Tesselations and Triangulations - Understanding Early Neolithic Social Networks

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Erich Claßen
Institut für Ur- und Frühgeschichte
Universität zu Köln, Germany

Andreas Zimmermann
Institut für Ur- und Frühgeschichte
Universität zu Köln, Germany

Abstract

Different mathematical-statistical methods can be used in the analysis of the spatial distribution of archaeological data. On the one hand, we will consider Delauney-Triangulations, which connect neighbouring points of a distribution so that compact triangles are built, and on the other, we shall be looking at the use of tessellations in such an analysis. Around the points of a given distribution, polygons are formed; the junctions of the polygons are found in the zones of lowest point density.
Delauney-Triangulations of Early Neolithic settlements in the Rhineland, of the so-called Bandkeramik Culture, have shown that settlements were subjected to a standardised spacing in the landscape. Different distance-classes have been observed, uncovering different structures within the Bandkeramik settlement system. Within settlement groups, determined by triangulation, settlement hierarchies can be recognised by the evaluation of archaeological material. It is possible to distinguish big "central" settlements, and secondary settlements that were, more or less, dependent on these.
Tesselations make the possible hinterland visible, and allows us to make estimates regarding the economic necessities of individual settlements or settlement groups.
The combination of geometrically possible, geographically probable and archaeologically testable contacts is used to decipher past communication networks.

Introduction[1]

This paper deals with the application of tessellations and triangulations to landscape archaeology. In out presentation given at the conference we showed how these methods can be applied to cave art (Claßen and Zimmermann 2003).

However, in the following, tessellation and triangulation are used to analyse settlements of the so called Bandkeramik. We will also deal with a more generalized variant of triangulation which we would like to call the 'calculation of second degree neighbourhoods'. All these methods can help us in understanding the distribution of archaeological sites or artefacts.

'Delauney triangulations' connect neighbouring points of a distribution so that compact triangles are built, this means that a quadrilateral is subdivided into two triangles whereby the angles should be as obtuse as possible. No line may cross another so that only 'natural' neighbours are connected. In the result we see a conclusive definition of neighbourhoods (Ripley 1981).

Tessellations, synonymous are the terms 'Voronoi diagrams', 'Dirichlet cells' or 'Thiessen polygons' form polygons around the points of a given distribution. This method is closely related to triangulations as the edges of the polygons divide the lines of the triangulation perpendicularly in half (Fig.1). The vertices of the lines of polygons are found in the zones of lowest point density (Okabe, Boots and Sugihara 1992).

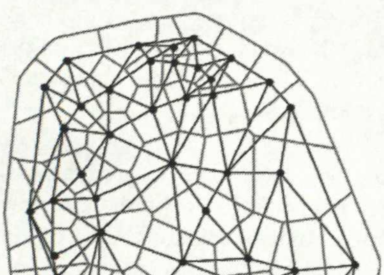

Figure 1 Schematic Triangulation (black) and Thiessen Polygons (red)

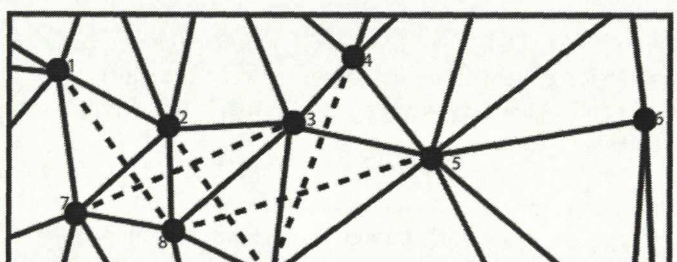

Figure 2 Schematic Triangulation of 'natural' neighbours (continuous lines) and 'neighbours of a second degree' (dotted lines)

The aim of the calculation of second degree neighbourhoods is to visualize additional structures in more complex distributions. In figure 2 these points are second degree neighbours which are connected by two lines in the triangulation of 'natural' neighbours. For example points 2 and 9 are neighbours to a second degree because the 'natural' neighbours, points 3 and 8, connect to one another.

The combination of possible geographical neighbourhoods, together with the archaeological data from the sites, should lead to an evaluation of the different possibilities in the sense of more or less probable past social networks.

Concerning the analysis of social networks, sociologists and social anthropologists have developed a broad range of methods (methods and theory: Wassermann and Faust 1994; ethnological applications: Schweizer 1996). In the coming years we aim to transmit these methods of social network analysis on to archaeological data. However, in this paper the attempt is made to deliver an insight on some archaeological data that may be seen as reflecting the social networks of the Early Neolithic.

As previously mentioned, we are dealing with the Early Neolithic of Central Europe (e.g. Lüning 1988). Bandkeramik is the term used to describe the culture of the first farmers in Central Europe. The name is derived from the typical ornamentation found on the vessels. Such pottery is found from the Carpathian mountains to the Parisian Basin and dates back to the time between 5500 and 4900 cal. BC. Important innovations from this time are farming and stokkbreeding, a sedentary way of life and the production of pottery.

At about 5300 cal. BC the farmers of the Bandkeramik arrived in the Rhineland. The settlements are situated mostly along small rivulets and consist of individual or several simultaneous farmsteads (e. g. Lüning and Stehli 1989, Stehli 1994). On the basis of the settlement size, the settlement duration, the supply with flint material and the peculiarities of the vessel decoration, we can reconstruct settlement groups. These settlement groups consist of a main settlement, several secondary settlements and/or single farmstead settlements.

In our definition a main settlement comprises up to ten farmsteads and was inhabited continuously for a long period of time. These settlements played a certain role in the procurement, processing and distribution of specific goods such as flint.

Secondary settlements are middle-sized hamlets, with three to four simultaneous farmsteads which were, to an extent dependent on the main settlements but which also developed their own traditions within time.

Single farmstead settlements were presumably more dependent on the main settlements.

Triangulations of Early Neolithic Settlements

The distribution map of Early Neolithic sites in the Rhineland shows clusters of sites and gaps in the distribution which are regarded as being meaningful (Lüning 1982:13-23, Fig.3 and 6).

One aim of the triangulation is to quantify the distances between neighbouring sites. In doing so it may be possible to realize certain regular distances, which can perhaps be explained by the past social relations.

On the one hand it is probable that less room between the individual settlements led to social stress owing to limited resources. On the other hand, if the settlements were situated further apart, it would have been difficult to keep contact and to work on common tasks. If a society strives for a balanced relation between communication and aggression, this leads to the establishment of certain rules as to where settlements could be founded. These possible rules can be reconstructed by analysing the distances between past settlements (Zimmermann 1992:108).

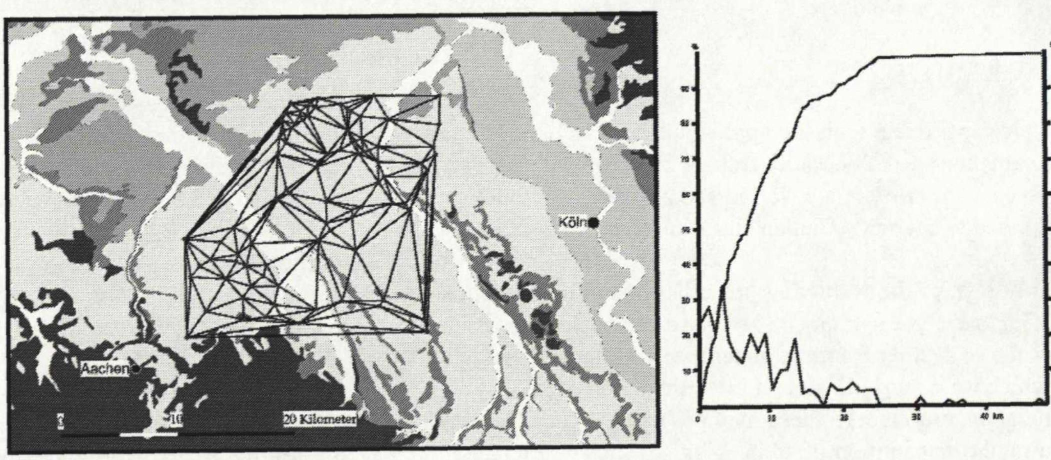

Figure 3 Triangulation of Early Neolithic sites in the lignite exploitation area west of Cologne, Germany. Map after Modderman 1970, Taf. 1, and a cumulative graph of the distances in the triangulation

In the Bandkeramik of the Rhineland regular distances between the settlements are visible because some ranges occur more frequent than others (Fig.3).

When looking at the triangulation we first recognize a maximum distance of about 1.5 km, which seems to be the maximum distance between two contemporaneous sites of one settlement group (Zimmermann 1992).

A peak at 3 km indicates the regular spacing between different settlement groups. This distance class corresponds with parallel running rivulets in the area under study. On the Aldenhovener Platte, where most of the settlements are fully examined, the distance between main settlements - with a high percentage of primary flint processing - is about 2 to 3 km (Zimmermann 1995:92).

Here we can see that archaeological and geographical information match. The settlement hierarchy developed on archaeological arguments - with main settlements, secondary settlements and single farmstead settlements - is supported by the regular geographical arrangement of main settlements.

The distances between 8 to 10 km and 13 to 15 km form the next groups. For the structures registered here, no sufficient explanations are available at the moment. It is possible that these groups mark the distances between settlement units on a higher level which may be connected with different natural landscape units.

The tessellations give an impression of the available land belonging to a settlement group. How far this land was used, and if this may have led to conflicts on resources, will be an aspect of further studies. The possible conflicts between neighbouring communities should appear in the archaeological database as apparent dissimilarities.

CALCULATION OF NEIGHBOURHOODS OF A SECOND DEGREE AND EARLY NEOLITHIC SOCIAL NETWORKS

At this point we have to consider triangulations of a second degree as they show the more complex and diverse relations. The possible relations of Early Neolithic settlements on the Aldenhovener Platte are shown in figure 5. In a next step we try to prove these possible connections using the archaeological data because the existence of some relations - which seem to be geometrically possible - are less realistic.

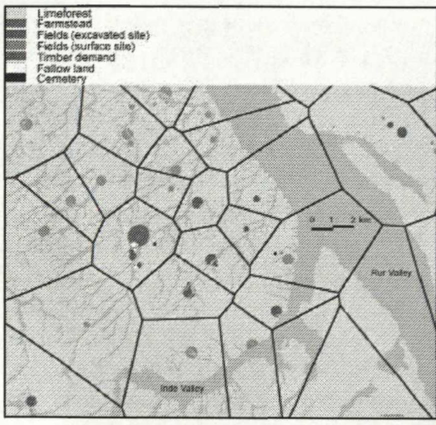

Figure 4 Tesselation of Early Neolithic settlement groups on the Aldenhovener Platte, Germany

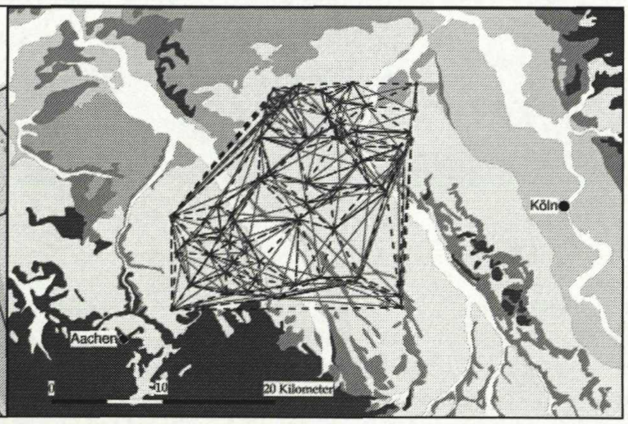

Figure 5 Triangulation of Early Neolithic sites on the Aldenhovener Platte, Germany. Continuous lines: 'natural' neighbours; dotted lines: 'neighbours of a second degree'. Map after Modderman 1970, Taf. 1

One way of checking the triangulation is via the very diverse pottery decoration (Frirdich 1994, Kolhoff 1999, Krahn-Schigiol 1999). However, as yet, this possibility has not been studied in detail.

Similarities in the pottery decoration of neighbouring settlement groups in one settlement phase show that some 'natural' neighbours don not share certain decorations, whilst some neighbours of a second degree do have a similar decorative spectrum (Fig.6).

TESSELATIONS OF EARLY NEOLITHIC SETTLEMENT GROUPS

If we calculate a tessellation of Early Neolithic settlement groups in the Rhineland the catchment area of each settlement group is displayed .

Figure 4 shows the estimated economic necessities for one settlement group in a single settlement phase with a duration of 25 years. The demand for farmsteads, fields, fallow land and timber acquisition has been calculated. The hinterland of the settlement- and field-area was needed for grazing the stock. The fact that there was no grassland to feed the animals led to grazing in the surrounding woodland, for which much more space was needed. In other settlement territories of the Bandkeramik land use models show that the whole possible hinterland was required for the upkeep of a population of livestock (Ebersbach and Schade this volume).

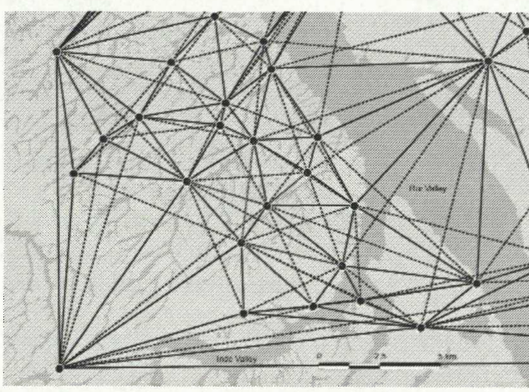

Figure 6 Part of the Triangulation of Early Neolithic settlement groups in the Rhineland. The red lines indicate similarities in the pottery decoration between different settlement groups in phase XII (after Kolhoff 1999, 107). Continuous lines: 'natural' neighbours; dotted lines: 'neighbours of a second degree'

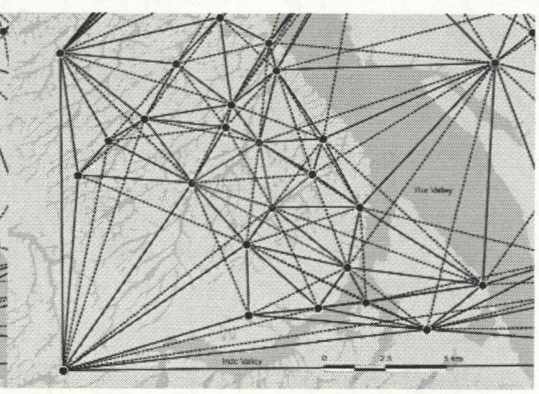

Figure 7 Part of the Triangulation of Early Neolithic settlement groups in the Rhineland. The red lines indicate similarities in the pottery decoration between different settlement groups in phase XIII (after Kolhoff 1999, 107).
Continuous lines: 'natural' neighbours; dotted lines: 'neighbours of a second degree'

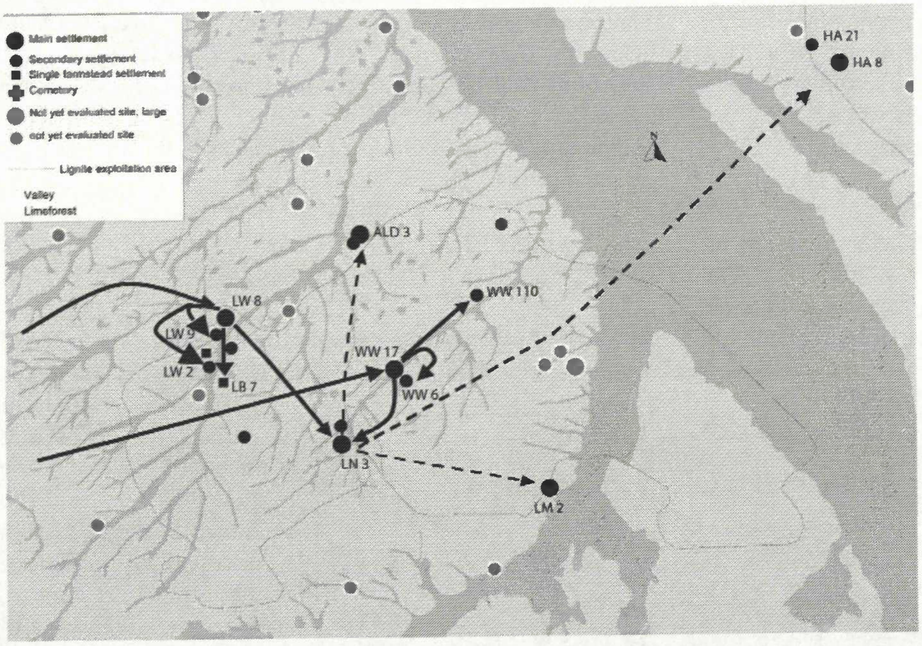

Figure 8 Simplified presentation of the flint raw material exchange on the Aldenhovener Platte, Germany

In the next settlement phase this picture changes slightly. Most 'natural' neighbours now have certain decorations in common, and even second-degree neighbourhoods located at greater distances from one another show similarities (Fig.7). Nevertheless, some settlement groups still appear to have had less contact with certain others.

Another source for the analysis of Early Neolithic social networks is the stone artefact raw material. On the Aldenhovener Platte a rather complex system of raw material exchange can be reconstructed. This region was mainly supplied with raw material from the west, which was won in the vicinity of Rijckholt.

To reconstruct the distribution of artefacts from one settlement to another criteria such as the amount of production waste, blades and final products are essential (Zimmermann 1982; 1995). They point to the production intensity and to the position of a settlement in the distribution system. The general raw material distribution network can be described as follows (Fig.8):

Firstly we can identify the supply of two main settlements with Rijckholt material, the reason being the high amount of primary processing that took place at the sites (LW8, WW17; Zimmermann 1988, Krahn-Schigiol 1999). This is shown by a high proportion of blanks with cortex which is an indication of the processing of flint nodules brought into these settlements.

These main settlements passed on cores, blades and final products to their neighbours in the settlement group (LW2, LW9, LB7, WW6; Langenbrink 1996, Gaffrey 1994, Krahn-Schigiol 1999).

One main settlement also supplied a smaller settlement that did not belong to the same settlement group (WW110; Bollig 2000).

In a further main settlement even more artefacts were produced in comparison to the two settlements already mentioned, although not from nodules but from prepared cores (LN3; Krahn-Schigiol 1999). This means that this settlement was supplied by one or both of the first mentioned main settlements with primary processing of nodules.

This main settlement probably gave parts of the produced artefacts to other settlement groups (ALD 3, LM 2, HA8 and HA 21; Deutmann 1997, Langenbrink 1992, Bender 1992, Hohmeyer 1997, Reepmeyer 2002).

The first network analysis of the raw material distribution network, which is not to be discussed in detail here, was conducted using the program package 'UCINET IV' (Borgatti, Freeman and Everett 1999) and considers the changes in the system from the middle Bandkeramik to the later Bandkeramik (Reepmeyer 2002:73-104).

Two settlements seem to change their position within the network, which means that a settlement declared as a producer and forwarder of raw material for the middle Bandkeramik became a receiver settlement in the later period.

If we look at the whole network, its structure does not change over time. The ratings for prominence show that the relations within the network can be described as being distributed rather uniformly. To keep it simple, all actors have nearly the same number of relations.

The network was therefore egalitarian.

There were enough settlements with a high production rate, so that each receiver settlement could interact with another producer settlement in a possible conflict situation.

This egalitarian network structure prevented the development of a more differentiated hierarchical settlement structure. This seems to change in the Middle Neolithic of the Rhineland, but this would be a subject for a further paper.

We are still in the investigation process, and of course our picture of the Bandkeramik settlements is not complete, However, we hope to specify the results presented here within a few years.

1 We would like to thank Lee Clare (Cologne) for the proof reading of this text.

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