Erich Claßen

Early Neolithic Social Networks in Western Germany

Abstract: Applications of the social network approach in archaeology have been conducted in the course of a PhD thesis at the University of Cologne (Classen 2006). These analyses dealt with exchange mechanisms involved in the distribution of raw material for flint artefact production, as well as with similarities in pottery decoration, which serve as an indicator of "communication networks" between settlements of the Early Neolithic "Bandkeramik" in the Rhineland. Network analytical methods were used to visualize networks and to describe the properties of the different networks in distinct phases of the Early Neolithic in Western Germany. One result of these analyses is a change in the relationships between settlements over time, which is regarded as indicative of a changing social structure. Whereas in the earlier phases, kinship seems to have had a greater influence on relationships, at the end of the Early Neolithic in Western Germany, alliances were formed for other reasons.

Archaeological Background

This paper deals with "Bandkeramik", which is the material culture associated with the first Neolithic settlers in Central Europe.

LBK settlements are found between the Carpathian Mountains in the east and the Paris basin in the west. While in the early stage of the LBK sites are only known from east of the river Rhine (cf. Lüning 1988, Fig. 1) after 5300 cal BC LBK occupation begins in the Lower Rhine Basin. In this region, about 100 Early Neolithic settlements have so far been located. The focus of this research is the lignite exploitation area west of Cologne. The LBK settlements on the "Aldenhovener Platte" are especially well known (Farrugia et al. 1973; Kuper et al. 1977; Boelicke et al. 1988; Lüning / Stehli 1992; idem 1994; Langenbrink 1996; Lüning 1997; Kolhoff 1999; Münch 1999; Bollig 2000; Frank / Päffgen / Zimmermann 2000; Clare 2004; Heller 2004; Krahn 2006; Rück 2006; Mischka in press), and also the "Hambacher Forst" (Cladders 1997; Reepmeyer 2002), and the state of research on a Loess Plateau known as the "Titzer Platte" (Classen 2006) is adequate. Only a short distance from this last-mentioned cluster of sites lies the settlement of Erkelenz-Kückhoven which is known for its well-preserved wooden well (Koschik 2004).

The settlements are mostly situated along small rivulets. For the approximately 350 years of LBK settlement activity in the Rhineland at least 14 settlement phases can be distinguished.

Additionally, different settlement groups have been defined on the basis of settlement size, settlement duration, supply with flint raw material, and the attributes of vessel decoration. These groups comprise a main settlement, smaller hamlets, single household settlements, and most probably a cemetery (cf. Zimmermann 2002).

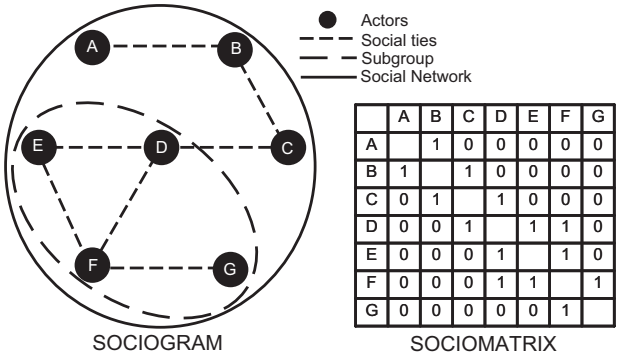
Social Network Analysis

In the following, in order to describe and analyse the social relations between LBK settlements, methods taken from social network analysis are applied, for which certain concepts are fundamental (cf. Wasserman / Faust 1994; Schweizer 1996).

Concepts and Methods

Actors are discrete individual, corporate, or collective social units. Actors are linked to one another by social *ties*. Any subset of actors, and all ties among them, is defined as a *subgroup*. Their properties are a major concern of social network analysis. Finally, a *social network* consists of a finite set of actors and the relation or relations defined by them. The crucial aspect of a social network is the presence of relational data.

The most common type of network is a *one-mode network*. This means that all actors belong to one set, e.g. students at a university. In keeping with this example, information flow between students and professors can be quantified and measured. This type of network is called a *two-mode network*, because it contains two different sets of actors. Furthermore, keeping the measurement of relations and the analytical



	A	B	C	D	E	F	G
A		1	0	0	0	0	0
B	1		1	0	0	0	0
C	0	1		1	0	0	0
D	0	0	1		1	1	0
E	0	0	0	1		1	0
F	0	0	0	1	1		1
G	0	0	0	0	0	1	

Fig. 1. Some fundamental concepts of social network analysis displayed as graph and with the corresponding matrix.

methods in mind, we have to distinguish between *directional* or *non-directional* relations, and between *dichotomous* and *valued* relations.

Relational data can be recorded in matrices or as graphs. In a *sociomatrix* the actors are listed in the rows and in the columns. The presence or absence of a relation is coded in the cells by either 1 or 0. In a *graph* – or sociogram – the actors are displayed by nodes, conjoined by lines representing the relational tie *(Fig. 1)*. Should the relation be directional, then the tie is shown as an arrow. Consequently, graph theory and matrix algebra are important for the mathematical analysis of networks.

One of the primary concerns in social network analysis is the identification of the "most important" actors in a network. Importance or *prominence* of an actor can be described by different *centrality* measures. The focus of a network on a few actors results in a *centralisation* of the whole network, and this centralisation can then be measured. When dealing with prominence, the following aspects are of importance:

To what extent does the activity of the single actors differ?

How autonomous are the actors?

What potential do the actors have in controlling information flow within the network?

Activity, autonomy and control can be measured on the basis of different characteristic values. These values are degree, closeness, and betweenness. These can be applied to both actors and networks.

The simplified graphs and matrices in *Fig. 2* illustrate the differences between these values.

Degree centrality measures all direct relations between individual actors, and in doing so indicates their activity. The more relational ties one actor shares with other actors the higher the degree of centrality will be (actor A in the star graph).

The degree centralisation is a measure that quantifies the variability of the individual actor indices. If the actors degree values are equal (circle graph), the degree centralisation of the network is low (0). If one actor is conjoined with all others, but these are not interconnected, the degree centralisation index is high (1) (star graph).

Where *closeness* is concerned, it is important to mention that indirect relations are also measured. The closer one actor is to all others, the more effective and autonomous the actor's position is within the network (A in the star graph, as well as A and C in the line graph).

Closeness centralisation is an index for the entire network. A high value signifies that a small number of actors are connected on direct paths, whilst the others are only joined indirectly. Consequently, the closeness centralisation of the star and the line is higher than that of the circle graph.

Betweenness not only looks at the indirect relations but also focuses on the possibility of actors to control the relational ties. It is obvious that A in the star graph, like A and C in the line graph has the potential to control information flow between other actors.

The value for betweenness centralisation of a network is high when just one or a small number of actors control relations. This being the case, the index is 1 for the star graph and 0 for the circle graph.

The centrality measures are usually standardised to the size of the whole network and expressed as

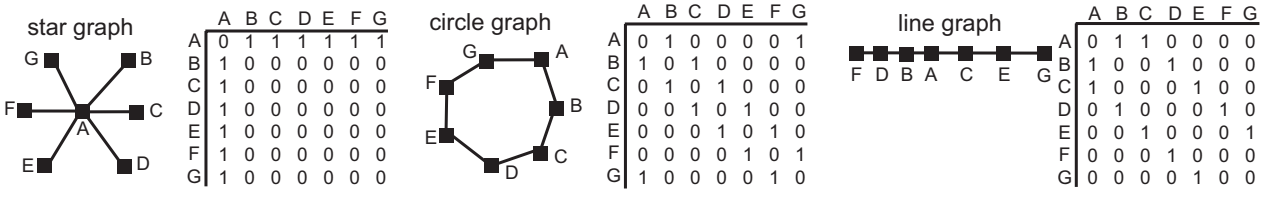
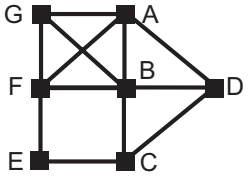


Fig. 2. Simplified graphs and the corresponding matrices for the study of centrality and centralisation (cf. Wasserman / Faust 1994, 171, Fig. 5.1).



Cliques: A, B, D;
B, C, D and A, B, F, G

Fig. 3. Simplified graph and its cliques (cf. Wasserman / Faust 1994, 255, Fig. 7.1).

percentage values (cf. Wasserman / Faust 1994, 169–219).

Whereas measures of centrality serve to analyse hierarchy and power within networks, a further analytical approach concentrates on cohesive subgroups within networks. Those methods used to identify cohesive subgroups try "to formalize the intuitive and theoretical notion of social group using social network properties" (Wasserman / Faust 1994, 249). One way of distinguishing subgroups is via the analysis of cliques.

A *clique* is a part of the graph where all possible lines between the nodes are present. When nodes belong to more than one clique, the role of the actors concerned is of particular interest.

In the graph in *Fig. 3* three cliques can be observed. Actor B is well integrated in the network and belongs to all three cliques. In contrast, node or actor E is less well positioned and does not belong to any of the cliques.

Network Analyses of Early Neolithic Settlements

In my example contemporaneous LBK settlements or farmsteads are regarded as actors (cf. Classen 2004; Classen in press). The relational ties which can be considered are both the similarities in pottery decoration and the exchange of flint raw material, which is in itself representative of economic relationships (cf. Zimmermann 1995).

The basis for the network analyses were 28 well examined settlements, marked by triangles in *Fig. 4*. In order to highlight the changes in the relationships

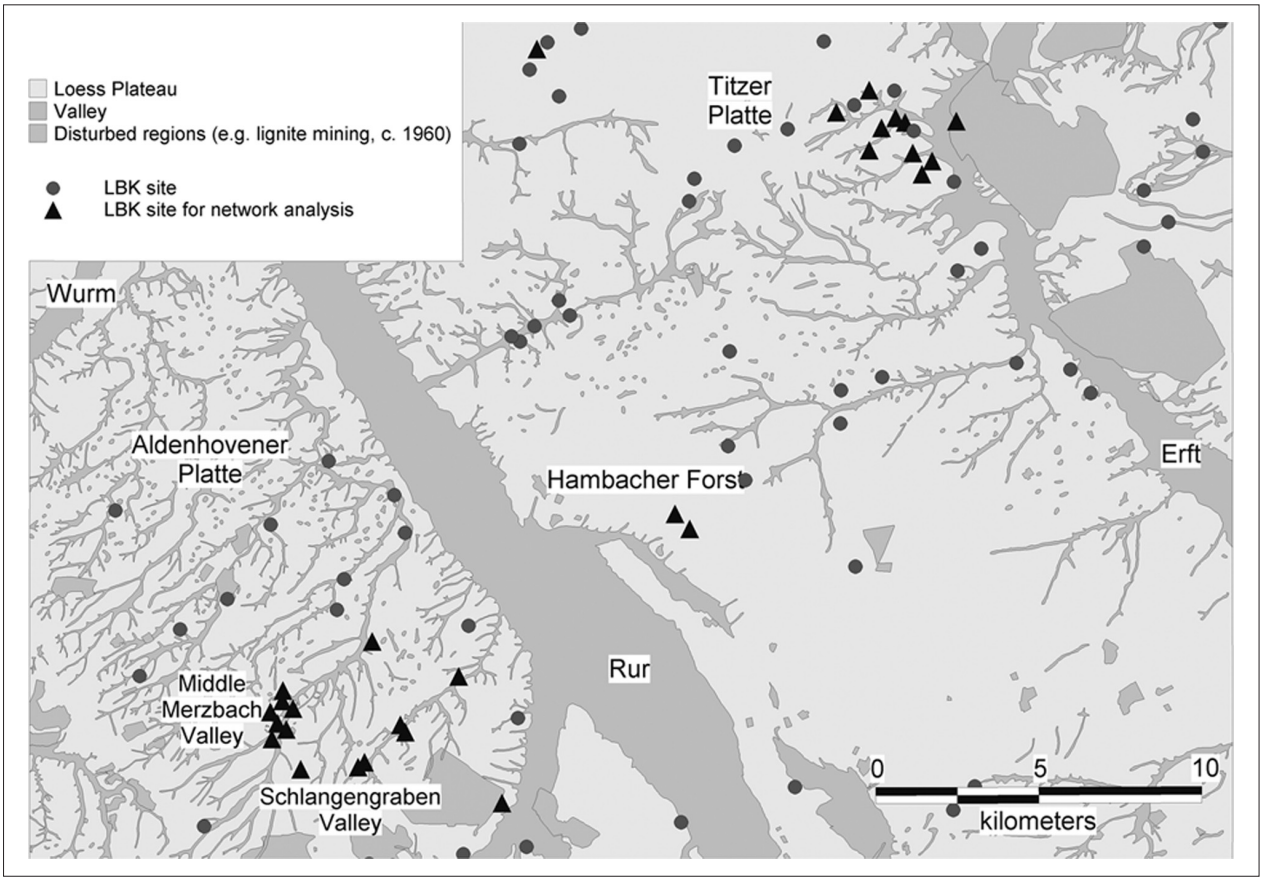


Fig. 4. Map of the research area in Western Germany.

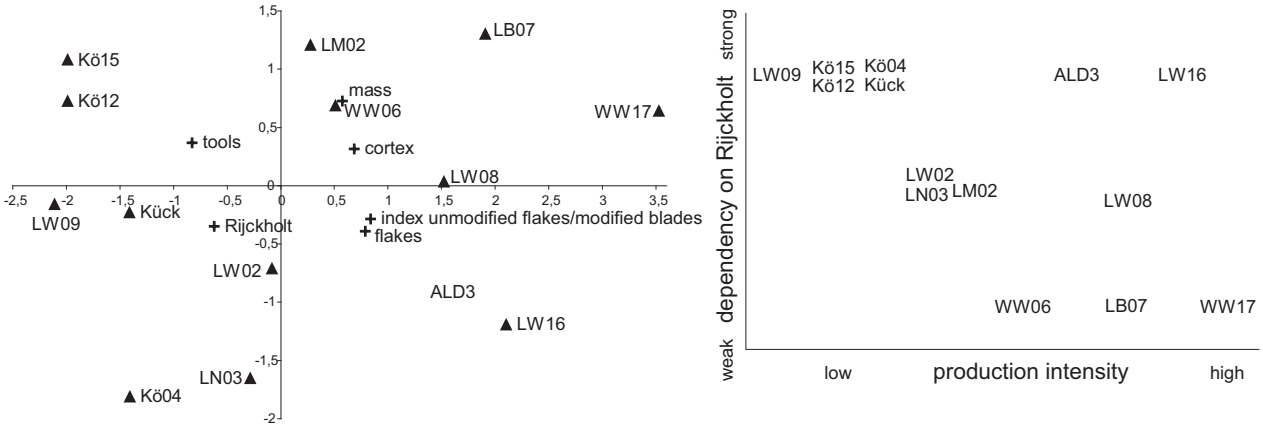


Fig. 5. On the left the result of a Principal Component Analysis [PCA] of certain features of stone tools. On the right the simplified diagram summarises these results. The main components reflect for all three phases the production intensity of a certain raw material, and the dependency on this material. Here the diagrams for the older phase serve as examples.

between LBK settlements over time all analyses were carried out for the three phases older, middle and late LBK, using the software package UCINET 6 (Borgatti / Everett / Freeman 2002).

The analysis of raw material exchange involved Principal Component Analyses of different features of the stone artefact inventories. The resulting main components for all three phases reflect the production intensity of a certain raw material (*Fig. 5*, x-axis), and the dependency on this material (*Fig. 5*, y-axis).

In this way it is possible to bring the analysed settlements into a hierarchical sequence with producers and distributors of a certain material on one end, and settlements receiving half-products and tools at the other (*Fig. 5)*. The sequence on the first main component of the PCA is used to define directional and dichotomous ties between the settlements, while also representing the transmission of material from settlements with higher production intensity to those where less production waste was found. It is assumed that no exchange of artefacts between settlements with similar production intensity took place.

For further interpretation of the network data from the three phases the factors settlement duration, settlement type, and geographical posi-

settlement/farmstead	degree [%]	closeness [%]	betweenness [%]
LW08-2	75	80	19,6
LW08-3	75	80	16,5
LB07	65	74,1	24,3
LW08-6	50	66,7	6,0
LW08-1	50	66,7	3,7
LW02	50	66,7	2,3
Kück	45	64,5	2,2
LW16	35	60,6	4,2
LM02	35	60,6	2,0
Kö12	35	60,6	1,0
LW08-8	30	58,8	0
LN03	30	55,6	0,4
LW09	25	52,6	1,1
LW08-4	25	52,6	0,3
LB08	25	52,6	0
WW06	20	51,2	0
LW08-5	15	45,5	0,3
ALD3	10	50	0
Kö09	5	45,5	0
Kö14	5	43,5	0
LW08-7	5	43,5	0
centralization	45,5	46	21,4

cliques	members (settlements/farmsteads)						
1	Kö12	Kück	LB07	LW02	LW08-2	LW08-3	LW08-6
2	LB07	LW02	LW08-1	LW08-2	LW08-3	LW08-6	LW08-8
3	LB08	LN03	LW02	LW08-1	LW08-2	LW08-3	
4	Kück	LB07	LM02	LW08-2	LW08-3		
5	LM02	LW08-2	LW08-3	LW08-4	WW06		
6	Kö12	LW08-2	LW08-3	LW08-4			
7	Kück	LB07	LM02	LW08-2	LW16		
8	LB07	LW08-1	LW08-2	LW16			
9	LN03	LW08-1	LW08-2	LW16			
10	ALD3	LB07	LW08-3				
11	LW08-5	LW08-6	LW09				
12	LW08-1	LW08-3	LW08-6	LW09			
13	Kück	LW08-3	LW08-6	LW09			

Fig. 6. On the left the centrality and centralisation measures of LBK settlements based on similar secondary motifs; on the right, tables resulting from searches made for cliques within the LBK settlements of the Rhineland. In both tables the older phase serves as an example. All analyses were carried out with the software package UCINET 6 (Borgatti / Everett / Freeman 2002).

tion of the settlements were also considered. In brief the network analyses on the raw material distribution system yielded the following results:

No changes can be observed in the general direction of the distribution. This means that during the entire 350 years of occupation those settlements closer to the raw material sources near Rijckholt show greater production intensity and were in the position to distribute blanks.

When examining the Lower Rhine Basin closely, it is important to distinguish between different settlement groups on the "Aldenhovener Platte" in the southwest and those on the "Titzer Platte" in the northeast.

The measurements of centrality for the settlements in these regions show that only the main settlements and a few neighbouring single farmsteads were main distributors of raw material within the research area. However, the centralisation of the network is low in all three phases, which means that none of the distributors had a powerful position within the exchange network.

In two settlement groups larger settlements changed their position as main producers and distributors within the system between the middle and the later LBK phase. Therefore, rights or duties connected with the exchange of raw material were rather stable for about 200 years, after which a change becomes visible.

With respect to the analysis of social relationships, the very diverse secondary motifs of pottery decoration were also considered. Previous studies have shown that these motifs may be interpreted as symbols indicative of traditions and group identity within early Neolithic society (Frirdich 1994; Krahn 2003).

The data base for the network analyses includes all decorated vessels from well-examined LBK sites dated to the three afore mentioned phases. In the datasets – actor-by-actor matrices – the cells indicate whether two settlements or farmsteads share secondary motifs. Analysis involved the measurement of prominence and the search for cliques within the phases. The left hand table in *Fig. 6* shows the degree, closeness, and betweenness centrality of the settlements in the older LBK. The identification of cliques within the LBK networks results in tables like *Fig. 6* on the right.

In the following, however, the results from these analyses are summarised without discussing such tables and values in detail.

In the older phase a high cohesiveness in the research area is obvious. This is indicative of strong conformity and possibly even social control during this phase. Very close relations between some of the settlements imply that the first settlers in the northern part of the Rhineland adapted to or continued traditions of earlier founded farmsteads in the Merzbach valley *(Fig. 7)*.

In the middle phase of the LBK the clique analysis leads to the definition of different subgroups *(Fig. 7)*. In general, however, the relationships are similar to the preceeding phase. Very strong ties continue to exist between single settlements on the "Aldenhovener Platte" and the subgroup east of the river Rur. These very intense relationships were upheld for a period of 200 years, and may reflect kinship ties.

With the beginning of the latest LBK phase the network changes. The well-embedded settlements in the former phases become less important. Some other settlements, in *Fig. 7* marked by arrows, now have a stronger influence on the decorative spectrum. Within the settlement groups single sites seem to distance themselves from one another. This means they display no similarities in the examined secondary motifs.

In summary, it can be stated that during the earlier phases of the LBK the observed relations have a causal connection with the settlement history of the distinct settlement groups:

Earlier founded settlements show high centrality measures and participate in the majority (69%) of the observed cliques; they are obviously better embedded than later settlements. Therefore kinship relations are seen as being responsible for the similarities in pottery decoration.

In the later phase new actors became important as producers and distributors of flint raw material. In addition, with reference to the pottery decoration, at this point in time there are fewer similarities, with the resulting greater number of "more diversely composed" cliques possibly indicating boundaries between exactly these settlements.

This change is interpreted as a breakdown in long-lasting kinship ties. Frirdich (1994) has referred to this in another context as the "emancipation of the younger generation". Settlements in neighbouring regions separate from one another; which is also implied by the construction of enclosures at the end of the LBK. This, combined with the reduction of long distance contacts in the later phase, strongly supports the opinion that social units were much smaller in the last generations of the LBK.

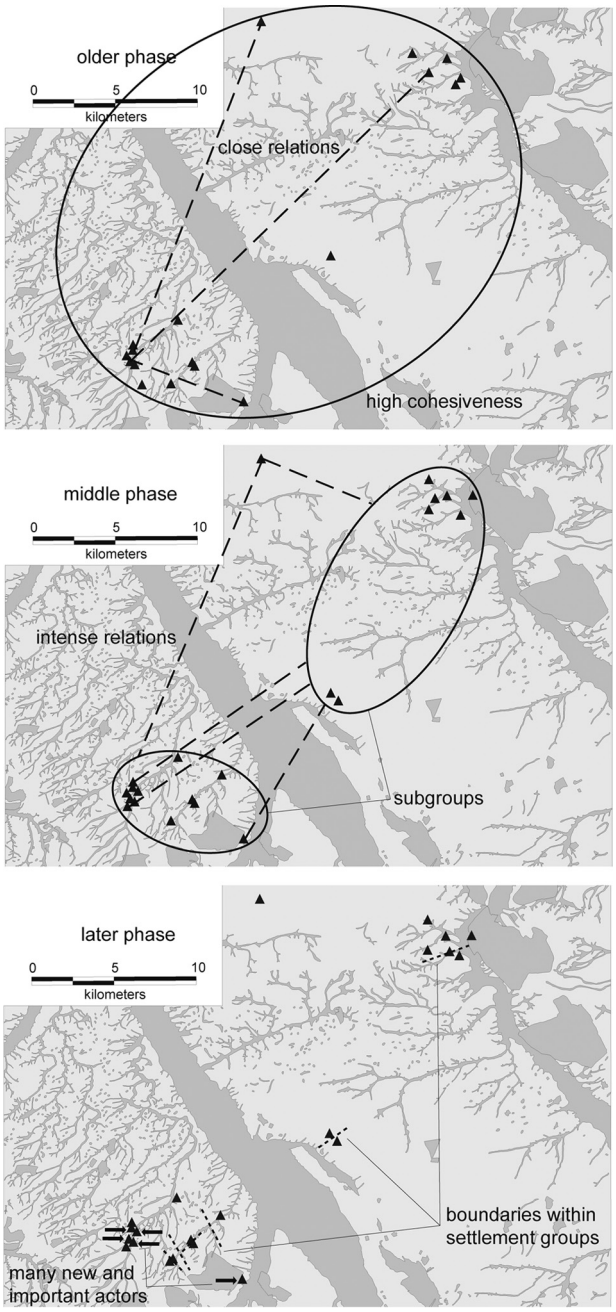


Fig. 7. Three maps of the research area summarising the results of network analyses undertaken for the stone tool inventories and for the similarities in pottery decoration for three phases of the LBK in the Rhineland.

The probably kinship-based structures that were responsible for the very stable social system of the older and middle LBK begin to change as early as a century prior to the end of the LBK in the Rhineland. Therefore, in my opinion, the disappearance of the typical LBK features is very much the result of processes related to social change.

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Erich Claßen

Bayerisches Landesamt für Denkmalpflege
Dienststelle Ingostadt
Unterer Graben 37
85049 Ingolstadt
erich.classen@blfd.bayern.de