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Regional groups and social interaction during the Central European Magdalenian

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1. Introduction

The area of the Central European Magdalenian (CEM), as understood in this paper, is circumscribed by the course of the Vistula and Bug rivers in the east, the Baltic Sea and North Sea in the north, the Alps and Carpathian Mountains in the south and the courses of the Rhône, Saône, and Meuse rivers in the west. Except for the latter, all demarcations are virtually self-defining, since they simply comprise all Magdalenian sites east of the Rhône-Saône-Meuse boundary known until today. This boundary, however, is not set arbitrarily, but in accordance with geographic conditions and with respect to the integrity of site clusters along the course of these rivers (Fig. 1).

The Central European Magdalenian is usually perceived as a rather homogeneous archaeological unit, the homogeneity of which is often explained by a comparatively fast unidirectional expansion of hunter-gatherers from their Franco-Cantabrian heartland up to the Vistula river (e.g. Bosinski, 1990; Svoboda *et al.*, 1996; Kozłowski *et al.*, 2012; for a different view see Maier, 2012). A closer evaluation of the regional diversity reveals, however, pronounced differences with regard to many aspects, such as the spatial distribution of sites, raw material procurement, and connectedness in exchange and communication networks. In the following, selected aspects of the regional diversity of the Central European Magdalenian will be discussed in order to identify regional and supra-regional groups within the CEM record. Eventually, a joint evaluation will be used to shed new light on the structure of the social network during the CEM.

2. The large-scale spatial pattern of the Central European Magdalenian

The overall distribution of the CEM sites reveals a highly differentiated spatial pattern, where regions with densely clustered sites alternate with areas from which virtually no evidence of a Late Upper Palaeolithic occupation has been reported so far (Fig. 1). The detection rate of newly discovered sites (Bocquet-Appel *et al.*, 2005: 1660) and the spatial analysis of this large-scale distribution pattern identifies factors such as research intensity and erosion as negligible for its emergence and indicates instead that it reflects the actual settlement behaviour of CEM hunter-gatherers to a great extent (Rozoy, 1988: 143; Maier, 2012: 87f). Given this assumption, two factors hold a very high explanatory potential for the emergence of this pattern: the course of the larger rivers and the occurrence of geological sediments with outcrops of high quality raw material.

Since rivers may serve as water sources and "guidelines" in the landscape, it is highly likely that they played a major role in both the recolonisation process of Central Europe and in the post-colonisation life of CEM hunter-gatherers (e.g. Kelly, 2003: 48ff; Nieves Zedeño & Stoffle, 2003). Looking at the map in fig. 1, it becomes apparent that the majority of CEM sites cluster along larger rivers or at least rivers of regional importance.

It is quite conspicuous that only 12 of the 405 analysed assemblages (3 %) come from sites that are located more than 25 km away from such a river. However, many rivers, such as the Moselle, Main, or Weser, are almost or even completely free of Magdalenian occupation. The question immediately arises as to what other factors might have made an area attractive or unattractive for CEM hunter-gatherers, and could thus explain the conspicuous gaps in the site distribution. Here, lithic raw material sources complement the picture.

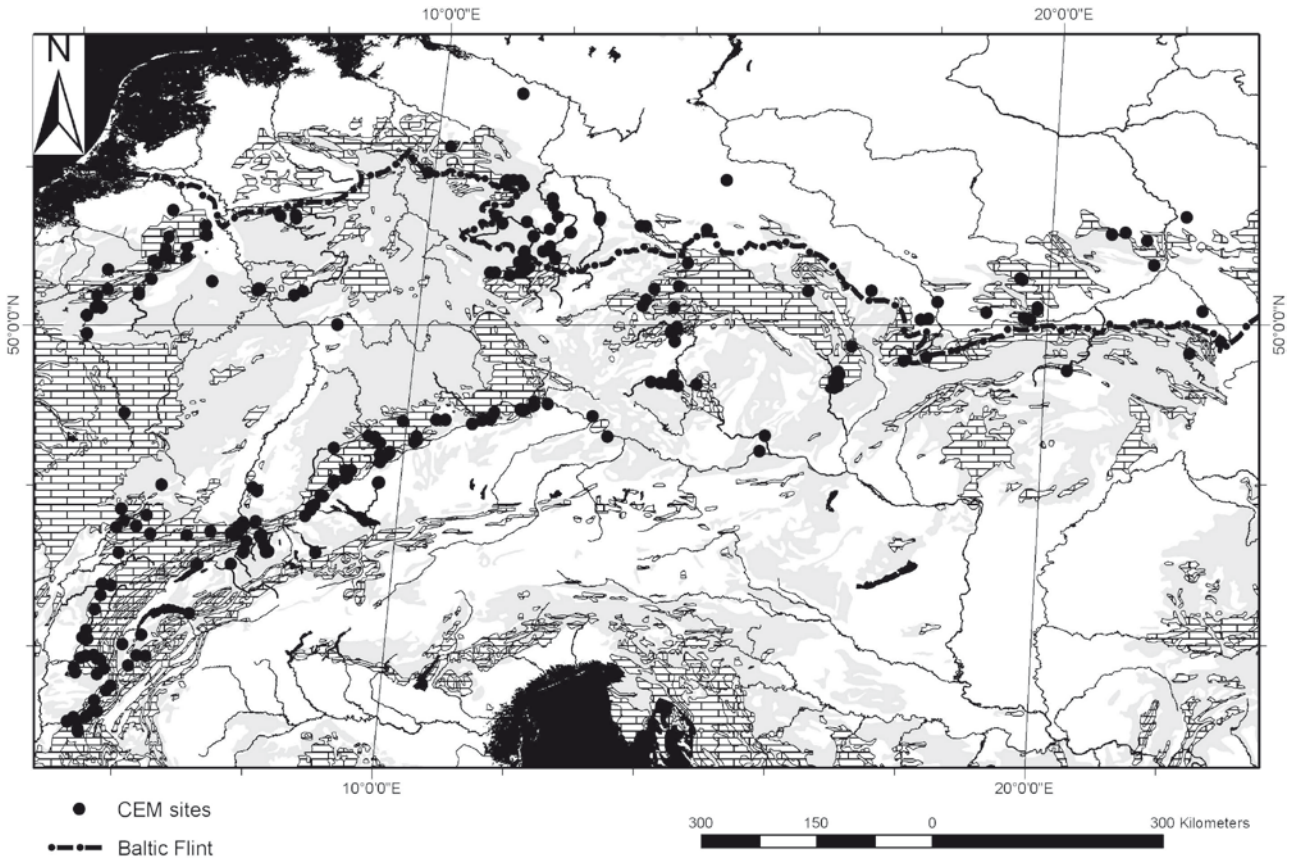

Fig. 1 – Distribution of sites assigned the Central European Magdalenian.
The hatched patches indicate areas that potentially yield sources of high quality raw material;
the light grey patches indicate areas that potentially yield sources of rather low quality raw material.
The dash-and-dot line indicates roughly the southernmost occurrences of Baltic Flint.
It becomes visible that most sites are located close to large rivers and those areas with potentially high quality raw material.

Lithic raw material, in particular rocks with a high silicon dioxide (SiO_2) content and preferably a cryptocrystalline matrix, was one of the basic pillars of Magdalenian technology. Those rocks are for instance Upper Cretaceous flint (96 % SiO_2) and Jurassic chert (Deecke, 1933; Wetzel, 1933; Floss, 1994). Other rocks with high silica content include Radiolarite, Lydite, and Kieselschiefer, these occur in Central Europe mainly in Ordovician, Silurian, Devonian, and Mississippian (Unterkarbon) contexts (Floss, 1994: 66). Middle Triassic chert, in contrast, regularly shows limy, unsilicified sections or veins of Chalcedony as well as hollows from fossils and is thus of lower quality. The same applies for Late Triassic chert (Keuperhornstein) which often has very pronounced fissuring (*ibid*., 108). When plotted against the background of those geological formations that potentially yield high quality raw materials (Fig. 1), the distribution shows that 11 % of the assemblages (n = 44) are located more than 5 km and only 2 % (n = 9) more than 25 km away, a distance that is easily walked within one day.

In sum, it can be stated that Magdalenian hunter-gatherers did not wander randomly about the landscape, but likely chose their settlement areas according to certain environmental features, most prominently larger rivers and the occurrence of high quality raw material. Even though these two factors were certainly not the only determinants guiding the decisions of Magdalenian hunter-gatherers, they have an undeniably high explanatory potential for the large-scale distribution of CEM sites.

3. Regional and supra-regional groups

The fact that the CEM sites cluster in certain regions raises the question whether or not these clusters represent the remains of regional groups. Here, a regional group is understood as a small to medium-sized community of hunter-gatherers which exploited a common territory. Social bonds are expected to be particularly strong within a regional group and the relatively small number of people results in intensive contact between all individuals of that group. By comparison, a supra-regional group consists of at least two regional groups and represents the wider social environment. In a supra-regional group, not all individuals are necessarily personally known to one another. Nevertheless, frequent contacts and the exchange of items and ideas occur regularly between several members of a supra-regional group.

3.1. Raw material procurement, indicator of regional groups

Magdalenian hunter-gatherers procured their raw materials very probably embedded in their daily and seasonal moves and did not, or only very rarely, acquire it by exchange (Binford, 1979: 250; Floss 1994: 320). Thus, CEM people had themselves been present in the source region of the raw material they brought with them. Starting from this reasonable assumption, the raw material procurement pattern provides a base for estimating the minimum range of the catchment areas that belong to certain sites. Extensive overlapping among catchment areas points to the collective exploitation of raw material sources and hence to a common usage of the same area and intensive interaction among the people involved. Mutually exclusive catchment areas, on the other hand, suggest a comparatively low level of interaction and rather point-s to independence and segregation (for a more detailed discussion see Maier, 2012: 95).

To evaluate the raw material procurement, 744 individual raw material transports from 151 CEM assemblages were analysed. It is notable that raw materials are not procured evenly from all around a given site but that their acquisition seems to be directed primarily along certain axes (Fig. 2). In most of the cases, sites located close to each other or in the same region exhibit strong overlapping in their catchment areas and thus a collective exploitation of the same raw material sources. However, it also becomes apparent that despite the spatial proximity of their sites, CEM hunter-gatherers occasionally exploited different and mutually exclusive sources. This can be observed, for example, for the sites in the Swiss Jura and the Swabian Alb or those in Bohemia and the Franconian Alb. Both the Swabian Alb and the Swiss Jura show a high concentration of CEM sites. The sites in the Swabian Alb contain raw material from the Regensburg basin at a distance of about 240 km to the east. In contrast, no raw materials come from the outcrops around Olten, located only about 70 km to the west, which were intensively exploited by the hunter-gatherers of the Swiss Jura. A similar situation can be observed for the outcrops around Flintsbach, where the Isar river joins the Danube. Despite an equal distance to the site clusters in the Franconian Alb and Bohemia, only hunter-gatherers from the latter area exploited the high quality outcrops in this region. This observation gives reason to suggest that Magdalenian hunter-gatherers were conscious of the limits of their exploitation areas and recognised their and their neighbours' respective boundaries.

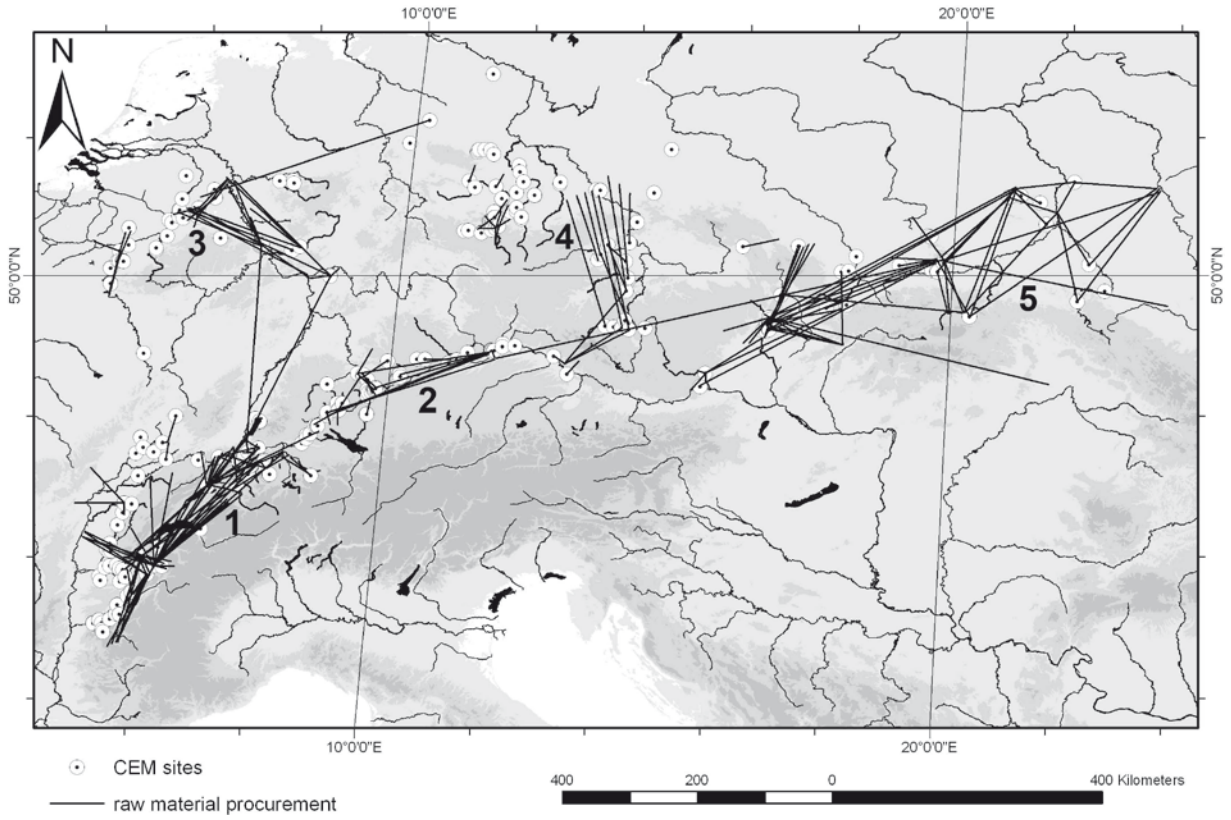

Fig. 2 – Raw material procurement pattern of the Central European Magdalenian. Lines indicate the connections between a site and the raw materials sources exploited for the production of its lithic assemblage.

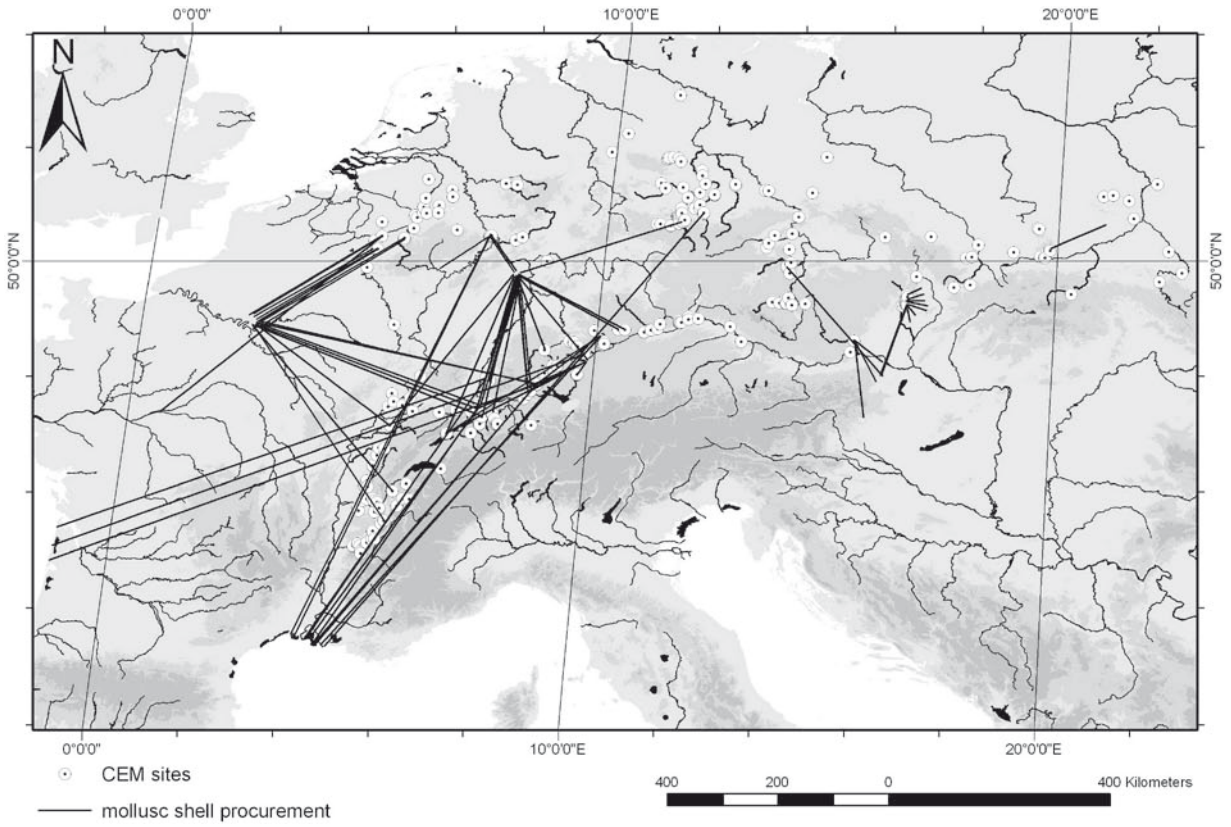

Fig. 3 – Mollusc shell procurement pattern of the Central European Magdalenian. Lines indicate the connections between a site and the supposed areas of origin of its mollusc shell assemblage.

Altogether, the evaluation of the procurement patterns indicates the existence of five regional groups (Fig. 2). These five groups are located (1) around the French and Swiss Jura, (2) in the Swabian and Franconian Alb, (3) in the Meuse-Rhine region, (4) in Eastern Germany and Bohemia, and (5) in Moravia and Poland (see Maier, 2012).

3.2. Mollusc shells, indicators of supra-regional contacts

In contrast to lithic raw materials which were procured on a regional scale, mollusc shells were generally transported over much greater distances. Being furthermore non-utilitarian objects of presumably rather symbolic value, their acquisition probably took place in a different way, where exchange seems to have played a major role (e.g. Sedlmeier, 1988; Floss, 1994; Álvarez Fernández, 2009). Their acquisition pattern can therefore be seen as reflecting exchange and large-scale inter-regional and supra-regional interaction networks. Mapping 198 indications of mollusc species from 62 assemblages, the resulting picture shows a conspicuous dichotomy (Fig. 3). On the one hand, the sites in the western part of the investigated area (comprising the sites in the Jura region, Swabian and Franconian Alb, and Meuse-Rhine area) are integrated into a spatially long-span network of intensive exchange and interaction that extends up to the Paris Basin and the areas adjacent to the west, the coasts of the Mediterranean Sea and Atlantic Ocean. On the other hand, the sites located in the eastern part (comprising Eastern Germany, Bohemia, Moravia and Poland) exhibit a less close-meshed exchange pattern. Most strikingly, evidence for an exchange of mollusc shells between the western and eastern groups is virtually absent (for a detailed discussion see Maier, 2012: 113).

Against this background, the five regional groups can be aggregated into two supra-regional groups. The first one comprises the sites of the three western regional groups, whereas the second comprises the sites of the two eastern groups.

3.3. Typological concepts, indicators for interaction intensity

So far, the division of the CEM into five regional and two supra-regional groups is based on the observations directly regarding the distribution of material objects. In this section, typological data is taken as an independent parameter in order to countercheck the above-mentioned findings. To this end, it is not the presence or absence of beforehand selected tool types considered indicative for the detection of regional groups (as e.g. suggested by Feustel 1961 or Hanitzsch, 1969) which was analysed. On the contrary, the typological composition of assemblages with ≥ 100 tools was evaluated and compared as a whole, performing a Linear Discriminant Analysis (LDA) (e.g. Leyer & Wesche, 2007: 188-194; Claude, 2008: 112-116). Based on this multivariate analysis, it was determined whether the compositions differ significantly between the regional groups and which types are especially important for the distinction. The classes were chosen in compliance with the five regional groups defined above. The proportions of tool types per assemblage served as independent feature variables. In order to account for rare types, the proportions were transformed prior to analysis using the Hellinger transformation (Legendre & Gallagher, 2001).

Here, only the major results can be presented briefly (for more details on statistics and results see Maier, 2012). The outcome of the LDA confirms the observed division of the CEM into 5 regional and two supra-regional groups to a surprising extent. Table 1 shows that in 76 % of all cases, the classification predicted by the LDA (posteriori) coincides with the original (a priori) group allocations. If this classification was carried out randomly, a "hit ratio" of only 20 % (1/5) would be expected. In those cases, where the predefined group allocation of an assemblage does not match the results of the Discriminant Analysis, the re-attribution is largely restricted to immediately neighbouring groups (Tab. 1 and Fig. 4).

Tab. 1 – Result of the Linear Discriminant Analysis (LDA) of spatial grouping (Fig. 4). Cross tabulation of given and predicted group memberships. Each row corresponds to an a priori group and each column to the classification (posteriori group) of the LDA (1: Jura Region, 2: Danube region, 3: Meuse-Rhine region,4: Eastern Germany & Bohemia, 5: Moravia & Poland) with the left table giving the numbers and the right table displaying the row percentages. E.g. read row 1 in the left table as: 32 assemblages of group 1 were classified as group 1, 2 as group 2, 1 as group 3, 0 as group 4 and 1 as group 5. (For more details see Maier, 2012).

	n			*LDA Classification results*					*%*				
	1	2	3	4	5	*Total*			1	2	3	4	5
1	32	2	1	0	1	*36*		1	88.9	5.6	2.8	0	2.8
2	2	15	1	0	1	*19*		2	10.5	78.9	5.3	0	5.3
3	4	2	16	1	0	*23*		3	17.4	8.7	69.6	4.3	0
4	1	0	2	16	3	*22*		4	4.5	0	9.1	72.7	13.6
5	0	2	2	2	8	*14*		5	0	14.3	14.3	14.3	57.1
Total	*39*	*21*	*22*	*19*	*13*	*114*		*76.3 % are classified correctly*					

Altogether, reallocations within a supra-regional group occur twice as often than between the two supra-regional groups. This especially marked with regard to the western group, where 12 assemblages are re-attributed within that group and only 3 were re-attributed to the eastern supra-regional group. The analysis indicates that the typological composition of an assemblage corresponds strongly with its geographical position and with its embeddedness into the interaction network as mirrored by the procurement patterns of raw materials and mollusc shells.

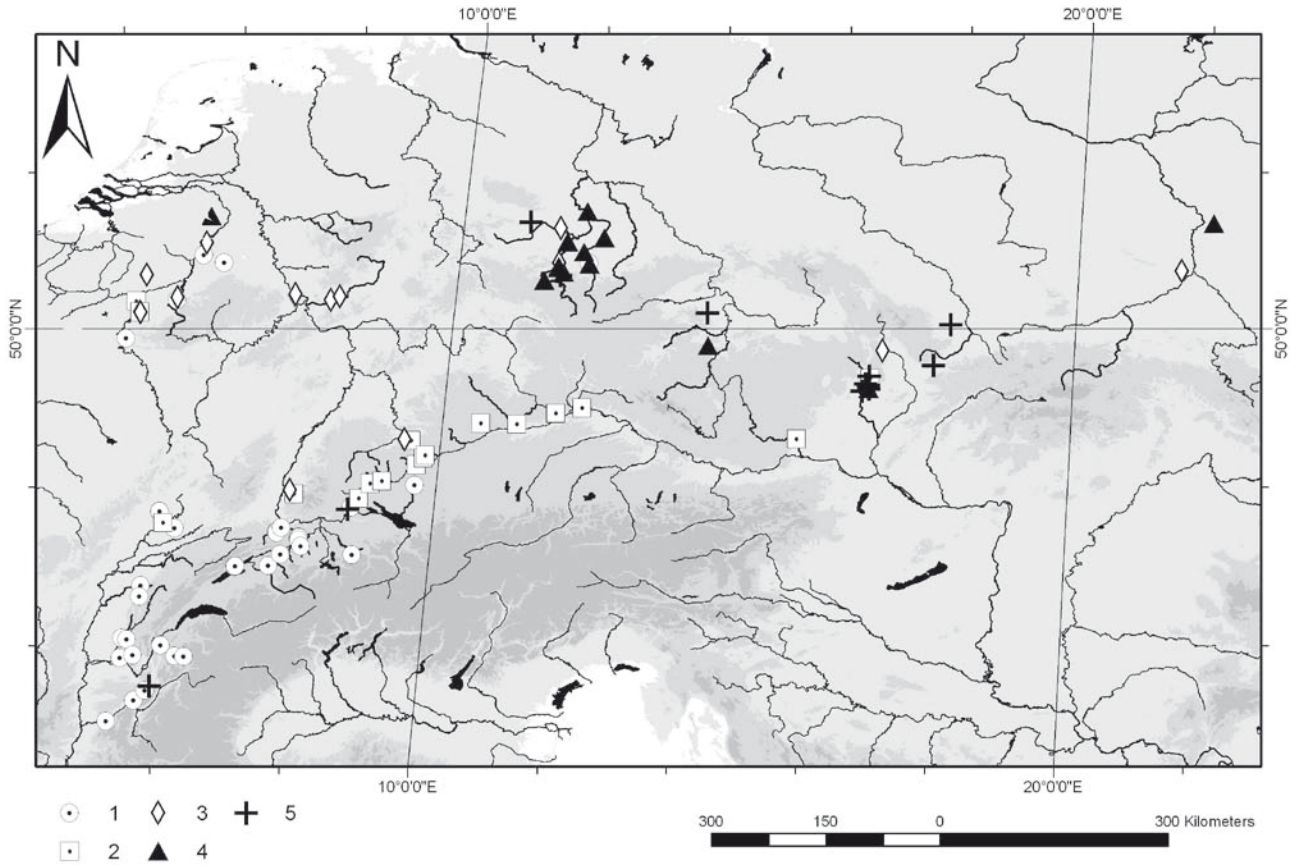

Fig. 4 – Typological posteriori classification of Central European Magdalenian sites as calculated by the Linear Discriminant Analysis (Tab. 1). It becomes apparent that re-attributions occur only occasionally and are mostly restricted to immediately neighbouring groups. Therefore, the initial regional grouping, as derived from the raw material procurement pattern, is largely supported by this multivariate statistical analysis. (For more details see Maier, 2012). Group 1, 2, 3, 4, 5: typologically classified by the LDA as belonging to the regional group in the (1) French and Swiss Jura, (2) Swabian and Franconian Alb, (3) Meuse-Rhine region, (4) Eastern Germany and Bohemia, and (5) Moravia and Poland.

4. Implications for the structure of the Central European Magdalenian social network

The results presented above provide information that allows to draw inferences about the general structure of social interaction between CEM hunter-gatherers. Therefore these results will be interpreted in the light of interaction processes in order to achieve an approximation to the structure of the social network of the Central European Magdalenian.

4.1. Regional boundaries – social agreements between regional groups?

It is highly likely that a raw material procurement pattern, where a certain source is highly frequented by one population but – despite its relative spatial proximity – not exploited by neighbouring groups, is a result of social agreements (e.g. Peterson, 1975: 60; Binford, 1982: 8; Kelly, 1995: 185). Since the observed pattern generated over a very long period, the spatial integrity and well defined catchment regions would be difficult to explain without social conventions that were passed on from one generation to the next. The absence of such conventions, or major ruptures within their transmission process probably would have generated a rather chaotic picture reflecting changes in the raw material procurement. In this case, it would be highly unlikely that borders between the different regional catchment areas would still be observable today. However, as these borders are still observable today, the record indicates that the five regional groups represent territory-conscious social units. Each unit exploited a certain region while deliberately sparing the resources of another region nearby. The boundaries of the groups' territories were certainly not rigid borders, impermeable to people from other groups. In comparison with recent hunter-gatherers (Peterson, 1975; Binford, 1982; Kelly, 1995) it appears rather likely that they were permeable to members of other groups in accordance with social mechanisms and conventions.

4.2. Typological conformity – a function of interaction?

Exchange of ideas can be traced following conceptual similarities and differences, since the transmission of cultural traits "functions like an inheritance system, producing significant similarities between those handing down the information and those adopting them" (Boyd & Richerson, 1985: 46). At the same time, phenomena such as innovation, guided variation, indirect bias, copying errors, or drift cause alterations of traditions (see Neiman, 1995; Bettinger & Eerkens, 1999; Bentley & Shennan, 2003; Eerkens & Lipo, 2005; Shennan, 2008: 77). An example for the long-span distribution of certain ideas during the period of the CEM is the ubiquitous presence of the concept of female figures of the Gönnersdorf type (Höck, 1993; Bosinski *et al.*, 2001). On the other hand, the typological analysis also showed regional differences in the application of tool concepts. Therefore, it can be said that the mode of cultural transmission in the CEM society must have been capable of ensuring an overall homogeneity in the distribution of concepts, but at the same time allowing for regional differences in the frequency (or popularity) of certain traits which impart an individual character to each regional group.

With regard to the fact that the degree of typological similarity is in good accordance with the degree of interaction as indicated by the acquisition pattern of raw materials and mollusc shells (see above), it appears that conformity varies as a function of the degree of interaction (cf. Neiman, 1995). As has been shown by Eerkens and Lipo (2005: 323), a rate of conformity of only 5 % is sufficient to reduce the typological variation within a population more than 50 % in comparison to unbiased transmission.

It can be said that within a regional group, where people were presumably in close contact to one another, the typological similarities are strongest and thus the bias towards conformity was also rather strong. But also between the regional groups, a regular exchange must

have taken place, because otherwise the effects of drift would have caused a much more pronounced typological segregation. Drift makes it highly likely that two systems that start with the same set of types will diverge from each other in the case of non-interaction. Therefore, "similarity over time is a function of the number of transmission episodes" (Neiman, 1995: 31), meaning it is also dependent on the degree of interaction. Of course, differences in the typological equipment may be a negative response to intensive interaction with other groups (Hodder, 1982), and similarities may occur coincidentally, however, coincidence is in the case of the CEM simply not a convincing explanation. The degree of typological similarities between the regional groups may therefore serve as an indicator for the intensity of inter-group interaction. The fact that the typological similarity between the assemblages belonging to the same supra-regional group is notably stronger than between those belonging to two different supra-regional groups therefore indicates that interaction within one of the supra-regional groups was probably stronger than between the two.

5. Conclusion: The Central European Magdalenian – a small-world network?

The above-mentioned observations raise an interesting question: How must a social network be organised that is able to generate a structure with a comparatively strong regionalisation on the one hand and a large-scale distribution of certain concepts on the other? On the basis of the results presented above, a picture can be drawn that shows — if not necessarily in much detail — at least the broad outline of the CEM social network.

Social networks, for reasons of simplification represented only by agents and connections between those agents, can be divided into clustered, random, and small-world networks (e.g. Watts & Strogatz, 1998; Bentley & Maschner, 2008). Basically, these networks differ with regard to their degree of clustering (the extent to which the connections of a typical agent are also connected to one another) and characteristic path length (the typical number of agents between one agent and another) (Bentley & Maschner, 2008: 252). In clustered networks, the agents are only connected to their immediate neighbours. Therefore, the characteristic path length is large, since many intermediate agents are necessary to cross the network from one agent to another (Fig. 5). In a random network, on the other hand, agents can connect freely with any other agent. Therefore, the number of distant connections increases strongly making the network less clustered and decreasing the characteristic path length by many shortcutting connections throughout the network (Fig. 6). Small-world networks take an intermediate position between these two extremes (Fig. 7). They are almost as clustered as regular networks, but do have a small number of shortcutting connections. Therefore, their characteristic path length is almost as short as for random networks (Milgram, 1967; Watts & Strogatz, 1998; Bentley & Maschner, 2008: 252). Thus, "in a small world, an agent perceives itself to be in a clustered neighbourhood, and yet the communication distance to any other agents is much shorter than if all agents were equally well connected" (Bentley & Maschner, 2008: 252).

With regard to the CEM, it appears likely that the communication network was highly clustered. By analogy with recent hunter-gatherer groups and in accordance with the archaeological record, it can be assumed that medium-sized hunter-gatherer groups, closely connected by kinship bonds, were the most important social unit at that time (Binford, 2001). These groups formed a community which is thought to correspond to one of the five regional groups. Thus it can be suggested that most CEM hunter-gatherers spent much of their lifetime in the social context of their regional group, and consequently that most connections in their social network were local or regional. According to annual or multiannual cycles, these regional groups got together with others for a joint hunt or

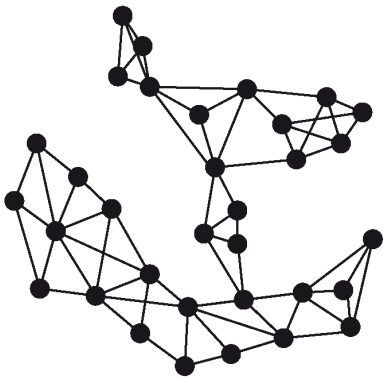

Fig. 5 – Example of a highly clustered network. Dots represent agents and lines represent connections. Here, all connections are local and the characteristic path length is thus comparatively large.

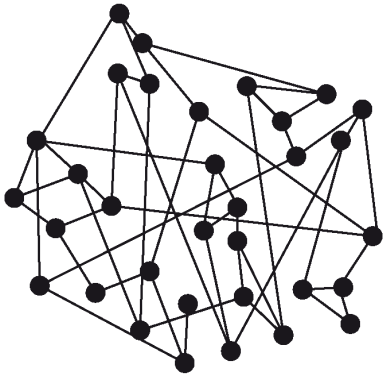

Fig. 6 – Example of a random network. Dots represent agents and lines represent connections. Here, many agents show distant connections and thus the characteristic path length is comparatively short.

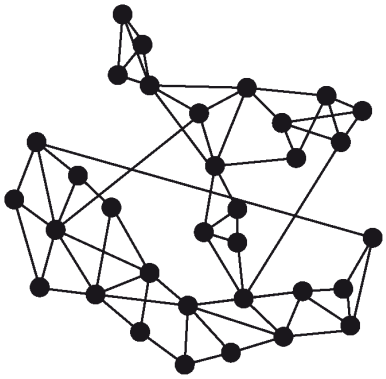

Fig. 7 – Example of a small-world network. Dots represent agents and lines represent connections. Here, most connections are local and the network is thus highly clustered. Few distant connections, on the other hand, decrease the characteristic path length significantly in comparison to the clustered network in Fig. 5.

other social events and after a while split up again. These meetings and cross marriages between regional groups then functioned as shortcutting connections in the social network and hence decreased the characteristic path length significantly. The resulting interconnectedness of the different hunter-gather groups was probably the reason for a general conformity of the lithic inventories which allows archaeologists to identify them as being produced by Magdalenian people, although each regional group kept an individual character in the composition of its lithic assemblages.

The distribution pattern of sub-recent shells of sea molluscs may be indicative for these shortcutting links. Within a regular network with exclusively local connections, a sea shell collected at the Atlantic coast must be passed on by a large number of individuals before it reaches the Swabian Alb. Since each step in this transport chain yields the chance to cut the transfer, passing on items over a distance of more than 800 km is easier to conduct within the structures of a small-world network, where an item passes only through the hands of a comparably small number of people (cf. Bentley & Maschner, 2008: 253).

Taking mollusc shell distribution as indicative for the intensity of shortcutting connections, the three western regional groups appear to have been closely connected to each other as well as to other groups in the Paris Basin and in southwestern France. Between the eastern and western supra-regional groups, in contrast, these shortcuts were very rare. This pattern of an eastern and a western community exhibiting very tightly meshed internal interaction networks within each community and at the same time relatively weak connections to the respective other community mirrors probably two independent but communicating populations. However, no later than 16,000 calBP the communication network must have been close-knit enough to ensure the diffusion of innovations throughout the whole investigated area at a speed below the resolution of 14C-dating, which is indicated by the appearance of barbed points around 16,000 calBP (Weniger, 1995: 175; Álvarez Alonso, 2007; Pétillon, 2008: 68) in the whole investigated area.

Acknowledgements

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Abstract

Social interaction and the transmission of cultural traits elude a direct archaeological observation. Nevertheless, their effect and intensity can be inferred from a number of parameters reflecting choice, social agreements and the exchange of ideas. A joint evaluation of patterns of raw material and mollusc shell procurement as well as typological differences and similarities reveals a marked regional diversity among Central European Magdalenian hunter-gatherers. The results speak in favour of the existence of five regional as well as two supra-regional groups and shed new light on the structure of social interaction during the Central European Magdalenian.

Keywords: Magdalenian, regional groups, raw material, mollusc shells, typology, social networks.

Résumé

Le Magdalénien en Europe Centrale est souvent perçu comme une unité archéologique assez homogène. Toutefois, une évaluation plus précise de la diversité régionale et la variabilité chronologique montrent des différences très marquées par rapport à plusieurs aspects, tels que la distribution spatiale des sites, leur composition typologique, leur connexion en réseaux, et leur contexte environnemental respectif. Une analyse détaillée de ces divers facteurs au sein du Magdalénien en Europe Centrale révèle l'existence de cinq groupes régionaux et deux groupes suprarégionaux et jette une lumière nouvelle sur la recolonisation de l'Europe Centrale après le dernier maximum glaciaire.

Mots-clés : Magdalénien de l'Europe Centrale, groupes régionaux, réseaux sociaux, matière première, typologie, coquilles de mollusque.

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