites in this extensive and variable geographically region. Rather than focusing on a more traditional approach largely dependent on intuitive interpretations of selected features of lithic assemblages, I have followed a theory-based approach, from which I have devised a number of quantitative indices of several key dimensions of hunter-gatherers ecological behavior: (1) land-use strategies (i.e. mobility and settlement), and (2) subsistence technology. I have also proposed that those indices, which I calculated from assemblage-scale archaeological data, should co-vary in particular ways consistent with the core tenets of ecological theory.  In general, they met those expectations for the data available for this study, providing statistical support for their reliability as proxies for ancient ecological behaviors. It is important to note that the results presented here, although not necessarily identical in their outcomes, indicate that some of these measures, originally developed for a very different area (Mediterranean Spain,) are a powerful and effective way to study these aspects of human socio-ecology during the Pleistocene (see Barton et al. 2013 for more details).

Grounded in a holistic perspective on forager social organization and supported by robust quantitative data, the results generated by this approach offer new and exciting opportunities to examine the relationships between ancient ecological behavior and the environment across space and time. Moreover they can be adapted for other space-time parameters and for different levels of sociocultural complexity. The results of this research also square with prior work targeting similar sets of questions related to the dynamics of late Pleistocene human ecological systems, and thus offer support for the methodological rigor that underpins the approach, situating it in the regional context characteristic of all forager adaptations (Barton, 1998; Clark, 1992; Barton et al., 2013; Popescu et al., 2007; Riel-Salvatore et al., 2008).

The analyzes of spatial and temporal variation of the proxies for land-use strategies and technological specialization indicate that, in these area of the Carpathian Basin, settlement and subsistence systems follow several patterns. They were anchored by basecamps located at both lower and higher elevations in the landscape for most of the MP. The UP continues this pattern of mostly logistical base camps at lower altitudes, but with evidence of both place provisioning and individual provisioning organized occupations at hgher altitudes. There was an increasing variation in land-use with elevation for the LUP. Faunal assemblages in all sites where NISP data are available, irrespective of whether they were classified as residential or logistical, show that hunting practices targeted toward large and medium-sized herbivores (mostly reindeer and horse), available in large herds and in close proximity to the sites. Although small game (e.g. hare, rabbits) might also have been exploited, inherent problems with recovery techniques in old archaeological collections rendered it largely invisible. Taken at face value, the small species constituted only a very small part of the foragers diet (Appendix 3, tables 3, 5-7). Overall, the measures of covariance indicate that, throughout the whole sequence, the assemblages co-vary primarily with geographical and environmental characteristics. In the extent to which it is possible to determine significant emporal change, it is between the pre-LGM MP/EUP, on the one hand, and the LGM / post-LGM LUP on the other. There are no indications of abrupt changes coincident with the MP-UP boundary or related to the biological differences across the MP and UP transition. The assemblage-scale changes that are apparent might better represent cumulative cultural learning and technological innovation *within* the morphologically modern humans lineage (Hill et al., 2009; Richerson and Boyd, 2000; Richerson et al., 2009).

That said, further testing aimed at the recovery of new data with more precise controls is clearly warranted. Any effort like this cannot resolve all, or even most, of the issues of human adaptation to long-term environmental challenges in the Carpathian Basin over the 130,000 years that constitute the late Pleistocene, but it throws into sharper relief many of the problems and questions related to forager adaptations in 'deep time.' Other sites exist in the region and are available for future study. In addition to presenting substantive results, my intent is to highlight the efficacy of alternative approaches to the study of old collections, and to advocate for a more powerful, theory-grounded suite of methods than the time-honored but very limited typological systematics in use for more than a century.

## Conclusions

In this chapter I used a large data set of Paleolithic assemblages to integrate evidence pertaining Late Pleistocene human ecology in three topographically distinct zones of the Carpathian Basin across a very long time span – especially so - if assemblages from Ripiceni-Izvor are indeed as old as MIS 6 (186-127 ka), as suggested by sedimentological data from a nearby site (Tuffreau et al., 2009).

Characterizing the spatial and temporal dynamics of human socio-ecological systems and their contexts is essential to understanding the drivers of coupled biological and cultural evolution. The changes in archaeologial materials documented here are more linked to human ecological responses to environmental change than to prehistorian-defined archaeological constructs. It is important to emphasize that, while other aspects of technology and typology might have changed over this long interval, fundamental aspects of the hunter-gatherer way of life – mobility and landuse – varied continuously over time within all these assemblages and not just between them.

Analysis of the Middle and Upper Paleolithic strata from these sites show that the lithic industries were different *not* because of biocultural differences in technological organization, landuse strategies, and organizational flexibility. Instead the evidence suggests that technoeconomic strategies, the intensity of artifact curation and how foragers used the land appear to have been more closely related to changing environmental conditions, task-specific activities, and duration of occupation. This agrees well with the results of studies conducted in other areas using similar variables and methods (Barton et al., 2013; Clark, 2008; Sandgathe, 2005) and with those predicted from theoretically-derived models based on evolutionary ecology ((Holdaway and Douglass, 2011). Given that human-environment interactions are mediated by technology, which conditions behavioral responses to ecological conditions as well as to resource abundance and availability, this is perhaps unsurprising and is, in fact, expected under those models. This leads to the conclusion that human landuse effectively changes the environment of selection for hominins and their lithic technologies, an important component of the interface between humans and the natural world. In other words, foragers move across the landscape in comparable ways in very different ecological settings, cross-cutting both biological morphotypes and prehistorian-defined analytical units (Clark and Riel-Salvatore, 2006, 2009).

This study also underscores the use of retouch frequency as a proxy for studying the linked relationships between technological organization and flexibility in techno-economic choices, mobility and landuse. The method itself has also been validated and shown to be a useful tool in many quite different archaeological contexts. It can be applied to different data sets, collections of variable quality and resolution, and it is not restricted to particular geographical, ecological, topographic and/or cultural circumstances.

I do not claim that there are no behavioral differences in human adaptation in this part of the world over the course of the Late Pleistocene but those differences most notable in the archaeological record appear to be primarily within, and not between, the analytical units defined by conventional systematics (see also discussions in Nejman, 2008, 2011; Riel-Salvatore et al., 2008; Shea, 2011). Conventional systematics tell us relatively little about fundamental behavioral differences in how technology was organized and how it articulated with landuse and mobility. Forager adaptations in some parts of Eastern Europe appear to have varied independently from the analytical units defined by the conventional techno-typological systematics used in the region for almost a century. Pattern similarities and differences between the MP and the UP do occur, of course, but more important are changes within them. If we consider these data in their broader ecological and climatic contexts, they allow us to rethink the dichotomy between MP and UP as only a segment in a longer and more complex sequence of events that leads to the fundamental shift in technological organization that took place during the LGM and the Tardiglacial.

Although new data systematically recovered with modern techniques are very important, it is equally important that theory driven, quantitative analyses of existing collections already stored in museums and universities be carried out. Unearthing new collections of stones, bones, and ceramics cannot by themselves resolve the important issues with which prehistoric archaeologists must contend unless they are theory driven and methodologically appropriate. Put another way, 'data' in and of themselves cannot be understood independent of the conceptual frameworks that define and contextualize them (Clark, 1993, 1999, 2003).

That said, just as any scenario derived from theory-based analyses of archaeological data must be tested with new data, the models presented above must also be tested against new data because an empirically derived model cannot be tested with data upon which it is based. One can hope for the future that more projects will develop along these lines and that new research on both older and new collections will shed more light on the understanding of long-term variation of human behavior in 'deep time.'

Figure 4.1. Geographical position of the sites discussed in text.

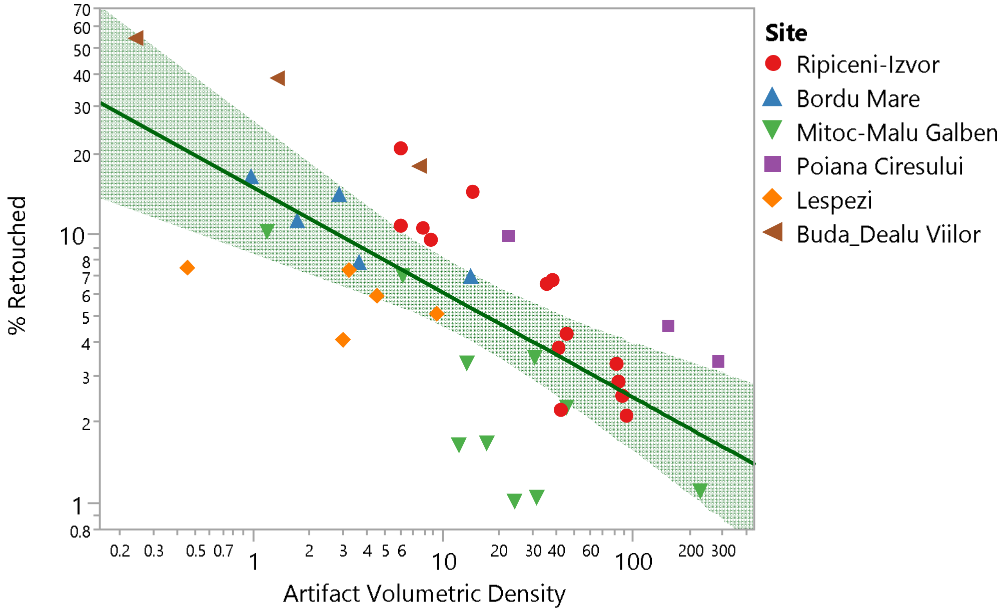


Figure 4.2. Covariance between Retouch frequency (retouched pieces / total lithics) and Artifact volumetric density (AVD) for all sites analyzed in text. *R* = - 0.68, p < 0.0001.

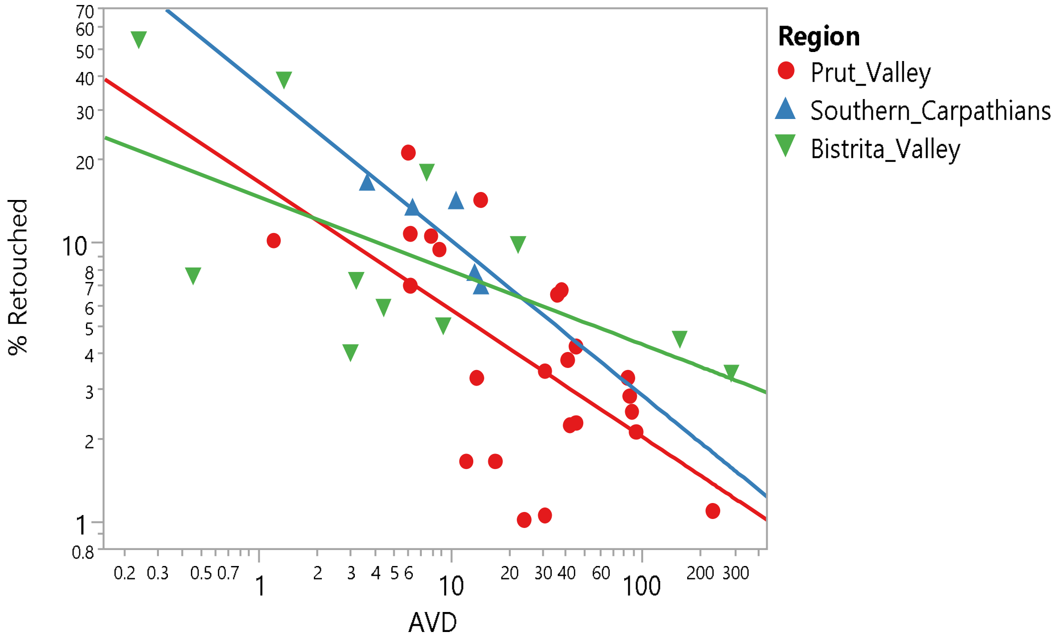
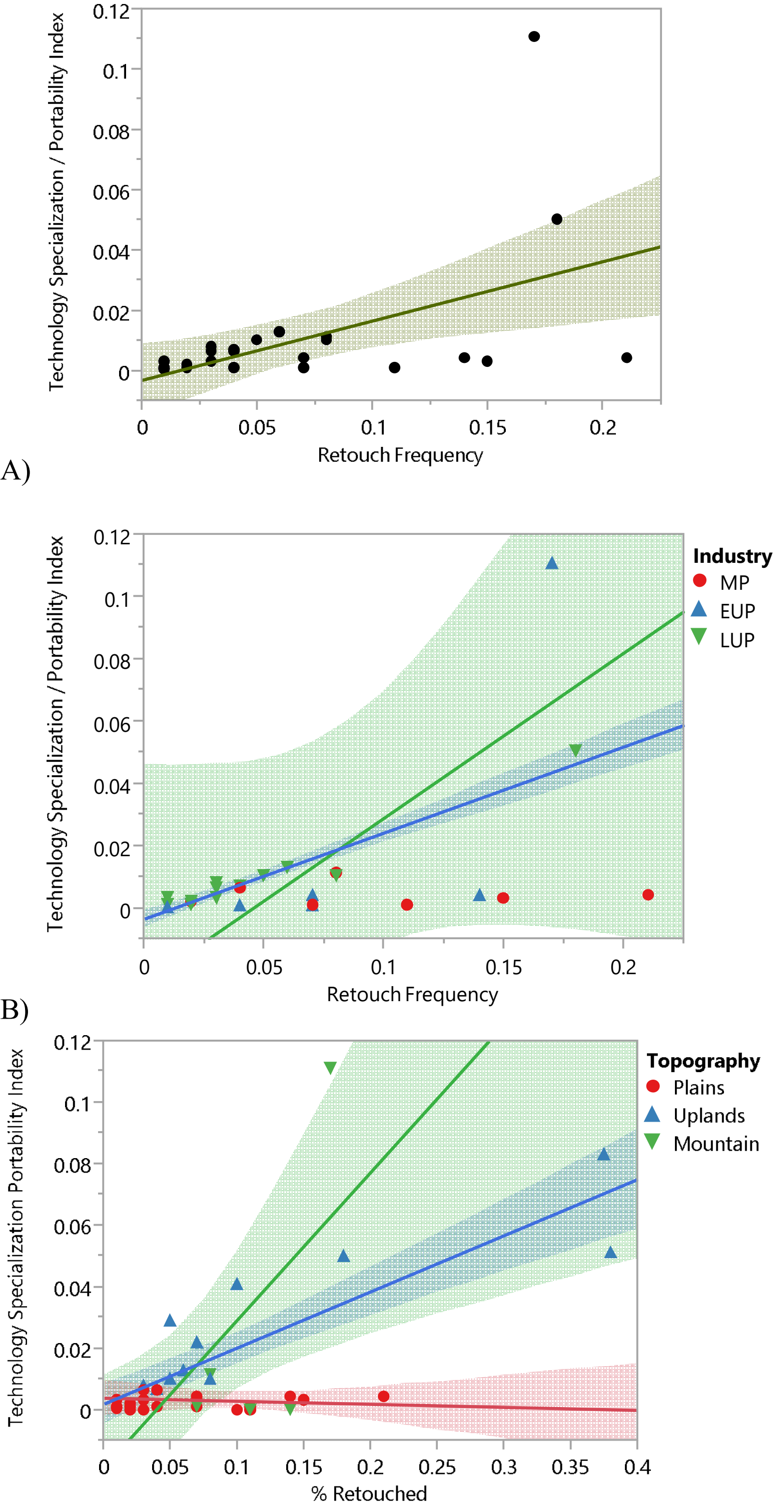


Figure 4.3. Retouch frequency (retouched pieces/total lithics) by Artifact volumetric density (AVD) for all sites by region. *R* = 0.68, p < 0.0001, by region. Middle Prut Valley: *R* = -0.622, p = 0.0012; Bistrița Valley: *R* = -0.63, p = 0.0370; Southern Carpathians: *R* = -0.83, p = 0.07.

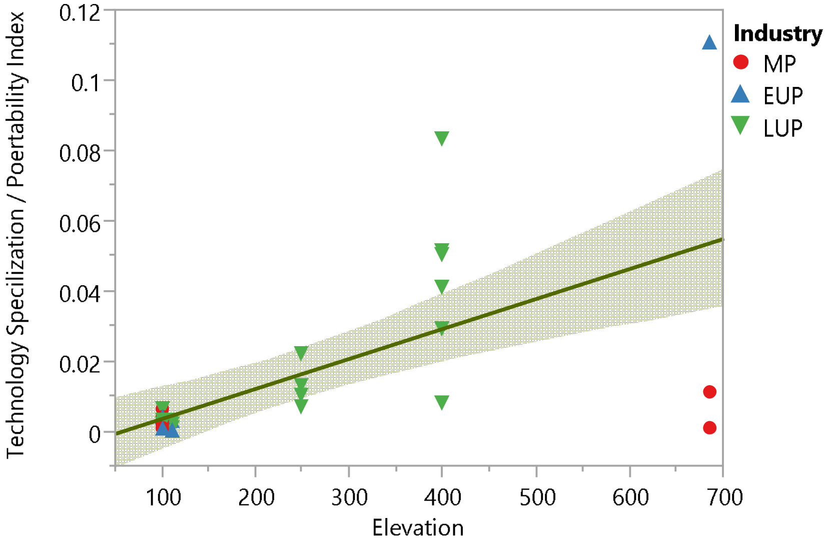


(A)

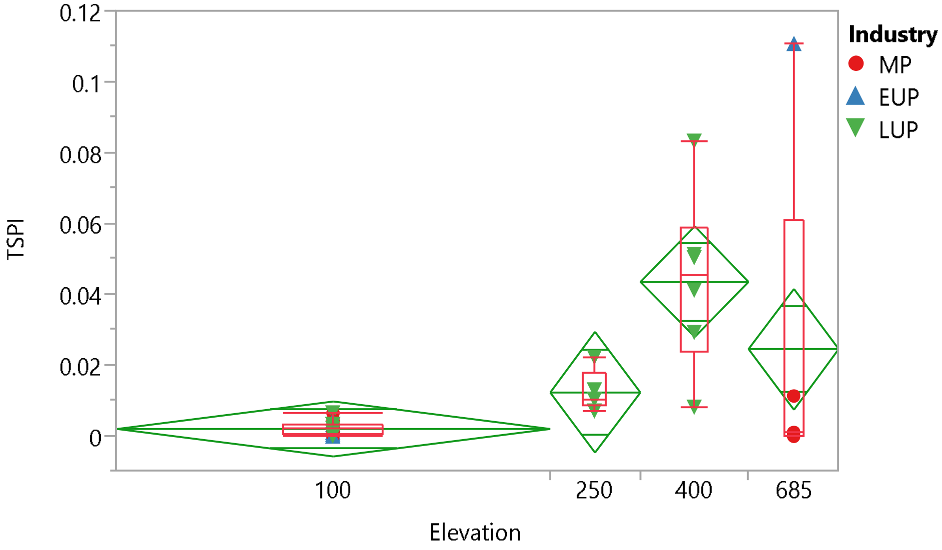
(B)

(C)

Figure 4.4. Covariance among proxies for ecological behaviors. A) Technological Specialization Portability Index (TSPI) by retouch frequency; B) by industry; C) by topography. *R = 0.50*, *p*= 0.007 for all sites together; *R*= 0.06, *p* = 0.89 for MP; *R*= 0.72, *p*= 0.08 for EUP; *R*= 0.96, *p* < 0.001 for LUP.



(A)



(B)

Figure 4.5. Covariance between altitude and TSPI for all assemblages studied in text (A). (B) shows boxplot with ANOVA analysis for TSPI by Altitude: $F = 8.61$, $p = 0.0002$.

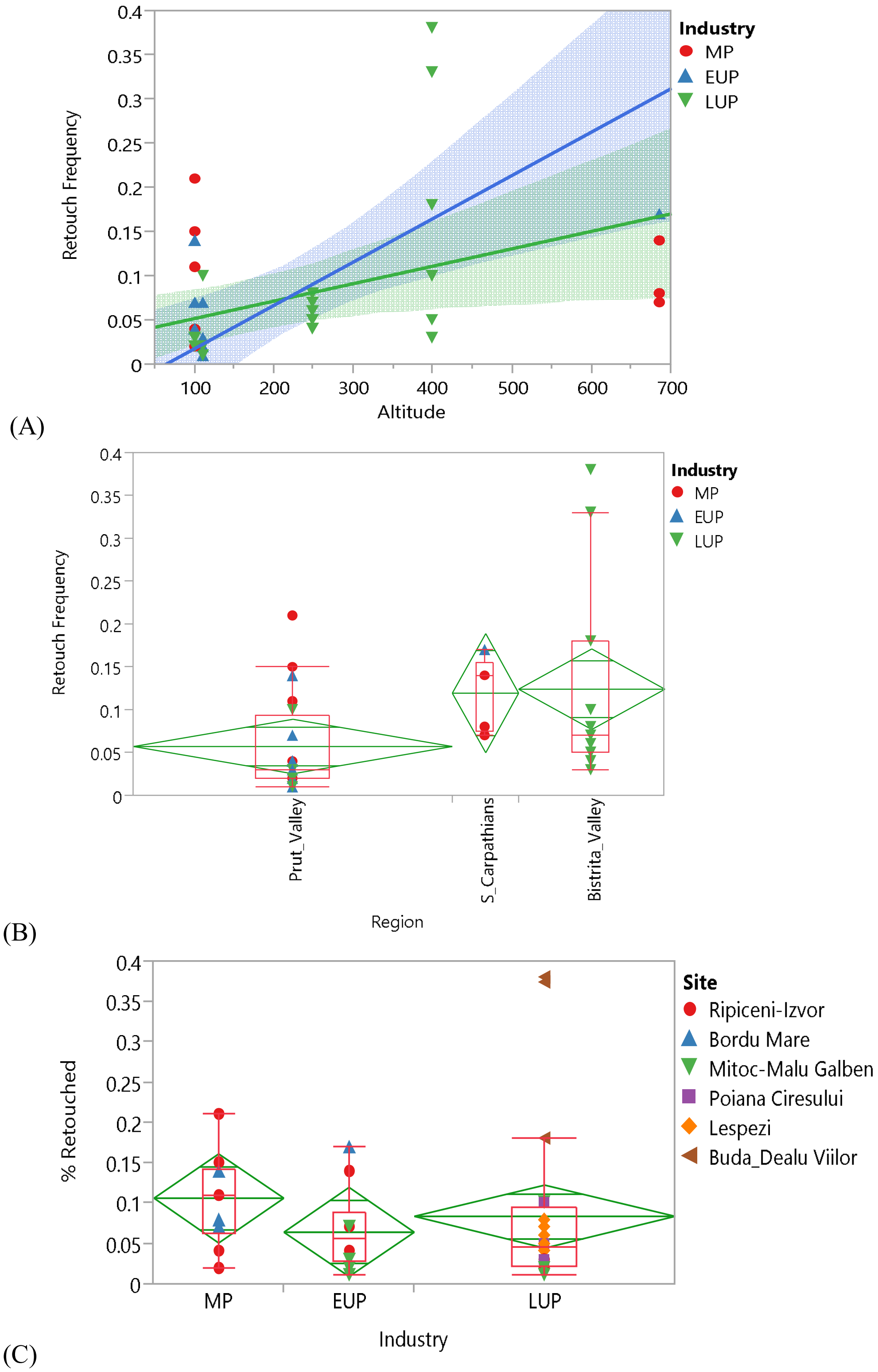


Figure 4.6. Covariance among landuse proxy and elevation (altitude) and geographical region for all assemblages. A) grouped by altitude: *R*= 0.391, *p*= 0.01, for all sites together; *R*= 0.01, *p*= 0.9834, for MP; *R*= 0.4754, *p*= 0.0274 for EUP; *R*= 0.39, *p*= 0.004, for LUP; B) grouped by region: *F*= 3.447, *p*= 0.025; C) grouped by Industry: *F*= 0.6609, *p*=0.5224

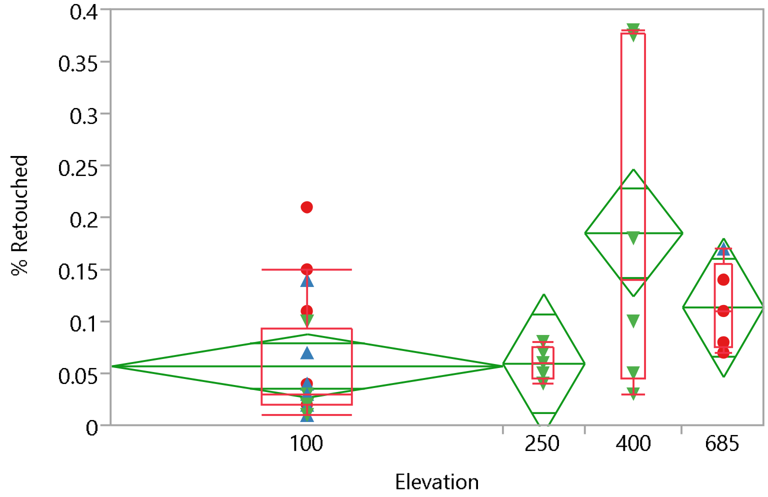
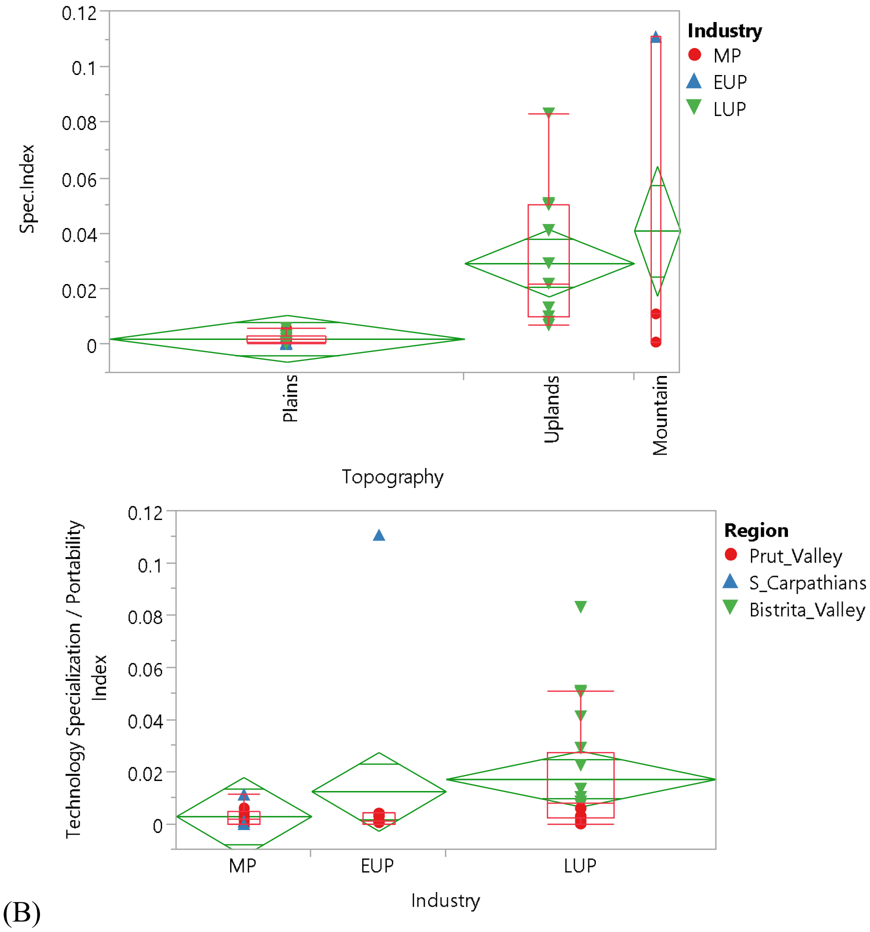


Figure 4.7. ANOVA analysis for the relationship between landuse and Altitude: *F = 5.257*, *p* = 0.004.

(A)



(B)

Figure 4.8. TSPI by topography for all sites discussed in text colored according industry (A): *F*= 7.5938, *p*= 0.0015; and (B) TSPI by Industry, colored according to region.

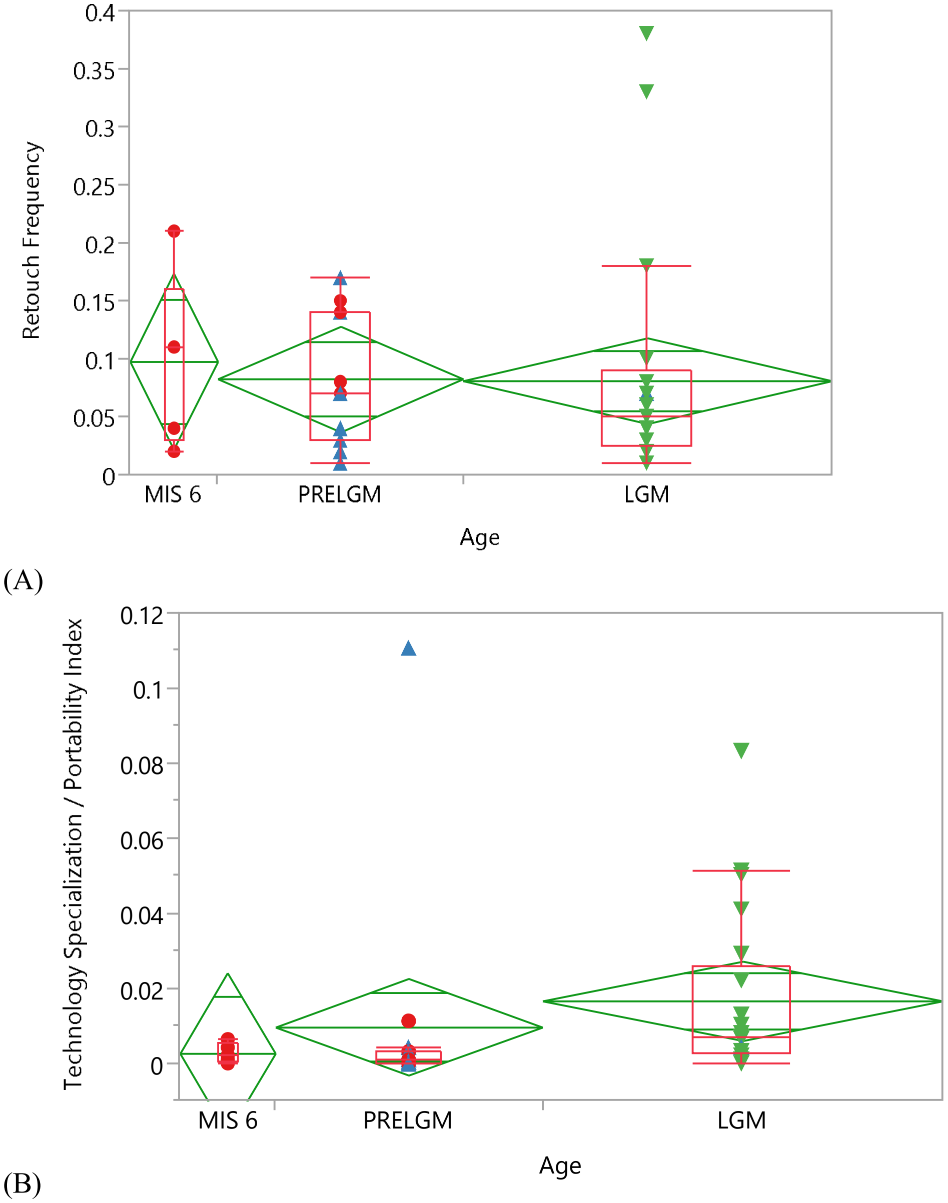


Figure 4.9. Temporal change in ecological behavior proxies for all assemblages grouped by industry. A) Retouch frequency by age; B) TSPI Index by Age.

# CHAPTER 5

## Concluding Remarks

The principal findings of this research are (1) that lithic technology varies independently of lithic typology so that an emphasis on one to the exclusion of the other cannot fail to produce conflicting results; (2) that the lithic and other variables used to monitor human adaptation do not change at the Middle-Upper Paleolithic transition at 40±5 ka, as would be expected if the conventional division between the two prehistorian-defined analytical units were based upon tool typology, rather than measures of adaptation; (3) when correlated changes do occur, they date to the interval between the Early Upper Paleolithic (EUP) (Aurignacian and other early Upper Paleolithic industries) on the one hand, and the Late Upper Paleolithic (LUP) (Gravettian, Epigravettian), on the other; that interval is dated at around 25 ka, some 15,000 years after the generally-accepted date for the MP-UP transition. A novel set of methods (4) (including artifact volumetric density – AVD, layers thickness, Technology Specialization / Portability Index – TSPI, were shown to be an effective way to monitor changes in the mobility and site function. All those methods have wide applications beyond the parameters of this study – in fact they can be used for any excavated site where the incidence of retouched pieces and débitage are recorded, and the volume of sediment excavated can be determined. Taken as a whole, the work supports the hypothesis that significant change occurs at the EUP/LUP transition and the LGM_rather then at the generally accepted MP/UP transition boundary. So far as the notion that modern humans replaced the Neanderthals at that boundary is concerned, it might not matter very much that changes in artifact typology do occur at about 40 ka if the adaptations of Neanderthals and moderns can be shown to be similar until c. 25 ka.

The dissertation attempts to answer a range of questions pertaining to human biogeography, behavioral change, and the ecological meaning of lithic technological variability during the Late Pleistocene in the Romanian Carpathian basin. The previous four chapters (and appendices) have summarized what is known about Late Pleistocene forager adaptation human in Romania, presented the available lithic, faunal and environmental data, and documented the major behavioral traits that took place during that time. Human behavioral ecology and lithic technological organization framed this discussion and proved to be a useful heuristic to approach the dynamics of human biogeography, intimately grounded in its distinctive ecological context. In this chapter I discuss the implications of the analyses presented here for our understanding of the processes by which Pleistocene hunter-gatherers adapted to biocultural and biogeographic changes in the study area. This permits an evaluation of some of the traditional approaches that have been used to interpret Paleolithic assemblages in terms of its human dynamics, and it underscores the importance of detailed regional studies in refining our comprehension of the behavioral and environmental complexities of the transition interval.

In Chapter 1, the Middle and Upper Paleolithic assemblages from six Late Pleistocene sites in the Romanian Carpathian Basin are introduced. In subsequent chapters, I used this large data set to integrate evidence from lithic and faunal assemblages spread across a very long time span and geographical area. On a methodological level, the approach described and employed here and in other various works is a useful method for distinguishing degrees of curation and expediency in lithic assemblages (Barton, 1998; Barton and Riel-Salvatore, 2014; Barton et al., 2013; Kuhn, 2004; Kuhn and Clark, 2015; Riel-Salvatore, 2007; Sandgathe, 2005; Villaverde et al., 1998). The patterns suggest that, rather than varying according to archaeologically defined lithic industries, (often associated with 'archaeological cultures'), behaviors and formation processes, associated with technoeconomic choices strategy, artifact curation intensity and land-use strategies seem more closely tied to environmental variation as reflected in a combination of geography, topography, and paleoenvironmental proxies. These results are very much in agreement with the results of studies conducted in other areas using either the same or other methods (Barton et al., 2013; Hauck, 2010; Kuhn, 2004; Kuhn and Clark, 2015; Nejman, 2011).

Chapter 2 outlines the conceptual framework under which the research was undertaken. It provides a synopsis of the state of the art of current Paleolithic research, at least in the Anglophone research tradition, and is addressed especially to Paleolithic archaeologists in Central Europe. Among the more important epistemological issues in this part of the world are the meaning of the variability in the archaeological record; the analytical utility of the different 'cultural' entities, how they are defined; and what behavioral significance might be assigned to pattern using them, and the overarching ideas about culture process that can be inferred from a rival paradigm, human behavioral ecology (HBE) (Adams, 1998; Anghelinu, 2006; Anghelinu and Niță, 2012; Dobrescu, 2008; Nejman, 2008; Neruda and Nerudová, 2011; Nigst, 2012; Popescu, 2009; Riel-Salvatore et al., 2008; Tostevin, 2007). I have demonstrated how HBE combined with lithic technological organization can help to elucidate these kinds of process questions of interest to many archaeologists in the Anglophone research traditions. This work underscores the fact that if right questions are asked and the appropriate methodology is applied, there is still much information to be gleaned from older collections that can be used to compare with new ones to obtain an integrated body of knowledge relative to prehistoric human behavior. I have shown how principles derived from evolutionary ecology can be used together with technological organization to identify important parameters of forager ecodynamics; to provide better answers to questions related to human behavior in the remote past, its dynamics; how diachronic comparisons can be made within and between sites and regions, employing a powerful and integrated methodology. Such an approach crosscuts, and can vary independently from, explanations for pattern derived from traditional prehistorian-defined Paleolithic systematics.

Chapter 3 presents the methodology I used in my research to provide a clearer understanding of Late Pleistocene formation processes and land-use strategies in the Romanian Carpathians basin. The methodology is exemplified by the study of the Middle and Upper Paleolithic assemblages from the site of Ripiceni-Izvor. I analyze artifact classes per unit volume of sediment rather than tool or blank frequencies (as is the common practice), as well as employ *Whole Assemblage Behavioral Indicators* (WABI), such as retouch frequency, as proxies for land-use strategies.

Correlations between the proportion of usable blanks that were retouched, artifact density, and the comparison of this ratio across the entire Paleolithic sequence at Ripiceni-Izvor, follow expected patterns but there also remains important within-assemblage variation that calls for examination. The occupations represented in the Ripiceni-Izvor assemblages appear to focus on core reduction and flake production, in some cases, and also on the manufacture and resharpening in others, frequently switching back and forth between provisioning and consumption (Kuhn, 1995; Barton et al., 2013; Barton and Riel-Salvatore, 2014). The results show that although tool production and resharpening activities might not have been the main activity at Ripiceni-Izvor, there is a reasonable degree of variation both within and between levels for some of the MP (I-III) and EUP (I-III) assemblages, and that some tool production and resharpening took place throughout the sequence.

As noted elsewhere (Riel-Salvatore, 2007; Barton and Riel-Salvatore, 2012, 2014), LUP core and debris densities, and blank discard, are less variable than in earlier assemblages. However, the overall pattern for both the MP and most of the EUP sequence do not differ greatly so far as general aspects of discard behavior are concerned (e.g., tool and flake production by level, retouch frequency and intensity of reduction) (Figures 3.8-3.10). The fundamental shift in assemblage formation behavior at the site is most evident when either the MP or EUP separately, or the MP and EUP combined, are compared with the LUP 'Gravettian' occupation. This marked difference is, in fact, documented in most of the analyses in this study. In other words, the major differences in lithic technology and human ecology is not between the MP and the EUP, but rather between the LUP (= Gravettian) and everything else.

The analysis of Middle and Upper Paleolithic strata from Ripiceni-Izvor suggests that technoeconomic strategies, artifact curation intensity and landuse appear to have been related to changing environmental conditions, task-specific activities, and duration of occupation. This agrees well with the results of studies conducted in other areas using similar variables and methods (Sandgathe, 2005; Clark, 2008; Barton et al., 2013) and with those predicted from theoretically-derived models based on evolutionary ecology and computational / mathematical modeling (Barton and Riel-Salvatore, 2014). Given that human-environmental interactions are mediated by technology, which conditions behavioral responses to ecological conditions as well as to resource abundance and availability, this is perhaps unsurprising and is, in fact, expected under those models. In other words, both Middle and Upper Paleolithic foragers moved across the landscape in comparable ways in very different ecological settings, cross-cutting both biological morphotypes and prehistorian-defined analytical units (Clark and Riel-Salvatore, 2006, 2009).

Chapter 3 also underscores the use of artifact volumetric density and retouch frequency as proxies for studying the linked relationships between formation processes, technological organization, and flexibility in techno-economic choices, mobility and landuse. The WABI methodology is shown to be a useful tool in collections of variable quality and resolution, and it is not restricted to particular geographical, ecological, topographic and/or cultural circumstances.

Although there are indeed behavioral differences in human adaptation in Eastern-Central Europe over the late Pleistocene, they appear to have varied independently from the analytical units defined by conventional techno-typological systematics used in the region for almost a century. The more important changes in MP and UP assemblages are within these analytical units rather than between them. If we consider these data in their broader ecological and climatic contexts, they allow us to rethink the MP and UP as only a segment in a longer and more complex sequence of events that lead to the fundamental shift in technological organization that took place during the LGM and the Tardiglacial. This fundamental shift is documented by the record at Ripiceni-Izvor. One can hope that in the future more projects grounded in these methods and using these variables will develop along these lines of evidence and that new studies of both old and new collections will help to advance our understanding of long-term variation in hunter-gatherer adaptation.

Chapter 4 synthesizes the results of the larger group of 40 assemblages from six sites with respect to hunter-gatherer land-use strategies in Romanian Carpathians basin and its adjacent areas (Figure 1). To do this I used evidence from the lithic assemblages in three topographically distinct zones derived from 40 levels or strata across a very long time span (Anghelinu et al., 2012; Păunescu, 1998, 1999). The results encompass a description of the spatial and temporal dynamics of socioecological systems and their contexts essential to understanding the drivers of coupled biological and cultural evolution. The changes I documented are linked to human ecological responses to environmental change rather than to prehistorians-defined archaeological constructs. While other aspects of technology and typology have changes over this long interval, fundamental aspects of the hunter-gatherer way of life – mobility and landuse – varied continuously over time within the studied assemblages and not just between them.

I have shown that describing the spatial and temporal dynamics of human socio-ecological systems and their contexts is essential to understanding the drivers of coupled biological and cultural evolution. The changes I documented are linked to human ecological responses to environmental change rather than to prehistorian-defined archaeological constructs. The emphasis that I made is that while other aspects of technology and typology might have changed over this long interval, fundamental aspects of the hunter-gatherer way of life – mobility and landuse – varied continuously over time within the studied assemblages and not just between them.

Bio-cultural differences in technological organization, landuse strategies, and organizational flexibility were the main drivers for the differences seen in lithic industries. Rather, as the evidence suggests, technoeconomic strategies, the intensity of artifact curation and how foragers used the land were closely tied to changing in environmental conditions, task-specific activities, and duration of occupation. This agrees well with the results of studies conducted in other areas using similar variables and methods (Barton et al., 2013; Clark, 2008; Sandgathe, 2005) and with those predicted from theoretically-derived models based on evolutionary ecology (Holdaway and Douglass, 2011).

My results also underscore the use of retouch frequency and the TSPI as proxies for studying the linked relationships between technological organization and flexibility in techno-economic choices, mobility and landuse. The method itself has been validated and shown to be a useful tool in many quite different archaeological contexts. It can be applied to different data sets, collections of variable quality and resolution, and it is not restricted to particular geographical, ecological, topographic and/or cultural circumstances.

This is not to say that human adaptation did not change over time in this part of the world over the Late Pleistocene. My work shows that that these differences appear to be primarily within, and not between, the analytical units defined by conventional systematics. In some parts of Eastern Europe these aspect of prehistoric life, appear to have varied independently from the archaeologically defined ‘cultures’.

Similarities and differences between the MP and the UP are apparent mainly in the retouched tool component monitor by typology, rather than the ecological behaviors represented by the lithic assemblages. When these data are viewed in their ecological and climatic contexts, they are allowing us to reconsider the MP - UP transition as one segment from a longer and complex sequance of events that culminated with the LGM and Tardiglacial adaptations.

Along with new data systematically recovered with modern techniques, it is esential however, to carry out more theory-driven, quantitative analyses of the collections stored in museums and universities. Unearthing new archaeological collections, although important cannot by themselves resolve the important issues with which prehistoric archaeologists must contend unless they are theory driven and methodologically appropriate. In other words ‘data’ can only be understood only if they are integrated within the conceptual frameworks that define and contextualize them (Clark, 1993, 1999, 2003).

The theory-based, empirically supported models presented in this Dissertation, need to be tested further. There are only a handful of applications but they show promise of new insights, especially compared to those typological approaches that have dominated parts of Europe for more than a century. One considerable strength of the approach is a deductive component manifest in null and alternative hypotheses and the test implications (patterns expected in data if the hypothesis is supported empirically) generated from them. It offers a more secure source of inference than the purely inductive approaches that typify prehistory in general. Lacking any overarching conceptual framework, strictly empiricist approaches are only as credible as the ingenuity of the investigator allows them to be. They can always be overturned by more ingenious interpretations. Thus continued testing of the approaches advocated here is essential. One can only hope that the results exposed in this Dissertation are a step further to the efforts of integrating Paleolithic archaeology in Eastern Europe into the modern-era of human origins, and that more projects will develop along the research protocols advocated here. New, theory-driven research on both older and new collections will shed more light on the understanding of long-term variation of human behavior in ‘deep time’.

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# APPENDIX A

# MIDDLE PRUT VALLEY AREA

## Ripiceni-Izvor

### Location

The Middle (MP) and Upper Paleolithic (UP) site of Ripiceni-Izvor is located in Northern Romania, Botoșani County, on the right bank of the Prut River, at 1.2 km north of Ripiceni village. Beginning with 1980, the site was flooded by the reservoir created by the dam at Stânca-Costești. The site was discovered in early 1900's and was first excavated by N. N. Moroșan in 1929-1930. The most extensive excavations were carried out by Nicolăescu-Plopșor and Al. Păunescu 1961-1964, and then by Al. Păunescu alone, from 1964 through 1981. Al Păunescu has undertaken here vast excavations unearthing 16 occupational layers on a stratigraphic sequence of 12.5 meters depth, on a total surface of approximately half a hectare (Păunescu, 1989a, 1993, pp. 217–218).

### Stratigraphic sequence

Two stratigraphic depictions of the site are available related to the two main excavators of the site (i.e. N. N. Moroșan, and Al. Păunescu). The one used here is based on the work of Al. Păunescu. N. N. Moroșan (Moroșan, 1938, pp. 33–34) excavated in two different sectors of the site, e.g., A and B, which are connected by a narrow trench.

Top to bottom the stratigraphic sequence of Moroşan is as follows:

1. Organic soil carrying traces of Neolithic and proto-historic occupations (0.45 thickness);
2. Loess with humus infiltrations and chalky blocs; contains Neolithic industry in its upper part and Magdalenian at 60-85 cm depth in point B (depth: 0.45 - 1.08 m;
3. Light yellow sandy loess; Magdalenian and Aurignacian industry between 1.50 – 3.00 m, depth (depth: 1.08 – 3.75 m);

4. Light yellow loess with rarely Aurignacian pieces between 3.50 – 4.00 m depth (depth: 3 75 - 4.28 m);

5. Yellow-green loessoide clay with black spots (depth: 4.28 / - 4.69);

6. Dark yellow green compact loessoide clay, with black spots; it represents the upper horizon of a swampy fossil soil; rare lithics belonging to the upper Mousterian (depth: 4. 69 - 5. 29 m);

7. Compact, green gray loessoide clay, pure sandy at certain spots; it corresponds to an inferior horizon of a swampy fossil soil; blackish tint at the upper part; lithic industry of the upper Mousterian (depth: 5. 29 - 6. 29 m);

8. Clay rich in iron oxides (depth: 6. 29 - 6. 74 m);

9. Green violet clay (depth: 6.74 - 7.00 m);

10. Pure sand, starting at 7. 55 m (depth: 7. 00 – 7.85 m);

11. Clayey sand mixed with terrace gravel (depth: 7.85 - 8.15 m);

12. Terrace gravel mixed in certain places with clay and sand; Levalloisian industry (depth: 8.15 – 11. 00 m).

Later, in 1993, Al. Păunescu published his own revised completed stratigraphy, which I present below, from top to bottom, as provided by the author. The letters refer to the lithologic deposits given as legend by Al. Păunescu (1993, p. figure 4):

1. Dark vegetal soil (t to z);

2. Grey dark soil with bioturbation (ş);

3. Loess with humus infiltrations (s);

4. Light yellow loess with bioturbation (r);

5. Reddish loess (p);

6. Light yellow loess with reddish spots (o);

7. Brown-red soil (n);

8. Dark reddish yellow loess with reddish spots (m);

9. Red yellow loess (l);

10. Red brown soil (k);

11. Red yellow loess (j);

12. Red transiting to light yellow soil, with chalky blocks (i);

13. Loess-like clay dark brown, with small chalky blocks (h);

14. Four clayey or sandy lenticles (? f-g);

15. Light brown clay (d-e);

16. Sandy, stratified, reddish-yellow clay (c);

17. Sandy, stratified, green-yellow clay (b);

18. Gravel containing sandy clay and fine sand (a);

19. 'Sarmatien' chalk substrate.

The depth of the deposits in these descriptions goes down to more than 11 meters and the two archaeologists have reached the gravels situated on the upper part of the terrace. Moroșan (1938) remarked in his study that there was no fossil soil in the loess formations, unlike what was known in other localities from the Prut and Dniestr valleys. On the other hand, he noted that for the so called “Magdalenian” industry, there is a perceptible sloping ground and thinning of the layers in between the two zones he excavated (Moroșan, 1938, p. 48). The profile that comes together with Păunescu’s monograph shows a succession of the layers on a very long profile and whose apparent horizontality has been seen as suspicious by some authors (Figure 2) (Cârciumaru, 1995; Noiret, 2009).

Ana Conea (Păunescu et al., 1976, pp. 9–10) has only provided very concise information about the deposits. The lower deposits (circa 3 meters thickness) correspond to alluviums of fine texture, (deposited during a rather humid climate). The upper deposits (circa 7 meters thickness) show loess like characters (deposited most probably during dry conditions, especially for the last four meters). A fossil soil had been identified at the depth of the Mousterian Layer III, indicating the existence of a woodland cover, whereas the superimposed layers (Mousterian IV-V, “Aurignacian” and “Gravettian”) correspond to steppe like conditions. Four bands of organic accumulations are described as remnants of poorly differentiated fossil soils, but whose precise location within the sequence was not described precisely.

Both Moroșan and Păunescu described the archaeological stratigraphy of the sites. Moroșan distinguished four cultural associations (bottom to top): (1) upper Levalloisian industry, more or less reworked in the terrace gravels, which he assigned to the Riss-Wùrm interglacial; (2) upper Mousterian, directly overlaying terrace gravels, of Wùrm I age or immediately after; (3) Aurignacian, between 4. 10 – 3.50 m in depth; The author states that the Aurignacian artifacts were found along with numerous Mousterian pieces, which would have been, according to him, only reused not made by the Aurignacians; (4) Magdalenian, between - 3. 00 m through - 1. 50 m, depth at point A (- 0.80 m in point B because of the sloping and thinning of the depositional layers (Moroșan, 1938, pp. 47–51).

Al. Păunescu (1993, pp. 23–25; 218–219), as well as other authors (Chirica, 1989, pp. 68–69, 2001, pp. 44–47), describe sixteen layers of archaeological accumulations for the site. From bottom to top the sequence goes as follows (see also Appendix A, table 1-2):

1. *Pre-Mousterian* level, reworked, found at the upper limit of the terrace gravel, yielding rolled artifacts and faunal remains (deposit 'a'), between -11 m – 10. 20 m;
2. *Mousterian layer I* between - 10. 20 m - 9. 30 m (deposit 'd') (typical Mousterian of Levallois debitage, rich in scrapers), placed over the terrace gravels (directly overlaying the Pre-Mousterian layer); faunal remains have also been recovered from the layer (see Appendix A table 2);
3. *Mousterian layer II* between - 9.30 m - 8.45 m (deposit'd' and 'e') (typical Mousterian of Levallois debitage) richer in lithic industry and faunal than the preceding one;
4. *Mousterian layer III* between -8.45 – 7.90 m, deposit ('e') and ('h') and between -7.90 m – 6.60 m deposits ('i'), ('j'), and ('k'). Typical Mousterian of Levallois debitage, with 'hearths', faunal remains and richer in lithic industry than both previous layers;
5. *Mousterian Layer IV* between -6.60 m – 5.60 m (deposit 'l') (Mousterian of Acheulean Tradition A, with Levallois debitage), very rich (the richest of all Paleolithic sequence) in scrapers, bifacial forms, leaf points, as well as faunal remains, lithic 'workshops', 'hearths', cores and debitage;
6. *Mousterian Layer V* between -5.60 m – 4.70 m (deposit 'm') (Mousterian of Acheulean Tradition A, of Levallois debitage), also rich in lithic industry, structures, lithic 'workshops' and faunal remains. It is overlaid by sterile archaeological deposits 'n' and 'o' at a depth between -4.70 m – 4.45 m);

7. *Mousterian Layer VI* between -4.45 m – 4.05 m (deposit ‘p’) (Denticulate Mousterian, with Levallois debitage and bifacial forms); the thinnest and poorest in lithic industry as well as fauna. It is followed by archaeologically sterile deposits ‘p’ (upper limit) between -4. 05 m and -3. 50 m;

8. *‘Aurignacian’ levels*, separated into four sub-levels (Ia, Ib, IIa, IIb), all four in deposit ‘r’ (light yellow loess, from -3.50 m through – 2.10 m). Only a few faunal remains have been recovered and several thousands of lithics;

9. *‘Gravettian’ levels*, separated into four sub-levels (Ia, Ib, IIa, IIb), within the dark green loess, mixed with carbonaceous clays, with bioturbation (deposits ‘r’, ‘s’, and ‘ş’), from -2.10 m – through -1.00 m; rich in lithic industry, notably IIb, but yielding only a few very corroded faunal remains.

## Site Features

### *Structures*

Păunescu reported evidence of habitation structures from several of the MP levels at Ripiceni-Izvor (Păunescu, 1965, 1978, 1989b). These structures were found in five of the six MP levels and have been divided into three types. Type A was found in Level II and consisted of a small agglomeration of twenty-two limestone blocks in a slightly arced arrangement (Figure 3). The feature was approximately 2.5 m in length by 0.87 m in width and was approximately 0.40 m deep. Several pieces of charcoal, a mammoth molar, and several other animal bones were found inside the arc, as well as nine pieces of flint, west of the limestone arc. The discoverer interpreted this structure as a lean-to in which the limestone blocks held wooden supports covered by animal hides or brush (Păunescu, 1993).

Type B structure is larger than Type A and was discovered in Level I. It measured 9.7 m in length and ranged from 1.5 – 2.00 m in depth. This structure was roughly rectangular in shape and appears to taper from one end to the other (Figure 4). Inside is more than 30 whole and fragmentary mammoth tusks were found, 36 mammoth molars, 8 rhino molars, and other bone fragments. More than 550 flint pieces have also been recovers in and around this feature. Păunescu (1978, 1989b, 1993) sees in it some sort of magical or religious place based on the apparent random distributions of the material in this feature; i.e. no pattern for a habitation structure can be discerned.

The third type (Type C) was oval in shape and measures 6.75 m in length, 4.5 m in width, and 46 cm thick. This feature seemed to have been the most convincing for a dwelling, and consisting of approximately 70 limestone blocks, 6 mammoth molars, 4 mammoth tusks, charcoal, lithic artifacts and bone fragments (Figures 5-6). In its western half, the feature was devoid of any bone fragments or limestone blocks in an area of 4-5 m sq. but contained numerous lithic artifacts and charcoal pieces, Păunescu reported two cultural levels from this feature, superimposed one over the other, without any sterile layer between them. The first level (lower, Figure 5) was 47 cm thick and contained numerous bone fragments, and a few lithic limestone blocks. One hearth, measuring 90 x 14 x 12 cm, was discovered in this level. In the northeastern edge of this hearth a lithic workshop was found. It delivered more than 5,000 pieces of debitage, from both levels and only a handful o retouched pieces.

Păunescu (Păunescu, 1978, 1993) contends that by comparing those structures stratigraphically, it is possible to observe a change during the MP from simple, temporary dwellings to more elaborate, complex, and most probably, more permanent dwellings. This proposition has never been tested.

Naturally occurring associations of human refuse and mammoth bones may be equally possible as an explanation for those structures at Ripiceni-Izvor. Moreover, the occupational layers at Ripcieni-Izvor, (both geoarchaeological and cultural material) are not snapshots of prehistoric hominins daily lives, but were rather accumulated over many depositional events, both natural and cultural. An alternative explanation for the Ripiceni-Izvor 'dwellings' can be drawn from research in other area, which focused on natural occurrences of modern elephant remains in South Africa (Haynes, 1988a, 1988b). Haynes has shown that elephant mass death sites are common. In their way to these sites elephants habitually trample the elephant bone accumulations, creating cuts and scratches that resemble stone tool cutmarks. Insofar as South African evidence is a good model of mammoth behavior and without other detailed analyses of the faunal remains, one cannot argue that the mammoth remains from the Ripiceni-izvor are either naturally occurring bone accumulations or intentionally produced.

The purported dwellings from Ripiceni-Izvor were excavated long before taphonomy and site formation processes emerged as issues in archaeological interpretation. Although the evidence that Păunescu has offered for habitation structures at Ripiceni-Izvor seems convincing, without critical studies concerning site formation one cannot rule out the role of naturally occurring processes as an alternative explanation.

The situation is different for the UP layers, which have not yielded such elaborated structures. There are only agglomerations of lithics, and limestone blocks that have been described as potential lithic workshops, as well as a single preserved 'hearth', in level Ib (Păunescu, 1989b, p. 134, 1993, p. 131, 134, 136).

**Palynological studies**

Marin Cârciumaru conducted palynological studies during the late 1970's, while the excavation at the site was still on progress (Cârciumaru, 1980, 1989, 1999; Păunescu et al., 1976) (Figure 1). The lithic industries recovered from across the sequence have been placed by Cârciumaru within a chrono-climatic scheme that he established for the Romanian territory in parallel with the climatic events form Western Europe. Although this scheme has been criticized by both Romanian and foreign researchers, it is in general with the faunal data recovered from the site Ripiceni-Izvor (see above, table 2, and Chapter 3 main text) (Allsworth-Jones, 2000, 1986; Păunescu, 1993; Djindjian, 2000).

In respect with the MP layers Cârciumaru considers that the layer I-III may correspond to more favorable, temperate climatic conditions, as shown by the presence of mixed oak elements. This phase is followed by a climate cooling when thermophile taxa decrease and the landscape is becoming more steppe like. It culminates in a following phase where no more soil formations could be observable anywhere in Romanian contexts; the landscape is now generally steppe-tundra like, cold and humid. It is to that cold phase that the MP ensemble IV-V could be assigned. The UP occupations followed after a hiatus of unknown duration and apparently began with a second episode of more favorable climate, whereas the rest of the UP sequence took place under a second interval of by cold and dry conditions, during which the woodland regresses again and it is replaced by tundra like dry landscape. The 'Aurignacian' (EUP) is present during both the more temperate and cold phase, whereas the 'Gravettian' (LUP) is assigned (except for the LUP IV) to the dry cold steppe environment (Păunescu et al., 1976; Cârciumaru, 1989).

One has to note the fact that while Cârciumaru's environmental assertions might be tenable, not the same can be said of the MP chronological assignment for those climatic events, given that the MP occupations may be significantly older, as suggested by analogy with new data from a nearby site whose stratigraphic characteristics are very similar to Ripiceni-Izvor (Doboș and Trinkaus, 2012; Tuffreau et al., 2009)

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# TABLES

Table 1. Summary data for the general composition of lithic assemblages at Ripiceni-Izvor.

| **Site** | **Industry** | **Chronology** | **Thickness** | **Area** | **Volume** | **Total lithics** | **Cores** | **Debitage** | **Retouched Artifacts** | **AVD** | **% Retouch** | **Bifaces & Backed artifacts** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ripiceni-Izvor I | MP | MIS 6? | 0.65 | 285 | 185.25 | 1119 | 48 | 796 | 237 | 6.04 | 21.18 | 4 |
| Ripiceni-Izvor II | MP | MIS 6? | 0.70 | 300 | 210.00 | 1282 | 45 | 1073 | 139 | 6.10 | 10.84 | 0 |
| Ripiceni-Izvor III | MP | MIS 6? | 0.60 | 400 | 240.00 | 1916 | 61 | 1627 | 203 | 7.98 | 10.59 | 2 |
| Ripiceni-Izvor IV | MP | MIS 6? | 0.63 | 1400 | 882.00 | 35890 | 1034 | 33392 | 1361 | 40.69 | 3.79 | 257 |
| Ripiceni-Izvor V | MP | MIS 6? | 0.55 | 700 | 385.00 | 16064 | 355 | 15384 | 340 | 41.72 | 2.12 | 27 |
| Ripiceni-Izvor VI | MP | ? | 0.25 | 150 | 37.50 | 324 | 8 | 261 | 50 | 8.64 | 15.43 | 1 |
| Ripiceni-Izvor A Ia | EUP | PRE LGM | 0.35 | 200 | 70.00 | 1011 | 52 | 814 | 145 | 14.44 | 14.34 | 5 |
| Ripiceni-Izvor A Ib | EUP | PRE LGM | 0.33 | 200 | 65.00 | 2306 | 121 | 2033 | 152 | 35.48 | 6.59 | 7 |
| Ripiceni-Izvor A II a | EUP | PRE LGM? | 0.30 | 300 | 90.00 | 4020 | 184 | 3664 | 172 | 44.67 | 4.28 | 9 |
| Ripiceni-Izvor A II b | EUP | LGM? | 0.30 | 400 | 120.00 | 4534 | 193 | 4035 | 306 | 37.78 | 6.75 | 24 |
| Ripiceni-Izvor Gr Ia | GR | LGM | 0.35 | 225 | 78.75 | 6936 | 211 | 6550 | 175 | 88.08 | 2.52 | 23 |
| Ripiceni-Izvor Gr Ib | GR | LGM | 0.35 | 200 | 70.00 | 6448 | 172 | 6142 | 134 | 92.11 | 2.08 | 14 |
| Ripiceni-Izvor Gr II a | GR | LGM | 0.30 | 230 | 69.00 | 5868 | 121 | 5581 | 166 | 85.04 | 2.83 | 16 |
| Ripiceni-Izvor Gr II b | GR | POST LGM? | 0.35 | 300 | 105.00 | 8632 | 239 | 8107 | 286 | 82.21 | 3.31 | 52 |

Table 2. Summary data composition for the faunal assemblages at Ripiceni-Izvor.

| **Site** | **Industry** | **Chronology** | **Faunal remains** |
|---|---|---|---|
| Ripiceni-Izvor I | MP | MIS 6? | *Equus transilvanicus, Bison priscus, Canis lupus, Megaceros giganteus, Ursus spelaues, Asinus hydruntinus, Mammuthus primigenius* |
| Ripiceni-Izvor II | MP | MIS 6? | *Megaceros giganteus, Bison priscus, Equus transilvanicus, Coelodonta antiquitatis, Cervus elaphus, Crocuta spelaea* |
| Ripiceni-Izvor III | MP | MIS 6? | *Coelodonta antiquitatis, Rangifer tarandus, Megaceros giganteus, Equus transilvanicus, Bison priscus, Mammuthus primigenius* |
| Ripiceni-Izvor IV | MP | MIS 6? | *Mammuthus primigenius, Rangifer tarandus, Coelodonta antiquitatis, Equus transilvanicus, Cervus elaphus, Bison priscus* |
| Ripiceni-Izvor V | MP | MIS 6? | *Mammuthus primigenius, Equus transilvanicus, Bison priscus, Coelodonta antiquitatis, Helix lutescens* |
| Ripiceni-Izvor VI | MP | MIS 6? | Undetermined remains |
| Ripiceni-Izvor AI a | EUP | PRELGM | *Cervus elaphus, Cepaea vindobonensis* |
| Ripiceni-Izvor AI b | EUP | PRELGM | *Equus spelaues,* cf. *cibinensis* |
| Ripiceni-Izvor AII a | EUP | PRELGM | *Bison priscus, Cepaea vindobonensis* |
| Ripiceni-Izvor AII b | EUP | LGM? | *Equus spelaeus* cf. *cibinensis, Cepaea vindobonensis, Helix pomatia* |
| Ripiceni-Izvor GrI a | GR | LGM | *Equus spelaues cf. cibinensis, Cepaea vindobonensis, Unio sp.* |
| Ripiceni-Izvor GrI b | GR | LGM | *Bison priscus, Equus spelaeus* cf. *cibinensis, Cervus elaphus, Cepaea vindobonensis, Helix pomatia* |
| Ripiceni-Izvor GrII a | GR | LGM | *Bison priscus, Equus spelaeus cf. cibinensis, Cepaea, vindobonensis, Helix pomatia, Spalax.* |
| Ripiceni-Izvor GrII b | GR | POSTLGM ? | *Bison priscus, Cervus elaphus, Equus spelaeus* cf. *cibinensis, Sus scrofa, Helix pomatia, Cepaea vindobonensis.* |

Table 3. Summary data composition for the retouched component at Ripiceni-Izvor.

| **Site/Layer** | **Tools : Flakes** | **Scrapers : Flakes** | **Scrapers : Notch & Denticulates** | **Bladelets : Flakes & Cores** | **TSPI[i]** |
|---|---|---|---|---|---|
| M_I | 0.44 | 0.24 | 1.82 | 0 | 0.004 |
| M_II | 0.31 | 0.13 | 1.2 | 0 | 0 |
| M_III | 0.34 | 0.22 | 3.82 | 0 | 0.001 |
| M_IV | 0.3 | 0.19 | 3.93 | 0 | 0.007 |
| M_V | 0.19 | 0.1 | 1.61 | 0 | 0.002 |
| M_VI | 0.52 | 0.15 | 0.45 | 0 | 0.003 |
| EUP_I | 0.53 | 0.11 | 0.33 | 0.05 | 0.005 |
| EUP_II | 0.42 | 0.08 | 0.33 | 0.05 | 0.003 |
| EUP_III | 0.15 | 0.05 | 0.81 | 0.03 | 0.002 |
| EUP_IV | 0.2 | 0.08 | 0.97 | 0.05 | 0.005 |
| GR_I | 0.06 | 0.02 | 1.46 | 0.09 | 0.003 |
| GR_II | 0.05 | 0.02 | 1.96 | 0.1 | 0.002 |
| GR_III | 0.06 | 0.02 | 1.84 | 0.12 | 0.003 |
| GR_IV | 0.05 | 0.02 | 2.21 | 0.21 | 0.006 |

# FIGURES

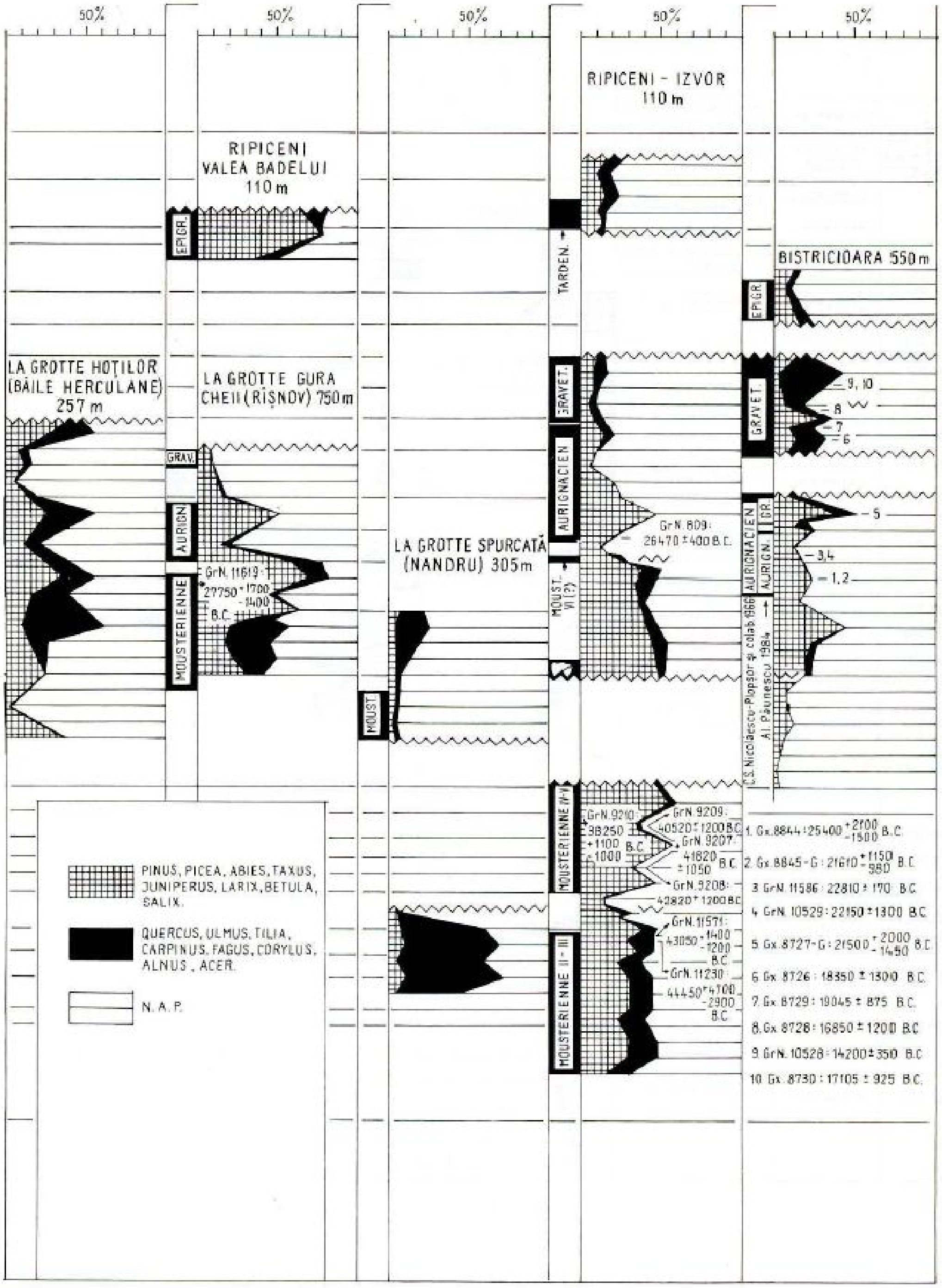

Figure 1. Synthetic pollinic diagrams for the site of Ripiceni-Izvor (Păunescu et al., 1976; Cârciumaru, 1989).

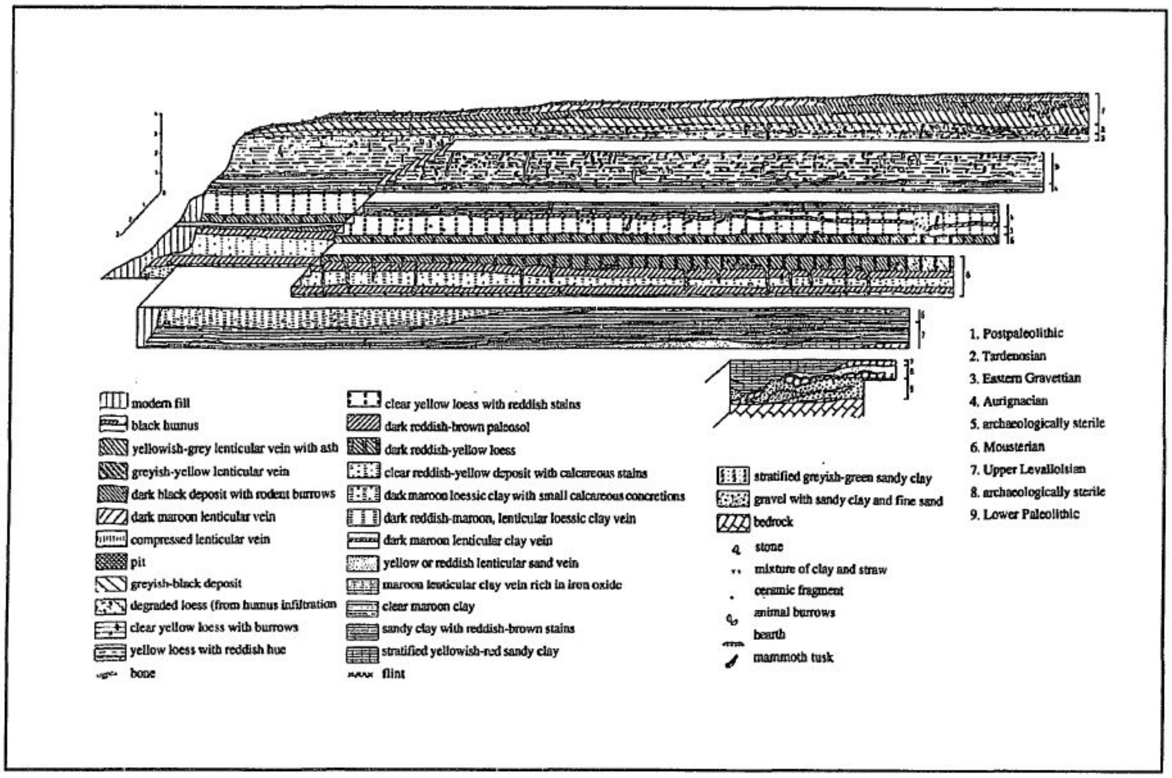

Figure 2. Ripiceni-Izvor, stratigraphic profile (after Păunescu, 1965, 1993).

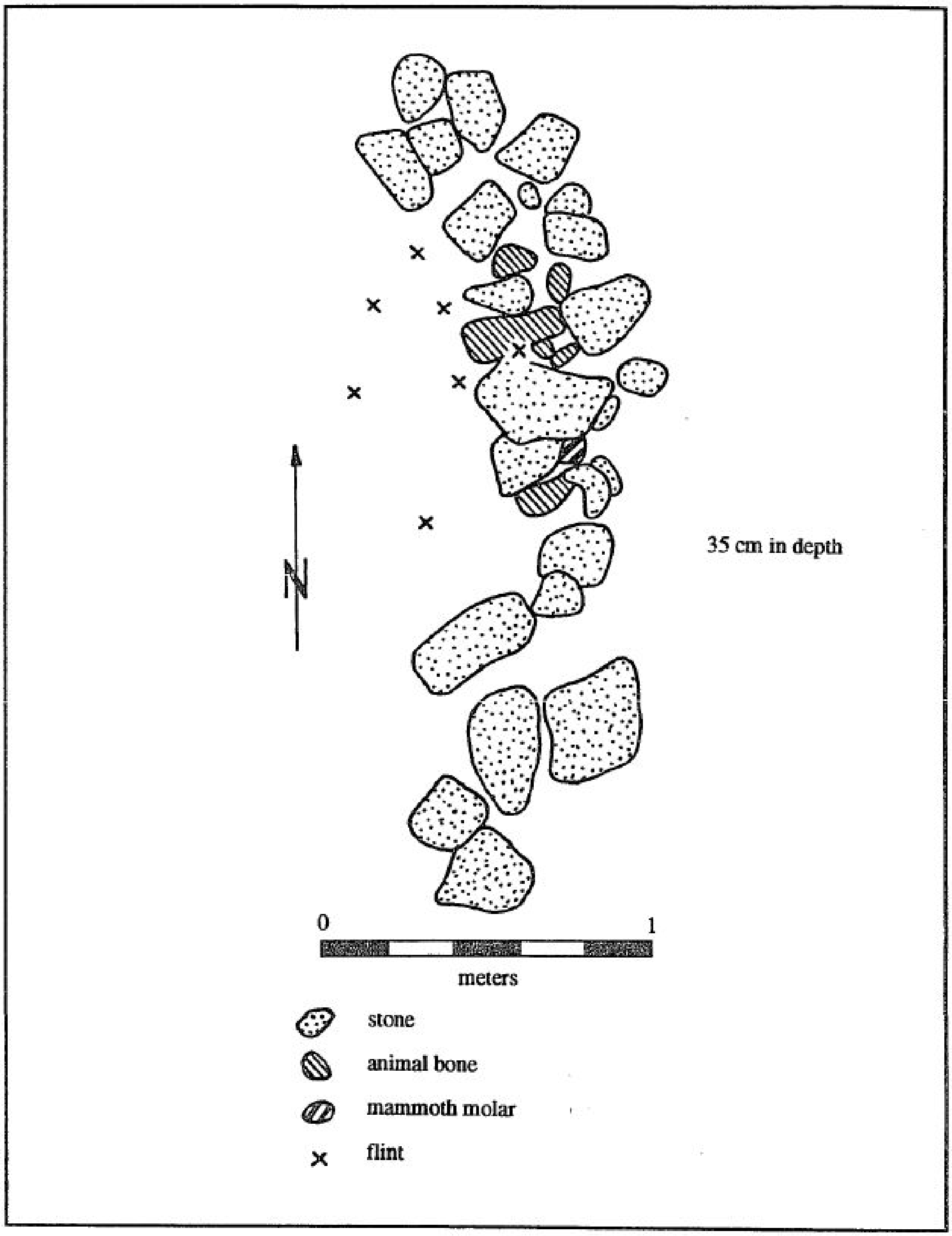

Figure 3. Ripiceni-Izvor, habitation structure Type A (Păunescu, 1965, 1993).

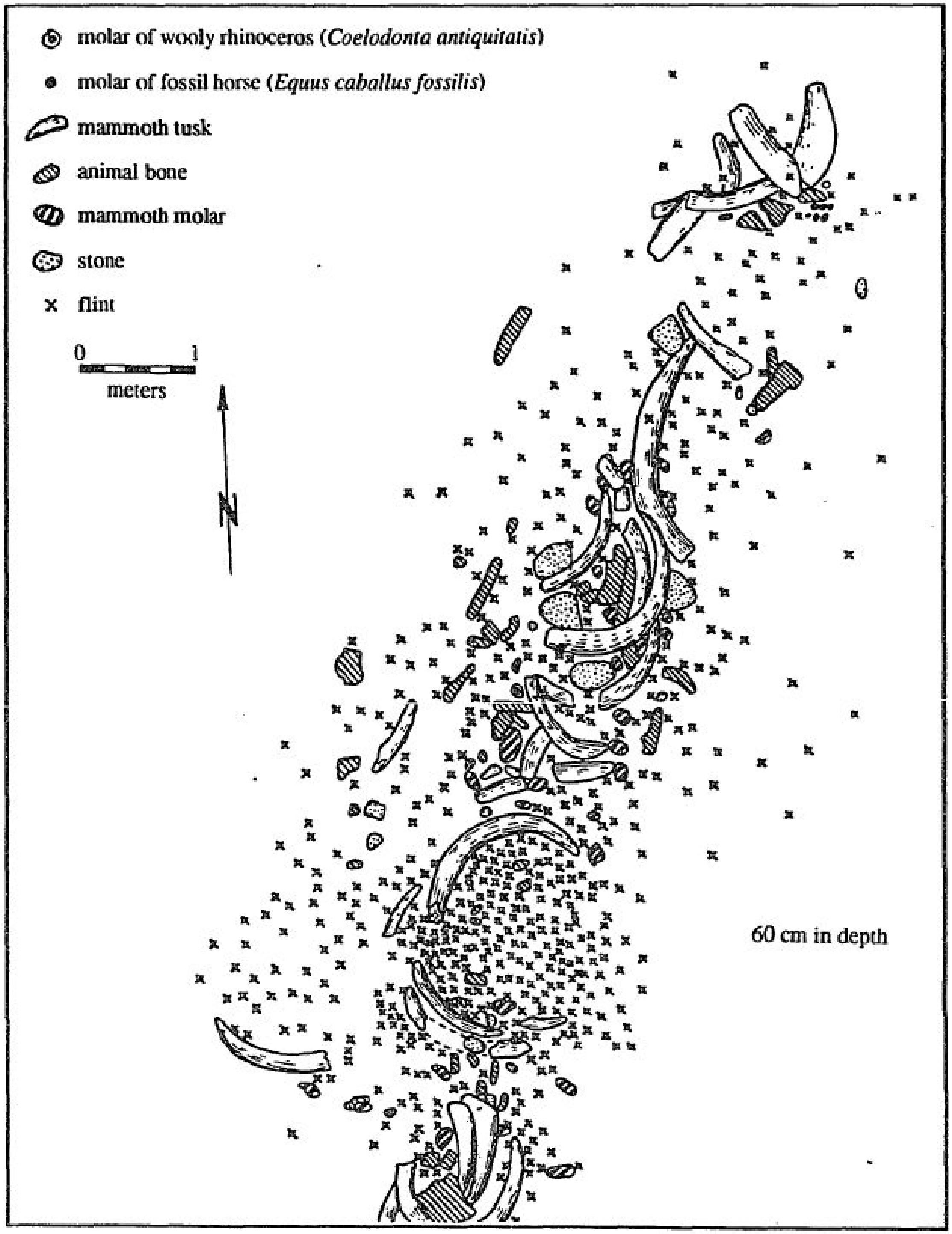

Figure 4. Ripiceni-Izvor, habitation structure type B (after Păunescu, 1965, 1993).

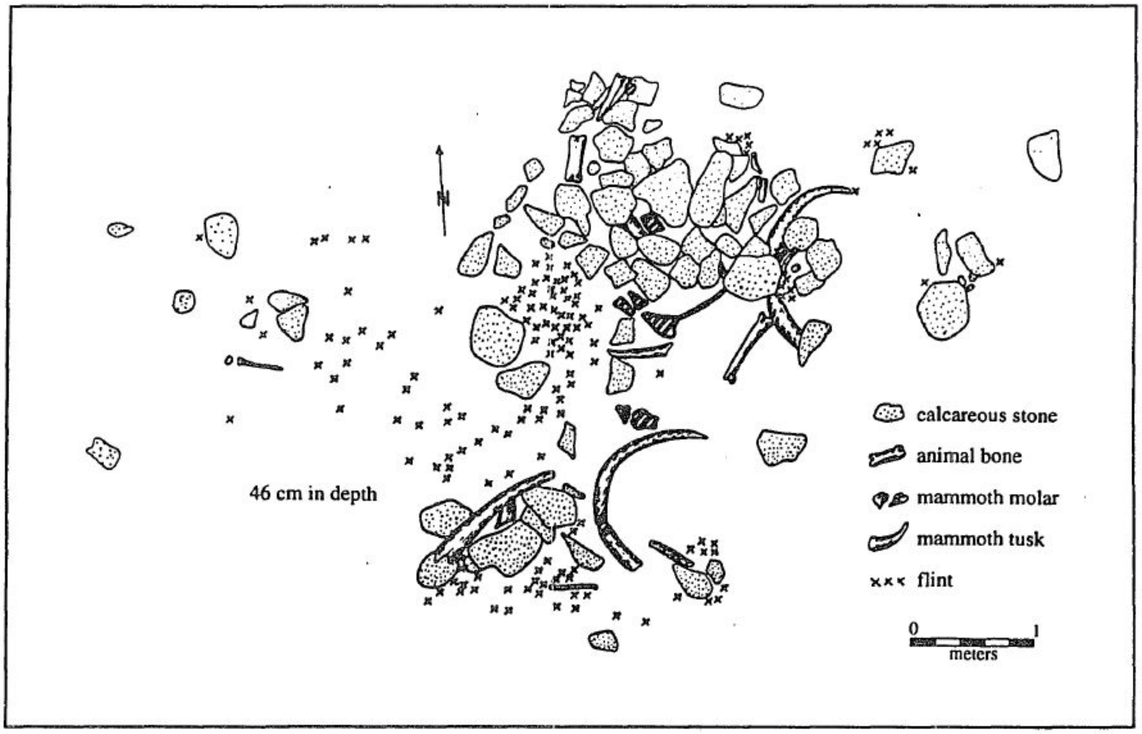

Figure 5. Ripiceni-Izvor, habitation structure type C (Upper Level) (after Păunescu, 1965, 1993).

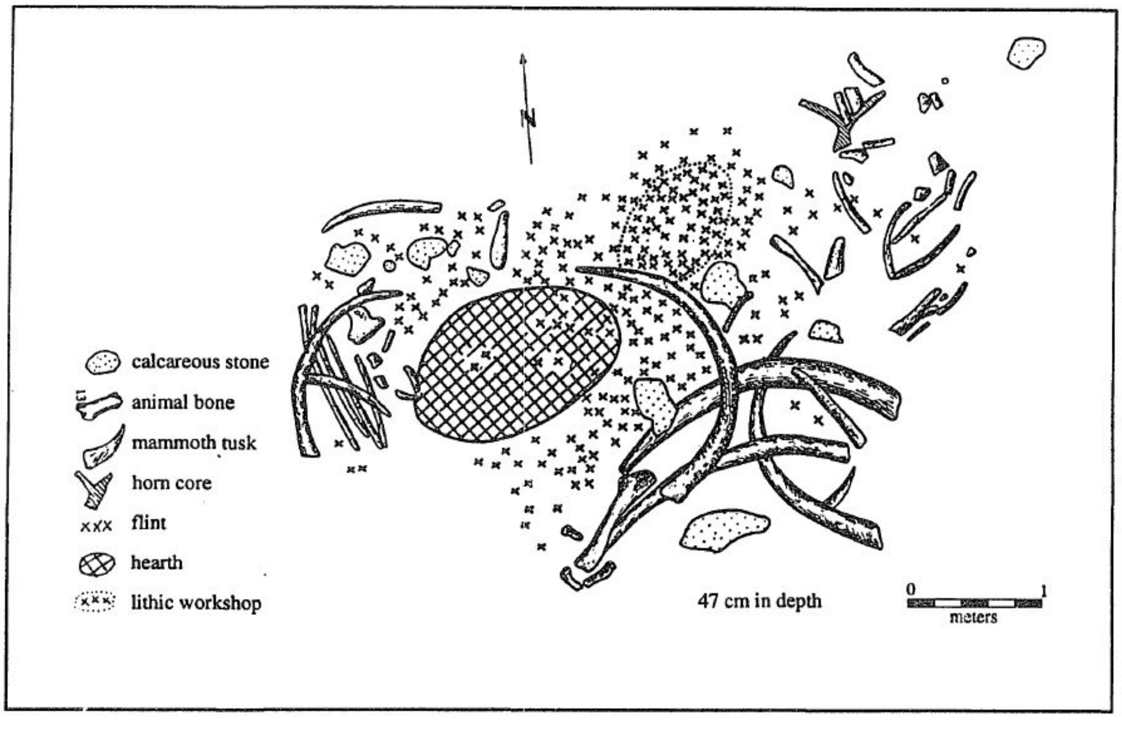

Figure 6. Ripiceni-Izvor, habitation structure type C (Lower Level) (after Păunescu, 1965, 1993).

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[i] Technology Specialization / Portability Index.

# APPENDIX B

# SYNTHESIS

## 1. Southern Carpathians – Bordu Mare Cave.

The Southern Carpathians caves were the subject of early interest by enthusiastic amateurs which, unfortunately, led to a massive loss of archaeological information during the late 19th century (Păunescu, 2001). Two important research stages followed this early one: the activities of Marton Roska (1911-1929) and the activities of the team lead by C. S. Nicolaescu-Plopsor (1951-1957). The results of their research led to unified taxonomy, and the identification of common features of the industries from the folowing caves: Bordu Mare (Ohaba Ponor), Curată and Spurcată (Nandru), Cioarei (Boroșteni), Muierilor (Baia de Fier), Cioclovina, Valea Coacăzei, Peștera Mare (Brașov) and later Hoților (Herculane) (Nicolăescu-Plopşor et al., 1957b, 1957d, 1955; Nicolăescu-Plopșor, 1956, 1956, 1957).

### 1.1 **Physico-geographic setting**

For a better assessment of the regional context of the lithic assemblages from the Bordu Mare cave I used in this work, it is useful to provide a concise presentation of the physico-geographical setting of the cave are where this ave and others are located, and of the geohronology of the Paleolithic layers (Figure 1, main text, tables 1, 3-4 below, Figure 1 below).

The Hațeg-Orăștie Depression, drained by the hydrographic basin of the Strei River and a part of the Mureş River drainage, there are some of the most important caves known in Romania that were kninhabited by Late Pleistocene hominins: Bordul Mare cave from Ohaba Ponor, Curată and Spurcată caves from Nandru (Nicolăescu-Plopşor et al., 1957b, 1957d, 1955; Nicolăescu-Plopșor, 1956, 1956, 1957)..

Bordul Mare Cave, is located in Pui commune, Hunedoara county, at the foot of the Șureanu Mountains (also known, in geological literature, as the Sebeș Mountains), at an altitude of 650 masl. The cave has a south-west oriented entrance which looks onto the wide panorama of the Hațeg Depression (Cârciumaru, 1999, Păunescu, 2001).

According to new micropaleontological analyses made by Cârciumaru and colleagues (Cârciumaru et al., 2011; see also Cârciumaru and Nițu, 2008), the limestone in which Bordul Mare Cave was carved can be assigned to the Upper Cretaceous. The Upper Cretaceous often includes conglomerates sandwiched between layers of limestone (Gherasi et al., 1968; Mureșan et al., 1980). This accounts for the numerous and diverse quartz and quartzite pebbles, alongside other types of rocks, of different sizes, which can be encountered on the limestone slopes near the Bordu Mare cave, and which were extensively used by the hominins during the Middle Paleolithic occupation. Flint and chert are also present among these cobbles that close to Bordu Mare cave (Cârciumaru et al., 2011; Nițu, 2012).

The Haţeg-Orăştie Depression is truly an area of hydrological convergence and, hence, means of commnication with very large geographic units with natural potential (Badea et al., 1987a, 1987b).

The Depression is bordered by mountain massifs to the south (Retezat and Ţarcu Mountains), west-northwest (Poiana Rusca Moutains), and east-northeast (Șureanu Mountains). The depression provides direct connections to surrounding mountain units, via the rivers descending from the heights, and to the more distant regions by the corridor of the Strei River which empties into the Mureș River and beyond, to the entire Transylvania Basin and the Hungarian Plain.

**1.2 Geochronology of Middle Paleolithic layers** (Figure 1)

Bordul Mare cave revealed four Middle Paleolithic (MP) layers and one Early Upper Paleolithic deposit (EUP) (Roska, 1924, 1925a, 1925b, 1943; Nicolăescu-Plopşor et al., 1955; Nicolăescu-Plopșor, 1957). One can find the discussions of the specific occupational layers and their designations in a number of studies that have been published over the years in different syntheses relative to Paleolithic in Romania (Cârciumaru, 1999; Cârciumaru and Nițu, 2008; Păunescu, 2001). Nowadays the bottom to top numbering is most widely used. Absolute dating (only $^{14}$C) is available only for the layers III (the most abundant of the entire sequence) and IV. Several radiocarbon dates have been obtained for layer III, establishing the occupational boundaries between 45,500 + 3500 / - 2,400 BP (GrN 14626) and 39,200 + 4,500 / - 2,900 (GrN 11618); for layer IV there is only one date of 28,780 ± 290 BP (GrN 14627).

Layer III was deposited in the glacial stage between the interstadial complex of Nandru (Nandru 2 phase - Brӧrup) and the inerstadial complex of Ohaba (Ohaba B climatic oscillation – Arcy-Kesselt). The climate was dry and cold and the landscape was dominated by a cold steppe, with grass pollen reaching almost 95 % (Cârciumaru, 1973, 1980). A list of macro-mammals from the site seems to be in agreement with pollen analyses, confirming a cold climate: *Ursus spelaues, Equus caballus fossilis, Cervus elaphus fossilis, Megaceros giganteus, Alces* cf. *machlis, canis lupus spelaues, Rhinoceros tichorhinus, Rhinoceros antiquitatis, Felix spelaea, Felix silvestris, Felix pardus, Equus asinus, Equus ferus, Equus abeli, Equus onager, Bos (primigenius), Bison priscus, Ovis argaloides, Lutra lutra, Deiceros antiquitatis, Rangifer tarandus fossilis, Ele[has primigeius, Martes martes, Sus scrofa, Saiga tatarica, Rupicapra, rupicapra,*

*Capra sewertzovi* (Roska, 1925b, 1930; Nicolăescu-Plopşor et al., 1955, 1957c; Păunescu, 2001; Cârciumaru and Nițu, 2008). Recent studies on the rodent fauna from the site (especially the occurrence of *Microtus arvalis*) also point to the existing of open areas at the time of occupation (Păunescu and Abassi, 1996). Palynological studies of layer IV revealed the existence of a wet temperate climate characteristics of the Ohaba interstadial complex (Arcy-Stillfried B, Arcy-Kesselt) (Cârciumaru, 1973, 1980). The large mammal fauna of layer IV is also consistent with this kind of climate, yielding the following species: *Ursus spelaeus, Equus caballus fossilis, Ovis (argaloides), Cervus elaphus fossilis, Canis lupus, Canis vulpes fossilis* (Roska, 1925a, 1925b, 1930; Nicolăescu-Plopşor et al., 1955, 1957c; Păunescu, 2001). The micro mammals also spport an interpretation of a temperate and humid climate, characterized by forest and humid areas species: *Microtus nivalis, clethrionomys glareolus, Microtus arvalis, Terricola* cf. *subterraneus, Sorex minutus* (Păunescu and Abassi, 1996).

Lacking radiometric dates, the dating for older layers (I and II) was based only on pollen analyses. Mousterian II was estimated to be prior to the age of 60,000 BP (Cârciumaru, 1973, 1980). This assumption requires confirmation by other independent radiometric dates. Layer I did not produce any pollen, but the characteristics of the deposit which overlays this cultural layer, have led others to consider that it belong to a glacial stage. The large mammals fauna do not contradict this interpretation, represented by species such as: *Elephas primigenius, Rhinoceros antiquitatis, Equus caballus fossilis, Hyeaena spelaea, Ursus spelaeus, Canis lupus, Canis vulpes fossilis, Capra sp.* (Roska, 1925a, 1925b, 1930; Gaál, 1928, 1943; Nicolăescu-Plopşor et al., 1955, 1957c). Layer II was deposited in a landscape dominated by pine, alongside spruce, juniper, willow, and birch, with fir and decidous trees dominating the late glacial stage that preceded the Nandru interstadial (Nandru-Amersfoort) (Cârciumaru, 1973, 1980). The large mammal fauna was dominated by *Ursus spelaues, Equus caballus fossilis, Canis lupus, Canis vulpes fossilis* (Roska, 1925a, 1925b, 1930: Gaál, 1928, 1943; Nicolăescu-Plopşor et al., 1955, 1957c). The presence of *Microtus arvalis*, is a marker for the open environment of the area (Paunescu and Abassi, 1996).

The uppermost occupational layer is associated with an Upper Paleolithic (UP hereafter) assemblage, and seems to have been deposited during a cold humid period, characteristic to a glacial stage, based on the faunal data.. The micromammal fauna recovered from this deposit include species such as: *Microtus oeconomus, Microtus nivalis, Microtus arvalis, Clethrionomys glareolus* (Păunescu and Abassi, 1996). The large mammal fauna is in agreement with the *rodentia* and include the following species: *Ursus spelaeus, Equus caballus fossilis, Felix catus ferus, Felis silvestris fossilis*, *Meles meles fosslis*, *Lutra lutra fossilis*, *Ovis (argaloides)*, *Cervus canadensis asiaticus fossilis*, *Equus* cf. *ferus fossilis*, *Ossa avium* (Roska, 1925a, 1925b, 1930; Gaál, 1928, 1943; Nicolăescu-Plopşor et al., 1955, 1957c; Păunescu, 2001).

Overall, although the results of the interdisciplinary research at this site are of variable quality, they allow some general remarks concerning the hominin occupations during the Late Pleistocene. As such one can say that the Middle Paleolithic first appeared at this locale during the glacial stage that preceded the interstadial complex Nandru, with the Mousterian layer I (bottom to top), and continues up to the end of the glacial stage with Mousterian layer II. This means that those first two occupational layers at Bordu Mare took place under cold climatic conditions, with open landscape.

Afterwards, the Mousterian III also is contemporary with a period of glacial conditions, with cold climate and open landscape, dominated by a cold and arid steppe. Mousterian layer IV took place during a temperate period belonging to the Ohaba interstadial complex, however, with forested landscape, characterized by the dissemination of thermophilous species.

### 2. Middle Prut Valley – Mitoc-Malu Galben and Ripiceni-Izvor (for Ripiceni-Izvor see main text (chapter 3) and Appendix A

### 2.1 Physico-geographic setting

Mitoc-Malu Galben ($48^{0}$ 07` N, $27^{0}$ 02` E) is located in Northeastern Romania (Botoșani county) on the right bank of middle Prut River, a few hundred meters south of the village Mitoc. The site is adjacent to Gireni creek, 400-500 m upstream from its confluence with the Prut river, and at approximately 110 m above sea level (Figure 1 main text).

The Prut River, emerges from the northern Eastern Carpathians (in Ukraine) and marks the frontier between Romania and Republic of Moldavia. From its headwaters, the river flows more than 900 km to empty into Danube downstream from the city of Galaţi. Two sites selected for this study are located along the middle section of the Prut between the localities of Radăuţi-Prut and Stânca Ştefăneşti.

In the Middle Prut area, the most ancient deposits are Late / Upper Cretaceous chalky limestones of Cenomanian age, with flint concretions at the top. Overlying these limestones disconformably are a sub-horizontal cover of Neogene deposits, of Badenian age (siliceous sand with flint nodules), then of Sarmatian age (Băcăuanu and Chirica, 1987, p. 87; Chirica, 1996; Noiret, 2009, pp. 20–23). The Sarmatian deposits consist of a clayey-marl with sandy intercalations, resting on a Buglovian floor, and are characterized by clayey-marl deposits north of Mitoc, then by limestone reef toward south, currently exposed in the valley by the rover (Prut) in transverse sections (Băcăuanu and Chirica, 1987, p. 88). Eroding up its bed, the Prut River also cut through Cenomanian, Sarmatian, Buglovian and Tortonian (i.e. gypses, sands, and quartzite sands with flint nodules, downstream of Rădăuți) deposits (Chirica, 2001, pp. 14–15). The middle Prut is characterized by rich flint outcrops between Rădăuți-Prut and Mitoc, where it flows in a anarrow channel, without upper terraces on the right and without limestone massifs. South of Mitoc, the channel broadens and the *toltryses* make their appearance; south of Ștefãnesti, the bed becomes very wide (Chirica, 2001, p. 13).

The Prut River has five fluvial terraces in this region as well as two 'intermediate' terraces downstream of Ștefănești (of 30-35 m, and 90-100 m) that are not recognizable over the entire length of the middle course of the river. The uppermost terraces are partly destroyed, while those up to 60-70 meters show a stratigraphic sequence clay plinth, marls and sands or Miocene chalks, and sandy alluvial deposits with gravels at the base, all covered by loess-like alluvial and colluvial silts of variable thickness, The plane is located at an absolute altitude of 80 meters (Băcăuanu and Chirica, 1987, pp. 89–91; Chirica, 1989, p. 22; Popp, 1971, p. 620). The upper terrace is represented only by the pebbly sandstone. The seventh terrace can be recognized through the sandstone, quartzite, menilites and marl pebbles. The sixth terrace is well developed, especially close to the village of Mitoc, where the alluvium thickness is less. Close to Stânca, its plinth corresponds to Buglovian limestone reefs, covert by the sands and gravels, then by loessic silts (for 10-23 meters thickness). The second terrace is found in the elongation of the lowermost terrace, with which it often unites; it stays on a Sarmatian plinth (8-10 altitude), covered by 3 to 15 meters of alluvium. It is only thanks to the plinth altitude and nature of the gravel that allows differentiating it from the inferior terrace, which is visible downstream to Ripiceni, but is rapidly covered by the waters of the reservoir dam from Stânca-Costești (Băcăuanu and Chirica, 1987; Noiret, 2009).

Flint nodules are found in the Upper Cretaceous deposits, but also in the alluvial deposits of the lower terrace. The Badenian and Upper Cretaceous deposits of the northern side of the middle sector of the valley were exposed by the river during the Riss-Wurm Interglacial marking the flint easily accessible for the hominins of the Middle and Upper Paleolithic (Băcăuanu and Chirica, 1987, pp. 91; Păunescu, 1993).

**2.2 Geochronological setting of the Mitoc-Malu Galben** (Table 1, 3, Figure 2)

The first stratigraphic description had been provided by N. N. Moroșan (1938, p. 59), as follows:

1. Organic soil (thickness: 0.30-0.85 m);
2. Light yellow typical loess (thickness: 5.20 m);
3. "Upper Paleolithic fossil layer" (thickness: 0.10 m);
4. Loess with similar structure to the upper loess (thickness: 1.00 m);
5. Sandy loess gradually transitioning to sandy clay (thickness: 1.20 m);
6. Light clayey sand (thickness: 2.00-3.00 m);
7. Terrace gravel "relatively thin that forms the base of the cup" (thickness: approx. 1.00 m).

One single human occupational layer was identified in layer 2 (typical loess without fossil soil), superimposed on the lower terrace formations, at more than 5 m below the organic soil. The lithic industry includes “flakes and a few slendered blades” that would correspond to an industry of developed Upper Paleolithic (Moroșan, 1938, pp: 60).

The work of C. S. Nicolăescu-Plopșor and N. Zaharia took place in 1956-1957, resulting in the identification of sedimentary deposits and paleosoils. Their stratigraphic sequence is as follows (Chirica, 2001):

1. Fairly consistent Tchernozem;
2. Sands alternating to “clay lands”;
3. Loess deposit with uniform color and granulation, “intercalées” par de couches déposées par innodation, de couleur moins foncée, ou comprises dans les impregantions de calcaire”;
4. Clay deposits “d'innodation, bleuâtres, incluant des lentiles de sols fossiles, de couleur jaune-rougeâtre”;
5. Dark colored paleosols;
6. Gravels and sand resting on the bedrock “formed exclusively of flint nodules”.

According to these archaeologists the erosional surface below the terrace sediments is of Mindel-Riss age; the clays and paleosols are equally belonging to an Interglacial, but Riss-Wurm in this case; and the underlying loess and sand deposits are of Wùrm age (Chirirca, 2001, pp. 36). Several lithic assemblages were identified within these deposits, but with uncertain stratigraphic and ‘cultural’ origin ranging from ‘Clactonian’ to ‘Early Upper Paleolithic’ (Honea, 1984; Chirica, 1989, 2001, pp. 31, 36, 86).

A new research project was developed beginning with 1991 that allowed a complete re-study of the stratigraphic sequence, and a succession of 13 sedimentary units, marked by humipherous soils and tundra gley, and resting on an abrupt slope made from Buglovian limestone eroded by the second Prut terrace. This sequence measures approximately 14 meters vertically and corresponds, in its lower part, to silty deposits, transitioning toward loessic deposits, then sandy loess, and finally sand deposits in its upper part. The sequence follows the slope' geometry oriented toward Prut River but also that toward the creek Ghireni Creek (Noiret, 2009, pp. 54).

Bottom to top, the stratigraphic sequence includes the following sedimentary units (Haesaerts, 1993; Haesaerts et al., 2003; Otte et al., 2007).

**Units 13 – 12:** hydromorphic colluvial units (13b, 12b), each of which is overlain by humiferous soils (13a, 12a) attributed to interstadial climatic episodes (called MG 13, before 32,700 BP and MG 12), slightly after the first Aurignacian workshops, with an estimated age of around 32,000 BP).

**Unit 11**: Deposits of low screed slope (11b); a paleosoils of Tchernozem type (11a), at the top of this unit, corresponding to interstadial episode MG 11 (Haesaerts et al., 2007);

**Unit 10**: Homogeneous sandy loess (10b), overlain by a humiferous horizon (10a; well expressed rendzina paleosoils, very bioturbated), corresponding to a climatic episode called MG 10;

**Unit 9**: Homogeneous sandy loess (9b), overlain by a humiferous horizon, corresponding to a climatic episode called MG 9;

**Unit 8**: Homogeneous sandy loess (8b) overlain by a humiferous horizon (8a; light brown poorly expressed paleosoils) corresponding to a climatic episode called MG 8 (around 27,000 BP);

**Unit 7**: Homogeneous sandy loess (7b) deposited starting at 27,000 BP (with the first Gravettian occupations), underlain by a thick tundra gley (7a), produced during permafrost conditions, and corresponding to the first major climate cooling in the Mitoc sequence, around 26,000 BP;

**Unit 6**: Brownish horizon at the bottom (6b), indicating a slight climate warming / improvement (called MG 6, following a cold episode registered by the tundra gley environment in 7a), then typical loess overlain by a tundra gley (6a);

**Unit 5**: Typical loess with a thin sandy layer at the base (5b), followed by an ash-grey tundra gley (5a);

**Unit 4**: Typical loess (4c; transition toward a colder and drier environment), followed by an ash-brown humiferous soil (4b, around 23,800 BP), super imposed by a thick tundra gley with numerous traces of roots (4a; stabilization phase); corresponds to several Gravettian occupations between 23,850 and 23,290 BP;

**Unit 3 and 2**; two loess units (3b, 2b) with thin layers of sand, each one overlaid by a low developed tundra gley (3a, 2a), indicating a colder and drier environment (between 22,000 and 20,000 BP);

**Unit 1**; approximately 1 m of stratified sands, alternating with levels of sandy silts and capped with a tundra gley (1b), followed by 1 m of homogeneous sandy loess (1a). Above this is a thick humiferous horizon corresponding to the surface Tchernozem.

Overall, the sequence shows that the climatic conditions became more and more rigorous, as shown by the recurring development of tundra gley, indicating the Upper Pleniglacial (Haesaerts, 1993, pp. 60). Top to bottom, the Gravettian assemblages IV and III are localized in the lower part of the typical loess: assemblage IV clearly derives from two distinctive occupations; assemblages III is not obvious multiple occupations, but more discontinuous (Haesaerts, 1993, pp. 67). The Gravettian II was found in the brownish horizon situated at the bottom of the unit 6. Gravettian I is located in the last homogeneous sandy loess (Unit 7b). The most important three Aurignacian ensembles are located in the sandy loess sediments of the unit 9 (Aurignacian III), in the humiferous horizon 10a (Aurignacian II), and mostly from the screed deposits of the unit 11 (Aurignacian I), below the soil recently discovered at the top of that unit (Otte et al., 2007), but also at the bottom of the sandy loess of the unit 10 (Aurignacian I).

## 3. Bistrița Valley sites

### 3.1 Physico-geographic and geological setting

The Bistrița river, which emerges from the Rodna Mountains (Northeasrtern Romania), to its confluence with the Siret river, has an overall length of circa 283 km. The river flows roughly in a NW-SE direction and cuts across two major geological units: the Carpathians Mountains and the Moldavian-Podolian platform. The Bistriţa valley is geologically heterogeneous, with formations that include marl limestone, sandstone, coral limestone, slay slate, menilith, and conglomerates cluster even in small sectors. Because of this variety of rocks and related erosional modes, the river valley widens into broad basins or stretches out into narrow gorges repeatedly. The slope of the valley margins varies as well, with affecting the intensity of slope processes (Dionisă, 1968, pp. 17–20).

The Bistriţa Valley's characteristics are particularly expressed in the Ceahlău area, where five of the main tributaries of the river meet. Here on the right bank, the erosion of the north-east exposed slopes took place, leaving them with a smooth gradient (Petrescu-Burloi, 2003). This small sector hosts most of the Paleolithic human presence known so far. Apart from the low slope gradients that help preservation, the recurrence of the Paleolithic sites in this location could be explained by several other factors, including the existence of numerous fresh springs or the intersection of several natural passages leading towards neighboring areas (Nicolăescu-Plopşor et al., 1966). The latter aspect seems to be supported by the constant presence of exotic raw materials in most archaeological context in the area. The intensity of historic settlements and modern activities coupled with the unusual intensity of field research also played their role in exposing most of those sites.

Quaternary deposits in the region are found on terraces and riverbeds. Due to the changing lithological substratum and intense erosion processes, the Bistrița has developed a large series of terraces, sometimes up to nine or ten. The Quaternary contexts are mostly found as Upper Pleistocene homogeneous loess-like sequences, and interstadials episodes whose deposits were not sharply contrasting in this mountainous area. Also, most sedimentary records of considerable depth constantly mix loessic layers with diluvial and colluvial deposits. The most complete sequence seems to have been preserved on the middle terrace (40-45 m or 55-65 m high), where most of the multi layered Paleolithic sites were found. Much like their archaeological content, however, the geo-chronological interpretation of the deposits on Bistrița terraces changed considerably in the last decades (Nicolăescu-Plopşor et al., 1966; Anghelinu et al., 2012).

### 3.2 The current chrono-cultural setting

The Upper Paleolithic cluster of settlements in the Bistrița valley represents just a tiny part in the regional picture of the Aurignacian and Gravettian / Epigravetttian techno-complexes in Eastern Romania and Republic of Moldavia. About 150 sites and small locales between the Carpathians and the Prut River have been discovered (Păunescu, 1998, 1999). A number of authors consider this large Gravettian phenomenon as sufficiently different from both the Moravian Pavlovian and the Kostenkian to the east to deserve a special name (e. g. 'Moldavian') (Noiret, 2009).

At the same time, contrary to the less expressive geological record of the Bistrița valley, the Prut and Dniestr (more toward east) loessic sequences also offered a much more complete picture of the late Pleistocene environmental changes in Eastern Romania and Republic of Moldavia (Haesaerts et al., 2003). A better state of preservation of the archaeological contexts and an intensive absolute dating campaign allowed for a more accurate reconstruction of the UP dynamics in settlements like Mitoc-Malu Galben, Molodova and Cosăuți.

Although provisional, because of variable quality of the research conducted in the area, during the last 5-6 decades, thanks to new recent projects some general ideas in respect with the geo-stratigraphic context can be summarized (Nicolăescu-Plopșor et al., 1966; Cârciumaru et al., 2006; Anghelinu et al., 2012; Anghelinu and Niță, 2012; Steguweit et al., 2009).

The first documented human presence during the Pleistocene in Bistrița valley does back to at least 27.3 ka, as shown by the downstream settlement at Poiana Cireșului. Some other settlements provided hints for an older human presence, particularly clear at

Poiana Cireșului, where at least one certain cultural layer lays below the Gravettian II (Cârciumaru et al., 2006).

At Bistricioara-Lutărie I, another important site in the region, the evidence is less secure, although a sample extracted during a recent field research, provided a ca. 28 ka BP date. However this AMS sample is not associated with archaeological material. But, as the authors suggest, if their extrapolation is correct, relying on the hypothetically same event at Dârțu, the natural fire at 28 ka BP can effectively mark a *terminus post quem* for most UP occurrences on Bistrița valley (Anghelinu et al. 2012; Steguweit et al. 2009).

The ages obtained at Dârțu do not have a direct archaeological context. Notwithstanding, even if the tighter chronology based on the Bistricioara natural fire is rejected, the 30 ka BP age at least provides a maximum age for the deposition of the pseudo-mycelian loess that contains all known 'Aurignacian' occurrences. At Cetățica, a nearby site, no new excavations and geological reassessments were undertaken. The small assemblage discovered here, (layer I) was recovered from within or immediately below the same reddish-brown soil that provided the 30-35 ka BP ages at Ceahlău-Dârțu. It seems therefore impractical to suggest a tight chronology for the first geological unit covering the terrace gravels on Bistrița middle terraces (the previous Würm I–II soil), because the sedimentary matrix can be indefinitely old. As suggested by the authors, it is important to notice that no less than 3 humic cycles were recorded at Mitoc-Malu Galben between 33 and 35 ka BP (Haesaerts et al., 2003).

Assembling previous ages and the new AMS dates, a continuous later human presence is further documented between 26 and 13.7 ka BP, from the southernmost spot at Lespezi to the northernmost at Bistricioara-Lutărie.

Although providing systematically older dates than those obtained through radiation counting method for the same cultural contexts, and irrespective of their taxonomical attribution, the new AMS chronology points to a considerably younger time span for the 'Aurignacian' and Gravettian layers involved, particularly when measured against prior estimations. No matter how vague or generous were the previous geochronological inferences related to the main loessic unit (Würm II, Ohaba Interstadial Complex), they were apparently too old (Anghelinu et al., 2012; Otte et al., 2007). Consequently, with the effects of percolation, bioturbation and periglacial phenomena like ice wedges (recorded in most profiles and reaching to considerable depths, see Figure 3) or sampling biases excluded, the thermophile elements need to be correlated to other positive climatic event(s), currently undefined. Any of the positive episodes corresponding to Mitoc-Malul Galben humic cycles MG6 or MG4 (see also above) appear as possible candidates. Given the severely incomplete nature of the geological archives and the oscillating climatic graph of the Upper Pleniglacial, it is quite difficult for now to make accurate correlations.

The chronology of the reddish soil separating the Old and Recent Epigravettian layers remains unknown. If one relies on the youngest dates obtained in the underlying cultural layers in the Ceahlău Basin (all conventional radiocarbon dates), this soil has to be younger than 16 ka BP. One can therefore only speculate on the climatic event(s) responsible for such a soil formation. However, in the advent that the late Epigravettian occurrences in the Tardiglacial loess above do indeed display a chronology comparable to Bistricioara 'La Mal' Epigravettian, its chronological range shrinks to 16 and 14.5 ka BP.

Several climatic events documented in the Prut – Dniestr area at CosăuțI, might provide possible analogies (Haesaerts et al., 2003).

Given the current state of knowledge, any accurate correlation between short – lived paleoclimatic events and human presence on the Bistrița Valley seems to be speculative. However, because the bioturbation produced by the reddish soil initially attributed to Wùrm II-III interstadials has simply overwritten previous loess-like deposits and no archaeological layer was deposited during its formation, it implies that C. S. Nicolăescu-Plopșor and co-workers were ultimately right: human presence in the area was generally associated with rather cold and not particularly humid climatic settings, favorable to loess deposition. Although scarce, existing faunal (e.g. boreal mollusks) and especially anthracological data point to a similar conclusion. It should be noted that charcoal samples were directly associated with hearths and hence to human choices of firewood. The observation suggests that Paleolithic hunter-gatherers were settling the valley during rather cold episodes, likely in proximity to the steppe-tundra biomass they were following. If most habitation involved here belong to the Gravettian and Epigravettian, the Bistrța valley is not exceptional among Central and Eastern Europe manifestations of this techno-complex, generally associated to cold environmental settings (Haesaerts and Teyssandier, 2003; Haesaerts et al., 2003).

Based on the current information it is quit possible that Bistrița's mountainous sector was occupied in distinct, possibly sub-millennial cycles, with each occupation stage likely clustered chronologically beyond the resolution of radiocarbon method. Both previous sampling issues and the contrasting results between classical radiocarbon and AMS ages obtained in the same settlement (see Bistricioara-Lutărie) seriously limit chronological inferences. Relying strictly on AMS ages and the directly associated archaeological contexts, the cycles clearly documented at Poiana Cireșului and Bistricioara-Lutărie (I, III) revolve around 27-24 ka BP (Gravettian) and 20-19 ka BP (Old Epigravettian). Bistricioara-Lutărie I and Bistriciaora-Lutărie 'La Mal' indicate an intermediate Late Gravettian occurrence around 21-22 ka BP and a late, Tardiglacial Epigravettian around 14.5-13.7 ka BP. However, a quite consistent series of classical radiocarbon dates also support a Gravettian presence around 23 ka BP and an Epigravettian stage around 16-17 ka BP (Anghelinu et al., 2012; Anghelinu and Niță, 2012; Cârciumaru et al., 2007; Haesaerts et al., 2003; Păunescu, 1998).

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# TABLES

Appendix B. Table 1. Sites and assemblages discussed in text.

| **Site** | **Context** | **Industry** | **Date 14C BP** | **AMS 14C Uncal. BP** | **References** |
|---|---|---|---|---|---|
| Bordu Mare | Cave | Aurignacian | | | Nicolăescu-Plopşor *et al.,*1957c; Păunescu 2001 |
| | | Mousterian IV | 28,780 ±290 (GrN14627) | | |
| | | Mousterian III | 45,500 +3,500/-2,400 (GrN14626) | | |
| | | | 43,600 +2,800/-2,100(GrN12676) | | |
| | | | > 41,000 (GrN11617) | | |
| | | | > 40,000 (GrA6036) | | |
| | | | > 40,000 (GrA6036) | | |
| | | Mousterian II | | | |
| | | Mousterian I | | | |
| Ripiceni-Izvor | Open air | Gravettian | | | Păunescu, 1993; Păunescu, 1998, 1999 |
| Ripiceni-Izvor | | 'Aurignacian' | 28,420±400 BP (Bln-809) | | |
| | | | 40,200+1100/-1000 BP (GrN-9210) | | |
| Ripiceni-Izvor | | Middle Paleolithic | 28,780±2000 BP (Bln-810) | | |
| | | | 43,800+1100/-1000 BP (GrN-9207) | | |
| | | | 44,800+1300/-1100 BP (GrN-9208) | | |
| | | | 42,500+1300/-1100 BP (GrN-9209) | | |
| | | | 46,400+4700/-2900 BP (GrN-11230) | | |
| | | | 45,000+1400/-1200 BP (GrN-11571) | | |
| | | | 38,900±900 BP (GrN-16394) | | |
| | | | 46,200±1100 BP (GrN-14367) | | |
| | | | > 41,00 BP (GrN-12973) | | |
| | | | > 36,950 BP (Bln-811) | | |

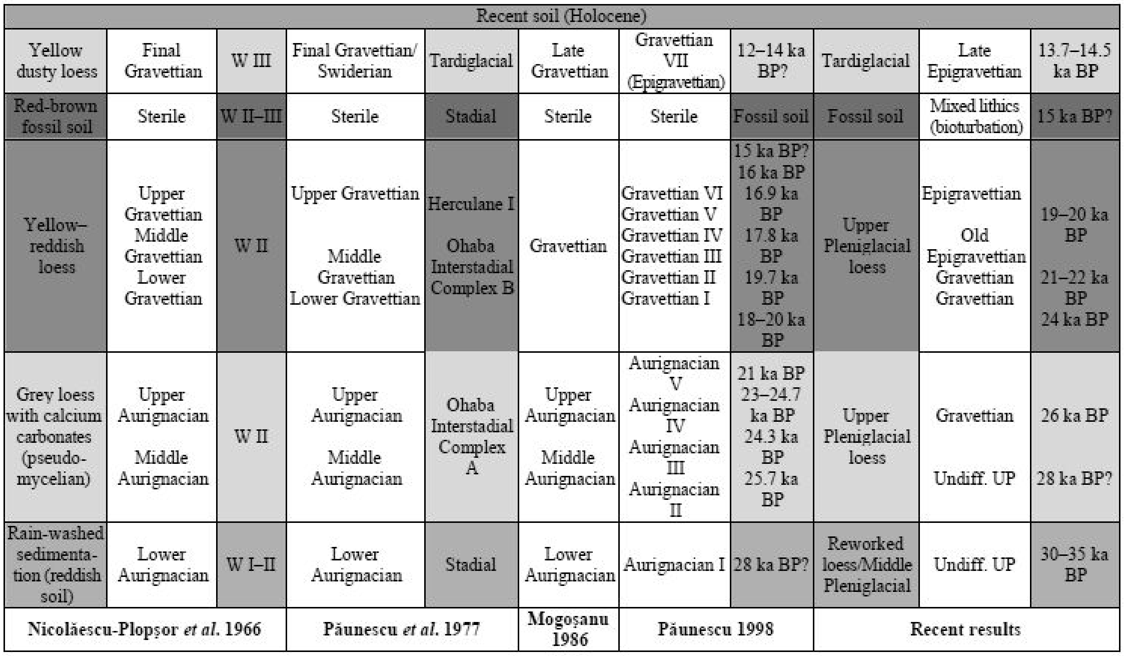
| Site | Context | Industry | Date 14C BP | AMS 14C Uncal. BP | References |
|---|---|---|---|---|---|
| Miroc-Malul Galben | Open air | Aurignacian | 27,410±430 BP (GrN-14914) |  | Otte et al., 2007; Noiret, 2009 |
|  |  |  | 31,850±800 BP (GrN-12637) |  |  |
|  |  |  | 27,100±1500 BP (GrN-15453) |  |  |
|  |  |  | 27,700±180 BP (GrA-27261) |  |  |
|  |  |  | 27,750±160 BP (GrA-27268) |  |  |
|  |  |  | >24,000 BP (GrN-13007) |  |  |
|  |  |  | 26,530±400 BP (GrN-15451) |  |  |
|  |  |  | 29,410±310 BP (GrN-454) |  |  |
|  |  |  | 25,380±120 BP (GrA-1355) |  |  |
|  |  |  | 26,910±450 BP (GrN-14037) |  |  |
|  |  |  | 24,400+2200/-1700 BP (GrN-15457) |  |  |
|  |  |  | 31,100±900 BP (OxA-1646) |  |  |
|  |  |  | 31,000±330 BP (GrA-1648) |  |  |
|  |  |  | 25,930±450 BP (GrN-15456) |  |  |
|  |  |  | 30,240+470/-440 BP (GrN-40443) |  |  |
|  |  |  | 31,160+570/-530 BP (GrN-20770) |  |  |
|  |  |  | 30,920±390 BP (GrN-20442) |  |  |
|  |  |  | 31,160+550/-510 BP (GrN-20444) |  |  |
|  |  |  | 32,730±220 BP (GrA-1357) |  |  |
| Mitoc-Malul Galben | Open air | Gravettian | 20,150±210 BP (GrN-13765) |  | Otte et al., 2007; Noiret, 2009 |
|  |  |  | 17,460+140/-130 BP (GrA-8399) |  |  |
|  |  |  | 20,300±700 BP (GrN-14031) |  |  |
|  |  |  | 20,540±110 BP (GrA-5000) |  |  |
|  |  |  | 19,100±120 BP (GrA-8234) |  |  |
|  |  |  | 23,850±100 BP (GrA-1353) |  |  |

| Site | Context | Industry | Date 14C BP | AMS 14C Uncal. BP | References |
|---|---|---|---|---|---|
|  |  |  | 23,290±100 BP (GrA-14671) |  |  |
|  |  |  | 23,650±400 BP (OxA-1779) |  |  |
|  |  |  | 23,390±280 BP (GrN-20438) |  |  |
|  |  |  | 23,830±330 BP (GrN-14034) |  |  |
|  |  |  | 24,650±450 BP (OxA-1780) |  |  |
|  |  |  | 27,150±750 BP (GrN-12635) |  |  |
|  |  |  | 24,780±120 BP (GrA-14670) |  |  |
| Bistricioara-Lutărie Shore | Open air | Epigravettian |  | 13,768±79 BP (Erl-11856) | Păunescu 1998; Anghelinu et al., 2012 |
|  |  |  |  | 14581±87 BP (Erl-11857) |  |
| Bistricioara-Lutărie III | Open air | Epigravettian |  | 19,749±149 BP (Erl-12851) |  |
| Poiana Ciresului | Open air | Epigravettian |  | 19,459± BP (Erl-12621) | Cârciumaru et al., 2006, 2010) |
|  |  |  |  | 20,020±110 BP (Beta 2241565) |  |
|  |  |  |  | 20,053±188 BP Erl-9964) |  |
|  |  |  |  | 20,076±185 BP (Erl-9965) |  |
|  |  |  |  | 20,154±97 BP Erl-12163) |  |
|  |  |  |  | 20,050±110 BP (Beta-244071) |  |
| Lespezi-Lutărie | Open air | Epigravettian/Late Gravettian | 17,620±320 BP (Bln-805) |  | (Păunescu, 1998) |
|  |  |  | 18,110±300 BP (Bln-806) |  |  |
|  |  |  | 18,020±350 BP (Bln-808) |  |  |
| Cetățica I | Open air | Late Gravettian | 19,760±470 BP (GrN-14631) |  | (Păunescu, 1998) |
| Podiș | Open air | Late Gravettian | 16,970±360 BP (GrN-14640) |  | (Păunescu, 1998) |
| Dârțu | Open air | Late Gravettian | 17,860±190 BP (GrN-12762) |  | (Păunescu, 1998) |
| Bistricioara-Lutărie II | Open air | Late Gravettian | 16,150±350 BP (GrN-10258) |  | (Păunescu, 1998; Anghelinu et al., 2012) |

| Site | Context | Industry | Date 14C BP | AMS 14C Uncal. BP | References |
|---|---|---|---|---|---|
| Bistricioara-Lutărie I | Open air | Late Gravettian | | 21,541±155 BP (Erl-11854) | Anghelinu et al., 2012; Steguweit et al., 2009 |
| Bistricioara-Lutărie I | | Gravettian | | 24,396±192 BP (Erl-11855) | |
| | | | | 24,370±300 BP (Erl-9967) | |
| | | | | 24,213±299 BP (Erl-9968) | |
| | | | | 26,869±447 BP (Erl-9970) | |
| Poiana Cireșului | Open air | Gravettian | | 25,135±150 BP (Beta-244072) | Cârciumaru et al., 2006, 2010) |
| | | | | 25,760±160 BP (Beta-244073) | |
| | | | | 25,860±170 BP (Beta-224157) | |
| | | | | 26,070±340 BP (Beta-206707) | |
| | | | | 26,185±379 BP (Erl-9963) | |
| | | | | 26,347±387 BP (Erl-9962) | |
| | | | | 26,677±244 BP (Erl-11860) | |
| | | | | 27,321±234 BP (Erl-11859) | |
| Bistricioara-Lutărie II | Open air | Gravettian | 18,800±1200 BP (Gx-8728) | | Păunescu, 1998 |
| | | | 20,995±875 BP (Gx-8729) | | |
| Cetățica I | Open air | | 23,890±290 BP (GrN-14630) | | |
| Buda | Open air | Gravettian | 23,810±190 BP (GrN-23072) | | |
| Bistricioara-Lutărie II | Open air | Gravettian | 18,330±300 BP (GrN-12670) | | |
| | | | 20,310±1300 BP (Gx-8726) | | |
| | | | 23,450+2000/-1450 BP (Gx-8727) | | |
| Cetățica II | Open air | Gravettian | 21,050±650 BP (GrN-14632) | | Păunescu, 1998 |

| **Site** | **Context** | **Industry** | **Date 14C BP** | **AMS 14C Uncal. BP** | **References** |
|---|---|---|---|---|---|
| Bistricioara-Lutărie II | Open air | Gravettian | 23,560+1150/-980 BP (Gx-8845) | | Păunescu, 1998 |
| | | | 24,100±1300 BP (GrN-10529) | | |
| | | | 24,760±170 BP (GrN-11586) | | |
| | | | 27,350+2100/-1500 BP (Gx-8844) | | |
| Bistricioara-Lutărie I | Open air | Undefined Upper Paleolithic Stage | | 28,069±452 BP (Erl-9969) | Anghelinu et al., 2012 |
| Dârțu | Open air | Undefined Upper Paleolithic Stage | 21,100+490/-460 BP (GrN-16985) | | Păunescu, 1998 |
| | | | 24,390±180 BP (GrN-12673) | | |
| | | | 25,450+4450/-2850 BP (Gx-9415) | | |
| | | | | 30,772±643 BP (Erl-9971) | Anghelinu et al., 2012 |
| | | | | 35,775±408 BP (Erl-12165) | |
| Cetățica I | Open air | Undefined Upper Paleolithic Stage | > 24,000 BP (GrN-14629) | | Păunescu, 1998 |
| Cetățica II | Open air | Undefined Upper Paleolithic Stage | 26,700±1100 BP (GrN-14633) | | |

Appendix B. Table 1. Sites and assemblages discussed in text (continued).



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Recent soil (Holocene) | | | | | | | | | | |
| Yellow dusty loess | Final Gravettian | W III | Final Gravettian/ Swiderian | Tardiglacial | Late Gravettian | Gravettian VII (Epigravettian) | 12–14 ka BP? | Tardiglacial | Late Epigravettian | 13.7–14.5 ka BP |
| Red-brown fossil soil | Sterile | W II–III | Sterile | Stadial | Sterile | Sterile | Fossil soil | Fossil soil | Mixed lithics (bioturbation) | 15 ka BP? |
| Yellow–reddish loess | Upper Gravettian<br>Middle Gravettian<br>Lower Gravettian | W II | Upper Gravettian<br>Middle Gravettian<br>Lower Gravettian | Herculane I<br>Ohaba Interstadial Complex B | Gravettian | Gravettian VI<br>Gravettian V<br>Gravettian IV<br>Gravettian III<br>Gravettian II<br>Gravettian I | 15 ka BP?<br>16 ka BP<br>16.9 ka BP<br>17.8 ka BP<br>19.7 ka BP<br>18–20 ka BP | Upper Pleniglacial loess | Epigravettian<br>Old Epigravettian<br>Gravettian<br>Gravettian | 19–20 ka BP<br>21–22 ka BP<br>24 ka BP |
| Grey loess with calcium carbonates (pseudo-mycelian) | Upper Aurignacian<br>Middle Aurignacian | W II | Upper Aurignacian<br>Middle Aurignacian | Ohaba Interstadial Complex A | Upper Aurignacian<br>Middle Aurignacian | Aurignacian V<br>Aurignacian IV<br>Aurignacian III<br>Aurignacian II | 21 ka BP<br>23–24.7 ka BP<br>24.3 ka BP<br>25.7 ka BP | Upper Pleniglacial loess | Gravettian<br>Undiff. UP | 26 ka BP<br>28 ka BP? |
| Rain-washed sedimentation (reddish soil) | Lower Aurignacian | W I–II | Lower Aurignacian | Stadial | Lower Aurignacian | Aurignacian I | 28 ka BP? | Reworked loess/Middle Pleniglacial | Undiff. UP | 30–35 ka BP |
| **Nicolăescu-Plopşor *et al.* 1966** | | | **Păunescu *et al.* 1977** | | **Mogoşanu 1986** | **Păunescu 1998** | | **Recent results** | | |

Appendix B. Table 2. Synthetic view of the chrono-cultural framework of the Bistrița Valley (After Anghelinu et al., 2012).

Appendix B Table 3. Summary assemblage information for the sites used in analyses. Estimated age is based on radiometric dates where available

| Site<br>Layer | Lithic Industry | Mean Age BP | Chronology | Context | Elevation a.s.l. | Region | Total lithics | Retouch artifacts | % Retouch | Bifaces & Backed | Bone artifact | TSPI | Fauna NISP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bordu Mare | MP | | PRE LGM | CAVE | 650 | S.Carp. | 63 | 9 | 0.14 | | | 0.000 | |
| Bordu Mare | MP | | PRE LGM | CAVE | 650 | S.Carp. | 44 | 6 | 0.14 | | | 0.000 | |
| Bordu Mare | MP | 42,800 | PRE LGM | CAVE | 650 | S.Carp. | 1711 | 120 | 0.07 | 2 | | 0.001 | |
| Bordu Mare | MP | 28,780 | PRE LGM | CAVE | 650 | S.Carp. | 177 | 14 | 0.08 | 2 | | 0.011 | |
| Bordu Mare | EUP | | PRE LGM | CAVE | 650 | S.Carp. | 18 | 3 | 0.17 | | 2 | 0.111 | |
| Ripiceni-Izvor | MP | | MIS 6? | OPEN | 100 | Prut | 1119 | 237 | 0.21 | 4 | | 0.004 | |
| Ripiceni-Izvor | MP | | MIS 6? | OPEN | 100 | Prut | 1282 | 139 | 0.11 | 0 | | 0.000 | |
| Ripiceni-Izvor | MP | 45,870 | MIS 6? | OPEN | 100 | Prut | 1916 | 203 | 0.11 | 2 | | 0.001 | |
| Ripiceni-Izvor | MP | 42,825 | MIS 6? | OPEN | 100 | Prut | 35890 | 1361 | 0.04 | 212 | | 0.006 | |
| Ripiceni-Izvor | MP | | MIS 6? | OPEN | 100 | Prut | 16064 | 340 | 0.02 | 27 | | 0.002 | |
| Ripiceni-Izvor | MP | | ? | OPEN | 100 | Prut | 324 | 50 | 0.15 | 1 | | 0.003 | |
| Ripiceni-Izvor | EUP | | PRE LGM | OPEN | 100 | Prut | 1011 | 145 | 0.14 | 4 | | 0.004 | |
| Ripiceni-Izvor | EUP | 28,420 | PRE LGM | OPEN | 100 | Prut | 2306 | 152 | 0.07 | 2 | | 0.001 | |
| Ripiceni-Izvor | EUP | | PRE LGM? | OPEN | 100 | Prut | 4020 | 172 | 0.04 | 4 | | 0.001 | |
| Ripiceni-Izvor | EUP | | LGM? | OPEN | 100 | Prut | 4534 | 306 | 0.07 | 20 | | 0.004 | |
| Ripiceni-Izvor | GR | | LGM | OPEN | 100 | Prut | 6936 | 175 | 0.03 | 23 | | 0.003 | |
| Ripiceni-Izvor | GR | | LGM | OPEN | 100 | Prut | 6448 | 134 | 0.02 | 14 | | 0.002 | |
| Ripiceni-Izvor | GR | | LGM | OPEN | 100 | Prut | 5868 | 166 | 0.03 | 15 | | 0.003 | |
| Ripiceni-Izvor | GR | | LGM? | OPEN | 100 | Prut | 8632 | 286 | 0.03 | 56 | | 0.006 | |
| Mitoc-Malu Galben | EUP | 31,600 | PRE LGM | OPEN | 110 | Prut | 1216 | 20 | 0.02 | | | 0.000 | 39 |
| Mitoc-Malu Galben | EUP | 31,075 | PRE LGM | OPEN | 110 | Prut | 18172 | 200 | 0.01 | 0 | 2 | 0.000 | 101 |
| Mitoc-Malu Galben | EUP | | PRE LGM | OPEN | 110 | Prut | 761 | 25 | 0.03 | 0 | | 0.000 | 32 |
| Mitoc-Malu Galben | EUP | 29,410 | PRE LGM | OPEN | 110 | Prut | 1031 | 36 | 0.03 | 0 | | 0.000 | 44 |
| Mitoc-Malu Galben | EUP | 27,490 | PRE LGM | OPEN | 110 | Prut | 286 | 20 | 0.07 | 1 | | 0.003 | 0 |
| Mitoc-Malu Galben | GR | 26,770 | PRE LGM | OPEN | 110 | Prut | 2240 | 37 | 0.02 | 3 | | 0.001 | 8 |
| Mitoc-Malu Galben | GR | 25,878 | LGM | OPEN | 110 | Prut | 3690 | 84 | 0.02 | 6 | | 0.002 | 44 |
| Mitoc-Malu Galben | GR | 24,473 | LGM | OPEN | 110 | Prut | 4573 | 46 | 0.01 | 6 | | 0.001 | 62 |
| Mitoc-Malu Galben | GR | 23,740 | LGM | OPEN | 110 | Prut | 11659 | 122 | 0.01 | 31 | | 0.003 | 151 |
| Mitoc-Malu Galben | GR | 19,510 | LGM | OPEN | 110 | Prut | 255 | 26 | 0.10 | 0 | | 0.000 | 28 |
| Lespezi-Lutărie | GR | | LGM | OPEN | 250 | Bistrița | 504 | 38 | 0.08 | 5 | | 0.010 | 15 |
| Lespezi-Lutărie | GR | 18,020 | LGM | OPEN | 250 | Bistrița | 1752 | 71 | 0.04 | 13 | | 0.007 | 203 |
| Lespezi-Lutărie | GR | | LGM | OPEN | 250 | Bistrița | 1355 | 100 | 0.07 | 29 | 1 | 0.022 | |
| Lespezi-Lutărie | GR | 18,110 | LGM | OPEN | 250 | Bistrița | 2260 | 133 | 0.06 | 29 | | 0.013 | 146 |
| Lespezi-Lutărie | GR | 17,620 | LGM | OPEN | 250 | Bistrița | 2319 | 117 | 0.05 | 24 | | 0.010 | 267 |
| Poiana Ciresului | EPIGR | 20,049 | LGM | OPEN | 400 | Bistrița | 6295 | 213 | 0.03 | 45 | 4 | 0.008 | 9244 |
| Poiana Ciresului | GR | 25,135 | LGM | OPEN | 400 | Bistrița | 243 | 24 | 0.10 | 10 | | 0.041 | N/A |
| Poiana Ciresului | GR | 26,317 | LGM | OPEN | 400 | Bistrița | 2578 | 117 | 0.05 | 74 | | 0.029 | N/A |
| Buda-Dealul Viilor | GR | 23,810 | LGM | OPEN | 400 | Bistrița | 1618 | 290 | 0.18 | 85 | | 0.053 | 1239 |
| Buda-Dealul Viilor | GR | | LGM | OPEN | 400 | Bistrițaam | 138 | 53 | 0.38 | 7 | | 0.051 | |
| Buda-Dealul Viilor | GR | | LGM | OPEN | 400 | Bistrița | 24 | 8 | 0.33 | 2 | | 0.083 | |
| Bistricioara-Lutărie | EUP | 27470 | PRELGM<br>LGM | OPEN | 550 | Bistrița | 1049 | 21 | 8.48 | 5 | 1 | 0.006 | |
| Bistricioara-Lutărie | GR | 24292 | LGM | OPEN | 550 | Bistrița | 1038 | 30 | 10.98 | 11 | | 0.011 | |
| Bistricioara-Lutărie | GR | 20000 | LGM | OPEN | 550 | Bistrița | 3033 | 37 | 7.15 | 18 | | 0.006 | |
| Bistricioara-Lutărie | GR | 17602 | LGM | OPEN | 550 | Bistrița | 1464 | 15 | 9.36 | 12 | | 0.008 | |
| Bistricioara-Lutărie | GR | | LGM | OPEN | 550 | Bistrița | 859 | 10 | 14.78 | 30 | | 0.035 | |
| Bistricioara-Lutărie | GR | | LGM | OPEN | 550 | Bistrița | 780 | 27 | 16.28 | 43 | | 0.055 | |
| Dârțu | EUP | 29096 | PRELGM | OPEN | 550 | Bistrița | 484 | 3 | 8.47 | 1 | | 0.002 | |
| Dârțu | EUP | 21100 | LGM | OPEN | 550 | Bistrița | 1112 | 22 | 9.26 | 6 | | 0.005 | |
| Dârțu | GR | 17860 | LGM | OPEN | 550 | Bistrița | 192 | 1 | 17.71 | 9 | | 0.047 | |

| Site<br>Layer | Lithic Industry | Mean Age BP | Chronology | Context | Elevation a.s.l. | Region | Total ithics | Retouch artifacts | % Retouch | Bifaces & Backed | Bone artifact | TSPI | Fauna NISP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dârțu | GR | | LGM | OPEN | 550 | Bistrițaam | 668 | 15 | 9.58 | 23 | | 0.034 | |
| Dârțu | GR | | LGM | OPEN | 550 | Bistrița | 9449 | 157 | 6.68 | 266 | | 0.028 | |
| Podiș | EUP | | PRELGM | OPEN | 500 | Bistrița | 357 | 7 | 17.09 | 4 | | 0.011 | |
| Podiș | GR | | LGM | OPEN | 500 | Bistrița | 888 | 16 | 10.59 | 27 | | 0.030 | |
| Podiș | GR | 16970 | LGM | OPEN | 500 | Bistrița | 1877 | 25 | 5.70 | 37 | | 0.020 | |
| Podiș | GR | | LGM | OPEN | 500 | Bistrița | 484 | 10 | 11.98 | 12 | | 0.025 | |
| Podiș | GR | | LGM | OPEN | 500 | Bistrița | 3730 | 71 | 9.44 | 149 | | 0.040 | |
| Cetățica-I | EUP | | PRELGM | OPEN | 500 | Bistrița | 152 | 8 | 26.32 | | | 0.0000 | |
| Cetățica-I | EUP | 23890 | LGM | OPEN | 500 | Bistrița | 214 | 9 | 14.02 | | | 0.0000 | |
| Cetățica-I | GR | 19760 | LGM | OPEN | 500 | Bistrița | 392 | 5 | 9.95 | 5 | | 0.013 | |
| Cetățica-I | GR | | LGM | OPEN | 500 | Bistrița | 213 | 5 | 15.02 | 7 | | 0.0329 | |
| Cetățica-I | GR | | LGM | | 500 | Bistrițaam | 269 | 4 | 14.13 | 11 | | 0.0409 | |

Appendix B Table 3. Summary assemblage information for the sites used in analyses. Estimated age is based on radiometric dates where available (continued).

| Site Layer | Industry | Area | Layers Thickness | Artifacts Volumetric Density | Core s | Debitage | Retouched | Total Lithics |
|---|---|---|---|---|---|---|---|---|
| Bordu-Mare I | MP | 30 | 0.200 | 10.50 | 2 | 52 | 9 | 63 |
| Bordu-Mare II | MP | 30 | 0.235 | 6.24 | 4 | 35 | 6 | 44 |
| Bordu-Mare III | MP | 110 | 1.10 | 14.14 | 38 | 1553 | 120 | 1711 |
| Bordu-Mare IV | MP | 30 | 0.440 | 13.41 | 5 | 158 | 14 | 177 |
| Bordu-Mare V | EUP | 30 | 0.165 | 3.64 | 0 | 15 | 3 | 18 |
| Ripiceni-Izvor I | MP | 285 | 0.65 | 6.04 | 48 | 796 | 237 | 1119 |
| Ripiceni-Izvor II | MP | 300 | 0.70 | 6.10 | 45 | 1073 | 139 | 1282 |
| Ripiceni-Izvor III | MP | 400 | 0.60 | 7.98 | 61 | 1627 | 203 | 1916 |
| Ripiceni-Izvor IV | MP | 1400 | 0.63 | 40.69 | 1034 | 33392 | 1361 | 35890 |
| Ripiceni-Izvor V | MP | 700 | 0.55 | 41.72 | 355 | 15384 | 340 | 16064 |
| Ripiceni-Izvor VI | MP | 150 | 0.25 | 8.64 | 8 | 261 | 50 | 324 |
| Ripiceni-Izvor AI a | EUP | 200 | 0.35 | 14.44 | 52 | 814 | 145 | 1011 |
| Ripiceni-Izvor A I b | EUP | 200 | 0.33 | 35.48 | 121 | 2033 | 152 | 2306 |
| Ripiceni-Izvor A II a | EUP | 300 | 0.30 | 44.67 | 184 | 3664 | 172 | 4020 |
| Ripiceni-Izvor A II b | EUP | 400 | 0.30 | 37.78 | 193 | 4035 | 306 | 4534 |
| Ripiceni-Izvor Gr Ia | LUP | 225 | 0.35 | 88.08 | 211 | 6550 | 175 | 6936 |
| Ripiceni-Izvor Gr Ib | LUP | 200 | 0.35 | 92.11 | 172 | 6142 | 134 | 6448 |
| Ripiceni-Izvor Gr IIa | LUP | 230 | 0.30 | 85.04 | 121 | 5581 | 166 | 5868 |
| Ripiceni-Izvor Gr IIb | LUP | 300 | 0.35 | 82.21 | 239 | 8107 | 286 | 8632 |
| Mitoc-Malu Galen Ainf | Aurignacian | 80 | 1.25 | 12.16 | 17 | 1179 | 20 | 1216 |
| Mitoc-Malu Gaben A I | Aurignacian | 142 | 0.563 | 227.51 | 119 | 17853 | 200 | 18172 |
| Mitoc-Malu Galben A II | Aurignacian | 100 | 0.563 | 13.53 | 26 | 710 | 25 | 761 |
| Mitoc-Malu Galben AIII | Aurignacian | 108 | 0.313 | 30.55 | 59 | 936 | 36 | 1031 |
| Mitoc-Malu Galben AIII Superior | Aurignacian | 92 | 0.500 | 6.22 | 19 | 247 | 20 | 286 |
| Mitoc-Malu Galben Gr.I | Gravettian | 116 | 1.13 | 17.09 | 57 | 2146 | 37 | 2240 |
| Mitoc-Malu Galben Gr.II | Gravettian | 132 | 0.625 | 44.73 | 42 | 3560 | 84 | 3690 |
| Mitoc-Malu Galben Gr. III | Gravettian | 178 | 1.063 | 24.17 | 90 | 4438 | 46 | 4573 |
| Mitoc-Malu Galben Gr.IV | Gravettian | 332 | 1.125 | 31.22 | 298 | 11240 | 122 | 11659 |
| Mitoc-Malu GalbenGr.Disperse | Gravettian | 112 | 1.875 | 1.21 | 8 | 177 | 26 | 255 |
| Lespezi-Lutărie VI | Gravettian | 837 | 1.3 | 0.46 |  | 466 | 38 | 504 |
| Lespezi-Lutărie V | Gravettian | 837 | 0.70 | 2.99 |  | 1681 | 71 | 1752 |
| Lespezi-Lutărie IV | Gravettian | 837 | 0.50 | 3.24 | 30 | 1225 | 100 | 1355 |
| Lespezi-Lutărie III | Gravettian | 837 | 0.60 | 4.50 | 50 | 2077 | 133 | 2260 |
| Lespezi-Lutărie II | Gravettian | 837 | 0.30 | 9.24 | 23 | 2062 | 117 | 2319 |
| Poiana-Cireșului II | Epigravettian II | 55 | 0.40 | 286.14 | 153 | 5929 | 213 | 6295 |
| Poiana-Cireșului III | Gravettian I | 55 | 0.20 | 22.09 | 5 | 214 | 24 | 243 |
| Poiana-Cireșului IV | Gravettian II | 55 | 0.30 | 156.24 | 14 | 2447 | 117 | 2578 |
| Buda-Dealu Viilor I | Gravettian I | 510 | 0.425 | 7.46 | 45 | 1283 | 290 | 1618 |
| Buda-Dealu Viilor II | Gravettian II | 510 | 0.200 | 1.35 | 7 | 78 | 53 | 138 |
| Buda-Dealu Viilor III | Gravettian III | 510 | 0.125 | 0.31 | 2 | 14 | 8 | 24 |

Appendix B, table 4. Summary data for lithic assemblages discussed in text.

Appendix B, table 5. Faunal remains from the Upper Paleolithic site of Mitoc-Malu Galben (after, Otte et al., 2007; Noiret, 2009).

| Site Layer | Horse | | Reindeer | | Bison | | Mammoth | | Deer | | Megaceros | | Rhinoceros | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI |
| Aurignacian inf. | 14 | 5 | | | 21 | 4 | 2 | 2 | | | | | | |
| Aurignacian I | 48 | 4 | 9 | 2 | 41 | 5 | | | | | 1 | 1 | 1 | 1 |
| Aurignacian II | 16 | 4 | 1 | 1 | 14 | 1 | 1 | 1 | | | | | | |
| Aurignacian III | 22 | 5 | 11 | 3 | 9 | 4 | 1 | 1 | | | | | | |
| Gravettian I | 7 | 3 | 2 | 1 | 2 | 1 | | | | | | | | |
| Gravettian II | 23 | 4 | 10 | 3 | 3 | 2 | 5 | 2 | | | | | | |
| Gravettian III | 39 | 6 | 7 | 2 | 15 | 5 | 1 | 1 | | | | | | |
| Gravettian IV | 65 | 13 | 21 | 6 | 57 | 9 | 2 | 2 | | | | | | |

| Site Layer | Wolf | |
|---|---|---|
| | NISP | MNI |
| Aurignacian inf. | | |
| Aurignacian I | | |
| Aurignacian II | | |
| Aurignacian III | 1 | 1 |
| Gravettian I | | |
| Gravettian II | | |
| Gravettian III | | |
| Gravettian IV | | |

Appendix B, table 5 (Continued).

Appendix B, table 6. Faunal remains from the Epigravettian II layer at Poiana Cireșului (Cârciumaru et al., 2006, Dumitrașcu, 2008).

| **Species** | **NISP** | **MNI** |
|---|---|---|
| Reindeer | 6463 | 72 |
| Bos/Bison | 106 | 5 |
| Elk | 69 | 2 |
| Horse | 15 | 1 |
| Chamois | 1 | 1 |
| Fox | 1 | 1 |

Appendix B, Table 7. Faunal remains from the Gravettian I layer at Buda-Dealu Viilor (Necrasov and Bulai-Ştirbu, 1972; Bolomey, 1989; Dumitraşcu, 2008)

| **Species** | **NISP** | **Percentage** |
|---|---|---|
| Bos/Bison | 1110 | 89,59 |
| Reindeer | 123 | 9,93 |
| Horse | 5 | 0,40 |
| Elk | 1 | 0,08 |
| Total | 1239 | 100 |

Appendix B, Table 8. Faunal remains from the Upper Paleolithic site of Lespezi-Lutărie (Bolomey, 1989; Dumitraşcu, 2008)

| **Species Layer** | **VI** | | **V+IV** | | **III** | | **II** | |
|---|---|---|---|---|---|---|---|---|
| | NISP | MNI | NISP | MNI | NISP | MNI | NISP | MNI |
| Reindeer | 4 | 1 | 90 | 12 | 60 | 6 | 181 | 9 |
| Horse | 4 | 1 | 73 | 9 | 50 | 4 | 43 | 3 |
| Bos/Bison | 2 | 1 | 12 | 2 | 16 | | 19 | 4 |
| Moose | 2 | 1 | 8 | 1 | 8 | 1 | 13 | 2 |
| *Megaloceros* | | | 2 | | 2 | | 8 | |
| *Tichorhinus antiquitatis* | | | 2 | | 1 | | | |
| *Elephas primigenius* | 1 | | 4 | 1 | | | | |
| Wolf | | | 5 | | 3 | | 1 | |
| Wolverine | | | 4 | 1 | | | | |
| Rabbit | | | 3 | 1 | | | 2 | |
| Beaver | | | | | 1 | | | |
| Marmot | | | | | 1 | | | |
| *Bison priscus* Boj. | 2 | 1 | | | 4 | 3 | | |
| Total | 15 | | 203 | | 146 | | 267 | |

# FIGURES

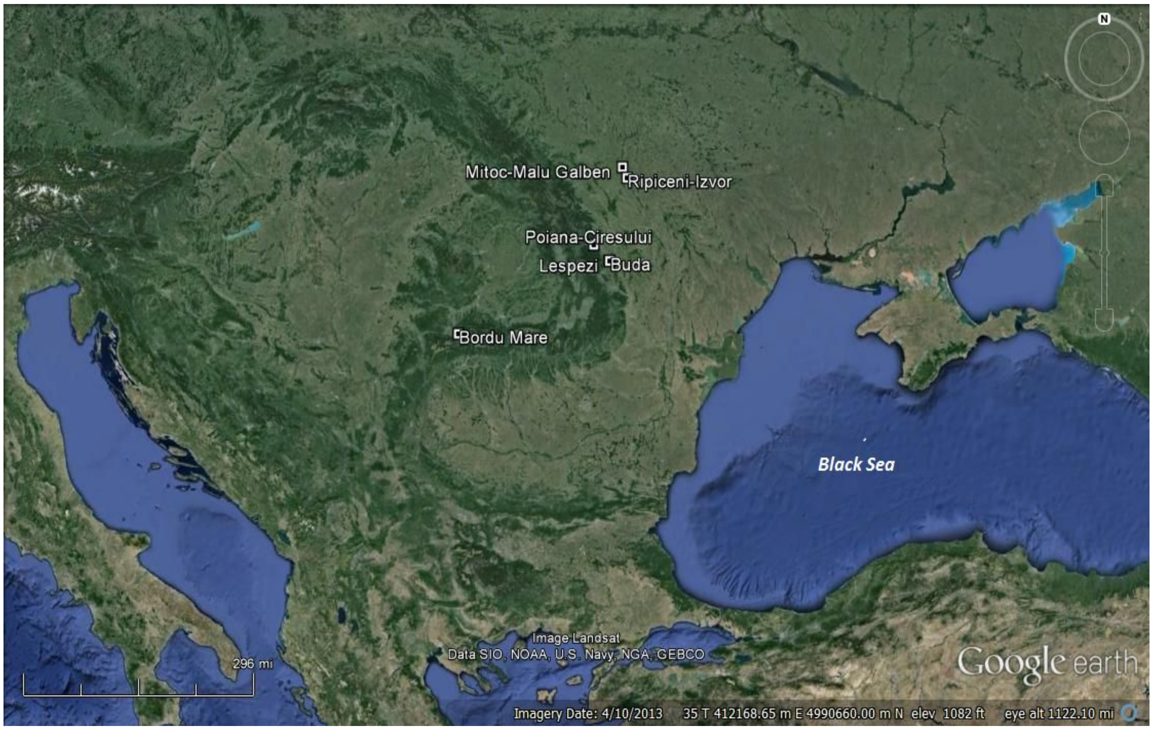


Figure 1. Geographical position of the sites discussed in text.

Figure 2. Pollen diagrams and the geochronology of the Middle and Upper Paleolithic in Romania (Cârciumaru, 1973, 1980, 1989).

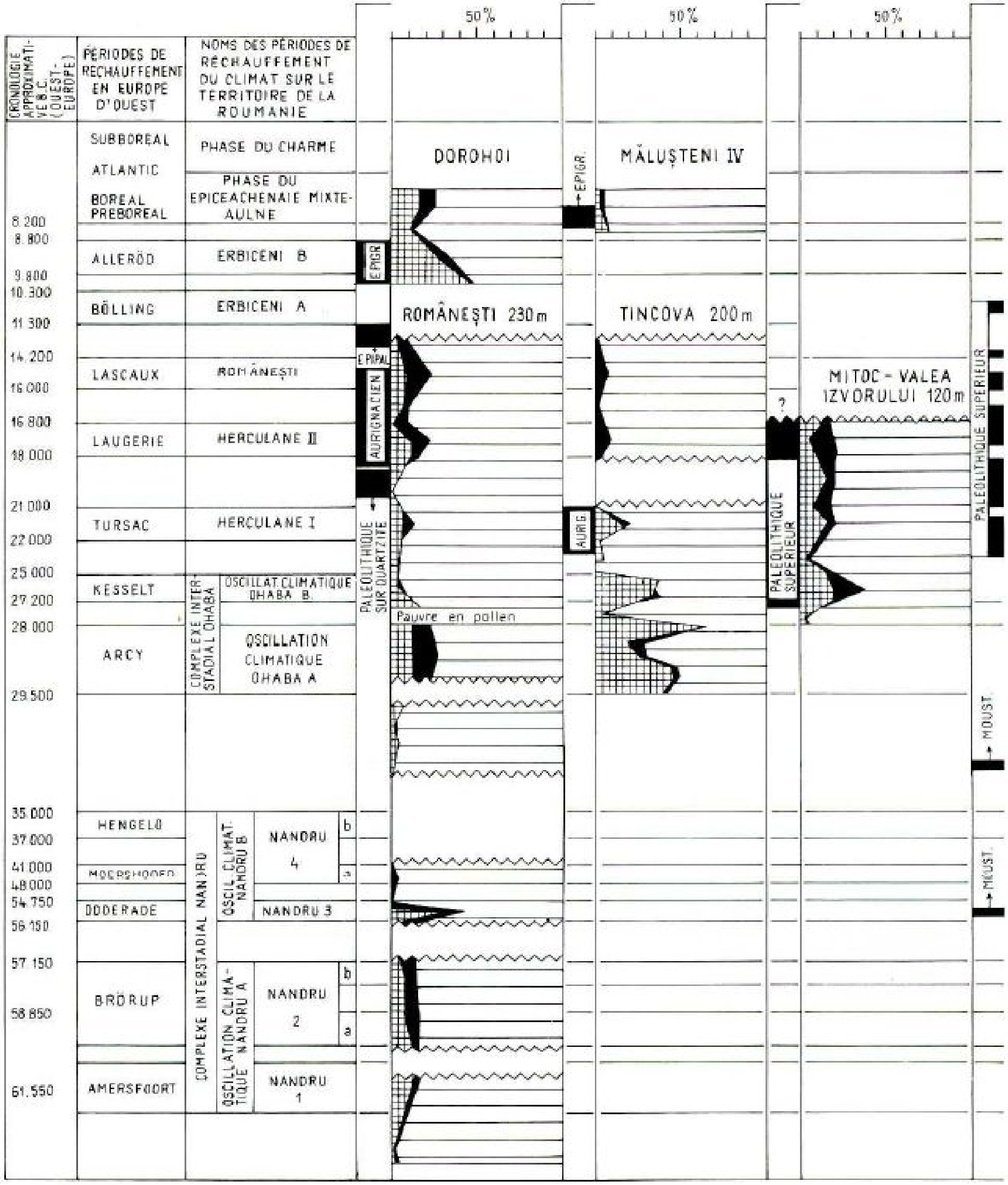


Figure 2 (continued) Pollen diagrams and the geochronology of the Middle and Upper Paleolithic in Romania (Cârciumaru, 1989)

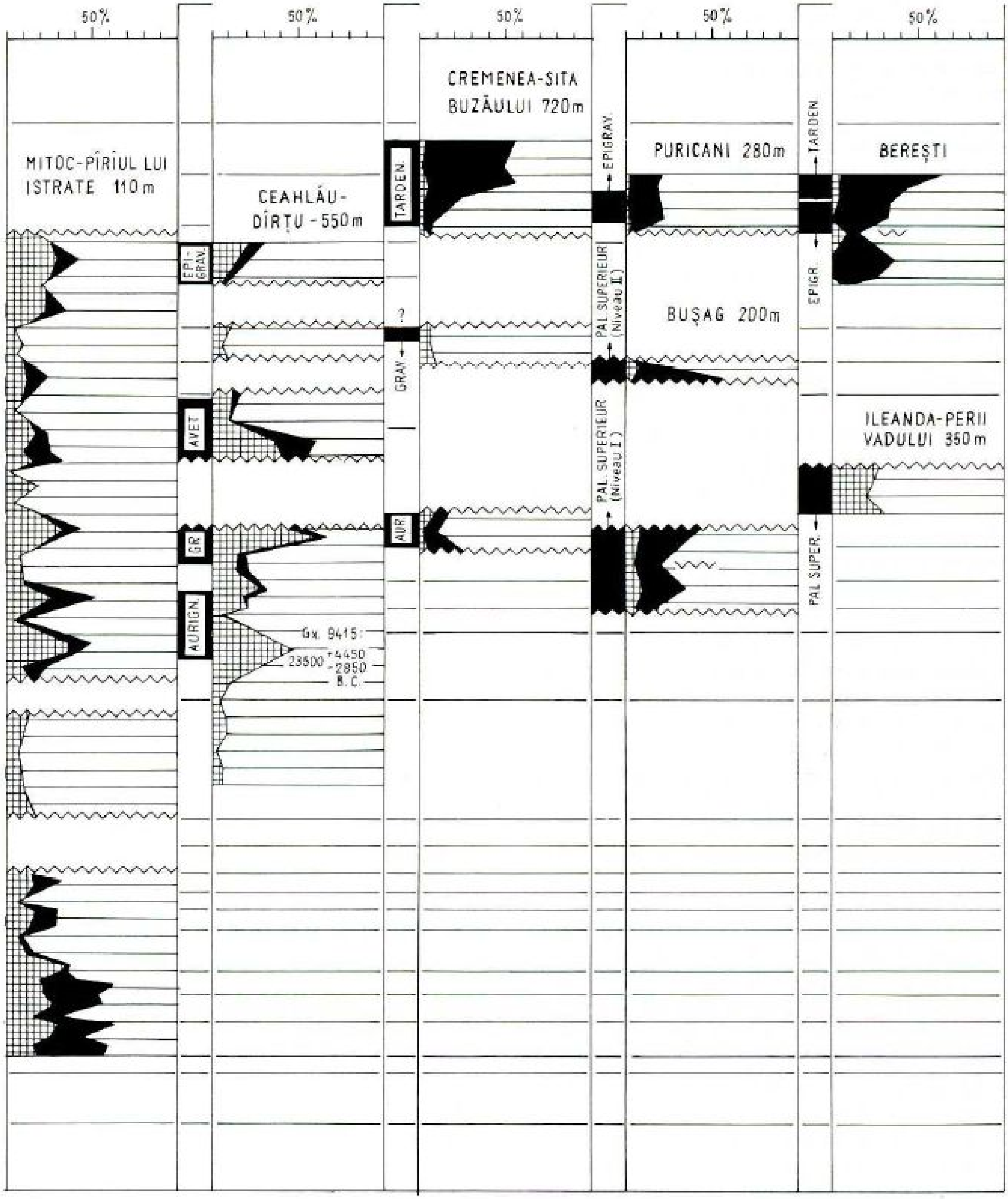


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Figure 3. Synthetic lithostratigrapy, geochronology and paleoenvironmental sequence for the site of Mitoc-Malu Galben (Haesaerts et al., 2003).

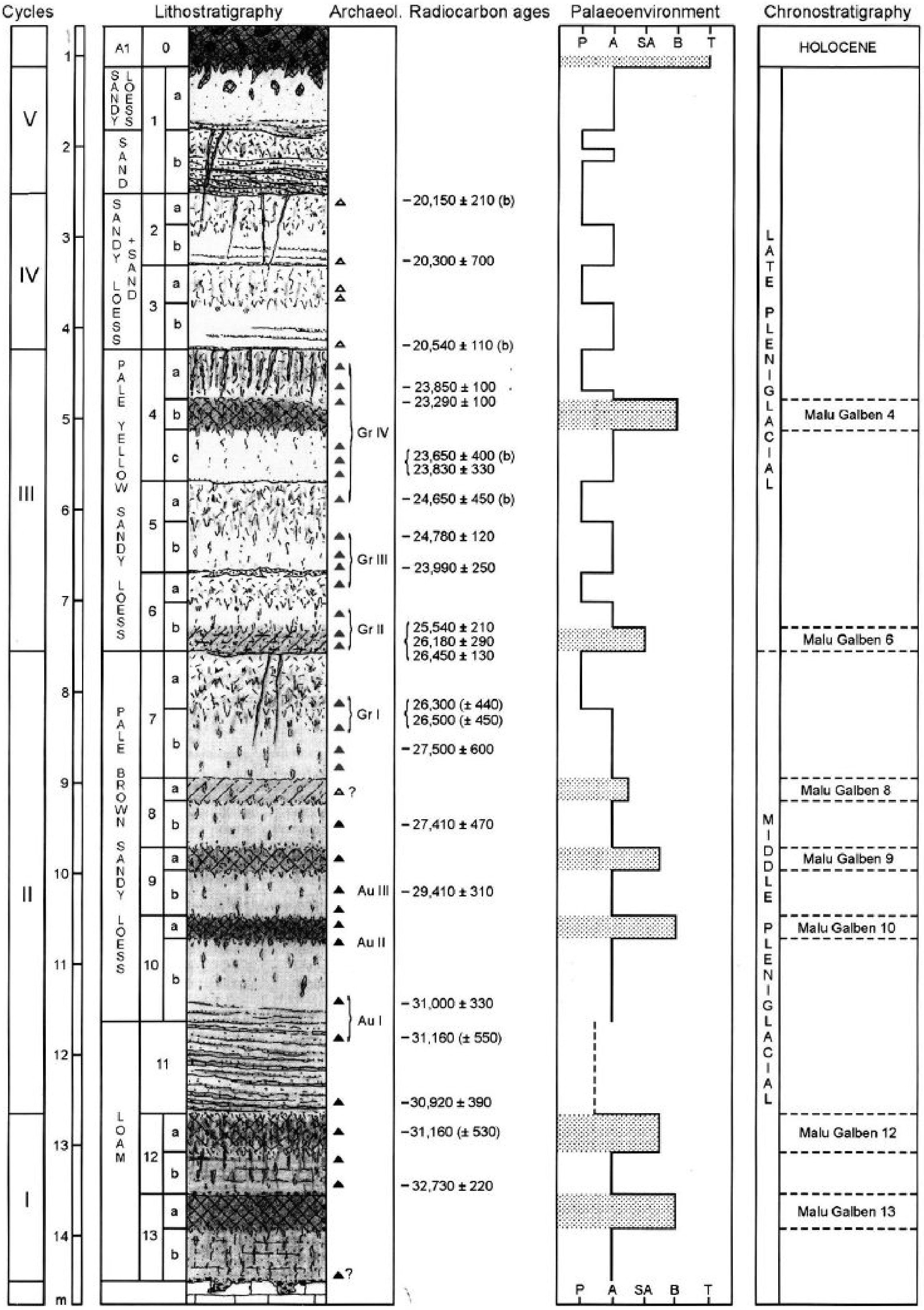

Figure 4. Synthetic geological and cultural framework from Bistrița's middle terrace (Nicolăescu-Plopșor et al., 1966, p. 17)

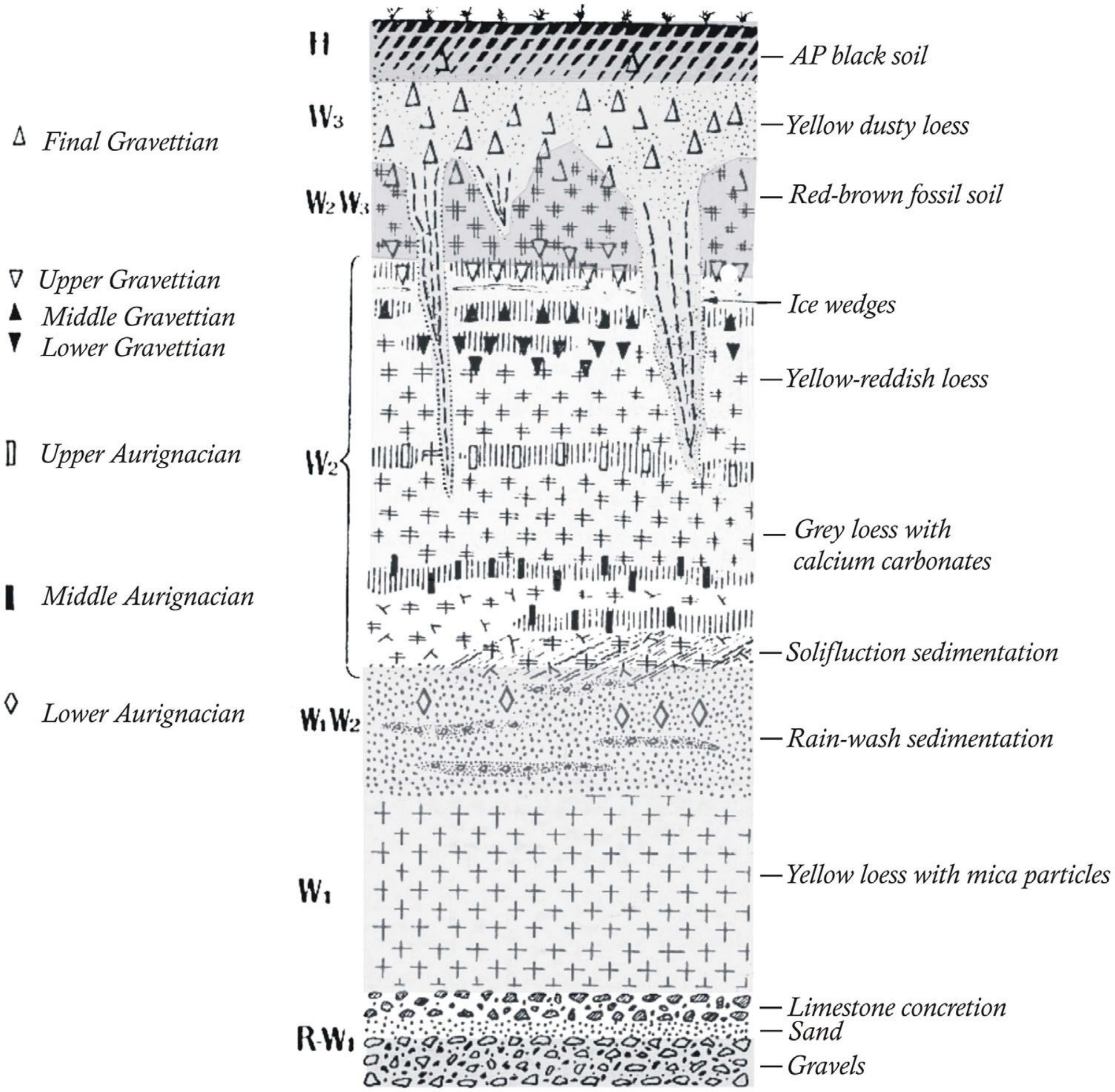

Figure 5. Poiana Cireșului-Piatra Neamț loess sequence including the Gravettian layers (drawing L. Steguweit) (Steguweit et al., 2009).

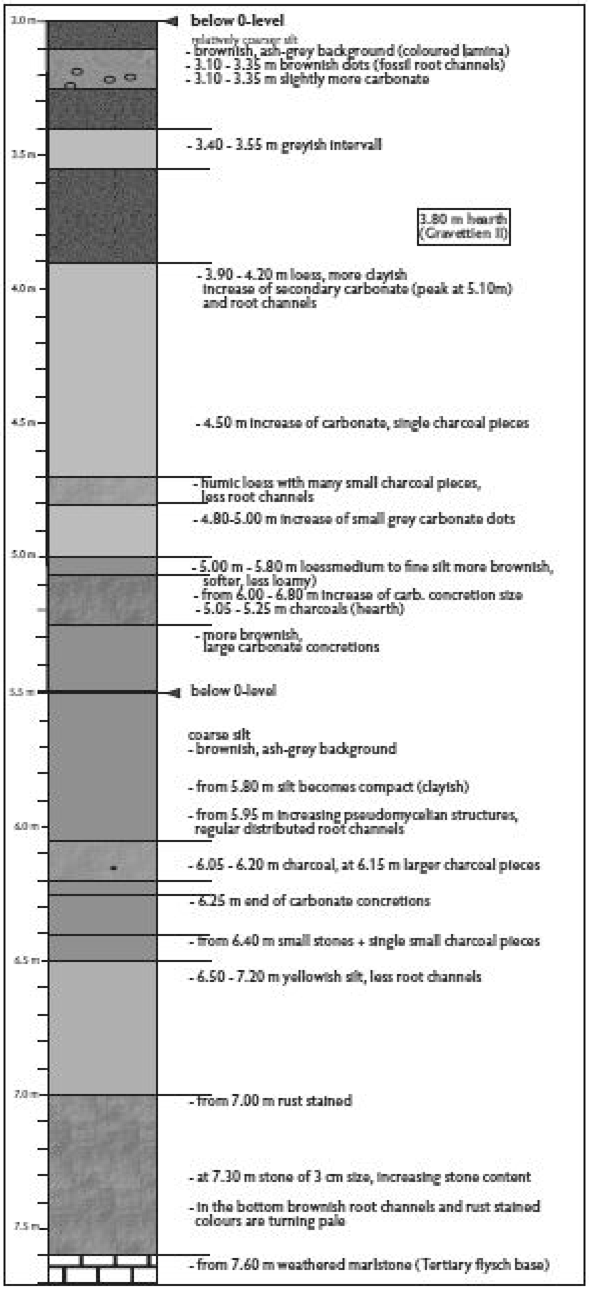

Figure 6. Current geologic profiles for the main sites in Bistrița Valley: 1: Ceahlău-Dârțu; 2. Bistricioara-Lutărie I; 3.Bistricioars-Lutărie III; 4. Bistriciora-Lutărie
'Mal' ('Shore') (from Anghelinu et al., 2012, p. 32).