



The Technology of Skull Modelling in the Pre-Pottery Neolithic B (PPNB): Regional Variability, the Relation of Technology and Iconography and their Archaeological Implications

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The manufacturing techniques of two PPNB plastered skulls each from Jericho, Kfar HaHoresh and Beisamoun were studied by a series of different and complementary analyses. These revealed that all share a common general technological background, and yet marked intra-site details of fabrication can be identified. All appear to have been locally produced. Similar conclusions are reached on the basis of iconographic features. Thus, although the artisans shared general concepts of the objects to be created and their means of manufacture, strong site-specific traditions were displayed. This conclusion is further reinforced by recent information concerning plastered faces from Ain Ghazal, as well as the preliminary reports on skulls from Ramad. Accordingly it is suggested that, while broad pyrotechnological and ritual information was most likely disseminated by oral communication, the artisans producing the plastered skulls were locally based and working within the framework of powerful on-site traditions. © 2001 Academic Press

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Introduction

The 9th millennium BP Pre-Pottery Neolithic B (PPNB) period in the Levant represents a major transformation in prehistoric lifeways from small bands of mobile hunter-gatherers to large settled farming and herding villages in the Mediterranean zone, the process having been initiated some 2–3 millennia earlier. The impact of this substantial shift in socio-economies is clearly reflected in the archaeological record by larger sites, more permanent and solidly constructed architecture, and changes in the forms of chipped stone and other tools for use in daily activities. However, in addition to the more obvious economic effects of these significant developments were changes in community and social organization as reflected also in ritual spheres concerning both the living and the dead.

Considerable evidence for mortuary practices during the PPNB period have been described in recent years. Post-mortem skull removal, commonly restricted to the cranium, but on occasion including the mandible, and apparently following preliminary primary interments of the complete corpse, was a widespread and long-lasting practice throughout much of the Levant and southern Anatolia during the early Holocene (see [Bienert, 1992](#) for a general summary). The origins of the tradition can be traced to the 12–11th millennia BP during the Late Natufian of the south/central Levant and continued to be practiced during both the pre-pottery Neolithic A and B periods till at least the end of the 9th millennium BP, and sporadically thereafter till the 6th millennium. Such treatment has commonly been interpreted as representing rituals connected with veneration of the dead or some form of “ancestor worship”.

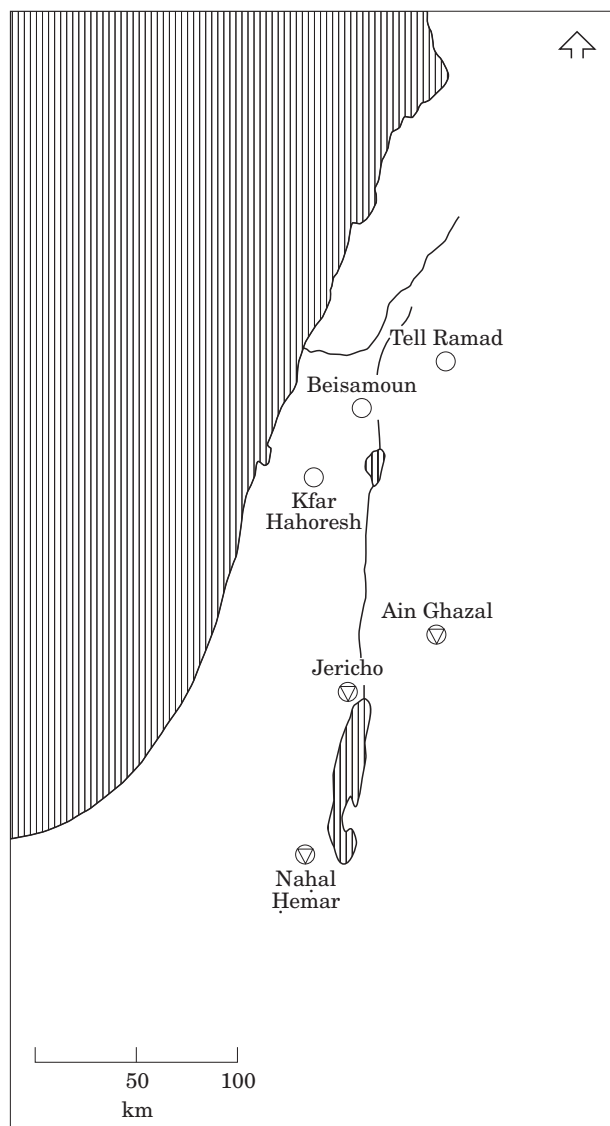


Figure 1. Location map of southern Levantine sites where PPNB modelled skulls were discovered.

Painted and/or modelled or otherwise modified human skulls represent a small sub-category of the above group, and have been reported to date from the central and southern Levant. In all reported instances the crania subjected to such treatment are of adults. Modelled human skulls from the early Neolithic of the Near East are among the most enigmatic of prehistoric artifacts. Specimens are known from several sites either in or immediately east of the Rift Valley (Figure 1), including Jericho (Kenyon, 1956; Kenyon & Holland, 1981: 305), Ain Ghazal (Simmons *et al.*, 1990; Butler, 1989), Beisamoun (Ferembach & Lechevallier, 1973), Nahal Hemar (Arensburg & Hershkovitz, 1988) and Tel Ramad (de Contenson, 1967, 1969, 1992). Recently, modelled skulls were discovered somewhat outside these geographical boundaries, at Kfar HaHoresh near Nazareth in the Lower Galilee

(Goring-Morris *et al.*, 1995a, b, 2000; Hershkovitz *et al.*, 1995).

While the retrieval and decoration of human crania from primary burial contexts has been documented in numerous ethnographic settings, the early Holocene specimens from the Levant are unique in their antiquity (comparable to them are only the modelled skulls of the Catacomb Culture of the northern Black Sea from the second half of the second millennium BC). They have consequently attracted scholarly attention from archaeologists and art historians alike since the initial discoveries by K. Kenyon at Jericho in the 1950s (Kenyon, 1956; Kenyon & Holland, 1981). While the practice of skull removal has been documented in the southern Levant earlier, skull modelling appears to have been restricted both geographically and temporally to the Levant (and perhaps Anatolia) during the PPNB, particularly during its middle and later phases (Bienert, 1991). This practice constitutes one of a suite of common material culture traits linking early Near Eastern agricultural societies in what has been termed the “PPNB Interaction Sphere” (Bar-Yosef & Belfer-Cohen, 1989) or “*koine*” (Cauvin, in Rollefson, 1990; Cauvin, 1994: 176–177), although the function of modelled skulls in the increasingly complex social and religious traditions of these groups remains hypothetical (Kuijt, 2000).

Previous authors have noted the diversity of techniques and styles employed in preparing and decorating the specimens recovered from caches at Jericho (Kenyon, 1956; Kenyon & Holland, 1981: 305; Goren & Segal, 1995), Ain Ghazal (Butler, 1989; Simmons *et al.*, 1990; Griffin, 1993; Griffin, Grissom & Rollefson, 1998), Beisamoun (Ferembach & Lechevallier, 1973), Nahal Hemar (Arensburg & Hershkovitz, 1988), Tel Ramad (de Contenson, 1967, 1969, 1992) and Kfar HaHoresh (Goring-Morris *et al.*, 1995a, b; Hershkovitz *et al.*, 1995). Excluding those from Nahal Hemar, all these skulls were covered by layers of what has been interpreted as lime plaster, in which the facial particulars were shaped. In the case of Tel Ramad, it has been suggested that the skulls were related to (or maybe even placed on) headless plaster statuettes/torsos (Cauvin, 1994: 154), but such evidence is as yet unknown from any other site. Our recent study of two of the Jericho skulls (Goren & Segal, 1995), revealed that in the materials used for modelling the face, burnt lime played only a marginal role, if any. The recent discovery of a well-preserved modelled skull at Kfar HaHoresh (Goring-Morris, 1991; Goring-Morris *et al.*, 1995a) provided a unique opportunity to employ powerful methods of non-invasive imaging in both the anthropological and technological analysis of the specimen. In order to examine and quantify previously inaccessible internal features, computed tomography (CT) and micro-focus radiography (MFR) were employed in assessing craniofacial morphology and reconstructing the process which produced the Kfar HaHoresh skull (Hershkovitz *et al.*,

1995, 1996). The apparent differences between the Jerich and Kfar HaHoresh skulls examined by us in terms of the materials in use and the overall modelling techniques, as well as the other diversities, motivated us to examine a number of specimens from several sites in order to investigate possible intra and inter-site variability. Accordingly three sites in different geographical zones were selected, from each of which two modelled skulls were examined technologically. The sites include Jericho in the Dead Sea Valley, Kfar HaHoresh in the Lower Galilee hill region and Beisamoun in the Huleh Valley.

Materials

Following are the details of the six modelled skulls chosen for the study (see also Tables 1–3):

A modelled skull from Jericho exhibited at the Ashmolean Museum, Oxford (reg. no. 1955-565, see Figure 2)

One of seven skulls discovered during Kenyon's excavations in Square D I, underneath a plastered surface (floor?) (Kenyon & Holland, 1981: 305). This is the only modelled skull of this series in which the eyes were modelled with cowrie shells (*Erosaria* sp.) rather than bivalve shells (Goren & Segal, 1995: Pl. 1). The modelled face of the skull has been seriously damaged over the course of time before excavation, retaining only the eye and nose infillings, the cheek casts and the artificial chin. As in most known modelled skulls, the mandible had been removed or perhaps remained in the burial in the process of the cranium removal. An artificial chin was reconstructed providing the face with a natural appearance so that the mouth, cheeks, eyes etc. appear approximately in their original locations. This stands in contrast with the Kfar HaHoresh specimens to be described below, in which features modelled in the vertical plane from chin to forehead were compacted by the absence of the mandible.

The outer surface of the plaster, in the few localities it was preserved, was probably coated with some pink pigment. This is hardly visible at present due to the conservation processes conducted during the 1950s including slaking the modelled part of the skull in polyvinyl acetate (PVA) and repairs of the cavities with pinkish wax. Yet this pigment was detected in our ICP-AES analyses of the outer plaster as iron oxides, probably ochre (Table 3, notice the high percentage of Fe₂O₃ in sample No. 50).

A modelled skull from Jericho, exhibited at the Rockefeller Museum, Jerusalem (reg. no. JPE 121.32)

This is another item from the above mentioned cache of seven skulls. In this case the eyes were modelled with bivalve shells. Traces of the red paint are clearly visible as well as a dark film of matter (resin?) which still coats

small patches of the bare bone. As in the previous skull, an artificial chin was modelled replacing the original mandible which was not included in the modelled artifact. This again enabled the creation of the modelled eyes in the original location of the skull's orbits without distorting the facial proportions. The eyes, each one of which is represented in this specimen by two fragments of bivalve shells, depict an open eyed image, as opposed to the closed eye illusion provided by the cowrie shells of the former specimen.

A modelled skull from Beisamoun, exhibited at the Israel Museum, Jerusalem

This is a relatively well preserved specimen from a cache of two modelled skulls (Lechevallier, 1978: 150–1, Fig. 47, Pl. XXXI:1 (left)), now deposited in the Israel Museum in Jerusalem. As opposed to the Kfar HaHoresh skulls and all but one of the skulls from Jericho, this specimen included the mandible. In the process of modelling, it was coated by a slab of plaster in the form of a horseshoe that was bound to the mandible and provided a realistic view to the modelled face.

The plaster mask that coats the facial bones of the skull differs in many details from those investigated at Jericho and Kfar HaHoresh. In contrast with the latter, it coats only the lower part of the face whereas the forehead remains exposed. The eye sockets were not infilled by any material but remained hollowed, their opening being narrowed to a slit by two patches of plaster, and thus providing a realistic image of a “nearly sleeping” face. A similar process was performed on the mouth in which the teeth were intentionally removed (Lechevallier, 1978: 180). In the front part of the mouth a cavity was left within the plaster coating with remains of vertical striations along its edges that probably represent the teeth. This creates the appearance of a “smiling” face with exposed teeth, similar to that of the stone masks from Nahal Hemar, and the mask from the Dayan collection said to have been found at Khirbet Duma in the southern Hebron Hills (Bar-Yosef & Alon, 1988: Pl. X–XI). The exterior surface of the plaster was coated with a reddish-brown pigment.

A modelled skull from Beisamoun, exhibited at the Prehistoric Museum in Kibbutz Ma'ayan Barukh (Figure 3)

A more fragmented specimen from the above mentioned cache, exhibited in the Prehistoric Museum of Kibbutz Ma'ayan Barukh in the Upper Galilee, Israel. The reconstruction of the plaster mask, which was very poorly preserved, is rather doubtful. However, it appears to be similar in most details to the other, better preserved item described above.

Table 1. Comparison of the modelling methods of the examined skulls and their inter-site and intra-site variability

Specimen attribute	Jericho, Ashmolean Museum	Jericho, Rockefeller Museum	Beisamoun, Israel Museum	Beisamoun, Ma'ayan Barukh	Kfar HaHoresh, Homo 1	Kfar HaHoresh, Homo 8
Bone surface modification and preparation for modelling	Infilling of the eye sockets, palatal arch and under the zygomatic process with a mixture of marl and sieved wadi sand.	Infilling of the eye sockets, palatal arch and under the zygomatic process with a mixture of marl and some burnt lime.	Removal of the teeth, attaching the mandible to the cranium and coating it and the maxilla with a slab of plaster in the form of horseshoe. Infilling of the nose cavity with lime mixed with some vegetal matter	Removal of the teeth(?). Attaching the mandible to the cranium and coating it. Infilling of the nose cavity with a mixture of clay, lime, powdered iron oxides and crushed calcite.	Removal of the incisors and canines from the maxilla. Coating of the nasolacrimal canal with bitumen, coating of the eye and nose cavities with a mixture of 1:1 lime to ash, infilling of the eye sockets, palatal arch and under the zygomatic process with a 2:1 lime to ash.	Unknown due to the fragmentary state of this specimen. Probably similar in general to KHH Homo 1, but with the use of pure lime plaster as the basal layer.
Chin representation	Shaping of an artificial mandible with a mixture of marl and sieved wadi sand.	Shaping of an artificial mandible with a mixture of marl and some burnt lime.	The original mandible is coated with a slab of plaster (as above).	As the Beisamoun skull from the Israel Museum.	The mandible is neither included nor reconstructed. The modelled face is compacted in the vertical plane from chin to forehead.	Most likely as KHH Homo 1.
Modelling of the facial outer surface	Coating of the cranium facial bones with a mixture of marl and some burnt lime.	Coating of the facial bones with a mixture of marl and some burnt lime.	Coating the mandible and the facial bones below the eye sockets with pure lime mixed with some vegetal matter.	Coating the mandible and the facial bones below the eye sockets with a mixture of clay, lime, powdered iron oxides and crushed calcite.	Modelling of the face with 5:1 mixture of lime and ash, by compacting the features from chin to forehead and raising them above their natural positions, due to the absence of the mandible.	Modelling of the face with almost pure lime, probably in a similar method to KHH Homo 1.
Eye representation	Cowry shells embedded in the plaster infilling the eye cavity.	Bivalve shell fragments embedded in the plaster infilling the eye cavity and partly covered with plaster "eyelids".	Opened cavities narrowed by plaster "eyelids".	As the Beisamoun skull from the Israel Museum.	"Coffee-bean eyes" created by the attachment of plaster "eyelids".	Most likely as KHH Homo 1.
Colouring	Probably similar to the Rockefeller Museum specimen, but uncertain due to bad preservation	Coating by a mixture of loam and iron minerals.	Iron minerals wash.	Mixing of powdered iron minerals and crushed calcite in the paste used for modelling the face, in order to obtain a reddish, glimmering material.	Iron minerals wash.	Coloured with cinnabar (vermilion, mercury sulfide) imported from Anatolia.

Table 2. List of the samples included in this study

Site	No.	Museum and Reg. No.	Description of the sampled part
Jericho	49	1955-565 (Ashmolean)	The inner plaster filling the zygomatic arches
	50		The outer plaster above the zygomatic arches.
	51		The artificial chin, representing the outer plaster.
	52		The infilling of the palatal arch.
	70	JPE 121.32 (Rockefeller)	The outer plaster underneath the chin.
	115		The inner plaster underneath the left zygomatic arch.
	116		Bituminous material coating the bone underneath the plaster.
Beisamoun	117	Ma'ayan Barukh Museum Israel Museum	Outer plaster from above the right zygomatic arch.
	95		The material composing the modelled face.
	118		Brown paint from the modelled face surface.
	119		Plaster layer of the left temple representing the entire section.
	120		The outer brown paint from the skull's base (best preserved).
K. Hahores	121	KHH Homo 1	Plaster from the skull's base (covering the palatal arch).
	26		The red pigment coating the modelled face.
	27		The outer plaster from the modelled chin.
	33		The soft inlay coating the eye cavity.
	34	KHH Homo 8	The dense plaster core infilling the eye socket.
	35		The outer plaster from the modelled chick.
	38		The soft inlay from the nasal cavity.
	122		The inner plaster layer from the modelled face.
	123		The outer plaster layer of the modelled face.
	124		The red pigment coating the modelled face.

Table 3. Results of the ICP-AES analyses (major components only, in weight % volume)*

No.	Museum No.	SiO ₂	Al ₂ O ₃	CaO	MgO	TiO ₂	P ₂ O ₅	SO ₃	Fe ₂ O ₃
50	1955-565 (A) (Jericho)	<i>14.41</i>	5.25	34.54	1.5	0.3	—	0.5	5.03
@		23.42	8.53	56.14	2.44	0.49	—	0.81	8.17
51	JPE 121.32 (Jericho)	<i>31.78</i>	5.3	26.11	1.26	0.44	1.11	0.71	1.7
		46.46	7.75	38.17	1.84	0.64	1.62	1.04	2.49
115		<i>6.19</i>	1.01	47.46	0.67	0.13	0.04	1.16	0.1
	117	10.9	1.78	83.61	1.18	0.23	0.07	2.04	0.18
		<i>9.03</i>	1.57	50.1	0.69	0.24	—	0.83	0.05
119	Israel Museum (Beisamoun)	14.44	2.51	80.15	1.10	0.38	—	1.33	0.08
		<i>1.30</i>	0.15	59.31	1.32	0.05	—	0.83	—
26	Homo 1 (Kfar HaHores)	2.05	0.23	93.45	2.1	0.08	—	1.3	—
		<i>28.60</i>	4.90	41.25	1.10	0.50	1.10	0.22	4.30
27	33	34.89	5.98	50.32	1.34	0.61	1.34	0.27	5.25
		<i>11.44</i>	0.87	56.61	0.62	0.10	6.90	0.28	0.46
		14.82	1.13	73.22	0.80	0.13	8.94	0.36	0.60
34	34	<i>31.26</i>	0.98	41.11	0.31	0.09	0.91	0.5	0.59
		41.27	1.29	54.27	0.41	0.12	1.20	0.66	0.78
		<i>22.3</i>	0.36	49.60	0.27	0.04	0.48	0.53	0.07
122	Homo 8 (Kfar HaHores)	30.28	0.49	67.35	0.37	0.05	0.65	0.72	0.10
		<i>2.67</i>	0.72	62.18	0.36	0.04	0.29	1.56	0.30
		3.92	1.05	91.28	0.53	0.06	0.42	2.29	0.44
123		<i>3.54</i>	1.14	61.23	0.33	0.07	0.43	1.55	0.43
		5.15	1.66	89.10	0.48	0.10	0.62	2.25	0.63

*Sample number: @ indicates a sample examined by SEM-EDS due to the small sample size.

Number in italics: measured value.

Bold numbers: values normalized to 100% after reduction of loss of ignition and undetected components (organic matter, CO₂ etc.).

A modelled skull from Kfar HaHores, exhibited at the Israel Museum, Jerusalem (Figure 4)

The skull marked as KNH-Homo 1 was discovered in a probable cache sandwiched between two plastered surfaces and in association with a headless gazelle carcass (Goring-Morris *et al.*, 1995a, b; Hershkovitz

et al., 1995). The skull and plaster surfaces were excellently preserved, although minor deformation and compaction had been caused especially in the occipital region by the weight of the overlying sediments over the years. However, the plastered surfaces were almost completely intact, and only suffered minor distortion

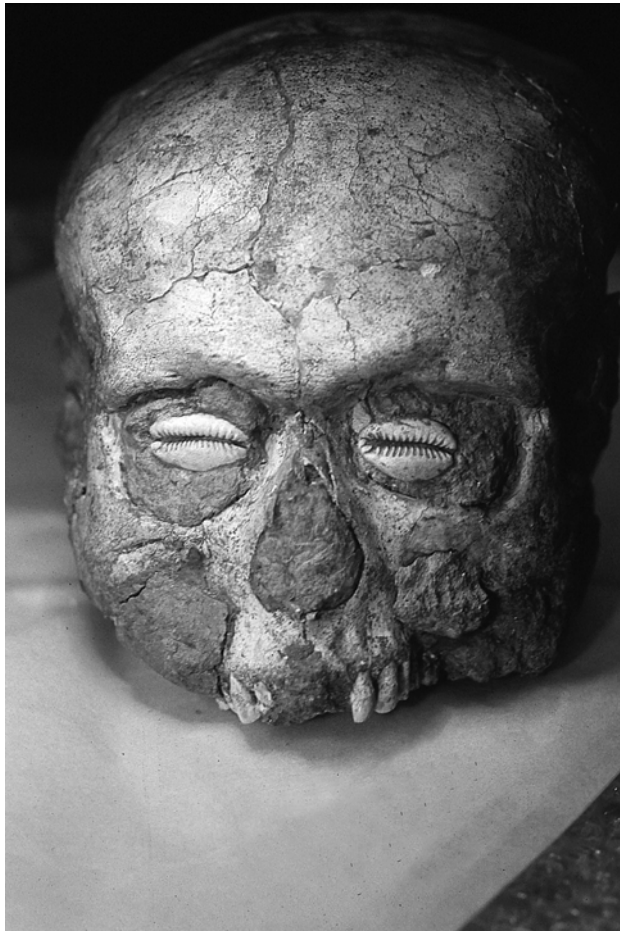


Figure 2. Modelled skull from Jericho, now at the Ashmolean Museum, Oxford. Photograph by Yuval Goren, courtesy the Ashmolean Museum.

(Goring Morris *et al.*, 1995a: Figures 8–10). The skull, comprising only the cranium, is of an adult male, some 25 years old. Facial features, including the nose, mouth, chin, eyes and cheeks (but not the ears) had been modelled. The resulting visage provided by the modelled features is of a squat and overly pronounced brachycephalic individual, particularly when viewed from a frontal perspective. This, of course, was necessitated by the features being modelled in the vertical plane from chin to forehead being compacted by the absence of the mandible, and all features thus had to be raised above their natural positions—chin, nose, cheeks, and eyes. This is clearly illustrated by the CAT scan analysis (Hershkovitz *et al.*, 1995, 1996). By contrast the horizontal plane was more or less modelled to natural scale. The entire plastered surface was covered by a red wash, though there is no evidence that this ever extended over the exposed areas of the skull.

This skull is remarkably similar to the three modelled skulls from 'Ain Ghazal, as witnessed by their detailed examinations (Griffin, Grissom & Rollefson, 1998), in its iconography though details of the construction methods differ (see below).



Figure 3. Modelled skull from Beisamoun, now at the Prehistoric Museum of Kibbutz Ma'ayan Barukh. Photograph by Yuval Goren, courtesy the Ma'ayan Barukh Museum.

It is interesting to stress that the overall countenance of the modelled face changes markedly dependent upon the precise angle or perspective from which it is viewed. From a slightly raised and offset viewpoint the skull almost provides a Buddha-like image. Under the circumstances it seems unlikely that the overall visage was intended to (or indeed could) accurately portray the life-like image of the individual concerned, though the separate features, e.g. the cleft chin, aquiline nose, puffy cheeks and eyes may have been realistic facial details of the individual concerned.

A fragmented modelled skull from Kfar HaHoresh

A newly discovered, and previously unpublished specimen, registered as KHH Homo 8. This skull was discovered during the 1994 excavation season associated with a poorly preserved, stone-built small oval installation on a lime-plaster surface in a different area of the site. Due to proximity to the surface the skull was severely damaged by modern ploughing. However, several parts of the modelled face were reasonably

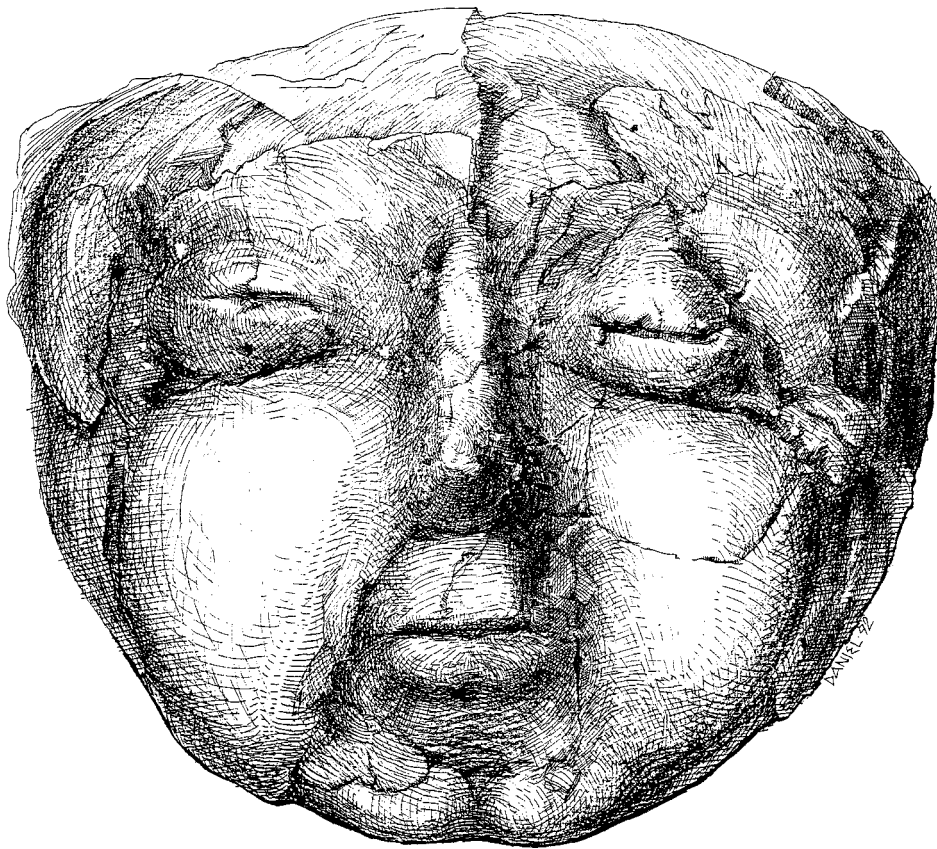


Figure 4. Modelled skull from Kfar HaHoresh (KHH-Homo 1).

preserved, including the left eyebrow, left cheek and the nose. These, together with some other fragments, enable an approximate reconstruction of the facial representation. It seems that stylistically, the modelled part of the skull is almost identical in most details to that of KHH Homo 1. However, the nose and the eyes are less pronounced and the coating colour is brighter red. From a close examination of the plaster fragments under a stereomicroscope it was clear that also in this skull the plaster had been applied in layers, as in Homo 1.

Methods

The distinction between ancient burnt lime and other calcareous materials is not an easy task. This results from one of the basic features of lime plaster, namely that the chemistry of the final product is similar to that of the primary raw material. During the process of lime production, calcium carbonate decomposes (at about 800°C and above) into calcium oxide (quicklime). Later hydration of the product with the addition of atmospheric CO₂ transforms it into lime (CaCO₃) which is chemically similar to the raw material (i.e. Wingate, 1985: 9). Since both limestone and lime plaster are

composed mainly of calcium carbonate (CaCO₃), the effectiveness of chemical analysis to differentiate between the two is low. However, the newly-formed calcium carbonate crystals are significantly smaller than the common calcite crystals forming most limestones, and their crystal structure is usually fibrous. Thus identification of burnt lime is possible with the aid of either an optical (petrographic) or a scanning electron microscope. In both methods, the examination should be performed at a wide range of magnifications. Low powered magnifications provide an overall view of the examined material, disclosing micromorphological features within it, such as the existence of microfossils, sand, grog or ash as well as post-depositional recrystallizations. By contrast, high powered magnifications are used for the distinction between burnt lime and unburned calcite crystals, and the identification of phenomena such as crystal ripening.

The optical microscope, although considered a low-powered technique, should be regarded in our opinion as the fundamental method for any other mineralogical and chemical examination. This is because it enables mineralogical and micromorphological examinations of larger samples and better identification of micromorphological features (Goren & Goldberg, 1991; Goren & Segal, 1995). Due to their congregated

nature, plaster products should be examined as blocks in which the integrity of the original matter is preserved, rather than as powdered samples or small sized grains. In this context the density of inclusions as compared to the matrix can be readily estimated, and evidence for incomplete or partial burning of the binding material can be identified due to typical abnormalities in the calcite crystals' interference colours, their crystal shape, and the partial structural distraction of foraminifers.

The technological examination of the modelled skulls consisted of the following stages:

- (1) The artifacts were subjected to low-powered, oblique illuminated stereomicroscopic examination. Due to the fragmentary state of preservation of most of these artifacts, their various units (layers and patches of applied material) could be observed and defined easily without using more elaborate techniques. In the case of the Kfar HaHoresh complete skull (KHH Homo 1) CAT-scans were taken of the modelled skull from several angles: frontal, anterior, posterior etc. (Hershkovitz *et al.*, 1995). The resulting CAT-scan images enabled us to define the various units of plaster coatings and infillings that made up the facial part of the skull. In the other skulls, the more fragmented state of preservation of their modelled faces, in such cases as they existed, enabled the characterization of such units with the aid of a stereomicroscope.
- (2) Small portions of each unit were removed using a stereomicroscope, a dental diamond saw and delicate spatulas and drills (a list of the samples is presented in Table 2). In most cases, small samples were removed by cutting or chipping a small fleck or fragment from a hidden part where coring would not cause any visible damage, or along previously exposed fracture edges. Samples for analytical methods that would not require bulk portions were drilled by a delicate dental drill or simply scraped with a tungsten carbide-tipped spatula after removal of the post-depositional encrustations. In the case of Kfar HaHoresh Homo 1, a naturally occurring break in the occipital part of the cranium was used for reaching its internal part. The orbital and nasal infillings were reached by cutting away small blocks of bone through the inner part of the skull, then drilling into the plaster core. This way, no visible damage was caused to the outer modelled plaster face. Samples of the facial plaster and red pigment were received from the conservator who restored the skull. This sampling procedure was performed, of course, in consideration of the museological value of these artifacts. Nevertheless, we insisted on obtaining samples that would be sufficient in size for a reasonable micromorphological examination, as in our opinion powdered

samples or tiny grains taken from a multiminerall aggregate may provide insufficient or even misleading results. Nevertheless no significant visible damage was caused to these artifacts.

- (3) The bulk plaster samples were subjected to Thin-Section Petrographic Analysis (TSPA), employing preparation methods advocated by Humphries (1992). The advantages of applying this method for a primary study of Neolithic plaster products were discussed in detail by Goren & Goldberg (1991). The thin-sections were prepared using about $0.5 \times 0.5 \times 1.0$ cm samples, the original organization and integrity of which was carefully recorded and preserved. The laboratory preparation for sliding consisted of gradual oven-drying in 60° centigrade in moderate vacuum conditions, impregnation with epoxy-resins, slicing and grinding, to prepare the thin sections. These were examined under a petrographic (polarizing) Zeiss Axiolab microscope, at magnifications ranging between $40\times$ and $1000\times$. Image analysing techniques were applied for examining the intensity, sphericity and sorting of the aplastic components, as well as the nature and volume of the matrix.
- (4) Chemical analyses were carried out on most samples using inductively coupled plasma atomic emission spectroscopy (ICP-AES). This method has considerable benefits, namely simultaneous multi-element quantitative analysis, high accuracy and low limits of detection. The major elements determined are listed in Table 3. The samples were ground in an agate mortar; 0.5 g of each was fused with 2 g of sodium peroxide at 530°C for 45 min, in a zirconium crucible. The flux was dissolved in water (~ 40 ml) and 25 ml hydrochloric acid (1:1). Two ml (250 mg/ml) Merk standard scandium solution was added as the internal standard, and diluted to 100 ml. The standard reference materials were prepared in a similar way. These were employed for checking the accuracy of the procedure. Sample solutions were analysed using a simultaneous ICP spectrometer. Precision for major elements was 0.005–0.34%, for traces: 0.4–0.95%.
- (5) In several cases scanning electron microscopy (SEM) energy dispersive X-ray spectrometry (EDS) analyses were made to smaller samples of plaster or pigments that were taken with consideration of the museological value of the artifacts. These were usually samples extracted from the frontal parts of the plaster inlays.
- (6) In order to positively identify the carbonate minerals and plant ash, Fourier-transform infrared (FTIR) spectrometry was applied for the examination of selected samples using a Midac portable spectrometer.
- (7) The identification of clay minerals was made by X-ray diffraction (XRD). The analysed samples

were powdered and immersed in diluted (3%) HCl in order to dissolve the calcite. The insoluble material was examined by a PW1710 diffractometer with a Cu tube anode in 35 kV, 40 mA.

- (8) Very thin layers of matter (namely the pigments) were also identified by non-destructive X-ray Fluorescence (XRF) analyses.

Results

The technological examinations of the six modelled skulls reveal a remarkable degree of inter-site variability in their construction methods and the materials used (Table 1). Technologically, the skulls are also characterized by considerable intra-site variability in their modelling methods and materials. Typologically, however, the amount of intra-site variability seems to be less pronounced than their inter-site variability. Following is a summary of the results, the raw chemical data is presented in Table 3.

The Jericho skulls

The analytical data concerning these artifacts indicates that two plastering mixtures were used simultaneously in the manufacture of the Jericho modelled skulls. The first one (henceforth the inner plaster) is indicated by nearly equal volumes (~40%–50% weight percent) of silica and carbonate (identified by FTIR as calcite), whereas the other (the outer plaster) is characterized by lower amounts of silica (~10%–20%) and higher amounts of calcite (~70%–80%). Another component which seems to be more dominant in inner than in the outer plaster is alumina (presumably representing the clay minerals identified by XRD, see below). These two materials appear together in the Ashmolean Museum skull (reg. no. 1955-565, see samples 49–52 in Table 2), as well as in many of the plaster statue fragments discovered at the site (Goren & Segal, 1995). The inner plaster is characterized by equal proportions of silica to calcite mixture, whereas the outer layers are composed of the more calcareous material (see samples 50–51 in Table 3). In the case of the modelled skull from the Rockefeller Museum (reg. no. JPE 121.32 3657) only the outer plaster material was observed in the analytical tests (Table 3), despite the fact that visual examinations suggested the existence of two layers. This was probably due to the fact that the same plastering material was applied in several successive construction layers in the form of patches or slabs.

Micromorphological examinations by TSPA shed some more light on the composition of these two materials. These are seen as follows:

The inner plaster material (Figure 5). The matrix is calcareous, silty (10%–20%) and loosely packed, displaying chamber structured voids. Concentrations of clay minerals appear as dots or lumps within the otherwise calcareous matrix. The silt is dominated by

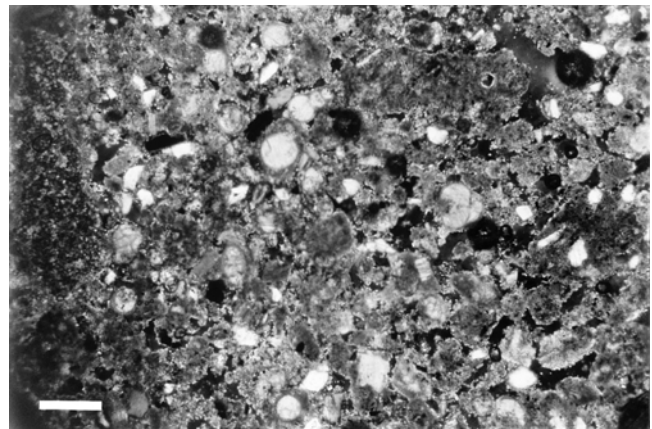


Figure 5. Jericho (sample 49), silty marl including foraminifers (the spherical bright bodies) and clay lumps (greyish spots in the matrix). $\times 100$, XPL. White bar length: 0.2 mm.

quartz but with the addition of many other detrital minerals, including: hornblende, zircon, feldspars (plagioclase and microcline), augite, tourmaline, epidote, mica and ore minerals. Foraminifers are extremely common as a major component within the matrix, usually infilled with monocrystalline, pure calcite. Although these constituents seem to be a natural part of the matrix (since it is very unlikely that single foraminifers and silt were mixed in the matrix intentionally by the artisan), none of them displays any sign of heating nor of mixing with burnt lime. This conclusion is reinforced by the presence of some “markers” that should have shown changes had they been subjected to prolonged heating to temperatures in excess of 800°C and above. First, the calcite crystals should have displayed evidence for partial decomposition and distortion of the shapes of the foraminifers or at least anomalous interference colours resulting from a partial twisting of their crystal structure. Secondly, the rather abundant hornblende grains within the silt fraction, that alter at 800°C into oxyhornblende (Deer *et al.*, 1982: 175), should have received the dark reddish colour rather than the green pleochroism which characterizes it in our samples. Thirdly, since the crystal structures of mica minerals are affected by heating, their interference colours ought to have changed from about 700°C and above. None of these criteria were observed in the material in question. Finally, calcareous clays tend to become isotropic at relatively low temperatures, starting at about 800°C (Tite *et al.*, 1982). Nevertheless, the matrix is highly birefringent. In conclusion, neither this mixture nor any part of it has ever undergone any recognizable changes resulting from exposure to heat. Neither were any evidence for mixing of burnt lime nor for heating the material itself identified in the thin-sections.

The temper or filler inclusions (sand sized components) include spherical chalk and limestone grains, angular grains of chert, single calcite crystals (sometimes twinned), larger fossils, fragments of charred

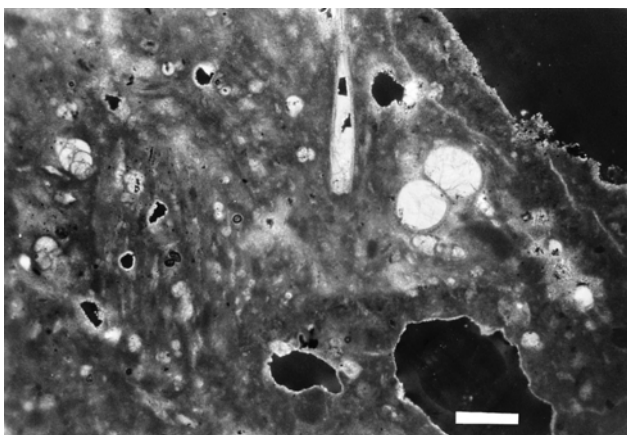


Figure 6. Jericho (sample 51), marl with the addition of some lime (unseen in this magnification). Foraminifers of various types appear as part of the matrix. $\times 100$, XPL. White bar length: 0.2 mm.

plant tissues, bone fragments and spherical, isotropic, apatite peloids.

The outer plaster material (Figure 6). It is characterized by very fine crystalline, compact matrix almost devoid of silt. Foraminifers infilled with pure monocrystalline calcite are extremely common in the matrix. Again, no evidence for full or partial decomposition and distortion of the shapes of the foraminifers resulting from heat is visible. Also appearing in the coarse fraction are some quartz grains, bone fragments and gypsum crystals. Limestone and flint grains appear but very sparsely. Examination of the matrix through high magnifications ($\times 400$ – $\times 1000$) reveals that burnt lime was probably mixed in it to some extent, presumably for providing a whiter shade to the marl. Nevertheless, most of the material is composed of unburned marl as in material group A, but without most of the aplastic components that appear in the latter.

In order to identify the mineralogy of the clay minerals two samples representing the two material groups were subjected to XRD. This analysis revealed the presence of kaolinite and illite.

The outer surface of both skulls was coated with brownish-red pigment (Figure 7). A similar phenomenon has been described in the case of another one of the Jericho modelled skulls, now deposited in the Ontario Museum, which was painted pink [using iron oxide], (Kingery, Vandiver & Pickett, 1988: 232). However, the latter was also painted with a black pigment (manganese-dioxide), which was not traced in the specimens examined by us. As opposed to the Kfar HaHoresh skull KHH Homo 1 (to be discussed below), in which a red ochre wash was applied to cover the modelled face, this pigment was composed of a mixture of iron minerals (probably hematite, identified by reflected light microscopy) and silty clay loam (Figure 7). This mixture was used for coating parts of the modelled face in a layer of about 0.3–0.4 mm thick.

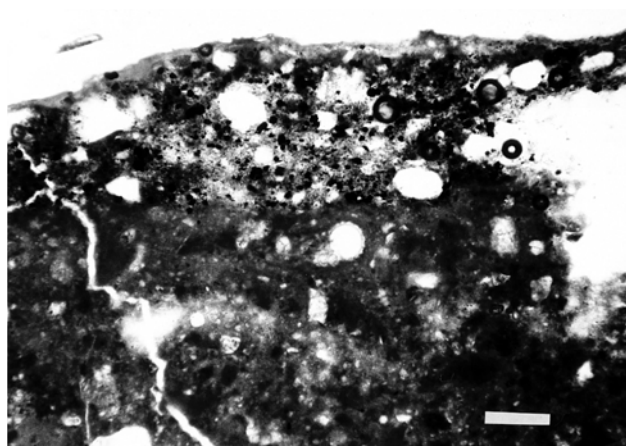


Figure 7. Jericho (sample 117), a cross section of the outer brownish-red paint coating the modelled face. The pigment is seen as a film of fine material in the upper part of the picture. Notice the iron minerals powder (black dots) that were mixed in the silty loam to provide the pigment material (compare it also to Figure 7). $\times 100$, PPL. White bar length: 0.2 mm.

The composition of the marl and the coarse fraction that accompanies it enable the identification of the origins of these materials. This combination suits well the Campanian-Mastrichtian lithostratigraphic section of the Judean Desert (Mt Scopus Group), which outcrops in close proximity to Jericho itself. This includes the calcareous Menuha and Ghareb Marls which also contain chalk layers, foraminifers and large fossils, and the Taqiya Formation which is also marly but contains clay minerals (in several layers montmorillonite and illite, in others kaolinite and illite) and gypsum horizons (Bentor, 1966: 72–73). Apatite concentrations, fish bones and chert are the main constituents of the upper phosphorite member of the Mishash Formation which is overlaid by the Ghareb Marl (Kolodny, 1967). One question that has to be resolved is related to the presence of the unstable heavy minerals in the silt fraction which is very atypical of the Judean Desert sediments. We assume that this silt, undoubtedly of aeolian origin, indicates that the mixture comprising the inner plaster material had been collected from colluvial sediments and not from the formation outcrops. This point still awaits further investigation.

In summary, the analytical data suggests that the Jericho modelled skulls were created of materials that were available in proximity to the site. The coarser mixture (inner plaster material), used for forming the core layers in one skull, was created of a silty marly loam with the addition of some local wadi sand as filler. The second, finer mixture (outer plaster material) included purer marl with lesser amounts of filler. It was this outer coat that was perhaps mixed with very small quantities of burnt lime in order to supply a whitish shade as well as more plasticity to the raw material and hardness to the final product. Nevertheless, as compared to other genuine lime plaster artifacts examined by us (such as the Kfar HaHoresh modelled skulls to

be discussed below), this unfired or slightly heated marl was crumbly and fragile. This was probably the reason for the bad state of preservation of most of the Jericho skulls despite the very dry and stable climate conditions of the Jericho area (and the Judean desert in general) which on other occasions led to the excellent preservation of other delicate and unstable materials. This contradicts, for example, the very good state of preservation of the sophisticated Kfar HaHoresh modelled skull KHH Homo 1 which was deposited in the much more humid conditions of the Galilee hills. The fragmentation of the other item (KHH Homo 8) was caused by modern ploughing, which is of course unrelated to the quality of its construction methods.

The Beisamoun skulls

As opposed to the Jericho skulls, the two Beisamoun skulls depict pronounced technical intra-site variability in their materials. This difference is most probably the reason for their different states of preservation, despite the fact that they were both deposited within the same pit (Lechevallier, 1978: 150). In the modelling materials, the following traits were observed.

The modelled skull from the Ma'ayan Barukh Museum.

As viewed under a stereomicroscope in a fractured plane of the plaster, only a single layer of material was utilized for constructing the modelled face. The material was immersed in glue of an unknown nature in the process of conservation. Therefore, it was examined only by TSPA. However, even this method alone supplied sufficient information for reconstructing the artisan's technique.

In thin-section the matrix is seen as an heterogeneous material including clay and burnt lime, ash, silt and opaque minerals. Within this groundmass, non-plastic inclusions are embedded, including mainly calcite crystals or their sparitic aggregates. The calcite crystals are clear, exhibit typical twinning and zoning features and split by their cleavage planes (Figure 8), indicating that they were intentionally crushed by the craftsman prior to their mixture in the paste. The admixture of crushed calcite in plaster in the PPNB has been recorded also in the case of the Nahal Hemar beads (Kingery, 1988; Goren, Segal & Bar-Yosef, 1993) and as a film coating wall plasters from Late Neolithic Tell Teo in the Huleh Valley and PPNB Wadi Ghwair in southern Jordan (as yet unpublished, we would like to thank Emmanuel Eisenberg and Mohammad Najjar for allowing us to examine the materials from their excavations and publish this information). Practically, the mixture of crushed calcite in the matrix does not have any technical benefit over the use of any other calcareous binder. The process of mining the mineral, usually from naturally-occurring veins in limestone, carefully crushing it and mixing it in the matrix was probably more elaborate and time-consuming than the use of more readily available

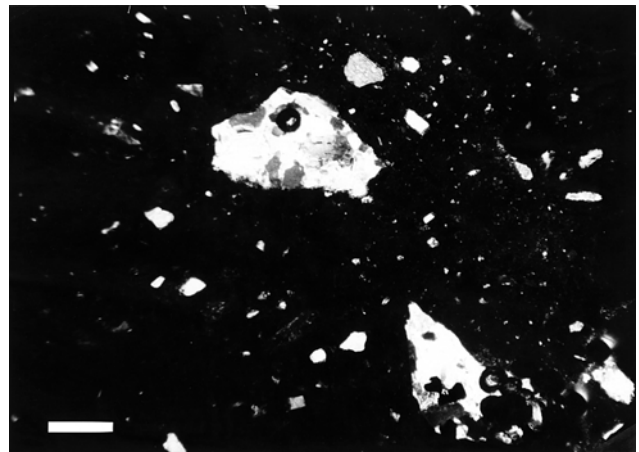


Figure 8. Beisamoun (sample 95), angular calcite crystals as an aplastic component (the matrix in this figure is darkened in order to highlight the calcite temper). $\times 40$, XPL. White bar length: 0.4 mm.

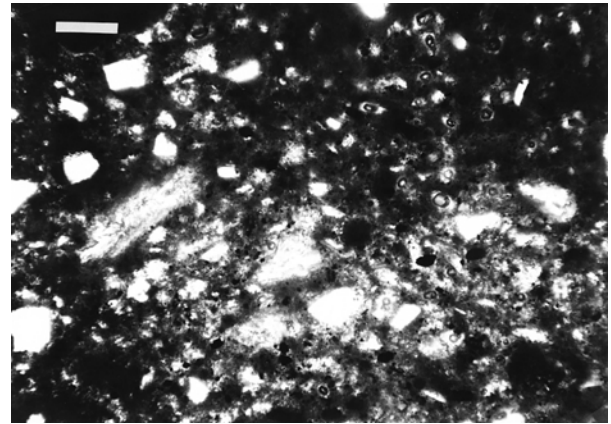


Figure 9. Beisamoun (sample 95), the matrix. Notice the powdered iron minerals, appearing as black dots. $\times 100$, PPL. White bar length: 0.2 mm.

sieved wadi sand. However, it may have been the glittering appearance that the calcite crystals provide when exposed to direct light that motivated this task. Thus, this technology was probably aimed at providing a lustrous material rather than supplying any technical advantage. The surface of the modelled skull was probably polished (with fine sand or ash) to burnish or buff the calcite crystals, thus amplifying the shine of the object.

Nevertheless, this effort created another problem. Any attempt to cover the outer surface of the modelled face with red or brown pigment, as attested in the other skulls examined here, would have covered this lustrous material. The creator of this skull circumvented the problem simply by mixing the pigment with the plaster (Figure 9), to achieve a somewhat less ruddy, but nevertheless lustrous surface. When examined in thin-section but under epi-illuminated (vertically reflected) light, the opaque minerals within the matrix are identified as hematite and "limonite" (ochre), appearing

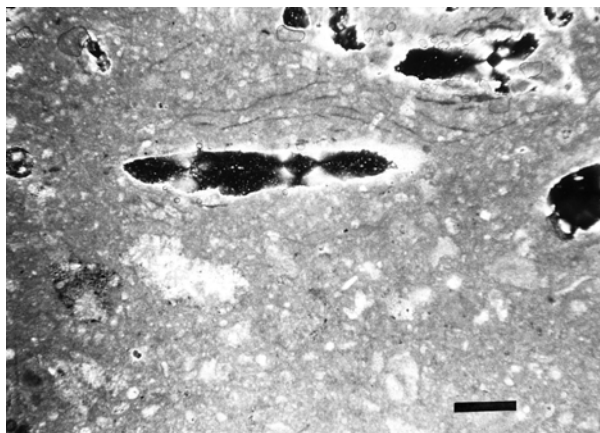


Figure 10. Beisamoun (sample 119), elongated voids, resulting from the disappearance of vegetal matter, in a matrix of burnt lime. $\times 100$, XPL. Bar length: 0.2 mm.

densely in the clay-lime matrix. Since this is the only specimen examined by us where crushed calcite is mixed in the matrix and the pigment does not coat the plaster but is mixed in it, we are confident that these two phenomena were related to each other for this reason. In conclusion, it seems that in the case of this skull, the modelling technique was intended primarily to create an aesthetic appearance but with little if any regard for the durability of the material. This was probably the reason for the extremely bad state of preservation of this object, as compared to the other modelled skull that was buried in the same pit.

The modelled skull from the Israel Museum. Close examination under a stereomicroscope disclosed that also here, only a single layer of plaster was applied. However, when drilled and sawed for sampling, this material proved to be extremely hard and dense. This was even more pronounced when compared to the friable nature of the plaster of the accompanying specimen from the same pit, discussed above.

Under the petrographic microscope (Figure 10), the plaster material appears as very dense and homogeneous burnt lime, with only several “ghosts” of decomposed foraminifers indicating a complete process of decalcination. In this material, sporadic elongated voids with a rounded tangential section appear, indicating the admixture of small quantities of vegetal matter (perhaps chopped straw). The chemical analysis (Table 3) also indicates a pure lime plaster. The analyses of the coating red pigment (Figure 11) verify that again, ferruginous stains were used. These are seen in the petrographic thin sections as a very thin (about 0.1 mm) film coating the outer surface.

The Kfar HaHoresh skulls

Due to the fragmentary state of preservation of KHH Homo 8, more detailed information was revealed from the well preserved specimen (KHH Homo 1). However,

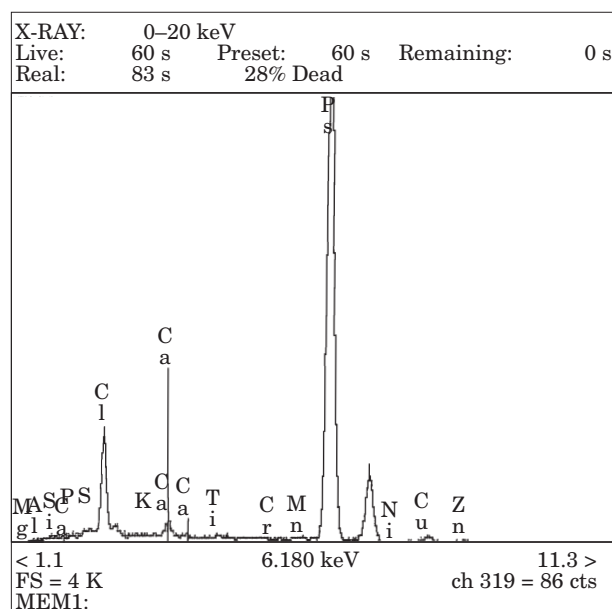


Figure 11. SEM spectrum of the red pigment from the Beisamoun skull of the Israel Museum. The highest peak is of iron minerals.

even the examination of the fragmented skull discloses some intriguing details about the unique treatment that was invested in each one of the examined objects.

Skull KHH-Homo 1. The CAT-scan images (Hershkovitz *et al.*, 1995) indicated the existence of three distinct plaster units. These were depicted in the CAT scans as different layers, representing various “densities” of material. These layers were sampled and examined both mineralogically and chemically.

The CAT scans of Homo 1 provided three different material “densities” (Hershkovitz *et al.*, 1995):

- (1) A relatively uncompacted, dark material coating the nasal cavities, the orbits and the cheek recesses.
- (2) A very dense, white material infilling the orbits, palatine process and the depression below the zygomatic processes.
- (3) A moderately dense material forming the outermost layer in which the facial details were modelled.

During the sampling process, the differences in the materials’ “density” were encountered as representing hardness. While layer 1 had a soft, almost powdery structure, layer 2 was extremely hard (hardly cut by a dental, diamond-tipped disc saw) and layer 3 was moderately hard. We were not able to obtain micro-hardness values since we had no access to adequate apparatus when the samples were extracted. This examination still awaits further research.

Micromorphological examinations of samples extracted from these three layers in KHH Homo 1 indicated that they were basically produced of similar

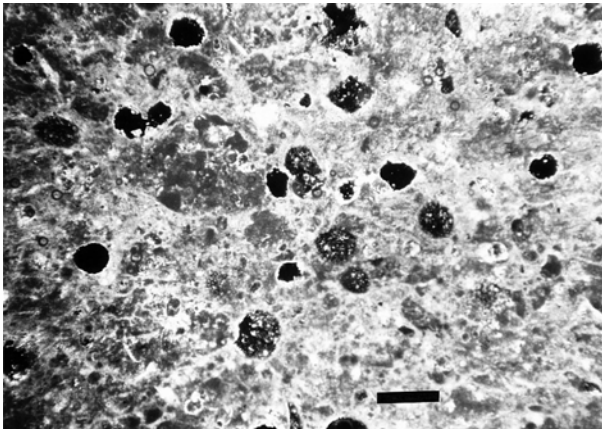
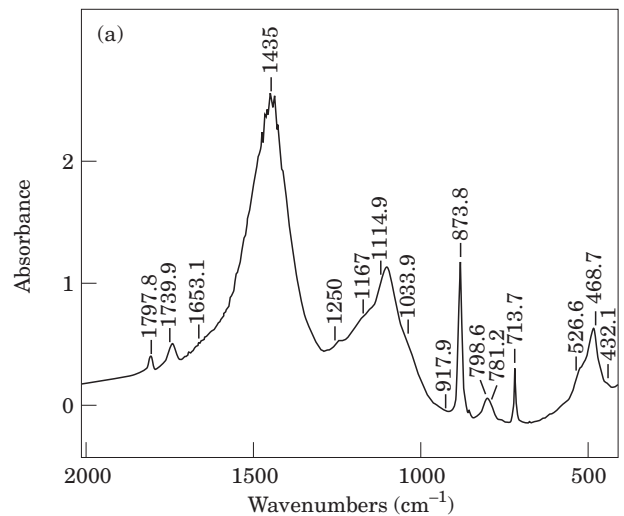


Figure 12. Kfar HaHoresh (sample 77), spherical voids of air bubbles in the lime matrix (black and grey spheres). Notice that some of the bubbles were infilled with chalcedony (dotted greyish material). $\times 100$, XPL. White bar length: 0.2 mm.

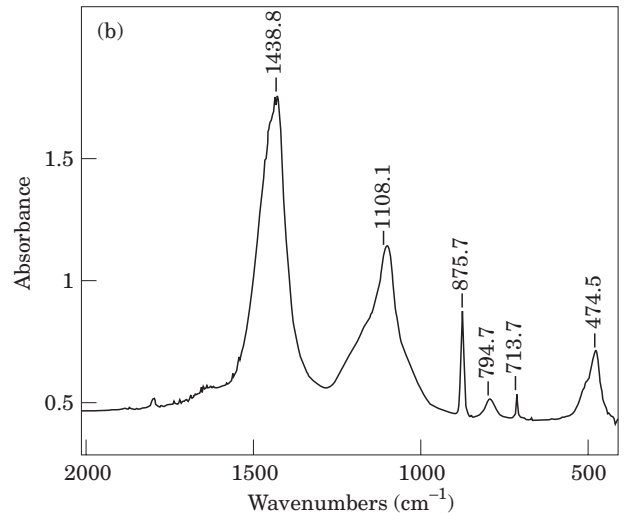
raw materials, in which burnt lime constituted the main component. However, the process of lime burning, as reflected in the thin sections, was not uniform. This was evident in the presence of partly decalcinated micro-fossils in the outer plaster (samples 27, 35) indicating that the original calcareous raw material was only partially converted into lime. Conversely, in the inner plasters foraminifers were either partly decomposed and scarce, or absent, indicating that the process of decalcination which completely demolished the structure of the limestone raw material had been successful. In addition to the burnt lime, other materials were added to form either a solid or a soft matter, as required. These are visible through TSPA as mostly amorphous, yellowish to pale brown bodies or layers, representing either herbal or chemically dissolved wood ashes in which the calcareous component was assimilated in the calcium carbonate matrix. Other post-depositional features are demonstrated by the neoformation of chalcedony within voids and bubbles (Figure 12), perhaps due to the dissolution of part of the silica and its secondary crystallization in voids as a result of water evaporation. These results agree with those of the chemical analyses (Table 3), which reveal that the two main components of the skull plasters are carbonate (CaO in the ICP-AES results, identified as CaCO_3 through FRIR) and silica (SiO_2). Since quartz is very stable and requires very particular chemical conditions for its solubility, it seems that opal, originating from plant phytoliths which formed a major component of the ashes, was the primary mineral in this process. Furthermore, since hardly any quartz silt or sand was identified in the petrographic thin-sections, we may assume that the silica is from the addition of ash to the paste and its secondary (post-depositional) alteration into chalcedony. In order to clarify this point, FTIR analysis of the plaster samples was carried out (Figure 13). The peak revealed at 1100 and the lack of splitting at 1170 indicate the presence of



KHHEYE
KHH skull eye plaster

Res = 4 cm^{-1}

02/21/94 14:00
Gain = 008



KHH-92-35

Kfar Ha Horesh plastered skull, outer plaster

Res = 4 cm^{-1}

10/26/93 12:12
Gain = 004

Figure 13. FTIR spectra of the plaster units of the Kfar HaHoresh skull KHH Homo 1. Top: plaster from the dense core in the eye socket. Bottom: outer plaster. Notice the peak at 1100 and the lack of splitting at 1170, indicating opal CT (and not quartz). The slightly split peak at 796 and the shoulder at 515 indicate wood ash.

opal CT. The slightly split peak at 796 and the shoulder at 515 indicate wood ash (Weiner, Schiegl & Bar-Yosef, 1995). Also in these analyses no quartz was detected.

Based on the chemical analyses, the quantities of lime in relation to ash (i.e. calcium, carbonate versus silica) in the different plaster layers of KHH Homo 1 vary radically from 5:1 in the outer plaster to about 1:1 in the inner layer coating the orbital and the nasal cavities (all the values mentioned here are in weight percent/volume, see Table 3). These phenomena lead us to two conclusions: (A). These plaster products were

constructed in several stages; (B). The varied mixtures were prepared intentionally.

The benefit of mixing silica (in the form of ash) in lime is in providing extra hardness of the product, due to the formation of a pozzuolanic reaction. This process, well-known to the Romans, was previously suggested to exist much earlier in the PPNB (Malinowski and Garfinkel, 1991). The degree of the pozzuolanic reaction varies with the proportions of lime and silica (Lea, 1956). In terms of hardness of the final product, it increases with the addition of silica to the lime to a certain point of equilibrium, after which it again decreases. The plaster units of the KHH Homo 1 skull provided different values of hardness because they were spread on different locations along this line.

The use of a mixture of burnt lime and ashes in Pre-Pottery Neolithic B plaster products was first reported by Balfet *et al.* (1969: 191) concerning "White Ware" vessels from Tell Ramad. It was suggested that a pozzuolanic reaction between lime and ash to form a hydrated silicate was used. This hypothesis was later negated by Kingery, Vandiver & Pickett (1988: 227), who re-examined some sherds of "White Ware" vessels from the same site and found neither evidence for the presence of calcium silicate gel nor in the data presented by Balfet and her colleagues (which was reinterpreted by them). Without taking any stand in the specifics of that debate, it is evident that at least in our case this technique was employed.

To sum up this section, we are reasonably convinced that ashes were intentionally mixed with burnt lime in variable amounts in order to achieve materials with different degrees of durability. The highest rates of ash (about 1:3 parts lime to 1 part ash) were used in the plaster layer which stuffed the nasal cavities, coated the orbits and filled the cheek recesses. This soft layer functioned as a bed for the purer (5:1), outer plaster. As suggested by Vitruvius (1960: 331), with respect to Roman "grey mortar" which had a similar structure, this basal layer was probably aimed at absorbing surplus water from the neighbouring plaster layers during compaction and curing. Nevertheless, from a purely technological point of view, in the case of plastering a small object such as a skull, the practice of such techniques seems to be highly sophisticated and even exaggerated. On the other hand, since dry bone is a rather porous substrate it absorbs moisture easily, a feature that may cause cracking of the finer paste in the process of dehydration. Perhaps this basal layer served to neutralize these "natural qualities" of the bone, enhancing the adherence of the plaster to the skull.

Another material which was detected in the mineralogical and chemical analyses was ferruginous ("limonite" or "ochre") which was applied in the production of the red paint (sample 26 in Table 3). Remains of magnesium oxide (1.1%) and titanium-dioxide (0.5%) in the outer plaster layer of our skull may indicate the use of other pigments, which might have been dispersed through time and are no longer

visible to the naked eye. As a consequence, the amounts of these two minerals gradually decrease towards the deeper plaster units (Table 3). On the other hand, these may also represent dispersed magnesite (MgCO_3) and anatase ($\alpha\text{-TiO}_2$), the former commonly replaces calcite, whereas the latter is commonly formed as a result of humus decomposition in sediments.

Traces of bitumen or another organic resin were detected by TSPA on the edges of the orbits. This material might have been used as a filler of the cavities through which the fresh plaster might have been drained, such as the nasolacrimal canal. The uses of bitumen in antiquity for funerary purposes and the origins of this raw material have been discussed by Connan *et al.* (1992). More specifically to this period, resin was used for decorating the Nahal Hemar skulls (Arensburg & Hershkovitz, 1988). A lump of bitumen was found at Kfar HaHoresh during the 1991 excavation season (Goring-Morris, 1991).

Based on the data outlined here, the plastering process of the skull from Kfar HaHoresh may be reconstructed as follows:

- (1) The sinuses and nasolacrimal canal were coated with bitumen in order to prevent plaster drainage into the skull cavity.
- (2) The nasal cavities, the orbits and the cheek recesses were coated with a mixture of about 1:3:1 lime to ash.
- (3) The orbits, palatine process and the depression below the zygomatic process were filled with a mixture of about 2 parts lime to 1 part ash which formed a denser and harder product. Some of this material drained when wet through the nasolacrimal canal into the skull cavity.
- (4) At this stage, the plastered face was modelled using a mixture of about 5 parts lime to 1 part ash. This paste was also used for shaping the eyes, the mouth and the nose.
- (5) Finally, the plastered face of the skull was painted with red ochre.

Skull KHH-Homo 8. In this case the fragmentary state of the modelled face enabled examination of its sections (as relatively fresh breaks) under a stereomicroscope. Here too, two superimposed plaster layers were observed. However, some of the plaster layers detected in Homo 1 were lacking, perhaps due to the only partial preservation of this specimen. Nonetheless, from the available technological data (to be discussed later) the two specimens differed in some details of their methods of construction. This stands in contrast to their typological identity, as evident by the preserved parts of this specimen.

In the plaster fragments preserved from KHH-Homo 8, only layers corresponding with A and C of KHH-Homo 1 were observed. This is due to the lack of the cranial parts in which material B might have appeared. However, in thin-section the material of

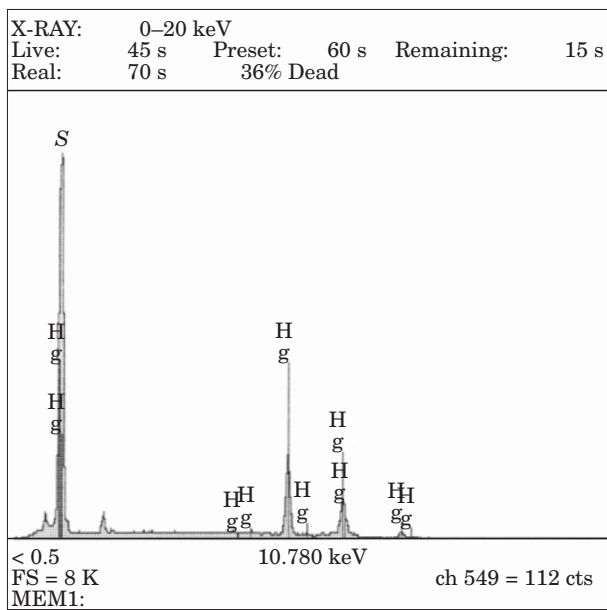


Figure 14. SEM spectrum of the outer pigment of the Kfar HaHoresh skull KHH Homo 8, indicating that cinnabar (HgS) was the colouring material.

these layers appears to be of a different nature than those of KHH-Homo 1. Features such as foraminifers, ash and recrystallized silica are lacking in both layers. The matrix appears as a homogenous, cryptocrystalline matter indicating the use of nearly pure lime. The chemical analysis supports this observation (Table 3, samples 122, 123). Thus it may be concluded that although this skull was modelled in layers that were let dry after each coating, only a single composition of paste was applied. The modelled face was thus constructed in two stages, but without using different mixtures of materials as in the case of the other specimen from this site.

However, the most outstanding result was obtained from the examination of the red pigment coating the modelled face of this skull. Here, both SEM-EDS (Figure 14) and XRD analyses have indicated that cinnabar (HgS, mercury sulphide) was used as pigment, and not iron minerals as in the other skulls examined here. This mineral pigment, also known as vermilion in ancient times, originates from hydrothermal deposits as veins or impregnations that are formed in volcanic zones. Closer examination by SEM of the colour reveal the existence of antimony inclusions that appear as crystals within the cinnabar matrix (Figure 15, Figure 16), together with lead traces. This mineral composition does not occur in the Levant. The closest source of cinnabar is in the Transcaucasus and in western Turkey (Ilani and Porat, 1993: 7), where it was known to be exploited in the Roman period by the people of Ephesos. The use of cinnabar for painting skulls has been recorded at Çatal Hüyük, in central Anatolia, during the Neolithic period (8th millennium

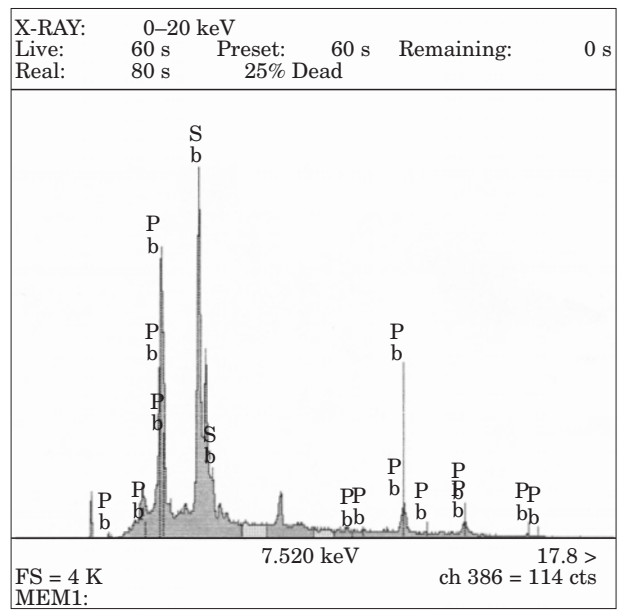


Figure 15. SEM spectrum of an inclusion, seen in Figure 16, within the outer plaster layer of the Kfar HaHoresh skull KHH Homo 8, indicating the presence of antimony (Sb) together with lead (Pb) as minor component.

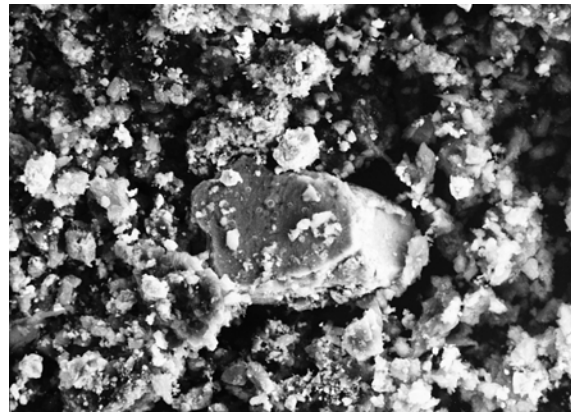


Figure 16. SEM view of an antimony crystal inclusion within the cinnabar matrix of the outer plaster layer of Kfar HaHoresh skull KHH Homo 8. Magnification: $\times 1100$.

BP) (Mellaart, 1967: 208). To our knowledge, this is the first clear indication found so far that links the somewhat later Anatolian tradition of skull decoration to the south Levantine one, though it should be noted that traces of cinnabar have been reported on a skull from PPNB Abu Hureyra on the Euphrates (Molleson, Comerford & Moore, 1992).

Discussion

The plastering of human skulls in the Near East can be seen as a direct development from, and an enhancement of the practice of post-mortem skull removal (Bienert, 1991). Skull removal first appears during the

Natufian (Belfer-Cohen, 1990: 305; Boyd, 1992), but becomes widespread during both the PPNA and PPNB, and is widely interpreted as representing an ancestor cult (Cauvin, 1994: 152–158). With the population explosion and advent of the first large-scale village societies in the Mediterranean Levant during the MPPNB major embellishments to ritual traditions occur. These take the form of occasional further treatment of skulls, including plaster modelling of the facial features (amongst others), as well as plaster busts and statues (Rollefson, 1998, and see there other references), and stone masks (Bar-Yosef & Alon, 1988: 23–24, Fig. 15, pl. 10, 1a–c; Bienert, 1990; Goren, Segal & Bar-Yosef, 1993). Additionally, the widespread practice of plastered floors and other surfaces (sometimes painted) also probably reflect more than purely mundane functions (Goren & Goldberg, 1991; Goring-Morris, 2000). It seems likely that these practices reflect more intensive symbolic and ritual behaviour, resulting from increasing scalar stress, with the emergence of some degree of differential access to resources, status and their transfer from one generation to another.

The plastered skulls recovered from the five sites that they are presently documented in the central Levant are all of young adults. Furthermore, there are some indications, still inconclusive, that they may all be males (Hershkovitz, pers. comm.). It is also possible that some skulls display specific morphological (brachycephalic) tendencies, perhaps resulting from *in vivo* skull deformation (Arensburg & Hershkovitz, 1989).

While the plastered skulls share several traits in common between sites, similarities in specific details are usually greatest within sites (Figure 17). Plastering is limited to the face, sides of the head and the base, but do not extend over the cranial vault, perhaps indicating that originally they were provided with a wig or some other form of head-covering (Griffin, Grissom & Rollefson, 1998; Goring-Morris, 2000). The Ramad skulls are unique in the modelling of the neck region, and indeed it has been suggested they may have originally been placed on plaster sculpted torsos (de Contenson, 1967, 1969, 1992; Griffin, Grissom & Rollefson, 1998). It seems unlikely that any plastered skulls were actually intended as life-like portrayals of the deceased, especially since many lack the mandible, resulting in an unrealistic, more markedly foreshortened, brachycephalic appearance. Modelling was thus usually accomplished without regard to the underlying bone structure, and features do not correspond to their correct anatomical positions. In only a single example, from Jericho, has the mandibular area been reconstructed in plaster (Kurth & Röhrer-Ertl, 1981: 436–438, Pl. IX: a,b). The single skull from Jericho with the mandible included (now in the Amman Museum), together with a poorly preserved plastered face from Ain Ghazal (Simmons *et al.*, 1990) are probably the most realistic depictions. Yet, for example, the cleft

chin on Homo 1 at Kfar HaHoresh may be a life-like detail.

Other specific anatomical features are often stylized to greater or lesser extent: chins are usually quite small and tend to be slightly pointed. Ears are sometimes, but not always indicated, and then usually in rather perfunctory fashion, as stubby appendages. As for eyes, the Jericho skulls (and plastered statue) are unique in the use of sea-shells, whether *Unio* or *Donax* (D. Bar-Yosef, pers. comm.), but on one occasion cowry, to portray the eyes as open. By contrast, those at Beisamoun are mere slits covering the empty orbits, while the two at Kfar HaHoresh and three from Ain Ghazal were shallow grooves incised into plaster protuberances, resulting in a closed or “sleepy” eyed appearance (Griffin, Grissom & Rollefson, 1998). However, one of the other skulls from Ain Ghazal was incised in such a manner as to indicate the eyes are open (Simmons *et al.*, 1990). This specimen originally may have had inlaid bitumen as an eyeliner, paralleling details of the plaster statues from that site, and one skull at Ramad may also be similar (Griffin, Grissom & Rollefson, 1998). Noses are generally quite straight and aquiline in profile, though the length often seems to reflect the presence or absence of the mandible. Homo 8 at Kfar HaHoresh has a markedly flat nose. Nostrils are often indicated in a quite perfunctory manner. Mouths are usually relatively straight horizontal slits in slightly puffed lips.

Where the surface plaster is preserved, all are coated with a pink through red to brownish hue, though as outlined above, the details vary in terms of the pigments used, the manner of their application, partial burnishing and the resulting effect of the finished artifact. It is uncertain whether other details, such as hair or beards, were painted in the manner of some busts.

The cache of three plastered skulls from Ain Ghazal appear to have been intentionally detached from their skulls prior to burial elsewhere. One of the Jericho skulls (presently housed in the Royal Ontario Museum, Toronto) appears to have been repaired in antiquity, with more recent plaster covering the earlier pigmented surface plaster in some places. Most, if not all of the plastered skulls, as with the statues, appear to derive from intentional favissae, the precise contexts of which are commonly rather obscure, probably after having fulfilled their symbolic secondary lives (see also Garfinkel, 1994).

A primary result of this study is the demonstration of the pronounced inter-site variability in the methods of the skull modelling, as well as in the iconographic details. The three sites examined here, although rather similar in their overall cultural sphere, are characterized by quite diverse methods of raw material application which represent very different technological concepts. This is probably part of the reason for the iconographic diversity of these artifacts among the sites, as opposed to their relative homogeneity within a

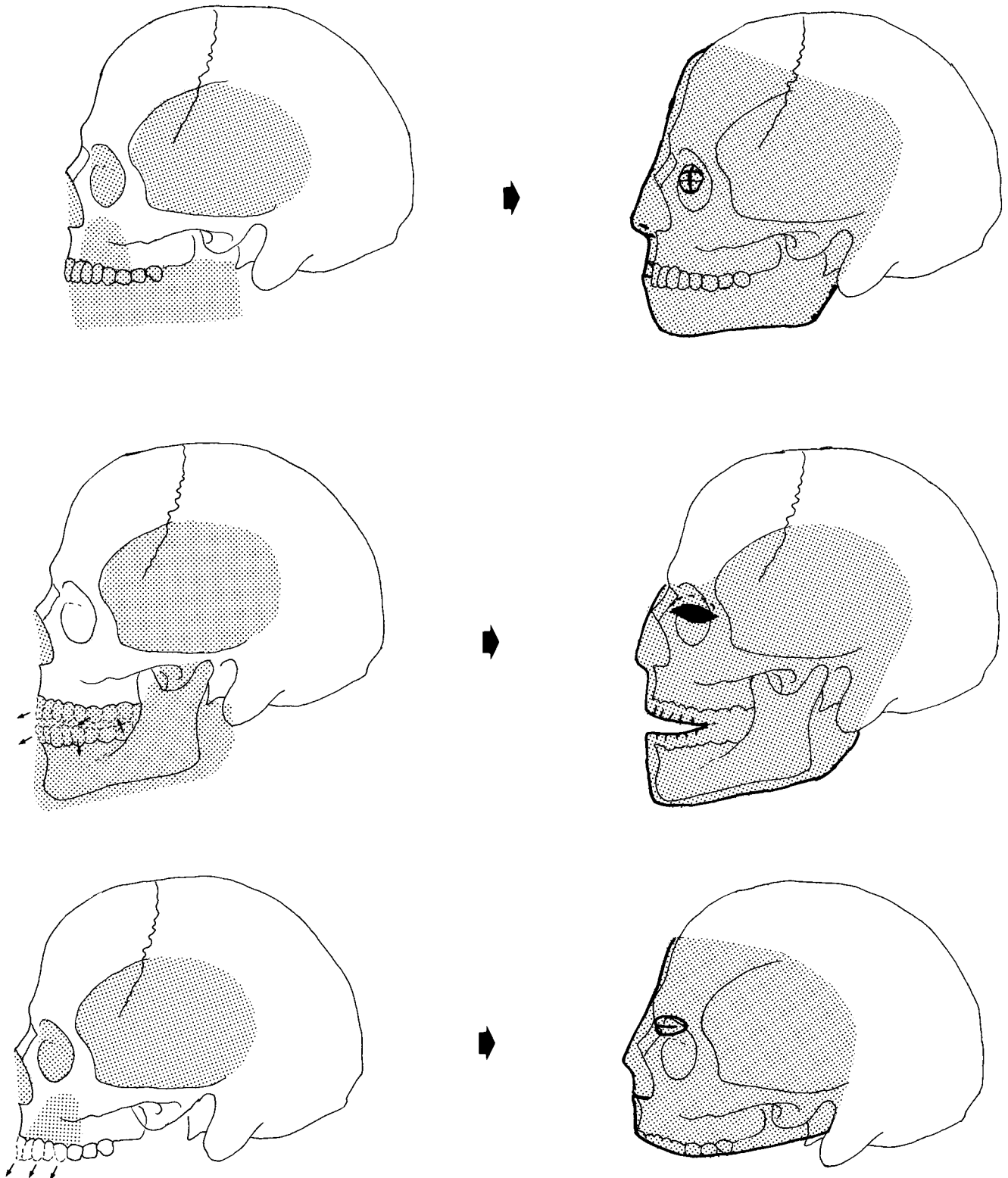


Figure 17. A schematic reconstruction of the modelling methods as indicated by the skulls from Jericho (top), Beisamoun (centre) and Kfar HaHoresh (bottom). Left: methods of pre-modelling bone modification (teeth removal and inlay of basal plaster layers). Right: the final products in relation to the skulls.

given site. Yet the apparent knowledge of the raw materials' properties by the artisan, as expressed at least in the Kfar HaHoresh and Beisamoun skulls, negate any possibility of "primitiveness" in the formation of these artifacts which may explain such diversity. The impression is of non-cannonized technical production in which some products depict high skills and control over the properties of the materials in use, and others of a very "formative" nature. This pronounced difference is best demonstrated by the contrast between the highly sophisticated Kfar HaHoresh skulls, as compared with the simplicity of the Jericho skulls examined here in terms of raw materials and construction methods.

A primary conclusion of this study is therefore, that each site employed its own specific technological sequence for the plaster production of "precious" artifacts. This is supported by recent description of the technological attributes of three plastered faces from Ain Ghazal: though found missing (in antiquity) the actual skulls to which the faces originally adhered, fibres, some twisted, were employed to fill and pad orifices and recesses prior to application of one main basal layer of plaster followed by a thin surface coating of pigmented plaster (Griffin, Grissom & Rollefson, 1998). The plaster comprises a mixture of marl and slaked lime and plant temper, resulting in technologically superior products in comparison with the well-known plastered statues and busts from Ain Ghazal. Though not studied in detail, the plastered skulls at Ramad also display marked site-specific traits, most obviously in the retention of mandibles in the modelling to render a more life-like visage (de Contenson, 1967, 1969). Otherwise, except at Beisamoun and a single specimen from Jericho as noted above, mandibles were not commonly included in plastered faces.

The relative sophistication of the specific technologies employed do not reveal any obvious chronologically vectored patterning: while all are attributable to the Middle and Late PPNB, the tentative sequence appears to be (from oldest): Ain Ghazal, Jericho, Kfar HaHoresh, Beisamoun and Ramad.

On the one hand all the investigated modelled skulls (and indeed the statues and busts) clearly share a common basic technological approach. Yet, the specific details of the technologies employed reveal a marked degree of intra-site homogeneity and inter-site heterogeneity. The most parsimonious explanation for such patterning probably lies in the dissemination of such technologies in the form of communicated general knowledge, rather than the actual physical movement of artisans from one site to another. This view has already been suggested by two of us in light of the examinations of plaster statues from Nahal Hemar and Jericho (Goren, Segal & Bar Yosef, 1993; Goren & Segal, 1995). The internal homogeneity within sites certainly appears to indicate local, community-level traditions with regards to specific details. However, it is at best speculative as to whether skull plastering was

practiced by only a limited array of individuals fulfilling such roles within any given community. Whether such artisans might, in addition, have fulfilled other, specific roles (shamans?) within the community is, of course, also unresolved. However, the very high diversity of post-mortem treatments afforded individuals, ranging from simple interment, through skull removal, daubing of the skull with pigment, application of caps and plaster modelling, as well as intentional secondary burials clearly indicate differential status of some sort within communities. These questions are relevant in the context of the emergence of craft (and other) specialization, since recently such an interpretation has been proposed for naviform flint knapping (Quintero & Wilke, 1995). Nevertheless it must be stated that the present state of comprehension of the PPNB in the south/central Levant is exceedingly complex; while individuals or certain groups within communities may have been particularly proficient in certain fields of expertise (whether "functional"/mundane or spiritual), there is presently no obvious unequivocal evidence to indicate that such individuals or groups depended primarily upon such skills for their livelihoods. Thus the situation during the PPNB should, at best, perhaps be viewed as "incipient craft specialization".

It was only a combination of the several technological approaches which latterly brought about the development of related pyrotechnologies such as pottery production and metallurgy. In this action the process of pozzolanic reaction (already known to the artisan of the Kfar HaHoresh skulls) was used in several cases in order to achieve a resistant, long-lasting product. This aspect is clearly related to "functional", rather than "spiritual" motives. However, other technologies documented here seem to have been applied for less "mundane" purposes. Although the use of crushed calcite as an aplastic component is well known from later (Chalcolithic and later) pottery assemblages, its advantages in the case of skull modelling are obscure. Similar is the case of mixing iron minerals in the paste. Although crushed calcite and high iron contents in pottery have some benefit in gaining better sintering and resistance to thermal shock, this point is totally irrelevant to the products in question. Their use was directed only by decorative purposes. Yet it must be stressed that it was probably this "innocent" decorative use that directed later potters to similar minerals in their search for materials which might produce more impact and thermal-shock resistant products. Therefore, these artistic, spiritually oriented artifacts that were probably not intended for daily uses acted as a preliminary framework on which the technological knowledge for producing later daily performing artifacts was gained.

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