The Intricacy of Neolithic Rubble Layers. The Ba'ja, Basta, and 'Ain Rahub Evidence

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General Discussion

Rubble layers are a common feature at many seventh millennium BC sites located on slopes in the Jordanian Highlands. Three of these sites are discussed here: At 'Ain Rahub, rubble layers were observed in 1985 in a deep trench transecting a slope; in Basta, they became subject of discussions in 1987, where they form substantial feature of the Post-LPPNB slope stratigraphy; and in Ba'ja, they were discovered quite unexpectedly during the fifth season of excavations (2003) in the flattest area of the site which, and remarkably, here have no catchment for such huge accumulations. At all three sites, the origin of these accumulations of angular, fist-sized stones were an enigmatic issue, and indeed partly still are.

Significantly, rubble layers have the unique potential to serve as an empirical source for furthering our comprehension of abandonment processes, subsistence shifts, and climatic change in the Eastern Mediterranean during the seventh millennium BC. Therefore, these rubble layers might even provide evidence for the role of natural causes in the decline of LPPNB traditions and lifeways (at around 6900 BC), the adoption of pastoralism during the FPPNB/ PPNC (first half of the seventh millennium BC), and the potential impacts on agro-habitats in the PNA (Yarmoukian/ second half of the seventh millennium)[1]. Although many local parameters are responsible for the accumulation of an individual rubble layer/slide (*cf.* below), the intense and wide spread appearance of rubble deposits by the end of the LPPNB and in the Pottery Neolithic must be related to the influence of a common agent which actuated and coordinated various local parameters and ingredients: Periods of heavier rainfalls and/or topography-related flash floods and aquatic slope erosion would appear to be the main factor of these accumulations or slides. In the light of evidence for climate change in the late seventh millennium BC (8200 calBP "Hudson Bay" event), in earlier contributions rubble layers/slides have been discussed solely in relation to the contemporaneous Yarmoukian (Weninger *et al.* 2005, 2007). Recent considerations, however, seem to acknowledge that rubble layers and slides are a much wider Neolithic phenomenon (Rollefson, this issue; Weninger, this issue). Indeed, Basta and Ba'ja have long attested to at least three rubble layer episodes during the LPPNB to PN which only partly and locally appear in the shape of slides.

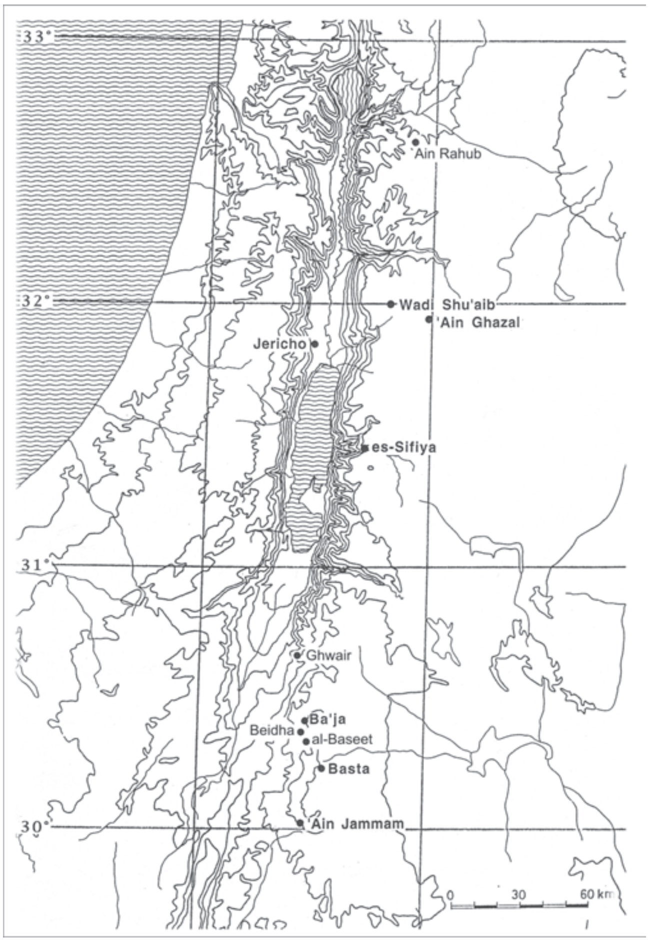

Fig. 1 Locations of LPPNB and PN sites mentioned in the text

The stratigraphic, structural, and chronological intricacy of the Jordanian Neolithic rubble layers and slides warns against a mono-causal explanation. Not one of the rubble deposits found in the Neolithic contexts discussed here is similar in terms of archaeological morpho-phenomenology and chrono-stratigraphy; rather, they represent locally restricted and quite dominant depositions of fist-sized angular stone rubble, the origins of which appear quite puzzling at first glance. As yet, the appearance of such accumulations in non-archaeological, *i.e.* natural Early Holocene stratigraphies has remained uninvestigated. Although representing events highly influenced by indirect or direct anthropogenic influence, rubble layers and slides could be an excellent chance to identify impacts of Rapid Climatic Change (RCC; Weninger, this issue; Weninger *et al.* 2009) or other environmental impacts which triggered the physical displacement of rubble. However, undertaking rubble layer/slide research is a very slippery terrain if it lacks consistent interdisciplinary approaches, and if explanations are dominated by absolute chronological, pheno-stratigrapical, pedological (*cf.* Lucke in Kafafi and Lucke, this issue) or geomorphological arguments. Especially the mere focus on supra-regional climatic change may lead us in wrong directions, as monogenetic explanations may do in general. For example, a drainage regime might have sorted and accumulated rubble without a major moist phase in the climate, and just benefited from local copious slope hydrology.

This paper summarises the archaeological features of the rubble layers; in depth geomorphological studies must follow, thus paving the way for interdisciplinary research designed to approach one of the most spectacular features of the Near Eastern Neolithic: the discontinuities in settlement history and subsistence modes during the seventh millennium BC in the Southern Levant, and their relation to rubble deposits and potential climatic/seismic impacts.

The identification of the various interacting local parameters, causes, and forces that might have contributed to the formation of any given rubble deposit is a prerequisite for any discussion of the role played by RCC, or any other factor, in rubble layer accumulation. Indeed, we have to accept that such complex phenomena will not just provide evidence for one singular cause: imagine, for example, the earthquake which triggers the flow of colluvial rubble, heavily soaked by regional RCC rains, taking up field stone clearing piles and cultural deposits on its way, before reaching its final place of deposition. The demand is that prior to an analysis of its conditions and characteristics, a rubble layer per se should not be taken as a signal for anything; in this respect, the following factors require careful consideration before an explanation is offered:

1. prevailing palaeo-drainage regimes and palaeo-topography
2. anthropogenic barriers and impacts (*e.g.* intra-site architectural barriers such as building terraces, agricultural barriers like valley terraces, size-sorting and stone extraction by man *etc.*)
3. evidence of seismic impacts
4. origin of rubble components (*e.g.* natural *vs.* anthropogenic, *e.g.* wall stone dressing, floor and wall components, *etc.*)
5. intra-site diversity of rubble within flow/deposit and its sorting (in terms of its sedimentology and deposit morphology)
6. identification, chronology, and morphology of rubble layers/slides in the Early Holocene landscapes surrounding the sites

Additionally, it should be stressed that the same factors (*e.g.* fluvial) that may have led to the deposition of rubble layers may also have caused their negative evidence, *i.e.* their removal from the stratigraphic sequence. A rubble slide deposit is only a snapshot of a site's sedimentary environment, and increased fluvial surface energy can also manifest itself in the complete or partial erosion of layers, including rubble slides.

Be this as it may, the rubble layers/slides preserved in settlements dating to the seventh millennium BC demand explanation, especially since their occurrence often appears related to disruptions in the history (intra-site and regionally) of occupation. Indeed, they represent a wider phenomenon in the Eastern Mediterranean in the seventh millennium BC (and in other, younger, time frames, too) at all places with an extant gravity regime (slope setting of sites). Indeed, many of our sites do have this landslide potential. In a further step, systematic surveys need to investigate potential rubble layers on pre-LPPNB and Late Pleistocene sites as well as below and above Post-Yarmoukian habitations. Additionally, geomorphological surveys need to clarify whether rubble layers only occur in archaeological contexts or have corresponding formations in the landscape.

It is very much a common feature of the debris and mud deposits/flows – or rubble layers/slides – that they appear far too extensive for the size of the catchment from the material is thought to stem. From the Basta and Ba'ja sites it is clear that the angular stones of the rubble layers must derive in a large part from flaking of the (dressed) wall stones, the fills of the double-faced walls, and (in Basta) the floor constructions. This means that the architectural debris from these sites produced most of the rubble found in the rubble layers. For Yarmoukian 'Ain Rahub such sources have to remain under discussion since the test trench only revealed in general (by the mudbrick fragments) an architectural context of the rubble layers, while *in situ* architecture wasn't caught.

In our previous publications (*e.g.* Gebel 2004b, 2006) we carefully spoke of rubble layers or rubble deposits; the term rubble slide was promoted by Weninger *et al.* (2007) in their discussion of the Yarmoukian landslides. However, recent (spring 2010) on-site discussions in Ba'ja and Basta with Christoph Zielhofer (Leipzig University, geomorphology) and Bernhard Weninger (Cologne University) regarding the diversity of rubble layers led to the conclusion that we should rather use the more neutral term rubble event instead of rubble slide, since only some of the rubble layers show moraine-like features.

Preliminary Definitions of Neolithic Rubble Layers and Rubble Slides

The following definitions are based on observations of Neolithic rubble layers at our sites ('Ain Rahub, Basta, and Ba'ja), and are bound to the occurrence of +/- fist-sized angular stones:

A rubble layer consists of +/- fist-size angular stones, generally – but not necessarily – embedded in a finer matrix; this matrix may contain material from re-deposited cultural layers (charcoal, ash, small flint artefacts and plaster fragments, *etc.*); occasionally rolled/rounded +/- fist-sized stones occur among the angular stones. These stone accumulations can be thin or they form thick and extensive horizontal layers following the inclination of an old surface or representing restricted lenses or piles. Components of rubble layers may not share a general orientation (although they often do), and the material can even be of purely anthropogenic origin, *e.g.*, from the typical LPPNB double-faced walls of which the dressed wall stones were sorted out and the angular fist-sized of the interior wall fill remained. On the other hand, rubble can also stem from purely natural sources, *e.g.* weathered bedrock from the slope above a settlement. On the upper parts of slopes, rubble layers have the tendency to be more shallow and linear, increasing in thickness and taking on fan-like in-sediment morphologies in lower lying parts. They also evened out surfaces by *e.g.* filling small surface runnels. In their migration onto the surface of a site they are often guided by wall remains still exposed on the slope surface. It should be noted that fist-sized rubble scatters on old surfaces are not deemed rubble layers.

Rubble slides are fluvially deposited rubble layers, or a sequence of fluvially deposited rubble layers, which may contain *in situ* occupational traces, ephemeral or solid installations (walls, burials, chipping floors, surfaces *etc.*; *cf.* Gebel *et al.* 1992). Sequences of fluvially deposited rubble slides may also contain or be interrupted by lenses and layers of other water-laid material (*e.g.* fine gravels) and/or aeolian sediments. Intra-site rubble slides potentially occur in all locations where a drainage or drainage regime forces the formation, movement, and deposition of fist-sized rubble.

Although the fist-sized stone rubble can contain natural colluvial material at some sites, it normally comprises (re-deposited) cultural layers and architectural rubble; in-site rubble contexts are rarely found sterile of artefacts. Rubble slides normally assemble in their sedimentary environment materials from any sources located higher up the slope, *i.e.* from settlement and field/garden contexts that were inhabited or influenced by humans during their deposition. Our definition of rubble slides includes that such deposits not only are attested on slope surfaces, but also filled drainages where they can appear – in case of later incisions – in the sections.

Seventh Millennium BC Rubble Slide Evidence East of the Rift Valley

The preliminary list of Neolithic sites with rubble layers east of the Jordan/Wadi Araba Rift Valley is (in alphabetical order, *cf.* also Fig. 1): ‘Ain Ghazal, ‘Ain Rahub, Abu Suwwan, Abu Thuwwab, Ba‘ja, al-Baseet, Basta, Ghwair, and Wadi Shu‘aib. Potential candidates for the rubble layer discussion are ‘Ain Jammam, Beidha (Fig. 5), Khirbet Hammam, al-Shalaf, es-Sifiya, and Umm Meshrat I and II (references for most of these

Fig. 2 es-Sifiya: Section of square with possible rubble layer (photo courtesy of H. Mahasneh)

Fig. 3 Ghwair: Section of an upper slope excavation area with rubble layers consisting of rock detritus and fine-grained (aeolian) material. View from W (photo by author with permission of M. Najjar)

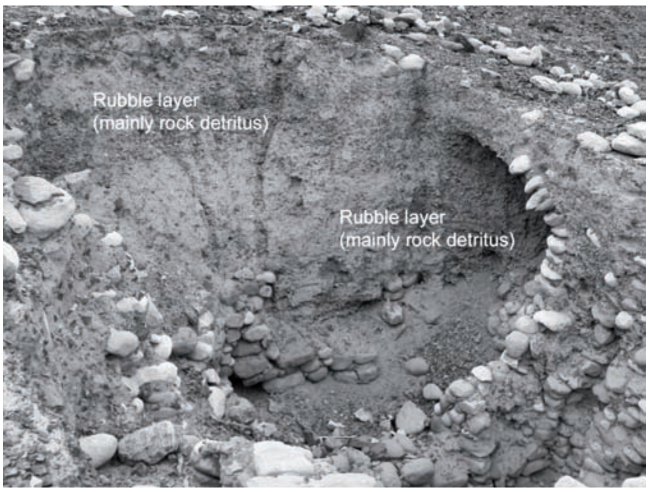

Fig. 4 Ghwair: Section of an uppermost slope excavation area with a rubble layers consisting exclusively of rock detritus in its lower parts, joined by fine-grained (aeolian?) material in its upper parts. View from W (photo by author with permission of M. Najjar)

Fig. 5 Beidha: Section with horizontally embedded gravel/ rubble layers of unknown date, located between Beidha's MPPNB architecture and the sandstone formations bordering the site in the N. View from SE

sites are given by Rollefson, this issue). Omry Barzilai, this issue, provided a general report on rubble layers from many areas west of the Rift Valley, also for the Natufian - PPNA and Chalcolithic periods; he also mentions additional anthropogenic sources of angular stone material which we do not have in the three sites discussed here.

As mentioned, we should be aware that the morphologies and phenomenologies of rubble layers and slides, featuring angular fist-sized stones and found more or less compacted in lenses or layers above and in Neolithic ruins, are not all the same. The nature of rubble layers depends on the catchment area from which materials are taken up and re-deposited. For example, the purely natural "rubble layers" on the upper slope at the site of Ghwair (Figs. 3-4) have a very limited source and catchment: Here a desert-varnish bearing outcrop weathered its "thermal" detritus into the LPPNB architecture in the shape of a rubble layer, fully covered it, and is still accumulating today. The proximity of this source of "rubble" to the architecture against which it has accumulated has made it almost impossible for other types of rubble (*e.g.* re-depositing cultural debris) to contribute to the "rubble layers" observed in this section. This situation may be different further downslope where rubble layers are also expected to contain the fist-sized angular stones from the settlement (*e.g.* Fig. 3). In Ghwair's uppermost slope, however, "rubble layers" are rather the result of aeolian/dune accumulations and a high share of bedrock weathering products (Fig. 4) from the extreme differences between the daily temperatures' maxima and minima.

'Ain Jammam is an example for rubble layers not necessarily aggregating in the upper parts of the slope: Due to the steepness of the slope, erosion transported all material downwards, including rock falls, cultural debris and fist-sized stones, until a stable surface developed in which the ruined L/FPPNB and PNA wall tops rest. Here, rubble layers with their share of anthropogenic material have to be expected in the more shallow middle parts of the slope, and are attested quite clearly at the lower fringes of the site.

The date (or dates) and stratigraphic position of the horizontal gravel/ rubble layers resting between Beidha's MPPNB architecture and the sandstone formation to the north (Fig. 5) need to become subject of future investigations; they can represent at least partly seventh millennium BC fills, but it is unlikely that the catchments reaching the area by the small gorges in the northern sandstone formation have not constantly delivered material onto the spot by the millennia. Nearby Siq al-Barid at least shows considerable deposits since Nabatean times.

For the (Post-) LPPNB es-Sifiya and al-Baseet slopes depositional conditions similar to Basta are expected with respect to their rubble layers: While such were observed in a section in the year 2000 at al-Baseet, such observations for es-Sifiya need to be verified.

One further issue should be addressed here: Recent considerations by Zeidan Kafafi (*cf.* also the contribution in this issue) tentatively claim that a meteorite impact in the Eastern Jordanian desert may have caused regional climatic change and mud/ rubble flows affecting seventh millennium BC settlements in Jordan. This notion, however, has so far not been substantiated by any solid data, and should be excluded for the time being from the rubble layer discussion.

In the following, the rubble layer data from the three sites discussed here are summarised.

The Basta Evidence

When the first evidence of rubble layers at Basta were discussed with Hans Joachim Pachur, Ulrich Kamp, and Markus Nüsser by the section exposures in 1987 there was much conjecture. However, even at this time, many of the ideas expressed already hinted towards very complex processes, including the temporal existence of agricultural fields and field clearing piles on the Post-LPPNB Basta slopes. In addition, the rubble layers were discussed with an even more intriguing feature of Basta's sedimentary environment in mind, the silt

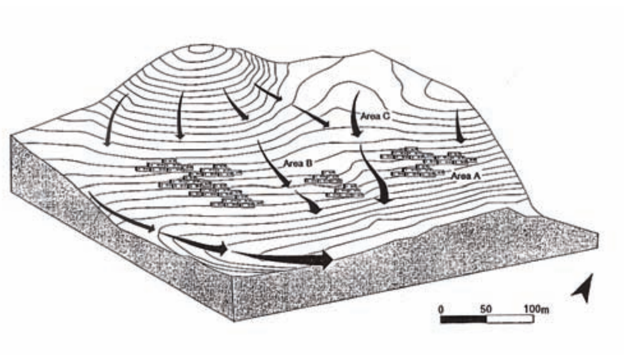

Fig. 6 Basta: Reconstructed LPPNB drainage pattern on Basta's present-day slopes. View from SSE (graph by U. Kamp, published in Gebel 2004: Fig. 1)

Fig. 7 Basta, Square B70, Loci 2-4: Surface of Upper Rubble Layers (URL). Note sub-topsoil Fine-Grained Deposits (FGD) in the sections. View from S

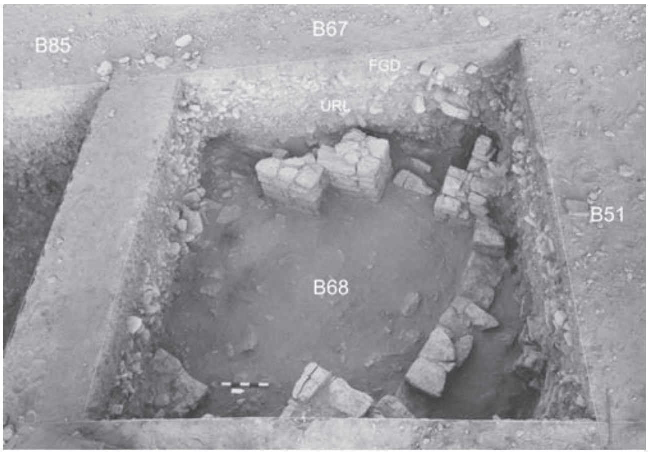

Fig. 10 Basta, Square B68: Partly removed Upper Rubble Layers (URL; *cf.* sections with URL) at the junction with the room fills. Uppermost tops of LPPNB wall ruins. View from E

Fig. 8 Basta, Square B68, Central Room/ Courtyard 1 of Building 1 with rooms adjacent to the NE: Section with Upper Rubble Layers (URL) covering the top of the LPPNB ruin. View from SW

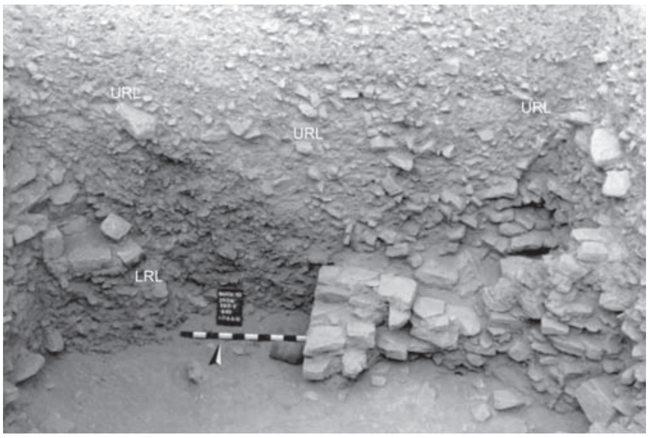

Fig. 11 Basta, Square B83: Top of ruined LPPNB wall (Locus 16) exposed underneath and in the Lower Rubble Layers (LRL), located at the same height as the flimsy FPPNB/ PPNC wall remains (Locus 10), to the left, in the LRL. Note the inclination of the mud flows to the E (downslope). View from S

Fig. 9 Basta, Square B85, Room/ Space 3 (foreground) of Building VII: Note the rubble flow of the Lower Rubble Layers (LRL) in front of walls (Locus 7, 16, and 8) and passing through the wall opening. View from E

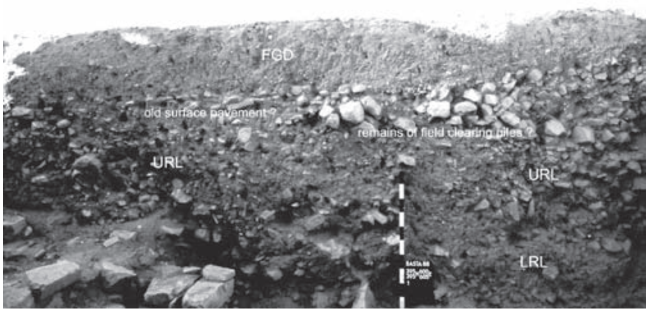

Fig. 12 Basta, Squares B86-87, S Section: Sequence of Fine-Grained Deposits (FGD), Upper and Lower Rubble Layers (URL-LRL) above the top of ruined LPPNB walls. Note the stone accumulations deposited after the URL formation, possibly representing an old land surface (pavement) and the remains of field clearing piles. View from N

cal BC	Basta Periods	Area A	Area B	Area C
		Fine-Grained Deposits (FGD)?	Fine-Grained Deposits (FGD)	?
				predominantly
6000				
		Upper Rubble Layers (URL)/	Upper Rubble Layers (URL)	
		downslope sedimentation of	with remains of clearing piles, debris	
	PNA	cultural debris	and mud flows	
				aeolian
		Lower Rubble Layers (LRL)	Architectural Phase B0 / Lower	
	PPNC-	downslope sedimentation of	Rubble Layers (LRL): curvilinear wall	
	related	cultural debris	fragments, fire places and surfaces	
			embedded in debris and mud flows	
6900				sedimentation
	FPPNB	Architectural Phase AI:	Architectural Phase BI: room fills,	(silts)
		rectangular rooms build of	burial ground, rectangular and	
		undressed cobbles	curvilinear rooms build of small slabs,	
			substructures	C208 and
		huge accumulations of		C217:
		workshop refuse (naviform	Architectural Phases BII-III	village fringe
		chipped stones)	room fills, large multi-roomed	activities
	LPPNB		and rectangular architecture,	(gardens,
		Architectural Phases AII-III:	substructures	burials,
		room fills, large multi-roomed		chipping floors),
		and rectangular architecture,		no buildings?
		substructures, “trash burials”	Architectural Phases BIV ?	
7500		in-room and in-channal burials		
		bedrock		bedrock (C217)

Table 1 Basta: Chrono-stratigraphical summary of the Post-LPPNB (after Gebel *et al.* 2006: Table 1).

deposits of Area C (Kamp 2004, Gebel 2006). Only in the 1992 campaign (Gebel *et al.* 2004) the post-LPPNB rubble layers at Basta received more devoted attention (on account of a planned deep sounding). Flimsy PPNC-related occupations (Fig. 15) were observed in the lowest parts of the Lower Rubble Layer, and for the first time Lower and Upper Rubble Layers (LRL, URL; Figs. 7-14)[2] were distinguished; these were separated frequently from one another by deposits/layers with a higher ratio of fine-grained sediment. In the campaigns prior to 1992 archaeological rubble layer observations were hardly carried out, and ironically they were referred to as the chebabian period, since the quick removal of these thick deposits required a high level of man-power. The rubble layers finding at Basta might be comparable with those at Wadi Shu‘aib (Simmons *et al.* 2001; Rollefson, this issue: Fig. 5) where two such events seem to separate the PPNB from the PN.

The Lower Rubble Layers (LRL, Table 1) of Basta Area B contain PPNC artefacts, curvilinear wallets (Fig. 15), chipping floor dumps and *Tridacna* bead workshop remains, fire places, samagah installations/surfaces, stone robbing pits dug into the LPPNB architecture (related hoard of stone figurines, *cf.* Hermansen in Gebel *et al.* 2004: 94, 101-102, Figs. 15-16), a pre-Yarmoukian arrowhead type, and very few intrusive? sherds showing a relation to Yarmoukian pottery, *etc.* (Gebel *et al.* 2004: Table 1); of course, they also contained re-deposited F/LPPNB materials. The LRL must have started to accumulate shortly after the abandonment of the settlement, since the walls of structures were still standing tall and the rubble layers migrated into the ruin, even penetrating through wall openings (*e.g.* Fig. 9). The Upper Rubble Layers (URL, Table 1) contain all sorts of re-deposited materials, including Palaeolithic to F/LPPNB and PN artefacts, re-deposited rubble of the LRL; in situ fire places and surfaces are less well preserved (compared with the LRL findings), and partially in situ finds of a PNA/Yarmoukian chipped stone industry as well as isolated Neolithic pottery sherds were found (Gebel *et al.* 2004: Table 1). As Figs. 8-11 indicate, the ruined wall tops of the LPPNB basements were still poking out of the surfaces at considerable heights during the URL depositions. This is somewhat puzzling, since it would mean – in terms of our current absolute chronological understanding of the rubble layers at Basta (Table 1) – that some ruined wall tops of the LPPNB basements were still visible after some 700 years. Wouldn’t this finding not indicate that the URL of Basta are somewhat older, *e.g.* dating around the mid of the millennium BC?

The Lower and Upper Rubble Layers of Basta

Fig. 13 Basta, Squares B104-105, N Section: Sequence of Fine-Grained Deposits (FGD), Upper and Lower Rubble Layers (URL-LRL) above (and between: LRL) the top of ruined LPPNB walls. Note the stone accumulations deposited after URL formation, possibly representing the remains of field clearing piles. View from S

Fig. 16 Basta, Square A12, NW Section (bulldozer cut): Huge silty rubble/gravel layers (Loci 61a-g of the NW Section), covering the top of the ruined western wall (Locus 2) of Room 16 and adjacent areas. The orientation of the rubble/gravel mixed with some cultural materials is oriented downslope. Possibly represents the fills of a seventh millennium BC runnel. View from E

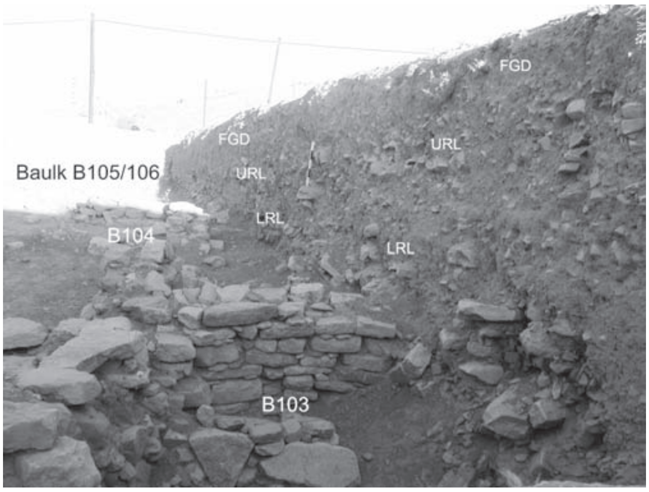

Fig. 14 Basta, Squares B103-105, S Section: Sequence of Fine-Grained Deposits (FGD), Upper and Lower Rubble Layers (URL-LRL) above the top of ruined LPPNB walls. Note the inclination of the rubble flows to the E. View from WNW

Fig. 15 Basta, Square B83, Locus 5: Flimsy curvilinear PPNC/ FPPNB wall fragment embedded in the Lower Rubble Layers (LRL). View from S

seem not to represent two major isolated depositional events, rather they appear as two sets of locally restricted depositions. It seems that larger parts of the Basta slopes are covered by rubble layers, with only smaller areas having escaped this depositions. Layer thicknesses are varied and have the tendency to increase downslope; in general, the Basta rubble layers tend to form restricted extensions, like large lenses, accumulations on old surfaces, and even piles. The thickness of the uppermost Fine-Grained Deposits (FGD; Christoph Zielhofer: "Kolluvium"; Figs. 12-14) increases considerably downslope.

Before we discuss the various scenarios of rubble layer formation at Basta, the only radiocarbon date that exists from the context of the rubble layers at the site (from the earliest LRL, should be presented: KIA 30847 (Basta 47244) dates the remains of a fire place (Square B83: Locus 8) contemporaneous with the deposition of the rubble to cal BC 6749, 6721, 6702 calBC (radiocarbon age: BP 7911 ± 56; P.M. Grootes, Leibniz Labor für Altersbestimmung, Kiel, pers. comm.) (Fig. 17). The date reflects perfectly the archaeological PPNC-related evidence we have from the Lower Rubble Layers in Basta (Gebel *et al.* 2004, Gebel 2006, Gebel *et al.* 2006).

The understanding of the palaeo-topographical slope settings are essential for the understanding of Basta's rubble layers (*cf.* Kamp 2004: Figs. 1-3; Gebel 2004a: Fig. 1C, 2004b: Fig. 1): The topographical unit Area A (Fig. 6) represents the NE parts of the Neolithic village on the slopes between a small gully (a present-day village street) in the SW and the bedrock outcrops with quartzite veins to the NE (Kamp 2004: Fig. 1). The lower parts of the slopes are very steep and border the bottom of Wadi Basta. The upper parts of Area A are rather flat and pass over into the flat topography of the former fields in Area C. Area B (Fig. 6) is located in the central, steeper and spur-like part of the Neolithic

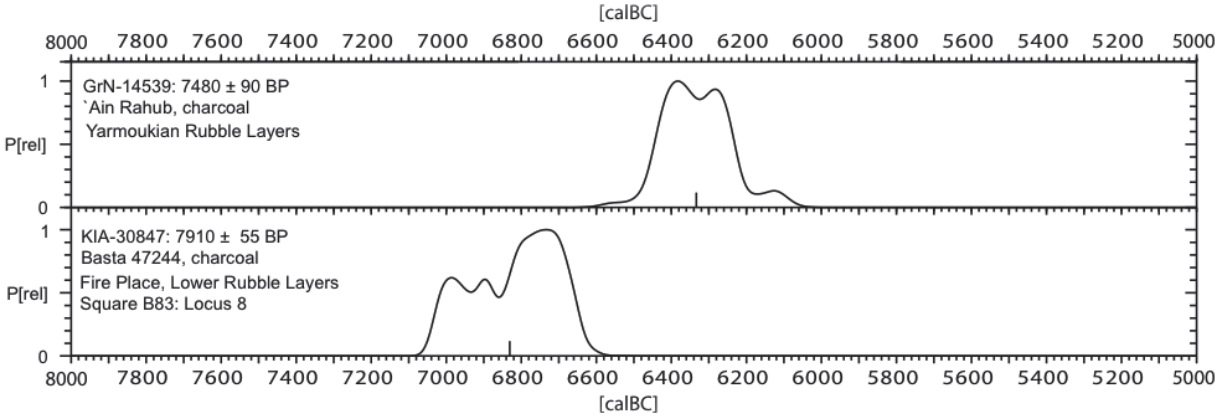

Fig. 17 Calibrated date from Yarmoukian-related rubble layers in ʻAin Rahub (top) and from the Lower Rubble Layers in Basta (bottom). Graph prepared by B. Weninger

village. It is also located on Wadi Basta's NW slopes between the aforementioned small gully (the present-day village street) in the NE and the flat slope areas in the W and SW. In the SE it reaches the bottom of Wadi Basta by a steep inclination. In the NW it meets a flat area which belongs topographically to Area C. The original spur-like topography of Area B seems to be the result of two Early Holocene drainages into Wadi Basta from the NW (Kamp 2004).

The post-LPPNB sedimentary stratigraphies of Basta are a sequence of depositional, re-depositional, and extraction events which modified the relief over the seventh millennium BC. While the natural impacts on the sedimentary environments of the slopes at Basta were reduced or controlled by F/LPPNB human occupation during the second half of the eigth millennium BC, natural causes and materials again gained the upper hand during the seventh millennium BC, *i.e.* following the close of permanent occupation at the site. During the F/LPPNB occupations at Basta a combination of domestic behaviour on the one hand, and natural alterations on the other (*e.g.* by drainage regimes, colluvial materials, heavy rain/snowfall, extreme temperature maxima/minima and other climatic parameters) impacted upon this particular landscape. Against this background, we have to expect (Kamp 2004, Gebel 2006, Gebel *et al.* 2006) the existence of protective structural measures, such as (terrace and barrier) walls and ditches, designed to offer some protection against both aquatic slope

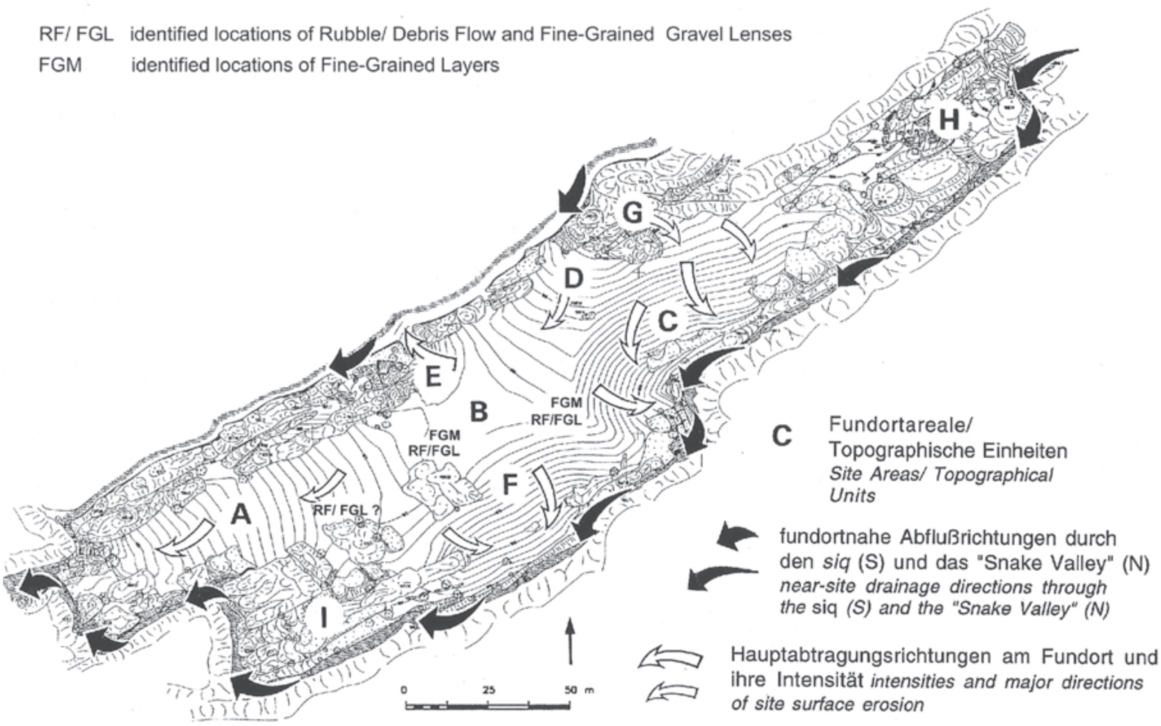

Fig. 18 Baʻja: Topography and identified locations of Rubble Flows/Fine-Grained Gravel Lenses (RF/FGL) and Fine-Grained Layers characteristic for the sub-topsoil layers (FGM), in contrast to the present-day surface drainage regime of the site

erosion and colluvial accumulation in LPPNB Basta; indeed, natural slope drainage represented a permanent threat to F/LPPNB villages on the slopes in the region. Intra-site rainfall and snow management, debris flow management, slope pressure management: All these factors should be reflected in the architecture, the architectural planning, and the stratigraphies at Basta. However, it is of note that the best evidence for protective walls, barriers, and ditches should be found on the fringes of the settlements.

In the lowest LRL at Basta, dated to the PPNC, rubble deposits were apparently used by squatters, still residing, manufacturing beads and chipping flints between the eroding ruins of F/LPPNB walls, *etc.* The decaying F/LPPNB structures produced thick, rather homogeneous, and consolidated fine accumulations and patches of disintegrating plaster and roof/ceiling materials, a characteristic of the LRL. In the upper LRL, fireplaces were still operated, and other in situ traces of human activities are in evidence; in fact, these layers witness some Yarmoukian-related features. In contrast, the URL show far fewer habitational traces; rather, they display locally restricted sequences of downslope sedimentation, possibly interrupted by (re-deposited) remains of field clearing piles. The URL may have become deposited around 6200 BC, if not earlier (*cf.* above).

The understanding of the huge silty rubble/gravel layers in Area A (NW Section, Loci 61a-g; Fig. 16; Gebel 2006; 69, Fig. 2.A), reaching thicknesses of 2-3 m and covering the ruined LPPNB wall tops is still premature. They do not contain much cultural debris at this spot, as opposed the section layers to the NE and the NE Section (Gebel 2004b). Their formation must have involved silty materials of Area C: it appears that they represent the fill of a seventh millennium drainage/runnel in at this spot (cf. the runnel's section/ inclinations in Fig. 2A of Gebel 2006).

Aside from the anthropogenic rubble of the village, physical weathering products (angular rock detritus from block size to sand/silt) and aeolian deposition were all important components to have contributed to the mass of material that developed in the catchments of Basta and penetrated into the settlement area (Kamp 2004). Today, the area witnesses torrential rainfall episodes, and we have every reason to assume that this was also the case in the seventh millennium BC; therefore, we must expect such events to still be visible in our squares and sections, too. The origin and important role of aeolian silt in the sedimentary environments of the site is still poorly known (*e.g.* a share of more than 30% was found in Area C, *cf.* Kamp 2004): dust storms may be the origin of these silts which accumulated for 2-3 m during and after the LPPNB in Area C, where even individual aeolian events could be traced. The site was subject to aeolian erosion in the seventh millennium BC, too (*cf.* also above the Area A silt evidence), but we do have yet a clue on the aeolian materials' share in Area's B rubble layers (Kamp 2004). In Area B the aeolian components seem to be of lesser importance.

The Ba‘ja Evidence

Under the heading: Huge Rubble and Fine Gravel Flows, Wall Rubble and Air Hollows we opened discussions focusing on the extraordinary evidence for high-energy events to have occurred at Ba‘ja and which were followed by LPPNB architectural reoccupation in Areas C and B-South of the site (Gebel and Kinzel 2007): Huge rubble deposits and other features characteristic of earthquake destruction were noted (Fig. 18). In addition to this, the – fluvial or seismic/ fluvial related – destruction of the eastern part of Area C by slope subsidence is also attested (Gebel and Bienert *et al.* 1997: Fig. 6), though it is still unclear as to the precise nature of the accountable high-energy event. The earlier earthquake in Area B-South (Figs. 21-22) was followed by thick depositions of stone rubble (RF, up to 1.5 m in height; Figs. 22-23) [2] with embedded water-

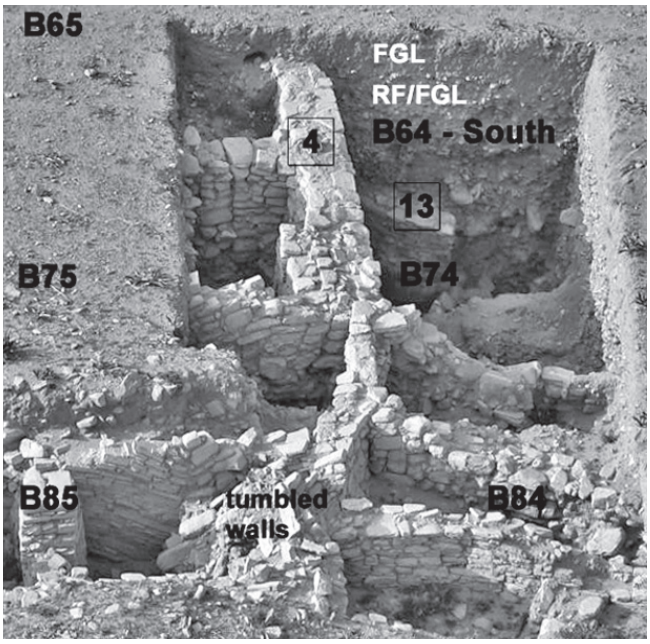

Fig. 19 Ba‘ja, Area B-South: Evidence of Rubble/Gravel Flows with Fine-Gravel Lenses (RF/FGL) exposed in Square B64-South and tumbled walls (earthquake damage?) in Squares B84-85

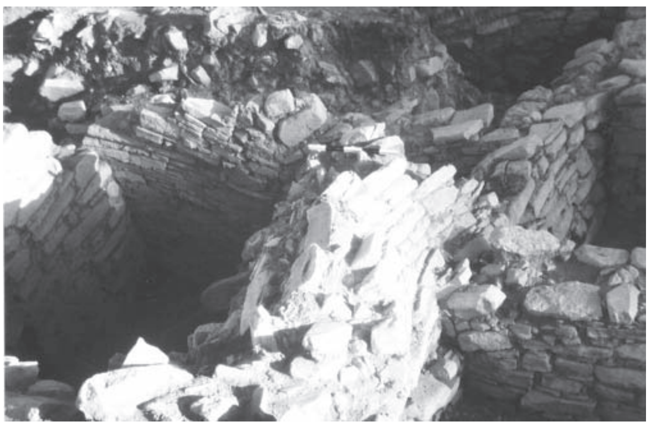

Fig. 20 Ba‘ja, Area B-South, Squares B84-85: Tumbled LPPNB walls (earthquake damage?)

Fig. 21 Ba'ja, Area B-South, Square B64-South, Loci 21 and 23: LPPNB wall rubble found with air pockets (earthquake damage?)

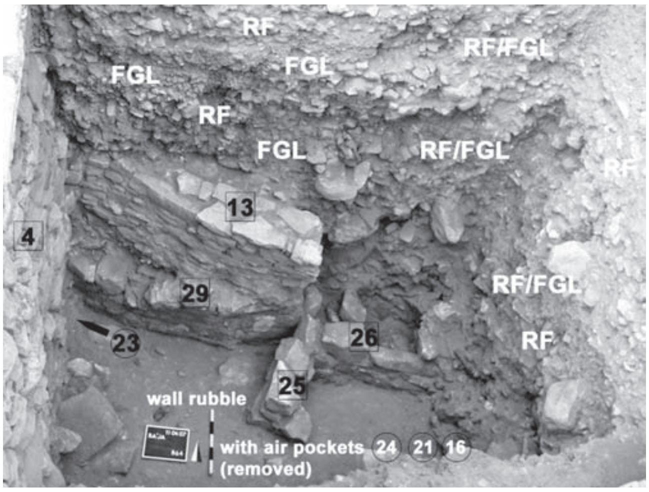

Fig. 22 Ba'ja, Area B-South, Square B64-South: Excavated earliest architectural remains (LPPNB) with partly removed wall rubble loci (earthquake loci with air pockets, *cf.* Fig. 17) and deposits of Rubble/Gravel Flows and Fine-Gravel Lenses (RF/FGL) above. View from S

deposited fine gravel accumulations (FGL) that rest against the tall standing wall (Locus 4) in Squares B64-South and B74 (Fig. 19) or were found under the later architectural re-occupation (Locus 5) in C-10/10 (Fig. 23); the water-deposited fine-gravel deposits/lenses are a strong indication of an aquatic slope erosion which took up and sorted floor/ ceiling components. Several spots provide indications for some deconstruction prior to the start of the latest architectural phase. Remarkably, there exists no catchment for a natural source of these RF/FGL materials at Ba'ja: Therefore, it must be concluded that they are of anthropogenic origin (contrary to an assumption in Gebel and Kinzel 2007, *cf.* below). The wall rubble resulting from the earliest earthquake (and from subsequent instabilities of house walls) were buried by these complex rubble and fine-gravel sequences in Squares B64-South and B74 and C-20/20. A further earthquake appears to be attested by the twisted walls in upper B84-85 (Fig. 20). Earlier considerations (Gebel and Kinzel 2007) that the RF/FGL flows result from flash floods reaching the central upper parts of the settlement from the gorge (Siq al-Ba'ja), and that the floor of the siq was much higher than today, require revision following new insights gained from recent fieldwork at the site (Christoph Zielhofer, pers. comm; spring 2010).

In the following we present and discuss the individual pieces of evidence for the rubble layers and related high-energy events. For a more detailed account of these findings, see Gebel and Kinzel 2007.

Area B-South (Figs. 18-22): The excavation in the southern half of Square B64 has provided insights into huge intra-site rubble and gravel flows (RF/FGL) resting against the aforementioned high wall Locus 4 in B64-South and B74 (Figs. 19, 22) and over the walls (Loci 13, 29, 25-26), and the wall rubble accumulations with air pockets (Loci 16, 21, and 24); similar features are reported from Area C – *cf.* below – at a distance of some 20-30 m). The wall rubble – sometimes still deposited in a fallen-domino arrangement – with air pockets was found to be mixed with a higher amount of loose, re-deposited material, including mortar/plaster/ceiling debris, containing charcoal, and appeared to have been, at least partially, intentionally buried. Wall 13 seems to have been reduced in height, probably during the erection of the upper phase of Wall 4 (= coarse-faced upper part of Wall 4). On top of Wall 13 rests the moraine-type flow of fist-sized stone rubble with embedded fine gravel lenses (RF/FGL) that is also attested in the east sections of B64 and B74 and reaches heights of 1.5 m. (Figs. 19, 22). In B74, fine gravel deposits migrated inside the "gate" of wall Locus 4, which was blocked during the RF/FGL events. Within these RF/FGL deposits, fireplaces and surfaces exist, proving that deposition happened in short episodes while the inhabitants were using the (temporary) surfaces. The whole accumulation, however, is rather homogeneous, contains aside the angular rubble occasionally fist-sized limestone gravel, and gives the impression of fast deposition in as restricted time. The third high-energy event in Area B-South is represented by the twisted walls in upper B83 and B84: The energy to which the walls were subjected causing them to lean in all directions, and therefore not abiding to a specific vector or pattern; this latter feature also leads us to conclude that this resulted from an earthquake.

Area C, Square C-10, Baulks C-20/20 and C-10/10 (Figs. 18, 23): Here, a stairwell in C-20/20 connects the two older occupational levels in C-10/10/-20/20/21, and a later occupation/building phase rests on the fist-sized stone rubble flow with embedded fine gravel lenses (RF/FGL). Similar to Area B-South, western Area C witnessed three major impact events: an extensive earlier wall rubble pile with air pockets in C20 (incompletely excavated) in a rather large open space, a huge rubble and gravel flow resting against high standing walls, and the reorganization of space and architecture during an upper architectural phase. During the latter, also the impressive stairwell in C21 (Bienert and Gebel 2004: Pl. 5) must have been erected. For the first time, we were able to isolate locally a distinct later architectural phase in Ba‘ja from an earlier occupation which represents a disruption of the site's architectural morphodynamic complexity of succeeding modifications that normally prevent the identification of clear sub-phases. Together with buttress Locus 114 of C10 and Wall 6 of C-10, this E-W running wall Locus 5 denotes the latest architectural phase in western Area C (Fig. 23). It is erected on a RF/FGL rubble flow with layers of small fluvial sorted and deposited gravel (8-15mm); this is also the case for buttress Locus 114, Wall 6, and buttress Locus 26. These water-laid fine gravels are also found in the north section of C20, where they accumulated against the E face of Wall 10 (former Baulk C-20/20). Here these fine gravels appear as lenses and layers inside the upper parts of a rubble flow, consisting of fist-sized stones. All the aforementioned wall remains and layers were covered by the light brownish fine-grained material (FGM) forming also the sub-topsoil layer in all Area B; its thicknesses reaches 60 cm. The RF/FGL rubble/ gravel seems to have terminated the earlier architectural occupation in western Area C, causing the reorganization of its space. The partial destruction of this phase appears to be evidenced by the deposition of the huge wall rubble in the open space of C20 and in the space between the Walls 120 in C20 and 5, 26 and 8 in C-10 (where many lintel stones were also found). The orientations of this wall rubble are various; the deposits feature a high frequency of air hollows, revealing a rapid and probably intentional filling of the space. It is assumed that this action relates to the deconstruction of walls in the area following an earthquake. This must also have twisted the complete stairwell Locus 129 in C20, simultaneously leaning it down by the height of one step: The earthquake, the subsequent deconstruction of architecture, and intramural filling of the large space in Area C20 preceded the migration of rubble/small gravel flows (RF/FGL) into the area. Water appears to be the agent of transport and movement of the RF/FGL before the walls of the latest occupation in western Area C were erected.

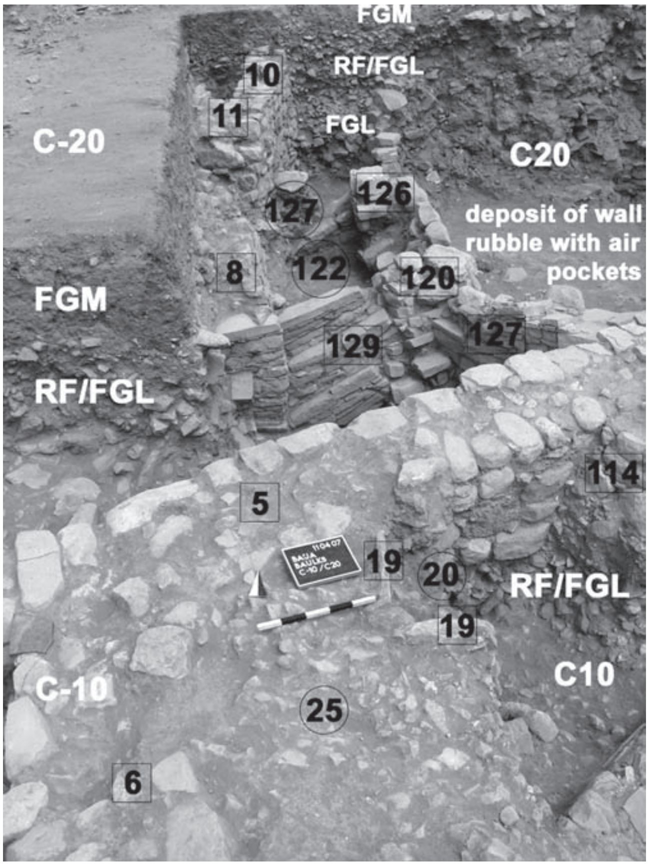

Fig. 23 Ba‘ja, Squares C10 and C20: Sequence of tumbled LPPNB stairwell, open space with LPPNB wall rubble showing air pockets (earthquake damage), Rubble/ Gravel Flows and Fine-Gravel Lenses (RF/FGL), latest LPPNB architectural phase remains, Fine-Grained Layers (FGM) deposits. View from S

Seismicity has so far been a rather neglected topic when discussing Neolithic rubble slides or the interruption/ abandonment of settlements. If we take as a measure the frequency of earthquake events to have affected the area in the last 2000 years, we can assume that every 200 years a medium-major earthquake should be expected; for example, in 551 A.D. Petra was almost totally abandoned after an earthquake destroyed its buildings, and Aqaba was twice destroyed in 363 and 1068 A.D. (Migowski *et al.* 2004, Korjenkov and Schmidt 2009). The LPPNB mega-sites are located along the Dead Sea Rift tectonics, and were therefore also vulnerable to destruction by such catastrophic events; however, and quite remarkably, our discussion of the descent of the mega-site phenomenon has until now failed to consider the role of seismicity in the related processes. Since LPPNB building units were mostly erected upon terraces or built on or into slopes, any leaning walls were simply explained away as the result of slope pressures, *e.g.* as was the case with the long wall in Ba‘ja's Area D; also, pronounced cracks in walls/pillars, *e.g.* in Basta B68: 18, were also subjected to this interpretation. Certainly, and without a doubt, this agglomeration of evidence calls for increased in-depth research into seismicity and its impact on our mega-site architectures.

In conclusion, the clearest evidence for LPPNB earthquakes affecting LPPNB sites stems from Ba‘ja Area B-South and western Area C. Here, it should also be noted that Area B-South lies between a southern sandstone outcrop and the northern sandstone ridge (Fig. 18), which are at a distance of some 15-20 m

Fig. 24 'Ain Rahub (site area dotted): Aerial view.

(Bienert and Gebel 2004: plan between Pages 122 and 123), and the lowermost architecture in these areas is probably in direct contact with the underlying bedrock. It follows that during an earthquake, shockwaves would have been transferred here directly into the walls of the structures. To summarise, the following earthquake features are attested in Ba'ja:

- walls pushed by perpendicular walls (tilting walls in various directions)
- wall rubble in fallen-domino arrangements; air pockets in their rubble
- lateral deflection and wall splitting

Blocked/inserted doorways/wall openings and wall reinforcements by adding parallel walls (*e.g.* the blocking and closure wall of the "gate" in B74) could very well be secondary earthquake evidence, meaning the result of space reorganization after an earthquake. There might then be a chance in Area B-South to find the skeletal remains of earthquake victims.

The 'Ain Rahub Evidence

At the Late Epipalaeolithic/Early Pottery Neolithic site of 'Ain Rahub (13 km NW of Irbid and 4,5 km NNE of Sal; Gebel and Muheisen 1985) Yarmoukian finds were encountered in rubble layers sealed within the stratigraphy of a terrace spur; the terrace remains belong to the lowest terrace in Wadi Rahub (Hannss' T1 Terrace, *cf.* Muheisen *et al.* 1988: 475ff.); the geomorphological setting of 'Ain Rahub (420 m a.s.l.) was studied by Christian Hannss in 1985 by stereoscopic analysis of aerial photographs. In the following years, much of the topography of the area, including the vicinity of the spring, was altered by street building, bulldozing, and rock blasting from the nearby licensed excavation of graves (Siegfried Mittmann, pers. comm.), finally hindering further excavations.

Physiographically, the location represents a terrace spur (Fig. 24: dotted area) between Wadi

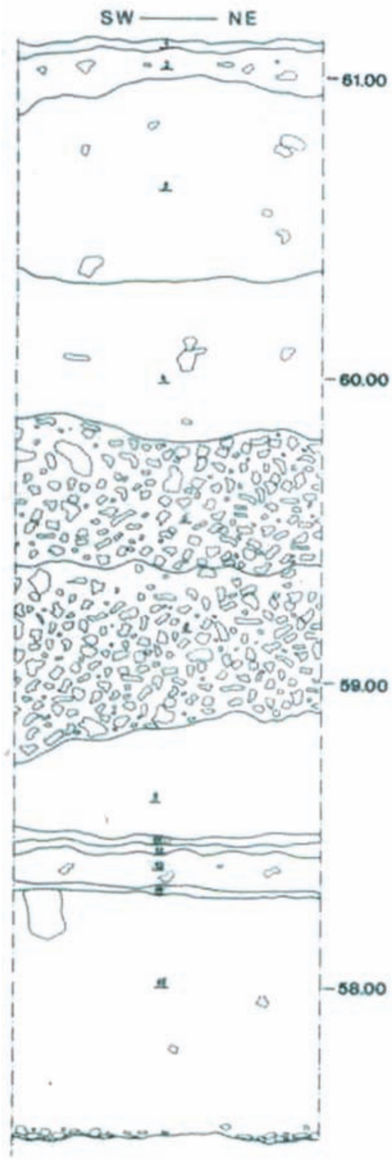

Fig. 25 ‘Ain Rahub, Test Unit, NW Section. (section width: 1,00 m)

Rahub and a tributary drainage. Its stratigraphy comprises alluvial, colluvial and cultural layers. In 1981, a final Natufian settlement (extending onto the spur) was exposed during bulldozing activities at the eastern foot of the spur. A test unit of 3x1 m cutting into the slope, carried out by Reinder Neef, was originally intended to reach the Natufian layers in order to determine the overall extension of the site in the spur’s slope. To our surprise, the Test Unit (Fig. 25-26) revealed concentrations of mud brick debris, grinding tools, and Yarmoukian pottery (Kafafi 1989) at depths between 59.70 and 58.80 m (excavation-internal height) (some even occuring at depths of 58.20 m; *cf.* Fig. 25) which are partly embedded in the rubble layers between 59.90 and 58.90 m. At that time, these finds represented the second Yarmoukian site east of the Jordan River, and still the nature of the site is not clear as all of its layers were sealed within the spur. The rubble layers resulted from possibly two immediately succeeding events and were formed by densely packed stones (Figs. 25-26), apparently representing mud flows which took up Yarmoukian cultural materials including Yarmoukian pottery and brick fragments on their way to deposition. Final Natufian (12000-10200 calBC) finds occurred *c.* 1 m below the lowermost rubble layer, concentrated at depths around 57.70 m.

Christian Hannss commented (Muheisen *et al.* 1988: 479) that the „sediments and limestone debris“ of the rubble layers „most likely are not of direct colluvial origin but were deposited as wadi accumulations. Major colluvial deposits cannot be expected here, as there are no extensive slopes above the lower terrace of ‘Ain Rahub.“ While the good preservation of the Yarmoukian sherds contradicts the interpretation of wadi accumulations, Hannss’ understanding that no direct colluvial origin of the rubble layers should be assumed appears plausible. Most likely, the ‘Ain Rahub evidence represents one or two intense rubble slides moving onto the Final Natufian/Post-Final Natufian slope surfaces from the immediate slopes to the north. Here a Yarmoukian settlement must have existed, the material of which became a component of the rubble slides.

The Yarmoukian rubble slide at ‘Ain Rahub is dated by one Quercus sp. charcoal date (GrN-14539: 7480 +/- 90 BP; W.G. Mook, Centrum voor Isotopen Onderzoek, Groningen and R. Neef, pers. comm. 1987). This 14C-age (Fig. 17), equivalent to a calibrated age of 6490 - 6170 calBC (95%), is in good agreement with other dates for the Yarmoukian (Weninger, this issue of *Neo-Lithics*). However, whether this date represents the date of the rubble slide itself (*e.g.* remains of a fire place during the deposition of the rubble), or not simply the (potentially earlier) date of transported charcoal from the Yarmoukian settlement, remains to be discerned. This interpretational problem applies to many of the available 14C-ages for the “Yarmoukian” rubble slides, and can – at the present state of research – only be resolved by application of direct (exposure) dating methods, *e.g.* OSL and 10Be, or by the radiocarbon dating of well-observed in situ features from within a rubble layer sequence.

Rubble Layer Archives: Research Perspectives

The intricacy of seventh millennium BC rubble layers at Neolithic sites in Jordan results from the polygenetic and polycausal elements that were involved in their formation. This should not make us ignoring their potential as an important source of information on climatic change. By this, we do not mean that the origin of rubble (be it anthropogenic or natural) is irrelevant to discussions, but we do suggest that even locally transported anthropogenic rubble may reflect a changed or changing climate regime. Due to the complexity of rubble layers, future analysis demands a multidisciplinary (*e.g.* prehistory, geomorphology,

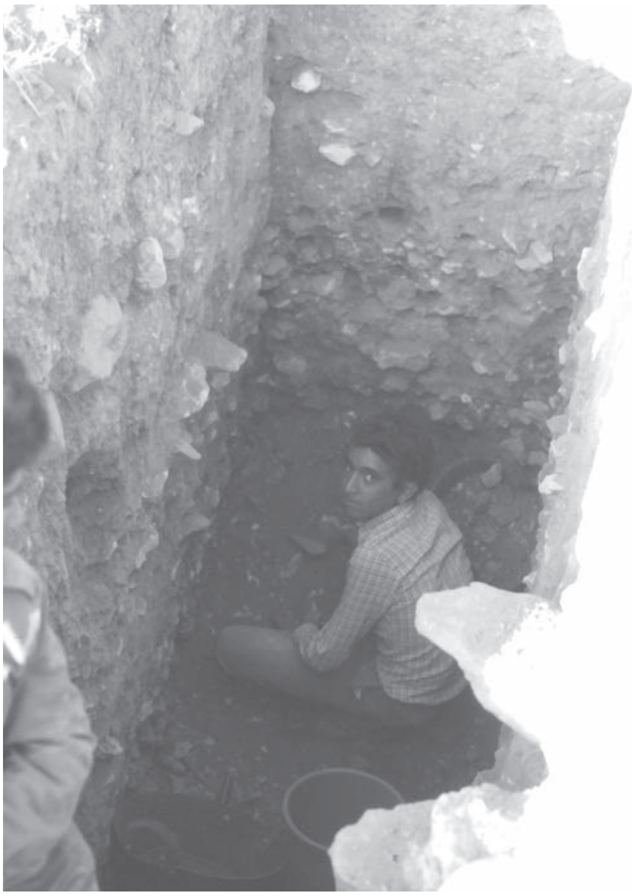

Fig. 26 'Ain Rahub, Test Unit: Excavation of the lower parts of the rubble layers. View from SE.

pedology, radiocarbon and other dating methods) approach, and any interpretation based upon a single genesis must be disregarded. Future rubble layer research must not only concentrate on collecting more rubble slide archives from more sites in different physiographic locations and from different Early Holocene contexts, but rubble layers also need to be properly excavated and observed in terms of microstratigraphy, depositional events, and in situ features. The excavation of rubble layers at prehistoric sites must take the form of a joint infield cooperation between archaeologists and geomorphologists. It follows that the analysis of rubble layers without direct correlation with the surrounding natural sedimentary environments amounts to an incomplete and fragmentary enterprise.

Rubble layers occurring during and immediately after prehistoric occupations are a most important source for improving our comprehension of a region's settlement history. Further, they not only provide us with an explicit understanding of the occupational fate of a given site, but they also help to identify (intra-site) areas within a site that were deserted during an otherwise permanent presence of humans at the same location. In the site's natural environment they are one of the important sources of information on land use, vulnerability of biotic resources, and anthropogenic eco-impacts.

The main problem lies with the absolute dating of rubble layers. Raised awareness is needed to identify potentially undisturbed in situ traces of occupation and surfaces in the depositional succession of rubble layers; indeed, this task should not pose too great a problem. Otherwise, the dating of rubble layers is subject to the high risk of dating much older re-deposited material taken up from transformed cultural phases further upslope.

Rubble layer awareness is required in all respects.

Acknowledgements: I would like to thank Bernhard "Bernie" Weninger for initiating the recent rubble slide and subsequent RCC discussion, and for re-awakening our concern of these phenomena which, since our 1987 season in Basta, we simply referred to as rubble layers. B. Weninger initiated an infield project on the rubble slides of 'Ain Ghazal, Basta, and Ba'ja (financed by the Sonderforschungsbereich 806 at Cologne University), starting section sampling work at 'Ain Ghazal in 2009. In Spring 2010, and in collaboration with us, additional geomorphological samples were taken by Christoph Zielhofer in Ba'ja and Basta, as well as 3D Laser Scanning of the rubble layers and related architectures by D. Hoffmeister, Cologne University. Since 1987, I have discussed the phenomenology and morphology of our rubble layers with many colleagues: Ulrich Kamp, Hans-Joachim Pachur, Christian Hannss, Bo Dahl Hermansen, Hans J. Nissen, Henning Fahlbusch, and others, but only the recent rubble slide/ RCC debate brought a new impetus into the discussion of this hitherto mysterious phenomenon. Since the 1980s, Gary Rollefson and Zeidan Kafafi discussed internally the rubble layers for their sites, and Gary Rollefson was among the first who understood the potential and implications of this topic. Recently, discussions were joined by Christoph Zielhofer, Leipzig University, through his infield geomorphological and geoarchaeological cooperation in Spring 2010, which are awaiting supplementation by his laboratory results. The photos of Basta were taken by Margreth Nissen and Gerald Sperling; all others are by H.G.K. Gebel. Graphical assistance was provided by Jana Pokrandt, and language editing was carried out by Lee Clare, Cologne University. I thank Hamzeh M. Mahasneh, Muhammad Najjar, and Alan Simmons for the permission to use the photos of Figures 23-25. All our research on the Neolithic of South Jordan would not be possible without the support of the Department of Antiquities of the Hashemite Kingdom of Jordan whose constant support we gratefully acknowledge here.

Notes

[1] All absolute chronology in this contribution refers to calibrated radiocarbon dates BC. The chronological abbreviations used here and their current absolute chronological equivalents are:
LPPNB Late Pre-Pottery Neolithic B (*c.* 7500 - 7000/6900 BC)
FPPNB Final Pre-Pottery Neolithic B (*c.* 7000 - 6800? BC)
PPNC Pre-Pottery Neolithic C (*c.* 6800? - 6500? BC)
PNA (Yarmoukian) Pottery Neolithic A (*c.* 6500? - 6200? BC)
The contents of this contribution became the basis for infield discussions in the field in the course of B. Weninger's project (*cf.* the Acknowledgements) in Spring 2010. The delayed *Neo-Lithics* 1/09 issue allowed some reference to be made to this project, but could not consider fully its results.

[2] The following abbreviations were used for the characteristic stratigraphic units of the Basta/ Ba'ja sedimentary environments. Since the origin and composition of the sedimentary features are not exactly similar, for each site different abbreviations are used.
FGM Fine-Grained Layers, characteristic for the sub-topsoil layers (Ba'ja)
RF Rubble/Gravel flow (Ba'ja)
FGL Fine-Gravel Lenses (Ba'ja)
URL Upper Rubble Layers (Basta)
LRL Lower Rubble Layers (Basta)
FGD Fine-Grained Deposits, characteristic for the sub-topsoil (Basta)

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Commentary

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Weninger's masterful compilation of paleoclimatic data clearly shows the occurrence of a number of episodes of rapid climate change (RCC), and it is expectable that such phenomena should have had environmental consequences across the globe. One RCC coincided with a phenomenon (the rubble layers) on a number of essentially contemporaneous archaeological sites in Jordan, and it was both tempting and obligatory to determine if the correlation offered some aspects of cause and effect.

The contribution by Barzilai covered the presence of "stone surfaces" in archaeological sites that might have originated from agencies other than natural ones, and this contention is certainly acceptable. One point that should be made is that when we have talked about rubble layers in the Late Neolithic/Yarmoukian period, we were not concerned simply with pavements, but with vast accumulations. The situation at Ard el-Samra appears to conform to such massive accruals, but it is not clear from Barzilai's article if the mounds of stones were beneath, above, or interspersed with Yarmoukian cultural debris; in other words, could this movement of angular debris be due to flash flooding and deposition of materials from the wadis and gentle hill slopes detectable in his Fig. 1?

Barzilai's description of anthropogenic sources of angular rock debris covers conditions that are well recognized throughout the Levant. At 'Ain Ghazal, for example, there are large and dense lenses of fire-cracked rock (FCR) – which is almost always fire-cracked flint – during the MPPNB in the Central Field, but such occurrences are of a very different character from the situation in the Yarmoukian period (as well as in the LPPNB and PPNC). In the Yarmoukian layers, the rubble is dense, deep, and virtually continuously distributed across the entire site, both within buildings (probably abandoned before the deposition) and in the broad spaces between the sparsely built-up Yarmoukian village area. In the MPPNB, FCR occurs densely but only sporadically in tightly defined clusters of debris, and always associated with ashy deposits.

The suggestions that FCR is associated with cooking is probably not the case, or at least not a complete accounting for the presence of the crackled flint. While many hearths include FCR in and around them, there are other hearths (particularly those inside the MPPNB houses) where FCR is absent or only intermittently present. Most of the FCR concentrations are in outdoor locations, so the association of FCR is likely concerned with some form of processing of materials other than food, but just what processing remains elusive.

Gebel also considers the likelihood that not all rubble deposits are due to climatic conditions, and that "prime movers" as explanatory devices are very often suspicious if not outright misleading and erroneous. Earthquake evidence at Ba'ja is particularly impressive, and much of the rubble that ends up in rubble layers may owe their ultimate origins not to natural causes, but to anthropogenic practices as well. Nevertheless, he notes that usually there are indicators that water transport was responsible at least in part to the accumulations.

What is important about the evidence from Basta, I think, is that the rubble layers occurred in layers equivalent to the final pre-ceramic period, thus antedating a Yarmoukian age[1]. This follows a refinement of the so-called "8.6-8.0 k.y.a. event" to indicate that it was a period of time that, while geologically speaking was a "sudden" development, actually spanned a relatively long time at its onset (see Weninger, this volume). This is also a strong piece of evidence that the "rubble event" actually consisted of several climatic pulses, and these pulses were not necessarily contemporaneous across the Near East but instead varied according to geomorphic and geographic elements affecting storm tracks. The suggestion Gebel makes, that the end of the large LPPNB occupation of Basta by the beginning of the 7th millennium BC, is also an excellent case for arguing that the LPPNB everywhere was as much affected by climatic deterioration as by cultural factors (*e.g.*, Rollefson and Pine 2007), although such cultural degradation certainly had a coeval impact of the environment.

Even so, the effects on the local environment at the end of the LPPNB/FPPNB/PPNC at Basta were clearly more powerful than in the north at 'Ain Ghazal and Wadi Shu'eib. This might relate to the differences in annual precipitation: the area around 'Ain Ghazal receives c. 250 mm rainfall each year, while the modern situation at Basta is only 160 mm (Neef 2004: 188). The PPNC occupation at 'Ain Ghazal continued, albeit across a much more reduced area of the site (less than three-fourths of the LPPNB site area and far below the density of residential structures and projected population levels)[2]. The population density declined even more at 'Ain Ghazal during the Yarmoukian period, although there was still a substantial population, perhaps as much as 300-400 people.

As was the case at Basta and Ba'ja, populations exploded during the earlier part of the LPPNB, and like the situation at the southern sites, there is a possible "sudden" impact on the site's people. While the population at MPPNB 'Ain Ghazal was modest and spread across the Zarqa River to the eastern bank to only a moderate degree, the sudden influx of LPPNB immigrants turned the East Field into a major "suburb" of the main site. But this eruption of settlement expansion may have been necessary; it is possible that the surge in population began to exhaust local resources, especially farmland and pasturage as well as wood resources for fuel for domestic use (Rollefson and Pine 2007). The extension of domestic buildings eastward across the Zarqa River was well-established, but before 7203 ± 95 cal. B.C. a large ritual structure was built, cutting into what appears to have been an essentially abandoned zone of ʻAin Ghazal by that time (Rollefson 1998: 51-54, but especially Footnote 24). The construction of this building, which required a major communal effort) may reflect deteriorating climatic conditions already before the beginning of the PPNC period, as was seen at Basta.

The situation that Gebel describes concerning earthquakes as a possible contributor to rubble deposits before the Pottery Neolithic period might also have a parallel at ʻAin Ghazal, although evidence remains weak at the moment. The final stage of the circular LPPNB "shrine" in the North Field appears to have suffered an architectural disruption that included severe damage and partial disintegration of the floor; a replacement of the circular building was rapidly undertaken about 5 m to the south, but the replacement appears to have been used for a brief time (Rollefson 1998: 47-48). The floor damage in the earlier building suggests the possibility of earthquake damage, although unrelated slope subsidence instead can't be dismissed at the moment. Another bit of evidence that might relate to earthquake damage at ʻAin Ghazal contemporaneous with the situation at Ba'ja comes from a two-story building in the south Field that dates to the LPPNB. In this case, the section exposed by bulldozer work shows an upper painted plaster floor that collapsed into the confines of a lower room. Such a collapse was seen in the North Field at ʻAin Ghazal, but this was certainly due to a fire that burned roof supports (Rollefson and Kafafi 1996: 13-14) and had little evident relationship to seismic activity.

The contribution by Kafafi, Lucke, and Bäumler leaves one somewhat nonplussed. Much of the article addresses architecture both prior to and within the period under consideration (the "8.6-8.0 k.y.a. event"). Two standing geological/archaeological sections were sampled (the eastern South Field and the western Central Field). Considerable effort is made to describe the composition and development of five very large and undefined archaeological layers (rarely identified as to archaeological age), but none of which deal with the layers that are evidently (from their illustrations) Yarmoukian in age. Much of the geological analysis relates to terra rossa development at ʻAin Ghazal, and this surely has little to do with the gray, rocky sediments that characterize Yarmoukian layers. The statement that "... it is not clear whether the ʻYarmoukian landslides' were indeed landslides or whether they were connected with heavy rains or earthquakes" is perplexing since it seems to be speculation that the research should have addressed in the first place. It is possible, of course, that the research project is ongoing and that this issue will be addressed in the future.

In summary, the discussion of the relationship of rubble layers with anthropogenic and natural agencies has shown that both could be responsible, and both kinds of activity could have been in play simultaneously at some sites, depending on topographical situation. And it is also possible, even probable, that the rare cloudburst that dumped enormous quantities of water on degraded slopes (either naturally, due to drought, or due to human activity due to deforestation and brush removal, or both) did, in fact, result in movement of masses of debris down the hillsides. The 8.6-8.0 "event" witnessed a long period of depressed temperatures and reduced rainfall, and over those 600 years it is likely that different combinations of natural and human agencies contributed to rubble layers in the hilly regions of the southern Levant.

Notes

[1] It is intriguing that Gebel inserts a couple of distinctions into the end of the late preceramic Neolithic period, using Late PPNB, Final PPNB, and PPNC subdivisions. This topic is deserving of more discussion in a later issue of Neo-Lithics.

[2] In their article, Kafafi *et al.* claim that ʻAin Ghazal's maximum area was c. 10 hectares; this is the case for the LPPNB settlement on the western side of the Zarqa River. There was also an LPPNB enclave of 3-4 hectares across the Zarqa River from the main settlement during this period).

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