WĀDĪ AN-NUʻAYḌIYYAH 1: ANOTHER NEOLITHIC BARRAGE SYSTEM IN THE AL-JAFR BASIN, SOUTHERN JORDAN

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Introduction

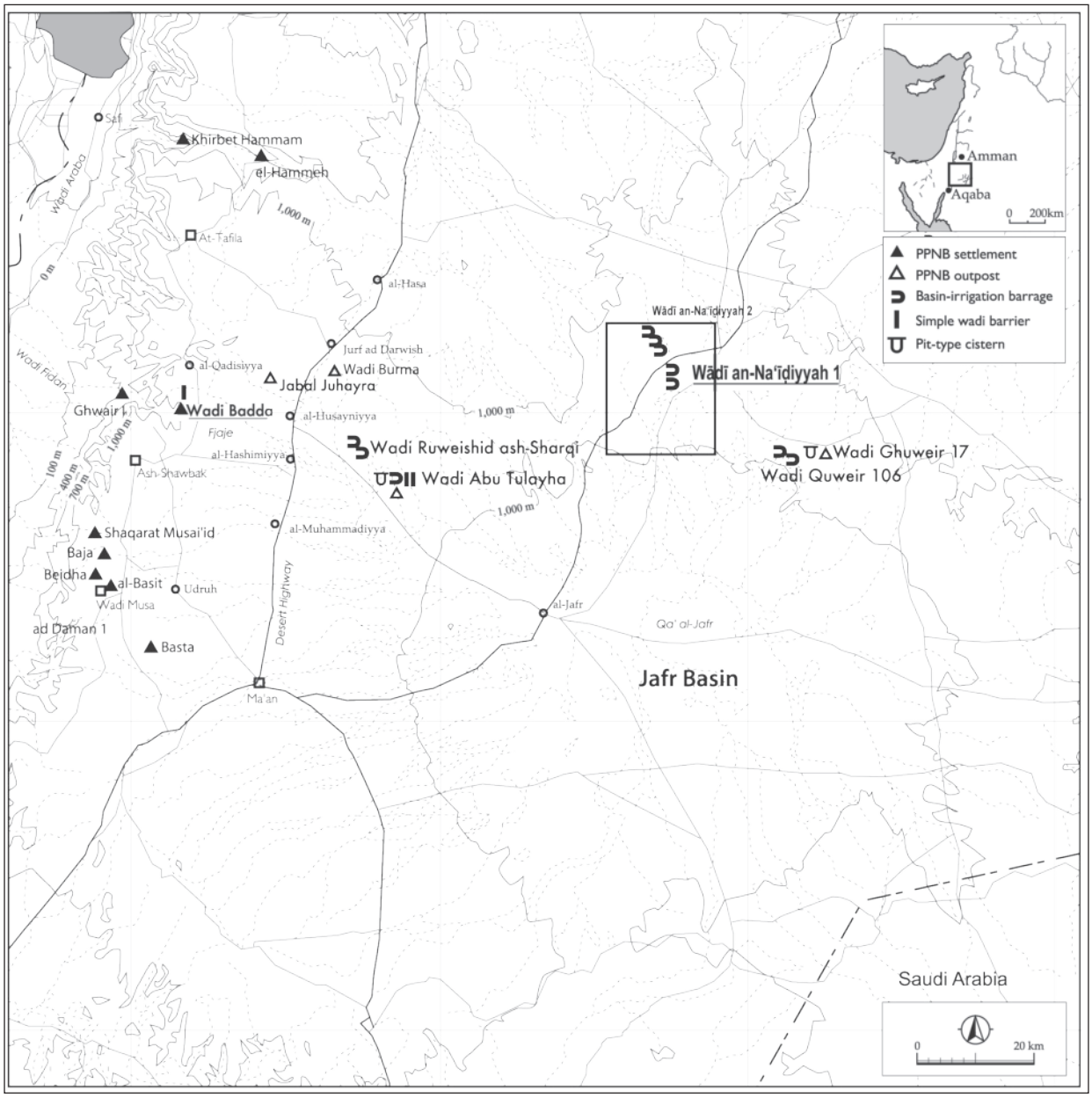
The Jafr Basin Prehistoric Project (JBPP), headed by the first author, started in 1995 with a view to tracing the process of pastoral nomadization in southern Jordan on the basis of archaeological evidence. The first and second phases of this long-term research project were conducted for twelve years, from 1997 until 2008, and addressed the establishment of a local chronology. For this objective, we excavated more than a dozen archaeological sites in the north-western part of the basin, our main research area. This series of investigations has enabled us to draw a rough sketch of a cultural sequence extending from the appearance of short-range pastoral transhumance in the latter half of the Pre-Pottery Neolithic B (PPNB), through a gradual shift into pastoral nomadism in the Pre-Pottery Neolithic C (PPNC) and the Late Neolithic (LN), until the establishment of fully fledged pastoral societies in the Early Bronze Age (EBA) (Fujii n.d.b: fig. 38).

The third phase of the project was designed on the basis of results from the PPNB agro-pastoral outpost of Wādī Abū Ṭulayḥa, which was continuously excavated in the latter half of the second phase (Fujii 2006a, 2006b, 2007a, 2007b, 2007c, 2008a, 2009; Fujii and Abe 2008). Our focus was on investigating the possible correlation between PPNB pastoral transhumance and the contemporary barrage system. The first field season, conducted over approximately two weeks between 13 and 24 September 2009, was devoted to a comprehensive survey of Neolithic water catchment facilities and neighboring agro-pastoral outposts. The survey suggested that the combination of the two components was the norm for the Jafr Pastoral PPNB and penetrated deep into the basin beyond the type-site (Fujii 2010a, 2010b). The second season took place for about three weeks between 14 September and 2 October 2010 and focused on rescue excavations at the Neolithic barrage site of Wādī Ghuwayr 106 and its neighboring outpost of Wādī Ghuwayr 17 (Fujii, *et al*. 2011; Fujii *et al*. 2011). The third and fourth seasons, our main concern here, was carried out for a total of six weeks between 4 and 29 September 2011 and 18 March and 5 April 2012. The target of the investigation was Wādī an-Nuʻayḍiyyah 1, another barrage system newly found in the northern part of the Jafr Basin. The investigation has provided further insights into the location, chronology, function and formation process of the Jafr PPNB barrage system as essential infrastructure supporting initial pastoral transhumance. This report briefly summarizes the investigation results from this unique extramural site.

The Site and its Setting

The site of Wādī an-Nuʻayḍiyyah 1 was found for the first time in the summer of 2011, during investigations at Wādī Ghuwayr 17 and 106, lying *ca.* 20km south-east of that site. Like the Wādī Ghuwayr sites, it is located on a limestone plateau behind the escarpment that defines the northern edge of the Jafr Basin (**Figs 1-2**). The surrounding natural environment is harsh and no perennial natural water sources are available. Local vegetation is very poor and no traditional villages are present. For this reason, local land use has long been limited to seasonal pasturing.

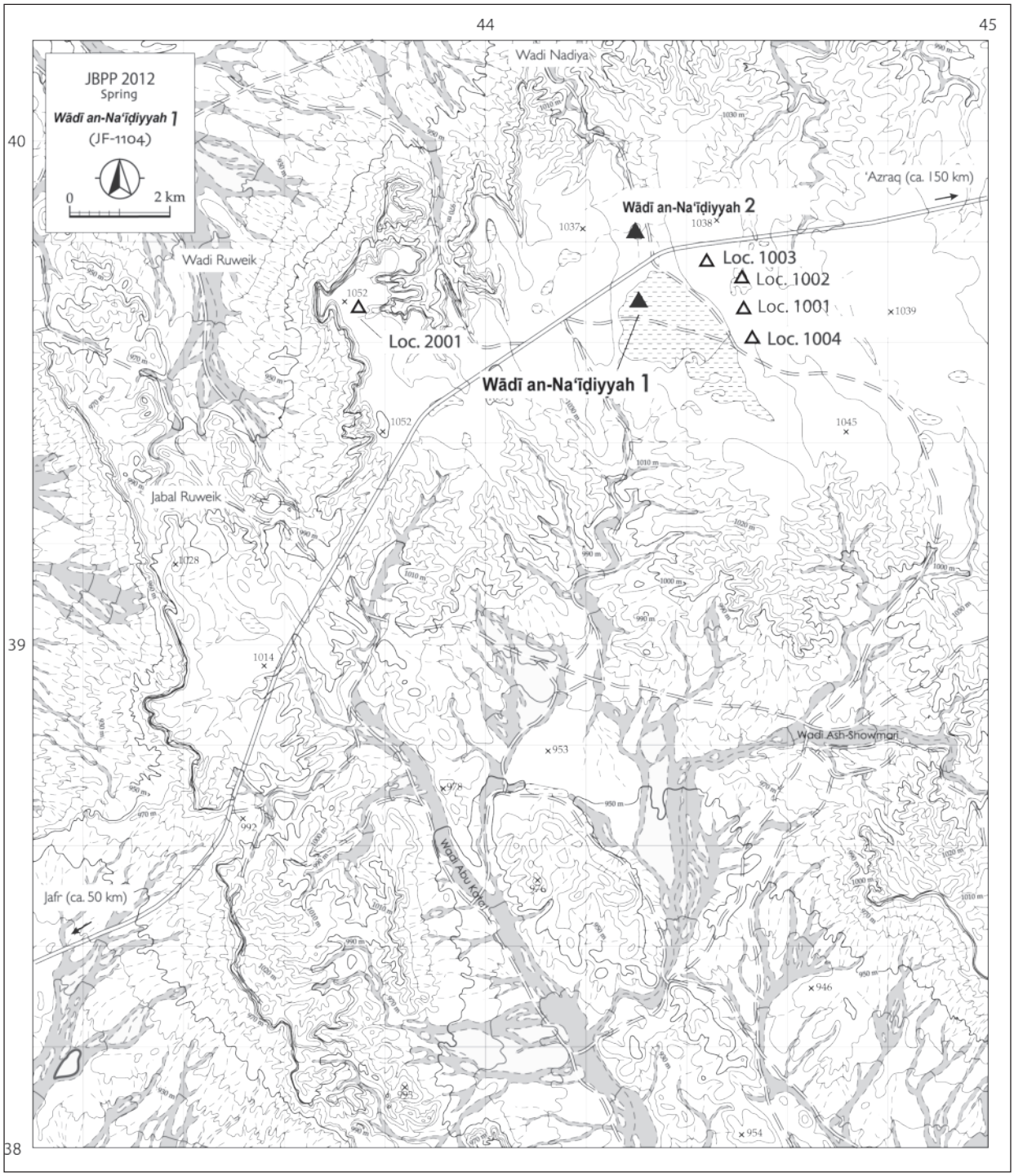
Wādī an-Nuʻayḍiyyah 1 is a simple, extramural site that consists only of two long freestanding stone-built walls (**Fig. 3**). It is isolated in the



1. Wādī an-Nu'ayḍiyyah 1 and PPNB sites in and around the Jafr Basin.

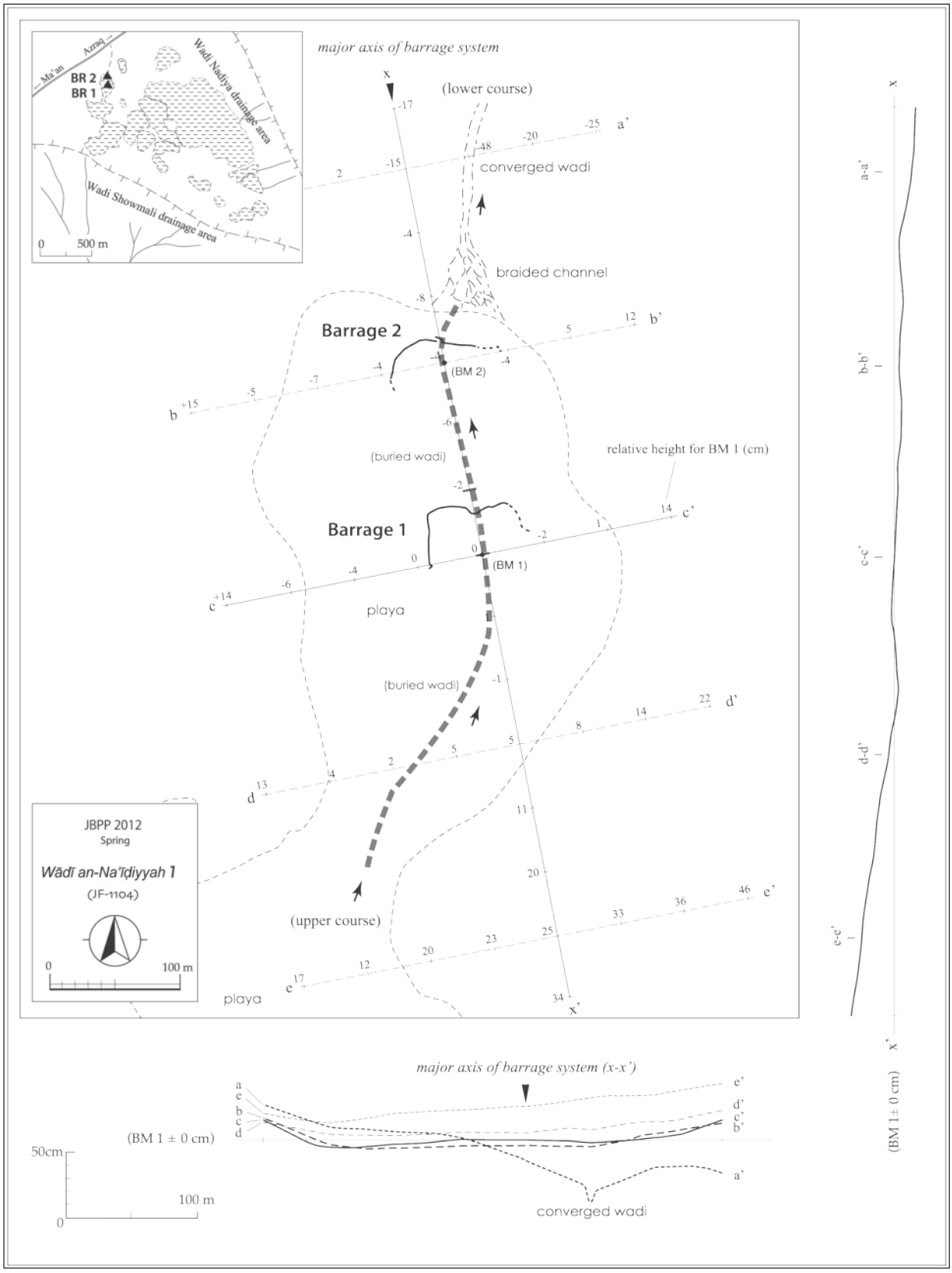
middle of a flint pavement desert (Ar. *ḥammād*) and appears not to have been associated with a neighboring settlement. However, as described below, four limestone and flint workshops (*loci* 1001-1004) are located nearby, suggesting the existence of neighboring encampments. In addition, another barrage site, Wādī an-Nu'ayḍiyyah 2, is situated *ca.* 1km lower down the same drainage system. Thus, we can argue that the barrage site of Wādī an-Nu'ayḍiyyah 1 is one of the major components of the Wādī an-Nu'ayḍiyyah site complex. Incidentally, Wādī an-Nu'ayḍiyyah flows northwards to join Wādī al-Ḥasā, one of the major drainage systems of the Transjordan Plateau. It follows that in terms of hydrology, the site belongs to the Wādī al-Ḥasā drainage system rather than the Jafr drainage system.

The two wall alignments occupy flat terrain in the northern half of an oval playa (Ar. *Qā'*) (**Fig. 4**). This playa, *ca.* 400m long and up to *ca.* 250m wide in terms of present surface area, is the lowest component of a semi-open playa system that forms the uppermost course of one of the headwaters of Wādī an-Nu'ayḍiyyah. Thus,



2. Location of Wādī an-Nu'ayḍiyyah 1 and its surrounding topography.

it follows that the two walls occupy the lowest part of the semi-open playa system, a location common to every PPNB barrage system known to date in the Jafr Basin (Fujii n.d.b; Fujii *et al*. 2011). A triangular braided channel is formed behind the lower barrage, *viz*. at the final outlet of the playa system, being followed by a small converging *wadi ca.* 3-5m wide and *ca.* 0.1-0.5m deep (**Fig. 5**). Both features are also common to the other examples, corroborating the suggestion that the Jafr PPNB barrage systems shared a number of common locational characteristics.



3. Wādī an-Nu'ayḍiyyah 1: site plan and elevations.

4: Wādī an-Nu'ayḍiyyah 1: distant view of the site (looking north-east).

5. Wādī an-Nu'ayḍiyyah 1: distant view of the site (looking south).

The Investigation

We adopted the same excavation methods used at the nearby barrage site of Wādī Ghuwayr 106. To begin with, we identified the main axis of the barrage system and established two arbitrary leveling points, BM-1 (*ca.* 1,026m; N 30˚41.689; E 036˚24.287) and BM-2 (*ca.* 1,026m; N 30˚41.771; E 036˚24.273), along that axis. Subsequently, we measured the relative elevations of the main axis and several perpendicular axes at 50m intervals, and plotted the outline of surrounding topographical features (**Fig. 3**). We then assigned serial numbers to the *in situ* wall remains of the two barrages at intervals of *ca.* 5-10m and produced general plans by plotting these marked points by plane table.

Following our previous investigations, we designated the two stone-built features as Barrage 1 and Barrage 2 in descending order of elevation, i.e. from the south to north. Barrage 1 was intensively examined by means of a total of six excavation areas (Areas 1-6) set up parallel to the major axis of the barrage system. The scrutinized wall sections totaled *ca.* 40m in length, equivalent to *ca.* 27 percent of the whole length of the barrage wall (*ca.* 150m). In addition, two trenches (Trenches 11 and 22) were opened to the north and south of the barrage wall for the purpose of exploring the location of a buried *wadi*. Barrage 2, on the other hand, was briefly examined with three small trenches. Excavated soil from the two features were not sieved owing to the extreme scarcity of small finds, but a small sample of basal deposits from Barrage 1 was collected with the aim of recovering any preserved organic remains. Several charcoal fragments and carbonized seeds were recovered by flotation and are now under analysis (Dr Hiroo Nasu pers. comm.).

The site stratigraphy was examined in every excavation area, as well as in a robber pit next to the west 'wing' of Barrage 1. It is summarized as follows (**Fig. 24**): Layer 1 – the surface layer – is *ca.* 5-10cm thick and consisted of light buff, slightly compact, silty sand deposits and a large amount of heavily abraded flint pebbles forming the present *Ḥamād* surface. Layer 2 is *ca.* 10-20cm thick, containing light brown, less compact, silty sand deposits and a small number of *Ḥamād* flints. Both layers covered the lower half of the barrage walls as subsequently deposited layers. (Layers 2a-2d are broadly identical to Layer 2 in terms of content, but point to thick fill deposits in an open-cut limestone quarry in front of the barrage wall.) Layer 3 consists of reddish brown, relatively compact, silty sand deposits *ca.* 30-40cm thick. The two barrages were constructed on the upper surface of this layer (often with a mud bank intervening in between). Layer 4 is a reddish-brown weathered limestone layer *ca.* 30-40cm thick and occasionally includes limestone cobbles and boulders, presumably from the open-cut quarry (**Fig. 12**). Layer 5 is a chalk layer more than 20cm thick, being extensively exposed at the base of the limestone quarry. This layer also includes high-quality limestone boulders, some of which were pulled off to leave small to large depressions at the base of the quarry. Such is our present understanding of the site stratigraphy, but further verification is needed to consolidate this tentative perspective.

Excavation of Barrage 1

Barrage 1 is located slightly to the east of the center of the oval playa, at a distance of *ca.* 250m from the present inlet of the playa and *ca.* 150m from its outlet (**Fig. 3**). It is constructed across the playa and opens toward the south-south-east. The barrage wall, *ca.* 150m in total length and up to *ca.* 0.4-0.7m in preserved height above the contemporary ground surface, spreads both 'wings' upstream to form a W-shape with a small protrusion at its center (**Figs. 6-8**). Seeing that fallen stones around the wall are very scarce, there would appear to be little difference between preserved and original wall heights. The playa surface in front of the barrage wall measures *ca.* 2-3 ha, which is the standard flooded area of the Jafr PPNB barrage (Fujii 2010c, n.d.b).

The barrage wall was constructed with a single row and up to three to five courses of undressed or partly dressed limestone cobbles and boulders *ca.* 30-80cm long. The central part of the barrage wall used halved cobbles and boulders, both of which were piled up with their fractured surface facing outward. Overall, the barrage wall was of high quality and relatively well-preserved considering that no clear evidence for clay mortar was confirmed. Of interest is the fact that three kinds of masonry techniques were used. The foundation course is usually constructed of upright boulders arranged in stretcher bonds. The middle courses, on the other hand, consist of cobbles piled up horizontally using the same stretcher bonds. The uppermost course uses smaller cobbles and a header bond technique. This eclectic masonry technique is shared by the PPNB agro-pastoral outposts as well as by contemporary barrages (e.g. Fujii 2007b: fig. 8, 2007c: fig. 6), suggesting that it was standard for stone-built structures in the PPNB Jafr Basin.

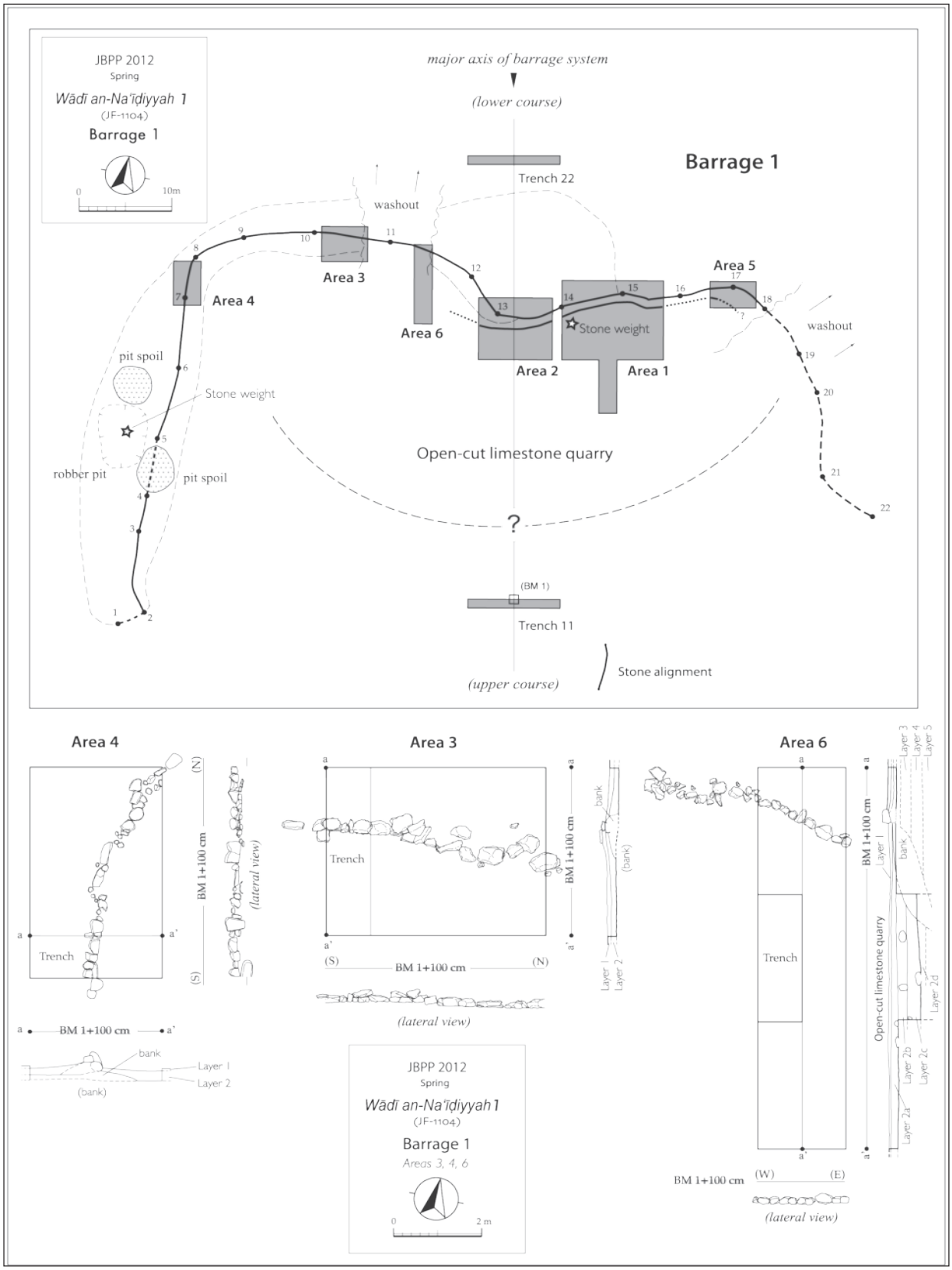
As with the lower barrage, the masonry wall of Barrage 1 was often supported by foundations and / or rear banks. Unexpected was the existence of a subterranean retaining wall up to *ca.* 1.2m high, which was constructed in front of the barrage wall (i.e. at the northern edge of the open-cut limestone quarry). This robust wall was probably intended to cope with strong sideways water pressure in order to prevent the barrage wall from collapsing. The discovery of such a robust revetment buried under the thick deposits in front of the barrage wall necessitates a re-examination of several previously investigated barrages in the Jafr Basin.

Area 1

Area 1 was established to examine the structure of a well-preserved wall section slightly to the east of the central protrusion of the barrage (**Figs. 9-11**). The excavation revealed a high quality masonry wall *ca.* 13m long and up to *ca.* 0.7m in preserved height, which was slightly outcurved in a downstream direction. It follows that the wall segment is combined with the central protrusion in Area 2 and, as a whole, describes a gentle S-shape. This is an ingenious device to disperse the strong sideways water pressure acting on the central part of the barrage. A small mud bank *ca.* 0.3m high and *ca.* 1m wide was confirmed behind the wall.

Of significance is the discovery of the subterranean retaining wall up to six stone courses or *ca.* 1.2m high. The wall ran parallel to the barrage wall, with an intervening rubble core *ca.* 1m wide between the two, thus forming a gentle double arc slightly out-curved towards the lowest course. The masonry technique of the revetment was of high quality with every course of construction material laid horizontally, occasionally using limestone rubble as adjusters. The revetment occupied the northern edge of the open-cut limestone quarry, which had been excavated down to the upper surface of Layer 5 or even beyond (**Fig. 12**). There is no doubt that the operation was intended to procure the good quality limestone cobbles and boulders present in Layer 4 and on the upper surface of Layer 5. As a matter of fact, the quarry base was uneven and still retained small to large depressions left by removed stones. The discovery of the open-cut limestone quarry in front of the barrage wall sheds light on the reason why the barrage occupies muddy ground without much in the way of exposed construction material, and why many of the limestone cobbles and boulders incorporated into the barrage wall are less weathered in comparison with other stones scattered around the site.

Also of interest is the origin of the fill deposits in the open-cut quarry. Unexpectedly, a small hearth (*loc.* 148/171) found between Layers 2d and 2e produced a C-14 date of 1266 ± 23 cal. BP [IAAA-113379]. Consistent with this date is the occurrence of an early Islamic gravestone



6. Barrage 1: plans and sections / elevations (including Areas 3, 4 and 6).

7. Barrage 1: general view (looking south-west).

8. Barrage 1: general view (looking north-east).

and a dozen contemporary plain ware sherds from Layer 2d in Area 2. As described below, the lower fill layers in Area 1 also yielded a few similar pottery sherds. These facts suggest that aside from the basal deposits (Layer 2e) and the fill deposits in the series of depressions, most of original deposits and pit-spoil in the open-cut quarry were washed away in floods after the early Islamic period. Incidentally, the same observation was made at Barrage 1 of Wādī Abū Ṭulayḥa (Fujii 2007b: 409-410).

Area 1 yielded a grooved stone weight from Layer 2b (**Fig. 34: 1**), a heavy-duty digging tool from Layer 2c (**Fig. 34: 7**) and a few early Islamic plain ware sherds (similar to the finds recovered in the neighboring Area 1) from Layer 2d. As discussed below, there is a high possibility that the two former artifacts derived from the original deposits in the open-cut limestone quarry.

Area 2

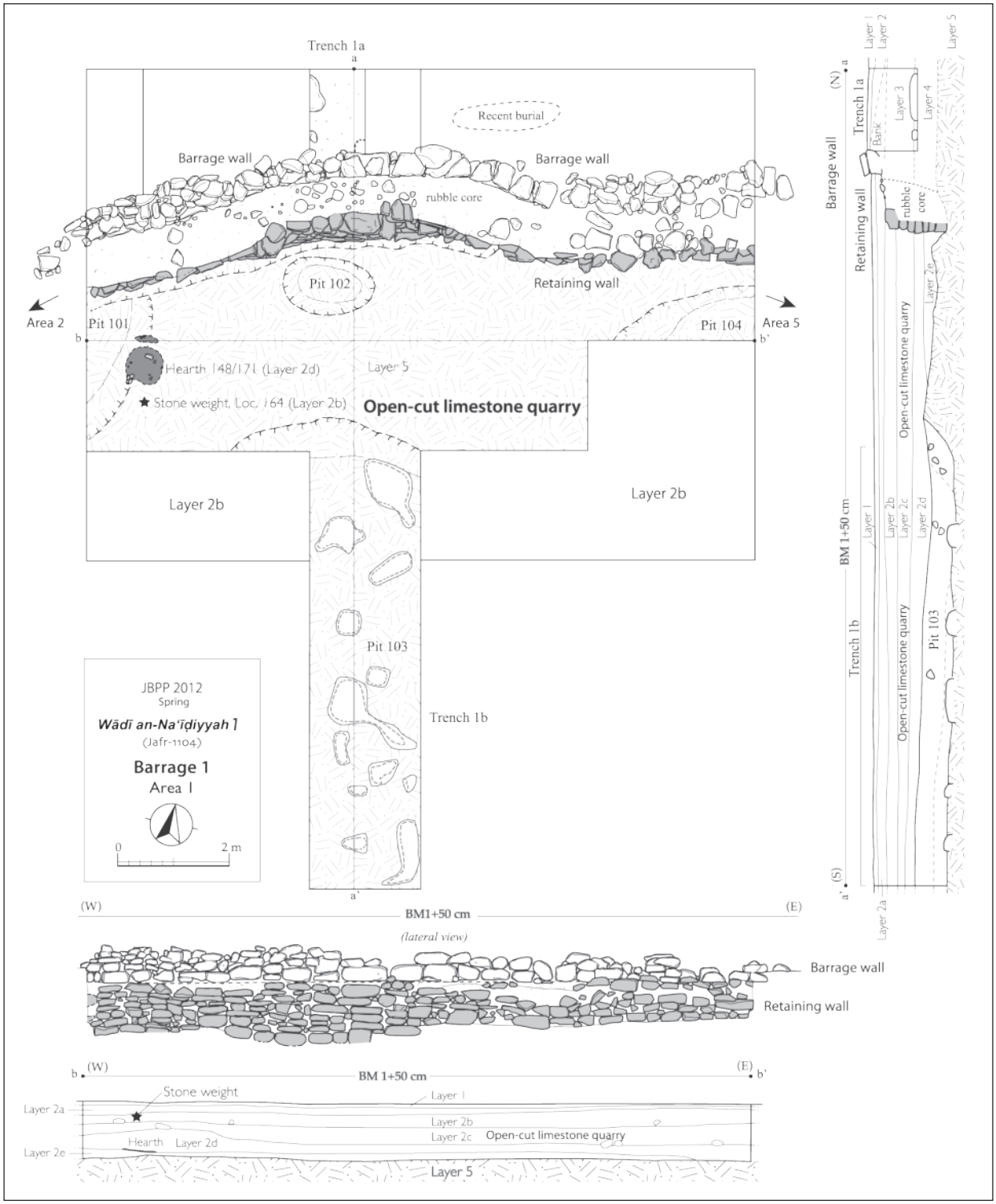
The operation in Area 2 examined the structure of the protrusion in the center of the barrage (**Figs. 13-15**). It was also protected with a revetment or robust subterranean retaining wall constructed at the northern edge of the open-cut limestone quarry. There is no doubt that, as suggested above, the central protrusion was combined with the slightly out-curving wall section at the neighboring Area 1 to divert the strong water pressure toward both sides. A similar device has been confirmed at most of the PPNB barrages known to date in the Jafr Basin (e.g. Fujii 2007b: fig. 9, 2007c: fig. 5; Fujii, Adachi *et al*. 2011: fig. 7), suggesting that they were constructed according to the same basic design.

It is inconceivable, however, that strong sideways water pressure acted on only one part of the barrage wall when we consider the flat topography in and around the playa. Of significance in this regard is the cross-section of Trenches 11 and 22 described below (**Fig. 21**). The existence of lenticular fluvial deposits (i.e. Layer 2') sandwiched between Layers 2 and 3 suggests that the central protrusion was constructed across a small *wadi ca.* 5-6m wide and *ca.* 20-30cm deep. If this is the case, it would follow that the present playa was formed after the construction of the barrage, probably as a result of its damming effect. As discussed below, this new perspective would provide valuable insights into the formation process of the Jafr PPNB barrage system.

An early Islamic gravestone and a dozen plain ware sherds were found in Layer 2d, a lower fill deposit in front of the central protrusion (**Fig. 34: 9-11**). As suggested above, their occurrence in the lower fill layer indicates that the original deposits in the open-cut limestone quarry were almost washed away by repeated floods after the Neolithic. One of the few possible exceptions to this is a small digging tool again recovered from Layer 2d (**Fig. 34: 8**). As with the similar artifact from the neighboring excavation area, there is a possibility that this stray find derived originally from the Neolithic quarry.

Area 5

This small excavation area was established to explore the eastern extension of the limestone quarry and revetment. Though not completed owing to time constraints, the limited deep sounding at the south-western corner revealed a stone alignment running parallel to the barrage wall (**Figs. 13, 16**). There is no doubt that this



9. Barrage 1: plan, lateral view and sections / elevations of Area 1.

robust wall section represents an eastern extension of the revetment attested to in Areas 1 and 2. It therefore follows that the open-cut limestone quarry extended at least as far as the eastern turning point of the barrage wall. The excavation also revealed a barrage wall up to four courses high, carefully constructed of halved limestone boulders. No artifacts were found.

10. Barrage 1: general view of Area 1 (looking west).

11. Barrage 1: general view of Area 1 (looking north-east).

12. Barrage 1: general view of the south trench of Area 1 (looking north-east).

Areas 3, 4 and 6

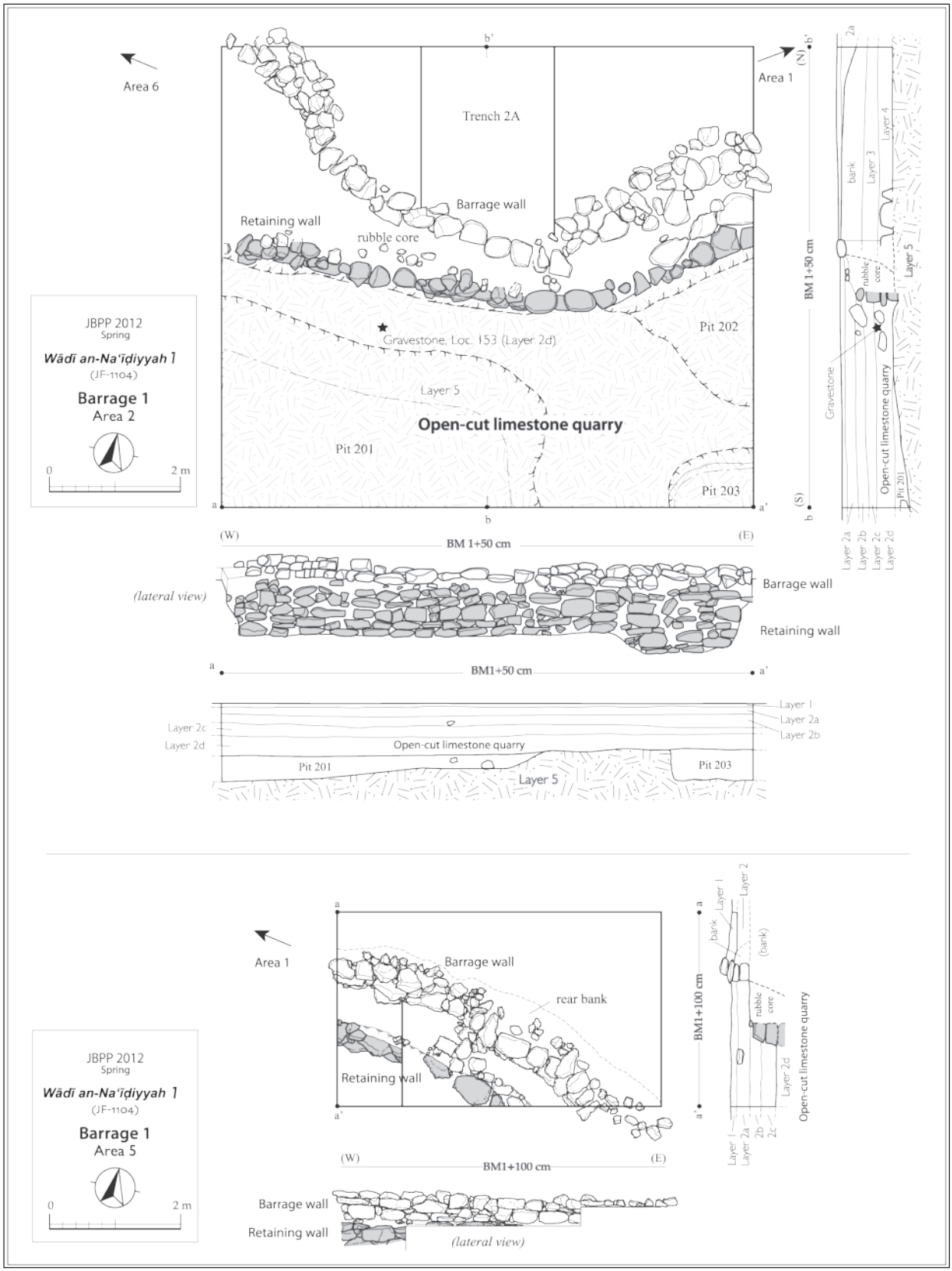
These three small excavation areas briefly explored the structure of the western half of the barrage. The limited excavations showed that it was much inferior in construction quality than the wall of the eastern half, being not more than a few courses high and constructed with smaller, less standardized limestone cobbles (**Figs. 6, 17-19**). This contrast suggests that the western half of the barrage was constructed as a simple barrier to retain a seasonal flood.

The same applies to the subterranean structure. Although the sub-trench set in the middle of Area 6 produced evidence for a western extension of the open-cut quarry attested to in neighboring Area 2, no clear evidence for the revetment was confirmed. What we found instead was a part of a mud bank that protected the front of the poorly constructed barrage wall. This means that the robust masonry revetment characteristic of the eastern half was replaced by the mud bank between Area 2 and Area 6. This is probably because this part of the quarry failed to yield any of the expected building stones. (As a matter of fact, the cross-section of the robber pit described below clearly indicates that no good quality building stones were present in the layers on the western half of the barrage.) The inferior quality of the barrage wall behind the bank may also be understood in the same context. Though not sufficiently explored in the other two excavation areas owing to time constraints, a combination of a non-productive open-cut limestone quarry, an inferior barrage wall and a front bank (instead of a revetment) appears to characterize the western half of the barrage. With the exception of several undiagnostic flint flakes, no artifacts were found.

Stone Alignment

A short stone alignment was found in the middle of the flooding area of the barrage, at a point *ca.* 13m south-east of BM-1 (**Figs. 6, 20**). Describing a gentle curve, it extended for *ca.* 5m roughly north - south. This feature was very simple in structure, being constructed of a single row and course of upright undressed limestone cobbles, partially supported by rubble. No artifacts were recovered around the feature.

Nothing can be said about the chronological correlation or otherwise of this feature with the neighboring barrage, except that the feature might once again be founded on the upper surface of Layer 3. The specific use of this unique feature is also unknown. A possible interpretation is that it represents a remnant of an embankment constructed along the buried *wadi*, but it appears too ephemeral for such a role. (It also casts doubt on the assumption that the similar example at Barrage 2 is far from the supposed



13. Barrage 1: plans, lateral views and sections of Areas 2 and 5.

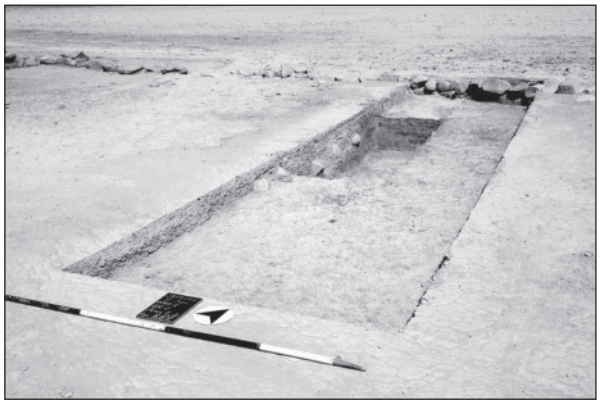
14. Barrage 1: general view of Areas 2 and 1 (looking north-east).

15. Barrage 1: general view of Area 2 (looking north).

16. Barrage 1: general view of Area 5 (looking north).

17. Barrage 1: general view of Area 3 (looking north-west).

18. Barrage 1: general view of Area 4 (looking north-north-west).



19. Barrage 1: general view of Area 6 (looking north-north-west).

position of the buried *wadi*.) Worth bearing in mind is an elderly workman's comment that local herders often still construct similar features as a water level gauge. According to him, this simple device enables them not only to know the water level of a flooded playa but also to guide their livestock so as not to get stuck in the mud. In view of the existence of a similar feature at Barrage 2 described below, this intriguing ethno-archaeological interpretation seems worth testing.

Trenches 11 and 22

Two long trenches were opened in search of possible evidence for the presence of a *wadi* that was likely dammed up by Barrage 1 (**Fig. 6**). Trench 11 was set up across BM-1 lying *ca.* 30m upstream of the barrage wall. Trench 22 was ar-

20. Barrage 1: general view of stone alignment (looking south).

ranged at a point 50m north of BM-1, or *ca.* 20m downstream of the barrage wall, again with the major axis of the barrage system at the center.

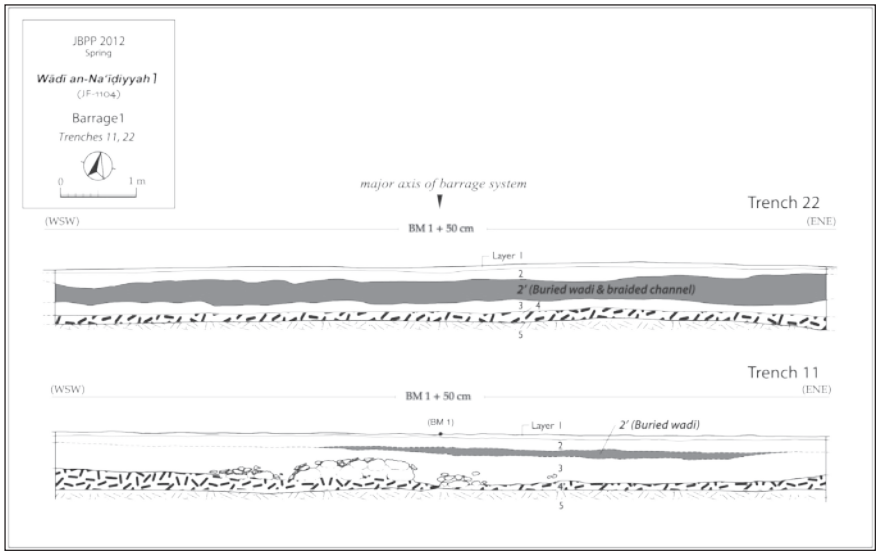
The deep sounding at Trench 11 confirmed that shallow fluvial deposits (Layer 2'), *ca.* 6 m wide and *ca.* 0.2-0.3m thick, were sandwiched between Layer 2 and Layer 3 (**Figs. 21, 22**). These probably represent the *wadi* being buried by the damming effect of the barrage. Given that the central protrusion of the barrage corresponded with this location, it would follow that a small stream flowed in a north-north-westerly direction taking an easterly course within the present playa (**Fig. 3**). This assumption, if correct, would explain the reason why the barrage system is located slightly to the east of the center of the present playa (newly formed through the damming effect of the barrage), and why its major axis is slightly off-center.

Trench 22 also yielded similar deposits between Layers 2 and 3 (**Figs. 21, 23**). However, it was much larger in scale (*ca.* 20-30cm thick and more than 10m wide) and, at the same time, conspicuously uneven on both its upper and lower surfaces. Seeing that the width of the buried *wadi* appears to be consistent between Trench 11 and the central protrusion of the barrage, it is most unlikely that the *wadi* suddenly became wider behind the barrage. A key to this enigma is the formation of a triangular braided channel behind Barrage 2 (**Fig. 3**), which suggests the possibility that these wide and uneven deposits represent a mixed picture of buried *wadi* and a braided channel newly formed behind Barrage 1, subsequently buried under similar fluvial deposits. As discussed below, this tentative perspective would contribute towards a better understanding of the formation process of the Jafr PPNB barrage system.

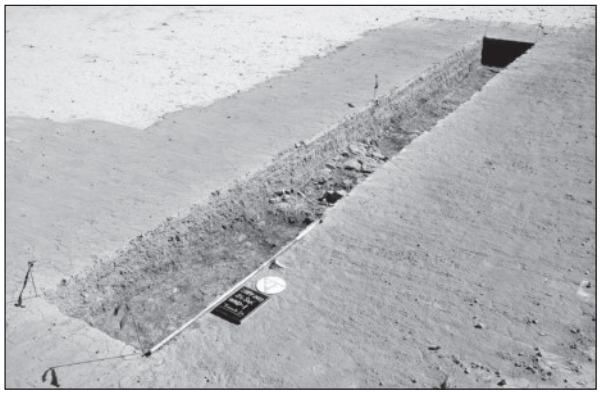
Incidentally, Trench 11 – to say nothing of Trench 22 – includes both Layer 3 and Layer 4. This means that the open-cut limestone quarry did not reach this area of the site. It follows that the southern edge of the quarry was located somewhere between the trench and the southern end of Area 1 (**Fig. 6**), a likely assumption when we consider the length of the two 'wings'.

Robber Pit

There was a large robber pit, probably dug by heavy machinery, beside the west 'wing' of the barrage. We partly cleaned its sections and examined the intact site stratigraphy outside the limestone quarry (**Figs. 24-26**). Since results of the

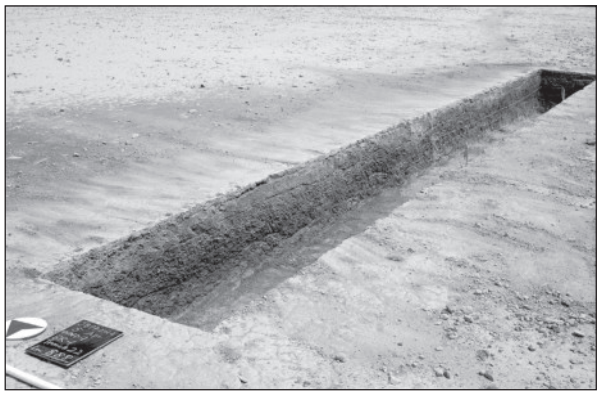


21. Barrage 1: sections of Trenches 11 and 22.

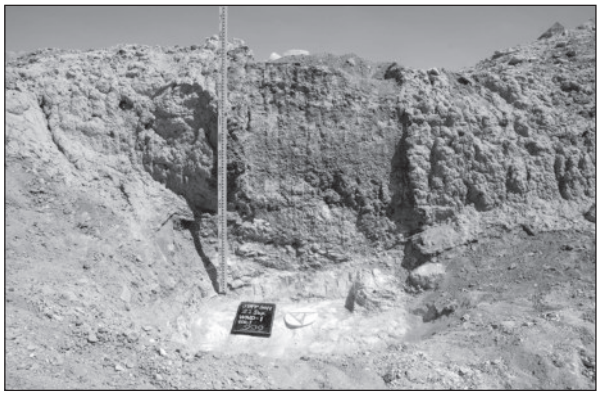


22. Barrage 1: general view of Trench 11 (looking north-north-east).

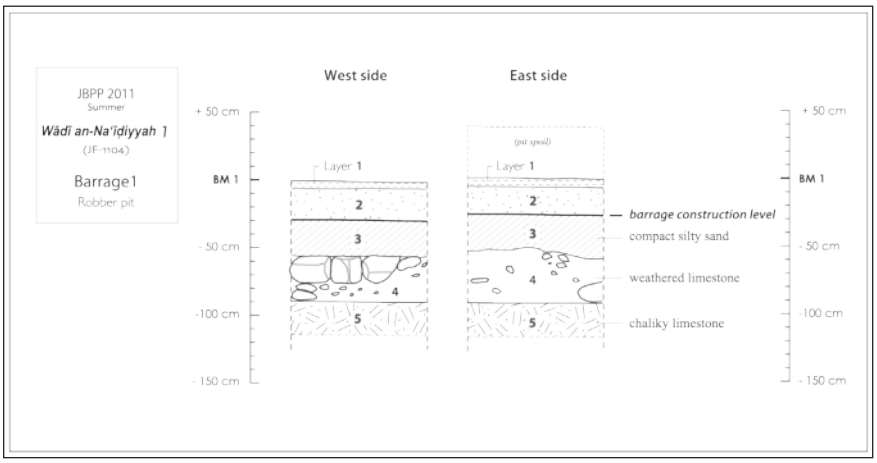
25. Barrage 1: general view of the western wall of the robber pit (looking south-west).



23. Barrage 1: general view of Trench 22 (looking north-north-east).



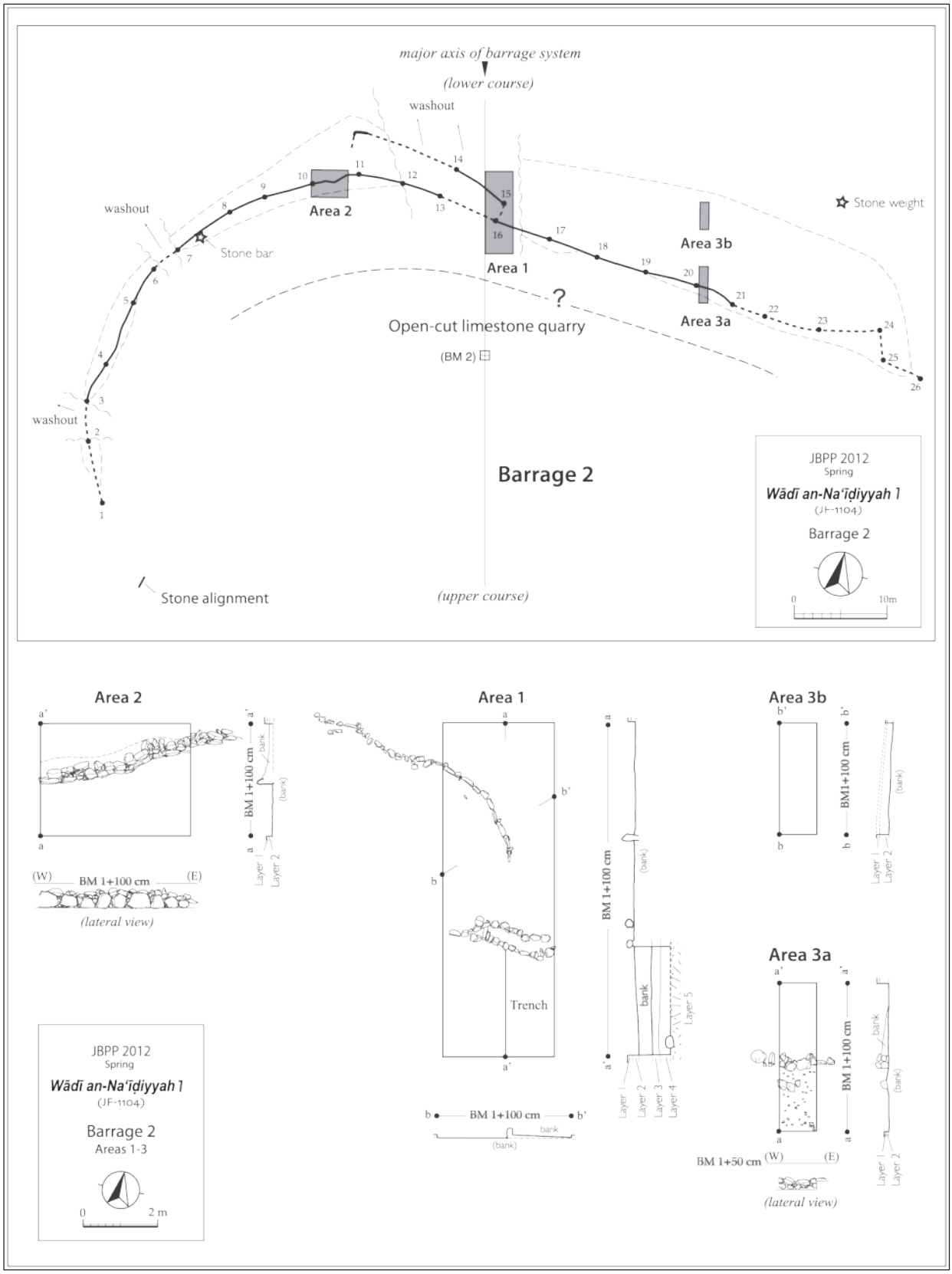
26. Barrage 1: general view of the eastern wall of the robber pit (looking north-east).



24. Barrage 1: cross-sections of the robber pit.

investigation have been collectively described above, no repetition is needed here. The two columnar sections provided valuable insights into the purpose of the open-cut limestone quarry.

Incidentally, the robber pit yielded a large stone weight, a chronological indicator of the Jafr PPNB barrage system (**Fig. 34: 2**). This limestone product occurred as a stray find in the base of the pit. Seeing that several limestone cobbles were scattered in and around the pit, it is conceivable that the diagnostic find was combined with the other cobbles to form an attractive stone-built feature, probably a tomb. It is our present interpretation that the stone weight was originally incorporated somewhere into the barrage wall and was then re-used in the erased feature as building material. Similar artifacts occurred as stray finds in Area 1 (**Fig. 34: 1**)



27. Barrage 2: plan and sections / elevations.

28. Barrage 2: general view (looking south-west).

29. Barrage 2: general view (looking north-east).

and behind Barrage 2 (**Fig. 34: 4**). These finds, though not *in situ*, are suggestive of a PPNB date for the Wādī an-Nu'ayḍiyyah 1 barrage system.

Excavation of Barrage 2

Barrage 2 is situated *ca.* 130m downstream of Barrage 1, or *ca.* 20m upstream of the playa outlet (**Fig. 3**). As with the upper barrage, it is constructed across the playa and is oriented to the south-south-east. The barrage wall, *ca.* 125m in total length and up to *ca.* 0.3-0.4m in preserved height, describes a roughly straight line in its eastern part and a gentle curve in its western part (**Figs. 27-29**). Overall, the barrage is much inferior in construction quality than the upper barrage, being up to a few courses high and constructed of much smaller and less standardized construction materials. Furthermore, it is devoid of both a central protrusion and a revetment (Instead, as noted below, it is equipped with a rectangular rear wall and an extensive foundation bank) The flooded area is slightly smaller in scale than Barrage 1, being estimated at *ca.* 1-2 ha. These contrasts between the upper and lower barrages are common

30. Barrage 2: general view of Area 1 (looking north-north-west).

to every Neolithic barrage system known to date in the Jafr Basin (Fujii 2007c, 2011c), providing a key to understanding their formation process (Fujii *et al*. 2011).

Area 1

The operation in Area 1 aimed to examine the structure of the central part of the barrage. It revealed three simple walls, which all sat on an extensive foundation bank overlying Layer 3 (**Figs. 27, 30**). The central wall stretched across the excavation area and can, therefore, be defined as the main part of the barrage wall. The front wall may be regarded as a simple barrier for protecting the barrage wall from erosion. The rear wall, on the other hand, formed the western edge of a rectangular rear 'fence' that extends along the central part of the barrage. Seeing that only this wall was constructed with upright slabs, it may have been packed with mud and rubble and used as a sort of rear support for the barrage wall. No datable *in situ* artifacts were found in the excavation area.

We opened a small sub-trench in front of the barrage wall for the purpose of exploring the origin of the huge volume of deposits used in the construction of the large-scale bank extending in front and behind the barrage wall. We found a forward extension of the foundation bank, but no clear evidence for the material source was obtained within the extent of the sub-trench. A possible interpretation is that, as with the western part of Barrage 1, a non-productive open-cut limestone quarry existed ahead of the sub-trench and supplied silty deposits as well as low quality building stone (This is highly likely as, in contrast to Area 1 of Barrage 1, Layers 4 and 5 in

31. Barrage 2: general view of Area 2 (looking north-west).

the sub-trench include small limestone cobbles only). There is a possibility that the non-productive open-cut quarry in front of the barrage was extensive, but a re-investigation is needed to verify this tentative perspective. No datable *in situ* finds were recovered.

Area 2

This excavation area was opened to explore the structure of the western part of the barrage wall. The limited excavation revealed a well-preserved masonry wall segment up to *ca.* 0.5m high that used upright limestone cobbles as foundations (**Figs. 27, 31**). However, unlike Area 1, no clear evidence for the front protection wall was confirmed. No diagnostic artifacts were found in the operation area, but a diagonally truncated stone bar made of cortical flint was recovered at a point *ca.* 15m south-west of the area, beside wall segment 7/8 (**Fig. 34: 3**).

Areas 3a and 3b

32. Barrage 2: general view of Area 3 (looking north).

These two small excavation areas were set up across wall segment 20/21 in the eastern part of the barrage **(Figs. 27, 32)**. The small soundings confirmed an eastern extension of the poorly constructed barrage wall, the front protection wall and the extensive foundation bank, all attested to in Area 1. The existence of the extensive foundation bank implies that the open-cut limestone quarry, a likely source of raw material, extended eastward too. It appears that as with Barrage 1, Barrage 2 was

33. Barrage 2: general view of stone alignment (looking north).

also reinforced in its eastern half, at least in terms of the foundation bank. As suggested below, this is probably because the eastern half of the playa gave passage to seasonal floodwaters. A stone weight was found behind the barrage wall, at a point *ca.* 15m east of Area 3b **(Fig. 34: 4)**.

Stone Alignment

Barrage 2 was also associated with a short stone alignment **(Figs. 27, 33)**. However, unlike the similar example at Barrage 1, this one was much smaller in size (*ca.* 1.5m long) and was located close to the western edge of the expected flooded area. As suggested above, this isolated feature might have been used as a water level gauge during the rainy season, but further verification is needed to validate this ethno-archaeological working hypothesis.

Small Finds

Small finds from the extramural barrage site are understandably very scarce, being limited to three stone weights, a diagonally truncated stone bar, a few dozen chipped flint artifacts and a limited number of early Islamic artifacts. Although none of them occurred *in situ*, they provide valu-

able insights into the date of the barrage system. In addition, several Arabic graffiti probably inscribed in the recent past were found on construction materials, but they are omitted from the following description.

Stone Weights

A total of three stone weights were recovered: two from Barrage 1 and the other from Barrage 2. All of them were made of a fine-textured, and therefore heavy, limestone boulder. The largest example (52.5cm long, 27cm wide, 24cm thick and *ca.* 46 kg in weight) occurred in an upper fill layer (Layer 2b in Area 1) of Barrage 1 (**Fig. 34: 1**). Unusually, this stone weight is made of a prismatic limestone boulder and, probably for this reason, substitutes a circumferential groove for a pair of lateral notches. The second largest example (45.2cm long, 39.4cm wide, 15.8cm thick and *ca.* 36.2 kg in weight) was recovered in the robber pit beside the west 'wing' of the same barrage (**Fig. 34: 2**). The existence of a small hole, *ca.* 10cm in diameter and *ca.* 3cm in depth, in the center of the ventral surface suggests that the artifact was made on a re-used pillar base, another chronological indicator of the Jafr Pastoral PPNB. Otherwise, this artifact is typical of Jafr PPNB stone weights, being modified into a violin-shaped profile by means of bifacial grooving and bilateral notching. The smallest example (35.4cm long, 21.2cm wide, 10.3cm thick and 9.4 kg in weight) was also recovered as a stray find behind the east 'wing' of Barrage 2 (**Fig. 34: 4**). It lay on the present ground surface, suggesting that it had been removed from its original position in the recent past. Though typical in overall profile, this product does not have a bifacial groove and is modified by means of a pair of lateral notches and partial trimming only.

Similar artifacts have been found at every PPNB barrage and outpost known to date in the Jafr Basin and can, therefore, be regarded as standard equipment of the Jafr Pastoral PPNB (e.g. Fujii 2007b: fig. 16, 2007c: fig. 9; Fujii, Adachi *et al*. 2011: figs. 32, 33, n.d.b: fig. 13). There is little doubt that the three stray finds from Wādī an-Nu'ayḍiyyah 1 share a similar date and function. Available evidence from the other barrages suggests that they were originally incorporated into the barrage wall, especially its central protruding reinforcement wall, as good luck talismans or ritual objects intended to secure the safety and longevity of the barrage. The three products might have attracted someone's notice precisely because they were used in such a conspicuous placement. Anyhow, the occurrence of these diagnostic finds is suggestive of a PPNB date for the barrage system of Wādī an-Nu'ayḍiyyah 1.

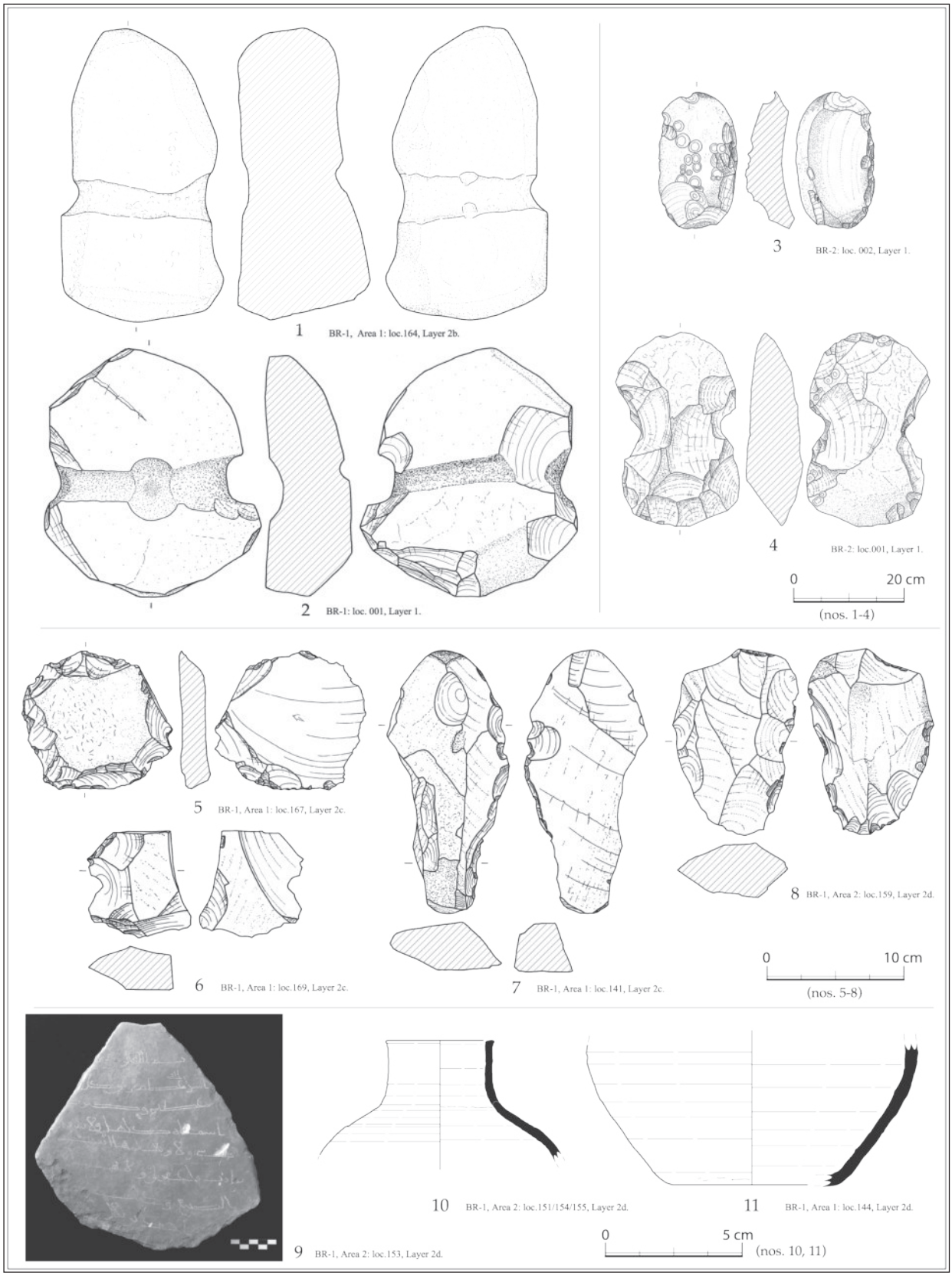
Stone Bar

A diagonally truncated stone bar, another chronological marker of the Jafr Pastoral PPNB, was recovered immediately beside wall segment 7/8 of Barrage 2 (**Fig. 34: 3**). This unique artifact, 25cm long and 3.4 kg in weight, is made of a cortical flint nodule with a large thermal-flaking scar on its ventral surface. It is produced taking full advantage of the original shape of the material, with secondary retouch being limited to diagonal truncation at both ends. In this sense, it can be defined as an *ad hoc* tool, along with the three stone weights described above. Slight edge damage is present at one end, suggesting that it was used as a digging tool.

A large number of parallel examples have been reported from the PPNB agro-pastoral outposts of Wādī Abū Ṭulayḥa (e.g. Fujii 2008: fig. 31, 2009: fig. 19) and Wādī Ghuwayr 17 (Fujii, Quintero *et al*. 2011: fig. 27). They were probably used for digging foundation pits for semi-subterranean masonry structures unique to the Jafr Pastoral PPNB. On the other hand, the find from the extramural barrage site was probably used in the open-cut limestone quarry in front of the barrage wall. The occurrence of another chronological indicator of the Jafr Pastoral PPNB has provided further insights into the date of the barrage system.

Chipped Flint Artifacts

The two major excavation areas at Barrage 1 yielded a few dozen chipped flint artifacts, which included two digging tools (**Fig. 34: 7-8**) and two large denticulates (**Fig. 34: 5-6**). In view of their large dimensions and heavy edge damage, there is a possibility that they were also used in the open-cut limestone quarry. This frequency of heavy-duty digging tools is characteristic of the Jafr Pastoral PPNB; similar examples have been found at Wādī Abū Ṭulayḥa (e.g. Fujii 2007a: fig. 28, 2009: fig. 15) and Wādī Ghuwayr 17 (Fujii *et al*. 2011: fig. 25).



34. Small finds from Barrage 1.

Early Islamic Artifacts

An Early Islamic gravestone and a dozen wheel-made, reddish, plain ware sherds occurred in Layer 2d in the two major excavation areas of Barrage 1 (**Fig. 34: 9-11**). In view of the fact that the sherds occurred concentrically around the gravestone, it is safe to say that both of them derived from a single tomb. However, the tomb appeared to have been swept away in repeated floods and no clear evidence was left in the two areas. Anyhow, their occurrence in the lower fill layer indicates that most of the original deposits (and / or pit spoil) of the open-cut limestone quarry was carried away by Early Islamic and subsequent floods. The same observation was made at Barrage 1 of Wādī Abū Ṭulayḥa (Fujii 2007a: 409-411).

Surrounding Survey

Our intermittent survey during the excavation of the barrage system recovered four pillar bases (*loci* 1001-1004) and one stone weight (*locus* 2001) around the site. Two of them (*loci* 1001 and 1004) were associated with a small flint workshop that produced naviform cores and blade components. These survey results contribute to a more comprehensive understanding of the barrage site.

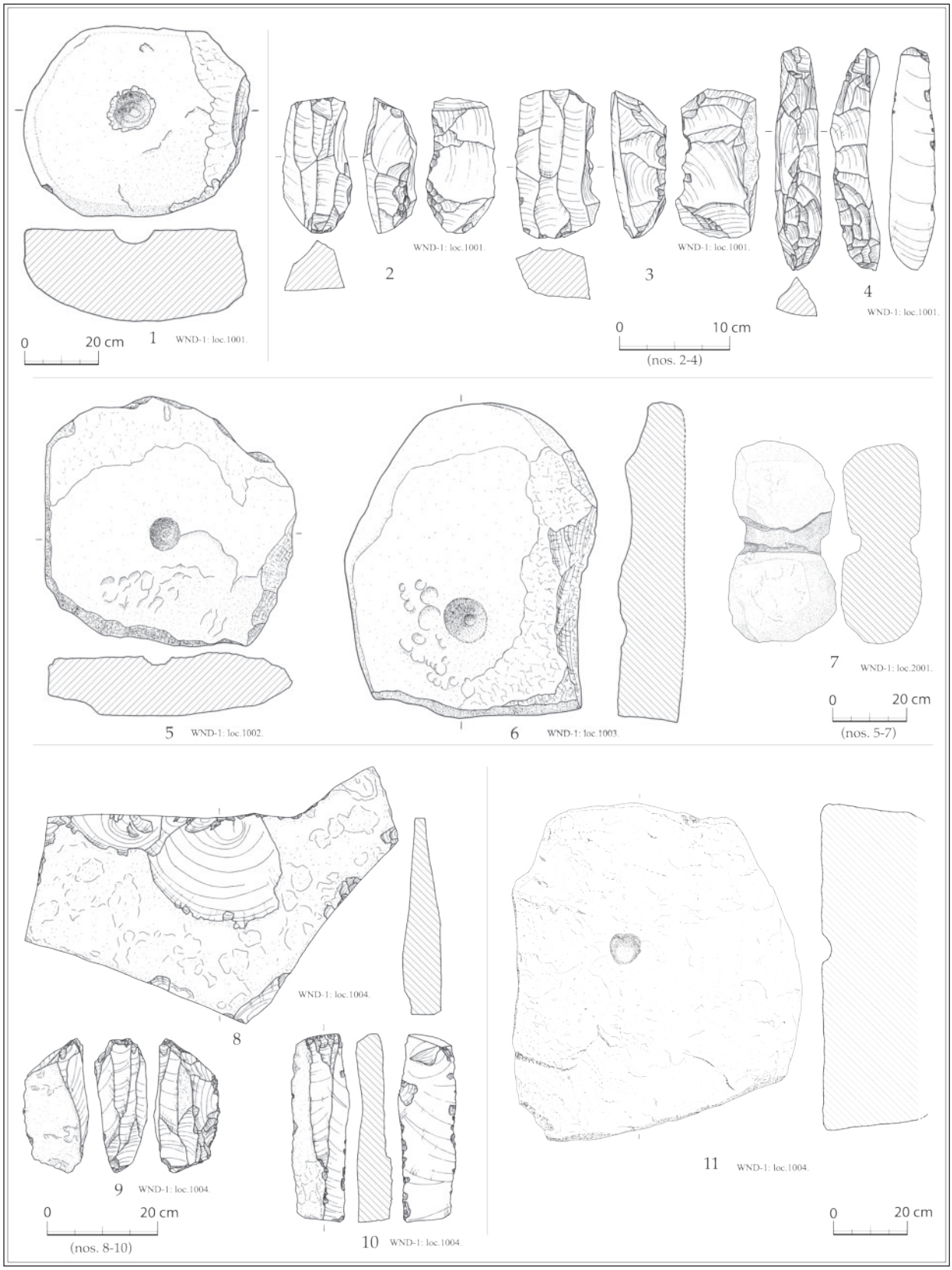
Loci 1001-1004

The four large pillar bases were found at *loci* 1001-1004, lying *ca.* 2km to the east of the barrage system (**Fig. 2**). These *loci* were located *ca.* 0.5-1km apart from each other, in an area of outcropping limestone situated in slightly undulating flint pavement desert (**Figs. 36, 37**). However, none of them appeared to be associated with clear evidence for structural remains.

The artifacts are made of large, flat limestone boulders, measuring *ca.* 60 - 90 cm long and *ca.* 50-100 kg or more in weight (**Fig. 35: 1, 5, 6, 11**). In terms of morphology, they are characterized by a relatively flat upper surface and a small concavity (*ca.* 7-10cm in diameter and *ca.* 3-5cm deep) produced roughly in the center of the upper surface. Similar products have been found at the PPNB outposts of Wādī Abū Ṭulayḥa (e.g. Fujii 2007a: fig. 30, 2008: fig. 30, 2009: fig. 19) and Wādī Ghuwayr 17 (Fujii *et al*. 2011: fig. 28) as well as Barrage 1 of Wādī Abū Ṭulayḥa (Fujii, Adachi *et al*. 2011: fig. 34) and Barrage 1 of Wādī Ghuwayr 106 (op. cit.). It appears that the four survey finds share a similar date with these excavated examples.

In view of their heavy weight and bulk, it is indisputable that the four artifacts were produced on the spot. This is not to say, however, that the limestone outcrops around them functioned as workshops for supplying limestone products to the nearby barrage system. This is because, first, neither half-finished products nor debitage were left at the outcrops and, second, because no pillar bases were incorporated into the Wādī an-Nu‘ayḍiyyah 1 barrage system. Considered in this light, it seems more likely that the limestone artifacts were not only produced but also actually used on-site to receive a wooden pillar for supporting a tent-like hut. Given this, the question is: who produced the pillar bases and built the huts? It is highly suggestive in this respect that a pillar base was incorporated into the central part of Barrage 2 of Wādī an-Nu‘ayḍiyyah 2 (**Fig. 39**). This may indicate that the temporary encampments were founded by barrage constructors who were involved in the construction of the neighboring two barrage systems. This assumption would explain the reason why the four pillar bases were scattered around the barrage site and occurred only as isolated finished products. The existence of the pillar bases is significant in that it suggests that the barrage system was associated with several contemporary encampments.

Interestingly, *loci* 1001 and 1004 included a small PPNB flint workshop which took advantage of the scatter of tabular flint nodules (**Fig. 38**). Given the interpretation suggested above, it would follow that the two encampments accommodated a small group of flint knappers who were probably also the barrage constructors. The workshops produced naviform cores and crested blades as main products (**Fig. 35: 2-4, 9**); tool blanks and retouched tools were rarely present. It is therefore conceivable that the workshops represent first stage ateliers for tool blank production. The blade blanks produced were probably removed to a nearby outpost such as Wādī Ghuwayr 17 or a yet-to-be-identified parent settlement far to the west. Anyhow, the co-existence of the PPNB flint workshops corroborates the dating of the encampments and, by association, the nearby barrage system. Incidentally, the surface collection included tabular scraper cores



35. Small finds from Barrage 2 (above) and surrounding loci (below).

36. Locus 1002: general view (looking north).

37. Locus 1004: general view (looking west).

38. Locus 1001: pillar base and flint workshop (looking north).

(**Fig. 35: 8**) and Jafr blades (**Fig. 35: 10**) too. This means that the flint scatters were re-used in the Chalcolithic - Early Bronze Age, another flourishing period in the Jafr Basin.

Locus 2001

In addition to the four pillar bases, a large stone weight – again made of a limestone boulder – was recovered at *locus* 2001 *ca.* 5.5 km to

39. Wādī an-N'īḍiyyah 2: pillar base incorporated into the central wall of Barrage 2 (looking north-east).

the west of the barrage system (**Fig. 3**). This artifact measured 54cm long, 34cm wide, 21.5cm thick and 57 kg in weight (**Fig. 35: 7**), and was similar in general profile to the find from Area 1 of Barrage 1 (**Fig. 34: 1**). It occurred in the middle of a flint pavement desert and was associated neither with a limestone outcrop, nor with a flint workshop or structural remains. However, in view of the close relationship between PPNB barrage systems and grooved stone weights (Fujii 2010c, n.d.b: fig. 13), there is a good possibility that this diagnostic artifact derived from the nearby barrage system of Wādī an-Nu'ayḍiyyah 1 or 2.

Summary and Discussion

The excavation has demonstrated that Wādī an-Nu'ayḍiyyah 1 represents a fourth example of a Jafr PPNB barrage system, after Wādī Abū Ṭulayḥa, Wādī ar-Ruwayshid ash-Sharqī (Fujii 2007b, 2007c, 2010a) and Wādī Ghuwayr 106. The following discussion briefly reviews the investigation results and pursues further details of this perspective.

Date and Function

Since these two key issues have already been addressed elsewhere (Fujii 2010c, n.d.b), no lengthy discussion is needed here. As for dating, both the occurrence of the diagnostic limestone artifacts and the incorporation of a semicircular, protruding reinforcement wall (into the central part of Barrage 1) are shared with every PPNB barrage known to date in the Jafr Basin, thereby corroborating the dating of the Wādī an-Nu'ayḍiyyah 1 barrage system. In addition, the existence of the four PPNB encampments (and

the contemporary flint workshops associated with two of them) around the barrage system support this dating. There is little doubt that the site of Wādī an-Nu'ayḍiyyah 1 dates back to the PPNB.

The issue of function also admits further in-depth discussion. It is now evident that the two elongated, stone-built features at Wādī an-Nu'ayḍiyyah 1 were used as basin-irrigation barrages to facilitate agro-pastoral adaptations within this desert landscape. A range of collateral evidence – their location on permeable terrain, a grand design aimed at creating a shallow and extensive flooded area and the imperfect waterproof properties of the barrage walls – all argue against their use for simple water impoundment, instead supporting the basin-irrigation hypothesis. A possible revision provided by the current investigation is that the open-cut limestone quarry in front of the barrage wall might have served as an anthropogenic watering place for initial pastoral transhumants and their livestock. If this is the case, it would follow that at least some of the Jafr PPNB barrages were multi-purpose dams possessing both the function of basin-irrigation and of supplying drinking water, a likely assumption when we consider the scarcity of reliable extramural water sources in the arid margins.

Open-Air Limestone Quarry

Additional comments should be made about the open-cut limestone quarry attested to for the first time at the barrage system of Wādī an-Nu'ayḍiyyah 1. The clear evidence came from Areas 1 and 2 of Barrage 1, where an extensive pit *ca.* 0.6-1.0m deep was found in front of the barrage wall. In view of the site stratigraphy (**Fig. 26**), there is little doubt that the pit represents an on-site quarry for procuring good quality limestone cobbles and boulders included in Layers 4 and 5. As a matter of fact, a dozen boulders still remain exposed at the base of Pit 103 in Area 1 (**Figs. 9, 12**). In addition, the two major excavation areas have several depressions left by removed building stones. Both observations clearly indicate that there was a large open-cut limestone quarry in front of the barrage wall. However, the extent of the quarry has yet to be confirmed. All we know at the present stage is that: (1) the northern edge is probably located between the revetment and the barrage wall, (2) the eastern and western edges extend beyond Area 5 and Area 6 respectively, (3) the southern edge lies between Trench 11 and the southern end of Area 1 (**Fig. 6**). It follows that the open-cut limestone quarry covered an area of at least 1,000 square meters in front of the barrage wall.

The discovery of the large-scale, on-site, open-cut quarry provides valuable insights into a few essential issues. To begin with, it sheds light on the source of the building stones used in the construction of the barrage system. Our previous report suggested that they were brought in from surrounding *wadi* beds (Fujii, Adachi *et al*. 2011), but this explanation is now harder to support. The presence of an on-site quarry has resolved the discrepancy between the barrage location in an area poor in exposed building materials on the one hand, and the expected volume of available construction materials on the other. It has also provided a convincing explanation of how the barrage managed to incorporate a large volume of less weathered limestone cobbles and boulders, which are usually difficult to procure on the *Ḥamād* surface.

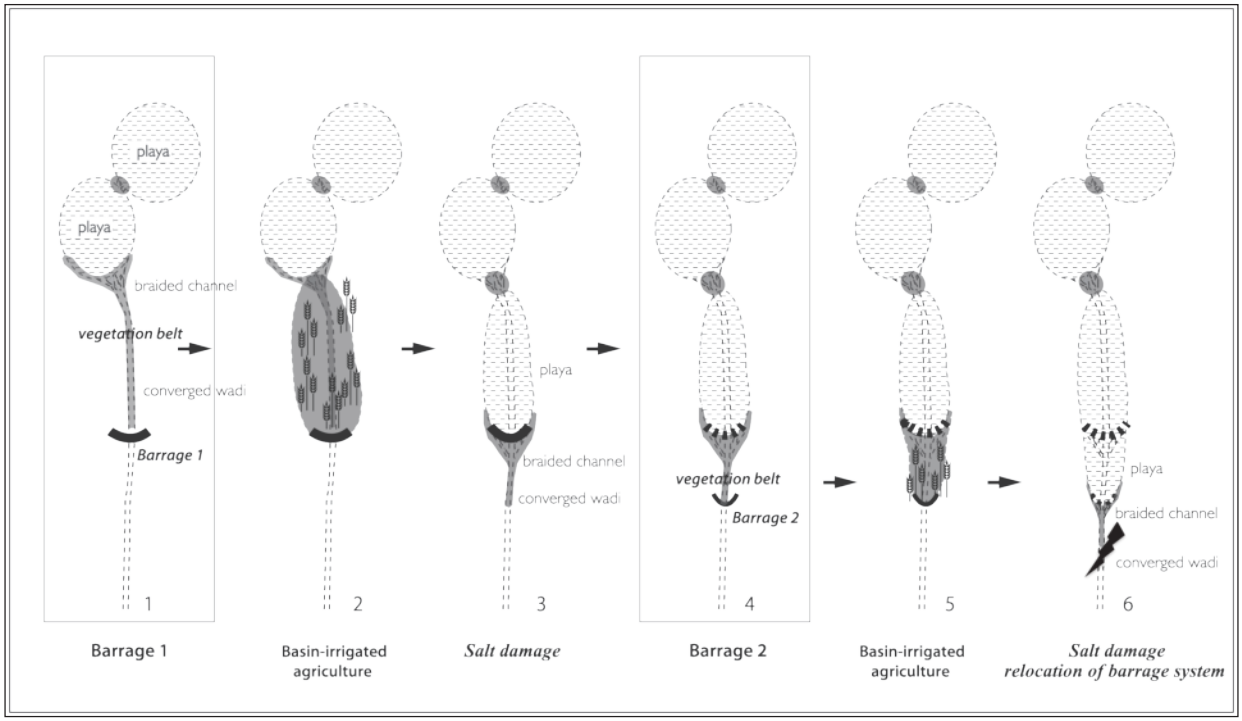
The discovery provides insights into the origin of halved boulders as well. As noted above, the central part of a Jafr PPNB barrage usually piled up halved boulders with their fractured surface facing outwards. The exposure of good quality boulders in the base of Pit 103 in Area 1, coupled with the site stratigraphy of Barrage 1, suggests that they were procured on the spot. Of significance is their violin-shaped profile with lateral concavities, which most likely facilitated their halving by direct percussion (These unique boulders probably supplied the raw material for the production of the large grooved stone weights as well). It is our present view that, immediately after quarrying, they were halved on the spot and transported to – and piled up at – the rear side to form the revetment and barrage wall. Presumably, this high degree of labor efficiency made it possible for a small group of pastoral transhumants to construct a large-scale barrage in the middle of flint pavement desert, poor in exposed construction material. As suggested above, there is also no doubt that the pit spoil from the open-cut limestone quarry served as construction material for mud banks and foundations.

Incidentally, both the unique construction method (i.e. on-site construction of stone walls at the edge of an open-cut quarry) and the use of halved boulders are shared by semi-subterranean structures at contemporary outposts such as Wādī Abū Ṭulayḥa (e.g. Fujii 2007: fig. 7, 2008: fig. 5) and Wādī Ghuwayr 17 (Fujii *et al*. 2011: fig. 10). The cistern at Wādī Abū Ṭulayḥa also used the same masonry technique (Fujii 2009: figs. 25, 26). These commonalities, though limited to construction, corroborate our perspective that the three major components – an agro-pastoral outpost as a fixed 'front-line' base for initial transhumants, a basin-irrigation barrage as a remote cereal field and a cistern as a reliable source of drinking water – constituted the Jafr Pastoral PPNB in a unified manner (Fujii n.d.).

Location and Formation Process of the Jafr PPNB Barrage System

Our previous report suggested that the Jafr PPNB barrages were constructed at the lower edge of the lowest component of a semi-open playa system, and that the downstream renewal of the upper barrage forced by salt damage led to the formation of a seemingly organized barrage *system* (Fujii *et al*. 2011).

The investigation at Wādī an-Nu'ayḍiyyah 1 necessitates a reconsideration of the first perspective. This is, first, because Trench 11 yielded evidence for a small *wadi* flowing northward across the central part of Barrage 1 (**Fig. 21**) and, second, because the present vegetation around the barrage system is concentrated not in the flooded areas in front of the two barrages, but in a braided channel and subsequent converging *wadi*, both located at the outlet of the playa (**Fig. 5).** The first consideration demonstrates that the barrage was constructed across the buried *wadi*. This means, in turn, that the lowest playa where the barrage system is now located was formed owing to the damming effect of the two barrages. The second consideration, on the other hand, confirms that – even though salt-resistant – dry land vegetation in and around a playa has a natural tendency to become established on well-watered and, at the same time, well-drained terrain free of salt damage. (It is precisely for this reason that the central part of a semi-open playa, to say nothing of a closed one, is devoid of vegetation even after heavy rain.) Taken together, it seems more reasonable to assume that the barrage system was constructed somewhere along the converging *wadi* so as to incorporate the limited vegetation belt as a future cereal field. The location at the lower end of the lowest playa is



40. Reconstructed formation process of the Jafr PPNB barrage system.

most unlikely, because it results in the exclusive incorporation of the saline area unsuitable for agriculture.

Taking these new perspectives into consideration, the formation process of the Jafr PPNB barrage system can tentatively be reconstructed as follows (**Fig. 40**): (1) the first barrage was constructed across a converging *wadi* (draining from the original, lowest playa of a semi-open playa system) so as to incorporate the contemporary vegetation belt as much as possible, (2) basin-irrigation agriculture successfully took place within the elongated flooded area of the barrage, (3) however, basin-irrigation of dry land inevitably led to salt damage in due course, (4) for this reason, it became necessary to relocate the barrage to a smaller vegetation belt newly formed downstream, (5) the relocation revitalized basin-irrigated agriculture but (6) top-soil salinization occurred again, but further shrinkage of the vegetation belt meant that further downstream renewal of the barrage system was abandoned.

This scenario sheds new light on the internal structure of the Jafr PPNB barrage system. Of significance is the fact that the existence of an upper barrage not only reduces the water pressure acting on a lower barrage, but also impedes the development of a second braided channel owing to its damming effect. Both of these explain the reason why the lower barrage is usually much smaller in scale and less substantial in structure than the upper barrage. Understandably, the damming effect increases in an exponential manner as the barrage system is renewed downstream. It is probably for this reason that the Jafr PPNB barrage system consisted only of two barrages and rarely developed further. It is conceivable that such deep-rooted structural unsustainability led to the repeated relocation of a barrage system (and a neighboring outpost as its operating body). In this sense, we can argue that the Jafr PPNB pastoral transhumance involved a potential for pastoral nomadization from the beginning, regardless of the post-PPNB climatic deterioration culminating in the 8.2 k event (Fujii *et al*. 2011).

Concluding Remarks

The investigation at Wādī an-Nu'ayḍiyyah 1 has provided further evidence to corroborate our previous perspectives on the date and function of the Jafr barrage system. Not only that, it has produced the following three new observations.

First, the Jafr PPNB barrage system proved to have been associated with an open-cut limestone quarry used as a source of material and the site for a revetment, as well as being a large depression that may have served as a watering place. Such a multi-purpose barrage was combined with an outpost and an intramural cistern to form the essential infrastructure that made up the pastoral adaption of the Neolithic Jafr Basin.

Second, the investigation has provided further insights into the location and formation process of the Jafr PPNB barrage system.

Third, the survey has shed new light on the surrounding encampments, thereby contributing towards a more comprehensive understanding of the barrage system or complex. The next field season, scheduled for the summer of 2012, will be devoted to an investigation of the adjacent barrage system of Wādī an-Nu'ayḍiyyah 2.

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