H.G.K. GEBEL, Z. KAFAFI, and G.O. ROLLEFSON (eds.), *The Prehistory of Jordan, II. Perspectives from 1997.* Studies in Early Near Eastern Production, Subsistence, and Environment 4 (1997). Berlin, *ex oriente.*

Ba'ja Hidden in the Petra Mountains. Preliminary Report on the 1997 Excavations

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Abstract: *This contribution offers a preliminary report on the findings of the 1997 excavations at the Late Pre-Pottery Neolithic B (LPPNB) site of Ba'ja (late 7th mill. BC), north of Petra, southern Jordan, discussed with regard to current understandings of the mega-site phenomenon of that period east of the Rift Valley. Basic information is provided for the present-day setting, the site preservation, its architecture and building techniques, and the various industries, ended by a summary with reference to basic implications Ba'ja provides for a promoted understanding of LPPNB phenomena. Information on the technologies of LPPNB baked clay containers and sandstone rings are presented here the first time.*

Key Words: *Ba'ja, Southern Jordan, LPPNB architecture and material culture, mega-site phenomenon.*

Introduction (H.G.K.G. and H.-D.B.)

Between June 16 and July 20, 1997, the first season of large-scale excavations was conducted at the LPPNB settlement of Ba'ja in southern Jordan (*cf.* GEBEL and BIENERT 1997 a,b; earlier publications: GEBEL 1986, 1988; GEBEL and STARCK 1988). The 1997 season was carried out under the joint directorship of the main authors of this contribution, and under the institutional umbrella of the German Protestant Institute for Archaeology, Amman Dept. in cooperation with ex oriente e.V. at Free University of Berlin. The German Archaeological Institute, Orient-Department in Berlin was represented in the project by a special research commission to be carried out on pre-planning aspects of LPPNB architecture.[1]

Project History

The LPPNB village of Ba'ja rests on an intramontane terrace in the steep sandstone formations some 10km north of Petra and 5km north of Beidha, respectively (Fig. 2). With available information[2], it was difficult for H.G.K. Gebel to relocate the site in autumn 1984, who then recorded its location more precisely and carried out three soundings in the framework of his project *Palaeoenvironmental Investigations in the Greater Petra Area- Holocene Research* (P.I.G.P.A.; GEBEL 1986, 1988, 1990, 1992; GEBEL and STARCK 1985)[3]. These investigations identified Ba'ja as one of the

[1] The excavations in Ba'ja were followed by an international symposium on the *Central Settlements in Neolithic Jordan* (Petra Mövenpick, 21- 25 July, 1997), organized by this projects' co-directors. This contribution benefited much from the discussions of this symposium.

[2] The site was originally found by M. Lindner and his team, who presented the collected chipped lithic finds to H.G.K. Gebel (for the history of finding Ba'ja *cf.* GEBEL and BIENERT 1997a, LINDNER 1996); it appears unlikely that Ba'ja would have been found by "normal" survey means. Here we would like to thank M. Lindner for his constant advice and support over the years, which also accompanies the renewed research on Ba'ja.

[3] In this report material and information of the earlier project is used (financed by the *Deutsche Forschungsgemeinschaft* through the *Sonderforschungsbereich* 19: Tübinger *Atlas des Vorderen Orients*). Sincere and deep thanks go to Wolfgang Röllig, that time chairman of the SFB 19 for all his support for this project. It allowed the first investigations of Basta and Ba'ja in 1984, establishing the initial interest in these sites for the later large-scale excavation projects (H.G.K.G.).

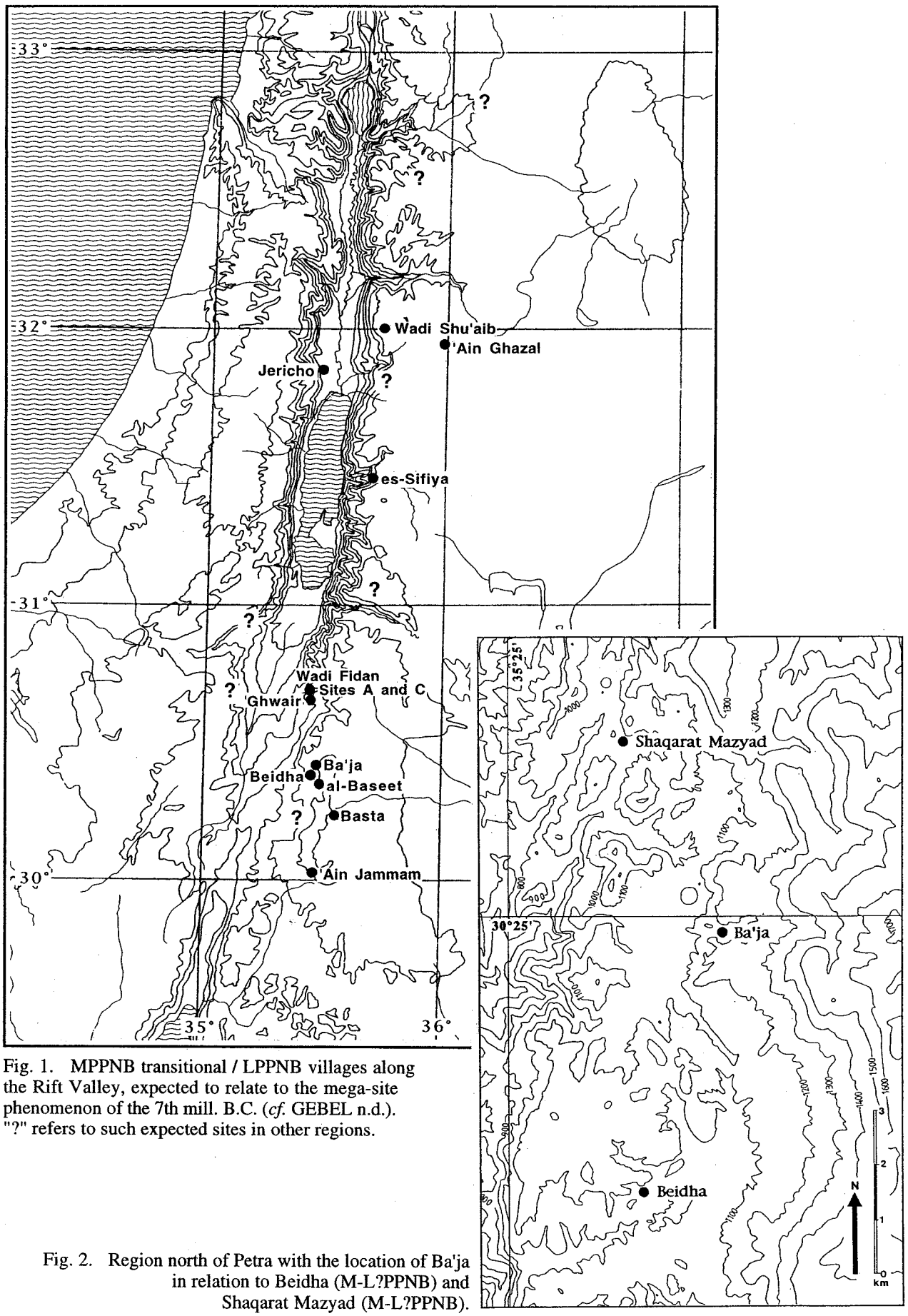

Fig. 1. MPPNB transitional / LPPNB villages along the Rift Valley, expected to relate to the mega-site phenomenon of the 7th mill. B.C. (*cf.* GEBEL n.d.). "?" refers to such expected sites in other regions.

Fig. 2. Region north of Petra with the location of Ba'ja in relation to Beidha (M-L?PPNB) and Shaqarat Mazyad (M-L?PPNB).

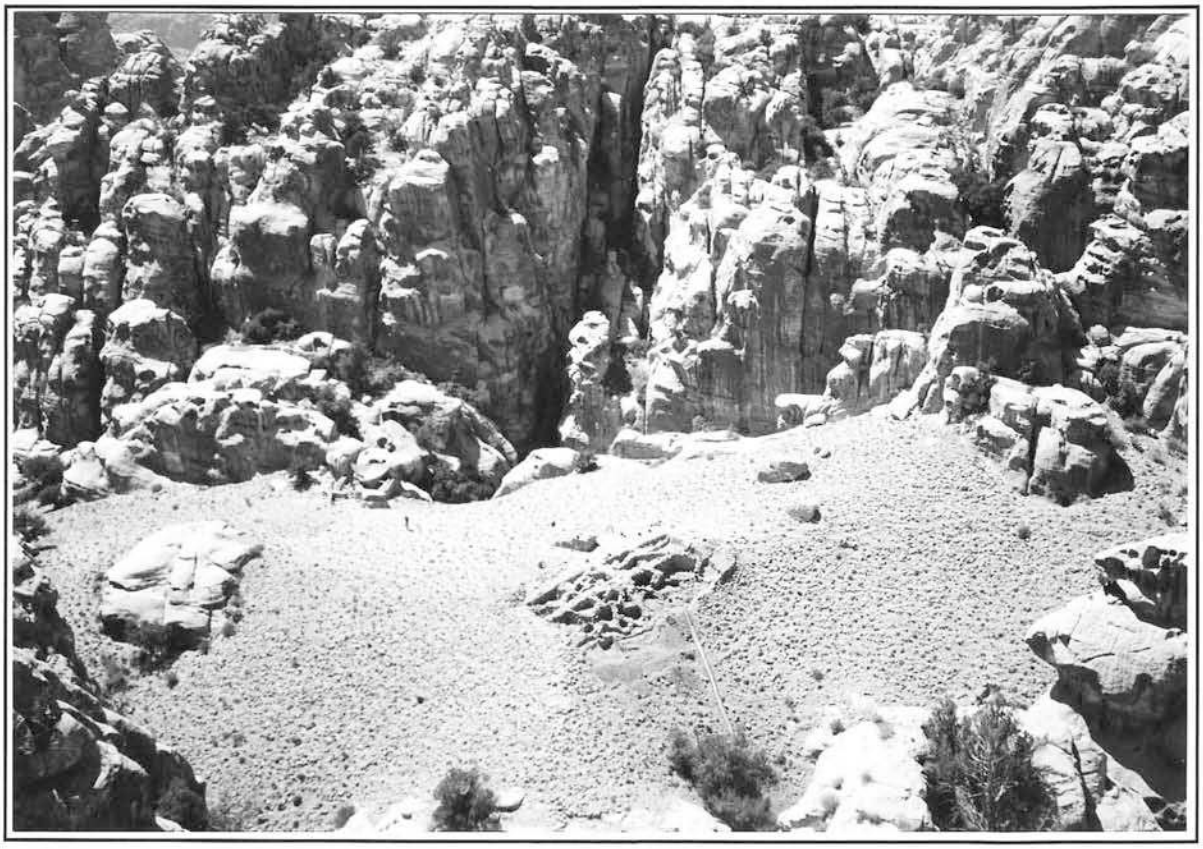

Plate. 1:A. Intramontane setting of the site with excavation in Area C from SE (photo: Schatz-Haerle).

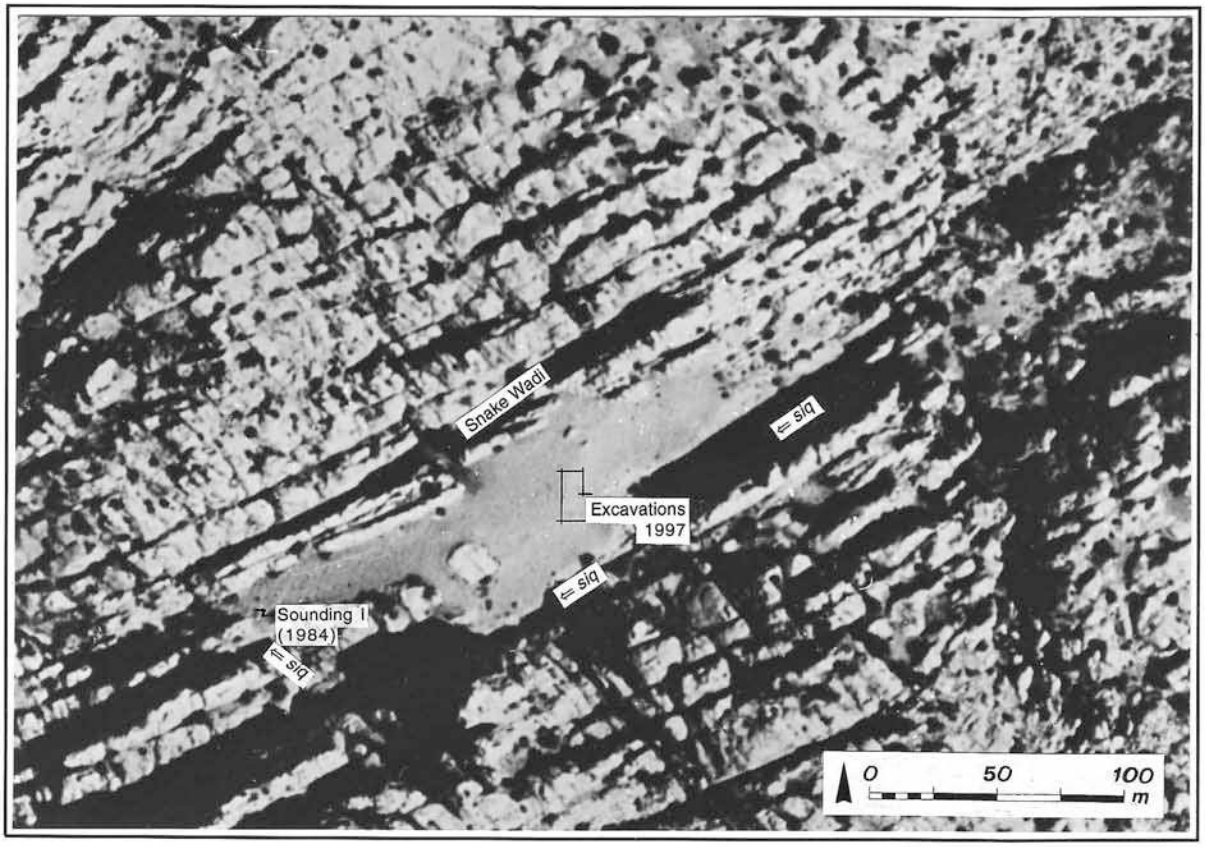

Plate 1:B. Aerial view of intramontane Ba'ja, surrounded by sandstone formations.

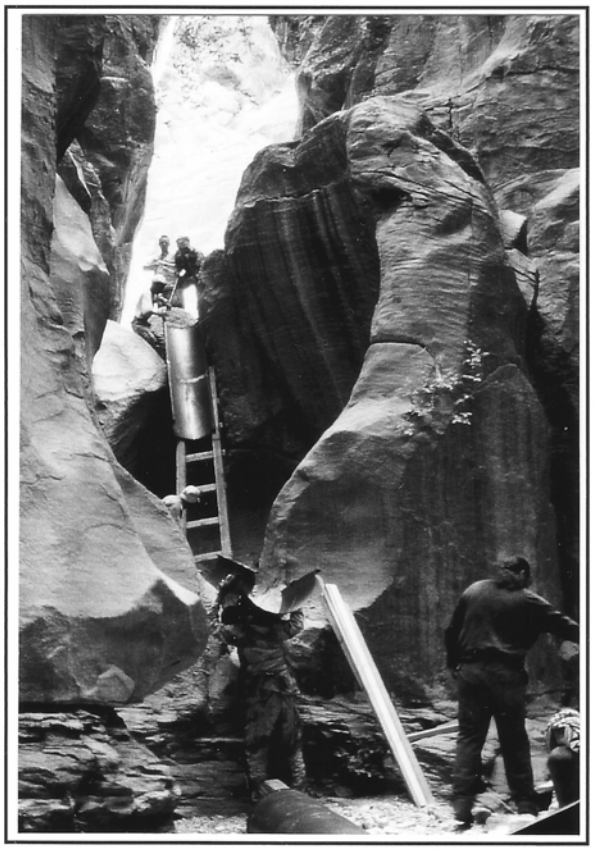

Plate 2:A. Working conditions: Bringing the sediment chutes up to the site through the *siq* (photo: Gebel).

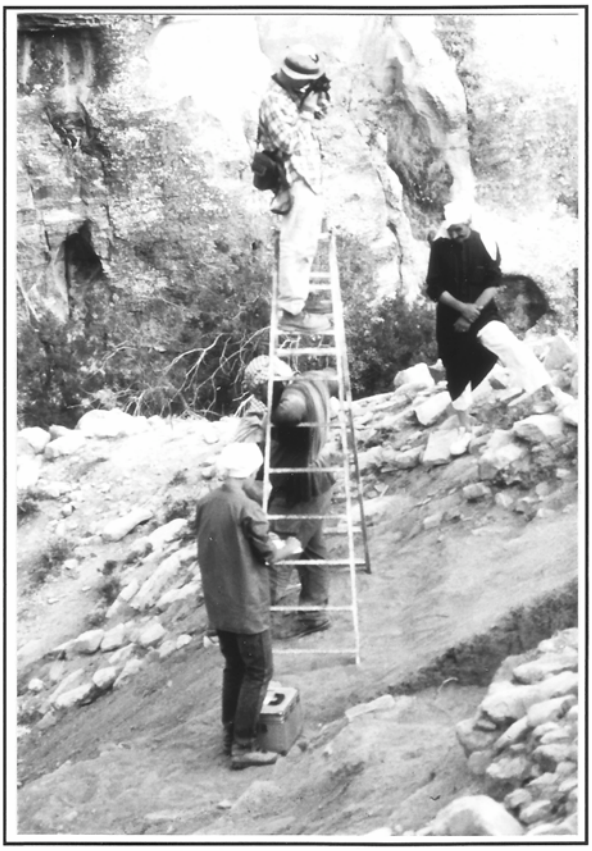

Plate 2:B. Working conditions: Photographers on a ladder at the edge of the *siq* slope (photo: Gebel).

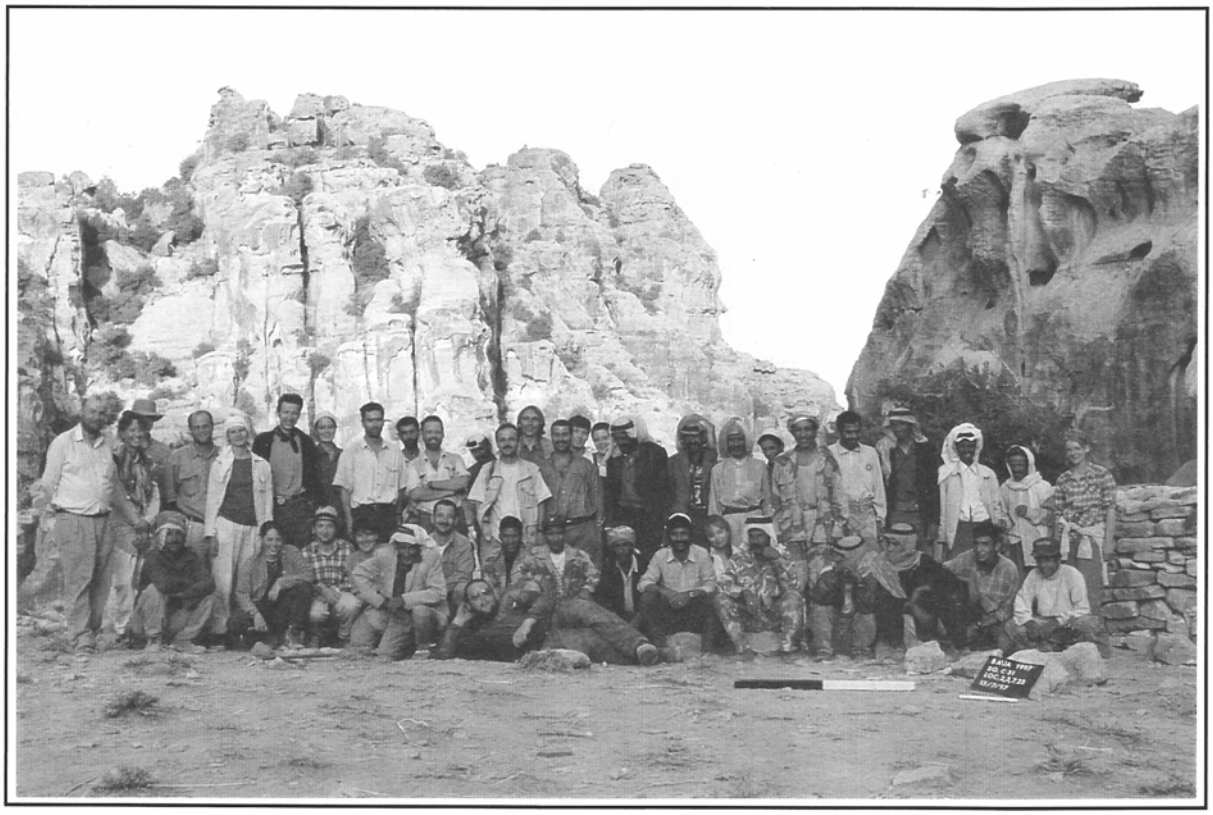

Plate 2:C. Excavation team 1997 (photo: Jeffs)

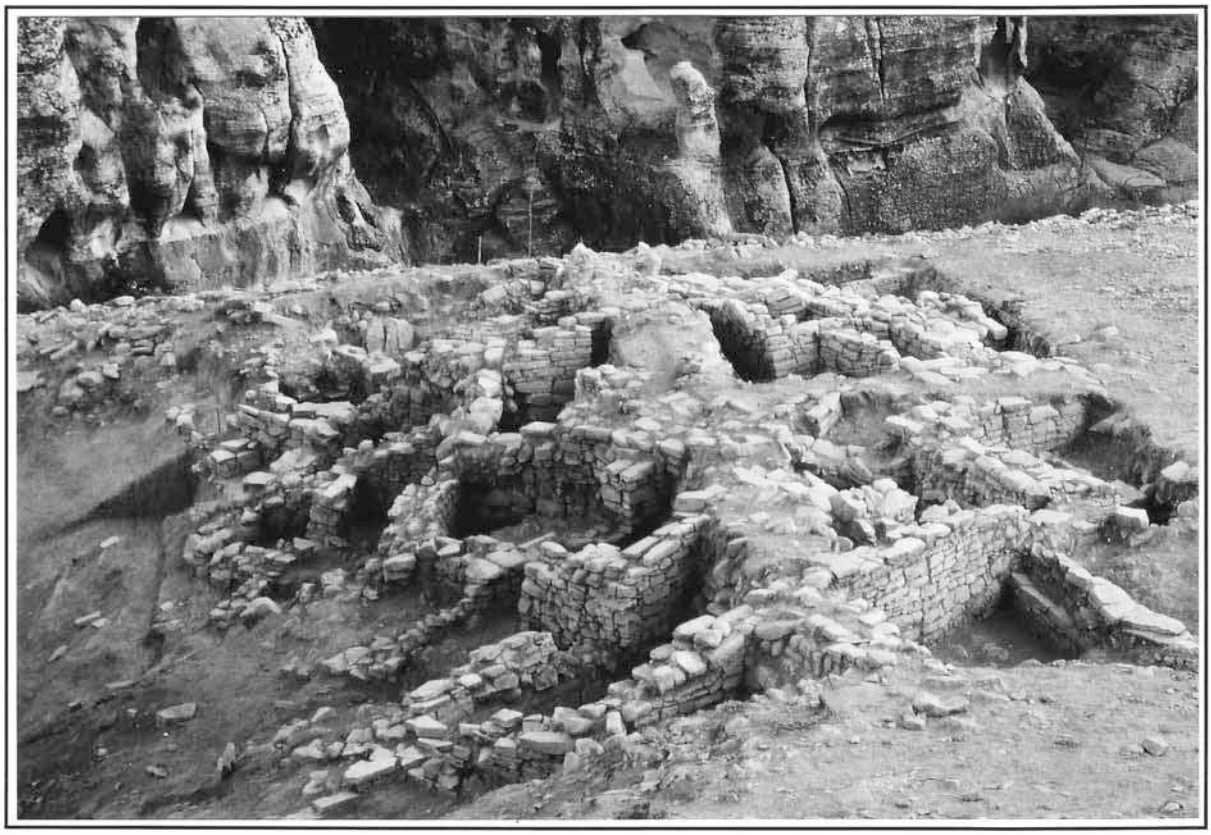

Plate 3:A. Excavation in Area C seen from north (photo: Gebel).

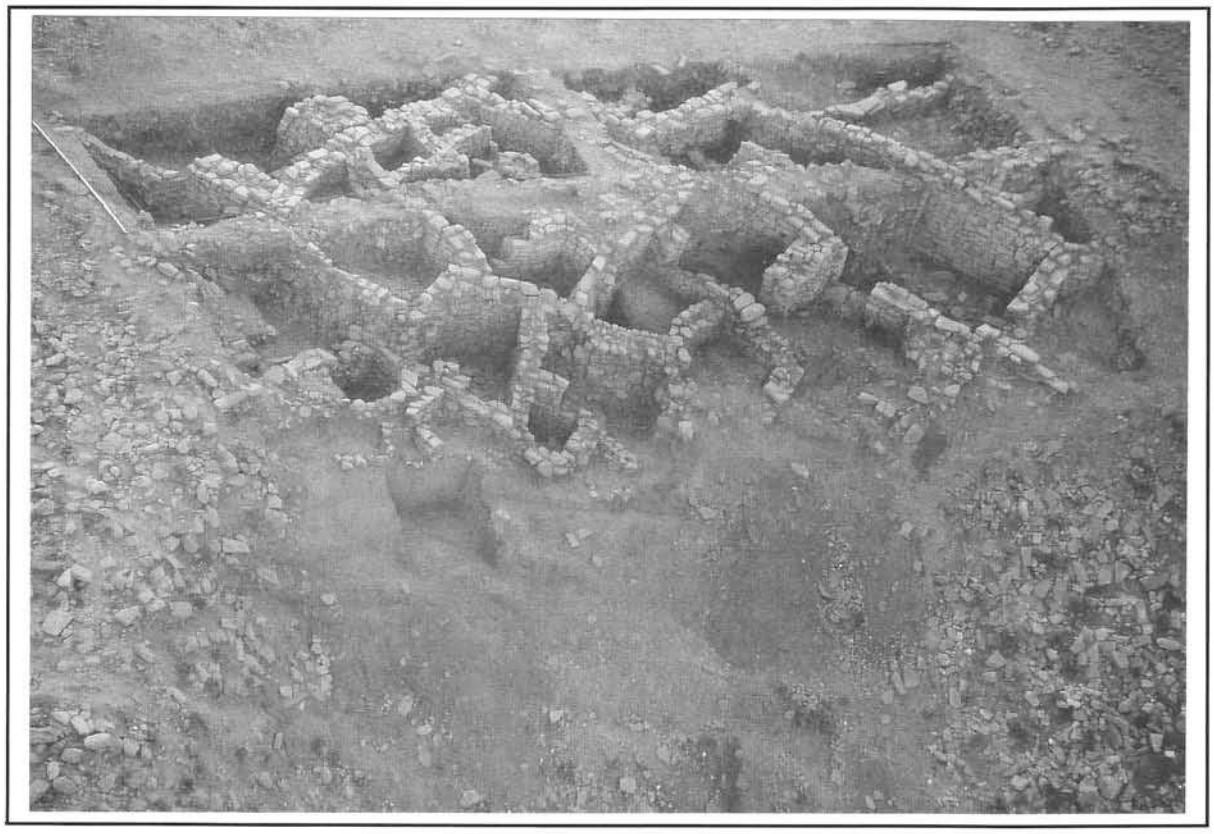

Plate 3:B. Excavation in Area C seen from southeast. Note the sharp line (foreground) between preserved walls and the exposed sterile deposits underneath (photo: Fengler/Höffgen).

large Late PPNB settlements in the Greater Petra Area, probably succeeding Beidha in the function as a regional center. A chain of settlements already existed in the MPPNB of the area (Beidha, Shaqarat Mazyad, adh-Dhaman; GEBEL 1990), which testified to the first permanent settlements and high population density in the region. It is from these that the LPPNB occupations must have emerged, although it cannot be considered certain that the sandstone areas developed demographically similar to what occurs in corridor settings on the fringes of the Arabian Plateau: mega-sites like Basta and 'Ain Jammam, or at the edges of Wadi Araba, sites like Wadi Fidan A and C, and Ghwair (GEBEL n.d.; RICHARDSON, this volume; Fig. 1).

In the years after the first investigations, Ba'ja's protected setting, the difficult access and the surrounding magnificent setting made it an attractive goal for only a few insiders. In 1996 H.-D. Bienert approached H.G.K. Gebel for an in-field cooperation. Since it had become imperative to contribute to the mega-site discussion by investigating also a smaller regional LPPNB center away from the corridors of that LPPNB large settlement expansion, Gebel proposed Ba'ja for this cooperation, provided that three field seasons would take place in order to the achieve the expected basic insights (*cf.* the goals discussed in GEBEL and BIENERT 1997).

Field Logistics and Conditions

Working at the site is a tough enterprise (Pl. 1-2), as was already experienced by the small team directed by Gebel in 1984. This year, a sounder infrastructure was established for 22 permanent team members (plus 3-4 part-time members; *cf.* Acknowledgments) from Germany, Jordan, the United States, England, and Sweden. During the most intensive work periods up to 24 local workman from the al-Amarin, al-Bdul, and al-Sey'idin tribes worked at the excavations. The co-directors shared their work in a way that the general organizational aspects were covered by Bienert, including supervision of the registration, while Gebel directed the excavations on the site.

To approach the site of Ba'ja demands climbing through a gorge (*siq*) for *c.* half an hour, crossing several barriers of fallen rocks reaching heights of up to 5m (Pl. 2:A). The entrance of the *siq* can be reached from the Jabu Plain west of the site by a four wheel drive, going through Siq Umm al-Hiran north of the Beidha/ al-Hishi/ Wadi Araba junction near al-Beidha Housing[1]. The site has no water nearby and almost no shady areas. All the water (in our case 130 l per day), food, and equipment, had to be brought up by carrying and climbing. On the site, there were no possibilities for personal hygiene; work was characterized by limited comfort, permanent stress on one's ankles (up to 40° steep slopes, *cf.* Fig. 4), few flat areas to rest, danger of snake and climbing accidents, etc. Two camps were maintained: a base camp with four houses at al-Beidha Housing, and the dig camp on the site. Most team members preferred to stay at the dig camp, since daily moves between the site and the base camp were very exhausting. However, the dramatic scenery (*cf.* Pl. 1:A) and the experience of its untouched natural setting were suitable compensation for much of the deprivation. Although the site can be approached with considerable difficulty from the east and the south, no more efficient track was found for transporting materials than that afforded by climbing through the *siq*.

Field Operations (Fig 4:A)

C. 250 m² (10 5x5m squares; 5 digging teams) were opened in the terraced housing area where the steep slope of Area C climbs up to the flat Areas B and D, forming at this spot a spur-like crest. Two of the squares were found free of any architecture, which resulted in a lively discussion of the state of preservation (see below). Two Test Units were opened, one above bedrock at the lowermost fringes in Area C (TU1, a step trench) in order to understand the Quaternary stratigraphy on which LPPNB layers rest, and one in the "Snake Valley" (TU2). The latter was in a small wadi immediately north of the site and yielded LPPNB ashy trash layers still preserved in a "sediment trap"[2]. It was investigated for its huge quantities of animal bones, chipped lithics, and occasional bone tools and ornaments in order to obtain a "control sample" for these find classes and to increase our sample sizes.

The archaeological surface reconnaissance mapped all the Neolithic (and other) wall remains visible on surface, the dense distribution of ground stone materials, and other surface features. In the last days of field work, the immediate vicinity of the site was surveyed in order to look for possible outliers of the occupation. (There seem to be none.). The site survey was the dangerous job of the surveyors who recorded the site's topography, including the bordering *siq*, wadi, and rock formations, by means of 5m-contour lines across the *c.* 1.2-1.5ha area of the site. (Fig. 4:A)

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[1] The site of Siq Umm al- Alda 1 (*cf.* SCHYLE and GEBEL, this volume) is to be found immediately to the right of this same track (after passing the track leading off to the Ba'ja *siq* entrance) at a spot where the track leaves the playa fills of the Jabu Plain and again enters a rocky sandstone gorge (Siq Umm al-Alda). From here it continues to M-L?PPNB Shaqarat Mazyad and the Wadi Araba.

[2] Many other spots, including the area of Sounding I from 1984, proved that the Neolithic settlers used the surrounding drainages and lower lying rock surfaces as disposal areas.

The practical goal of the excavation itself was to uncover the architectural remains down to the earliest floor of the upper occupation. Sieving was applied whenever *in situ* layers occurred in room fills.

Present-day Environment[1] (H.G.K.G. and R.N.)

Bioclimatologically, Ba'ja presently lies in a cold-temperate, semi-arid zone. The average annual precipitation is around 200-250mm[2], but there are large fluctuations in this area. The deeply dissected nature of the sandstone around much of the site has resulted in small landscape units with favorable edaphic conditions, such as small valleys and rock crevices where runoff water can collect. Here can be found small, well-developed stands of the evergreen oak (*Quercus calliprinos* s.l.). On more exposed places in rock crevices, for example, one can find pistachio trees and shrubs (*Pistacia atlantica* or *P. khinjuk*) and the Phoenician juniper (*Juniperus phoenicea*). (Fig. 3)

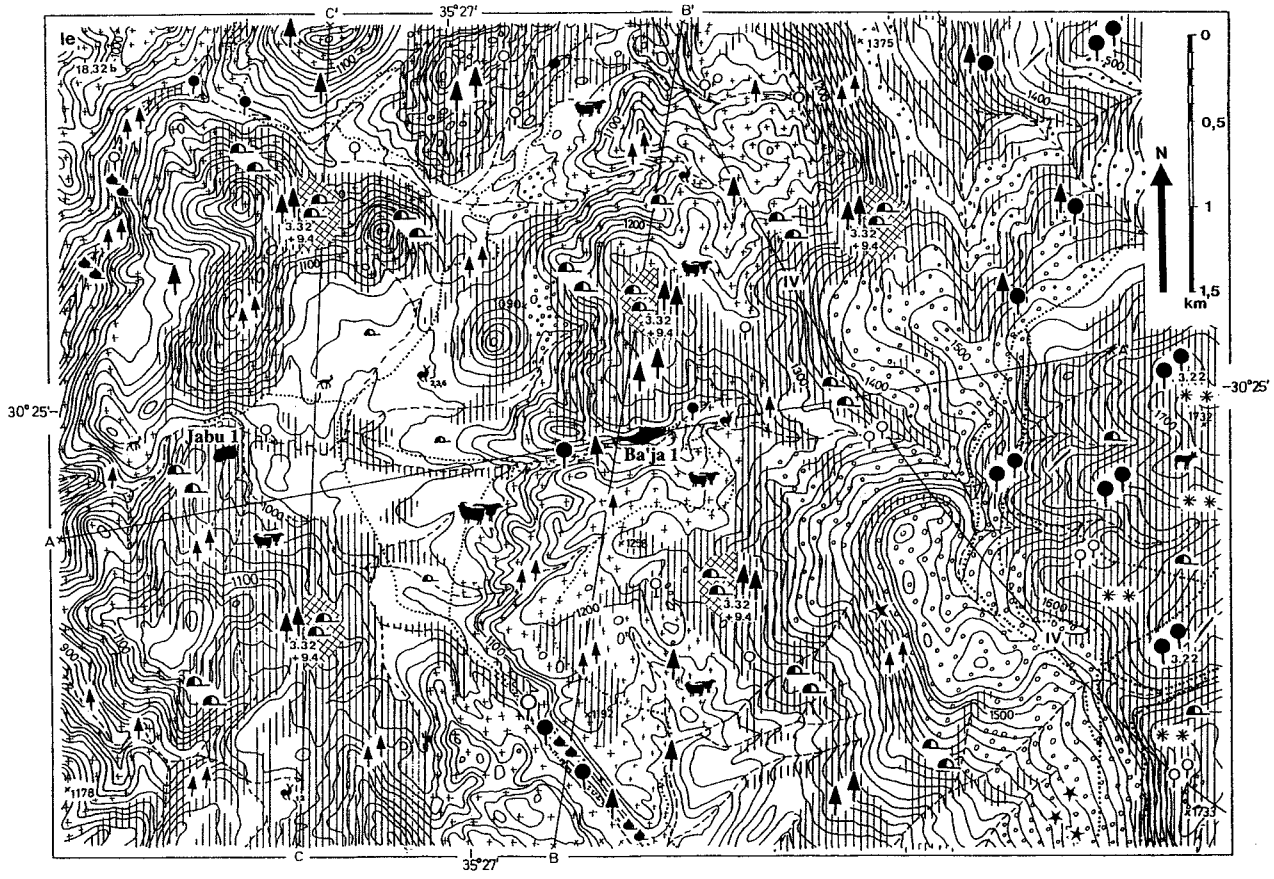

Fig. 3. Present-day environment of Ba'ja (from GEBEL 1992; for legend, see GEBEL 1990).

Phytogeographically, the setting of Ba'ja is at the westernmost edge of the Irano-Turanian open forest steppe vegetation, which penetrates the sandstone area from the eastern limestone slopes of the Arabian Plateau with its characteristic element, the wormwood *Artemisia sieberi* (addressed before as *Artemisia herba-alba*). Somewhat farther south, this steppic artemisia cover even reaches as far as *c.* 2km west of Beidha (down to the 1040m- contour line; *cf.* GEBEL 1988: Fig. 2). These converging floral regions, the Irano-Turanian and the Xero-Mediterranean represented by oak, juniper, pistachio, create the habitat diversity of this area. Artemisia here became an undergrowth of the open juniper forests on the slopes just east of Ba'ja. Pure Xero-Mediterranean forests are preserved at higher altitudes some 3-4km east of Ba'ja: the famous woods of al-Hishi. The "vegetation of the rocky sandstone

[1] For the reconstruction of the environment in the late 7th millennium BC, see the description of the Palaeophysiographic Units V-VI in GEBEL 1990 (attached sheet) and 1992: 95.

[2] Ba'ja lies just west of the isohyet of 200/300mm in dry/wet years (marked with "IV" in Fig. 3). Rainfall within the areas can vary considerably: *e.g.* in 1966/67 200mm were recorded, but for 1959/60 only 50mm.

areas" north of the Jabu Plain (described by GEBEL and STARCK 1985: 96) is another type of floral community of the area. The Jabu Plain itself is characterized by its own plant cover, that of *playa* surfaces suitable for rain-fed agriculture (GEBEL and STARCK 1985).

Even today the diversity of the vegetation provides many different habitats attractive for a long list of mammals potentially living here: hedgehog, Arabian wolf (extinct?), fox, a small fox, wild cat (extinct), lynx (extinct), badger (extinct?), striped hyena, mountain leopard (extinct), various rats, mice, gerbils, jerboa (?), crested porcupine, ibex (extinct), wild boar, hare, hyrax, bats, and others.

The present-day environment (Fig. 3) is used for sheep and goat grazing and, to a small extent, for rain-fed agriculture (wheat and barley) on the Jabu Plain and some hydrologically favoured intramontane spots with loose sediments.

The mean daily day temparature in the area is in January 8°C, in August 28°C. The mean daily range of temperature is 10°C in January, and 14°C in August. Mean monthly relative humidities are for January around 60%, in August around 40%. (NAJ I and II 1984 and 1986).

Site Setting and Topography (H.G.K.G. and H.-D.B)

The location of Ba'ja, known locally also as "al-Mehmad", is at 35° 27' 45" E / 30° 24' 55"N; the altitudes for the identified cultural layers on the site range from 1060 to 1095m according to the surveyors' work (HARTL-REITER 1997) and are based on double-checked barometric readings and the consultation with the Topographical Map of Petra, al-Bayda Sheet (Royal Jordanian Geographic Centre 1997). Earlier determinations followed available maps (such as the topographical map Jordan 1:50.000, Petra sheet: 3050 I, Ministry of Economy / USAID to Jordan, n.d.) and had ascribed the site to *c.* 1120 to 1160m a.s.l. The region today belongs to the territories of the al-Amarin.

The Neolithic layers rest on a terrace (Pl. 1:B) that can be described as the remnant of an intramontane *playa*-like fill within the basin-like structure of al-Mehmad. The present-day topographical units (Areas A-I: Table 1, Fig. 4) of the site must have basically developed their shape after the resolution of this catchment (Upper Pleistocene, if compared with other spots in the Petra region) after this fill was partly transported out of the basin while forming the deeply incised *siq* by the coarse-grained material transported down from the limestone plateaus to the east.

Table 1. Ba'ja : Topographical Units.

Area	Setting, topographical features, and drainage directions (directions taken from the report by T. Krämer; *cf.* also Fig. 4)	Commonly referred to as
Area A	narrow, agriculturally terraced western slope (NE-SW)	"The Towel"
Area B	flat surface southwest of the site's highest part (no major drainage direction)	"The Saddle"
Area C	steep slope with the majority of the LPPNB terraced housing on the site's eastern extension (various drainages, N-SE/S/SW)	"The Amphitheater"
Area D	uppermost northern parts of the site with dense surface evidence of LPPNB walls (Area G belongs topographically to this area; NE-SW)	"The Acropolis"
Area E	small narrow slope with many wall remains starting north of Area B, ending in the wadi ("Snake Valley") bordering the site in the north (SE-NW)	"Snake Valley Slope"
Area F	southern central steep slope (W-S and NW-SE)	
Area G	small uppermost part of the site east of Area D (NW-SE)	
Area H	easternmost part of the site with little archaeological surface evidence (N-S/SE)	"The Restroom Area"
Area I	low terrace above the *siq* with no archaeological surface evidence (N-SW/S/SE)	

The site is bordered by the Siq al-Ba'ja to the south and vertical rock formations to the north. Its longitudinal axis is oriented SW-NE and is about 290m in length, with a width that varies from *c.* 20m at the western and eastern accesses to about 90 m in the central area. The area potentially occupied in the later 7th millennium B.C. is about 1.2-1.5ha, which is *c.* 5000m^2 larger than preserved Beidha. But contrary to nearby Beidha, the inhabitants had very limited possibilities to expand into the surrounding area; there seems to be no evidence for any outliers. (See below; in this respect, we may have to revise hypotheses concerning space pressure at Ba'ja; *cf.* GEBEL and BIENERT 1997a).

Functional units so far identified at the site are domestic areas on terraces (with evidence for indoor sandstone ring workshops) and dump areas in the westernmost parts of Area A, in "Snake Valley", and most likely in the *siq*. No evidence for burial grounds, animal pens, or open spaces were found in the limited area of excavation (*c.* 2%), which was placed in the centre of the Neolithic village. Finds of human bones in the dumps of Test Unit 2 (Fig. 4:A) led us expect intramural burials.

Vicinity Survey (B.M.-N.)

The aim of the 6 day-survey in the vicinity of Ba'ja was to locate possible smaller Neolithic outliers and sites from other periods. It was especially the smaller valleys that might have sustained more

Neolithic and later settlements or camps (*cf.* GEBEL and BIENERT 1997) due to the good water storage capacity of thick aquifers that might have existed at those times, which could have supported agricultural activities.

The survey was based on aerial photos (1: 30,000) covering the whole area of Ba'ja. As a preparation for the survey, these pictures were examined with a reflector stereoscope to mark areas with accumulations of soft sediments. However, the survey did not show any clues of Neolithic activities in the area other than Ba'ja itself. Surfaces and profiles of the gullies in the small valleys were sterile except for modern trash on the surface of some areas.

Neolithic artifacts were found only in a sediment trap of "Snake Valley" immediately north of and below the Neolithic village, investigated as Test Unit 2 during excavations. Here was a thick mass of just less than 2 cubic meters of ash, silt, burnt stones, LPPNB flint artefacts, and abundant animal but very few human bones.

Some of the surrounding plateaus showed post-Neolithic activities similar to the probable Nabataean terrace walls on Plateau "K" north of Ba'ja, where we also discovered sherds and non-diagnostic flint artifacts. The Iron Age sites of Jabal Shdeifeh northeast of Ba'ja and of Umm Baben southwest of Ba'ja had already been located by M. Lindner (Lindner, pers. comm.). In a gully near Jabal Shdeifeh we found only a fan scraper and the medial part of a tanged arrowhead, hints of pre-EB activities in this area. Just across the main gorge to the southeast of Ba'ja exists a small plateau (Area A) with a short linear setting of stones. The only artifacts found here were some non-diagnostic flints in a small ravine.

As a first result we may state that no other Neolithic settlements appear to have existed near Ba'ja. Two reasons support this:

1) The water situation was precarious, and springs might have been rare. Fossil springs exist in the slopes of the limestone plateau to the E, which once must have supplied the inhabitants of Ba'ja with water (in addition to the spring-time pools and aquifers of the surrounding wadis). Although we can imagine perennial springs in the area, given a less destroyed Early Holocene vegetation cover (GEBEL, pers. comm.), the capacities of these sources were not sufficient to permit even more people to stay all the year round than already those inhabiting Ba'ja itself.

2) The habitats around Ba'ja, even under conditions of an intact arboreal cover, were limited (farmland, grazing grounds, collecting areas for firewood, nuts, plants, etc.). Like the settlement of Ba'ja, which could not expand because of vertical rock formations and gorges, the areas that supplied the inhabitants with food were also restricted and not expandable. Only the big Jabu Plain west of the Ba'ja *siq* entrance offered extensive good farmland. But this area was, for topographic reasons, outside the direct control for the inhabitants of Ba'ja, and was different from the directly neighbouring intramontane small valleys and plateaus. We expect that the latter belonged to the catchment area of Neolithic Ba'ja rather than supporting other permanent settlements[1].

Site Survey (B.M.-N.)

The fact that LPPNB architectural remains are still visible on many parts of the site surface prompted a special site survey, undertaken parallel to the excavations in 1997. This survey[2] aimed to document and map surface evidence for the following goals:

1. reconstruction of the approximate extent of the LPPNB settlement;
2. identification of probable LPPNB settlement centres;
3. mapping of preserved architectural surface remains;
4. classification and description of structural features;
5. identification of possible activity areas by mapping ground stone surface distributions; and
6. recording of post-Neolithic activities and structures on the site.

As described below, the wall preservation on the surface resulted from the fact that a stone pavement rapidly developed from the decaying LPPNB village ruins, which sealed the surface after all cavities/ rooms were filled with fallen upper wall sections and colluvial sediments. This cover protected the area against further erosion.

In addition to the *in situ* walls, *manos* (handstones) and grinding slabs were found all over[3] the site's surfaces (Fig. 4). When almost completely preserved, they were included in the mapping in order

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[1] These intramontane areas of difficult access are still exploited for herding by the local Bedouins, who also use some of the larger plateaus as camp areas.

[2] The 1:500 mapping was undertaken with EDM-Station. We am grateful to both our surveyors Ute Kopricz and Christian Hartl-Reiter for their help in mapping the surface evidence.

[3] The distribution of the ground stone items in Area A (*cf.* Fig. 4:A) is affected by the random sampling of K.I. Wright (see below) in 1987.

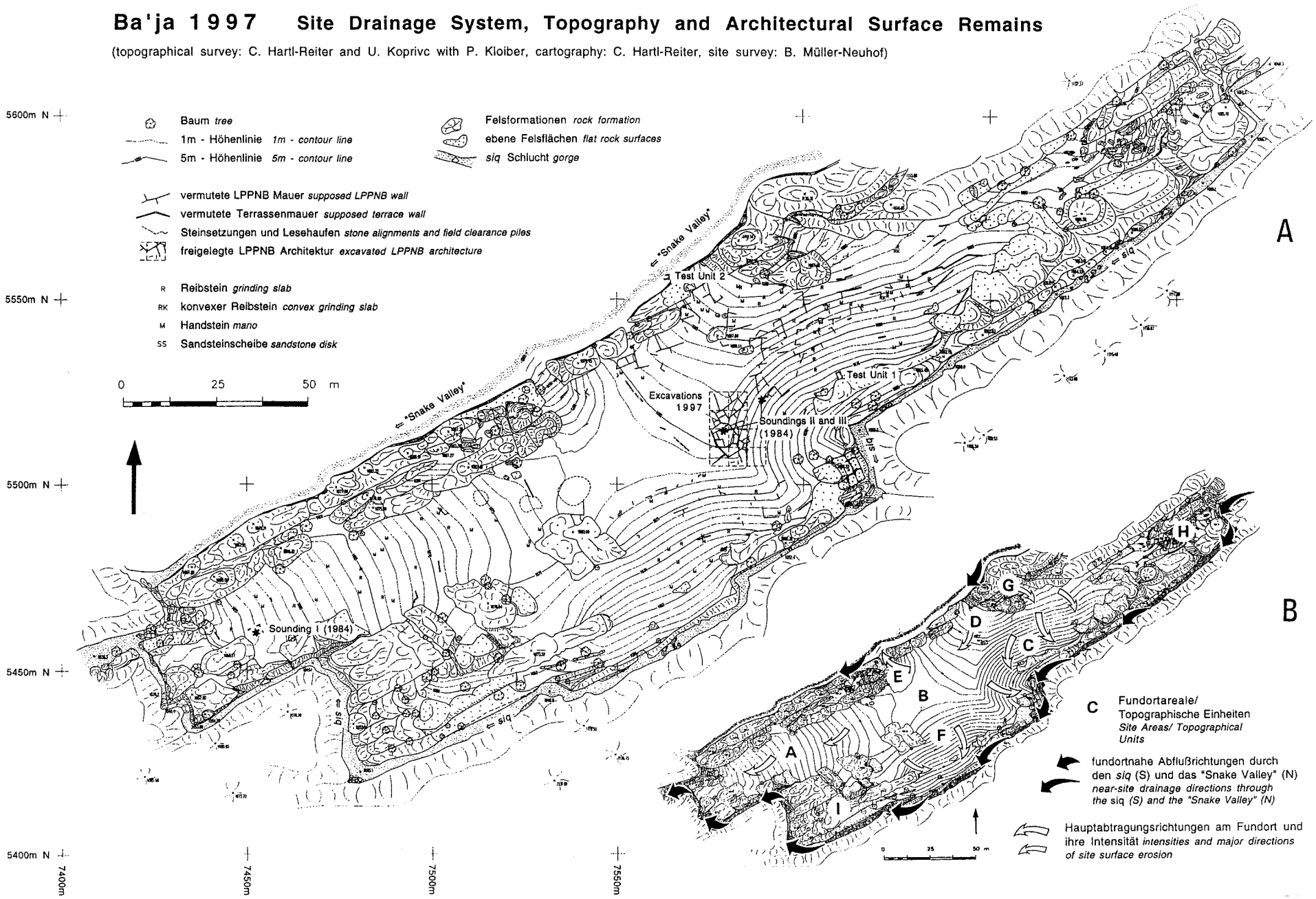

Fig. 4. A. Topography of Ba'ja, LPPNB architectural surface remains, other surface evidence, areas of investigation in 1984 (P.I.G.P.A.) and 1997; B. site drainage system.

to identify probable areas of food processing[1], although such activity areas could not be detected (see last paragraph of this section).

Surface architectural remains were divided into the following three categories:

1. Double-faced walls, consisting of courses with flat, sometimes large stones, mostly dressed on exterior faces. Connecting walls, often but not necessarily meeting at right angles (*cf.* Fig. 4), were interpreted as house/room walls. The walls of this first category can be dated to the LPPNB, as this is strongly supported by the characteristics they share with the LPPNB walls in the excavated area.
2. Undressed walls, built of larger undressed stones. The use of these structures as terrace walls is assumed due to their setting parallel to the contour lines of the slopes, as well as the absence of connecting walls. Comparison with similar masonry, mostly of Nabataean origin in the vicinity of Ba'ja, supports this interpretation and lets us presume a general post-Neolithic date for construction.
3. Stone clusters, not interpreted as walls, included low piles of stones (field clearance piles) of irregular shape and simple stone alignments. The latter also are set parallel to the contour lines of the slopes, but they do not have the massiveness of terrace walls. They might indicate other sorts of slope consolidation. All these structures are difficult to date, and no finds were associated with them. The fact that some structures of this category overly Category 1 walls points to a later date of construction.

Thus, at least two different phases of occupation respectively activities could be identified in Ba'ja.

Phase 1 is mainly documented by LPPNB house walls (double-faced walls). It seems that either the LPPNB occupation did not extend over all the site areas or it is not preserved in all of them. At least the lower and the middle parts of the very steep slopes (Area C, F, and partly E) did not reveal building remains; if this is not the result of erosion, then one reason might insufficient foundation engineering in LPPNB Ba'ja (see below).

The centre of LPPNB building activity may have been located in the upper parts of Areas C and F and in all of Area D. Intensive use of Area B as a housing area can be assumed because of the flat surface it provides, if this can be taken to represent the LPPNB topography. Due to later leveling and agricultural activities, no traces of LPPNB buildings could be identified here.

The reason for the absence of structures on the slope of Area A, which is not as steep Areas C and F, is unclear. It might be assumed that the climate here was less favorable for housing due to its comparatively long exposure to sun during day and a lack of access to winds. *Manos*, grinding slabs, and some terrace walls typical for Nabataean agricultural masonry represent the only surface evidence in Area A. The sounding by Gebel in 1984 in the lower end of this slope yielded no architectural remains, but the thick ash/silt layers contained animal bones, flint artefacts, ornaments, charcoal, etc. This indicates that this area was used as a dump area in the LPPNB (GEBEL and STARCK 1985).

Phase 2 illustrates the post-Neolithic activities in Ba'ja, which are mainly characterized by terrace walls and some stone clusters (Categories 2 and 3). They overlay LPPNB architectural remains and indicate, together with leveled Area B, activities associated with terraced agriculture and herding, but no permanent settlements appear to have been on the site after the LPPNB. This is also proved by the pottery found on the surface which is, even taking into account the collections of M. Lindner and his team, far too diffuse to indicate a later permanent occupation. Since most of the sherds found are Nabataean, we have at least one date for the post-Neolithic activities.

As already mentioned above, the distribution of *manos* and grinding slabs in some areas of the site could not finally be interpreted as representing Neolithic or post-Neolithic food processing zones. We think that they derived mostly from eroded LPPNB walls in which they were used as building material, which was a common feature for the LPPNB (GEBEL, pers. comm.[2]). Another factor that might have influenced their current surface distribution is a possible post-Neolithic re-use, supported by the fact that they were rarely embedded elements of the surface pavement.

Geomorphological Site Setting and Site Preservation (T.K. and H.G.K.G.)[3]

Present-day Surface

The formation of the present-day surface is the result of aeolian, fluvial, and anthropogenic action.

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1 Sandstone disks were also mapped.

2 They did not use only broken grinders in the house walls of Ba'ja and Basta: very often complete and perfect-looking pieces were used as building material. This unexplained feature must have reasons beyond the practical evidence (H.G.K.G.).

3 Parts of this section were translated from the report provided by T. Krämer.

Aeolian activity is limited due to the wind-protected setting of the intramontane terrace of Ba'ja. However, some deflation affected the thin fine-grained top soil, which helped to concentrate the Neolithic building debris to form a stone pavement.

Rain occurs as strong events from late autumn to early spring. The catchment areas of surface water from outside the settled area is not extensive at all; it mainly enters Areas D and G from small gorges north of G, but it does not penetrate into the top soil. Erosional forms are represented by rill and gully erosion. The erodibility is very high, especially in Areas C and F with their high relief intensity (slope of 22° and more). Erodibility in Areas A and D with 13° is weaker. In flat areas and the LPPNB ruins (*e.g.* Square C31 and other intramural parts on the spur on which the excavation took place), erosion "changed" into colluvial deposition. This is especially evident in Area B.

The LPPNB settlement considerably influenced erosion and sedimentation on the slopes of Ba'ja. On the one hand the massive presence of building debris helped to protect from deflation, which otherwise would have reduced the underlying fine-grained sediments. On the other hand, terrace and room walls hindered erosion and accumulated colluvial material upslope behind the structures (clearly visible in the section drawings).

Conditions of Site Preservation[1]

The settlement extends over the eroded steep slopes of Areas A, C, D, E, F and across flat areas with colluvial deposits, such as Area B. During use and after the settlement was deserted, the small rooms were quickly filled by building debris (wall plaster, ceilings, roofs, and walls; *cf.* section: Stratigraphy and Table 2); these kinds of fill reach thicknesses of up to 1.8m. In the colluvial deposits, rubble layers alternate with sandy deposits, whose inclinations are parallel with the slope, while settlement layers and the architecture are bedded horizontally. This interbedding triggers different erosional energy, and structures that function as barriers receive more erosional impact. This in time results in a leveled surface with walls outcropping from the settlement underneath. Since we are dealing with a rill and gully erosion, a rippled relief developed downslope, which can be nicely observed in Area C. In order to explore the extension of the site and the layers on which its architecture was founded, Test Unit 1 was taken down to the bedrock at the bottom of Area C (Figs. 4-5); in addition, we also excavated the step trench in northwestern C3 for this purpose (Fig. 6, Pls. 4:C and 5:C).

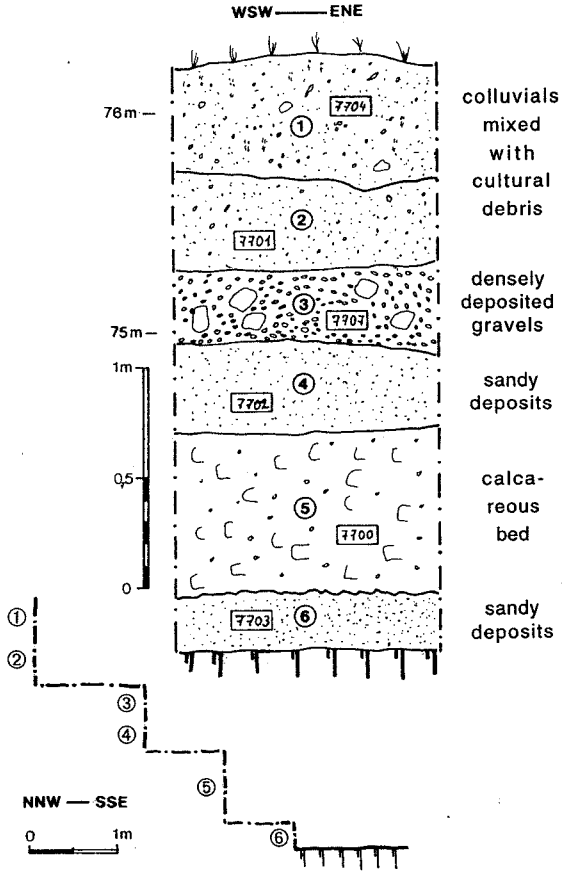

Fig. 5. Pre-occupational slope stratigraphy: supposed intra-montane basin sediments in Test Unit 1 (field record: T. Krämer).

Results from Test Unit 1 and the Step Trench in C3

The stratigraphy of TU1 (Fig. 5) is sterile of cultural remains except for Layer 1 (colluvial material with LPPNB finds). The lower layers (2-5) appear to represent fluvial episodes. The interbedding of sands and gravel/calcareous bands give evidence of different erosional energy. Sandy deposits might hint towards the existence of intramontane lakes. Such lakes would have existed before the *siq*

[1] Other influences on site preservation, not discussed in detail here, include: field clearance activities of historic farming through which stone piles accumulated (Area B), destroyed stone pavements thrown down the slopes for the same reason, and the effects on erosional energy these measures had together with the erected (predominantly Nabatean?) field terrace walls.

cut into the sandstone formations along existing clefts, or during periods when this way was blocked and erosional charges accumulated in the basin of al-Mehmad.[1]

Given the course of the *siq* and considering the morphology of Area C, it seems likely that the western slope of Area C is a cutbank created by high waters flushing down the siq, which also created the amphitheater shape of Area C. The position of this cutbank would make sense in this respect: it is situated just above a spot where, because of a strong rock barrier, the *siq*'s course twice (Fig. 4). This is also where the steepest and narrowest parts of the *siq* begin. If blockage of the *siq* is assumed to have occurred here (or further down?) in the post-Neolithic, it certainly would have resulted in a heavy impact on the preservation of structures potentially located on the lower two-thirds of the slope. This might explain the situation in the step trench in C3 and its immediate surrounding, where a sharp line cuts through the architectural remains at a certain elevation: no architectural remains were preserved below 1077.00m, 1077.60m, and 107800m, although floors and walls extended above these levels.[2]

Discussion: Preservation of the LPPNB Remains

The morphology of a pre-occupational cutbank in Area C would suggest that we are dealing with similar phenomena and affects persisting for site preservation in post-occupational times, and that this was a danger (aquatic activity undercutting the settlement in Area C), of which the settlers must have had been aware, too[3]. This premise can be attacked with the argument that there was not enough water to have caused impacts at heights around 1077m.a.s.l. That would require that, compared with current conditions, the bottom of the *siq* would have to have been 22m higher than at present!

But more than one cause may have operated in this situation. The reinforced terrace wall in C1/11 and the "half" wall fragments in the southern parts of C1 and C2 give evidence for an important problem facing the Ba'ja residents: walls sliding down slopes. This introduces a "slipping " option for the explanation of the lack of site preservation in its lower two thirds, which are the steepest parts in all of the settlement. A "slipping" of complete rooms or even parts of buildings probably did not need a specific layer agent, since the pressure of hundreds of tons of structures on the soft sediments underneath created enough instability in the terraced housing. It is likely that the settlers were aware of this problem: between the western and eastern terrace walls (see below) in C1 - C11 and C2 - C12, at a relatively firm setting on the aforementioned spur, stratified and even two-storied architecture with wall heights of up to 2.2m exist. Towards the steep eastern steep slope they restricted building to only single-phase rooms.

All this evidence suggests that two reasons might be responsible for the present limits of structural remains at the eastern fringes of the excavated area: 1) post-occupational slipping supported by 2) the erosion on a cutbank operating with a temporarily higher *siq* bottom.[4]

Stratigraphy (H.G.K.G.)

The general sequence of events resulting in the stratigraphy registered in the excavated area appears more or less clear and is presented -to avoid a long description- in Table 2. The actual sequence at an individual spot often is more complex, and it is not at all easy to reconstruct the microstratigraphical events and their interbedded deposits. More work must be invested to understand the microstratigraphy, since it is especially important for the interpretation of activities at higher levels (on roofs and upper floors and on terraces further uphill).

In the excavated area we are so far dealing with one main building phase, which shows alterations of an original groundplan through added walls and reinforcements, blockages and insertions of wall openings, and the possible addition of another story in C21 (Fig. 7). These subphases seem to represent locally restricted functional changes, most likely associated with social factors. So far, the western rooms in C21 are a special case: an opening in a lower wall was blocked before the height was increased by a superimposed wall, leaving a step between both faces. This step seems to have been a

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1 The sterile sediments reached in C3 much resemble the common *playa*-like fills in formerly closed intramontane basins of the greater Petra-Area. The nearest such sedimentary environments to Ba'ja are currently exposed at the eastern edge of the Jabu Plain, which itself seems to be a vast *playa*-fill in an unknown palaeotopography. The *playa*-fills of the Petra-Area are a hitherto neglected but excellent source of information for the Pleistocene geography and prehistory, for which these sediments contain rich materials.

2 The next step must be to evaluate the correlation of the stratigraphies of both trenches: TU1 needs to be extended upslope, and the trench in C3 needs to be extended downslope. Dating the deposits is a further need. The hypothesis of the *siq* blocking needs further investigation, too (*e.g.* investigation of preserved sediment traps along and inside the siq.

3 If a damming by fallen rocks happened in post-PPNB times, could it have accumulated gravels that raised the bottom of the *siq* to elevations that were dangerous for the house ruins above?

4 However, there is another possibility. A less sophisticated and dramatic explanation for the sharp cut through the rooms in C3/13/23/33 is that it is the result of minor slipping processes of what was the lowermost architecture in this setting, and that no structures ever existed further downslope.

support for the joists of an upper floor; its height also coincides with the top of a western partition wall. The room below had red-stained wall plaster and contained at least one fallen lintel.

As of yet, no detailed information can be given on the deeper stratigraphy in the excavated area. Since we have no detailed evidence on the palaeotopography of the intramontane terrace at the time when the LPPNB settlers entered al-Mehmad -area, we are unable to make any conclusions concerning a possible occupational phase beneath the remains of Squares C1/11/21/31. The elevational evidence from northwestern C3 may indicate that there is no substantial building phase below; nevertheless, LPPNB sites have demonstrated that they always are good for a few surprises!

Observations at nearby Basta revealed a long use of LPPNB structures, using stable groundplans and maintained with care. The duration of occupation at Ba'ja points in the same direction, although building in Ba'ja suffered from the special topographical constraints and impacts, which might have also influenced the duration of occupation. One major source of information is lost in this special topography: the amount of accumulated cultural debris in refuse areas. While elsewhere thick deposits of trash deposits provides an idea about the intensity/duration of occupation, in the case of Ba'ja this information has gone down the adjoining drainages. What has remained on the site itself are the remains of only the last occupants. In this respect, a careful survey for the small sediment traps in surrounding drainages and terraces are also important for future investigations.

Table 2. Generalized room stratigraphy attested in Ba'ja (Note: Not all deposits/ events need to be represented in a room stratigraphy.).

	Deposit	Event	Position
1a	surface pavement: dense but unstable due to the slope; cover of wall stones protect layers underneath	erosion (little deflation impact)	above (embedded) preserved wall tops, sometimes preserved wall tops are part of surface pavement
1b	topsoil: up to 15 cm thick, fine grained material with finds	very limited soil formation	only exists in certain protected spots
2	colluvial deposit: may reach thicknesses of 70cm, carrying stone rubble of all sizes, including wall stones and finds	erosion of building debris and from upper housing terraces, site's surface with outcropping room walls gets evenly "closed" (post-Neolithic)	intramural or laid against preserved walls or covering walls; may accumulate even as nearly soil-free stone piles
3a	upper main room fill: material of latest collapses and decay of walls /floor/ ceiling / roof, sometimes intermixed with colluvial material arriving from further upslope	collapse and decay of last exposed walls/ ceiling/ roof inside and outside the room, possible share of colluvials transported from higher upslope (immediately after the end of the LPPNB occupation)	depending on the topographical position of the room : central to upper room stratigraphy
3b	main room fill: composed of material from tumbling walls, decaying wall plaster, and upper floor/ceiling/ roofs with their inventory; may contain deposits influenced or created by ruin dwellers	rapid filling of the room interior by the structure's own debris; lower fill may contain temporary floors, fireplaces or other evidence of LPPNB ruin users (immediately after the end of the LPPNB occupation)	major part of room stratigraphy
4	lowermost room fill: shallow layers with temporary floors and high density of cultural debris and artifacts/ animal bones, representing last permanent occupation and ruin use (mostly food processing and preparing, *tabuns*)	first products of collapse and decay mixed with the evidence of last permanent room occupations and/or the remains of LPPNB ruin dwellers	lowermost room stratigraphy above first floors
5	*in situ* deposits related to room function: food processing and preparation, stone ring manufacture, disturbed by events in 4)	related to room function in the LPPNB community	near-floor stratigraphy
6	building and altering of structures (accumulation of immense quantities of stone materials on an unstable slope, partly dug into sterile deposits underneath)	terracing the slope topography by building and changing structures, related impacts (LPPNB)	main building phase encountered above sterile deposits of possibly an intramontane terrace (former basin)

Architecture[1] (H.G.K.G., H.-D.B., J.T.)

The architecture of Ba'ja represents the cellular LPPNB architecture now known from many LPPNB sites in Jordan (Fig. 1). Characteristic for this architecture are 1) small quadrangular/ rectangular/ polygonal rooms connected by wall openings, 2) rooms were built, apparently without open spaces, on terraces in a *pueblo*-type manner, and 3) "aesthetic" double-faced walls with nicely set courses with interwedged smaller stones[2]. We are at the beginning of the study of a vernacular LPPNB

[1] The research on the Ba'ja architecture included an investigation on the role of architectural pre-planning, which was commissioned and funded by the Deutsches Archäologisches Institut, Orient-Abteilung. We thank Ricardo Eichmann for his trust in our approach to these difficult questions.

[2] This LPPNB "wall aesthetics" could be misunderstood as a dating feature. We do have this wall technique in the LPPNB where ever tabular stone materials existed (even today); the erection of these walls and their dressed wall faces was executed

architecture, a new and most rewarding chapter in the history of Near Eastern architecture. It is the richest source we have so far for the understanding of PPNB social patterns, as this is well demonstrated by the contribution of G. Rollefson in this volume. A future need will be more attention for functional aspects attested archaeologically, to be reconstructed from more work on room furnishings and inventories. A major concern in that respect must be the proper investigation of room fills that might contain materials from a second floor or the roof underneath slope wash layers.

Building Layout and Functional Aspects (Fig. 6; Pls. 2-5)

As explained before, only Squares C1 - C2, C11 - C12, C21 - C22 and C 31-32 of the excavation area contained well preserved architecture, which represented a *pueblo*-type terraced housing, with some evidence for true two-storied structures (at least in the westernmost rooms of C21; *cf.* Fig. 7 and Pl. 5:A). The top of the wall ruins occurred just below a thin layer of colluvials or were exposed on surface.

The principal rooms in the excavated area are more or less rectangular and thus probably planned on even terraces. They are expected to have a deeper stratigraphy and be partly two-storied. Terrace walls clearly exist (the one running NNW-ESE in C11/C1, and one N-S and somewhat bent in C12/C2); both these walls protected the large rooms between them, most likely fortifying here against the spur-like topography. Their structural engineering did not differ much from ordinary walls, although they were somewhat thicker. This might have caused stability problems; for example, the terrace wall in C11/C1 was reinforced by a second wall to the west. Since that action did not seem to provide reasonable stability for the terrace, two additional buttresses were added, partly built over the first reinforcement wall (Pls. 4:A and 5:B).

While we have no evidence so far for architecture west of this reinforced terrace wall (either due to erosion or to the possibility that we are still too high in excavation), the evidence on the eastern side is clear: here a chain of small rooms (C2/12/southern C13) existed without evidence for an upper story, a feature that would not be unexpected in this extreme slope setting. Their ground plans tend to be polygonal, which is interpreted as an adaptation to the contour lines of the slope in order to establish a degree of structural stability. At least the easternmost rooms in C2/12 seem to have been dug into the sterile layers underneath, on which floors may have been created using a cobble bed with superimposed whitish (lime) plaster (*e.g.* Pls. 4:C and 5:C). It became clear at this spot, at least, that walls were also founded directly on such floors (Pl.5:C: here a small partition wall) without any further foundation!

The depths reached in Squares C11, C12 and especially in C31 and 32 are not sufficient to conclude on the rooms' functions. Here we still are in the room fills from three sources: activities of ruin users intermixed with material from fallen walls (and in some cases possibly from second stories or the roof) and colluvial debris carrying LPPNB artifacts.

We cannot identify yet functional units. But, with reference to ground plans in Basta, 'Ain Jammam (WAHEEB and FINO, this volume) and es-Sifiya (MAHASNEH, this volume), there are reasons for the assumption that we have two building units in the excavation area that roughly follow the scheme of a central courtyard with adjacent small rooms. These courtyards are probably represented by the large spaces mostly covered by C11 and C21/C32. In the large room mainly in C11 we found a sequence of fire pits, a stone-lined structure with an inserted grinding slab and many *manos* (food-processing area), as well as a large amount of sandstone disks ready to be transformed into stone rings (production of this prestige goods on a household level).

The construction formula consists of a courtyard or large room with surrounding rows of small cells, which seems to be common for the LPPNB of southern Jordan. This element of LPPNB planning was altered where topographical conditions dictated, as on the slopes of Ba'ja. We stress that regional climate should receive more attention in the interpretation of LPPNB courtyard houses; representing "closed" units centering inwards (NISSEN, MUHEISEN, and GEBEL 1991: Fig. 1), they are shady and cool in summer and retain warmth in winter (Ba'ja at 1060 to 1095m a.s.l., Basta at 1460-1420m, 'Ain Jammam at 1290-1240m; see discussion in GEBEL n.d.). The rooms within such a unit are connected only by wall openings for ventilation and light and possibly through the ceilings; wherever two-storied structures existed, the lowermost rooms might have had a cellar-like character preserving the produce of the inhabitants from climatic impacts. If there is a social meaning behind these ground plans, this must remain speculation: The use of common walls for the units results, in principal, in complexes without passages and open spaces. This makes them in a way a communal

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with great care, resulting also in good stability for these walls. But when no such building materials were available, *e.g.* near cobble-carrying wadis (as attested with the settings of Wadi Fidan A and C or Ghwair), this architecture *appears* "non-LPPNB". As attested now at Ba'ja, even in areas with tabular raw materials a large variety of wall qualities (*cf.* Pl. 5:D) may appear, but this was the consequence of less skilled repairs or changes of ground plan and not from later period construction episodes. "Wall-face chronologies" are dangerous. (H.G.K.G.)

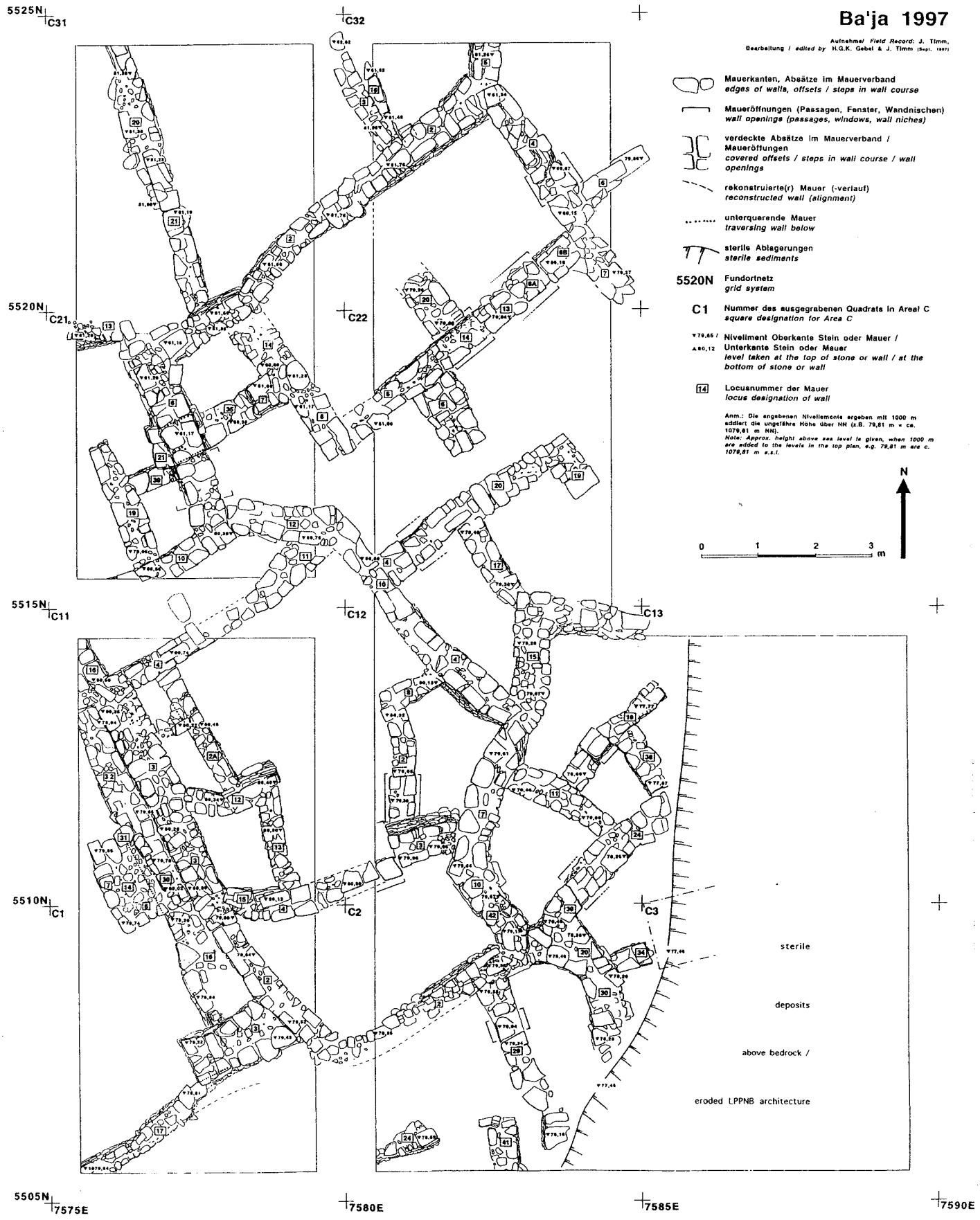


Fig. 6. Architecture of Main Building Phase excavated in Squares C1-3, C11-13, C21-22 and C31-32.

Plate 4:A. Terrace Wall in C1/11 (Loci 2-3), with attached reinforcement wall (Loci 16/32) and buttresses (Loci 3 and 6/7/14), from S (photo: Fengler/Höffgen).

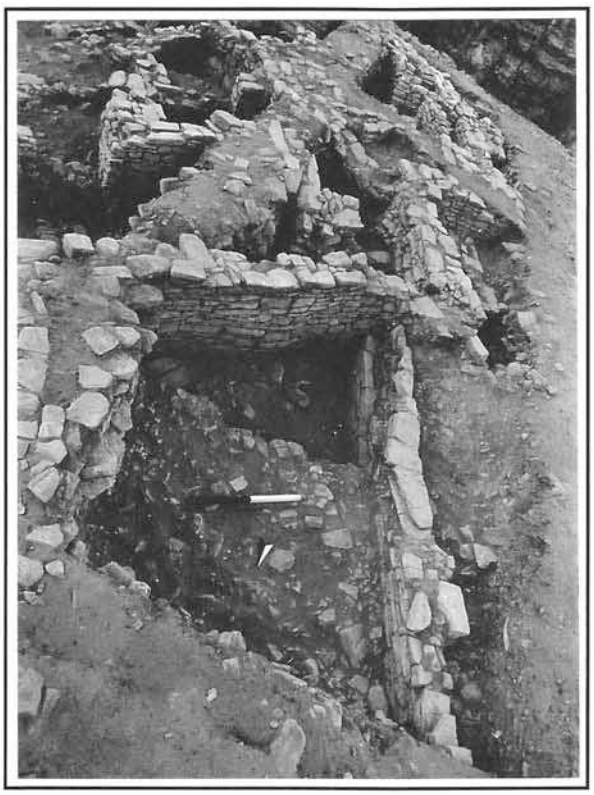


Plate 4:B. View from N with the large, partly excavated room in C31 (foreground), followed by C21, C11, and C1 (photo: Fengler/Höffgen).

Plate 4:C. Northeastern corner of C2 with floor cut by erosion, and trench into sterile sediments, from NE (photo: Fengler/Höffgen).

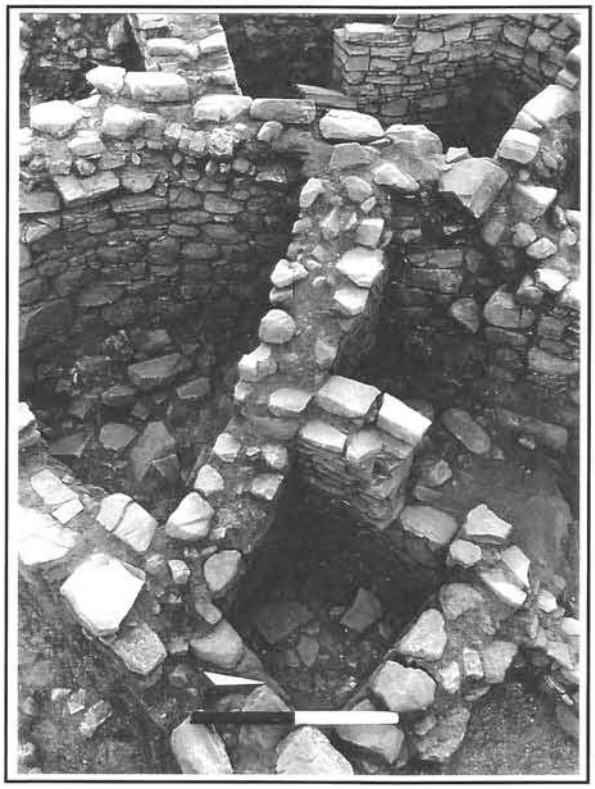


Plate 4:D. Part of the curved terrace wall Loci 42/10/7 in C3/13, and the adjoining polygonal/ irregular rooms, from NE (photo: Fengler/Höffgen).

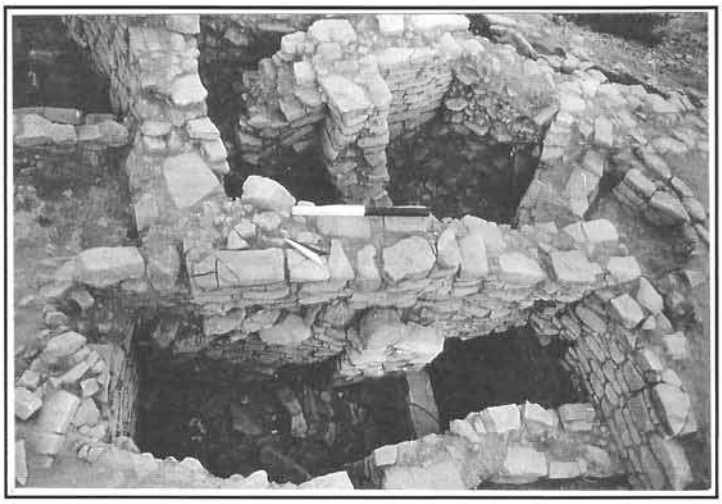


Plate 5:A. View into a two-storied room in C21 (foreground) with a room partitioning wall, a fallen lintil, and the support for the second floor, from W (photo: Fengler/Höffgen).

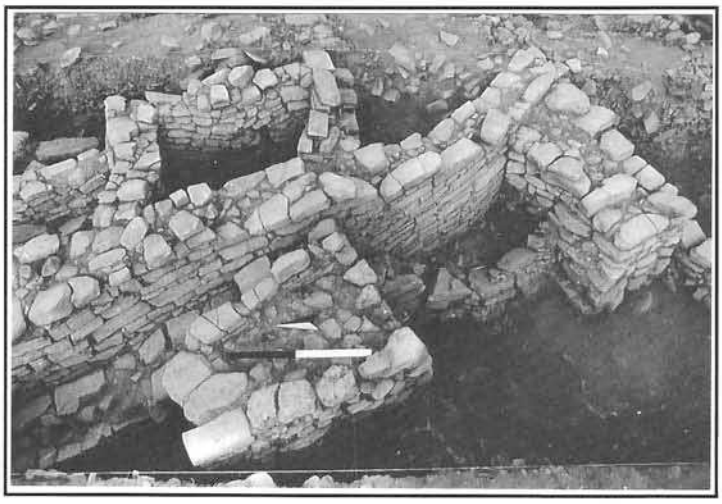


Plate 5:B. Another view (*cf.* Pl. 4:A) of the reinforced terrace wall in C 1/11, from W (photo: Fengler/Höffgen).

Plate 5:C. Stone layer on the sterile deposits used as the foundation for a lime plaster floor, on which a small partition wall was directly built (C3, Loci 3-6) (photo: Fengler/ Höffgen).

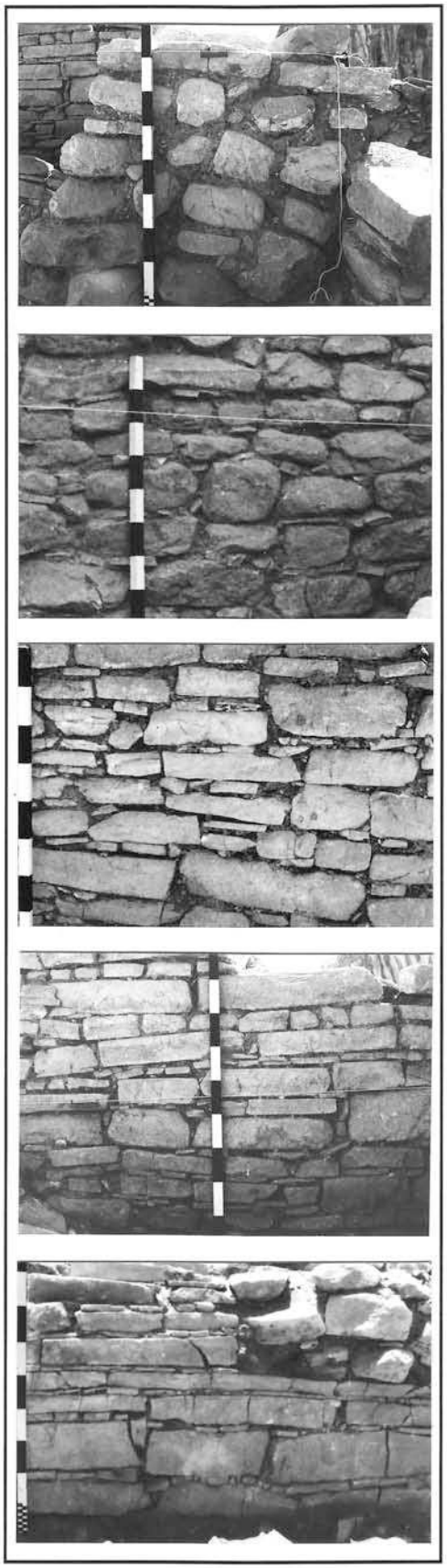
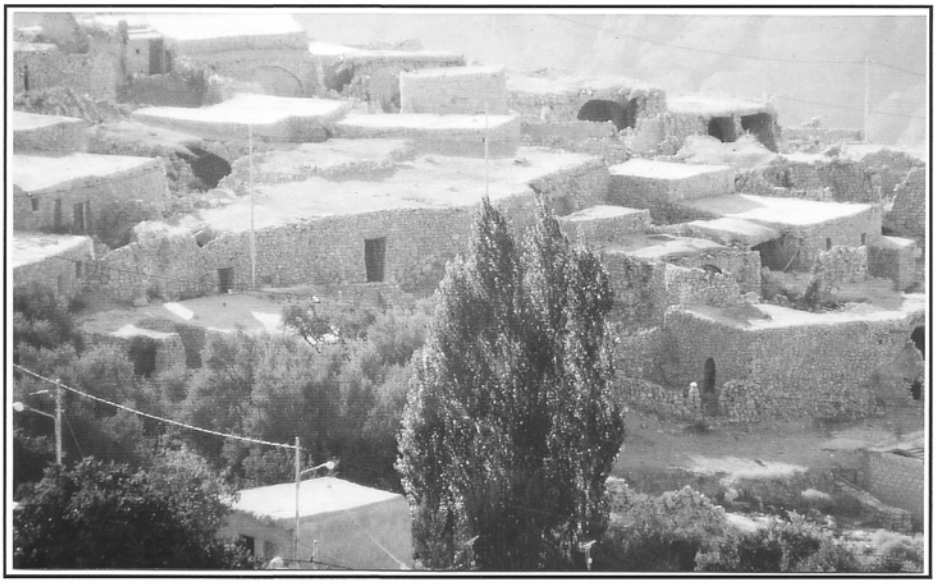


Fig. 5:D. Examples of the various qualities of stone masonary attested in Ba'ja (photos: Gebel).

Plate 6:A. Surface of a clay sherd from the LPPNB layers in Ba'ja (photo: Bienert/Fengler/ Höffgen).

Plate 6:B. Traditional terraced housing in the region: Dana village.



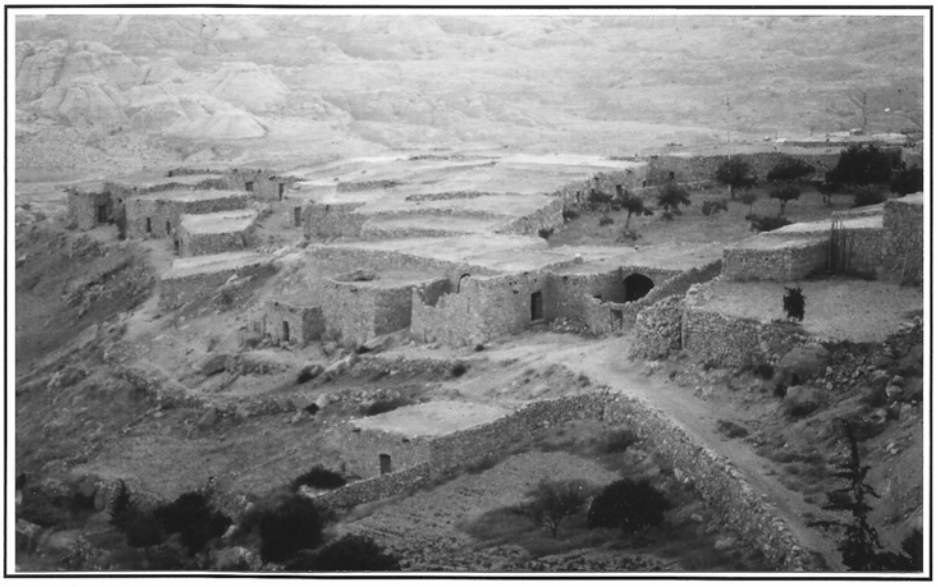


Plate 6:c. Traditional terraced housing in the region: Tayiba village.

fortified complex not easy to enter and better to control. Most likely we are dealing with an architecture with an internal orientation in most respects (GEBEL n.d.). If we may speak at all of "public" and "private" sectors for the community of Ba'ja, communication between the units may have occurred via the roofs of the terraced housing, the roofs serving as "public" spaces for the settlement.

Three types of activities have so far been identified by *in situ* evidence: 1) The previously sandstone ring manufacture, 2) food processing, and 3) food preparation. The last is represented by the chain of small rooms in the east of C2/ C13/ C23: here the clay sherds of many installations were found, together with many animal bones and ash. Most likely the ash was disposed downslope, a feature quite common for the *tabun* areas in the fringes of present-day traditional villages in the region. So far we interpret these clay sherds as the remains of ovens used for baking and roasting. Their use and function might be similar to those still in use today (*cf.* GEBEL *et al.* 1994).

We have not found burials in the architecture yet, but most probably we can expect them eventually. Human remains were encountered among the trash deposits in Test Unit 2 in the "Snake Valley" just north of the site (just 30-40m north of the excavated area). Given the LPPNB habit to bury intramurally, and to remove post-cranial bones of disturbed burials (during rebuilding episodes, for example) into dumps, this evidence from TU2 is a strong hint for burials inside the Ba'ja architecture.

Functional changes in the architecture were reflected by inserted walls, changed wall courses, blocked wall openings, etc. To interpret these changes remains a task of a comprehensive functional analysis that must take into account the different wall qualities (Pl. 5:D). We have no evidence for any later occupation influencing the main building phase encountered so far in Ba'ja (except for activities of ruin dwellers, which we expect to belong to the LPPNB, too). Thus we consider the different wall techniques as applied within a single phase, representing functional changes and carried out by persons with different masonry skills. As far as can be interpreted, the walls of the stable and long-lived ground plan were planned and built by masonry specialists, while later alterations could have been carried out on the "household level" by persons without specialist skills.

However, in general one could say that the quality of buildings and building techniques in Ba'ja is somewhat "less skilled" compared to Basta, 'Ain Jammam, and es-Sifiya, and that (lime?, not analyzed yet) plaster floors are rare compared with these large sites[1]. Ba'ja, in this respect, triggers the implication of a more rural settlement.

A pre-planned, intentional ground plan seems to be inherent in the architecture. Preconceived layout ideas were executed by adaptation to the slope topography and by building on surfaces created by terraces. The evident digging of rooms into the sterile layers is another sort of "terracing" measure. As suggested by the site survey, walls did not necessarily follow contour lines. Most likely long-used major walls served as stable compound and terrace/retaining walls for the terraced architecture, and this explains that both social *and* physical topography were elements of planning and spatial stability.

Building Techniques (J.T.)

The dramatic topographical setting of the LPPNB architecture in Ba'ja required building techniques that were not necessarily matched by the builders' skills. The techniques can be characterized as follows:

As for the floor and sub-floor construction, we have limited evidence so far. We can distinguish between casual temporary earth floors within the lower room fills and intentionally constructed lime and stone slab floors. While the first are common and the result of use (including activities that raised intra-mural levels), identified by horizontally bedded finds, the latter two types are not well attested: lime floors, if set in a room at all, seem to be preserved only for earliest excavated occupations, and one floor paved with large sandstone slabs (Locus 22 in a room-like structure in Sq. 11 between walls Loci 2A and 3). The best example of a lime (?) floor with preserved patches stained in red (Pls. 4:C and 5:C) was found in the NE corner of C2 (Loci 33/36) and partly in C3 (Loci 4-5): It was constructed on a surface, which was dug into the sterile fine-grained sediments underneath. Hereon, the builders placed a layer of over-fist-sized gravels, which was filled and leveled by finer stones and a thick lime "bed". Near the floor's surface this bed had an increasingly higher lime component; in the uppermost centimeter it was a solid but crumbly preserved plaster spread. Stray fragments and *in situ* evidence prove the existence of red and cream stained plaster coats. (For terminology and similar floor construction from Basta, see REHHOFF KALISZAN with GEBEL n.d.). All these layers had a thickness of 5-6 cm, and extended up onto the interior wall in bathtub fashion. It represents the standard construction of LPPNB floors in the area.

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[1] Red-stained plaster was found *in situ* only attached to the walls of the lowermost room in C21, where we have evidence of two storeys, and at one other wall. Particles of red-stained plaster in the room fills were rare, too, and this was also true for the Soundings SI-III in 1984.

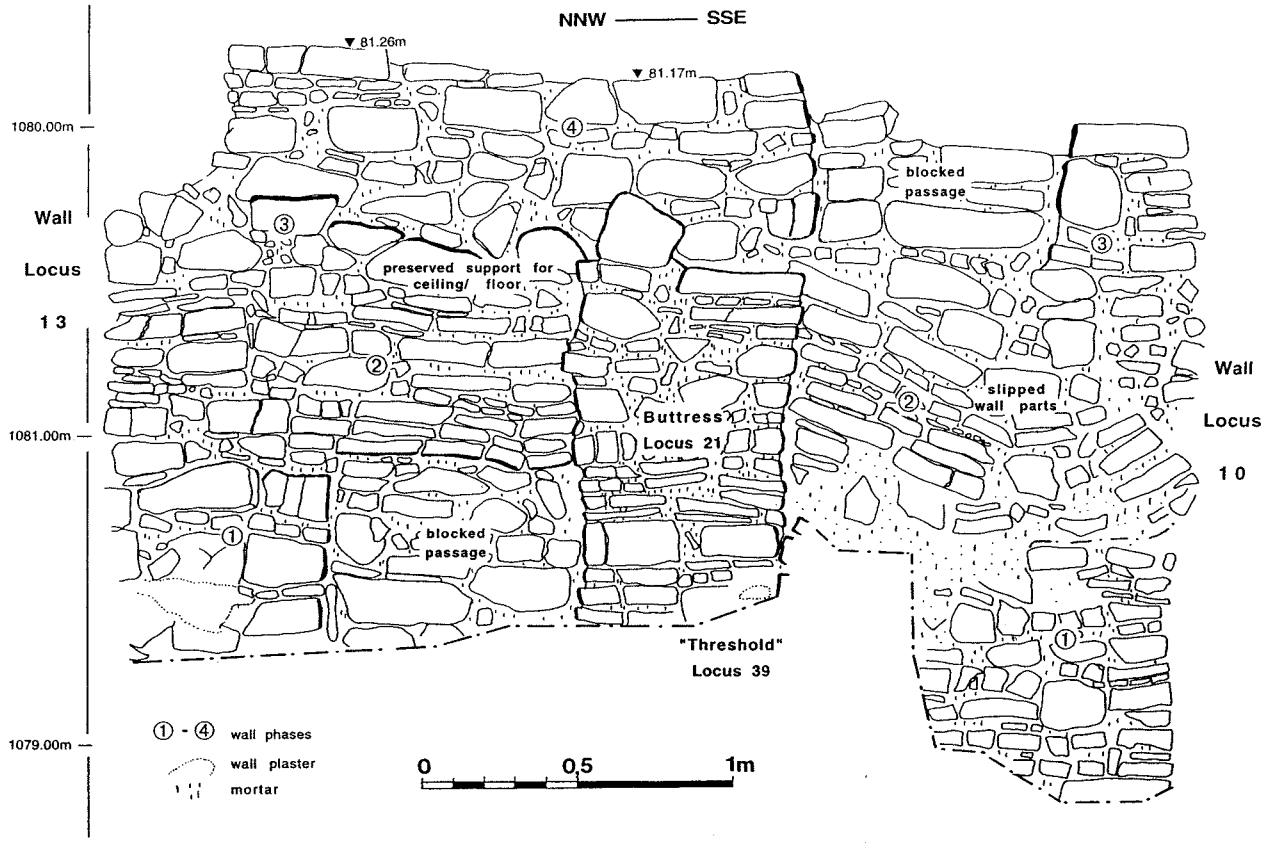

Fig. 7. Western face of wall Locus 6 in the two storied room in western C21 (drwg.: Dahl Hermansen).

Channel-like subfloor construction for leveling the building grounds and probably for a dry room climate (as attested in Basta, es-Sifiya, and 'Ain Ghazal) is not yet attested for certain.[1] So far we have not reached evidence for wall foundations; however the example Pl. 2:C shows that walls could be just founded on a floor.

The wall techniques in Ba'ja can be well compared with other LPPNB sites. All wall qualities are attested, ranging from cobble walls to properly set double-faced walls made of selected regular thick local sandstone slabs that were roughly dressed and stabilized by "interwedged" smaller stones in parallel courses (*cf.* GEBEL and BIENERT 1997). Plate 5:D illustrates the different wall types present. The faces of double-faced walls were not linked with headers, which caused a considerable structural instability in this slope setting (*e.g.*, the long wall that fell apart in C1/2, Loci 17/2 or the fragment of Wall 24 that washed downslope in C2). The double-faced walls reached thicknesses of more than 60cm; the spaces between the two faces were filled with mortar and smaller stones of various sizes. Mortar was used for all the walls; dry stone masonry is not yet evidenced. The mortar does not seem to contain lime, but instead it appears to consist of silty-sandy material of possibly on-site origin. (A possible source might be the *playa* sediments underneath; GEBEL, pers. comm.). Wall plaster is rarely attested *in situ*; a "larger" piece of red-stained wall plaster was found just above the floor on the walls Loci 6 and 13 in Square C21.

Another element of structural instability is often visible at wall joins: meeting walls were frequently just abutted against each other without bonding, although often wall corners were constructed properly with bonding courses. However, the Neolithic architects knew measures to respond to the structural instability of room and terrace walls. For example, in C1/11 they added another wall (Loci 16/32) in front of an endangered terrace wall and applied additional necessary buttresses (Locus 3 and Loci 6/7/14) (Plate 3:A).

[1] However, the sediments of the floor layers excavated in the room west of Wall 6 in Square C21 were found trickling into cavities below, a common feature that in Basta announced such channel-like subfloor construction.

Connections between the rooms only are reflected by window-like wall openings, the size of which often would not allow a small person to pass through. They have nicely built jambs and lintels of large tabular sandstone. A true passage with fallen lintels was found between Walls 6 and 19 in Square C21 (Plate 3:B).

The stone building material comes from two sources: the majority was selected from the nearby consolidated bedded layers in the Ordovician sandstone formations, while the cobbles for the "less aesthetically" built walls probably derived from the gravels of the *siq*, which also brought down types of sandy limestone.

There is indirect evidence for roof construction. The good preservation of the small rooms indicate their rapid filling. This material could only have come from upper floors or roofs and the possible walls of second stories (*cf.* GEBEL and BIENERT 1997). We reconstruct the roofs and upper floors as being supported by wooden beams (which need not have spanned large rooms, anyhow), over which a secondary layer of branches and twigs was laid. Periodical renewals of mud plaster may have resulted in a considerable thickness of ceilings, as can be seen in present-day traditional architecture in the region.

Although the wall techniques at Ba'ja evidence a high skill in setting "aesthetic" courses and precisely built corners and wall openings, the constructive skills and the structural know-how of the builders was somewhat undeveloped for the needs of terraced slope architecture: the lack of wall foundations, non-bonded walls, the absence of headers in double-faced walls. The last two features reflect a "naive" static understanding. The builders were not able to cope with the dangers of an earthquake-afflicted region and the extreme slopes on which they settled. The structural engineering at Ba'ja was not yet developed enough for a stable terraced housing, and it might not have been accomplished here during the LPPNB.

Flint Industry (Figs. 10-11) (H.G.K.G.)

The primary production of the flint industry contains very few "true" naviform cores and their typical preparation waste. There are instead bi-directional cores that recall the intention of the naviform technology, this material- and effort- efficient detachment of blades flourishing in specialized workshops of the LPPNB (for cores found at Ba'ja, see BIENERT and GEBEL n.d.). The bi-directional Ba'ja cores often have circular striking platforms with detachments all around the core's edges. Cores were reduced completely, and blades in Ba'ja are shorter on average than those from the workshop areas in Basta, for example. A contributing factor might be the fact that the tabular flint exploited by the Basta workshops is rare at Ba'ja: instead, most of cores are of a grayish flint raw material group, also well-known from Basta (MUHEISEN n.d.: Flint Raw Material Group 3). They are mainly nodules with minimum sizes of 8cm, but sizes may range up to 20cm or more. The raw material comes from the limestone formations east of Ba'ja, transported in part from here through the *siq* to Ba'ja, where they occur as lenticular and/or semi-tabular forms. Their matrix is fine-grained to slightly fine-grained and homogeneous with almost no inclusions; the flaking ability shows a tendency for a tenacious character, sometimes resistant against an uncontrolled spread of the removal energy (good flaking quality). Colours vary from "gray - pinkish gray - light gray - white- pinkish white" to "white - very pale brown - light gray, gray, light brownish gray - pale brown - light yellowish brown".

Aside from the non-naviform bidirectional cores at Ba'ja, there are also unidirectional blade cores in addition to many flake cores. Workshops have not been found at Ba'ja yet, and cores are generally quite rare. We expect that this may be the result of constant clearance of this potentially harmful waste, as evidenced by the masses found in TU1 and Sounding I. Nevertheless, this is no argument to assume a significant number of workshops on the site.

According to first insights and observations from 1984, the tool kit appears somewhat restricted as compared with Beidha and Basta. It comprises the following tool classes :

1. heavy duty tools: hammerstones (frequent), celts (frequent), adzes, and chisels;
2. non-formal tools (all sorts of retouched blades and flakes);
3. formal tools (types): leaf-shaped arrowheads (frequent), tanged arrowheads, scrapers (frequent), borers with tips <2mm, heavy duty borers, and denticulated blades (rare).

Since we lack drawings of the 1997 materials at the present time, we selected similar material from earlier surface collections for illustration (Figs. 10-11). Many of these types were also present in Sounding I in 1984 (GEBEL 1986: Fig. 11, except piece No. 20). Leaf-shaped arrowheads with two S-shaped edges seem to occur often; one Khiamian point was found on the surface.

As a preliminary observation, we would interpret the tool kit as representing daily need activities on household levels rather than representing manufacturing goods on an "industrial" surplus scale. However, the expected tools used for chiseling/ graving the sandstone rings (see below) have not been identified yet among the chipped lithic implements.

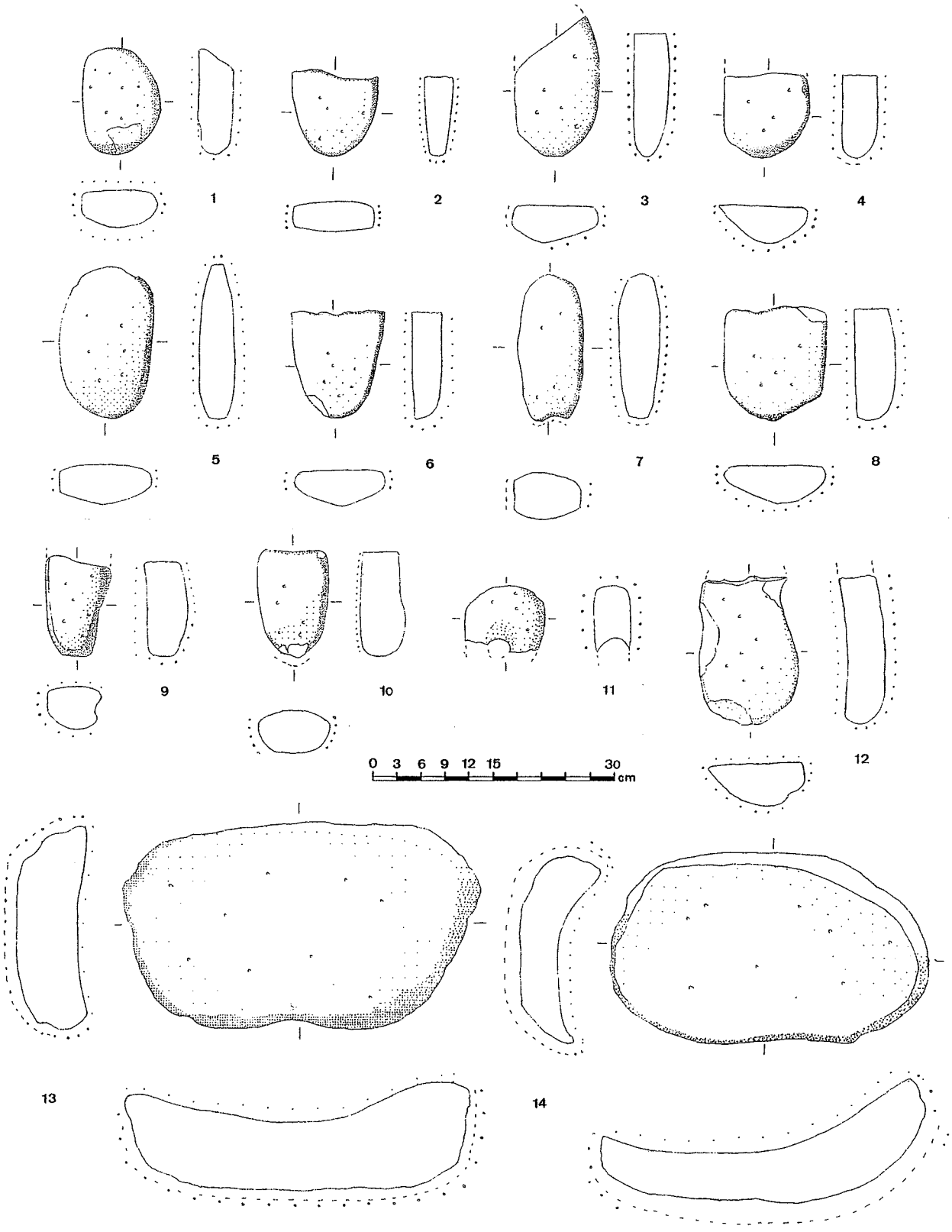

Fig. 8. Ground stone industry (surface investigation K. Wright, 1987): 1-9 handstones (1-2 bifacial ovate/ lenticular, 3-6 bifacial ovate/ triangular, 7 bifacial loaf/ ovate, 8 bifacial rectilinear/ triangular, 9 bifacial rectilinear/irregular), 10 handstone/ pestle, 11 "weight", 12-14 grinding slabs (12,14 saddle; 13 trough) <illustrations by K.I. Wright>.

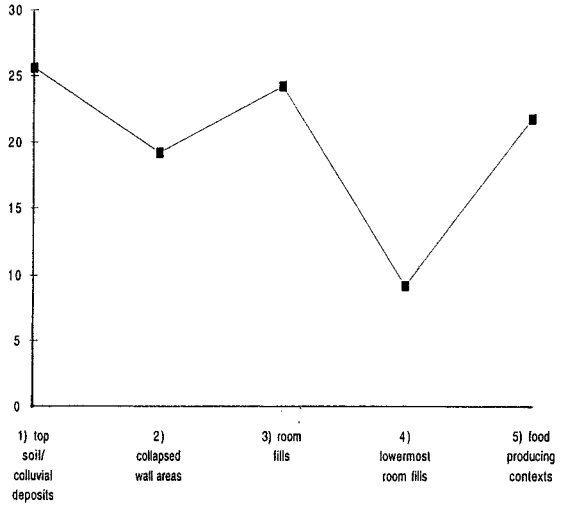

Fig. 9:a. Frequencies of ground stone tools in the various stratigraphical units (%).

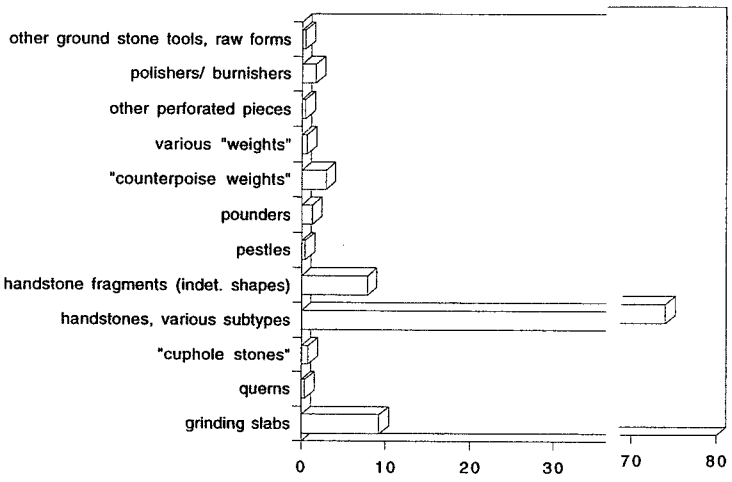

Fig. 9:c. Frequencies of ground stone tool classes as distributed in all excavated loci (%), *cf.* Table 3.

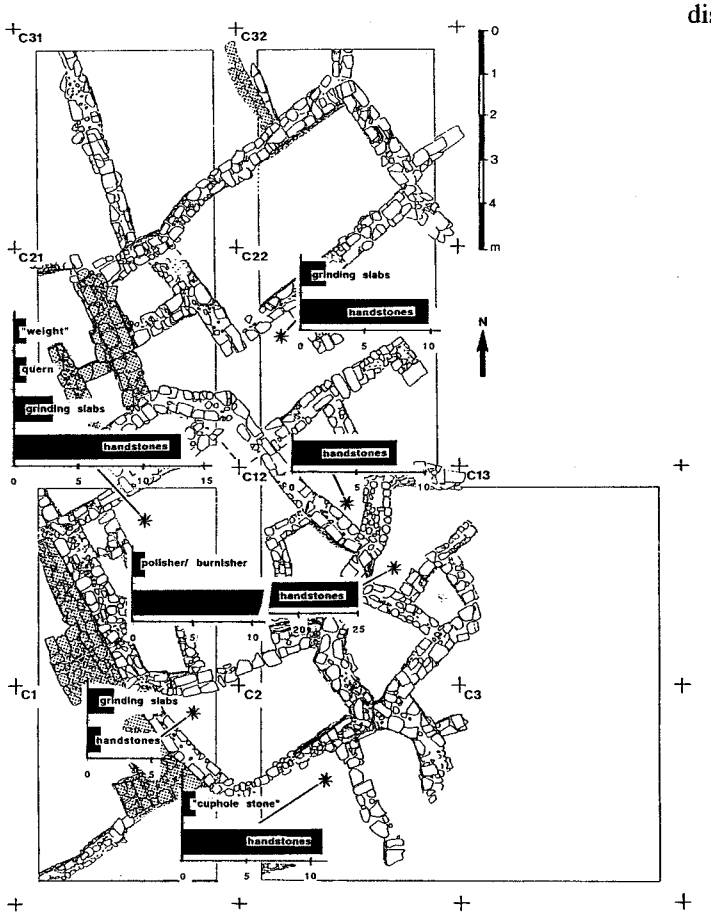

Fig. 9:b. Major *in situ* evidence of grinding activities in the excavated LPPNB layers by numbers of attested ground stone tools

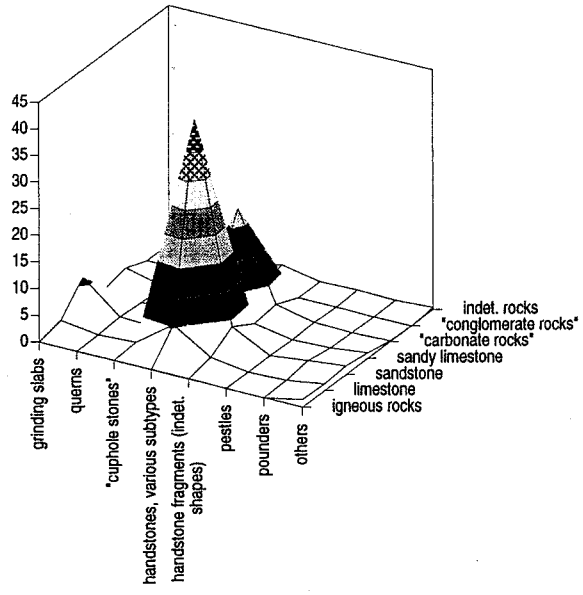

Fig. 9:d. Frequencies of ground stone tool classes as represented in the raw material classes (%).

Fig. 9. Frequencies of ground stone stools and their raw materials from the LPPNB layers in Area C.

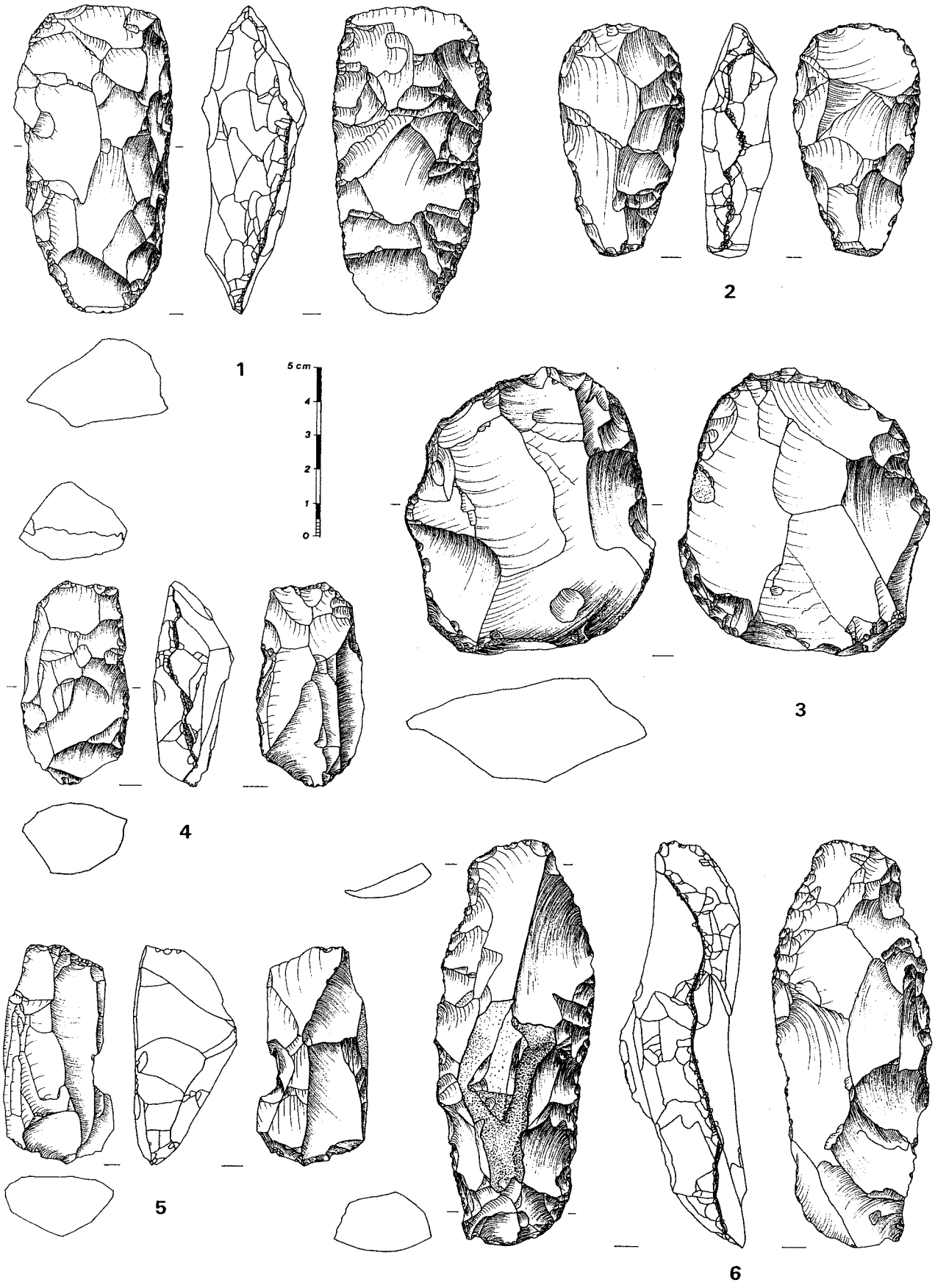

Fig. 10. Selection of heavy duty tools : 1-2 celts; 3 cleaver-like instrument; 4-5 adzes; 6 adze/ celt (all from surface). <illustrations by I. Raidt; material of the P.I.G.P.A. collections>.

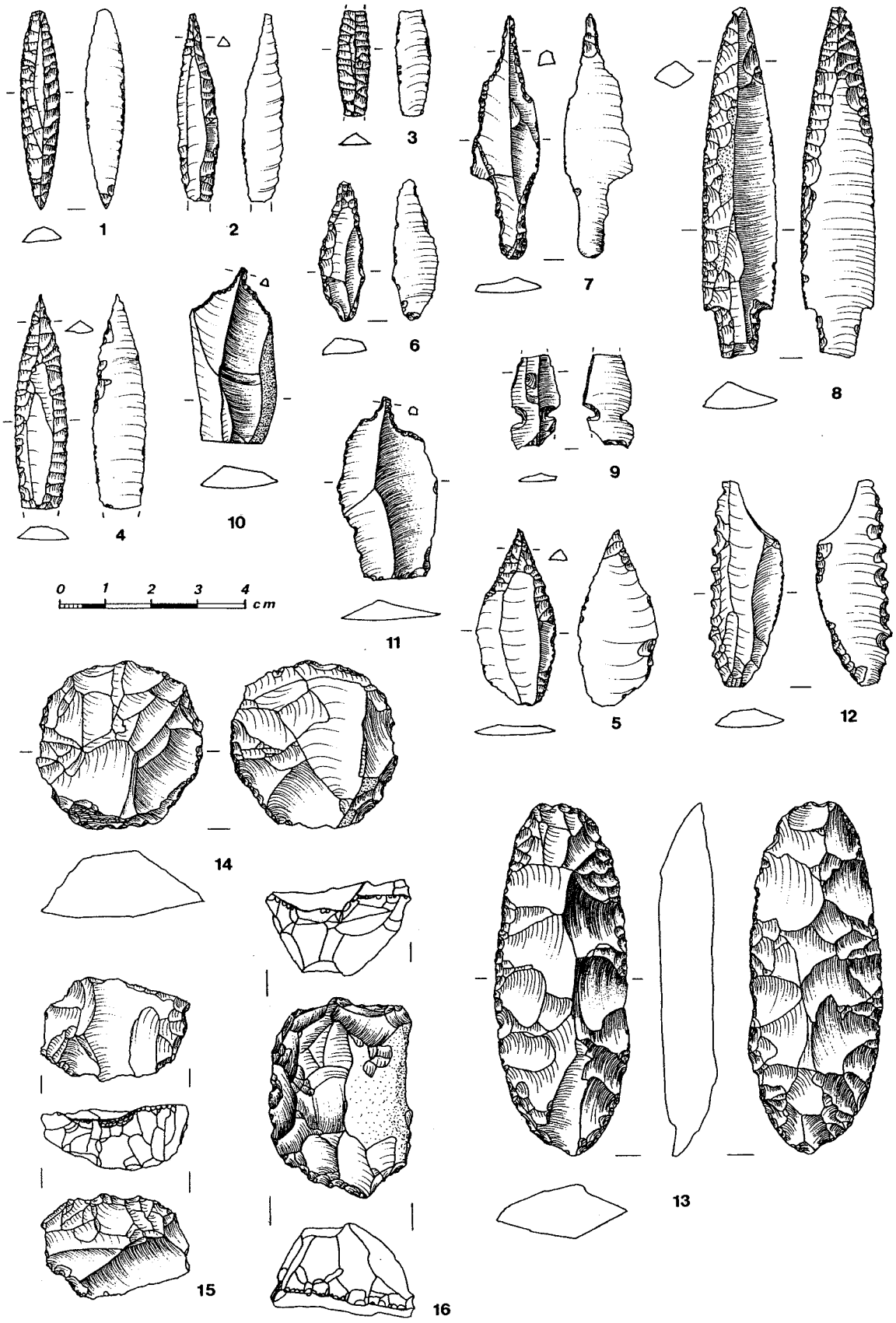

Fig. 11. Selection of chipped stone tools (from surface): 1-9 arrowheads (1-4 elongated and 5 unfinished leaf-shaped; 6 atypical leaf-shaped; 7-8 tanged; 9 Khiamian point); 10-11 borers with tips <2mm; 12 denti culated blade; 13 foliate; 14-16 scrapers (14 round, 15 one-sided, 16 two-sided) (all from the surface). <illustrations by I. Raidt; material of the P.I.G.P.A. collections>.

We excavated the dump area of TU2 in "Snake Valley" in order to enlarge our chipped lithic assemblage. In this sample (F.no. 2123), only a small number of cores was found together with some crested blades, but a large number of bi-directional blades is attested, together with a dominating element of flakes.

Ground Stone Industry

The ground stone industry attested is typical for the LPPNB large settlements and also well represented in Ba'ja. However, stone vessels are rarely attested, which remains a puzzling feature.

Results from the 1987 Surface Investigation of Ground Stone Artifacts (K.W.)[1]

The aim of the systematic surface collection at Ba'ja[2] was to compare it with stratified assemblages from 'Ain Ghazal, Basta and Late PPNB sites in the Azraq Basin. Documentation of ground stone assemblage variations from sites in different environments is a prerequisite to an understanding of changes in the technology and organization of plant-food processing and consumption with the growth of agricultural villages (WRIGHT n.d.). The surface sampling procedure at Ba'ja itself was intended 1) to permit estimation of the full variation of ground stone and 2) to obtain a statistically useful sample.[3]

Technology, Typology, and Raw Materials

Ground stone artifacts have received little attention in prehistoric studies, a circumstance that is puzzling since they are highly relevant to the origins of food production. Most studies of these artifacts have dealt with them as "finished products" and classified them according to a wide range of typologies based on various morphological criteria. In place of these "normative" typologies, a recent analysis of ground stone assemblages in the Levant has shown that these tools may be better understood as products of a particular set of lithic reduction strategies (WRIGHT n.d.). Different tool forms may be the result of differentials in blank selection, manufacture, use, refashioning and discard of these items, as has been shown for certain chipped-stone assemblages (*cf.* DIBBLE 1987). In fact, many of the analytic techniques that have been applied to chipped stone are valid for ground stone, even debitage analysis, since many ground stone tools are made via flaking as well as pecking and abrasion. In this summary, only the descriptions of the sampled Ba'ja tools are presented. (For the definitions of the classes see WRIGHT n.d. and the final report of this study)[4].

As at Beidha and Basta, the great majority of the Ba'ja artifacts are large and made on local sandstone types (see following section). Sandstone is not necessarily the best material for grinding/ pounding tools, as sand grains are easily detached and the use-life of the tool is shortened by many "resharpenings." Basalts are superior materials for grinding tools (the nearest large source of basalt to Ba'ja would have been Shobak, 35km away). However, the use of local materials for large utilitarian ground stone tools is characteristic of village sites in the PPNB.

Grinding Slabs/ Querns

Saddle-shaped Grinding Slab (N = 4) (Fig. 18:11-14)

Two complete and two fragmentary saddle slabs were recovered. Of the complete examples, only one is very large (No. 9609). These artifacts were heavily used and were made by flaking and

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1 This contribution is a summary of a final report provided by K. Wright for the final publication of the project *Paleoenvironmental Investigations in the Greater Petra- Area - Holocene Research* in 1990. The typology therefore is slightly different in some aspects from the classification published in WRIGHT 1992b.

2 This surface investigation was carried out in Ba'ja while visiting the Basta Joint Archaeological Project in 1987. My thanks go to the Department of Antiquities, and its local representative at Petra, Suleiman Farajat, for providing me this opportunity, and to the Basta J.A.P. for its hospitality. Hans Georg K. Gebel invited me to study the surface ground stone industries of Ba'ja; Cornelia Becker, Reinder Neef and H.G.K. Gebel helped me carry out this strenuous work. I appreciated and acknowledge my discussions in Basta with Nabil Qadi, Yarmouk University, about LPPNB ground stone industries.

3 For the systematic sampling, Area A (*cf.* Fig. 4) was divided into 24 squares of 5 meters on a side. Using a table of random numbers, a 50% sample was chosen from this universe. Twelve squares were randomly selected for collection and all ground stone artifacts found in each of these squares were removed for study. When this procedure was completed, a small judgement sample of large grinding slabs from Area F was collected. The total number of artifacts removed from the site was 53.

4 It should be noted that the descriptive typology as used herein is regional in scope, hierarchical, and flexible enough to permit addition of new types when new material is excavated. In format this typology is structured in ways similar to those for chipped stone tools. That is, the typology is based on variations in blanks, primary and secondary reduction techniques, and the morphology and wear patterns of use surfaces. These variations permit general functions to be identified, although determination of specific functions must await residue or chemical analyses.

pecking. Large, squamous flake scars cover the dorsal sides, indicating that removal of extra weight from the blank was desired.

Trough Grinding Slab (N = 1) (Fig. 8:13)

A single complete trough grinding slab was recovered. This is the largest and heaviest ground stone artifact in the sample; trough grinding slabs or querns are well known from PPNA until the Middle PPNB sites such as Nahal Oren, Jericho, and Beidha.

Slab/Quern Fragments (N = 4)

The grinding slab fragments require little comment. All are made of sandstone.

Miscellaneous Grinding Slabs/ Querns (N = 3)

The three small slabs included under this category are small (hand- held?) saddle-shaped grinding slabs that could have been easily moved from one place to another. We have simply called these "small grinding slabs." They are made on elongated cobble blanks similar to those used for loaf- shaped handstones. However, the concave use surfaces indicate that these are actually lower stones in a pair of tools. Similar tools are common at Basta (QADI in GEBEL *et. al.* 1988: Fig. 12:1).

Mortars

Mortar Fragments (N = 1)

This fragment is classified as a mortar since there is evidence for a concave surface indicating pounding but no finishing to suggest that it was a vessel. It may be noted that rough mortars are not particularly common among PPNB sites, although carefully made stone vessels are very common.

Handstones (N = 4)

Three of the handstones of this class are made of sandstone and one is of quartzite. These tools appear to have been made on loose surface cobbles as blanks, most of which do not appear to have been water-worn. These tools tend to be about 100 to 150 mm. in length and 80 to 90 mm. in thickness. They could thus be used with one hand. Similar tools are documented at Beidha (WRIGHT n.d.) and Basta (QADI in GEBEL *et. al.* 1988: Fig. 12:6).

Bifacial Ovate/Planoconvex Handstones (N = 2)

Only fragments of this type were recovered, though enough of the tools remain to make them identifiable. One of them is of limestone. These types are common at Beidha, too.

Bifacial Ovate/ Triangular Handstones (N = 7) (Fig. 8:3-6)

This is the most common handstone type in the collection and reflects the use of handstones in a rocking motion. Strictly speaking, such tools are actually "trifacial," having a flat surface opposite to two adjacent surfaces which form an angle. Similar tools are seen at Beidha and Basta (*e.g.* QADI in GEBEL *et. al.* 1988: Fig. 12:7). These tools would be expected to represent an advanced stage of use.

Bifacial Loaf/ Oval Handstones (N = 3) (Fig. 8:7)

Three complete examples were found. The lengths of these are similar to the widths of the complete saddle slabs . Occurrence of use-striations along the transverse or short axis of the tools supports the hypothesis that these were used with two hands with the long axis perpendicular to the long axis of the grinding slabs. The oval cross-section may be an indication that these tools had not yet been heavily used (WRIGHT n.d.).

Bifacial Loaf/ Lens Handstone (N = 2)

Two fragments of this type were found. It is possible that the tools with lens-shaped cross-sections were originally oval in section but have been worn to the flatter shape through long use.

Bifacial Loaf/Triangular Handstone (N = 1)

Bifacial Loaf/ Plano-irregular Handstone (N = 1)

One fragment of this type was found. Some tools at Beidha having plano-irregular sections appear to have been made on large flakes detached from large cores (WRIGHT n.d.). It is not clear whether this was the case here.

Bifacial Rectilinear/ Lens Handstone (N = 1)

Bifacial Rectilinear/ Triangular Handstone (N = 2) (Fig. 8:8)

Bifacial Rectilinear/Plano-irregular Handstone (N = 1)

Bifacial Irregular Handstone a posteriori *(N = 1)*

One fragment of this type was found. Unifacial handstones may be an "early stage" in the lithic reduction (through use) of these tools (WRIGHT n.d.). If this is so, these tools would appear to have been discarded early in their use-lives.

Unifacial Ovate Handstone (N = 1)

Handstone Fragment (N = 6)

Six tools could not be identified as to type and thus were classed simply as fragments.

Perforated Stones

Counterpoise Weight (N = 2)

Two counterpoise weights were retrieved from Ba'ja. They are fragmentary but robust in size and appear to be similar to objects seen at Beidha and at Basta (QADI, pers. comm.). Their functions are unknown but the off-central perforation suggests use as weights, perhaps to hold ropes.

Multiple Tools

Miscellaneous Pestle/ Handstone (N = 6) (Fig. 8:10)

Three complete and three fragmentary handstone/pestles were recovered. A handstone was classed as also being a pestle if flake scars were seen on the ends, oriented in such a way as to suggest pounding use (*i.e.*, with the negative bulb of percussion near the end of the artifact). Similar tools are seen at Basta (QADI in GEBEL *et al.* 1988: Fig. 12:10).

Summary and Conclusion

The lithic technology of the Ba'ja ground stone is quite similar in most respects to that of the nearby PPNB sites of Beidha and Basta. The collection contains morphological types that are attested in Beidha (mainly Middle PPNB) and an more commonly in Basta (Late PPNB) assemblages.

The Ba'ja surface collection is dominated by grinding tools, of which handstones are the most common. As handstones are smaller and more portable objects, they might be expected to have entered the archaeological record more quickly than larger tools such as querns. Ethnoarchaeological studies elsewhere in the world show that this tends to be the case (HAYDEN and CANNON 1984). The same studies also indicate that the number of querns or grinding slabs may be a useful indicator of village population, especially of the number of adult females (HAYDEN and CANNON 1984: 81). This possibility is of interest for questions about potential changes in domestic subsistence tasks with the origins of agriculture (WRIGHT n.d.). The stone vessels to be expected at Ba'ja were not represented in the collection.

Ground Stone Artifacts from the LPPNB Strata (H.G.K.G.)[1]

Ground stone tools were encountered in the following contexts (in stratigraphic order, *cf.* Table 2):

1) surface pavement/ top soil and colluvial deposits;
2) collapsed wall areas (sometimes with portions of the material deriving from further upslope);
3) room fills (in the upper parts with colluvial deposits);
4) lowermost room fills, sometimes intermixed with disturbed LPPNB food processing loci[2];

[1] The project is indebted to Bo Dahl Hermansen, assisted by Ghattas Sayej, for recording the 1997 ground stone findings. The raw material classification made use of the raw material groups identified at Basta (QADI n.d.).

[2] These food processing loci partly seem to originate from LPPNB use of the house ruins.

5) *in situ* LPPNB food processing contexts; and
6) built into walls (used as building material; no recordable frequencies).

The ground stone material is distributed by frequency according to these general contexts, as shown in Fig. 9:a.[1] Keeping the complex formation processes of the loci in mind (*cf.* Table 2), the majority of the ground stone tools came from contexts evidencing 1) their secondary function as building materials and 2) their use on roofs or in upper stories: some 20% were found in the debris of collapsed walls and *c.* 25% were deposited as colluvial material primarily from such contexts higher up the slope. Another *c.* 25% were found in room fills that not only resulted from the collapsing walls of the immediate structure, but also might contain material from eroded nearby (including roofs or upper stories), food processing layers, or layers with other grinding/ pounding activities. About 20% of the pieces were found in contexts indicating their *in situ* use, and approximately 10% came from disturbed, previously primary contexts (*e.g.* C21,25+34).

The *in situ* evidence includes a high concentration of ground stone tools, mostly in connection with (other) evidence of food preparation (ash layers, hearths, fire places, destroyed "tabuns", burnt animal bone concentrations, etc.) in C1,13; C2,11; C11,23+33; C12,18; C12,29; C22,3+11; C21,32. Fig. 9:b shows the numbers of grinding tools associated with food processing loci (mainly handstones and slabs). Food processing loci without ground stone tools occur in the tabun areas in the chain of partly preserved rooms at the eastern edge of excavation.

As of yet, no detailed information is available on the typology and frequencies of ground stone tools excavated from Ba'ja; the complete determination of raw materials also remains to be undertaken. But a preliminary assessment of these features is provided in Table 3.

Table 3. Raw materials represented in the ground stone tool classes (percentages by pieces, without consideration of questionable pieces; fragments and complete pieces distinguished only for the handstones.

Ground stone tool classes	igneous (incl. volcanic) stone		limestone (incl. 2x quartzitic limestone)		sand-stone		sandy limestone		"carbonate stone"		"conglo-merate stone"		indet.		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
grinding slabs			5	1,03	29	5,98	3	0,62	8	1,65					45	9,28
querns					2+1?	0,41									2	0,41
"cuphole stones"			2	0,41			2	0,41							4	0,82
handstones, various subtypes (4)	1?		26	5,36	198	40,82	40	8,25	87+3?	17,94	1	0,21	7	1,44	359	74,02
handstone fragments (indet. shapes)			5	1,03	18	3,71	6	1,24	9	1,86					38	7,84
pestles (3)									1	0,21			1	0,21	2	0,41
pounders			1	0,21	4+1?	0,82	1	0,21							6	1,24
"counterpoise weights"	3	0,62	1	0,21	6	1,24	3	0,62	1	0,21					14	2,89
various "weights"			1	0,21	1	0,21	1	0,21							3	0,62
other perforated pieces (2)	1	0,21											1	0,21	2	0,41
polishers/ burnishers	3	0,62	4	0,82			1	0,21							8	1,65
other ground st. tools, raw forms (1)					1	0,21							1	0,21	2	0,41
Total	**7**	**1,44**	**45**	**9,28**	**259**	**53,40**	**57**	**11,75**	**106**	**21,86**	**1**	**0,21**	**10**	**2,06**	**485**	**100,0**

(1) includes 1 sandstone disk, 1 "celt" (unknown material)
(2) includes 1 igneous rock "macehead" (QADI n.d.: "bead"), 1 sandstone "hemisphere"
(3) including a phallus-shaped piece (unknown material)
(4) includes 1 round handstone (sandy limestone)

Handstones comprise the most numerous class of ground stone tools by far (Fig. 9:c; 74% or 359 complete pieces, or *c.* 80 with the fragments). The frequency relationship between handstones with planoconvex/ triangular and semi-rectangular small sections is about 1:4.5; the relationship between incompletely and completely preserved handstones is *c.* 1:15 (!). Handstones show a clear preference for sandstone as raw material, followed by a raw material tentatively identified as "carbonate stone" (Fig. 9:d). This raw material group is somewhat problematic, since neither the source nor the petrographic description is presently on a sound basis.

Grinding slabs are less frequent in the sediments than observed on the surface. Their range mostly covers the types illustrated as Fig. 4:5-6 in WRIGHT 1992. The two querns belong to the types illustrated as Fig. 4:10 and 1(WRIGHT 1992); the latter extremely large specimen (31x66x42cm) was found resting on its obverse side. The "cuphole stones" (on pebbles or cobbles with ground obverse

[1] This evaluation is based on *c.* 80% of the ground stone tools found, comprising all loci with more than 5-6 ground stone tools; fragments and complete tools were not distinguished.

rims) normally are taken to be mortar-like tools, but it is worth to mentioning that they do not have regular depressions, a feature which would be expected for the anticipated uniform motion. The single pestle found was formed by pecking the central longitudinal part of a semi-rectangular hand-stone.

The raw materials attested in the ground stone industry (Fig. 9:d) appear predominantly local, although the source of the important "carbonate rocks" needs to be identified.

Baked Clay Industry (H.G.K.G.)

One of the most outstanding finds of the 1997 season is the presence of burnt sherds of clay that represent vessels or container-like installations; almost no rims or base fragments have been identified. Most of the evidence comes from the 4)- and 5) contexts (*cf.* Table 2) in the easternmost chain of rooms in the excavated area, associated with the latest LPPNB site use.

Since the ceramic discoveries at Basta (NISSEN, MUHEISEN, GEBEL *et al.* 1987: Pl. 5:2-3; NEUBERGER n.d.) it is not surprising to find clay installations or vessels in the Late Pre-Pottery Neolithic B. The only question was if we were dealing with fired pottery or simply sun-dried materials.

A quick survey of the baked clay samples from Ba'ja sorted them into the following classes: sherds from an unidentified kind of container or vessel that clearly exhibit finished inner and exterior surfaces and often reduction cores, and pieces that belong to the class of burnt building materials (mud? plaster). The sherds are very coarse (Pl. 6:A), soft to fragile, and have thicknesses of around 20mm. Chaff and mineral tempering is present, although "naturally" tempered material with various mineral inclusions appear, including weathered sandstone particles.

Below we describe four representative samples:

Sample 1615.1 (large fragment of burnt building material with imprints of reed/ twigs, is part of a smoothed edge of plaster; no organic temper; was burned in an reducing atmosphere; dissolves in water: no consolidation of clay minerals, meaning that the firing temperature was below 550°C.

Sample 1608 (fragment of burnt building material): mineral but no organic temper <1mm; smoothed on one side; dissolves in water: exposed to fire well below 550°C, consolidation reversible.

Sample 1615.2 (sherd of a container)*:* organic tempering (chaff) with natural mineral inclusions or even intentional mineral temper > 2mm; slight central reduction core, but also slight signs of an oxidizing atmosphere in the outer parts; smoothed on both surfaces; does not dissolve completely in water: clay minerals are partly consolidated (burnt slightly below 550°C).

Sample 1614 (sherd of a container): carbonate encrusted fragment; smoothed on both sides; chaff tempered; rim slightly bends inwards; clear reduction core; "outer" part with a thick oxidation zone; does not dissolve in water (but too porous for keeping liquids): fired probably around 600°C, consolidation of clay minerals not reversible.

Samples 1615.2 and 1614 present a problem: is this really "pottery" in the technological sense? Technologically, pottery can be understood as intentionally fired containers that have irreversibly consolidated clay minerals. This happens at *c.* 550°C. In that sense we would indeed have evidence for pottery at Ba'ja, but only if this material was heated intentionally; *i.e.,* that it represents an intended technological undertaking. This is not at all certain. If the sherds really belong to *tabuns*, they were fired as pottery due to their function: *tabuns* easily can be carried in a sun-dried stage to the operating place (GEBEL *et al.* 1994).

As can be seen from Table 3, there is no evidence for the use of stone vessels in Ba'ja, which are so common in other LPPNB sites. It might be argued that this reflects that these functions already were taken over by clay containers. But the virtual absence of rims and base fragments, and the curvature of the sherds attested in Ba'ja, indicate that more likely the sherds are from very large installations, beyond the dimensions of typical (stone) vessels. As a preliminary interpretation, also based on the fact that these sherds occur in and with large ashy accumulations containing burnt animal bones and charcoal, we suggest the sherds are from a sort of *tabun* functioning as described in GEBEL *et al.* 1994. In southern Jordan, food preparation by roasting and baking in clay ovens might be one beginning for the use of clay for vessel-like products. The introduction of a large variety of portable and standardized vessels that were heat-tolerant and leak-proof for cooking directly over fires, that were able to store water and other liquids, that created appropriate storage facilities for many different sorts of food, etc., is a development later than the LPPNB of southern Jordan, and it even might not have reached all the areas in southern Jordan during the Pottery Neolithic that in many regions in this region remained aceramic. But we should not be worried with pottery in the LPPNB; instead, we should admit our unsupported preconceptions that might subconsciously emerge from the term "Pre-Pottery" into our considerations.

Prestige Goods Manufacture (H.G.K.G. and H.-D.B.)

Prestige Goods in General

Except for the recovered evidence of sandstone ring production, ornaments were quite rare in 1997. This is explained by the fact that we were mainly digging in room fill accumulated from fallen roofs and walls, with only limited investigation of *in situ* layers and their inventories; furthermore, and no burials were encountered. Therefore, there is no reason to exclude a wealth of this artifact class, although they might not be as well represented in Ba'ja as on the main routes along the plateau ('Ain Jammam, Basta). So far, we have some sewn-on mother-of-pearl objects, tiny rings made of the same material, beads made from Red Sea mollusks, a very few "greenstone" objects, and beads of various stone varieties (*cf.* Fig. 12).

Sandstone Ring Industry 1997[1]

One of the most outstanding LPPNB prestige goods found at Ba'ja is the sandstone ring. Revealed in all its manufacturing stages, it is clear that Ba'ja was a production center and a source of distribution of this product. Production seems to have taken place in specialized households at Ba'ja. Several loci contained concentrations of sandstone disks and sandstone waste classes (Pl. 7, Figs. 14 and 15:a); in one instance, there was even a supply of the disks ready for concentric graving of the interior portion (Stages 2-3; Pl. 7). It is not clear yet if production occurred only on the household level or if an "industrial scale" was involved, too. So far, all waste classes appear in the same contexts, which indicates that all steps of the *chaîne opératoire* were executed in one social environment. However, the level of skill[2] for this technology does not necessarily require talent work hierarchies". The principal stages and waste classes distinguished on a preliminary level are presented in Table 4 and Pl. 7; a replicative system analysis is a must to achieve a thorough reconstruction of the *chaîne opératoire*.

The precise function of this artefact type, always interpreted as being an ornament, is actually not clear at all (*cf.* STARCK 1988: "pendants or clasp-like ornaments"), and this is the reason for the continued use of the neutral term "sandstone rings". The interpretation as arm bangles was questioned by the argument that the inner diameters are a bit too small for even dainty adult hands; they may vary from 30/40mm to 90mm, with an average between 60-80mm. However, we must admit that we do not know which segment of the community used them. The standard diameter would fit well for sub-adults currently living in the area.

Aside from the great amount of sandstone ring material found, only a single fragment of a ring (F.no. 1234.10) was made from a bitumen-rich, highly fossiliferous chalky-marl (called oil schist) or a bituminous limestone (AFFONSO and PERNICKA, this volume and n.d.). Most of the sandstone rings and manufacturing debris were heavily encrusted with carbonate.

In the following we describe the hitherto identified characteristics of the six major stages (Pl. 7, Fig. 14) of the sandstone ring *chaîne opératoire*:

Stage 0: Acquisition and selection of the locally abundant raw material in the schistic - tabular veins of local Cambrian sandstone formations and in unidentified limestone formations. A limestone and two, possibly three qualities of sandstone were exploited: ferruginous sandstone (high mechanical resistance), clayey-silty sandstone (medium mechanical resistance), and possibly feldspathic sandstone (arcosic sandstone; low mechanical resistance). Preference was given to the reddish-violet ferruginous sandstone, occasionally to whitish tabular sandstone. Bichrome layered varieties were collected intentionally, too; certainly the choice of raw material had a prestige aspect.

Stage 1: Fracturing the tabular piece in a roughly round shape, and initial bifacial flaking. Pl. 7: Stage 1 shows pieces that still have the linear edges from fracturing the resource. Some disks apparently were given up at this stage because the selected raw material was too "schisty", which resulted in removals of layers rather than of flakes.

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[1] Basic information on the Ba'ja rings morphology is given in STARCK 1988 and not repeated here. Ba'ja provides for the first time insights into the manufacturing technologies of this unique ornament class, clearing away problems of earlier misunderstandings. At Basta and 'Ain Jammam sandstone (and also limestone) disks also rarely occur, and they were misinterpreted ("throwing disks") here. At Basta some sandstone raw ring tori and pieces such as those in NISSEN, MUHEISEN and GEBEL *et al.* 1991: Fig. 5:2 are attested, but no large-scale workshops are assumed for Basta. However, the sandstone ring waste and the aforementioned piece in Fig. 5:2 give strong evidence that occasional production of sandstone rings took place in Basta, including a variety made from bituminous limestone.

[2] A more efficient technology would have been the use of "Kreisschneider", a flint tool with two tips of which one served for cutting the interior circle, while the distance of the two tips would have provided a standard radius. The graving out of an interior disk is much more costly in effort. This technology was first suggested by Bo Dahl Hermansen while studying this ornament class in Basta contexts.

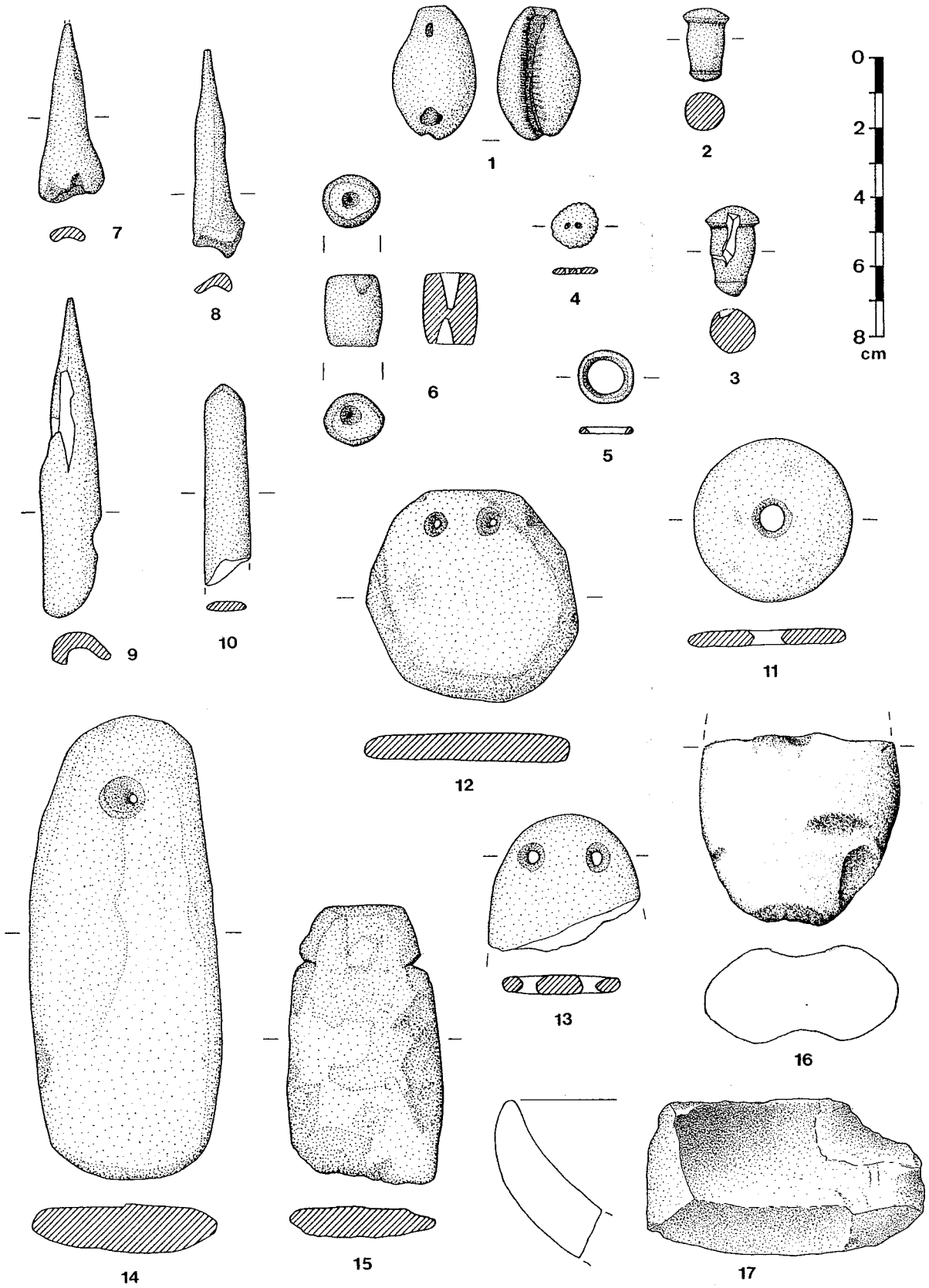

Fig. 12. Stone objects, bone implements, and ornaments. 1-6 ornaments; 7-10 bone industry; 11-16 stone objects, 17 small vessel. (1 perforated cowrie shell; 2-3 ear ornaments ? <bituminous limestone?>; 4 button / sewn-on object <mother-of-pearl>; 5 ring <mother-of-pearl>; 6 unfinished bead <"greenstone">; 7-9 bone awls; 10 bone spatula; 11-13 perforated sandstone disks/ pendants, sandstone whetstone ?; 14 sandstone palette, 15 soft limestone ? (common item in the LPPNB of the area), 16 "Näpfchenstein" <grey limestone>; 17 rim of small limestone? vessel) <illustrations by S. Shraideh (1-15) and I. Raidt (16-17; material of the P.I.G.P.A. collections)>.

Table 4: Preliminary classification and frequencies of sandstone ring waste and fragments according to production stages.

Fragment Classes	Stage	n	%
Fragments of finished products			
fragments of finished sandstone rings	Stage 6	249	99.6
fragments of finished rings made from carved oil shale (bituminous limestone; *cf.* AFFONSO and PERNICKA, this volume)		1	0.4
Total		**250**	**100.0**
Waste/ fragments of unfinished sandstone ring products			
circum-bifacially flaked sandstone disks (including some Stage 1- specimens)	Stage (1-) 2	77	40.3
incompletely graved interior disks with the outer raw ring still attached, broken during this stage of manufacture	Stage 3	4	2.1
fragments of raw rings (raw tori) with traces of graving/ chiseling on both sides, broken during this stage of manufacture	Stage 4a	45	23.5
fragments of semi-finished rings with final grinding on at least one side, broken during this stage of manufacture	Stage 5a	22	11.5
fragments of almost finished sandstone rings	Stage 5a-6a	11	5.8
graved-out interior disk (sections show pointed edges from graving / chiseling; always preserved completely)	Stage 4b	17	8.9
interior disks with central or off-center "biconical" perforations resulting from chiseling/ graving a hole alternately from the two sides; this graving motion is oriented to the center, whose thickness is reduced in that way, and where the hole finally appears to be opened by a sort of punch blow (signs of bursting off on the other sides found); holes often are polygonal or squared (influenced by inwardly oriented grooves, see above)	Stage 5b	15	7.9
Does such a stage exist? No products were found, but piece Fig. 12:11 possibly gives evidence for such by-products.	(Stage 6b ?)	(1?)	
Total		**191**	**100.0**

Stage 2: Subsequent circum-bifacial flaking transferred Stage 1 products into perfectly round disks (Fig. 15:c). The exterior diameter was controllable at this stage of work, and working accidents could still be corrected by creating rings with smaller diameters.[1] The maximum exterior diameters concentrated between 85 - 100mm (Fig. 15:c), as opposed to exterior diameters of 70-90mm for finished rings; the maximum exterior diameters of the sandstone disks and the raw rings nicely fit with each other (Fig. 15:e), showing that further reduction and adjusting occurred during Stages 2 and 4a. The random sample in Figs. 15:b and d reveals that the sandstone disks of Stage 2 may vary considerably in weight and thickness, and that, at least for these parameters, no standards were set for this stage of work.

Stage 3: Concentric graving/ low-pressure chiseling of an interior disk. This was the most effort- consuming part of the work, possibly carried out on a semi-resistant support. Working traces indicate a chisel-like instrument with a sharp edge of *c.* 1.5mm, which left stepped grooves with quadrangular sections that became deeper and wider after their starting point (lengths 9- 12mm). Possibly a flint tool was used for this, but none has been identified in the tool kit yet. This graving/ chiseling process was carried out from both sides (for the section developments *cf.* Fig. 14) until a raw torus (raw ring) for the intended sandstone ring could be removed.

Stage 4a: Removal of the raw torus from the interior disk. Start of final grinding and graving of interior and exterior sides, which involved a great deal of danger of fractures at weakest, thinnest parts.

Stage 5a: The raw torus for the sandstone ring underwent several stages of grinding for the obverse sides and graving/ grinding for the exterior/ interior edges. This process, especially its sub-stages, is still imperfectly understood: while the obverse sides might have been ground on the flat surfaces such as a tabular piece of the hard ferruginous sandstone, it remains subject to further investigation just how the interior and exterior facets of the ring were smoothed. Graving scars from a tangential motion occur on the exterior sides of the rings, and a similar process is in evidence for the interior sides (nicely shown in the drawings of STARCK 1988; Fig 1; however, here Piece 4294 indicates also the graving of grooves from the obverse sides or the cutting by facets). Both measures (obverse grinding and inverse/exterior graving and grinding) may have been applied in no strict order.

[1] As some pieces show: if an intended diameter failed, bifacial flaking was continued until a smaller perfect diameter was gained.

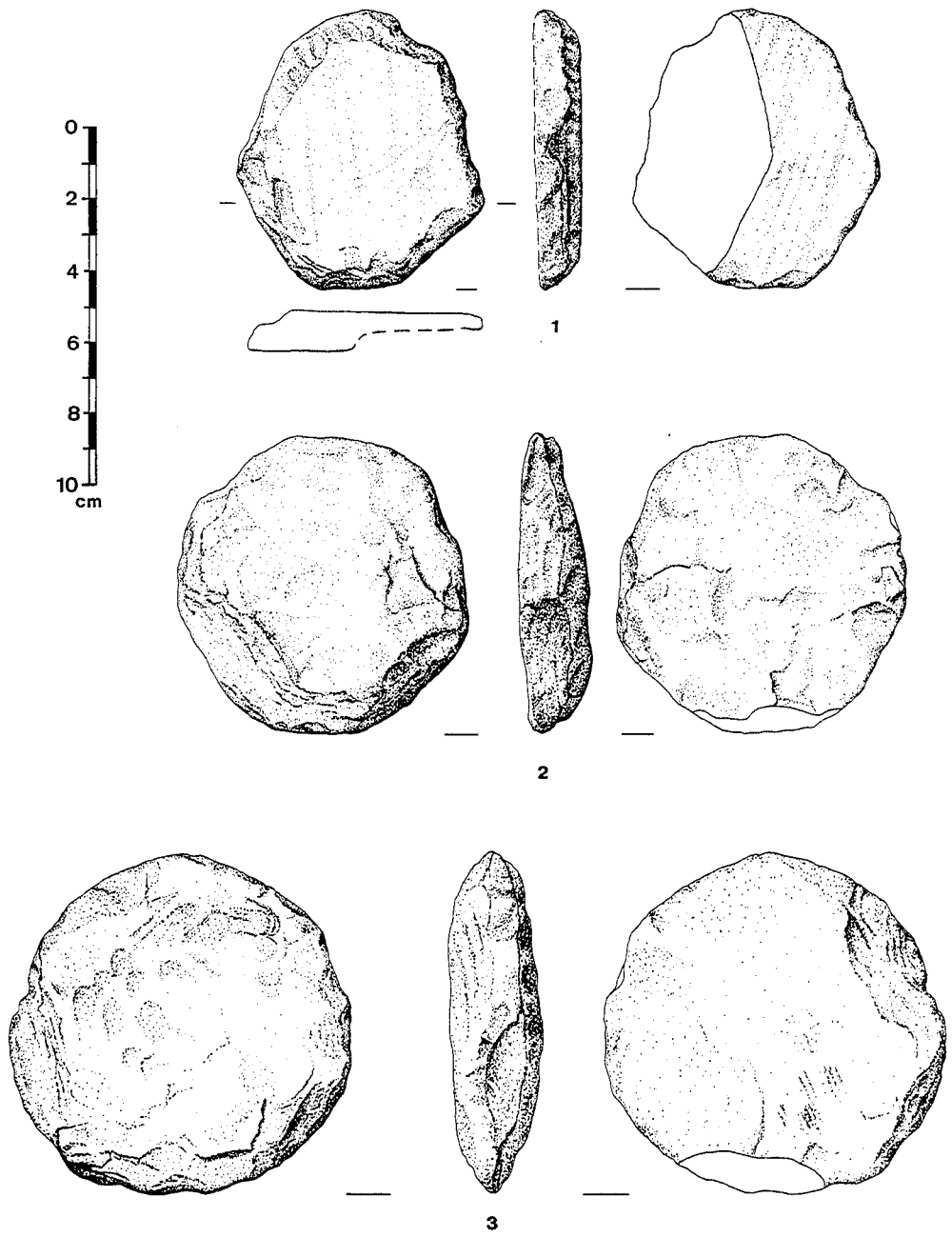

Fig. 13. 1-3 examples of flaked sandstone disks, used as blanks for graving and chiseling out the sandstone rings (bangles?). <illustrations by I. Raidt; material of the P.I.G.P.A. collections>.

Stage 6a: Final grinding sub-stages, occasionally or often combined with "reserved painting". This sequence of sub-stages is not understood perfect-ly either. A bichrome decoration is common for this stage and is the result of the coloured raw material itself and the removal of an applied black (or rarely red) stain by grinding it off from the interior or obverse surfaces ("reser-ved painting", *e.g.* F.nos. 1237.7 and 1291.2).[1]

[1] In some cases (*e.g.* 1207, 1221, 1268.2, 1248.2,4) the whitish variety of sandstone was used and then stained blackish, probably in order to reach a colour closer to the more durable and work-intensive (and thus more precious?) reddish-violet qualities. The very rare pieces with a burnished red paint (*e.g.* 1286.1) have an extremely smooth feel on the skin.

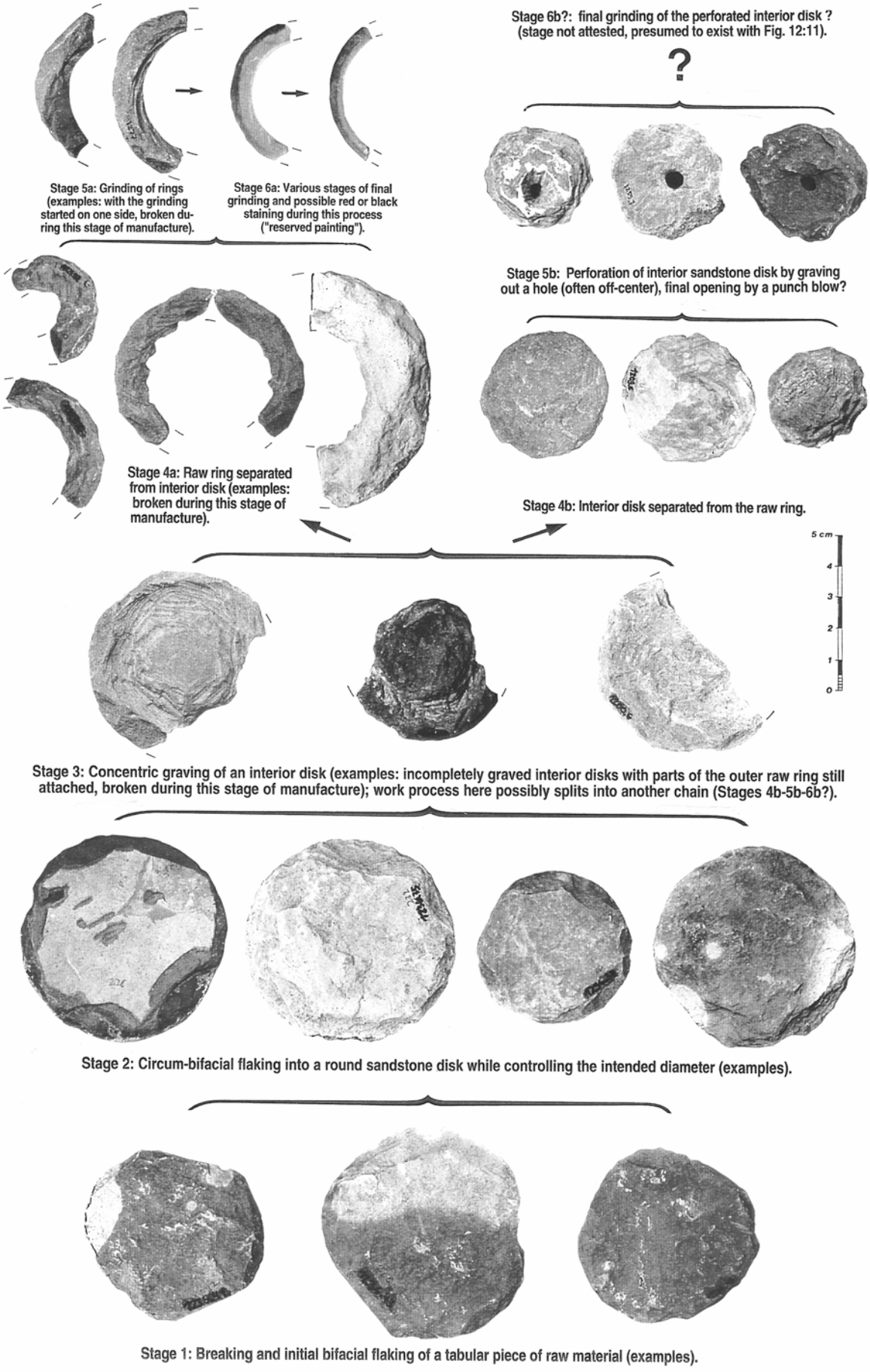

Plate 7: *Chaîne opératoire* of the sandstone ring production.

The most numerous products found were those of Stage 2 (including some of Stage 1), representing 40% in the 1997 sample. The frequencies of waste/fragments in Fig. 15:a clearly show that accidents were related to the removal of raw rings (Stage 4a) that lost the "support" of an attached interior disk (Stage 3), and were thus in danger of breaking at their thinnest or smallest sections during the following grinding attempts on their surfaces. Fractures during graving out the interior disc only rarely occurred (Stage 3, *cf.* the examples in Pl. 7). The loses in Stages 5a-6a reached figures similar to that for 4a.

Interior disks (Stage 4b) may have been transferred into perforated interior disks (Stage 5b), but their further treatment and function remains unclear. Together, they represent 17% in the 1997 sample. No finished artefacts of this possible side-chain of sandstone ring production (Chain b, Pl. 7) were found, with the exception of one artefact (Fig. 12:11) that might represent an intended item. The weights of interior disks are relatively uniform compared with the disks of Stage 2 from which they were taken (Fig. 15:b).

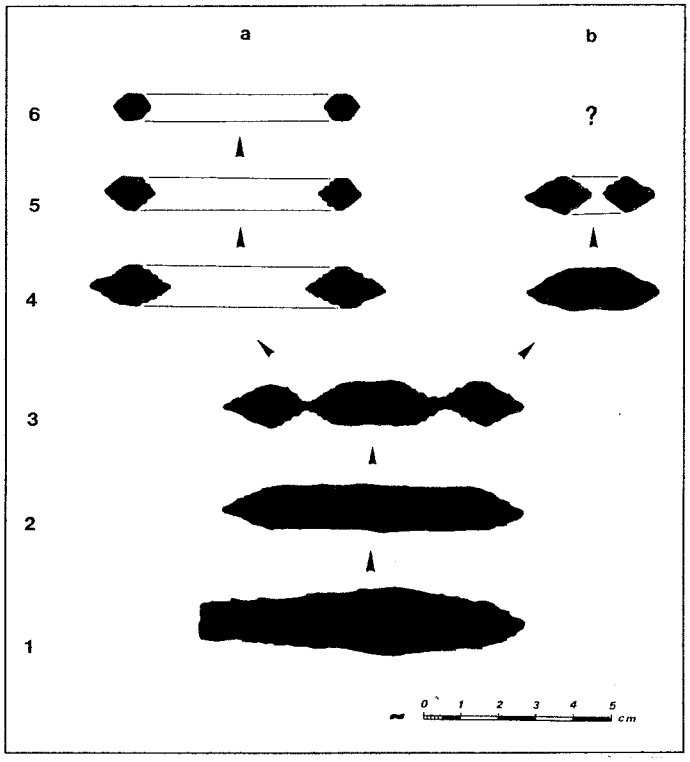

Fig. 14. Development of sections in the *chaîne opératoire* of sandstone ring production.

Subsistence Evidence

Faunal Remains

Exploited animals included wild and domestic goat, domestic sheep, aurochs (*Bos primigenius*), an equid (*Equus africanus*?), wild boar, a small and a large type of gazelle, hedgehog, hyrax, hare, and a small carnivore (fox?) (SÖFFNER 1996, based on the material found in Sounding 1; C. BECKER, pers. comm., based on an on-site check of the material from TU2).

Archaeobotanical Remains (R.N.)

Only carbonized botanical remains were preserved at Ba'ja, mainly wood charcoal. Most of the charcoal belonged to a juniper species, most probable the Phoenician juniper, which still is one of the main components of the woody vegetation in the vicinity. All the wood identifiable as construction wood belonged to juniper. The rest of the charcoal was pistachio, most probable *Pistacia atlantica* or *P. khinjuk*. The absence of oak wood in the samples is remarkable.

Remains of fruits that could have been collected belonged to wild pistachio, hawthorn (*Crataegus azarolus/aronia*) and fig (*Ficus sp.*). Remains of cultivated plants were scarce, suggesting that crop plant cultivation was less important in PPNB Ba'ja. Only a few remains (the so-called glume bases and spikelet forks) from the processing of emmer wheat (*Triticum dicoccum*), , were retrieved. It should be considered that the direct vicinity of the site hardly offers the possibility for the laying out of fields.

Summary and Discussion (H.G.K.G.)

Main results of 1997 excavations

1) The occupation is Late Pre-Pottery Neolithic B (2nd half of the 7th mill. bc) on the basis of its architecture and associated material culture; occupational layers within the room fills of fallen roof/ wall materials most likely are related to the end of the same period, representing the use of the ruins after sedentary habitation came to an end or shifted elsewhere outside the (excavated) area.

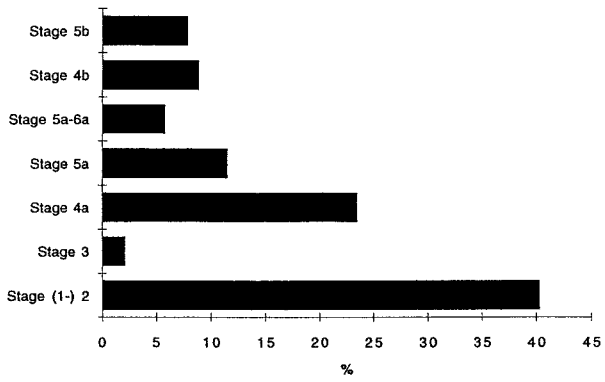

Fig. 15:a. Waste/ fragments of sandstone ring production stages (%), *cf.* Table 4.

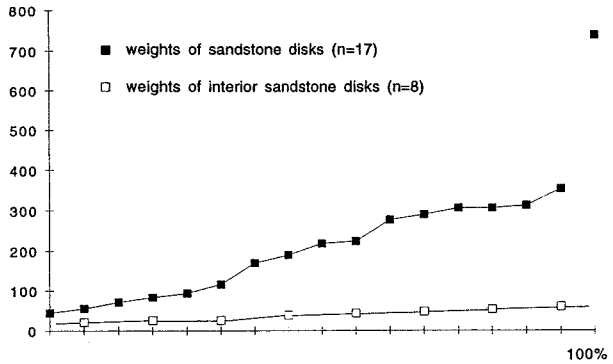

Fig. 15:b. Comparison of weights (g) of sandstone disks (Stages (1-) 2) and interior sandstone disks (Stage 4b), based on the data of a random sample.

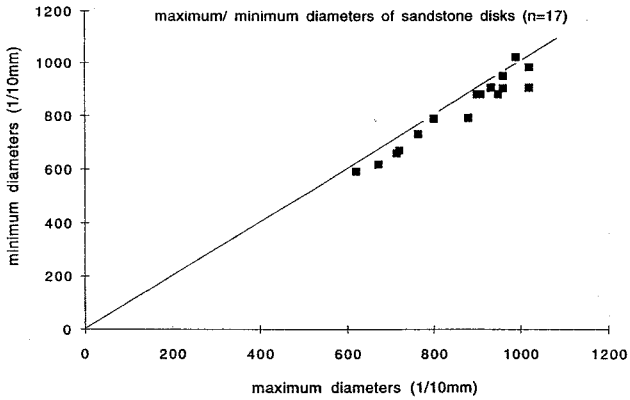

Fig. 15:c. Scattergram of maximum/minimum diameters (1/10mm) of sandstone disks, based on the data of a random sample.

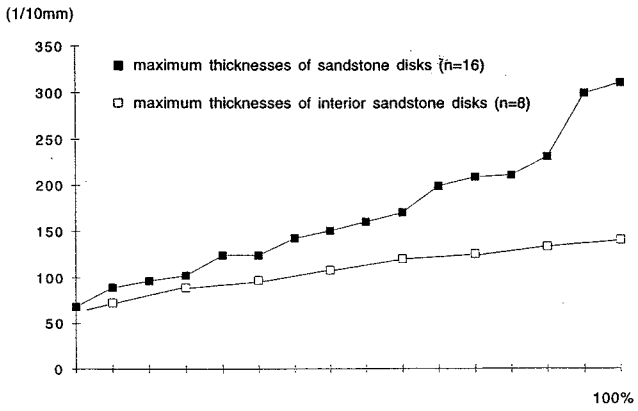

Fig. 15:d. Comparison of maximum thicknesses (1/10mm) of sandstone disks (Stages (1-) 2) and interior sandstone disks (Stage 4b), based on the data of a random sample.

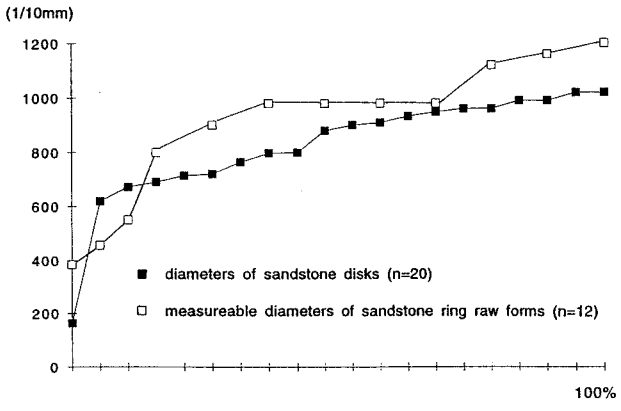

Fig. 15:e. Comparison of maximum diameters (1/10mm) of sandstone disks (Stages (1-2) and of measureable fragments of sandstone ring raw forms (Stage 4a), based on the data of a random sample.

2) The type of architecture resembles in all respects what has been found at Basta, 'Ain Jammam, Ghwair 1, and es-Sifiya, but only partly at 'Ain Ghazal; it is a multi-roomed association of rectangular and polygonal rooms around courtyard-like open spaces. There seem to be no open spaces between building units, which occur in a *pueblo*-type manner on terraces (*cf.* present-day examples from the region in Pl. 6:B-C). Connections between rooms was effected through wall-openings, the large central rooms or courtyards, and most likely, the public spaces of roof tops. Two stories are attested in one spot (western C21).
3) Architectural subphases exist that altered a ground plan within the framework of the major terrace walls. Whenever topography required it, the ground plan of the smaller rooms became curvilinear or polygonal. Room sizes varied from 1.5-15m^2. Subphases can be distinguished by additions onto existing wall tops, blockage or insertion of wall openings, as well as additions to the ground plan, e.g. reinforcement buttresses and walls to stabilize a terrace and the rooms behind.
4) The lower two-thirds and steepest part of the site – at least in Area C – was eroded away in post-occupational periods. Currently the best explanation evokes aquatic force during a temporarily raised *siq* base, in connection with slippage of architecture and deposits down the unstable slope.
5) Contact zones of the cultural layers with the underlying sterile deposits so far show that the palaeotopography on which the settlement rests accumulated in its upper parts as water-laid sandy sediments (*playa*-like deposits) that may represent a once closed intramontane basin-like structure. At certain spots it was obvious that rooms were dug into these sterile layers.
6) The ground stone industry is attested mainly by grinding tools in considerable amounts. Their contexts indicate food processing areas, including on the roofs, and a secondary function as building material.
7) The chipped lithic industry is striking in that it does not seem reflect specialized naviform workshops. Instead, there was a non-naviform bidirectional blade technology represented by cores with detachments from all around a circular platform. The tool kit mirrors no show specialization and reflects activities on household levels, including hunting and possibly wood acquisition and working.
8) The baked clay samples represent burnt building material (plaster) and sherds of containers/ vessels, possibly the remains from *tabuns*. The latter were either intentionally burnt or exposed to fire while in use, but they can nevertheless be considered technologically as pottery (partly fired beyond 550°C).
9) The ornament industry is not very rich so far. However, the site certainly was a fabrication center for sandstone rings on at least a household level. All stages of the manufacture of this prestige item are attested, and we can expect that it played a major role for the settlement's exchange pattern (trade).
10) Plant foods included at the very least emmer wheat, wild pistachio and perhaps fig. Juniper and pistachio were exploited as fuel, with juniper the principal timber material. Animal protein in the diet came from the following species: wild and domestic goat, domestic sheep, aurochs (*Bos primigenius*), an equid (*Equus africanus*?), wild boar, a small and a large type of gazelle, hedgehog, hyrax, hare, and a small carnivore (fox?). Hunting played a major role in Ba'ja in addition to herding.

Selected Interpretations on Building in Ba'ja

The terrace walls were the stable element of spatial organization. While the layout of the individual building units seem to have been inwardly oriented (courtyard houses), the general structure of the settlement appears to represent a corporate organization (as opposed to "public"). This must have been a major concern for the maintenance of those buildings that stabilized the secure setting of houses on the slope. The closed agglomeration aspect of the building units themselves were protective for their inhabitants, and it may actually have functioned as a fortification. Ba'ja's protected setting itself may be a conscious selection that reflected the need felt by the inhabitants for protection and defense.

Planning of buildings basically relied on adapting frameworks according to local topographical conditions, whereby preconceived courtyard buildings were erected. "Free" or re-planning elements in these plans were restricted to alterations influenced by social or functional changes, and are confined to such within an unit itself.

The southern Jordan LPPNB large courtyard building seems to be a new building type not known in the MPPNB. The assumed corporate character of the settlement not only has present-day parallels in the traditional architecture of the region, but also with the *pueblos* in the southwest of North America (e.g. the Anasazi) or mountain settlements in the Old World arid zones from Libya (Tripolitanian-Tunisian mountainous regions) to Central Iran (*e.g.* Abyaneh/ Kashan). Cellular buildings using storage cellars and using other heat/cold-protecting elements are common for such clima-

tic settings, and there are even strong similarities in masonry techniques in these regions compared to the LPPNB of Jordan.

Ba'ja provides additional insights into specialized and non-specialized construction. Building layouts were executed by skilled specialists, but repairs and minor alterations might have been done by less skilled members of the community. There are clear deficits in Ba'ja's structural competence (walls placed without foundation on floors, double-faced walls made of stretchers only, unbonded walls.), which represents a sort of "naive" building technology.

Settlement System Questions

Unlike the research situation for other LPPNB large settlements, more information is available on the possible M-LPPNB settlement pattern in the Greater Petra-Area (through the surveys by Diana Kirkbride and H.G.K. Gebel). According to earlier (GEBEL 1986, 1988, 1990) and more recent results (surveys around Basta), we do not expect a hierarchical settlement pattern in the sense called for by central place theory, at least not in the southern extension of the mega-site episode in the second half of the 7th millennium bc (GEBEL n.d.). The hypothesis is that we are dealing with "anodal" systems, with fast-growing, isolated, and self-sufficient settlements being "central" in the sense of being the regional foci of local land-use and for the distribution of exchanged goods. These "centers" may have developed a size and social complexity that deserve an interpretation beyond a village understanding (see contributions and discussions at the Symposium: *Central Settlements in Neolithic in Neolithic Jordan*, published in *Neo-Lithics* 2/97, especially the arguments of Rollefson and Gebel).

Ba'ja possibly came to exist after nearby Beidha was abandoned, and Shaqarat Mazyad (*cf.* Fig. 2), another MPPNB site in the immediate area was possibly deserted around this time. Occupation then might have concentrated in Ba'ja and possibly at al- Baseet, a newly discovered LPPNB site in Wadi Musa (FINO, pers. comm.). Ba'ja was a rural center beside the main corridors along the plateau and the Wadi Araba; however, it sits at *the* major N-S connection through the sandstone areas of Greater Petra. It belongs to the adventurous spread of large village communities, the mega-site phenomenon, into southern Jordan.

Acknowledgments: The field work was made possible through the excavation permit granted by the Department of Antiquities, Amman. We gratefully acknowledge the support of its director-general, H.E. Dr. Ghazi Bisheh, especially during his visit, without which the successful fieldwork would have been less efficient. The cooperative support and friendliness of Muhammad Salamin, the representative of the Department of Antiquities, was also vital for our excavation. Suleiman Farajat, an old companion of the Ba'ja investigation (the representative in 1984), helped our season much by organizational support.

With deep appreciation we thank our excavation team for the splendid work and good spirits under the very hard conditions: Christian Hartl-Reiter and "Umm Ba'ja" Ute Koprivc (topographical surveyors); Bernd Müller-Neuhof (archaeological surveyor); Tobias Krämer (sedimentologist), Jan Timm (architect); Stephan Fengler and Nina Höffgen (photographers); Philip Rassmann (registrar); Abd al-Nasser Hussein al-Hindawi, Benjamin Jeffs, Muhammad Fadel Khatatbeh, Christiane Meckseper, Sandra Schatz-Härle (square supervisors); Salaheddin al-Abbasi, Annalisa Alvrus, Ulrika Andersson, Jessica Anderson, Brian Conn, and Lena Gebel (assistant square supervisors). In the latter third of the season, the project was joined by Reinder Neef, German Archaeological Institute - Eurasien-Abt. (palaeobotanical samplings). Considerable support came also from part-time participants: Patrick Kloiber (topographical surveyor), Johannes Meier, Julia Littmann (dig assistants), and Sonja Striegl (reporter). During the final work we received the well appreaciated help of Bo Dahl Hermansen and Ghattas Sayej. The project owes sincere gratitude to Bernd Müller-Neuhof, who considerably helped in the pre-excavation organization.

Thanks also go to our workman: Abdallah Ruweiri al-Bdul, Abdallah Su'elim al-Sey'idin, Abdallah Suleiman al-Maraske, Ahmad Ibrahim Hassan al-Amarin, Aid Ikhidian M'baraq al-Amarin, Ali Abdallah al-Amarin, Attallah Su'elim, Eid Awad Suleiman al-Amarin, Eid Salame al-Sey'idin, Faisal ibn Abdel Aziz al-Amarin, Harun Ali Suleiman al-Bdul, Harun Muhammad Salem al-Amarin, Hussein Suleiman al-Amarin, Jebrin Ibrahim, Kasem Eid Steijan, Khalil Salem Rufeiya,, Lafi Salem Salameh al-Bdul, M'lafi Eid Muhammad al-Amarin, Maddallah Ali Salame al-Marei'i, Mahmood Ibrahim al-Amarin , Muhammad Musa Eid al-Amarin, Salim Ali (Abu Ghasem), Su'elim Ali, Suleiman Abdallah. Further thanks go to our cooks in the second half of the season, Radvan Suleiman and his assistent Fadhel. Above all, we appreciated the help of Muhammad Salim, our waterman, and the assistence in work policies by Sheikh Ibrahim of the al-Amarin and the mukhtar of Beidha Housing, Eid Steijan. They both gave us the best and warmest hospitality in their housing, including a large mansaf for our big group.

We had the pleasure to receive the following guests: Ghazi Bisheh, Moawiyah Ibrahim, Suleiman Farajat, the members of the symposium: Central Settlements in Neolithic Jordan (*cf.* Neo-Lithics 2/97), and others.

Zeidan Kafafi, Hans J. Nissen, and Gary O. Rollefson help the project as discreet consultants in many ways, and have their share in its success.

Logistic support was received from the following individuals: Eid Nawafleh and Wendy Botham (Petra Moon Tourism Services), Helge Fischer (CARCIP).

Principal funding for the 1997 season was received from the Deutsche Forschungsgemeinschaft (Bonn), the Deutsches Archäologisches Institut, Orient- Abteilung (Berlin), the Evangelische Kirche in Deutschland (EKD), and ex oriente e.V. at Free University of Berlin. In addition, financial and materials support for the project came from Dr.Dr. Manfred Lindner, Nürnberg; Foto Wegert, Berlin; Konica Deutschland; and Agfa-Gevaert AG, Leverkusen.

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