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► **To cite this version:**

Anabel Ortiz Lopez, Bérénice Chamel. Taphonomic agents in the formation of mortuary deposits : excavation methods and treatment of human bones at the pre-pottery neolithic sites of Bal'as and Tell Halula (Syria). Broadening Horizons 3, 3rd Conference of Young Researchers Working in the Ancient Near-East, Jul 2010, Barcelone, Spain. pp.41-56. <halshs-00828701>

HAL Id: halshs-00828701

<https://shs.hal.science/halshs-00828701v1>

Submitted on 31 May 2013

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Taphonomic agents in the formation of mortuary deposits: excavation methods and treatment of human bones at the pre-pottery neolithic sites of Bal'as and Tell Halula (Syria)

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Abstract

Many archaeologists and anthropologists who work in the Near-East are confronted with taphonomic agents induced by environmental characteristics; the specific physical and chemical agents of this particular environment, as well as human activity has modified not only the human remains but also the structure of the burials. These taphonomic processes must be understood because they determine the final image of the funerary deposits at the moment of the excavation.

We describe here the methods of excavation and treatment of human remains applied to two sets of human skeletal remains from two different archaeological sites with different characteristics of deposition and therefore different requirements during and post excavation.

The site of Balas, located in the interior of Syria, yielded a small number of human remains from the Khiamian period. They are all covered by calcareous encrustations. The protocol introduced here enabled these encrustations to be removed. The remains were bathed in diluted acetic acid, thereby causing minimal damage to the bones.

Tell Halula is an archaeological site corresponding to one of the earliest large villages of sedentary farming communities (8700-6500 BP). It is situated in the Middle Euphrates Valley (Syria) and a large number of burials have been discovered within the site. Diagenetic factors as well as the kind of rituals specific to the site called for specific protocols to be set up and implemented during the excavation and treatment of the remains.

1. Introduction

When a mortuary deposit is excavated in an archaeological site, the archaeologist or anthropologist finds a static picture of the human remains. To understand the circumstances which might have led to that picture, it is necessary to take account of the fact that the formation of the deposits or burials of human remains is the result of a dynamic process, of a taphonomical history (Nilsson 2003; Duda, Sellier 1990; Duda et al. 1990)

Many archaeologists, anthropologists and archaeozoologists are confronted by the taphonomic processes which act on the artefacts and on the bones. The recognition and consideration of these phenomena both in the field and subsequently in the laboratory can help us to avoid some mistakes in interpreting the story behind the burials.

We present here strategies of excavation and treatment of human remains applied to two different sets of anthropological remains from Syria. The first discovered in the Khiamian (10th millennium cal. BC) – middle PPNB (8th millennium cal. BC) site of Balas is characterised by the very poor state of preservation of the bones, which are covered by calcareous encrustations. The second, the ‘sitting’ burials from the middle PPNB site of Tell Halula (8th millennium cal. BC), comes from typically dry conditions of steppe environments, and is a very particular kind of mortuary deposit.

Both the environmental characteristics and the specific physical and chemical agents of each of these contexts involved the intervention of specific diagenetic factors. These factors act on the preservation of the bones, change their appearance and in some cases can make the interpretation of the funeral deposit very difficult. Intrinsic and extrinsic factors¹ in the post-depositional processes have to be understood in order to suggest a proper interpretation and to extract as much information as possible from the human remains (Quintana, Alesan 2003).

The strategies we describe here can help the anthropologists and archaeologists who work in the Near-East to have a better understanding of the deposits both during excavation, and later in the laboratory when the encrustations on bones is removed in order to have access to their original surface.

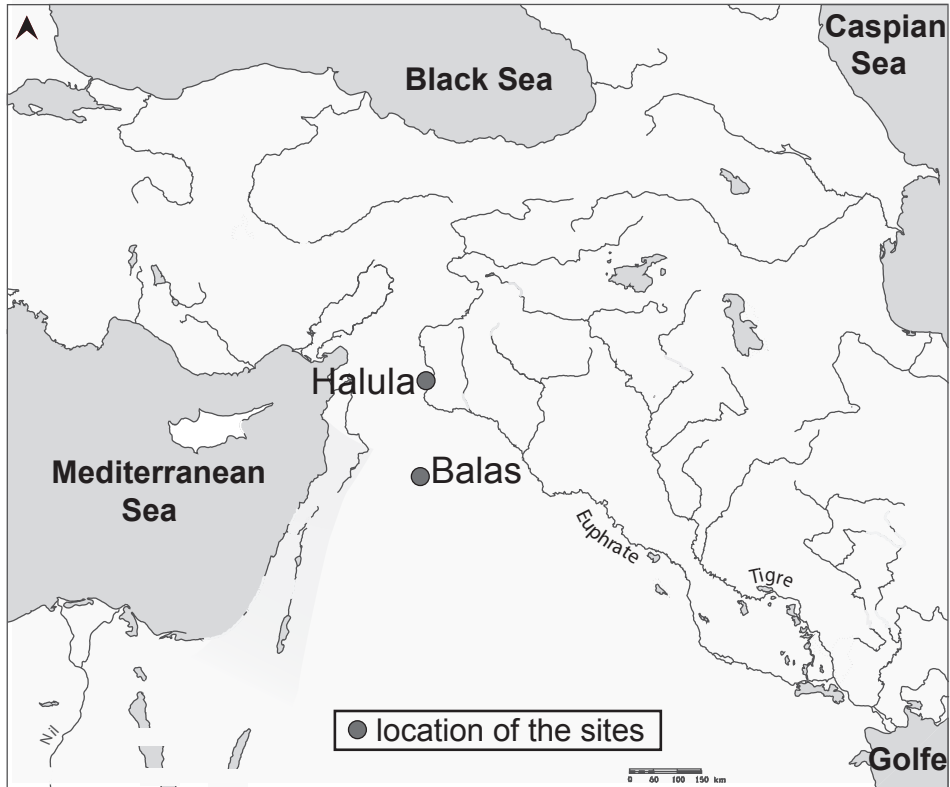
2. The balas massif: Experimental protocol for removing calcareous encrustations

2.1. Archaeological and anthropological context

The first collection of human remains used in this study comes from the massif of Balas. It is set in the interior of Syria, near the town of Salamiyeh (fig. 1). Several sites

1. Intrinsic factors depend on the nature of the bone and on the complexity of the skeletal structure. Extrinsic factors can be environmental or human. (Quintana, Alesan 2003, 18)

Figure 1: Map of Syria with the location of the two sites mentioned in the text



from the Khiamian and middle PPNB periods have been discovered recently during the arid margin prospection program² (Jaubert, Geyer 2006).

The human bones come from two sites of the massif of Balas, Wadi Tumbaq 1 and Jarette Gazella, from the 2006 and 2007 excavation campaigns directed by Frederic Abbès (CNRS, UMR 5133, Archéorient). The site of Wadi Tumbaq 1, dated to the Khiamian period (10th millennium) is set on an artificial terrace in front of a cave. The houses discovered here are round. The site of Jarette Gazella is dated from the middle PPNB (8th millennium) and has both rectangular and round houses (Abbès 2008; Chamel 2008).

The bones recovered were scattered on the floor of the houses without any visible funerary context and no formal burials have been discovered up to the present time.

2. The research program named «*Les marges arides*» from the Maison de l’Orient et de la Méditerranée (Lyon, France) is directed by B. Geyer. The goal is to analyse the relation between humans and environment in an area with multiple strains.

Ten bone fragments came from the terrace of Wadi Tumbaq 1, and 78 from the two sectors of Jarette Gazella. There is a MNI of 2 individuals from Wadi Tumbaq 1, and 4 individuals from the site of Jarette Gazella (Chamel 2008). All the bones are in a very bad state of preservation, and the anatomical elements of the skeletons are not all present. They have suffered considerable damage from their taphonomic situation, making age and sex estimation very difficult.

2.2. Taphonomical context

All the bones from the two sites studied are covered with calcareous encrustations, which prevent all anthropological research and even identification of the bones. Calcareous deposits on bones and teeth happen in warm environments with limited rainfall (Stahl, Brinker 1991), such as the Near-East. There are a lot of other examples in the world, either in cave environments (Natufian sites, Bocquentin 2003), or in open air sites such as Khirokitia (7th millennium, F. Le Mort personal communication).

The encrustation process starts in the vadose³ zone, above the ground water. In a warm environment the moisture in the ground is not sufficient to flush the salts from the sedimentary matrix. The soluble salts of calcium-carbonate derived from the sediments and transported by the water are therefore precipitated on the surface of the bones, covering them with calcareous encrustations (Lyman 1994).

2.3. The experiments

It was decided to remove the calcareous encrustations from the bones in order to reveal their surfaces; indeed, the main aim of this work was to have access to the information on the surface of the bones, such as taphonomical damage, research into discrete traits age and sex estimation and pathological observation.

Although several other authors have been confronted with this problem, there are few publications about the exact protocol for removing calcareous encrustations from the surface of bones with minimum damage to the outer surface of the bone. A literature search showed that the best way to remove the encrustations from the surface of the bones without mechanical scraping is to dip the bones in a solution of acetic acid with demineralised water (Stahl, Brinker 1991; Price et al. 1992). Nevertheless, the use of acetic acid is often described as quite dangerous both for the person who performs the experiments and for the bones, because although the action of the acid dissolves the inorganic salts such as the calcium of the calcareous encrustations, it can also dissolve the calcium present in the bones (Price et al. 1992; Lambert et al. 1990).

However, several protocols published recently propose the use of a very concentrated acid solution for dipping bones which have been exposed for a long time

3. The vadose zone is the portion of earth between the land surface and the phreatic zone or zone of saturation.

(Nielsen-Marsh, Hedges 2000). With some adjustments to this method, a protocol had been set up by us with the help of experimentation.

The method proposed here helps to remove calcareous encrustations from the human bones. The experimental protocol was conducted in 2007-2008 as part of a master's dissertation in the University of Bordeaux 1. All the steps described here were performed in a chemistry laboratory, and must be modified to match the reality in the field. During the experiments the operator took some precautions such as the use of an extractor hood, gloves, glasses and white coat.

In order to conduct the adapted protocol to the Balas bones, the first objective was to determine the encrustation stage on the bones. Four stages have been recognised and the concentration of acid in the bath is adapted to the rate of encrustation (table 1). In order to determine the average weight of the encrustation in the sites of Balas, each bone was weighed before and after cleaning. Before dipping the bones in the acetic acid solution, it is important to wash the bones with water to remove all the dirt which might otherwise disturb the cleaning action of the acid preparation.

Table 1: Table presenting the different encrustation rates of the bones from Balas

Stage 0	no encrustations
Stage 1	partial encrustations (not covering the whole bone)
Stage 2	thin layer of encrustation (smaller than 0,5 mm)
Stage 3	thick layer of encrustation (superior to 0,5 mm)

The first experiment tested different concentrations of acid and demineralised water on non-archaeological bones, as well as different lengths of exposure time. All the changes that occurred during this first experiment have been noted. This first experiment emphasises the fact that the concentration of acid in the water needs to be very carefully measured in order not to damage the bones. Strict time control is very important too, since even a low concentration of acetic acid will damage the bones if the exposure is too long.

2.4. The protocol

Thanks to several stages of experimentation on eight non-archaeological bones (from the Bordeaux 1 University collection), using variations of acid concentration and length of exposure, it may be said that a concentration of 10% of acetic acid and 90% of demineralised water seems not to be dangerous to the outer surface of the bone. However, it must be kept in mind that non-archaeological bone is not as fragile as archaeological

bone, and it is true that the reaction of the bones to the acid treatment depends on the former state of preservation of the bone (Nielsen-Marsh, Hedges 2000).

Several baths are necessary to remove all the encrustation, especially for bones with a high rate of encrustation (stage three means an encrustation layer of 0.5 mm). Sometimes the bath needs to be changed because the precipitation of the soluble salts on the bones seems to happen in several stages, for example if some dirt is under the first layer of encrustation it will prevent the acetic acid solution from cleaning the bones. Three baths are necessary to remove all the encrustations when the bone is completely covered. For bones with light encrustations, one or two baths are sufficient.

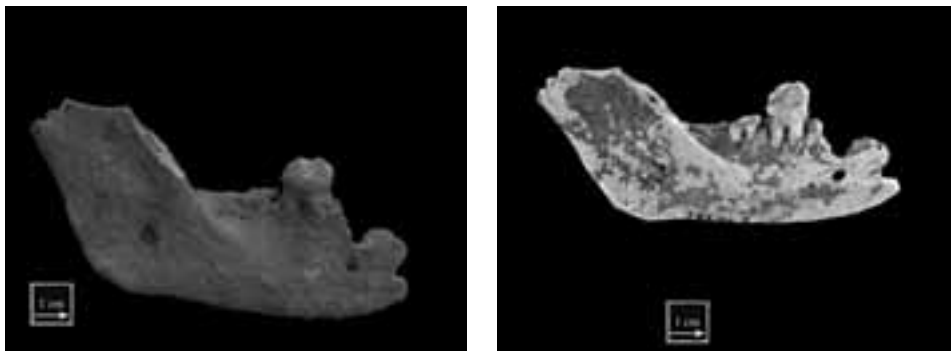
After the cleaning process, all the bones which have been dipped in the acetic acid solution need to be rinsed very carefully, because the acid can stay in the bone and continue to attack it. The best way to avoid this is to leave the bone in fresh water for a whole day, and then to test the water with litmus paper to see if the pH of the water in which the bones soaking is equal to the pH of the water from the tap. The use of a pH meter is also appropriate because the results are more accurate.

The bones are weighed after cleaning and the result shows that the average weight of encrustation in Balas is 35 % of the total weight of the bone.

This method for removing calcareous encrustations from the surface of bones enables all the usual anthropological studies to be carried out on the bones, such as dimensions, age and sex estimation, paleopathological features and investigation of discrete traits (the search for epigenetic variants on the bones).

After cleaning, we can also see that nearly all of these bones showed some taphonomic damage. There is some weathering on the bones, which in this case are desiccation striations, cracks and exfoliation of the surface. One bone from Wadi Tumbaq 1 shows some traces of rodent scratching, and several other bones from the same site show some evidence of root etching (Lyman 1994). Without cleaning the bones, none of these studies could have been undertaken (fig. 2).

Figure 2: Part of a mandible from the Jarette Gazella site covered by calcareous incrustation (left); the same mandible after the cleaning protocol (right)



2.5. Limitations of the process

One of the first questions asked is about any restrictions with regard to further analysis of the bones following the cleaning process. Radiocarbon dating can be undertaken after a treatment with acetic acid because the carbon from the acid will combine and leave in a gaseous form during the dating protocol (Oberlin, personal communication). In the case of human bones from the Near-East, it seems that the collagen of the bones is very often damaged due to the environmental conditions and in such cases it is very difficult to date them.

Stable isotope analysis can also be performed on the bones which have been washed with a diluted solution of acetic acid; in fact, in some protocols for preparing bones for stable isotope analysis, acetic acid and acetone have been used to wash the diagenetic alteration from the bones in order to avoid contamination (Moore et al. 1989). The most important limitation concerns organic remains or residues which might be still present on the bones (cf. Tell Halula). In this case, the chemical removing of calcareous encrustations from the outer surface of the bones might also remove the organic residues.

It is important, therefore, to be very clear before beginning the treatment what the purpose of the research on the bones is. It is a good idea to leave a sample of bones untreated and reserved them for future analysis. After the acid treatment, the bones can be strengthened with a preservative. Finally, for future research it is very important to keep a record of the treatment of each sample including the concentration of acid related to demineralised water, as well as the time of exposure and the number of baths.

3. Field anthropology at Tell Halula: problems and reflections about the taphonomical process in the formation of burials

The Neolithic settlement of Tell Halula is located in the middle Euphrates valley, in a zone of contact between several natural ecosystems (semi-arid steppe, low mountains and the riverside) (fig. 1) and its occupation during Prehistory covers a chronological sequence from the 8th millennium to 6th millennium cal BC. From its first occupation, tell Halula was one of the earliest large villages of sedentary farming communities in the Near East (Molist 2007).

Since 1991, a research project developed by the UAB, directed by Miquel Molist and a team of several archaeologists, anthropologists and different specialists has developed at tell Halula. The main objective of the project is to provide new data about and interpretations of the way of life of the Neolithic people from the site but also to increase our understanding of the process of neolithisation and the consolidation of the first farming communities in the Near East.⁴

4. The Spanish Project of Tell Halula archaeological site has been made possible through the help and collaboration of the General Directorate of Antiquities and Museums (DGAM) of Syria, the IPHE of Spanish

Broad horizontal excavations have enabled new insights to be gained into how space was organised by the inhabitants of Tell Halula and how they disposed of their dead. Excavations have documented a succession of at least 14 different occupational events corresponding to the MPPNB occupation period of the site, largely defined by the construction/destruction of rectangular residential buildings made of mud brick (Guerrero et al. 2009). The residential buildings were placed in the same location throughout the period and follow a standardised plan and a regular construction method. During the early Neolithic in Tell Halula it was common practice to bury the dead in close proximity to the domestic space. Typically the burials are individual inhumations in pits, always placed inside the houses. The location of the burials is a significant feature. They have a very regular distribution, always being placed under the floor of the main room of the house, the majority of them located in the anterior area (Anfruns, Molist 1996; Molist 2007; Guerrero et al. 2008).

The presence of burials in all the domestic units in the different occupational phases excavated is noteworthy and is an extraordinary instance of regularity in sepulchral practices at an early period.

The particularities of the funerary ritual, the specific context and environmental characteristics of the site make the burials from tell Halula an important and valuable data set.

During the 80-90s a new sub-discipline emerged in France called “anthropologie de terrain” or “archaeoethanatology” in which the main goal was to reconstruct the attitudes of ancient populations towards death (Duday, Sellier, 1990; Duday et al. 1990; Duday 2009). This discipline involves the study of the human skeleton and the analysis of the acts linked to the management and treatment of the corpse (Duday 2009, 6). A focus is therefore placed on developing methods that will allow the anthropologist to obtain a thorough understanding of the taphonomical processes of the burials. The sub-discipline uses archaeological data as well as ethnoarchaeology and forensic taphonomy to create a reference corpus not only of the different types of burial but also of the taphonomical phenomena experienced by the burials. These are inferred from observation of the state of articulation, the movement and rotation of the bones, and wall or compression effects (Duday et al. 1990; Duday 2009; Nilsson 2003; 2005). The main goal is to reconstruct the ritual context in which the burial was carried out (Mirjana 2005, 100). In order to apply these ideas at Tell Halula (where the taphonomic analysis is being undertaken) it is first necessary to understand the specific characteristics of these burials and how and to what degree they have conditioned the formation process.

Ministerio de Cultura and Ministerio de Ciencia y Innovaci on (HAR2010-18612). Finally the *SAPPO* research group is supported by the Universitat Aut noma of Barcelona and the Generalitat de Catalunya (SGR-2009-00607).

3.1. The position of the body inside the grave

As noted above, it is a characteristic of the funerary rituals at tell Halula that the dead are buried in graves dug directly under the floor. In most instances, the burial pits were created in a similar way, with vertical sides, reverse funnel morphology and concave or rectilinear walls. The pits were sealed with a compact mud plug (Guerrero et al. 2009). Bodies were deposited individually inside the inhumation pit and in most cases followed a specific and unusual pattern of burial. In most of the graves, the individuals were buried in a sitting position and in a tight hyper-flexed position, with angles of flexion generally near zero degrees. Although the position of the arms is more variable it is common to find the arms located between the thorax and the lower extremities.

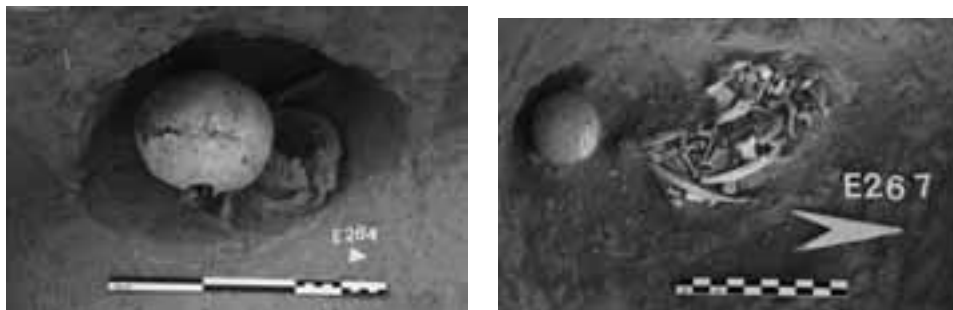
The gravity effect

The sitting position in which individuals at Tell Halula were placed introduces many specific dynamics to the process of decomposition and the resulting spatial distribution of the bones and the artefacts in the grave (Nilsson 2003). The high position and the superimposition of the different anatomical parts of the body along with the hyper-flexion and the sitting position all cause an increase in the potential instability and collapse of the bones as the body decays.

The effect of gravity in these circumstances becomes a very important variable that needs to be taken into account when interpreting the funerary practices, making the automatic application of the “anthropologie du terrain” unsuitable.

However, not all the graves in tell Halula are equally well preserved. Another group of burials involve a set of disarticulated or semi-articulated bones at the bottom of the grave. In some cases the possible original position of the individual can be envisaged because the skull is above the other bones and because of the verticality of the

Figure 3: Two burials of two children recovered from the same house. Note that the skeleton in burial 4HE264 (see label in photo) is articulated (left) while skeletal remains from burial 4HE267 are disarticulated (right).



long bones. In others cases it seems that other taphonomic events have taken place. These are currently being analysed.

As well as and related to the position of the body there is another factor to consider. Objects placed on the upper part of the body will, during the process of decay, come into an imbalance situation caused by taphonomic processes, and fall into the secondary empty spaces thus created. This results in significant displacement of the objects because they tend to fall to the bottom of the grave.

Documenting the graves

It has already been noted that the graves in Tell Halula are dug into the floors of the houses. This repeated pattern allows us to excavate some burials in section without losing any information relating to their archaeological context. The more usual horizontal method of excavation of the skeleton in a sitting position would not enable a complete record of the distribution of the different anatomical parts inside the grave to be carried out. This would make the observation of the state of articulation impossible because only the skull and the epiphysis of the long bones can be observed.

In order to document the distribution of the bones in the grave a very detailed level of observations in the field needs to be made, otherwise the super-imposition of the different anatomical parts that characterise burials from tell Halula would not provide anthropologists with a complete understanding of the skeleton. To this end a strategy was adopted of recording the different anatomical parts through the use of *decapages* during excavation. The result is a sequence of different cross-sections of the burial where all the anatomical parts and objects are documented.

Drawing is a useful tool for such recording and allows the anthropologist to observe the state of articulation and thus interpret the funerary ritual. In this way, the identification of the bones can be done on the field, as well as in the laboratory. This is particularly useful when the anthropologist is not in the field.

However, the plan of the burial alone is not sufficient to understand all the phenomena involved in the formation of each specific *decapage*, and it is necessary to collect all the archaeological and osteological observations that anthropologists make in the field. These are very useful for reconstructing not only the original anatomical position of the deceased but also the ritual involved, which would otherwise be unrecoverable. These include observation of the state of articulation of the bones which is one of the most important variables, together with a record of the anatomical aspect of the bones as they emerge. Descriptions about the sediment from the filling or surrounding the bones, the morphology of the pit burials, the presence of animal holes and biological disturbances observed at the time of excavation are also really useful for making a proper interpretation of the burial.

3.2. The preservation of clothing and vegetal fabric

The second most significant feature of the funerary record in tell Halula is the preservation of vegetable/plant fabric and clothing. These fabrics have survived until now due to the extremely dry state of the field, which caused the fibres to mineralise (Alfaro 2002).

This factor introduces a list of specific dynamics which occur during the process of decomposition of the body and the distribution of the human remains within the grave. From preliminary identification, it seems there are several kinds of vegetal tissues and different clothing technologies and plant fibres used.

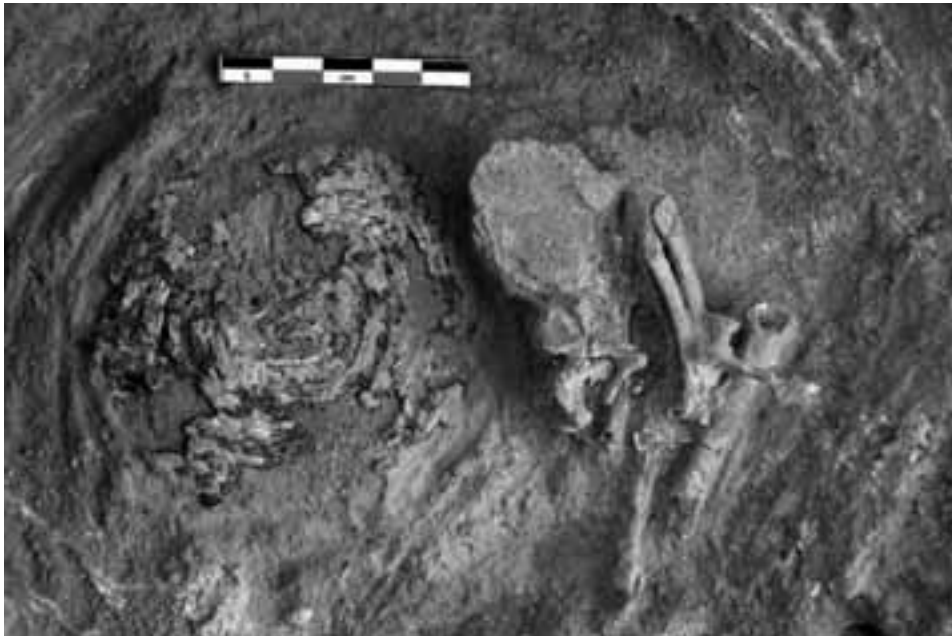
It has also been observed that the relationship between a burial and other tissues is not always the same. In some instances it is possible to find more than one kind of fabric within the same context, rug and linum being a common example.

In some cases, the fabrics surround the individual completely, in other cases only some anatomical parts. The fabric can be used as a mat on the bottom of the grave, or to covering the head or baskets which were used as containers.

There are also some indirect indications such as the “wall effect” or “compression effect” that inform about the existence of some perishable elements in the grave, such as containers which have not been preserved.

The composition of the fabric and clothing can determine the taphonomic history of the burial because they can modify or delay the order in the disarticulation of the

Figure 4: Basket remains documented at the bottom of the grave 4HE264



body, in that they act as restraints and fastening devices and so alter the process of decomposition of the body (Mirjana 2005)

Further burial excavations and specific analyses are presently being carried out in order to obtain a greater understanding about the function of the different clothing and their role in the funerary rituals.

These phenomena make it necessary to develop a meticulous record in the field. The anthropologist has to pay special attention to the order, composition, localisation and possible superposition of the different fabrics, as well as their relationship to the different anatomical parts.

Whenever possible it is best to excavate them in positive to obtain a better picture of their composition. However, this is not always possible and the excavation strategy has to be flexible and adapted to the characteristics of each burial. The delicacy of these remains requires quick action, exposing the remains to the environmental conditions for the least amount of time possible.

Extraction proceeds once the fabrics have been located, described and planned. The samples that are more interesting to save must be selected. It is important to take two samples of each kind of fabric in order to analyse both the botanical composition and the techniques used to make the clothing. It is also interesting to conserve the second sample for fuller observation.

3.3. State of preservation conditioned by the specific rituals and the effect of aridity

The last point to be raised is the preservation state of the burials. Excavation of the burials means the removal of the bones from the environment in which they have been preserved. In the specific case of Tell Halula, both the funerary ritual and the aridity of the environment make human remains a very fragile record. Some burials show different rates of the preservation from others, depending on the way the grave was filled, the position of the body and the age of the individual.

From the moment the burial is opened, the clock begins to tick for the recovery of potential information from the skeletal remains. The bones, which are extremely dry, start to break up quickly and the vertical position of the bones causes some fragments and bones in an imbalanced position to fall down causing further damage.

This situation can make some biological observations and other kinds of analyses difficult, such as the estimation of sex and age of the individuals, paleopathology and occupational markers, qualitative parameters, and overall, biometry. For this reason it is important to recover as much information as possible relating to the biological traits in the field (Quintana, Alesan 2003, 24)

3.4. Summary and future work at tell Halula

The proper interpretation of the funerary rituals depends on the strategy of excavation and the detailed recording of the graves and is the last step in the understanding of the taphonomical history of the burials which is a complex process in which there were several determining factors.

It is important to realise that the excavation of burials is a destructive practice in which any information which has not been recorded means the loss of one or level of detail which might have provided more information about the way of life of the pre-historic communities.

Taphonomical analyses are presently being developed at Tell Halula through the excavation of new burials in order to improve understanding of death and the life of the first settled farming societies in the Near East. This should also contribute more generally to the better understanding of the taphonomical process related to burials in a sitting position.

4. General considerations

For a long time, there were very few anthropological studies of neolithic human remains in the Near-East. But for several years now, an important community of researchers has decided to pay more attention to anthropological remains (Bocquentin 2003; 2006; Bocquentin, Bar-Yosef 2004; Moore, Molleson 2000; Stordeur, Khawam 2006).

However, published papers about taphonomical studies of human remains from the Near East are less common (Bocquentin 2003; Richter et al. 2010). Most anthropologists and archaeologists agree that taphonomical analysis has become necessary in order to obtain as much qualitative and also quantitative information from deposits of the human remains as possible. Indeed it is first necessary to understand the taphonomical processes specific to particular environments and contexts before undertaking the interpretation of biological and ritual information.

Although the methods described already exist, it was desired to adapt them to the Near-Eastern environment and specifically to the excavation and treatment of the human bones in different situations. The collaboration between the two sites: Bal'as and Tell Halula, is based on the need to share conclusions about the taphonomic processes which occur in the Near-East.

Acknowledgements

We would like to thank the two directors of the sites, Frederic Abbès for Balas and Miquel Molist for Tell Halula, along with the persons who made this study possible.

On the one hand, Claude Manigand, Maryelle Bessou and Pascal Murail from the Bordeaux laboratory for their help with the experimental protocol of Balas, and Françoise Le Mort for her daily assistance. On the other, all the archaeologists and anthropologists who have collaborated on the excavation and study of the burials through 20 years of excavations at tell Halula, without whom this paper would not have been possible, and specially Josep Anfruns for sharing his experience from many years working in Syria with me (Anabel Ortiz).

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