# Early Upper Palaeolithic before the Aurignacian

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**Abstract**
Between ~60 and ~25 ka BP two big changes are recognizable in the archaeological record of Europe: Modern humans replaced Neanderthals and the Middle Palaeolithic was replaced by the Upper Palaeolithic. The Early Upper Palaeolithic across Europe, especially before the Aurignacian, is characterized by a huge variability of different technocomplexes. The so-called transitional technocomplexes, thought to have been produced by Neanderthals, are considered to be either local innovations by Neanderthals or the product of cultural transmission of behaviours from incoming modern human populations. This study tests whether local innovation or diffusion of behaviours are supported by the Early Upper Palaeolithic record of the Middle Danube region in Central Europe. The results using eight assemblages from seven archaeological sites suggest that the transitional technocomplex of the region, the Szeletian, is best explained by diffusion of behaviour from incoming modern humans to local Neanderthal populations.

## 1 Introduction

In the western Eurasian archaeological record we observe during Marine Isotope Stage (MIS) 3, i.e., between ~60 and ~25 ka BP, the replacement of Neanderthals by modern humans, the appearance of the Early Upper Palaeolithic (EUP) and the appearance of what is often called behavioural 'modernity'. In the literature the latter two are also referred to the Middle-to-Upper Palaeolithic transition. Most scholars agree that these huge changes in the archaeological record relate to the colonization of northern latitudes by modern humans, but some argue that the changes in material culture at the Middle-to-Upper Palaeolithic transition are happening before modern humans dispersed into Europe and hence are unrelated. However, the topic remains heavily debated (see discussions in, e.g., Akazawa *et al.,* 2013; Barker *et al.,* 2007; Brantingham *et al.,* 2004; Conard, 2006; Klein, 2009; Mellars & Stringer, 1989; Mellars *et al.,* 2007; Rabett, 2012; Zilhão & d'Errico, 2003).

The archaeological record of the Middle-to-Upper Palaeolithic transition throughout Western Eurasia is characterized by large differences between Middle Palaeolithic and Upper Palaeolithic assemblages (e.g., Klein, 1969a, 1973; Mellars, 1989a) and by a complex patterning of various EUP assemblages with huge regional variability (see discussions in e.g., Brantingham *et al.,* 2004; Conard, 2006; Zilhão & d'Errico, 2003). For the longest time the Aurignacian technocomplex has been considered the signature of modern humans dispersing into and within Europe (e.g., Klein, 1973; Mellars, 1989a; Davies, 2001). Other technocomplexes at more or less the same time as the Aurignacian include the so-called transitional technocomplexes (e.g., the Châtelperronian, Szeletian, etc.), and other EUP technocomplexes like the Bohunician or the Streletskian .
The role of the Aurignacian, including the Proto-Aurignacian and Early Aurignacian, in the debate of the colonization of Europe by modern humans, the replacement of Neanderthals and the appearance of the EUP has changed over the decades (e.g., Nigst, 2012; Teyssandier, 2008). The Aurignacian is one of the two EUP technocomplexes in Europe that are securely associated with modern human remains in Europe (Bailey *et al.,* 2009; Hublin, 2015). The other EUP assemblage associated with modern humans is AH IVb of Kostenki 14 (Sinitsyn, 2003, 2010). The potential association of the Uluzzian of Grotta di Cavallo with the modern human teeth from the same site remains debated due to the lack of information on the site formation processes (Benazzi *et al.,* 2001; Banks *et al.,* 2012; Rontichelli *et al.,* 2014; Zilhao *et al.,* 2015).
It is becoming increasingly clear that the Aurignacian (including the Early Aurignacian and the Proto-Aurignacian) postdates the first EUP technocomplexes at least in some parts of Europe. Nevertheless, the Aurignacian seems to appear not all over Europe at the same time (e.g., Davies, 2001, 2007; Conard, 2006; Nigst, 2006, 2012; Nigst *et al.,* 2014). This debate is dependent studies that combine a strong stratigraphy and site formation component with a high-resolution dating program in a climatostratigraphic approach (e.g., Nigst *et al.,* 2014; Pirson *et al.,* 2011). Key for such approaches are long loess-palaeosol sequences with a rather high palaeo-environmental resolution, like Willendorf II (Nigst *et al.,* 2014) in the Middle Danube region or Mitoc-Malu Galben (Otte *et al.,* 2007) in the East Carpathian region. In the Middle Danube region it is known for a long time that there exist other EUP technocomplexes besides the Aurignacian: the Szeletain and the Bohunician (e.g., Valoch, 1990, 2000; Skrdla, 2003; Svoboda & Bar-Yosef, 2003). Their chronostratigraphic position has been debated for a long time, and it has become clear that the Aurgnacian is not the first EUP in this particular region (Haesaerts, 1990; Valoch, 2000; Svoboda & Bar-Yosef, 2003; see also Nigst, 2012, 2014 for a summary).
In this study, I look at what is known about the EUP technocomplexes before the Aurignacian and what their patterning can tell us about population interaction with regard of the Neanderthal – modern human replacement. I use primarily examples from the Middle Danube region as a case study and put them in a wider picture of the colonization process of Europe.

## 2 The Aurignacian, the Early Upper Palaeolithic and the Middle to Upper Palaeolithic transition

The on-going debate on the Middle-to-Upper Palaeolithic transition centres on (i) the

definition of the involved technocomplexes (Late Middle Palaeolithic, Bohunician/Initial Upper Palaeolithic, transitional technocomplexes and the Aurignacian), (ii) the spatio-temporal patterning of these technocomplexes, and (iii) the relationship of these technocomplexes and similarities or differences in hominin behaviours. In many regions across western Eurasia these technocomplexes seem (at least in part) to overlap in time (for more detailed see discussions in e.g., Akazawa *et al.,* 1998; Brantingham *et al.,* 2004; Conard, 2006; Mellars *et al.,* 2007; Zilhão & d'Errico, 2003). A good example is provided by the Middle Danube region, for which it was argued – based on the radiocarbon dating record - for a long time that there was a coexistence of Bohunician, Szeletian, and Early Aurignacian (e.g., Svoboda *et al.,* 1996; Nigst, 2006, 2010). Other work taking into consideration pedostratigraphy in a climatostratigraphic approach (Haesaerts, 1990; Haesaerts *et al.,* 1996; Nigst, 2012, 2014; Nigst *et al.,* 2014; Nigst & Haesaerts, 2012) or other dating techniques like luminescence dating (Richter *et al.,* 2008, 2009) have argued for a chronostratigraphic model in which the Aurignacian post-dates the Bohunician and Szeletian. This patterns holds true even after the demonstration of an Aurignacian at ~43.5 ka cal BP at Willendorf II (Nigst *et al.*, 2014).
While the age and potential overlap of the EUP technocomplexes across Europe might be a matter of debate, all scholars would agree that, in general, the EUP of Europe is characterized by a huge variability of lithic and organic technologies. In the local sequences we observe a succession of a late Middle Palaeolithic (LMP) followed by EUP assemblages assigned to (a) various transitional technocomplexes (e.g., Châtelperronian,[e.g., Roussel *et al.*, 2016], Szeletian [Valoch, 1993], etc.), (b) the Bohunician or Initial Upper Palaeolithic (e.g., Tostevin, 2000a, 2012; Nigst 2012), (c) other EUP technocomplexes like the Streletskian, Spitsynian, and Kostenki 14 Layer IVb assemblage (which are often known from only one or two sites or site clusters) (e.g., Sinitsyn, 2010), and (d) the Aurignacian (including Proto-Aurignacian and Early Aurignacian). Most archaeologists would attribute this large variability to regionally different cultural traditions. However, genetic data suggest that that these (and later archaeologically very diverse populations) belonged to the same metapopulation in western Eurasia (e.g., Seguin-Orlando *et al.,* 2014). Some scholars have stressed other than cultural factors such as site function (e.g., Klein, 1969b; Hoffecker *et al.,* 2010), population dispersal, population density, adaptation to particular environmental niches or seasonally different patterns of mobility and responses to resource stress (Davies, 2001, 2007; Nigst *et al.,* 2014). The debate is ongoing and new data on environmental context but also new approaches to test population contact scenarios are strongly needed.
In the discussion of the population history around the Neanderthal by modern human replacement the so-called transitional technocomplexes have played a major role. Transitional technocomplexes are characterized by a mixture of Middle and Upper Palaeolithic features, including tool types and technological aspects that characterize such transitional technocomplexes. Important in order to be classified as a transitional technocomplex is the fact that they show similarities with the local LMP (see definition criteria of a 'transitional' technocomplex after Kuhn 2003). Following this definition the occurrence of features in these assemblages not observed in the local LMP, but in those of other regions, does not allow for them to be classified as transitional technocomplexes. The Bohunician, sometimes grouped into the IUP *sensu* Kuhn (Kuhn *et al.,* 1999), does not show this link to the local LMP (e.g., Tostevin, 2000a, 2003b, 2007, 2012; Nigst 2012, 2014) and should therefore not be classified as a transitional technocomplex.

Of specific interest in current debates is the emergence of so-called transitional technocomplexes like the Châtelperronian of Western Europe and the Szeletian of the Middle Danube region. In the past several models have been proposed to explain the existing spatio-temporal patterns in the human fossil and the material culture records in general and the emergence of the transitional technocomplexes in particular (for a recent summary see e.g., Nigst, 2012). These include the local evolution model, arguing that modern human behaviour evolved locally several times in different geographic locations without influence from outside (e.g., Bordes, 2002; d'Errico *et al.,* 1998; d'Errico, 2003; Zilhão & d'Errico, 1999a, 2000; Zilhão, 2006b), and the "diffusion" (e.g., Bar-Yosef & Pilbeam, 2000; Bar-Yosef, 2006; Davies, 2001, 2007; Demars & Hublin, 1989; Harrold, 1989; Hublin *et al.,* 1996; Klein, 1973, 2008, 2009; Kozlowski & Otte, 2000; Mellars, 1989b, 2005; Nigst, 2006; Svoboda *et al.,* 1996; Svoboda & Bar-Yosef, 2003) and "stimulus diffusion" models (Tostevin, 2000a, 2003b, 2007, 2012; Nigst, 2012, 2014), stating that the changes in the LMP and the development of the transitional technocomplexes are a result of modern humans dispersing into western Eurasia and influencing local Neanderthal populations and the material correlate of their behaviours.

Whereas over the last decade we have seen a lot of progress in the provision of more accurate age estimations for the various LMP and EUP technocomplexes, there has only been little progress in the implementation of new approaches to the study of the (mainly) lithic assemblages. Improvements in dating include, in terms of AMS radiocarbon dating, more refined sample preparation (e.g., Bird *et al.,* 1999; Higham *et al.,* 2006; Haesaerts *et al.,* 2010, 2013) and the subsequent application of these sample preparation protocols (e.g., Haesaerts *et al.,* 2013; Higham *et al.,* 2011, 2012; Hublin *et al.,* 2012; Richter *et al.,* 2009; Talamo *et al.,* 2012), as well as application of TL and OSL dating (e.g., Richter *et al.,* 2008, 2009). Additionally, combining all these new age estimations with quaternary geological studies to obtain high-resolution chronostratigraphic positions (Haesaerts *et al.,* 2009, 2010, 2013; Nigst & Haesaerts, 2012; Nigst, 2012, 2014; Nigst *et al.,* 2014; Pirson *et al.,* 2011) for LMP and EUP assemblages.

The lithic assemblages are currently described using various approaches. Most studies apply the traditional *chaîne opératoire* approach (e.g., Bordes, 2002; d'Errico *et al.,* 1998; Flas *et al.,* 2011; Roussel, 2011, 2016; Teyssandier, 2007, 2008; Zilhão & d'Errico, 1999a; Zilhão, 2013; Zwyns, 2012). This approach is problematic because of its emic goals and typological nature (Tostevin, 2011, 2012; Nigst, 2014). In such an approach the units of analysis are types of reduction sequences and, hence, these units change between assemblages. Tostevin (2000a, 2000b, 2007, 2012) has introduced an approach designed specifically to test for cultural transmission and is applied in the present study in a slightly altered way (for a more detailed description see Nigst, 2012, 2014).

## 3 Methodology

### 3.1 Models of Modern Human and Neanderthal interaction

For the Middle Danube region it has been argued that the Szeletian is a transitional technocomplex because it shows some similarities with the local LMP, i.e. roots in and a development out of the local LMP are considered as the most viable scenario (regardless of the cause for this development) (Valoch, 1990, 1993, 2000; see also

Svoboda *et al.,* 1996; Svoboda, & Bar-Yosef, 2003; Tostevin, 2000a, 2000b, 2003a, 2006, 2012; Nigst, 2006, 2010, 2012, 2014).

Scholars have proposed two contrary explanations for the changes in human behaviour that result in the development of the Szeletian. The first one explains the Szeletian as the result of independent innovative processes within the local LMP Neanderthal groups (e.g., d'Errico *et al.,* 1998; d'Errico, 2003; Zilhão & d'Errico, 1999b, 2000; Zilhão, 2006a, 2006b), thus without any influence from modern humans; this model has also been labelled the 'local evolution', 'independent evolution', 'no contact', or 'indigenist' model. The second explanation proposes the Szeletian is the result of changes in late Neanderthal behaviours caused by the diffusion of behaviour or ideas from modern humans dispersing into Europe (diffusion and stimulus diffusion models). This explanation is often also called the 'acculturation' model (e.g., Allsworth-Jones, 1986; Bar-Yosef, 2002, 2006, 2007; Demars & Hublin, 1989; Hublin *et al.,* 1996; Hublin, 2000, 2007, 2012; Klein, 1973, 1995, 2008, 2009; Mellars, 1989b, 2004, 2005). It roots in Klein's (1973) proposal for the development of the Châtelperronian out of the Mousterian under influence of an allochthonous Early Upper Palaeolithic. While the diffusion model assumes direct contact between the 'acculturator' and the 'acculturated' (diffusion of behaviour), the stimulus diffusion model (Kroeber, 1940; for the introduction in archaeology see Tostevin, 2000a, 2007, 2012) does not require direct contact; as described by Kroeber (1940), stimulus diffusion works over larger distances without direct contact between 'innovator' and 'recipient' groups.

Testing for local evolution, diffusion and stimulus diffusion can be aided by utilizing a theoretical framework for assessing scenarios of culture contact and their material results preserved in the archaeological record. Such a framework has recently been proposed by Tostevin (2000a, 2007, 2012) and uses the concepts of social intimacy and taskscape visibility for the analysis of culture contact scenarios among hunter-gatherer societies. Central to this approach is that visibility of lithic artefacts, and of their production and use, are dependent on the location and social intimacy of contact. Following Tostevin, this means that we can expect that individuals will be exposed to different parts of a lithic technology, depending on whether the contact between two populations happens in residential sites or on pathways in the landscape. Tostevin formulated testable models of the material results of population contact at different levels of social intimacy (see Table 28.1 in Tostevin, 2007).

In order to test the models of local evolution, diffusion and stimulus diffusion, one, therefore, has to test for contact between populations and the diffusion of behaviours or ideas from one population to another – or alternatively to demonstrate that this did not happen. The argumentation has to be two-fold: (1) On the one hand comparing assemblages and showing that they are different or similar with regard to learned behaviours, and, (2) showing that diffusion (or local evolution) is possible or impossible due to the age and chronostratigraphic position of the assemblages.

Here, I use Tostevin's framework outlined above, the definitions of the models (local evolution, diffusion and stimulus diffusion), and incorporating arguments related to stratigraphic and chronological position. For each model a number of model expectations can be formulated and are listed below and summarized in Table 1. The models are based on several assumptions or expectations that have to be rejected in order to disprove the model. Some of these expectations are interrelated.

Table 1: Expectation of the models of the Middle-to-Upper Palaeolithic transition in the Middle Danube region. Abbreviations: EUP: Early Upper Palaeolithic, LMP: late Middle Palaeolithic.

| | **Local evolution model (no contact)** | **Diffusion model (direct/socially close contact)** | **Stimulus diffusion model (indirect/socially distant contact)** |
|---|---|---|---|
| **Similarity in core reduction with contemporary EUP populations' material culture** | No | Yes | No (but for parts of core reduction possible) |
| **Similarity in tool production with contemporary EUP populations' material culture** | No | Yes | Yes |
| **Continuity/similarity with local LMP** | Yes, continuity can be expected | Yes, continuity is possible | Yes, some continuity can be expected |
| **Contemporary EUP** | No contemporary EUP populations in the same or other regions | Contemporary EUP populations in the same or other regions | Contemporary EUP populations in same or other (even more distant) regions |
| **Interstratification** | No | Possible, but not necessary | Not to be expected, but possible |

Expectations of the local evolution model:
* *No similarity in production modes and/or final products with contemporary EUP populations' material culture*. If similarity in either production modes or final products (or both) can be shown, this would make diffusion of behaviour/ideas between Neanderthals and modern humans highly likely.
* *No contemporary EUP populations are present*. The presence of any other (whether local or not) EUP population - and therefore contact between the two groups - makes diffusion of behaviour/ideas between Neanderthals and modern humans highly likely.
* *No interstratification of Szeletian and other EUP (mainly Bohunician and Aurignacian) assemblages exists*. Interstratification of the local transitional technocomplex and another EUP technocomplex would demonstrate the use of the same territory by these groups in more or less the same time window and therefore make contacts between these groups extremely likely.
* *Similarity with local LMP material culture exists*. For the local evolution model it is key that there exists similarity with the local LMP and not with a non-local LMP (see the definition of a 'transitional technocomplex' by Kuhn, 2003).

Diffusion model expectations:

* *Similarity in production modes or in both production modes and final products with contemporary EUP population's material culture*.
* *Local contemporary EUP populations are present*. The presence of any other EUP population makes diffusion of behaviour/ideas between modern humans and Neanderthals highly likely.
* *Some continuity with local LMP can be observed*. Transitional technocomplexes are characterized by some similarity with the local LMP.
* *Interstratification of Szeletian and other EUP assemblages is possible, but not necessary for the model to be accepted*. In this regard the absence of interstratification does not allow rejection of the diffusion model, but on the other hand the presence of interstratification allows rejection of the local evolution model.

Stimulus diffusion model expectations:
* The i*dea of a final product (e.g., shape) but with different production mode is the same as in contemporary assemblages in the same or another region*. This can involve the same tool-kit or the merely the idea of a product. As an example hafted composite projectile technology as a concept - rather than a specific type of it - is diffused.
* *Contemporary EUP populations are present*. The presence of any other, local or non-local EUP population makes diffusion of ideas between Neanderthals and modern humans extremely likely. Ii is important to mention here that stimulus diffusion works over huge distances and the 'innovator' and the 'receiver' do not have to be in direct contact.
* *Some continuity with local LMP can be observed*.
* *Interstratification of Szeletian and other EUP assemblages is not to be expected and not necessary for the model to be accepted*. Nevertheless, interstratification is possible within this model.

### 3.2 Lithic and chronostratigraphic analyses

The approach to lithic technology utilized here can be described as a reduction sequence approach based on an attribute analysis (for a full description see Nigst, 2012). Attribute analysis (e.g., Auffermann *et al.,* 1990; Hahn, 1982, 1988; Nigst, 2012, 2014; Schäfer, 1987; Tostevin, 2000a, 2012) is rooted in a detailed piece-by-piece analysis of the entire assemblage or a random selection of it. One of the advantages of such an approach is that it does not make assumptions about potential end products already at the data-recording step. The goal is to explore the variability within and between assemblages by identifying, describing and comparing central tendencies in knapping behaviours. This methodology was adopted from Tostevin (2000a, 2003a, 2003b, 2007, 2012) and focuses on independent behavioural domains or steps during any lithic knapping/reduction process. Each of these steps is located in the reduction sequence at a point where the knapper has to make a decision from various available options, e.g., how to control the angle between the platform and the blank release surface (i.e., the exterior platform angle). The assessment of similarities/differences between the studied assemblages utilizes a pair-wise comparison. To do so, a measure of difference in calculated in order to quantify similarities/differences between pairs of assemblages.
The approach used here differs slightly from the one of Tostevin (2000a, 2012). While Tostevin focuses on five independent behavioural domains (core modification,

platform maintenance, direction of core exploitation, dorsal surface convexity system, and tool manufacture; see Tostevin, 2000a, 2003a, 2003b for more details), this research uses nine domains (direction of cortex removal, core types, platform treatment, core surface treatment, direction of blank removal, bladelets, blank shapes, tool types, blank selection), which are organised along an idealized reduction sequence for the comparison between assemblages (see Nigst, 2012 for details). The idealized reduction sequence is a build up of a number of individual steps. The steps can be divided into sub-steps. Most importantly, such an approach allows comparison of the assemblages of different technocomplex and period attribution (e.g., Middle and Upper Palaeolithic ones) because it is based on comparable units of analysis between the assemblages. A good example for a comparable unit of analysis is the exterior platform angle. Two examples of non-comparable units of analysis are the Micoquian *chaîne opératoire* and Early Aurignacian *chaîne opératoire*, both are typical examples of units of analysis in studies applying a *chaîne opératoire* approach.

This study uses an attribute analysis based on 72 attributes of which approximately 10 are recorded on each lithic object, about 35 on all unretouched debitage pieces and the remaining ones on special pieces like retouched pieces or cores. The attributes comprise quantitative and qualitative ones. Each attribute is well defined (for a detailed list including definitions and drawings see Nigst, 2012). Data analysis employs standard descriptive and frequency statistics. The comparison between the assemblages is a pair-wise comparison. Statistical tests are used to assess whether differences are significant or not. Depending on the type of variable the t-test, Pearson's $\chi^2$-Test, Fisher's Exact Test or likelihood-ratio test are used (Nigst, 2012, 2014).
In order to describe the difference (or similarity) between two assemblages and to quantify the differences in knapping behaviours preserved in these assembalges a measure of difference is calculated. To do so, the value '1' is attributed to each different sub-step (attribute value) and the value '0' to non-different sub-steps (Table 2). These values are then added up and divided by the number of sub-steps to provide a measure of difference for each step. The values for the steps are subsequently added up and divided by the number of steps (domains). This measure of difference can potentially range between 0 (which means 'no difference' or 'identical knapping behaviour') and 1 (which means 'maximum possible difference' or 'totally different knapping behaviour').

Table 2: Example of the comparison of the knapping behaviours and calculation of the measure of difference using the assemblages of Vedrovice V (Szeletian) and Stránská skála IIIc (Bohunician). Abbreviations: UP: unprepared, P: prepared, sd: standard deviation, cre: crested, deb: debordant, lent: lenticular, tra: trapezoidal, tri: traingular, L: length, W: width, EPA: exterior platform angle, PT: paltform thickness. For details on core types A to F and definition of steps/substeps see Nigst (2012).

| **step/substep** | **Vedrovice V** | **Stránská skála IIIc** | **difference** | **measure of difference** |
|---|---|---|---|---|
| *B1: cortex removal* | | | | |
| B1.1: direction of cortex removal (> 66% cortex) | unidirectional | unidirectional changing to crossed | yes | 1 |
| *Measure of difference* | | | *1/1* | *1* |

| | | | | |
|---|---|---|---|---|
| *of step B1* | | | | |
| *C1: core type* | | | | |
| C1.1: core types | A: 2, B: 1, C: 1, D: 3, F; 1 | A: 9, C: 8, D: 29, F: 3 | no | |
| *Measure of difference of step C1* | | | *0/1* | *0* |
| *C2: platform treatment* | | | | |
| C2.1: platform types | UP: 233; P: 119; n=352 | UP: 444; P: 323; n=767 | yes, p=0.008 (chi-square) | |
| C2.2: EPA | 80.73; sd=12.37; n=365 | 84.93; sd=15.05; n=664 | yes, p=0.000 (t-test) | |
| C2.3: core tablet | no | no | no | |
| C2.4: platform thickness | 3.62; sd=3.12; n=461 | 4.55; sd=2.52; n=741 | yes, p=0.000 (t-test) | |
| *Measure of difference of step C2* | | | *4/3* | *0.75* |
| *C3: core surface treatment* | | | | |
| C3.1: crested blanks, debordant flakes, etc. | cre: yes; deb: yes | cre: yes, deb: yes | no | |
| *Measure of difference of step C3* | | | *0/1* | *0* |
| *D1: direction of blank* | | | | |
| D1.1: orientation of dorsal scars | unidirectional more, concentric less, bidirectional less or same | bidirectional changing to unidirectional | yes | |
| *Measure of difference of step D1* | | | *1/1* | *1* |
| *D2: blank types – bladelets* | | | | |
| D2.1: bladelet production? | no | no | no | |
| *Measure of difference of step D2* | | | *0/1* | *0* |
| *D3: blank shapes* | | | | |
| D3.1: cross-section | lent: 30; tra: 156; tri: 639; n=825 | lent: 90; tra: 341; tri: 293; n=724 | yes, p=0.000 (chi-square) | |
| D3.2: L/W-ratio | 1.18; sd=0.44; n=219 | 1.82; sd=0.80; n=731 | yes, p=0.000 (t-test) | |
| D3.3: W/T-ratio | 3.90; sd=1.42; n=219 | 4.15; sd=1.84; n=731 | yes, p=0.034 (t-test) | |
| *Measure of difference of step D3* | | | *3/3* | *1* |
| *E1: tool types* | | | | |
| E1.1: MP or UP types dominating | MP | UP | yes | |
| E1.2: unique retouch type? | leafpoint: bifacial retouch | no | yes | |
| *Measure of difference of step E1* | | | *2/2* | *1* |
| *E2: blank selection* | | | | |
| E2.1: blank selection - L/W-ratio | no diff., p=0.302 (t-test) | no diff., p=0.154 (t-test) | no | |
| E2.2: blank selection – Length | no diff., p=0.441 (t-test) | longer, p=0.001 (t-test) | yes | |
| E2.3: blank selection – Width | no diff., p=0.096 (t-test) | wider, p=0.000 (t-test) | yes | |
| E2.4: blank selection | thicker, p=0.022 | thicker, p=0.001 (t- | no | |

| | | | | |
|---|---|---|---|---|
| – Thickness | (t-test) | test) | | |
| E2.5: blank selection – dorsal scars | no diff., p=0.085 (likelihood ratio) | no diff., p=0.236 (likelihood ratio) | no | |
| E2.6: blank selection - cross-section | no diff., p=0.678 (two-tailed) (Fisher's Exact Test) | no diff., p=0.236 (likelihood ratio) | no | |
| E2.7: blank selection - platform type | no diff., p=0.816 (two-tailed) (Fisher's Exact Test) | no diff., p=0.362 (likelihood ratio) | no | |
| E2.8: blank selection - EPA/PT-ratio | no diff., p=0.944 (t-test) | smaller, p=0.000 (t-test) | yes | |
| *Measure of difference of step E2* | | | *3/8* | *0.375* |
| ***Total measure of difference*** | | | ***5.125/9*** | ***0.569*** |

As mentioned above, we need to address the question of stratigraphic and chronological position of the assemblages in order to test the model of local evolution, diffusion and stimulus diffusion. This is key as some expectations of the models (see Table 1) can only be assessed by stratigraphic and chronological data. The stratigraphic position of the studied assemblages at the selected sites and the chronological data (e.g., radiocarbon dates) available are not the only elements to be considered, so are the positions of the assemblages in a regional chronostratigraphic framework. For the Middle Danube region such a framework exists in rather good resolution due to the long loess-palaeosol sequences like Willendorf II in Austria (e.g., Haesaerts *et al.,* 1996; Nigst & Haesaerts, 2012; Nigst *et al.,* 2014; see also summary in Nigst, 2012, Chapter 7). Data used include stratigraphic data as well as pedo-sedimentary signatures (e.g., soil types, erosion interfaces, etc.), palynological and malacological data, and radiocarbon dates on high quality conifer charcoals. Details on methodology and datasets used can be found in Haesaerts *et al.,* (2010; see also references therein). This chronostratigraphic framework is further correlated to other climate proxies (like the Greenland ice-core data).

## 4 The Middle Danube region as a case study area

The Middle Danube region is an ideal case study area to investigate the Middle to Upper Palaeolithic transition because of several factors. First, the region's EUP archaeological record is very rich, and, second, the region is characterized by long loess-palaeosol sequences with rather high palaeoclimatic resolution (e.g., Willendorf II, Austria; Nigst *et al.,* 2014). In this study eight assemblages from seven sites have been included. The sites are Willendorf II, Stratzing 94 (both in Austria); Vedrovice V, Stránská skála IIa, IIIa, and IIIc, and Kůlna cave (all in the Czech Republic) (Table 3). In the case of the two archaeological horizons (AH) at Willendorf II and the one AH at Stratzing 94, the entire assemblages were studied. From the much larger Vedrovice V collection a sample of 4098 artefacts was analysed. The data of Stránská skála IIa, IIIa, and IIIc, and Kůlna cave were taken from Tostevin (2000a, 2003a).

Table 3: Assemblages used in this research. Abbreviations: AH: archaeological horizon, n: number of studied lithics.

| Site | Assemblage | Technocomplex | n | Reference |
|---|---|---|---|---|
| **Large and small fraction studied** | | | | |
| Willendorf II | AH 3 | Aurignacian | 500 | Nigst, 2012 |
| Willendorf II | AH 4 | Aurignacian | 2452 | Nigst, 2012 |
| Vedrovice V | – | Szeletian | 4098 | Nigst, 2012 |
| Stratzing 94 | AH 2 | Aurignacian | 326 | Nigst, 2012 |
| **Large fraction from Tostevin (2003a), small fraction studied** | | | | |
| Stránská skála IIIc | – | Bohunician | 4506 | Tostevin, 2003a; Nigst, 2012 |
| **All data from Tostevin (2000a)** | | | | |
| Stránská skála IIIa | Layer 4 | Bohunician | 581 | Tostevin, 2000a; see also Nigst, 2012 |
| Stránská skála IIa and Stránská skála IIIa | Layer 4 (IIa) and Layer 3 (IIIa) | Aurignacian | 497 | Tostevin, 2000a; see also Nigst, 2012 |
| Kůlna Cave | Layer 7a | late Middle Palaeolithic | 294 | Tostevin, 2000a; see also Nigst, 2012 |

## 6 Results

The pair-wise comparison of the eight assemblages attributed to the late Middle Palaeolithic and the EUP resulted in a large range of the measure of difference values, from 0.255 to 0.921 (Table 4 and Figure 1). The lowest measure of difference values are – as expected - those of the assemblages showing similar knapping behaviours. These assemblages are also those that are traditionally assigned to the same assemblage type (i.e., a specific technocomplex like the Bohunician or the Aurignacian). The measure of difference shows the largest values, i.e. different knapping behaviours, when one compares those assemblages, which are chronologically most distant (i.e., late Middle Palaeolithic and Aurignacian). Among all pair-wise comparisons involving assemblages of two different technocomplexes, the Szeletian to Bohunician comparisons show the lowest measure of difference values (Figure 1 and Table 4, IDs 8 and 9). This suggests more similar knapping behaviours between the producers of the Szeletian and Bohunician than between the producers of any other two techncomplexes, e.g., the Szeletian and Aurignacian.

Table 4: Measure of difference of the assemblages of Willendorf II-AH 3, Willendorf II-AH 4, Stratzing 94-AH 2, Stránská skála IIIc, Vedrovice V, Kůlna Cave-Layer 7a, Stránská skála IIIa-Layer 4, and the grouped assemblages of Stránská skála IIa-Layer 4 and Stránská skála IIIa-Layer 3. Abbreviations: Aur: Aurigncian, LMP: late Middle Palaeolithic, Sz: Szeletian, Boh; Bohunician, ID: assemblage pair identity number used in Text and Figure 1.

| Compared assemblages | Compared techno-complexes | Measure of difference | Tool product ion measure of difference | Core reduction measure of difference | ID |
|---|---|---|---|---|---|
| WII-AH3 vs. SSIIa-4 & SSIIIa-3 | Aur-Aur | 0.255 | 0.188 | 0.274 | 1 |
| SSIIIc vs. SSIIIa-4 | Boh-Boh | 0.255 | 0.313 | 0.238 | 2 |
| WII-AH4 vs. Stra94-AH2 | Aur-Aur | 0.280 | 0.679 | 0.167 | 3 |
| WII-AH3 vs. Stra94-AH2 | Aur-Aur | 0.296 | 0.250 | 0.310 | 4 |
| WII-AH4 vs. SSIIa-4 & SSIIIa-3 | Aur-Aur | 0.333 | 0.250 | 0.357 | 5 |
| Stra94-AH2 vs. SSIIa-4 & SSIIIa-3 | Aur-Aur | 0.335 | 0.465 | 0.298 | 6 |
| WII-AH3 vs. WII-AH4 | Aur-Aur | 0.375 | 0.438 | 0.357 | 7 |
| VedV vs. SSIIIc | Boh-Sz | 0.569 | 0.688 | 0.536 | 8 |
| VedV vs. SSIIIa-4 | Boh-Sz | 0.574 | 0.875 | 0.488 | 9 |
| VedV vs. Kulna 7a | LMP-Sz | 0.639 | 0.125 | 0.786 | 10 |
| VedV vs. Stra94-AH2 | Sz-Aur | 0.652 | 0.643 | 0.655 | 11 |
| VedV vs. SSIIa-4 & SSIIIa-3 | Sz-Aur | 0.736 | 0.563 | 0.786 | 12 |
| WII-AH3 vs. VedV | Sz-Aur | 0.741 | 0.625 | 0.774 | 13 |
| Kulna 7a vs. Stra94-AH2 | LMP-Aur | 0.828 | 0.643 | 0.881 | 14 |
| WII-AH4 vs. VedV | Sz-Aur | 0.847 | 0.813 | 0.857 | 15 |
| Kulna 7a vs. SSIIa-4 & SSIIIa-3 | LMP-Aur | 0.866 | 0.688 | 0.917 | 16 |

| | | | | | |
|---|---|---|---|---|---|
| WII-AH3 vs. Kulna 7a | LMP-Aur | 0.889 | 0.625 | 0.964 | 17 |
| WII-AH4 vs. Kulna 7a | LMP-Aur | 0.921 | 0.938 | 0.917 | 18 |

[insert Figure 1 about here]

Based on the measure of difference the differences between the Szeletian and the late Middle Palaeolithic are slightly greater than between the Szeletian and Bohunician suggesting more different knapping behaviours. This is especially interesting with regard to the argued origin of the Szeletian in the local late Middle Palaeolithic (e.g., Valoch, 1993). More research on this is needed. The difference between the individual measures of difference values of the Szeletian-Bohunician and Szeletian-LMP comparisons is minimal and cannot be regarded as significant.
Measure of difference values for Aurigancian and Szeletian comparisons are also greater than those of Bohunician and Szeletian assemblage comparisons. Hence, the knapping behaviours of Bohunicians and Szeletians are more similar than those between Aurignacians and Szeletians. When considering scenarios of Aurignacian or Bohunician influence of the producers of the Szeletian – as proposed in the past - this allows us to argue that the Szeletian emerged under the influence of the Bohunicians rather than under that of the Aurignacians. This statement can be further re-enforced using the chronostratigraphic position of these assemblages in our chronostratigraphic framework of the EUP assemblages across the Middle Danube region (see below).

Evaluating the chronostratigraphic position of the studied assemblages involves making use of the chronostratigraphic framework mentioned above. The assemblages studied here are marked in Figure 2. The Aurignacian assemblages (black triangles in Figure 2) occur in several chronostratigraphic positions, with Willendorf II-AH3 being the oldest and attributed to the onset of Greenland Interstadial (GI) 11, i.e. before 43,500 cal BP (Nigst *et al.,* 2014). The Szeletian assemblage of the site Vedrovice V in Moravia occurs in the so-called Bohunice soil, a brownish forest soil, and is correlated with GI 12 (Haesaerts, 1990; Nigst & Haesaerts, 2012; Nigst, 2012, 2014). The Bohunician assemblages of Stránská skála IIIa (Layer 4) and IIIc are both assigned to the lower palaeolsol in the Stránská skála sequence. Unfortunately, it is currently unclear how the Stránská skála sequence can be securely correlated to the chronostratigraphic framework used here (Haesaerts *et al.,* 2009; Nigst & Haesaerts, 2012; see also Nigst, 2012, 2014). The radiocarbon dates produced for Stránská skála suggest they belong to GI 11 or they are younger (Svoboda & Bar-Yosef, 2003; Richter *et al.,* 2008, 2009). The radiocarbon dates from Stránská skála were produced using charcoal samples, which, however, have not been subjected to the same strong selection and sample cleaning protocols (e.g., Haesaerts *et al.,* 2013; Nigst *et al.,* 2014) nor to ABOx-SC pretreatment (Bird *et al.,* 1999; Haesaerts *et al.,* 2013). Therefore, we need to keep in mind that the reported ages for Stránská skála might be underestimations of the true ages. Similarly, the non-ABOx-SC pretreated set of charcoal samples from Bohunice-Kejbaly (sites I to IV) has been shown to underestimate the age by several thousand years (Valoch, 2008; Richter *et al.,* 2009). Due to the similarities between the assemblages of Bohunice-2002 excavation (essentially the same site as Bohunice-Kejbaly, closest to Kejbaly IV) and Stránská skála IIIc (Tostevin & Škrdla, 2006), the Bohunician assemblages of Stránská skála are in this study assigned the same chronostratigraphic position as those of Bohunice-2002 (i.e., in GI 12). Interestingly, the Bohunician assemblage of Bohunice-Kejbaly is located at the bottom of the Bohunice soil, which is well correlated with GI 12 (Haesaerts *et al.,* 2009; Nigst & Haesaerts, 2012; Nigst, 2012, 2014; Nigst *et al.,* 2014). Artefacts stratigraphically located at the bottom of the Bohunice soil were not deposited there when the soil formed (i.e., when the soil was active), but were already in the sediment before soil formation. Consequently, the Bohunician occupation of Bohunice-Kejbaly is most probably older and must predates GI 12 (Nigst, 2012, 2014). Here, I position it in the rather cold Greenland Stadial (GS) 13.

[insert Figure 2 about here]

The exact chronostratigraphic position of Layer 7a in Kůlna cave is difficult to establish. The only available chronometric age estimations are different to all other assemblages used in this research. Current age estimations include radiocarbon dates, which most probably underestimate the true age of the samples significantly, and ESR and OSL ages (Rink *et al.,* 1996; Nejman *et al.,* 2011), suggesting a chronostratigraphic position in at least GI 12, but most likely older.
Taking into account the position of all studied assemblages in the chronostratigraphic framework, it is evident that Bohunician and Szeletian occur in the same palaeosol, the so-called Bohunice soil, at several locations and therefore were present in the same interstadial event (GI 12). But we need to keep in mind that the Bohunician at least at the Bohunice type-site occurs prior to GI 12 in the cold GS 13 (e.g., Nigst 2012; 2014). A potential contact between the two populations is therefore possible from a chronostratigraphic point of view. This is congruent with the data on lithic technology presented above.
The Aurignacian occurs in the regional chronostratigraphic framework later; it is documented for the first time at the onset of GI 11 (Nigst *et al.,* 2014). A contact of the Aurignacians and the Szeletians (as has been argued by, e.g., Valoch, 2000; Mellars, 1989a) is therefore highly unlikely as the Szeletian is only documented for GI 12 (in the Bohunice soil).

## 7 Discussion

### 7.1 Local evolution, diffusion or stimulus diffusion?

The results presented above require a more detailed discussion of the local evolution, diffusion and stimulus diffusion models. The lowest measure of difference value of all inter-technocomplex comparisons for the Szeletian-Bohunician comparisons and the occurrence of both technocomplexes in GI 12 are two factors, which violate the expectations listed for the local evolution model, while they do not violate those of the diffusion and stimulus diffusion models. Therefore support of both these models is justified, while the local evolution model for the emergence of the EUP has to be rejected in its current definition.
Can we distinguish direct from indirect contact – or diffusion and stimulus diffusion models? Following an approach proposed by Tostevin (2007), we can argue that with stimulus diffusion we expect similarities only in the tool kit (cultural transmission through socially distant contact scenarios) while with diffusion we expect similarities

also in the core reduction, so the blank production (cultural transmission through socially intimate contact scenarios). Following my earlier work (Nigst, 2012, 2014) this can be achieved by dividing our heuristic tool, the measure of difference, in a ‘core reduction measure of difference’ and a ‘tool kit measure of difference’ (Table 4). Using such an approach, one can reassess the dataset and study at the values for core reduction and tool kit measures of difference separately (Table 4 and Figure 3). The values clearly show that the similarity of the Bohunician and Szeletian is routed in the similarity of the core-reduction-related knapping behaviours, rather than in the tool kit morphology. Hence, it is likely that in the Middle Danube region diffusion rather than stimulus diffusion is the best explanation for the patterns in the archaeological record, and, in turn, implies direct contact between the Szeletians and Bohunicians, which most probably also led to interbreeding events. It should be possible to detect such interbreeding events in future genetic studies on human or Neanderthal remains of that time and region. Unfortunately, we currently do not have any human remains from the Middle Danube region and dated to the GI 12 at disposal.

[insert Figure 3 about here]

### 7.2 Modern human colonization of Europe

The findings reported and discussed here are in good agreement with the hypothesis that the Bohunician is the material culture correlate of a dispersal of modern humans into Central Europe (Bar-Yosef, 2006, 2007; Tostevin, 2000a, 2003b, 2007, 2012; Nigst, 2012, 2014; see also Hoffecker (2009) for a summary). Valoch (1976) recognized for the first time similarities between the Central European Bohunician and the Near Eastern Emirian, this was further studied by Skrdla (2003) using refitting analysis. Svoboda & Bar-Yosef (2003) and Tostevin (2000a, 2003a, 2003b, 2007, 2012) have shown systematically that the knapping behaviours observed in assemblages assigned to the Bohunician in the Middle Danube region are very similar to those of assemblages assigned to the Emirian or Initial Upper Palaeolithic (IUP) *sensu* Kuhn (Kuhn *et al.,* 1999) in the Near East. While Tostevin (2012) studied the Near Eastern assemblages of Boker Tachtit, Levels 1, 2 and 4, and Kebara Cave, Units VI and IV to I, the assemblages of Ksar Akil (Lebanon), Layers XXV to XXI, and Üçağızlı 1 Cave (Hatay, Turkey), Layers F to I (e.g., Kuhn *et al.,* 2008), can also be assigned to the Bohunician/IUP, although at this stage we are missing a detailed comparison to the assemblages studied with a methodology congruent with the one used by Tostevin (2000a, 2012) and my work (Nigst, 2012, 2014). While no human remains are known from the Bohunician in the Middle Danube region, the IUP in the Near East is associated at Ksar Akil (Lebanon), Layer XXV/XXIV (Bergman & Stinger, 1989; Metni, 1999), and at Üçağızlı 1 Cave (Hatay, Turkey), Layers F to I (Kuhn *et al.,* 2009), with modern human remains, hence the assumption that the Bohunician in the Middle Danube region was also produced by modern humans is well justified.

Age estimations of the IUP in the Near East are only available from Ksar Akil, where the base of the IUP remains undated, and Üçağızlı 1 Cave. At Ksar Akil the IUP layers are at least 44,900 to 43,600 cal BP old (Bosch *et al.,* 2015) and the IUP at Üçağızlı 1 Cave is dated to 45,900-38,400 cal BP (Kuhn *et al.,* 2009). These age estimations – keeping in mind that the base of the IUP sequence at Ksar Akil in currently undated – are in agreement with the Bohunician ages of the Middle Danube region. If true, this would also suggest a rather rapid dispersal of these modern humans into Central Europe. In the future more work is needed to increase the quality and quantity of age estimations for IUP assemblages in the Near East and in Southeastern Europe.

## 8 Conclusion

This study - presenting a case study on population contact using the datasets from the Middle Danube region - does not support a local evolution model for the emergence of the EUP. On the contrary, all data are in good agreement with current models of a diffusion of behaviours through direct contact between Neanderthals and modern humans. Therefore, it can be argued that the historical process of the so-called Middle-to-Upper Palaeolithic transition in Central Europe is best explained by contact of incoming modern human populations with local Neanderthal ones. The diffusion of behaviours should not necessarily be viewed as a one-way process. The results showing similarities in core reduction related knapping behaviours suggest diffusion, i.e., direct or socially intimate contact, rather than stimulus diffusion, i.e., indirect or socially distant contact. The proposed pattern of modern human dispersal into Europe prior to GI 12 in GS13 has to be tested in the future with new data including material culture remains and new human fossils from modern excavations with a good understanding of stratigraphy and site formation processes.
Future studies will have to (i) use a methodology that is suited to test for cultural transmission, like for example the one used here, (ii) investigate the variability within and between technocomplexes against a high-resolution environmental record, and (iii) make use of high-resolution chronostratigraphic frameworks, which currently are only provided by the long loess-palaeosol sequences of the Eurasian loess belt. Long loess-palaeosol sequences of sites in a bottom slope situation as sediment trap and with a rather high palaeoenvironmental resolution are key in such an endeavor. Mitoc-Malu Galben is one of the few of such sites in the East Carpathian region, although its sequence currently starts after the period discussed in this study. Future work trying to expand the base of the Mitoc-Malu Galben sequence either at the site itself or in neighbouring locations will contribute new and necessary data to the debate of the Neanderthal-modern human replacement and Middle-to-Upper Palaeolithic transition outside the case study area presented here.

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**References**

T. Akazawa, K. Aoki & O. Bar-Yosef, 1998. *Neandertals and Modern Humans in Western Asia,* Plenum Press, New York.

T. Akazawa, Y. Nishiaki & K. Aoki, 2013. *Dynamics of Learning in Neanderthals and Modern Humans, Volume 1: Cultural Perspectives,* Replacement of Neanderthals by Modern Humans Series, Springer, Tokyo.

P. Allsworth-Jones, 1986. *The Szeletian and the transition from Middle to Upper Palaeolithic in Central Europe,* Clarendon Press, Oxford.

B. Auffermann, W. Burkert, J. Hahn, C. Pasda & U. Simon, 1990. Ein Merkmalsystem zur Auswertung von Steinartefaktinventaren, *Archäologisches Korrespondenzblatt*, 20, 259-70.

S. Bailey, T. Weaver & JJ. Hublin, 2009. Who made the Aurignacian and other early Upper Paleolithic industries? *Journal of Human Evolution*, 57(1), 11-26.

W. Banks, F. d'Errico & J. Zilhão, 2012. Human–climate interaction during the Early Upper Paleolithic: testing the hypothesis of an adaptive shift between the Proto-Aurignacian and the Early Aurignacian, *Journal of Human Evolution*, 64, 39-55.

G. Barker, H. Barton, M. Bird, P. Daly, I. Datan, A. Dykes, L. Farr, D. Gilbertson, B. Harrisson, C. Hunt, T. Higham, L. Kealhofer, J. Krigbaum, H. Lewis, S. McLaren, V. Paz, A. Pike, P. Piper, B. Pyatt, R. Rabett, T. Reynolds, J. Rose, G. Rushworth, M. Stephens, C. Stringer, J. Thompson & C. Turney, 2007. The ‘human revolution’ in lowland tropical Southeast Asia: the antiquity and behavior of anatomically modern humans at Niah Cave (Sarawak, Borneo), *Journal of Human Evolution*, 52(3), 243-61.

O. Bar-Yosef, 2000. The Middle and Early Upper Paleolithic in Southwest Asia and Neighboring Regions, in O. Bar-Yosef & D. Pilbeam (eds), *The Geography of Neanderthals and Modern Humans in Europe and the Greater Mediterranean,* Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, 107-56.

O. Bar-Yosef, 2002. The Upper Paleolithic Revolution, *Annual Review of Anthropology*, 31, 363-93.

O. Bar-Yosef 2006. Neanderthals and Modern Humans: A Different Interpretation, in NJ Conard (ed), *When Neanderthals and Modern Humans Met,* Kerns Verlag, Tübingen, 467-82.

O. Bar-Yosef, 2007. The Dispersal of Modern Humans in Eurasia: a Cultural Interpretation, in P. Mellars, K. Boyle, O. Bar-Yosef & C. Stringer (eds), *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans,* McDonald Institute for Archaeological Research, University of Cambridge, Cambridge, 207-17.

O. Bar-Yosef & D. Pilbeam, 2000. *The Geography of Neanderthals and Modern Humans in Europe and the Greater Mediterranean,* Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge.

S. Benazzi, K. Douka, C. Fornai, C. Bauer, O. Kullmer, J. Svoboda, I. Pap, F. Mallegni, P. Bayle, M. Coquerelle, S. Condemi, A. Ronchitelli, K. Harvati & G. Weber, 2011. Early dispersal of modern humans in Europe and implications for Neanderthal behaviour, *Nature*, 479(7374), 525-8.

C. Bergman & C. Stinger, 1989. Fifty years after: Egbert, an Early Upper Palaeolithic juvenile from Ksar Akil, Lebanon. *Paléorient*, *16*(2), 99-111.

M. Bird, L. Ayliffe, L. Fifield, C. Turney, R. Cresswell, T. Barrows & B. Davis, 1999. Radiocarbon Dating of "Old" Charcoal Using a Wet Oxidation, Stepped-Combustion Procedure, *Radiocarbon*, 41(2), 127-40.

JG. Bordes, 2002. *Les interstratifications Châtelperronien / Aurignacien duRoc-de-Combe et du Piage (Lot, France). Analysetaphonomique des industries lithiques; implications archéologiques,* PhD dissertation, University of Bordeaux.

M.D. Bosch, M. Mannino, A. Prendergast, T. O'Connell, B. Demarchi, S. Taylor, L. Niven, J. van der Plicht & JJ. Hublin, 2015. New chronology for Ksâr Akil (Lebanon) supports Levantine route of modern human dispersal into Europe, *Proceedings of the National Academy of Sciences*, 112(25), 7683-8.

P. Brantingham, S. Kuhn & KW. Kerry, 2004. *The Early Upper Paleolithic beyond Western Europe,* University of California Press, Berkeley, Los Angeles and London.

N. Conard, 2006. *When Neanderthals and Modern Humans Met,* Kerns Verlag, Tübingen.

W. Davies, 2001. A Very Model of a Modern Human Industry: New Perspectives on the Origins and Spread of the Aurignacian in Europe, *Proceedings of the Prehistoric Society*, 67, 195-217.

W. Davies, 2007. Re-evaluating the Aurignacian as an Expression of Modern Human Mobility and Dispersal, in P. Mellars, K. Boyle, O. Bar-Yosef & C. Stringer (eds), *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans,* McDonald Institute for archaeological Research, University of Cambridge, Cambridge, 263-74.

PY. Demars & JJ. Hublin, 1989. La transition néandertaliens/ hommes de type moderne en Europe occidentale: aspects paléontologiques et culturels, in B Vandermeersch (ed), *L'homme de Néandertal 7 - La transition,* ERAUL 34, Liège, 29-42.

F. d'Errico, 2003. The invisible frontier. A multiple species model for the origin of behavioral modernity, *Evolutionary Anthropology*, 12(4), 188-202.

F. d'Errico, J. Zilhao, M. Julien, D. Baffier & J. Pelegrin, 1998. Neanderthal Acculturation in Western Europe?: A Critical Review of the Evidence and Its Interpretation, *Current Anthropology*, 39(2), S1-S44.

D. Flas, 2011. The Middle to Upper Paleolithic transition in Northern Europe: the Lincombian-Ranisian-Jerzmanowician and the issue of acculturation of the last Neanderthals, *World Archaeology*, 43(4), 605-27.

P. Haesaerts, 1990. Evolution de l'environnement et du climat au cours de l'Interpléniglaciaire en Basse Autriche et en Moravie, in J.K. Kozlowski (ed), *Les industries à pointes foliacées du Paléolithique supérieur européen,* ERAUL 42, Liège, 523-38.

P. Haesaerts, F. Damblon, M. Bachner & G. Trnka, 1996. Revised stratigraphy and chronology of the Willendorf II sequence, Lower Austria, *Archaeologia Austriaca*, 80, 25-42.

P. Haesaerts, I. Borziak, V. Chirica, F. Damblon, L. Koulakovska & J. van der Plicht, 2003. The East Carpathian Loess Record: A Reference for the Middle and Late Plenigalcial Stratigraphy in Central Europe, *Quaternaire*, 14(3), 163-88.

P. Haesaerts, I. Borziak, V. Chirica, F. Damblon & L. Koulakovska , 2004. Cadre stratigraphique et chronologique du Gravettien en Europe Centrale, in J. Svoboda & L. Sedlácková (eds), *The Gravettian along the Danube, Proceedings of the Mikulov Conference, 20.-21. November, 2002,* The Dolni Vestonice Studies, Brno, AS CZ.

P. Haesaerts, VP. Chekha, F. Damblon, NI. Drozdov, LA. Orlova & J. van der Plicht, 2005. The Loess-Palaeosol Succession of Kurtak (Yenisei basin, Siberia): a Reference Record for the Karga Stage (MIS 3), *Quaternaire*, 16(1), 3-24.

P. Haesaerts, I. Borziac, VP. Chekha, V. Chirica, F. Damblon, NI. Drozdov, LA. Orlova, S. Pirson & J. van der Plicht, 2009. Climatic signature and radiocarbon chronology of Middle and Late Pleniglacial loess from Eurasia: comparison with the marine and Greenland records, *Radiocarbon*, 51(1), 301-18.

P. Haesaerts, I. Borziac, VP. Chekha, V. Chirica, NI. Drozdov, L. Koulakovska, LA. Orlova, J. van der Plicht & F. Damblon, 2010. Charcoal and wood remains for radiocarbon dating Upper Pleistocene loess sequences in Eastern Europe and Central Siberia, *Palaeogeography, Palaeoclimatology, Palaeoecology*, 291(1-2), 106-27.

P. Haesaerts, F. Damblon, PR. Nigst & JJ. Hublin, 2013. ABA and ABOx Radiocarbon Cross-Dating on Charcoal from Middle Pleniglacial Loess Deposits in Austria, Moravia, and Western Ukraine, *Radiocarbon*, 55(3-4), 641-7.

J. Hahn, 1982. *Der Speckberg bei Meilenhofen, Teil II: Archäologie des Jungpaläolithikums,* Kataloge der prähistorischen Staatssammlung.

J. Hahn, 1988. *Die Geißenklösterle-Höhle im Achtal bei Blaubeuren I: Fundhorizontbildung und Besiedlung im Mittelpaläolithikum und im Aurignacien,* Konrad Theiss Verlag, Stuttgart.

FB. Harrold, 1989. Mousterian, Chatelperronian and Early Aurignacian in Western Europe: Continuity or Discontinuity? in P Mellars & C Stringer (eds), *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans,* Edinburgh University Press, Edinburgh, 677-713.

T. Higham, L. Basell, R. Jacobi, R. Wood, CB. Ramsey & N. Conard, 2012. Testing models for the beginnings of the Aurignacian and the advent of figurative art and music: The radiocarbon chronology of Geißenklösterle, *Journal of Human Evolution*, 62(6), 664-76.

T. Higham, R. Jacobi, L. Basell, CB. Ramsey, L. Chiotti & R. Nespoulet, 2011. Precision dating of the Palaeolithic: A new radiocarbon chronology for the Abri Pataud (France), a key Aurignacian sequence, *Journal of Human Evolution*, 61(5), 549-63.

T. Higham, R. Jacobi & CB. Ramsey, 2006. AMS radiocarbon dating of ancient bone using ultrafiltration, *Radiocarbon*, 48(2), p. 179.

J. Hoffecker, 2009. The spread of modern humans in Europe, *Proceedings of the National Academy of Sciences*, 106, 16040-5.

J. Hoffecker, IE. Kuz'mina, EV. Syromyatnikova, MV. Anikovich, A. Sinitsyn, VV. Popov & VT. Holliday, 2010. Evidence for kill-butchery events of early Upper Paleolithic age at Kostenki, Russia, *Journal of Archaeological Science*, 37(5), 1073-89.

JJ. Hublin, 2000. Modern-Nonmodern Hominid Interactions: A Mediterranean Perspective, in O. Bar-Yosef & D. Pilbeam (eds), *The Geography of Neanderthals and Modern Humans in Europe and the Greater Mediterranean,* 157-82.

JJ. Hublin, 2007. What Can Neanderthals Tell Us About Modern Human Origins? in P. Mellars, K. Boyle, O. Bar-Yosef & C. Stringer (eds), *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans,* McDonald Institute for Archaeological Research, University of Cambridge, Cambridge, 235-48.

JJ. Hublin, 2012. The earliest modern human colonization of Europe, *Proceedings of the National Academy of Sciences*, 109(34), 13471-2.

JJ. Hublin, 2015. The modern human colonization of western Eurasia: when and where? *Quaternary Science Reviews*, 118, 194-210.

JJ. Hublin, F. Spoor, M. Braun, F. Zonneveld & S. Condemi, 1996. A late Neanderthal associated with Upper Palaeolithic artefacts, *Nature*, 381, 224-6.

JJ. Hublin, S. Talamo, M. Julien, F. David, N. Connet, P. Bodu, B. Vandermeersch & M. Richards, 2012. Radiocarbon dates from the Grotte du Renne and Saint-Césaire support a Neandertal origin for the Châtelperronian, *Proceedings of the National Academy of Sciences*, 109(46), 18743-8.

RG. Klein, 1969a. Mousterian Cultures in European Russia, *Science*, 165(3890), 257-65.

RG. Klein, 1969b. *Man and Culture in the Late Pleistocene: A Case Study,* Chandler, San Francisco.

RG. Klein, 1973. *Ice-Age Hunters of the Ukraine,* University of Chicago Press, Chicago.

RG. Klein, 1995. Anatomy, behavior, and modern human origins, *Journal of World Prehistory*, 9(2), 167-98.

RG. Klein, 2008. Out of Africa and the evolution of human behavior, *Evolutionary Anthropology*, 17(6), 267-81.

RG. Klein, 2009. *The Human Career. Human Biological and Cultural Origins,* 3 ed. The University of Chicago Press, Chicago.

JK. Kozlowski & M. Otte, 2000. The Formation of the Aurignacian in Europe, *Journal of Anthropological Research*, 56(4), 513-34.

AL. Kroeber, 1940. Stimulus Diffusion, *American Anthropologist*, N. S. 42(1), 1-20.

SL. Kuhn, 2003. In what sense is the Levantine Initial Upper Paleolithic a "transitional" industry? in J. Zilhao & F. d'Errico (eds), *The Chronology of the Aurignacian and of the Transitional Technocomplexes: Dating, Stratigraphies, Cultural Implications,* Instituto Portugues de Arqueologia, Lisbon, 61-9.

SL. Kuhn, MC. Stiner & E. Güleç, 1999. Initial Upper Palaeolithic in south-central Turkey and its regional context: a preliminary report, *Antiquity*, 73, 505-17.

SL. Kuhn, MC Stiner, E. Güleç, I. Özer, H. Yilmaz, I. Baykara, A. Açikkol, P. Goldberg, KM. Molina, E. Ünay, 2009. The early Upper Paleolithic occupations at Üçağızlı Cave (Hatay, Turkey), *Journal of Human Evolution*, 56, 87-113.

P. Mellars, 1989a. Major Issues in the Emergence of Modern Humans, *Current Anthropology*, 30(3), 349-85.

P. Mellars, 1989b. Technological Changes at the Middle-Upper Palaeolithic Transition: Economic, Social and Cognitive Perspectives, in P. Mellars & C. Stringer (eds), *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans,* Edinburgh University Press, Edinburgh, 338-65.

P. Mellars, 2004. Neanderthals and the modern human colonization of Europe, *Nature*, 432, 461-5.

P. Mellars, 2005. The impossible coincidence. A single-species model for the origins of modern human behavior in Europe, *Evolutionary Anthropology*, 14(1), 12-27.

P. Mellars & C. Stringer, 1989. *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans,* Edinburgh University Press, Edinburgh.

P. Mellars, K. Boyle, O. Bar-Yosef & C. Stringer, 2007. *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans,* McDonald Intitute for Archaeological Research, University of Cambridge, Cambridge.

M. Metni, 1999. A re-examination of a proposed Neandertal maxilla from Ksar 'Akil Rock Shelter, Antelias, Lebanon, *American Journal of Physical Anthropology*, 108(Supplement 28), p. 202.

L. Nejman, E. Rhodes, P. Škrdla, G. Tostevin, P. Neruda, Z. Nerudová, K. Valoch, M. Oliva, L. Kaminská, J. Svoboda & R. Grün, 2011. New Chronological Evidence for the Middle to Upper Palaeolithic Transition in the Czech Republic and Slovakia: New Optically Stimulated Luminescence Dating Results, *Archaeometry*, 53(5), 1044-66.

PR. Nigst, 2006. The first modern humans in the Middle Danube Area? New Evidence from Willendorf II (Eastern Austria), in N. Conard (ed), *When Neanderthals and Modern Humans Met.* , Kerns Verlag, Tübingen, 269-304.

PR. Nigst, 2010. The Aurignacian in Eastern Austria: Preliminary Results of an Analysis of the Lithic Technology of Willendorf II, layer 3, and its Implications for the Transition from Middle to Upper Palaeolithic in Central Europe, in C.

Neugebauer-Maresch & LR. Owen (eds), *New Aspects of the Central and Eastern European Upper Palaeolithic - methods, chronology, technology and subsistence,* Verlag der Österreichischen Akademie der Wissenschaften, Vienna, 81-99.

PR. Nigst, 2012. *The Early Upper Palaeolithic of the Middle Danube Region,* Leiden University Press, Leiden.

PR. Nigst, 2014. First Modern Human Occupation of Europe: The Middle Danube Region as a Case Study, in K. Boyle, RJ. Rabett & CO. Hunt (eds), *Living in the Landscape: Essays in Honour of Graeme Barker,* McDonald Institute for Archaeological Research, Cambridge, pp. 35-47

PR. Nigst & P. Haesaerts, 2012. L'Aurignacien en Basse Autriche : résultats préliminaires de l'analyse technologique de la couche culturelle 3 de Willendorf II et ses implications pour la chronologie du Paléolithique supérieur ancien en Europe centrale, *L'Anthropologie*, 116(4), 575-608.

PR. Nigst, P Haesaerts, F. Damblon, C. Frank-Fellner, C. Mallol, B. Viola, M. Götzinger, L. Niven, G. Trnka & JJ. Hublin, 2014. Early modern human settlement of Europe north of the Alps occurred 43,500 years ago in a cold steppe-type environment, *Proceedings of the National Academy of Sciences*, 111(40), pp. 14394-9

M. Otte, V. Chirica & P. Haesaerts, 2007. *L'Aurignacien et le Gravettien de Mitoc–Malu Galben (Moldavie roumaine)*, Liège, ERAUL vol. 72.

S. Pirson, D. Flas, G. Abrams, D. Bonjean, M. Court-Picon, K. Modica, C. Draily, F. Damblon, P. Haesaerts, R. Miller, H. Rougier, M. Toussaint & P. Semal, 2011. Chronostratigraphic context of the Middle to Upper Palaeolithic transition: Recent data from Belgium, *Quaternary International*, 259(0), 78-94.

RJ. Rabett, 2012. *Human Adaptation in the Asian Palaeolithic: Hominin Dispersal and Behaviour during the Late Quaternary,* Cambridge University Press, Cambridge.

D. Richter, G. Tostevin & P. Škrdla, 2008. Bohunician technology and thermoluminescence dating of the type locality of Brno-Bohunice (Czech Republic), *Journal of Human Evolution*, 55(5), 871-85.

D. Richter, G. Tostevin, P. Skrdla & W. Davies, 2009. New radiometric ages for the Early Upper Palaeolithic type locality of Brno-Bohunice (Czech Republic): comparison of OSL, IRSL, TL and 14C dating results, *Journal of Archaeological Science*, 36(3), 708-20.

J. Rink, H. Schwarcz, K. Valoch, L. Seitl & C. Stringer, 1996. ESR Dating of Micoquian Industry and Neanderthal Remains at Kůlna Cave, Czech Republic, *Journal of Archaeological Science*, 23(6), 889-901.

A. Ronchitelli, S. Benazzi, P. Boscato, K. Douka & A. Moroni, 2014. Comments on "Human-climate interaction during the Early Upper Paleolithic: Testing the hypothesis of an adaptive shift between the Proto-Aurignacian and the Early Aurignacian" by W. Banks, F. d'Errico, J. Zilhão, Journal of Human Evolution, 73, 107-11.

M. Roussel, 2011. *Normes et variations de la production lithique durant le Châtelperronien: la séquence de la Grande-Roche-de-la Plématrie à Quinçay (Vienne)*, PhD dissertation, University of Paris Ouest Nanterre-La Défense, Paris.

M. Roussel, M. Soressi & JJ. Hublin, 2016. The Châtelperronian conundrum: Blade and bladelet lithic technologies from Quinçay, France, *Journal of Human Evolution*, 95, 13-32.

D. Schäfer, 1987. *Merkmalanalyse mittelpaläolithischer Steinartefakte,* PhD dissertation, University of Berlin.

A. Seguin-Orlando, T. Korneliussen, M. Sikora, AS. Malaspinas, A. Manica, I. Moltke, A. Albrechtsen, A. Ko, A. Margaryan, V. Moiseyev, T. Goebel, M. Westaway, D. Lambert, V. Khartanovich, JD. Wall, PR. Nigst, R. Foley, M. Mirazon Lahr, R. Nielsen, L. Orlando & E. Willerslev, 2014. Genomic structure in Europeans dating back at least 36,200 years, *Science*, *346*(6213), 1113-8.

AA. Sinitsyn, 2003. The most ancient sites of Kostenki in the context of the Initial Upper Paleolithic of northern Eurasia, in J. Zilhao & F. d'Errico (eds), *The Chronology of the Aurignacian and of the Transitional Technocomplexes: Dating, Stratigraphies, Cultural Implications,* Instituto Português de Arqueologia, Lisboa, 89-107.

AA. Sinitsyn, 2010. The Early Upper Palaeolithic of Kostenki: Chronology, Taxonomy, and Cultural Affiliations, in C. Neugebauer-Maresch & LR. Owen (eds), *New aspects of the Central and Eastern European Upper Palaeolithic - methods, chronology, technology and subsistence,* Österreichische Akademie der Wissenschaften, 27-48

P. Skrdla, 2003. Comparison of Boker Tachtit and Stránská skála MP/UP Transitional Industries, *Journal of the Israel Prehistoric Society*, 33, 37-73.

J. Svoboda & O. Bar-Yosef, 2003. *Stránská skála. Origins of the Upper Paleolithic in the Brno Basin, Moravia, Czech Republic,* Peabody Museum of Archaeology and Ethnology, Havard University, Cambridge, Massachusetts.

J. Svoboda, V. Ložek & E. Vlèek, 1996. *Hunters between East and West. The Paleolithic of Moravia,* Plenum Press, New York.

S. Talamo, M. Soressi, M. Roussel, M. Richards & JJ. Hublin, 2012. A radiocarbon chronology for the complete Middle to Upper Palaeolithic transitional sequence of Les Cottés (France), *Journal of Archaeological Science*, 39(1), 175-83.

N. Teyssandier, 2007. *En route vers l'Ouest: Les débuts de l'Aurignacien en Europe,* Britisch Archaeological Reports International Series 1638, John and Erica Hedges Ltd., Oxford.

N. Teyssandier, 2008. Revolution or evolution: the emergence of the Upper Paleolithic in Europe, *World Archaeology*, 40(4), 493-519.

G. Tostevin, 2000a. *Behavioral Change and Regional Variation across the Middle to Upper Paleolithic Transition in Central Europe, Eastern Europe, and the Levant,* PhD dissertation, Harvard University, Cambridge, Massachusetts.

G. Tostevin, 2000b. The Middle to Upper Paleolithic Transition from the Levant to Central Europe: in situ development or diffusion? in GC. Weniger & J. Orschiedt (eds), *Neanderthals and modern humans: discussing the transition. Central and Eastern Europe from 50,000 - 30,000 BP,* Neanderthal Museum, Duesseldorf.

G. Tostevin, 2003a. Attribute Analysis of the Lithic Technologies of Stránská Skála IIIc and IIId in Regional and Interregional Context, in JA. Svoboda & O. Bar-Yosef (eds), *Stránská skála. Origins of the Upper Paleolithic in the Brno Basin, Moravia, Czech Republic,* 77-118.

G. Tostevin, 2003b. A Quest for Antecedents: A Comparison of the Terminal Middle Palaeolithic and Early Upper Palaeolithic of the Levant, in AN. Goring-Morris & A. Belfer-Cohen (eds), *More Than Meets The Eye. Studies on Upper Palaeolithic Diversity in the Near East,* Oxbow Books, Oxford, 54-310.

G. Tostevin, 2007. Social Intimacy, Artefact Visibility and Acculturation Models of Neanderthal-Modern Human Interaction, in P. Mellars, K. Boyle, O. Bar-Yosef & C. Stringer (eds), *Rethinking the human revolution: new behavioural and biological perspectives on the origin and dispersal of modern humans,* McDonald Institute for Archaeological Research, University of Cambridge, Cambridge, 341-57.

G. Tostevin, 2011. Levels of Theory and Social Practice in the Reduction Sequence and Châine Opératoire Methods of Lithic Analysis, *PaleoAnthropology*, 2011, 351-75.

G. Tostevin, 2012. *Seeing Lithics: A Middle-Range Theory for Testing for Cultural Transmission in the Pleistocene,* Oxbow Books, Oxford.

G. Tostevin & P. Škrdla, 2006. New excavations at Bohunice and the question of the uniqueness of the type-site for the Bohunician industrial type, *Anthropologie (Brno)*, XLIV(1), 31-48.

K. Valoch, 1976. *Die altsteinzeitliche Fundstelle in Brno-Bohunice,* Academia, Praha.

K. Valoch, 1990. La Moravie il y a 40 000 Ans, in C Farizy (ed), *Paléolithique Moyen Récent et Paléolithique Supérieur Ancien en Europe. Ruptures et Transitions: Examen Critique des Documents Archéologiques,* Musée de Préhistoire d'Ile de France, 115-24.

K. Valoch, 1993. Vedrovice V, eine Siedlung des Szeletien in Südmähren, *Quartär*, 43/44, 7-93.

K. Valoch, 2000. More on the Question of Neanderthal Acculturation in Central Europe, *Current Anthropology*, 41(4), 625-6.

K. Valoch, 2008. Brno-Bohunice, eponymous Bohunician site: new data, new ideas, in Z. Sulgostowska & AJ. Tomaszewski (eds), *Man - Millennia - Environment. Studies in Honour of Romuald Schild,* Institute of Archaeology and Ethnology, Polish Academy of Sciences, Warsaw, 225-36.

J. Zilhão, 2006a. Genes, Fossils, and Culture. An Overview of the Evidence for Neandertal-Modern Human Interaction and Admixture, *Proceedings of the Prehistoric Society*, 72(2), 1-20.

J. Zilhão, 2006b. Neandertals and moderns mixed, and it matters, *Evolutionary Anthropology: Issues, News, and Reviews*, 15(5), 183-95.

J. Zilhão, 2013. Neandertal-Modern Human Contact in Western Eurasia: Issues of Dating, Taxonomy, and Cultural Associations, in *Dynamics of Learning in Neanderthals and Modern Humans Volume 1,* Springer Japan, 21-57.

J. Zilhão & F. d'Errico, 1999a. The Chronology and Taphonomy of the Earliest Aurignacian and Its Implications for the Understanding of Neandertal Extinction, *Journal of World Prehistory*, 13(1), 1-68.

J. Zilhão & F. d'Errico, 1999b. Reply to P. Mellars *et al.*,, The Neanderthal Problem Continued, *Current Anthropology*, 40(3), 355-64.

J. Zilhão & F. d'Errico, 2000. La nouvelle « bataille aurignacienne ». : Une révision critique de la chronologie du Châtelperronien et de l'Aurignacien ancien, *L'Anthropologie*, 104(1), 17 - 50.

J. Zilhão & F. d'Errico, 2003. *The Chronology of the Aurignacian and of the Transitional Technocomplexes: Dating, Stratigraphies, Cultural Implications,* Trabalhos de Arqueologia 33, Instituto Português de Arqueologia, Lisbon.

J. Zilhão, W. Banks, F. d'Errico & P. Gioia, 2015. Analysis of Site Formation and Assemblage Integrity Does Not Support Attribution of the Uluzzian to Modern Humans at Grotta del Cavallo, PloS one, 10(7), p. e0131181.

N. Zwyns, 2012. *Laminar technology and the onset of the Upper Paleolithic in the Altai, Siberia,* Leiden University Press, Leiden.

**Figures**

Figure 1: Comparison plot of measure of difference values of the assemblages of Willendorf II-AH 3, Willendorf II-AH 4, Stratzing 94-AH 2, Stránská skála IIIc, Vedrovice V, Kůlna Cave-Layer 7a, Stránská skála IIIa-Layer 4, and the grouped assemblages of Stránská skála IIa-Layer 4 and Stránská skála IIIa-Layer 3 sorted from lowest to highest values. The technocomplexes involved in the comparisons are shown in the legend. Abbreviations: Aur: Aurignacian, Boh: Bohunician, LMP: late Middle Palaeolithic, Sz: Szeletian. For the compared assemblage pairs IDs see Table 4.

Figure 2: Chronostratigraphic framework of the Middle Danube region and chronostratigraphic position of the assemblages mentioned in the text (Symbols: Triangle (upwards): Aurignacian; Diamond: Szeletian; Square: Bohunician; Triangle (downwards): late Middle Palaeolithic). Shown is also correlation with the East Carpathian region (Molodova V, Mitoc-Malu Galben and Cosautsi) and the GRIP ss09sea records. For the GRIP ss09sea and Eastern Carpathian region correlations see Haesaerts *et al.* (2003, 2005; see also Haesaerts *et al.*, 1996, 2004, 2009, 2010; Nigst, & Haesaerts, 2012; Nigst *et al.*, 2014). Correlation of Stránská skála sequences with Haesaerts' chronostratigraphic framework is limited due to stratigraphic resolution of the Stránská skála sequences, hence the uncertainty of exact chronostratigraphic position of the assembalges. Abbreviations: Stratigr.: Stratigraphy; Palaeoenviron.: Palaeoenvironment; P: periglacial, with deep frost or permafrost; A: arctic; SA: subarctic; B: boreal; Interstad: Interstadial; Mol: Molodova V; MG: Mitoc-Malu Galben; GI: Greenland Insterstadial; H4: Heinrich Event 4. Stratigraphy, Correlations and Drawings: P. Haesaerts; Archaeology: Ph. Nigst.

Figure 3: Scatterplot of the tool production measure of difference (horizontal axis) and the core reduction measure of difference (vertical axis) for the 18 assemblage pairs of Table 4. If there are three or more assemblages pairs per compared technocomplex combination convex hulls are used to visualize the group boundaries and the overlap (solid line: LMP-Aur, dashed line: Aur-Aur, dash-dot line: Sz-Aur). The technocomplexes involved in the comparisons are shown in the legend.

Abbreviations: Aur: Aurignacian, Boh: Bohunician, LMP: late Middle Palaeolithic, Sz: Szeletian.