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A THREE-DIMENSIONAL MODEL OF THE PALAEOLITHIC SITE OF HUMMAL (CENTRAL SYRIA)

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Introduction

The Palaeolithic site of Hummal (Central Syria) with its huge stratigraphy, covering the whole Palaeolithic era, is predestined for a digital reconstruction. Therefore an important project, parallel to the regular excavations in the Palaeolithic site of Hummal, is the development of a three-dimensional model of the site itself and the reconstruction of related site-formation processes. This work is based on data collected during the last ten field seasons. The surface modelling includes three-dimensional survey points located in the adjacent area. Points of reference related to profiles and surfaces as well as the position of finds are also included.

Hardware and software

Since systematic excavation work began at Hummal in 1997, a cartesian coordinate system has been used for the measurements. The y-axis of this system marks the north axis and deviates about 30 degrees from geographic north. Measurements in the beginning were taken by two optical theodolites. Since 2005 two electronic distance meters (hereafter: EDM) have been in use: one Leica TPS 400 and the second a Leica Builder R200M. These two EDMs are connected directly to two Asus EeePC 900 office-notebook computers.

To save and organise the data on the computer, the software AutoCAD is utilised. The AutoCAD application TachyCAD provides the tools and drivers for the communication between the EDM and the computer. For the calculation of the grids for the surface, the software Surfer 8 is used. In order to calculate the slope and aspects of the layers of the Yabrudian complex, the author prefers to work with the Open Source GIS solution GRASS GIS.

Datasets

For the reconstruction of the excavation, several datasets were available (fig. 1). First of all there was an existing database, covering the surroundings of the well. These data were collected during the 2004 season by Tobias Tonner with conventional methods and optical instruments. The maximal distance between the points is about one metre. During the subsequent campaigns a second dataset was compiled covering the areas inside the well. These data were recorded with a high accuracy with two EDMs. The third dataset contains interpolated points representing the surfaces of the excavation. The use of these points allows us to increase "artificially" the density of points in order to refine the 3D model. The whole surveyed area extends over about 5000 square metres. Within this perimeter over 5000 points are available, with a density of one point per square metre on average.

Figure 1 - Distribution of data points in Hummal (triangle: sourroundings, black points: inside well, grey points: interpolated).

The reconstruction of the topography of the layers was carried out using the information from the excavation profiles. Therefore most of the original profile drawings had to be digitised.

For the digitising our team tested two different methods: a digitising tablet, where the analogue drawings and photos can be traced directly; and scanning the analogue data and importing it into AutoCAD to redraw the documents.

We found that it is possible to create accurate digital versions with both approaches, so the user was allowed to choose in which way to digitise the data. Finally the cross-sections were aligned to their original position in the 3D plan of Hummal.

As the limits between the layers in AutoCAD are represented by lines, the author developed a macro (fig. 2) which extracts the start, middle and end point of each line. This step is necessary due to the specifications of the modelling software. The software allows the user only to work with point data for the calculation of surfaces. Furthermore, the macro permits the creation of separate files for each layer in order to reconstruct each and every layer separately.

```
For Each elem In ThisDrawing.ActiveSelectionSet
    If elem.ObjectName = "AcDbLine" Then

        'Set up Filenames
        str1 = "C:/Syria/" & elem.Layer & ".txt"
        str2 = "C:/Syria/Total.txt"

        'Open files
        Open str1 For Append As #1
        Open str2 For Append As #2
        Set line = elem

        'Get first point of line
        spt(0) = line.StartPoint(0)
        spt(1) = line.StartPoint(1)
        spt(2) = line.StartPoint(2)

        'Get last point of line
        ept(0) = line.EndPoint(0)
        ept(1) = line.EndPoint(1)
        ept(2) = line.EndPoint(2)

        'Calculate point in the middle
        pt(0) = ( spt(0) + ept(0) ) / 2
        pt(1) = ( spt(1) + ept(1) ) / 2
        pt(2) = ( spt(2) + ept(2) ) / 2
```

Figure 2 - Snapshot of the Macro to extract the line data.

Modelling techniques

For the reconstruction of the site and the spatial organisation of layers, the software Surfer 8 was used to calculate and illustrate the surfaces of the excavation and the layers. Surfer 8 enables the use of several algorithms to generate surfaces from point data. In the present work, two different algorithms have been applied to calculate the according grids for digital models.

Kriging algorithm

With this method an individual value is estimated for every point, which has to be interpolated. The estimation of this algorithm refers back to the points located around the point which has to be interpolated. Specific parameters and values used for reconstructing the site:
Density (maximal distance between estimated points): 0.05 m
Number of sectors (search of points): 6
Search radius: 25 drawing units

Minimum curvature algorithm

This algorithm makes it possible to fit a plane to the existing points with the presetting that the plane has the lowest bend possible. This method incorporates all recorded points as a whole. In Surfer 8 the principle of tensions (Smith & Wessel 1990) is used. Parameters and their particular values applied for reconstructing the site:
Tension of the interior (bending of the plane at the record): 0
Tension of the boundaries bending at the corners/borders): 1
Density: 0.05 m

A considerable advantage of the minimum curvature algorithm is the possibility of including predefined fault lines representing breaks in the surface of the model. After several tests (see Results), the author decided to apply the minimum curvature method with faults for the reconstruction of the site and the minimum curvature algorithm without faults for the surface reconstruction of the different geological layers. Due to the amount of files (n=72) for the reconstruction of the layers, it was necessary to write an automation script for Surfer 8. The script calculates two different grids for each layer. First it generates a grid which covers the maximum extensions of the profiles. The second grid is calculated by using the maximum extent of the excavation.

Each grid is calculated with a size of 100 rows and 100 columns, so the maximum distance between points is on average 0.1 m for the maximum extension grids and about 0.5 m for the whole area. In order to create synthetic cross-sections at user-defined coordinates, another script was written by the author. It creates a single text file with the coordinates of the layers along a line.

Results and interpretation of the modelling process

Site reconstruction

The two different methods of modelling produced three different models (fig. 3) in different qualities. First of all there is the result of evaluating the Kriging algorithm (fig. 3:top): in principle it is not at all satisfactory as the resulting picture is not sharp enough and angles of profiles too low. Furthermore weird structures emerged in areas with too little data. As a second test there is the first outcome of the minimum curvature method without faults: again the resolution of the picture is not sharp enough, angles of profiles are too low or too high (steep) and wavy instead of flat profile planes. The third approach shows the result of the minimum curvature with faults, producing a satisfactory outcome, profiles are straightened, their angle is nearly perfect and artificial structures in areas of low data density do not appear.

In conclusion, it became clear that the minimum curvature algorithm with faults provides the best results. With this method it

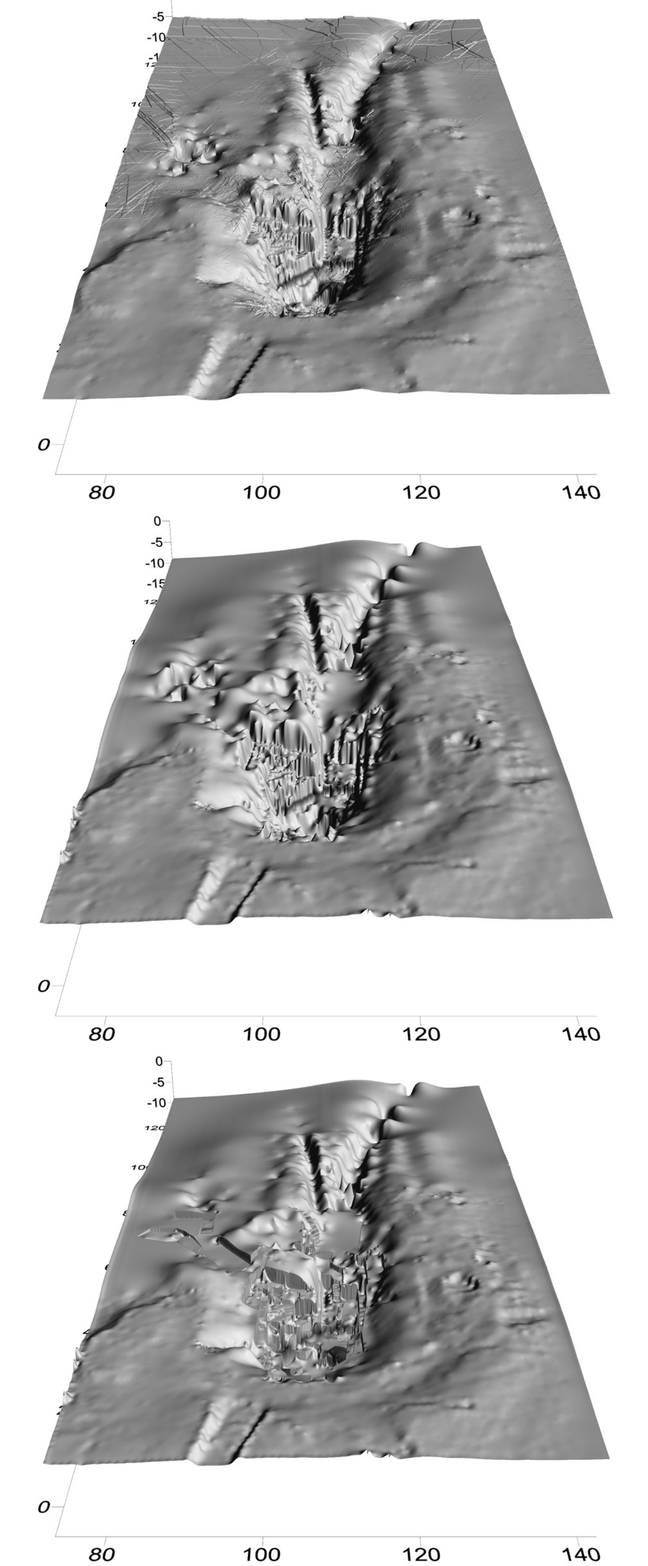

Figure 3 - Different models as results of the different methods and variables. Top: Kringing algorithm; middle: minimum curvature without faults; bottom: minimum curvature with faults.

is possible to create a real model of the excavations in Hummal which can be adjusted for several purposes. One possible use is the creation of a virtual reality model in order to permit an internet user to visit Hummal in three dimensions. Another application is the possibility for the excavation team to visualise or check certain aspects in their three-dimensional situation. This helps to understand old observations in their proper context and to check already excavated parts of the site with the latest models and interpretations. To bring this tool to perfection, texturing with real photographs from the site is under construction at the time of writing.

Reconstruction of the layers

More interesting at present might be the results of the layer reconstruction. The primary objective of the reconstruction of the layers was the correlation of the two Mousterian sectors in the west and south of the site. For this purpose a synthetic section along a north–south axis (fig. 4) had to be created. As is visible in the cross-section, the layers in the middle of the site are disturbed by the modern well. Due to this it is not possible to connect the two Mousterian sections of Hummal by a virtual reconstruction of the several geological layers and archaeological levels.

The cross-section shows clear slopes in all layers on both sides of the well. The directions of the slopes are consistently plunging towards the actual well. Hitherto this phenomenon was explained as the result of a sinkhole beneath the site. Further investigations of this bending, however, have shown that it is probably a result of the draw-down of the water table in the well. During the draw-down in a well, the water level depends on the amount of water which flows out and its recharge. figure 4 shows the situation in such a well. If no water is pumped out, the water level stays nearly level, if the level of the ground water is horizontal. With pumping or increased outflow, the water level begins to create a funnel, represented by the dashed line in figure 5. This funnel grows bigger with continued outflow. With continued drainage, the buoyancy of the sediments decreases, and they subside under their own weight, causing a bending of the layers in the direction of the draining funnel.

The draw-down is not necessarily due to human activities. A natural drop of the water table can also induce such subsidence. The result of such a drying out would be the same as a human-caused draw-down. The funnel of the natural draw-down looks the same and causes similar deformations in the ambient stratigraphy. As it is impossible to differentiate between these two

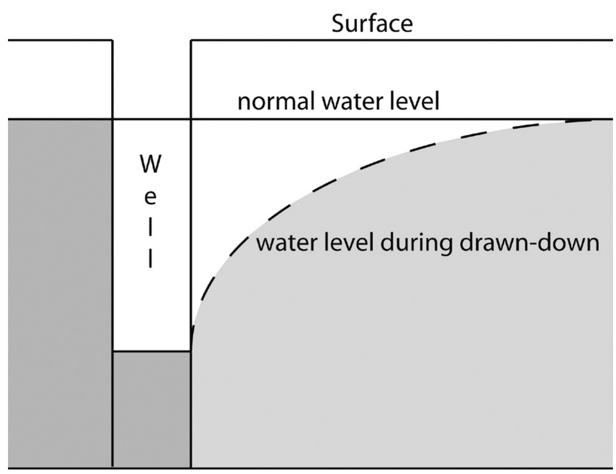

Figure 4 - Drawn down of the water level during the use of a well.

phenomena, it is to be expected that both mechanisms were involved in the deformation of the strata. At the moment it is also impossible to determine when those events took place.

Calculations of a possible drawn-down and the resulting bend showed that the bend of the funnel is similar to the bend of the layers, only smaller. This result leads to the conclusion that the draw-down during the use of the well cannot be the only reason for the bending of the layers. Geological analysis of the sediments in Hummal has shown that some layers have the characteristics of peat (Ismail-Meyer 2009). Peat has the ability to shrink from 1 metre thickness to 10 centimetres due to the loss of saturation with water. Reconsidering the fact that the draw-down leads to a relative drying out, inducing bending and loss of thickness in peat layers, we can assume that such events caused the bending of many layers in Hummal. As the peat layers are present in the lower parts of the stratigraphy, the effects of bending in the upper layers are greater than the deformation of the deeper layers. More investigations in the site itself have to be done in order to retrieve more information about the hydro-geological aspects of Hummal. For the moment, however, it can be assumed that these two phenomena are mainly responsible for the bending of several layers in Hummal.

Relation between orientation of layers and finds

Along with the reconstruction of the layers in Hummal the author pursued the objective of comparing the orientation of finds with the orientation of the layers in the Yabroudian complex (fig. 5). The idea of the comparison was to determine if it is possible to see the bending of the layers in the orientation of the archaeological objects. If this were the case, the orientation of artefacts could be a possible approach to describe the properties of the orientation and surface of a layer.

Characteristics of the Yabroudian complex

The first artefacts with Yabroudian characteristics in the El Kowm region were discovered in the early 1980s by several researchers; Cauvin (Cauvin & Cauvin 1979), Copeland, Hours and Muhesen (Besançon *et al.* 1981). The Yabroudian can be characterised as a cultural entity with no Levallois technique and a high proportion of side scrapers. Offset and transversal side scrapers are especially typical for this entity. The retouch is always very steep and is classified as Quina or demi-Quina (Le Tensorer 1996). Copeland & Hours (1983) gave the first description of the Yabroudian tools of Hummal Ib. A good example of the definition of the Yabroudian was that given by François Bordes in 1955: "*Du point de vue typologique, ce qui caractérise cette couche (couche 25 de l'Abri I [de Yabroud]), c'est la dominance des racloirs de tous types, l'importance des racloirs transversaux et déjetées étant particulièrement sensible*" (Bordes 1955:487-488).

Within a total number of flints of 703 pieces in the Hummal Ib collection, a total of 216 retouched tools were reported (Copeland & Hours 1983). More than the half of the tools (n=142) are scrapers. Among the scrapers more than one-third are offset (n=25) or transversal (n=26) scrapers. The material in the Hummal Ib collection was originally assumed to be in situ. After a re-examination of what is still preserved of this collection, it is clear that the material available today cannot be described as in situ at all, as there is a mixture of Yabroudian and Hummalian artefacts. Furthermore, the area within the well, where the original material was collected, can no longer be identified for certain.

Preliminary investigations Hummal took place until 1983 and were then interrupted for several years. In 1997 the work in Hummal was resumed, when more Yabroudian artefacts were found. Since 1999 excavations have been regularly undertaken at Hummal, including the Yabroudian layers. Systematic measurements of finds started in 2000 with the help of a cartesian coordinate system. Since 2005 the objects have been measured digitally by EDM and computer (see section 2 above).

Figure 5 shows the sectors of the Hummal site where the Yabroudian complex has been identified since the 2000 field season. Most of the finds were present in the central and eastern sectors. In the western side, excavations have not yet reached the Yabroudian levels. The Yabroudian layers in the southern part, which were only discovered during the 2010 season, have so far delivered just a few pieces.

The Yabroudian in Hummal comprises a distinct complex of five layers where locally several sublevels can be recognised. The geological aspects of the sediments are only summarised briefly here as they are presented elsewhere in this volume (Le Tensorer *et al.* 2011).

Layer 8 consists of light-coloured, detritic carbonate silts. Within the top 10 cm, the sublevel 8a is embedded. This level contained 94 lithic artefacts and a large number of animal remains (n=716). During the 2006 season it turned out that the distinction of Level 8a in the eastern section is much more difficult than in the central section, where it was possible to separate layer 8a from the deeper sediments of layer 8. In the eastern section only the separation between the layers 7, 8 and 9 was possible. Level 8a was not distinguishable. Due to this fact, the material was recorded as Layer 8.

Layer 9 is similar in composition to Layer 8 and shows evidence of four lacustrine periods of carbonate formations in a presumably cool and humid environment (Meyer 2000). Within the whole layer (about 30 cm thick) only two bones were found during the excavations.

Layer 10 consists of a dark clay, a perfect stratigraphic marker. This dark clay could be essentially the inorganic remains of a former peat layer, as described above. Remarkable about layer 10 is the fact that its thickness varies from east to west, from about 30-40 cm to only a few centimetres. This striking change in thickness can be traced back to two different events. First there is an erosional event after the sedimentation of layer 10 (Meyer 2000; Le Tensorer *et al.* 2011) and secondly the compression of the peat. From the archaeological point of view, layer 10 can be separated into at least two sublevels (Le Tensorer 2005).

Layer 11 can be described as a typical desertification cycle, which is shown by three different sublevels. First an aeolian sand level

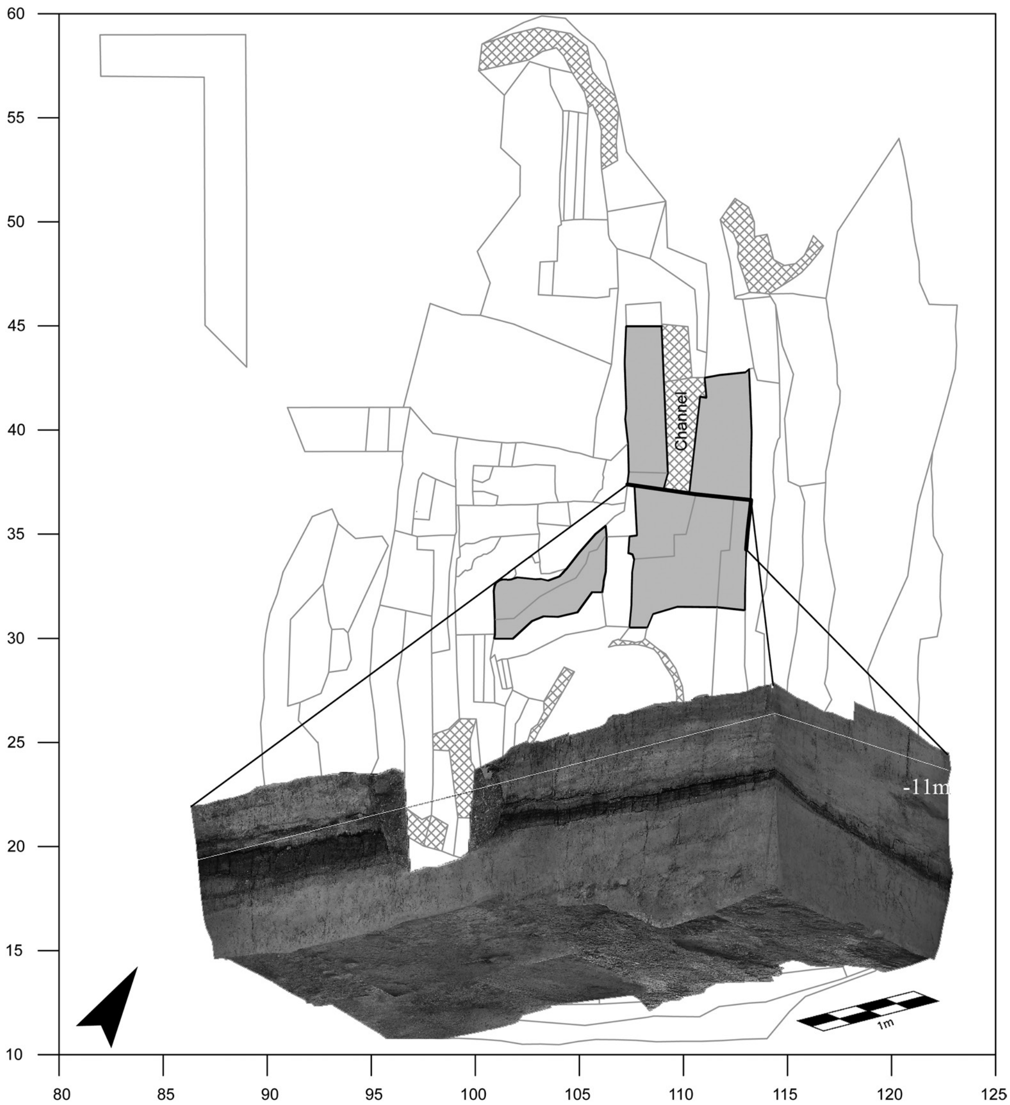

Figure 5 - Situation of Hummal and Yabroudian complex.

(11aS), preceded by a level with detritic granules (11a) and a light clay deposit (11b). As in layer 8, a differentiation between the east and centre sections can be seen. In the central section, the sand level 11aS was clearly visible during the excavations. In the eastern section, the layer seems to have disappeared. Also the separation of levels 11a and b was not possible in the eastern section. As for layer 8, all the objects were recorded as layer 11.

Layer 12 consists of a yellowish clay level. Its texture varies between silty and travertinated. As in the layers described above, it is almost sterile and produced only a few flints (n=20) and again a comparatively high number of bones (n=67).

Layer	8	9	10	11	12	Total	1b
Flakes	1794	6	106	48	113	**2067**	401
Blades	8	0	1	0	0	**9**	19
Retouched tools	16	0	8	3	4	**31**	245
Cores	3	0	3	1	0	**7**	24
Bifaces	0	0	0	0	0	**0**	10
Choppers	0	0	0	0	0	**0**	3
Percuteur	0	0	0	0	0	**0**	1
Total lithics	1821	6	118	52	117	**2114**	703

Figure 6 - Numbers of objects within the yabroudian complex of Hummal.

The Lithic material

As the overall number of lithic artefacts in the lower levels of the Yabroudian complex is still relatively small (fig. 6), it was decided, for the following study, to sum up the material from the different sub-levels, in order to obtain statistically relevant samples. Among the 2114 lithic pieces from Yabroudian contexts, all the retouched tools are scrapers (n=31). The main part of the lithic materiel are flakes smaller than 2 cm (n=1764), which are not determinable any further.

The remaining artefacts are different classes of flakes, including six Kombewa flakes, and one Kombewa core and two cores on flakes. Figure 7 shows the distribution of the types within the five layers. It is remarkable that almost half of the objects come from layer 8. The same phenomenon is visible when looking at

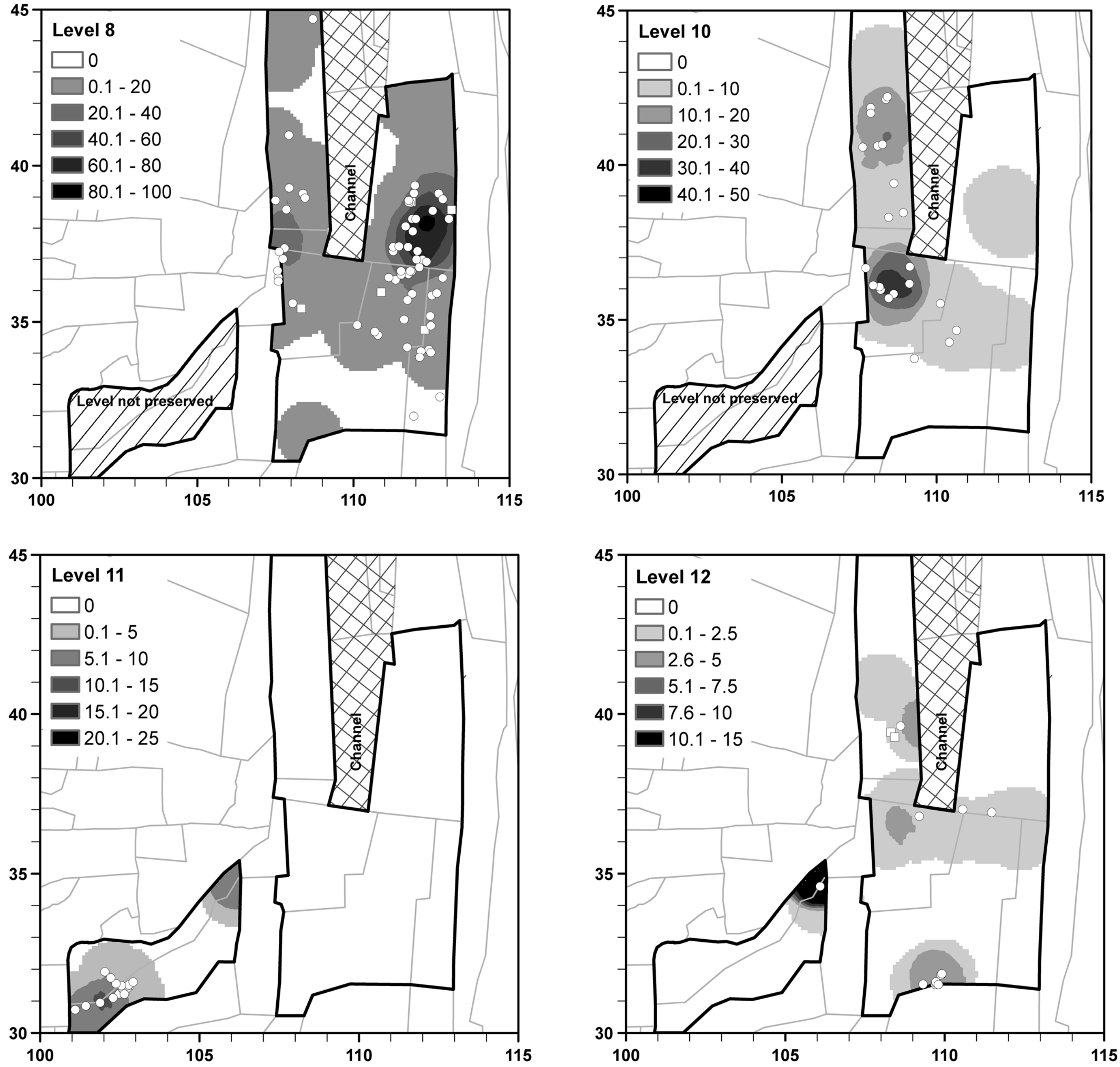

Figure 7 - Distributions of finds (shaded: Density map of bones, o: lithic material, squares: manuports).

the bones of the Yabroudian layers. As in the old collection of Hummal Ib, the offset and transversal scrapers make up one-third of the tools. In the layers 8 to 12 they only appear as a small percentage (~20%, n=6). As the overall number of pieces is very low, the materiel is not sufficiently representative.

The differences in the distribution of the finds over the several layers can be explained easily. The western part of layers 8, 9 and 10 was disturbed by several influences. Hence only a few objects were collected in 1999, without being measured as they were not in situ. As excavations went on in 2000 the objects of layers 11 and 12 appeared in situ and accordingly were measured individually. In the eastern part of the Yabroudian complex, the material from all layers was found in situ. It was only in two strips along the channel (fig. 7) that no objects were found. These areas result from the construction of the channel in the 1950s, which was used for the irrigation of extended cultivation.

The most interesting feature in the distribution of finds occurs in layer 11. Whereas in the western part of the excavations many objects (n=137) were found, in contrast, in the eastern section of layer 11 no objects were discovered at all. There are two plausible reasons for this. On the one hand, it is possible that only the western part was used in Paleolithic times. On the other hand, it is conceivable that the material was dislocated from its original position and moved to another position. The second option is supported by the fact that in layer 11 a pedogenesis took place, but no former surface is conserved (Meyer 2000).

Orientation of the finds

The orientation of the finds was measured by way of trial according to the system proposed by McPherron (2005). In this method two points are taken per each artefact; one at the distal and one at the proximal end of the find. The orientation of the objects can then be calculated with a simple calculation in a Microsoft Excel spreadsheet. The idea of recording the orientation was that it is a simple approach to describe the circumstances of discovery of the finds in an easy and accurate way. These results were then compared with the values of slope and aspect of the relevant layers. The goal of this comparison was to determine, if there is, in the Yabroudian layers, a correlation between a possible movement (erosion, draw-down, sliding, etc.) reflected by the orientation of artefacts and bones.

The definition of the orientation of finds (fig. 8) and of the layers is as follows:
- bearing: horizontal orientation of the object going from 0 degrees (due north) to 180 degrees (due south);
- plunge: vertical orientation of the object going from 0 degrees (horizontal) to 90 degrees (vertical);
- slope: horizontal orientation of the layer:
  000°: orientation towards north
  090°: orientation towards east
  180°: orientation towards south
  270°: orientation towards west
- aspect: vertical angel of the layer
  00°: layer is horizontal
  90°: layer is vertical

With these definitions and the data from Hummal, it is now possible to compare the orientation of objects with the orientation of the layers (fig. 9). The mean value of the horizontal orientation of the objects (fig. 9, bearing) shows that most of the objects are oriented towards the east (layer 8) or northeast. In contrast to this, the aspects of the layers show an orientation towards the southeast. The second observation is the relatively high variability in the orientation of artefacts in all layers. As there is no alignment visible in the layers, a normal distribution of the artefacts can be assumed.

On the other hand the finds from all layers plunge down. Most remarkable is that all objects are orientated more steeply than the slope of layers. For this phenomenon, only one explanation can be proposed so far: The objects were originally deposited with a certain tilt and later moved by erosion or the action of flowing of water. In layer 12 particularly the influence of water is not that absurd. In this layer geological and micromorphological analysis demonstrated the presence of a shoreline in that area (Meyer 2000).

For a more detailed interpretation of the described phenomenon, it is necessary to have a look at the distribution of the bearings and plunges of the finds (figs. 10 and 11). The majority of finds in layer 10 have an orientation between 0 and 75 degrees, while in Layer 8 no preferential direction of the objects is visible. In Layer 12 there are only 10 objects, which do not allow an interpretation of orientations. The rise in the middle shows clearly that the objects of layer 10 are orientated towards

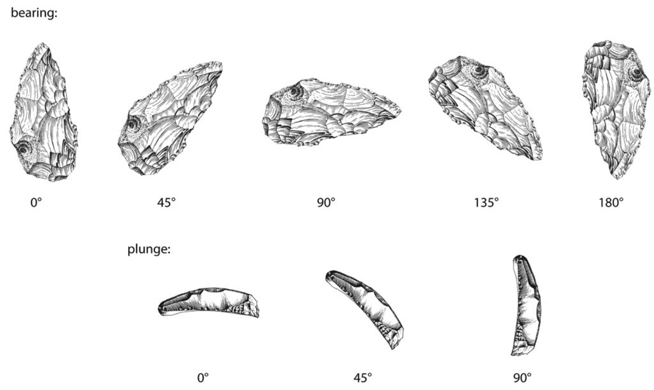

Figure 8 - Explanation of orientation of finds (drawings: J.-M. LeTensorer).

Layer	8		10		12	
n	144		137		14	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Bearing (objects)	92.73	53.22	79.55	54.99	78.32	53.51
Plunge (objects)	8.26	8.66	10.82	10.78	19.89	21.98
Aspect (layer)	147.1		150.3		173.9	
Slope (layer)	9.5		11.3		19.4	

Figure 9 - Table showing the orientation of layers and objects.

northeast by trend, but the distribution of finds (fig. 7) shows that all finds come from the same area. If we take layer 8 as a reference, we can guess that the objects from layer 10 will show the same variability in their horizontal orientation. It is necessary therefore to excavate the area east of the channel to obtain more materiel for a better database.

The next step is the comparison of the plunges in the different Yabroudian layers (fig. 11). The rises show that most of the objects have a vertical tilt of between 0 and 15 degrees. This means that almost all artefacts were lying nearly horizontal or parallel to the layer itself, so the theory of a major influence of water in layer 12 has to be rejected.

Conclusions

The construction of a topographical model of Hummal (Central Syria) is an important project complementary to the excavation. The data used for the present paper are basically topographical points recorded during the field work. First of all, several datasets recorded for different purposes during several field seasons had to be merged into a comprehensive database.

The first result in the modelling process with the Kringing algorithm was not satisfactory because of low angled profile planes and computational artefacts resulting in aberrant structures in the northern part of the excavation, where data points are mis-

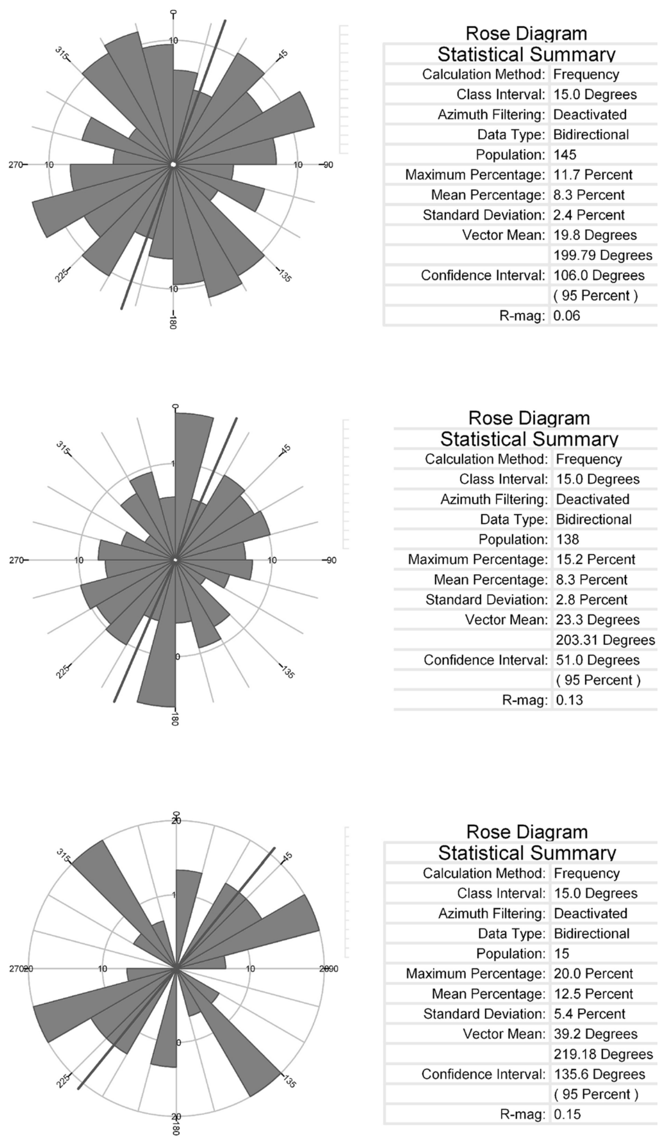

Figure 10 - Distribution of bearings within the yabroudian material.

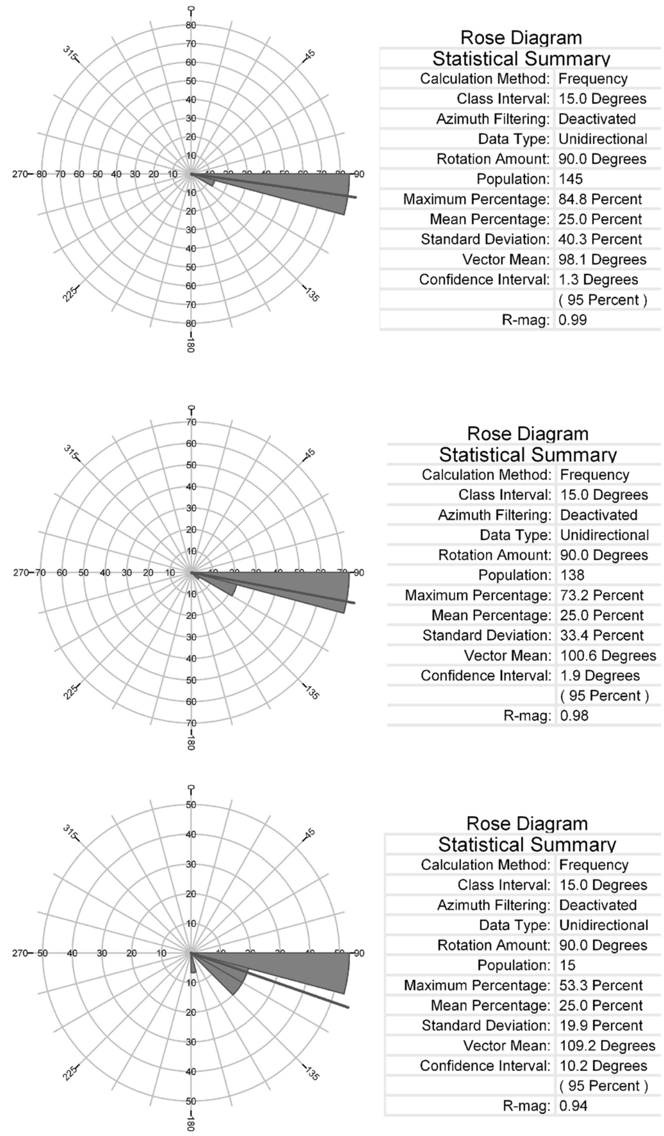

Figure 11 - Plunges of the yabroudian finds within the several layers.

sing to some extent. Furthermore this first model produced an insufficient visualisation.

For the second model a minimum curvature algorithm was used. With this algorithm it was possible to use fault lines defining breaks in the surface for the planes of profiles. With the help of this tool it was possible to rectify the aspect of the profiles. The quadratic structures in the northern part were removed by using the highest possible tension of the boundaries. Evaluating the second reconstruction, some cuts into or some conical structures in front of the profiles were recognised. This happened if a point at the foot of a profile was not directly located beneath the upper line of the same profile (i.e. when the profile was slightly caning). In this case the lower points were arbitrarily moved up to about 20 cm. For the modelling process of a whole excavation area like Hummal, such a minimal adjustment induced no deformations in the model.

The second important issue was the reconstruction of the layers. The foundations of this process are the geological profiles. For the reconstruction of the geometry of the layers, as well as the archaeological levels, again the minimum curvature algorithm was applied. On this base, a synthetic section along a north-south axis was constructed, with the aim of comparig the two Mousterian complexes in the western and southern sectors of the site. A direct correlation is hampered by a huge intrusion of an ancient well shaft. The interpretation of this cross-sectioncut showed that it is not possible to compare the two sections with this approach alone. However, the cross-section cut revealed an interesting phenomenon: all the layers in the Mousterian sections of Hummal are bending towards a centre located in between the two sections. This unnatural bending can be seen in hydrological changes of the water table, rising or falling naturally or artificially, particularly through excessive water extraction by pumping in the past few decades.

Another issue was the analysis of the orientation of the archaeological finds in the Yabroudian layers. Therefore a method of measuring this was applied, recording two points per object (McPherron 2005). With these data it is possible to calculate the horizontal and vertical orientation of the objects. As the number of artefacts and the extent of the excavated surfaces are limited, it is difficult to demonstrate precise taphonomic processes. However, the small samples are a very good example for testing new approaches describing the archaeological surfaces.

With the actually existing data it is possible to elaborate a good 3D model with a limited effort in a rather short time. The software applied (AutoCAD and TachyCAD) and procedures adopted to record the data in the field and for the modelling process (Surfer 9) are highly efficient. For the reconstruction of the topography of layers, it is necessary to collect more data during forthcoming field seasons in order to create more precise models, and thus to describe the geometry of the layers with better accuracy.

References

Besançon J., Sanlaville P., Muhesen S., Hours F., Copeland L. (1981) - Le Paléolithique d'El Kowm. Rapport préliminaire. *Paléorient* 7(1):33-55.

Bordes F. (1955) - Le Paleolithique inferieur et moyen de Jabrud (Syrie) et la question du Pre-Aurignacien. *L'Anthropologie* 59:486-509.

Cauvin J., Cauvin M.-C., Stordeur D. (1979) - Recherches prehistoriques à El Kowm (Syrie) - Première campagne 1978. *Cahiers de l'Euphrate* 2:80-117.

Copeland L. & Hours F. (1983) - Le Yabroudien d'El Kowm (Syrie) et sa place dans le Paléolithique du Levant. *Paléorient* 9(1):21-37.

Ismail-Meyer K. (2009) - Reconstruction of some Site Formation Processes of Hummal (Syria). *Frankfurter geowissenschaftliche Arbeiten*. (Serie D, Physische Geographie) 0,45-58.

Le Tensorer J.-M. (2005) - Le Yabroudien et la transition du Paléolithique ancien au paléolithique moyen en Syrie: l'exemple d'El Kowm. *Munibe, Anthropologia-Arkeologica* 57(2):71-82.

Le Tensorer J-M. (2006) - Les Cultures paléolithiques de la steppe syrienne: l'exemple d'El Kowm. *Annales Archéologiques Arabes Syriennes* 42:43-61.

Le Tensorer J.-M., von Falkenstein V., Le Tensorer H., Muhesen S. (2011) - Hummal: a very long Paleolithic sequence in the steppe of central Syria – considerations on Lower Paleolithic and the beginning of Middle Paleolithic. In: J.-M. Le Tensorer, R. Jagher, M. Otte (eds.), *The Lower and Middle Palaeolithic in the Middle East and Neighbouring Regions*. Liège, ERAUL 126:235-248.

McPherron S.J.P. (2005) - Artifact orientations and site formation processes from total station proveniences. *Journal of Archaeological Science* 32(7):1003-1014.

Meyer K. (2000) - *Mikromorpholgische Untersuchungen an Ablagerungen der artesischen Quelle Hummal, Syrien*. Unpublished Diploma Thesis, Basel, Seminar für Ur- und Frühgeschichte.

Smith W.H.F. & Wessel P. (1990) - Gridding with continuous curvature splines in tension. *Geophysics* 55(3):293-305.