Neumark Nord 2/2:
Spatial Analysis of an Eemian open-air Site

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1. Introduction

This paper deals with the spatial analysis of find-material at the Palaeolithic site of Neumark Nord 2/2 (NN 2/2). NN 2/2 is an open air site located near Leipzig in Eastern Germany. The site is located in an open cast lignite mine which is now flooded for recreational purposes. The excavations at Neumark have taken place from 2004 until 2008 and have been performed by the local *Landesamt fur Denkmalpflege und Archaeologie Sachsen Anhalt* in corporation with Leiden University represented by Prof. Dr. Roebroeks and and the Romisch Germanisch Central Museum in Mainz represented by Prof. Dr. Gaudzinsky-Windheuser.

The site of Neumark Nord 2 consists of a filled-in lake. Sediments vary from silty loams to coarse sands. The site has been dated to approximately 120 thousand years BP using various dating methods (SIER 2008). Pollen evidence has shown that the sequence falls exactly within the Eemian interglacial. The pollen evidence along with detailed micromorphological research has shown that sedimentation in the basin was relatively fast and constant and took some two thousand years. (ROEBROEKS in prep)

The find material from the site consists of flint artefacts and bone fragments. During the excavation most of the finds were measured in using tape and rods and drawn using pencil and paper, these drawings were then digitized to flat drawings. In 2006 under supervision of dr. Kamermans a program was started to get all the data into a GIS and get an understanding of the overall spatial distribution of these finds throughout the site.

After the digitization of all the finds it was deemed helpful to start research into three dimensional GIS for the Neumark Nord assemblage in addition to more conventional two dimensional techniques. Because true three-dimensional GIS is not yet readily available (Zlatanova 2002), methods have varied per research topic. The research at hand was aimed at getting grips on the overall spatial patterns and testing existing hypotheses rather then reevaluating the entire excavation.

The main research questions are the following:

1. Is the overall spatial distribution of find material at NN 2/2 a direct effect of human behaviour?

2. Are there clusters of find material present in the lower horizons of the NN 2/2 sequence?

3. If so, what is the size and nature of these clusters?

4. How did the shallow depressions in the lower horizons come into existence?

Other focus on methodological issues:

1. Can three-dimensional modelling and simulation of the geological situation at NN 2/2 improve our understanding of the taphonomic aspects thereof?

2. How and to what extent can modern end-user computer applications aid archaeological researchers now and in the future?

2. Hypotheses on the spatial distribution

Various people have had their say on the spatial distribution of material present at the site of Neumark Nord 2 (LAURAT 2006, POP 2009, GURTOV 2009). The most common difference between the various theories on the deposition of the find material is whether human agents or natural processes have been the cause of spatial patterns that we see now.

2.1 Human agents at work?

A number of researchers have tried to assign particular features at the site to human activity. The most notable of these features are the clusters of find

material in the lower horizons of the NN2/2 sequence. These clusters have been interpreted as filled-in holes that were dug to aid the construction of a tent. The holes are spaced in such a way that it would seem to represent the ground plan of a small tent (figure 1).

Whether there are actually clusters present, their size and the origin of them has been analysed using conventional two dimensional clusters analyses and through new three dimensional methods.
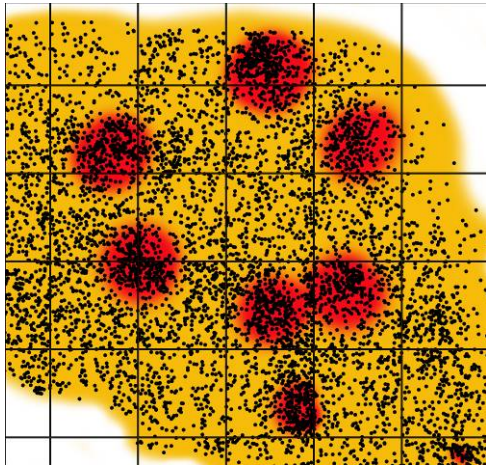

Figure 1: *Distribution of finds in a particular area at NN2/2, the gridcells are 1 x 1 metre. The red spots would indicate 'clusters'.*

2.2 Natural factors of the deposition of find material at NN2/2

Micromorphological analysis of sediments from NN2/2 has shown that there was a relatively steady inlet of (rain-) water together with silty and sandy sediments (MUCHER in prep). The geological research (HESSE 2009) concluded the same. A reasonable assumption is therefore that the bone and flint finds may have been transported as well.

Hesse 2009 has through the analysis of the geological reconstruction of NN 2/2 tried to recognize gullies through which the finds have swirled towards the depressions/clusters in the lower horizons of the sequence.

Natural causes for the spatial distribution of finds may lead to structured deposition and therefore rather straightforward distribution patterns. Using conventional methods of two-dimensional plotting of finds can give a good idea of the nature of spatial patterning but it lacks some explanatory power when it comes to context-related deposition patterns. Therefore some three-dimensional methods have been used in the analysis of natural factors as well.

3. Methods

As mentioned above, several techniques were used in the analysis of the distribution of finds at NN 2/2. of these, some are conventional two-dimensional methods but for most of the taphonomic issues three-dimensional visualization and simulation had to be drawn on.

3.1 Cluster analysis

In order to investigate the presence and nature of clusters in the lower horizons of the NN 2/2 sequence, visual cluster analyses were carried out. A great number of dot density maps were generated in ESRI Arcmap v9.3 to get an idea of the overall density variation throughout the area that was deemed to contain clusters. These plots have shown that there may be some clustering present but clusters are hardly in a particular (tent-) setting (picture 2). Using a coarse cell matrix for some plots makes very clear how the clustering is part of a larger distribution pattern (picture 3).
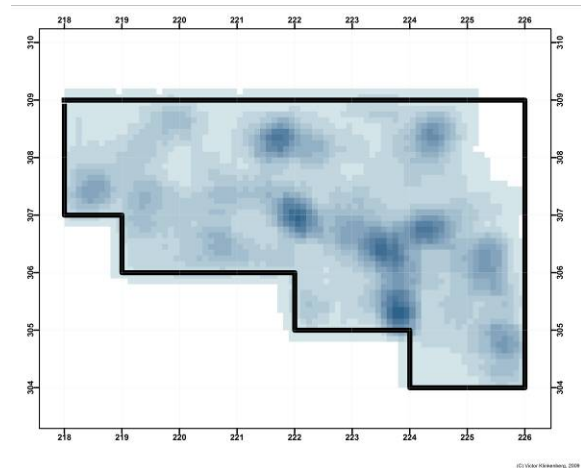

Figure 2: *Dot density map of finds in a particular area at NN 2/2. Dark colours represent high density. Excavation grid is 1x1m. Dot density cell size 10cm, 12 equal interval classes, 0.5x0.5m square averaging.*
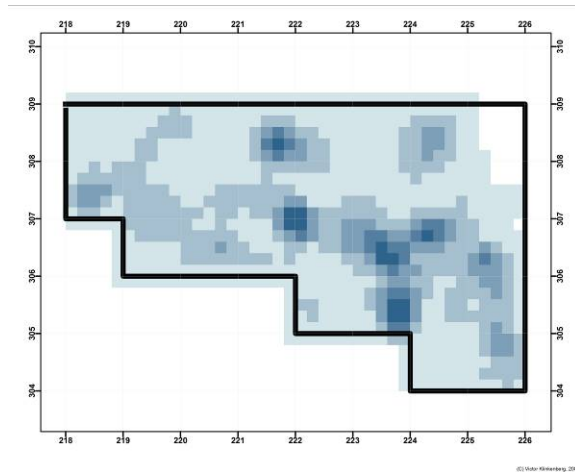
Figure 3: *Dot density map of finds in a particular area at NN 2/2. Dark colours represent high density. Excavation grid is 1x1m. Dot density cel size 20cm, 15 equal interval classes, 0.5x0.5 square averaging.*

3.2 Three-dimensional visualization

The forenamed clusters were originally recognized as such during the excavation and have gotten lots of attention by the excavators and subsequent research-ers. The clusters were described as "a shallow depression containing coarser sand then the surrounding matrix and a large find-concentration" (LAURAT pers. comm.). In contrast with this statement, the horizon that is represented by these depressions has not been included in the final geological report of the site (HESSE 2009).

Three-dimensional visualization using ESRI Arcscene v9.3 of the finds from the area with the supposed clusters/depressions shows that there are very clear vertical dips in the find-cloud (picture 4). This together with photographic records from the profiles at NN 2/2 suggests that there indeed is a seperate geological or geomorphological horizon present in the lower parts of the NN 2/2 sequence.
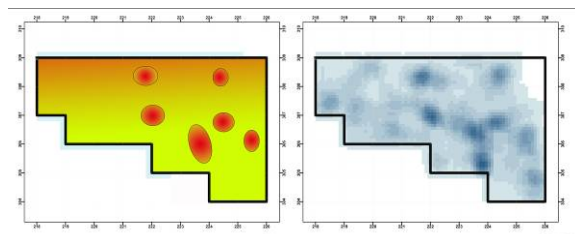

Figure 4: *Approximate location of depressions (left) and find density plot (right)*

Plotting the most obvious depressions shows a pattern which is remarkably similar to the pattern that the find density plots show. Visually scanning the three dimensional findcloud has shown six distinct

depressions, most are roughly circular in plan but one depression is elongated in shape.
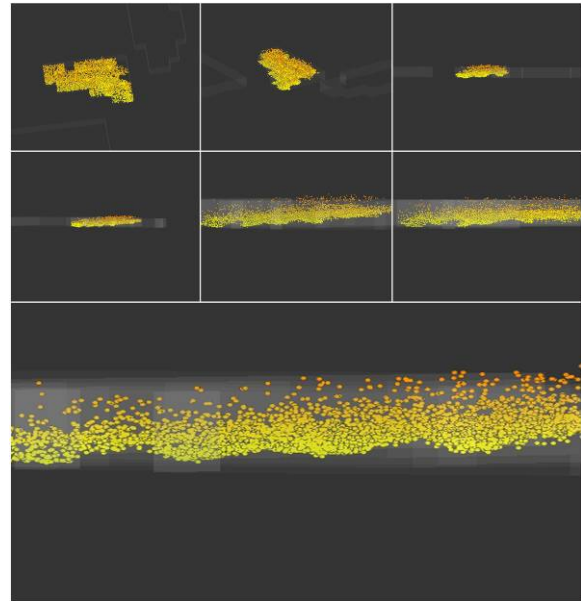

Figure 5: *Sequence of images of an animation of the area with hypothesized clusters/depressions. Each dot represents one find.*

3.3 Simulation of taphonomic processes

To better understand the taphonomic processes at NN 2/2, a three-dimensional computer model of the geological subsurface was made. This model is a representation of an empty Neumark without any other aspects of the original natural environment. Using Next Limit's RealFlow software for water modeling, the Neumark model has been used to recreate situations of rainfall and surface flow. Although this is just a preliminary set-up, it does show how rainfall would have interacted with flint and bone on a surface like the one that was excavated at Neumark. Unfortunately for this study, for a proper simulation of the natural environment stronger computation power was needed. But even though there was only one simple laptop available for this study, the simulations do show that the depressions may well have been caused by a combination of rainfall and surface flow (picture 5). Whether the infill of the depressions with flint and bone is also due to these processes is subject to pending analyses.
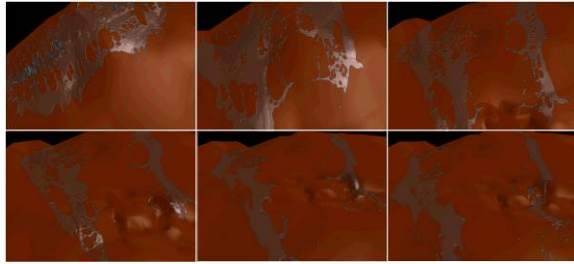
Figure 6: *Sequence of images from an animation of a simulation of the area with depressions. In this simulation a small amount of water is seen flowing down the model of the Neumark subsurface*

4. Conclusions

Spatial analysis of the find material at Neumark Nord 2/2 has shown that there may be some clustering of find material present in the lower horizons. The location of clusters seem to correlate well with particular geological phenomena. The approximately 75 cm diameter clusters may therefore be of natural origin.

Simulation of rainfall and surface-flow on a computer generated three-dimensional model of the subsurface of NN 2/2 has shown that the depressions in the lower horizons of NN 2/2 have probably been created by natural phenomena rather then human agents. Whether the particular find concentrations in these depressions is the result of the same processes is not yet sure.

Three dimensional modelling and simulation of taphonomic processes may prove to be an essential tool for future archaeologists; the speed and ease with which it is possible will only grow. The simulations presented in this paper are due to poor computation speed rather low-resolution but future simulations may contain models for every grain of sand, thereby simulating completely-real-life situations.

The relative ease with which the simulations have been created has shown that the potential of three dimensional modelling and simulation is within reach of every archaeologist, the researcher at hand had no prior knowledge of three dimensional modelling or possessed any other computer related expertise.

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