

# PPNB BARRAGE SYSTEMS AT WĀDĪ ABŪ ṬULAYḤA AND WĀDĪ AR-RUWAYSHID ASH-SHARQĪ: A PRELIMINARY REPORT OF THE 2006 SPRING FIELD SEASON OF THE JAFR BASIN PREHISTORIC PROJECT, PHASE 2

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## Introduction

Since the spring field season of 2005, the Jafr Basin Prehistoric Project has been focused on the investigation of Wādī Abū Ṭulayḥa, a PPNB agro-pastoral outpost in the northwestern part of the basin (Fujii 2006a, 2006b). The spring field season of 2006 suspended the operation at the outpost for some time, in order to investigate a neighboring barrage system. The investigation, conducted from March 25 through April 13 in 2006, showed that three barrages were constructed along a small tributary wadi flowing eastward in the south of the outpost. Available evidence suggests that the barrages were roughly coeval with the neighboring PPNB outpost and are likely to fall into two in terms of use. In light of the large dimensions and the location at a flat permeable terrain, Barrage 1 was possibly used for primitive basin-irrigation. The occurrence of agricultural utensils such as querns and sickle blades at the neighboring coeval outpost argues for this assumption. (Two similar barrages were found at Wādī ar-Ruwayshid ash-Sharqī, another archaeological site investigated in this field season). Barrages 2 and 3, on the other hand, were much smaller in dimension and constructed on a slightly dissected downstream valley where limestone bedrock layers are exposed. It appears that both of these were intended to reserve drinking water for the inhabitants of the outpost and their livestock.

Given these findings, it follows that the site of Wādī Abū Ṭulayḥa was a truly agro-pastoral outpost based on both transhumance and small-scale, basin-irrigated agriculture. This means that the irrigated agriculture as well as the transhumance to arid peripheries dates back to the PPNB period. Thus, the discovery of the two barrage systems in the Jafr basin may require a

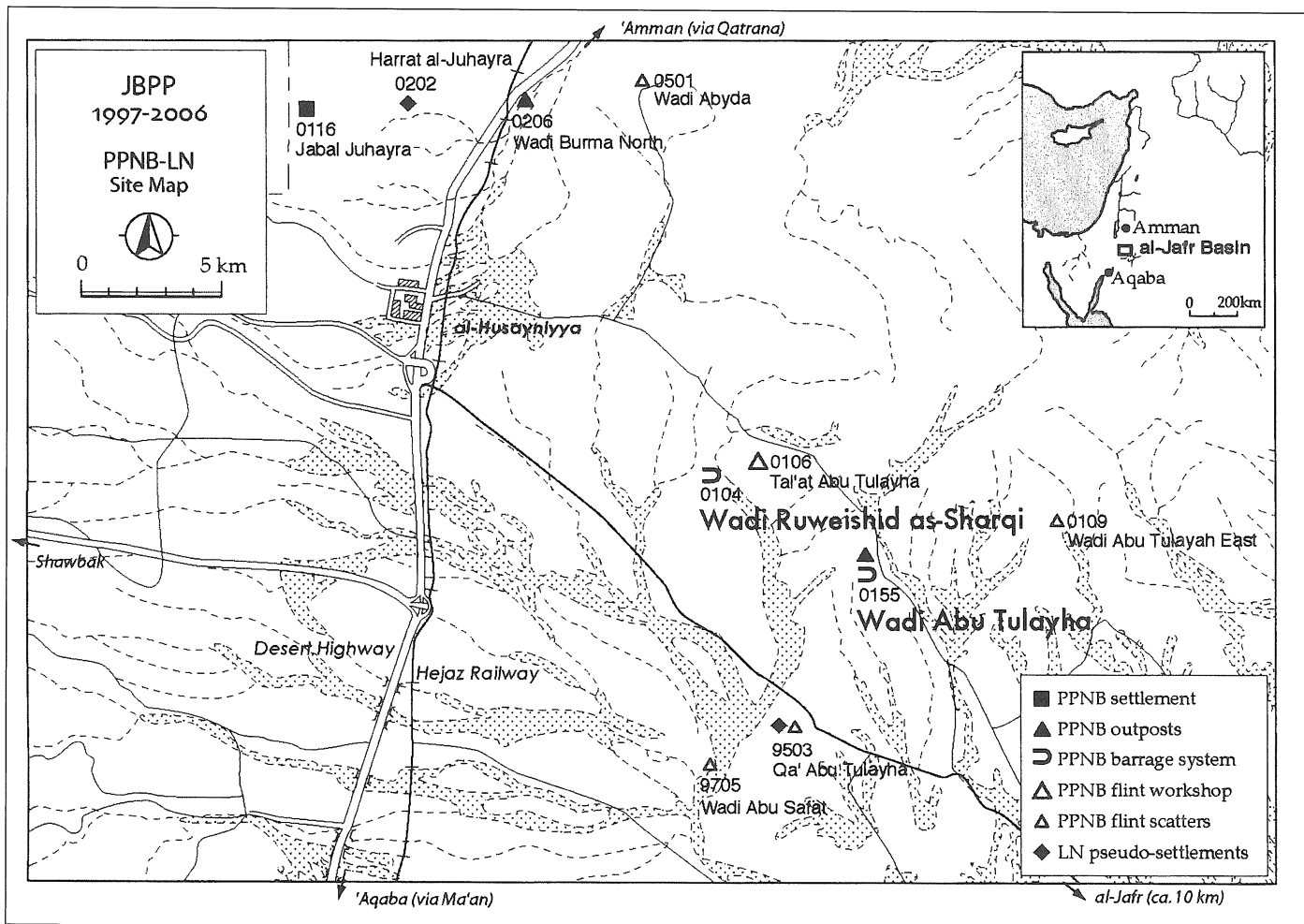
reassessment of the traditional perspective that the irrigated agriculture originated in the Pottery Neolithic in southern Mesopotamia and its surrounding regions. This report is intended to summarize the investigation results of this field season. Additionally, the archaeological implications will be briefly discussed.

## The Site and Site-setting

The PPNB agro-pastoral outpost of Wādī Abū Ṭulayḥa is located in the northwestern part of the Jafr basin, in southern Jordan. Topographically, the outpost occupies the eastern edge of a gently undulating, flint-strewn desert (or *Ḥamād* in Arabic) that extends between the two major drainage systems in this area: Wādī Abū Ṭulayḥa to the east and Wādī ar-Ruwayshid ash-Sharqī to the west (Fig. 1). The site itself belongs to the former drainage system through a small tributary wadi that flows eastwards across the southern fringe of the site (Fig. 2).

The barrage system was found along this tributary wadi. The surrounding terrain is covered with abraded flint pebbles, which form *Ḥamād*, a typical topography of the Jafr basin. The monotony of the flat and black-ish landscape is broken by some white shining playas (or *qā'* in Arabic) and wadi beds where limestone bedrock layers are exposed. Since the annual average precipitation in this area is less than 50mm (Bender 1968: 10; Jordan National Geographic Center 1984: Fig. 114; Alex 1985: 360), the vegetation is very poor, and is limited to thorny shrubs dotted along wadi beds. It should be added, however, that herbaceous plants burgeon in early spring.

The topography around the site is divided into two sections; Barrage 1 is in between (Figs. 3-4) the sections. While a flat terrain (includ-



1. The site map of the Jafr basin in the PPNB-LN periods.

ing some small playas) is characteristic of the upstream area, a gently undulating topography marks the downstream area. Barrage 1 occupies the eastern edge of the upstream plain. Barrages 2 and 3, on the other hand, are situated in a slightly dissected downstream valley. A distance of ca. 200-250m or a gap in elevation of ca. 3.5-4.5m intervenes between Barrage 1 and the other two barrages. The following discussion will show that the contrast in topographical conditions holds a key to understanding the division of roles between the two Barrages.

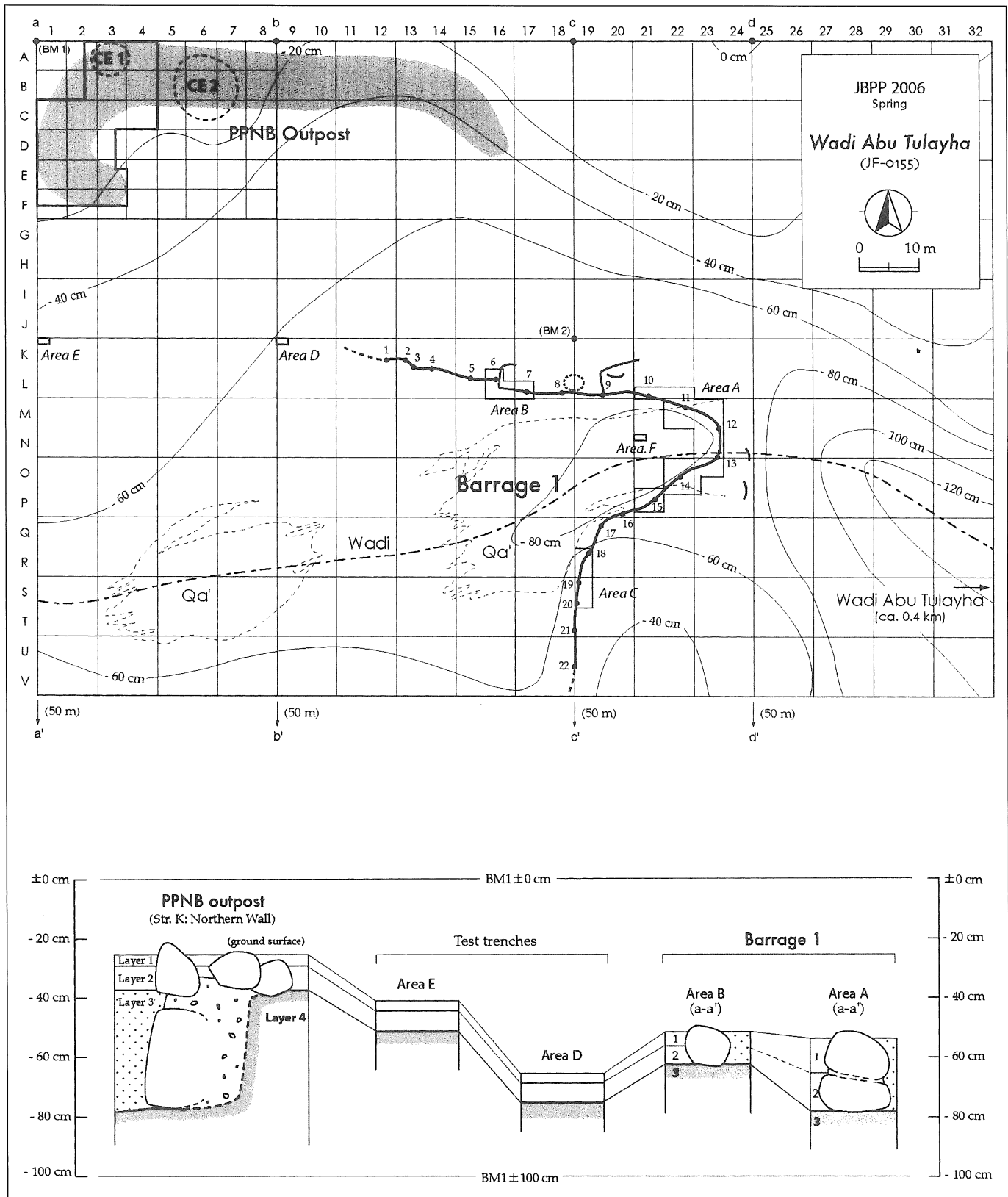
### The Excavations

Barrage 1 and its neighboring PPNB outposts were the first found during our 2001-2002 winter season survey (Fujii 2002). They were test-sounded in the spring of 2005 in the first field season at the site (Fujii 2006a). The two smaller barrages in the lower course were found by chance during the summer field season of that year when we addressed the excavation of the

outpost. The third field season was conducted in the spring of 2006. The concern of this report results from the collection of investigations of these three barrages.

Since Barrage 1 was large in scale, it was partly excavated. The focus was on its converging point. The two smaller barrages were entirely excavated. The excavation of Barrage 1 was conducted based on a 5m by 5m grid and locus system that subdivided a 10m by 10m major grid system covering the core area of the site. On the other hand, Barrages 2 and 3 were investigated by means of a 3m wide trench that was set up to follow original orientations, independent of the major grid system referred to above. Nevertheless, the datum point at the northwestern corner of the major grid system was consistently used during these operations in order to compare the elevations of individual barrages.

Since these barrages yielded a limited number of finds due to their extramural nonresidential nature, excavated soil, ca. 30 cubic meters

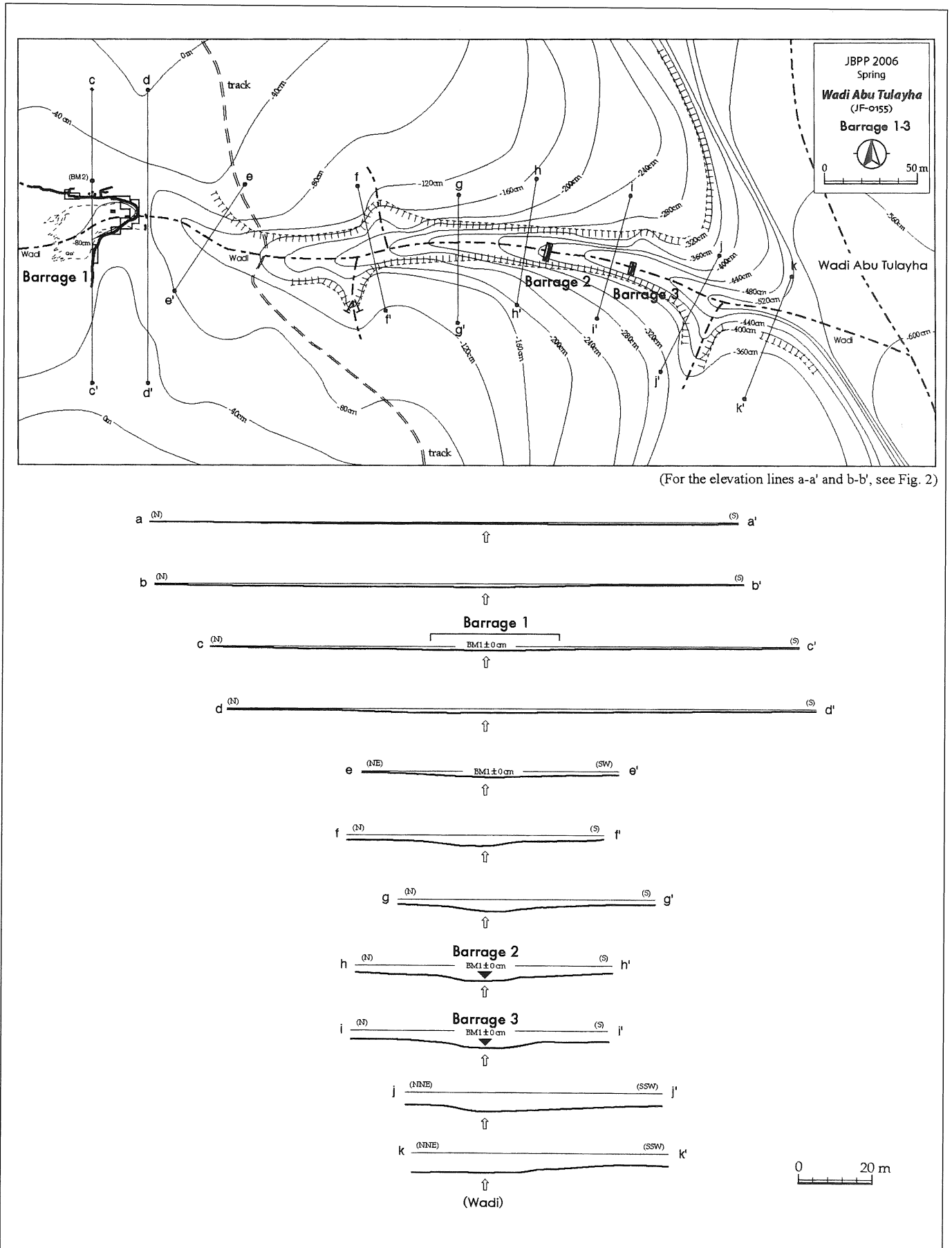


2. The contour map and site stratigraphy of Wādī Abū Ṭulayḥa.

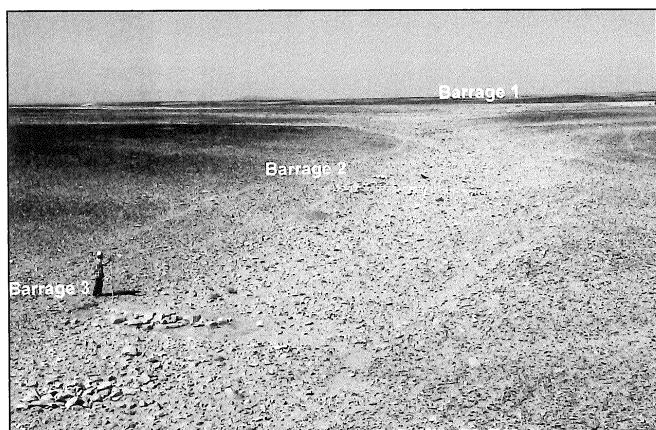
in total, was not sieved. However, a few dozen bags of soil samples from Area F of Barrage 1 were saved for water flotation; retrieving floral remains was the goal.

### Wādī Abū Ṭulayḥa Barrage 1: Structural Remains

As mentioned above, Barrage 1 was situated at the eastern edge of the upstream plain,



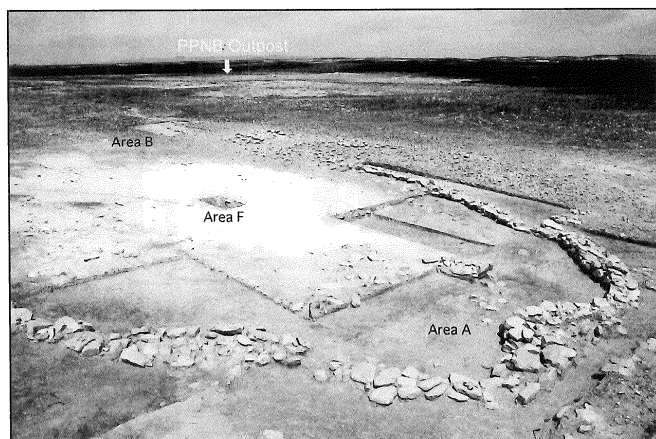
3. The contour map and elevations of the barrage system at Wādi Abū Ṭulayḥa.



4. A general view of the barrage system at Wādī Abū Ṭulayḥa (from ENE).

at a location ca. 50m southeast of the neighboring PPNB outpost. It was a roughly V-shaped, stone-built, freestanding wall with a total length of ca. 120m. It was constructed across the tributary wadi, and was oriented toward the upper course (Fig. 5). Encompassed by the wall was a small playa that formed in the center of the flooded area. Undressed or partly dressed limestone and flint cobbles (ca. 20-50cm long) were used as the main construction material, but no clear evidence for clay mortar was confirmed except for the presence of wall alignments at the converging point.

A total of six operation areas, Areas A to F, were set up along the wall (Fig. 2). The main operation was conducted at Area A which covered the converging point extensively. A total of ten squares were excavated in this area. Full or partial excavation depended on the relative position of the wall alignment in a square. The north and south wings, on the other hand, were briefly examined at Areas B and C respectively.



5. Wādī Abū Ṭulayḥa Barrage 1: A general view (from SE).

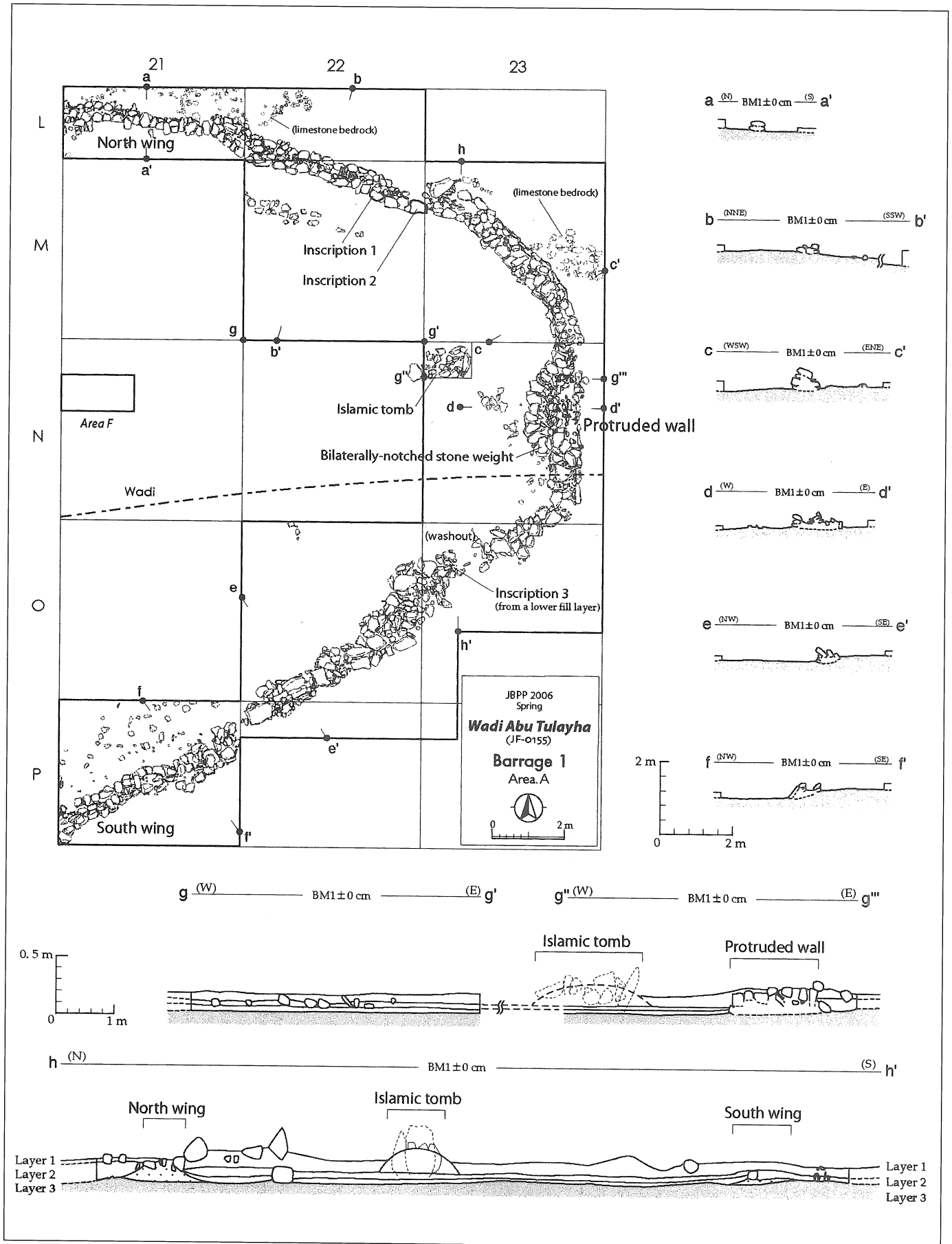
In addition, two isolated test trenches, Areas D and E, were opened between the barrage and the PPNB outpost in order to explore the stratigraphical correlation between the barrages. Area F, in front of the converging point, was intended to be an area dedicated to sampling silt deposits for various analyses.

#### Area A

The excavation at Area A showed that the wall of the converging point, the core of the barrage, was two rows (or ca. 0.5-1.0m) wide and preserved to a height of three or four courses (or ca. 0.3-0.5m) (Figs. 6-7). Small rubble and clay were packed into a narrow space sandwiched between the two outer walls. The construction materials were arranged in stretcher bond for the foundation course and in header bond for upper courses, respectively (Fig. 8). Interestingly, a similar masonry technique was also applied to the semi-subterranean structures at the neighboring PPNB outpost; underground retaining walls were built in stretcher bond and upper walls were often constructed in header bond (Fujii in this volume).

Nevertheless, sturdy and careful construction was limited to the central part. The walls of both wings were built in a simple manner. The wall segment at Square L-21, for example, gradually changed into a simple structure of a single row and course. The same is roughly true of the south wing and such technological simplification was confirmed at its distal end. The contrast in structure between the core and the distal parts is probably attributable to the difference that sideways water pressure had on them.

Of interest is a semi-circular protruded wall attached to the center of the converging point (Figs. 9-10). The wall was constructed with larger limestone cobbles, which, unlike the other wall segments, were piled up consistently in header bond from the foundation course; because of this, the area had dual support. Smaller rubble and upright slabs were found in a narrow space that was compacted with rubble and clay. These devices corroborate the theory that strong sideways water pressure acted upon this part. A bilaterally notched stone weight, (a key to the dating of the barrage), was found incorporated into the right-hand corner of the protruded wall (Fig. 10; Fig. 16:1).



6. Wādi Abū Ṭulayḥa Barrage 1: The plan and elevations/sections of the wall of the converging point.



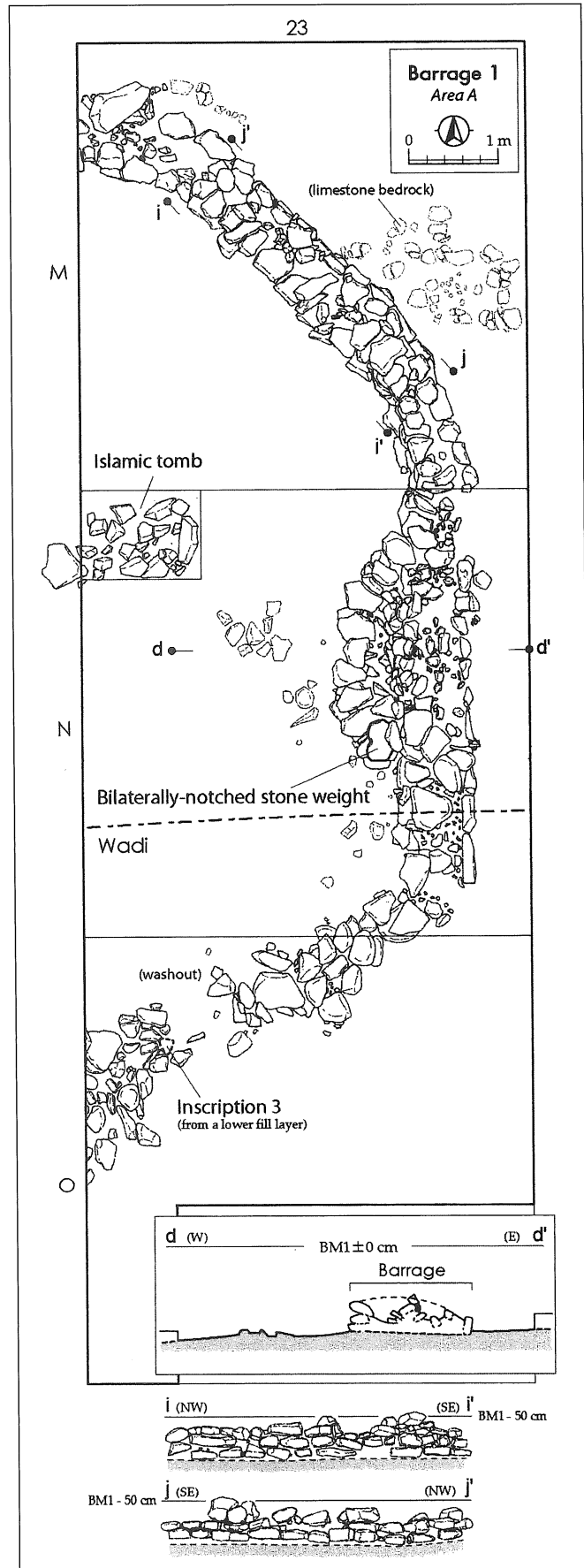
Wādī Abū Ṭulayḥa Barrage 1: A general view of the converging point (from S).



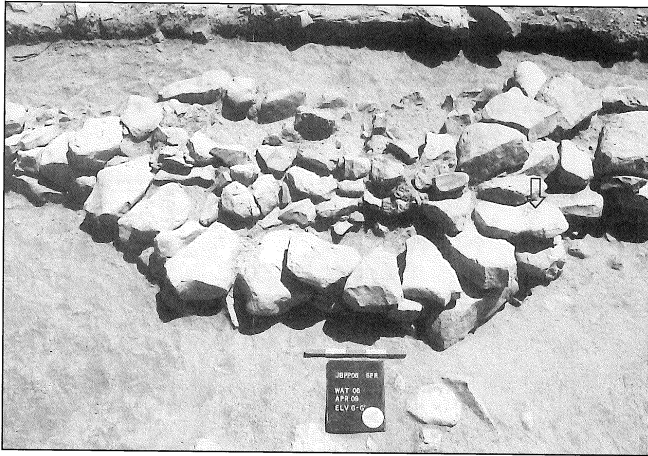
Wādī Abū Ṭulayḥa Barrage 1: A close-up view of the converging point (from N).

Also of interest is the disturbance of the wall segment immediately south of the protruded reinforcement wall. The state of preservation of this wall is in marked contrast to that of the wall segment that is located in a symmetrical position with the reinforcement wall in between. The disturbance was probably caused by washout. Both the thick deposit of silty sand and the concentration of finds corroborate the washout theory. The washout may have had a negative effect because of the existence of the sturdy reinforcement wall. The washout itself, however, is likely to have happened much later than the period of time in which construction of the barrage occurred.

In addition, a small oblong mound fringed with limestone slabs was found in front of the converging point (Fig. 11). It was oriented west-east and equipped with an upright slab at both ends. Because of these findings, there is no doubt that the tomb was for a Muslim. A Kuf-



9. Wādī Abū Ṭulayḥa Barrage 1: The plan and elevation of the protruded reinforcement wall.



10. Wādī Abū Ṭulayḥa Barrage 1: A close-up view of the protruded reinforcement wall (from W).

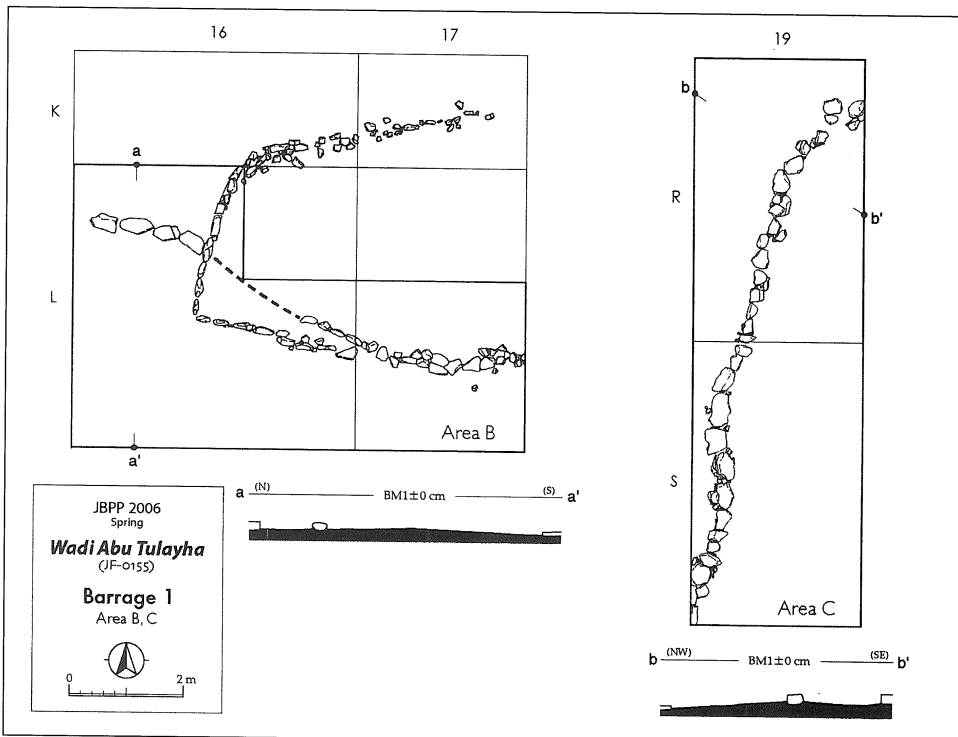


11. Wādī Abū Ṭulayḥa Barrage 1: A general view of the early Islamic tomb (from S).

fic inscription (Fig. 19) and a dozen red-painted pottery sherds, (probably of the Umayyad period), (Fig. 15: 12-16) occurred from the surrounding loci, including the washed-out part noted above. These findings suggest an early Islamic date for the tomb. Construction probably occurred by converting the construction material of the neighboring barrage. Of note is a clear stratigraphical gap between the two features, which demonstrates that the barrage belongs to a period much earlier than the early Islamic age. Additionally, two Hismaic (or Thamudic E) inscriptions were found incorporated into the wall alignment of the north wing (Figs. 6, 17-18).

### Area B

A limited excavation at Area B showed that the middle wall alignment of the north wing was very simple in structure, and was constructed with a single row. A course of limestone cobbles were arranged in stretcher bond (Figs. 12-13). The wall was partly disturbed by a rectangular structure that was built with a single row and course of upright slabs. In light of the scarcity of fallen stones, it appears that the wall remains almost intact. This wall segment is the sincerest form of the technological simplification that began with the western end of the converging point. The decrease in sideways water pressure probably made the endurance of the wall possible.



12. Wādī Abū Ṭulayḥa Barrage 1: The plans and elevations of the wall segment at Area B and C.





13. Wādī Abū Ṭulayḥa Barrage 1: A general view of the wall segment at Area B (from W).

#### Area C

Similar findings became evident at the south wing. Again, the wall was constructed with a single row and course of undressed limestone cobbles arranged in stretcher bond (Figs. 12, 14). As was the case with Area B, fallen stones were very scarce, indicating that the wall was very simple in structure from the beginning.



14. Wādī Abū Ṭulayḥa Barrage 1: A general view of the wall segment at Area C (from S).

#### Area D and E

The soundings at Area D and E substantiated that Barrage 1 coincides with the neighboring PPNB outpost in terms of site stratigraphy (Fig. 2). Barrage 1 was constructed on the upper surface of Layer 3 at Area A, which is comparable with the construction surface of semi-subterranean structures at the neighboring PPNB outpost. It should be kept in mind, however, that stratigraphical correlation in *Ḥamād* is less conclusive because of poor sedimentation. This is particularly the case with a single-period site like Wādī Abū Ṭulayḥa.

#### Area F

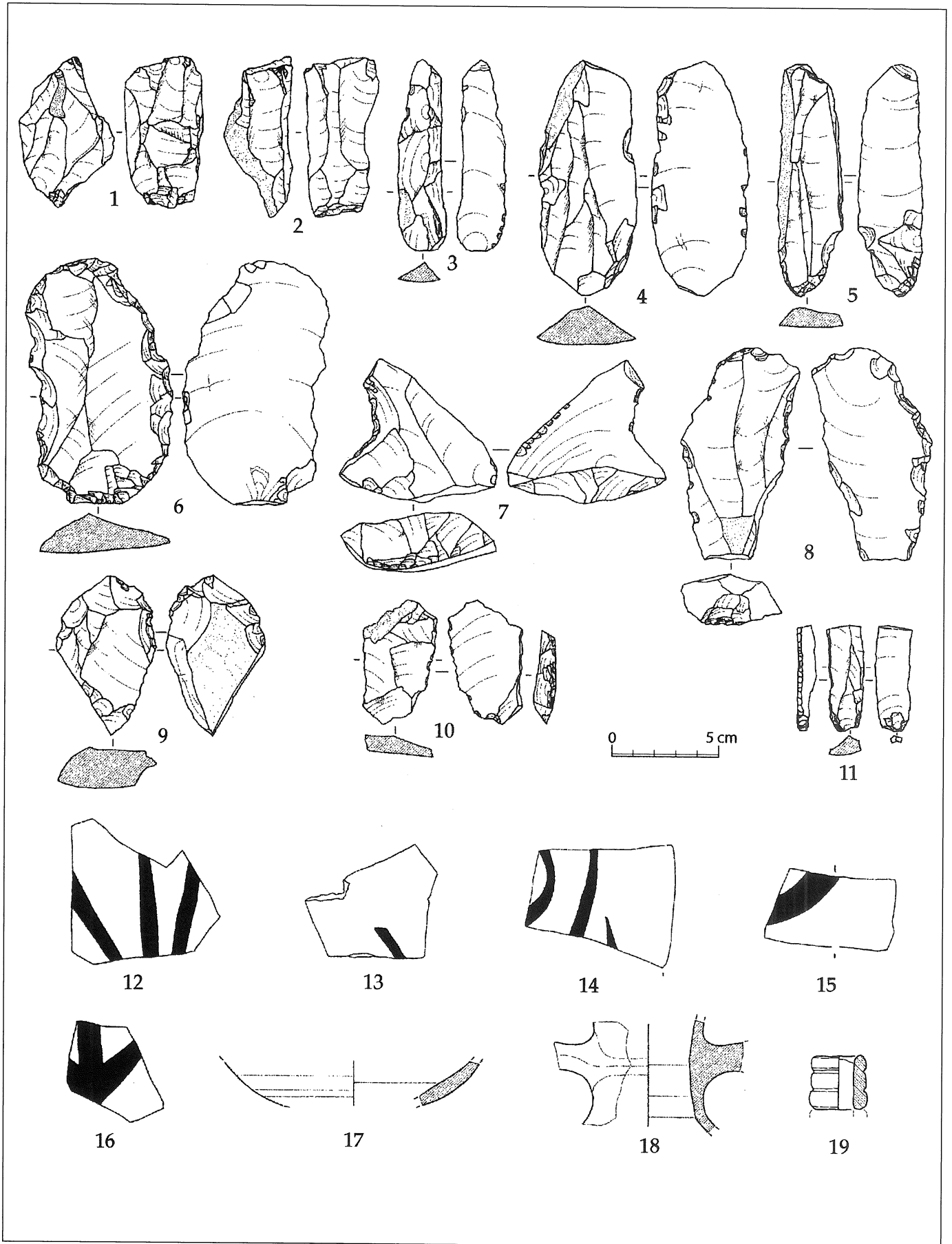
Since Area F consisted solely of ponded silty deposits, it was difficult to make a clear stratigraphical division. For this reason, the sounding of this area was conducted based on an artificial layer system every 5cm. The sounding was carried out down to a depth of ca. 0.5m from the present ground surface or ca. 20cm below the construction surface of the barrage. Soil samples from every artificial layer were brought to the various analyses centers, analyses is now in progress. Dr. Kaoru Kashima, natural geographer of our team, tentatively concludes that the construction surface of the barrage coincides with the sudden appearance of diatomous fossils (Kashima pers. com.).

#### Wādī Abū Ṭulayḥa Barrage 1: The Finds

Despite the relatively extensive excavation, finds from Barrage 1 were very scarce: a few dozens flint artifacts, a handful of pottery sherds, a bilaterally notched stone weight, and three inscriptions were the only items found. To make matters worse, finds from the original context of the barrage were still more infrequent. This is no wonder, however, in view of the nature of the barrage as an extramural non-residential structure. Despite these difficulties, some of the finds provide a key to the dating of the barrage.

#### Chipped Flint Artifacts

This category included a naviform core (Fig. 15: 1), a crest blade (Fig. 15: 3), a Jafr blade core (Fig. 15: 2), several retouched blades (Fig. 15: 4-5), flakes (Fig. 15: 6-10), and a backed bladelet (Fig. 15: 11). Unfortunately, none of these items occurred from the original context



15. Wādī Abū Ṭulayḥa Barrage 1: The finds.

of the barrage. Besides, the items vary in date from the Epipalaeolithic (the backed bladelet), through the PPNB (the naviform core and crest blade), to the Early Bronze Age (the Jafr blade core). Needless to say, these stray finds are useless for the dating of the barrage.

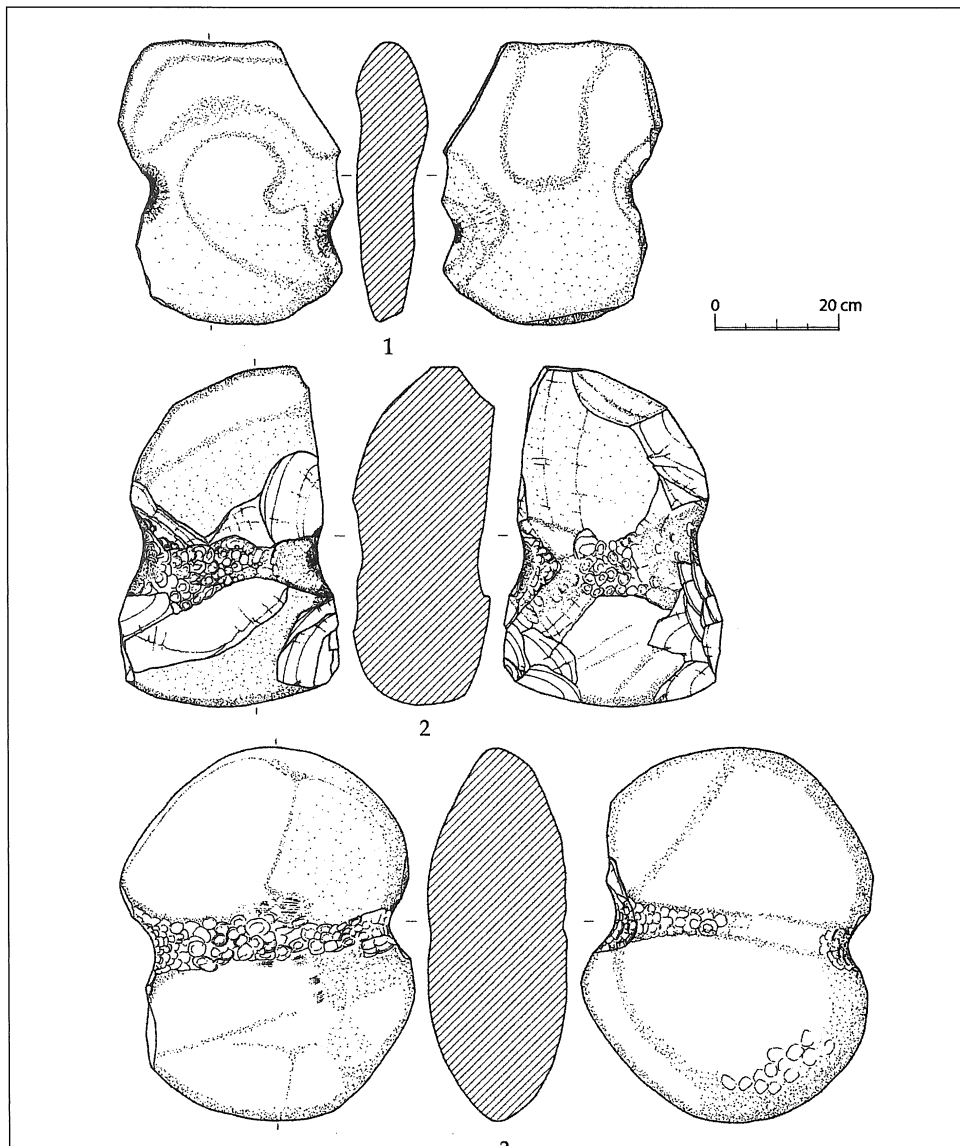
#### Pottery Sherds

The vast majority of pottery sherds were collectively unearthed from fill layers around the washed-out part. They fall into two groups: red-on-buff painted ware sherds (Fig. 15: 12-16) and darkish plain or incised sherds (Fig. 15: 17-18). There is little doubt that the first group falls within the Umayyad pottery repertoire. In light of the consistency of paste, wall thickness, and painted motif, the sherds originated from a single pottery, probably a deep bowl. The second

group, on the other hand, included a shallow bowl made on a wheel (Fig. 15: 17) and a pilgrim flask with a pair of perpendicular loop handles at the neck (Fig. 15: 18). It seems that both of these belong to the same horizon as the first group. These pottery sherds may have washed out from the small mounded tomb described above. The occurrence of the early Islamic pottery sherds from the upper fill layers provides a lower limit for the dating of the barrage.

#### Bilaterally Notched Stone Weight

The only datable *in situ* find from Barrage 1 is a bilaterally notched limestone weight that was incorporated into the protruded reinforcement wall at the converging point (Fig. 16: 1). It was ca. 45cm long and ca. 35cm wide, having a weight of ca. 25kg. Parallel examples occurred



16. Bilaterally notched stone weights: 1. Wādī Abū Ṭulayḥa Barrage 1; 2. Wādī ar-Ruwayshid ash-Sharqī Barrage 1; 3. Wādī ar-Ruwayshid ash-Sharqī Barrage 2.

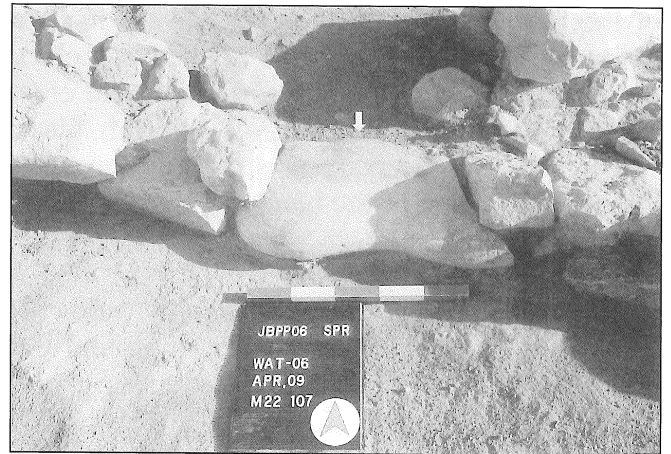
from the neighboring PPNB outpost (Fujii in this volume). Other examples are two barrages at Wādī ar-Ruwayshid ash-Sharqī referred to below (Fig. 16: 2, 3). This fact is suggestive of the synchronism among them. Interestingly, every barrage made it a rule to contain only one stone weight in the right-hand corner of the protruded reinforcement wall at the converging point. It is therefore most unlikely that the stone weight from Wādī Abū Ṭulayḥa Barrage 1 happened to be incorporated into the wall as a converted construction material from the neighboring outpost. Rather, it seems more reasonable to assume that it was intentionally built in the key wall probably in hope of the safety and eternity of the barrage. It is highly suggestive in this respect that it is a heavy-duty tool for tying something down in combination with a rope. Its ritual use is also corroborated by the fact that it is much larger in size than the utilitarian goods from the outpost.

#### *Hismaic and Kuffic Inscriptions*

The barrage also yielded two Hismaic inscriptions (Inscription 1 and 2) and a Kuffic inscription (Inscription 3). Inscription 1 was inscribed on an undressed construction material ca. 40cm long and contained several Hismaic letters arranged in a single line (Fig. 17). Inscription 2, also inscribed on an undressed construction material of the same size, had a few lines of letters of the same type (Fig. 18). (An epigraphic study of these inscriptions, conducted by Dr. Risa Tokunaga, is due to be published elsewhere in the near future). As noted above, both of these were incorporated into the wall alignment of the north wing (Fig. 6). What is important is the fact



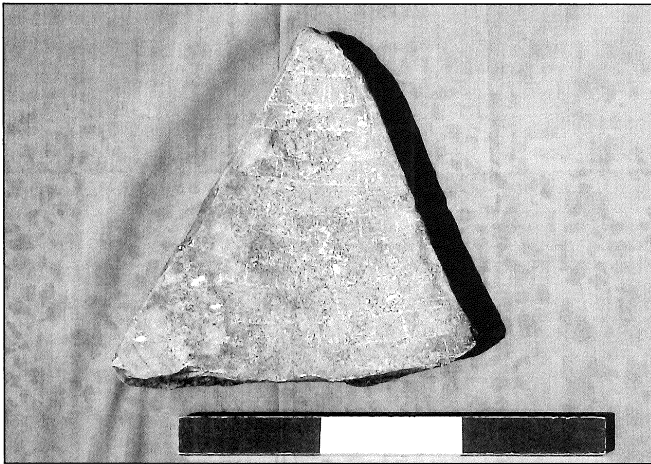
17. Wādī Abū Ṭulayḥa Barrage 1: A close-up view of Inscription 1 (from S).



18. Wādī Abū Ṭulayḥa Barrage 1: A close-up view of Inscription 2 (from S).

that, in both cases, the Hismaic letters were inscribed only on the upper exposed surface of the construction materials. No letters were found on the reverse side. It is therefore unlikely that the two inscribed stones happened to be incorporated into the wall in the course of the construction of the barrage. Rather, it seems more reasonable to assume that someone inscribed the letters on the wall materials of the preexisting barrage. Given this, both inscriptions warrant the dating of the barrage to BC times, because it is widely accepted that some of the Hismaic inscriptions were contemporary to the Nabateans (King 1990). Since no relevant features exist around the site, these two inscriptions were probably inscribed by pastoral nomads or travelers who happened to pass by the barrage.

Inscription 3, on the other hand, was unearthed from a lower fill layer at Square O-23 where traces of a washout were confirmed (Fig. 6). It was inscribed on a triangular limestone slab and contained a dozen lines of fine Kuffic letters (Fig. 19). The letters were inscribed by means of a knife-like tool with a sharp edge and every line was separated with a slightly curvilinear line. The incision was probably with the same edged tool. The question is: what is the original archaeological context of this stray find? A likely explanation is that the find originated from the mounded tomb nearby. Given this, it follows that the find was a grave-post for the tomb. The occurrence of the Umayyad pottery sherds from the surrounding loci may argue for this assumption. It is notable, however, that the tomb was less disturbed. A pair of large limestone slabs, probably likened to grave-posts,



19. Wādī Abū Ṭulayḥa Barrage 1: A close-up view of Inscription 3.

was still preserved at both ends (Fig. 11). Thus, it is also conceivable that both the inscription and the pottery sherds came from another tomb that was completely washed away. Whatever the case, the quality of writing strongly suggests that a well-educated person was concerned with it. The buried person was also probably of social eminence. They may have been travelers (or, possibly, pilgrims) who happened to pass by the barrage. Unfortunately, the inscription itself is too weathered to be fully legible, but Dr. Risa Tokunaga, epigrapher of our team, is continuing her efforts to retrieve the archaeological implications of this important find.

### Wādī Abū Ṭulayḥa Barrage 2

Barrage 2 was located ca. 200m east or downstream of Barrage 1 (Fig. 3). Unfortunately, it was poorly preserved; a semi-circular wall and a straight retaining wall attached to it barely survived at the southern edge (Figs. 20-21). This barrage was different in many respects from Barrage 1. First, while Barrage 1 was constructed at an upstream plain, it occupied a slightly dissected valley in the lower course of the same tributary wadi. Second, while Barrage 1 was constructed on a permeable silty sand layer, it was constructed on an impermeable limestone layer. Another remarkable difference is its smaller dimensions and simpler structure. While Barrage 1 consisted of a V-shaped wall ca. 120m in total length and varied in structure depending on loci, Barrage 2 was both small in size and simple in structure. These contrasts allow us to define this small barrage as a simple wadi barrier for reserving drinking water.

The finds from Barrage 2 were limited to four flint artifacts that occurred from the surface and fill layers. They contained an opposed-platform microblade core (Fig. 23: 1), two undiagnosed blades (Fig. 23: 2), and a notch made on a robust blade with a plain striking platform (Fig. 23: 3). Since they are both heterogeneous in nature and secondary in archaeological contexts, they are useless for the dating of Barrage 2. All we can say is that the existence of the semi-circular protruded wall is suggestive of a technological affinity to Barrage 1.

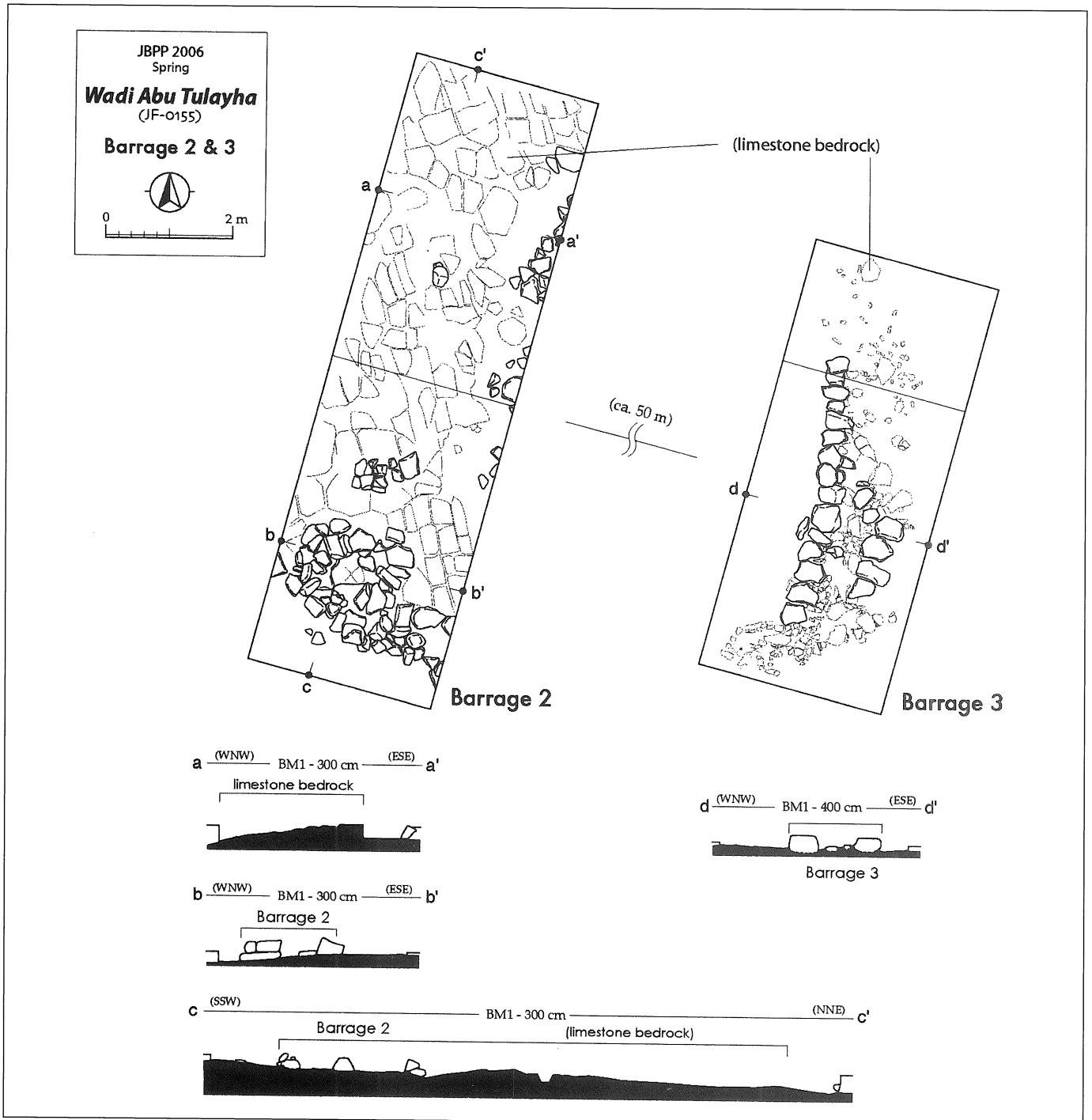
### Wādī Abū Ṭulayḥa Barrage 3

Barrage 3 was constructed at a location ca. 50m downstream of Barrage 2, under similar topographical conditions. As with Barrage 2, undressed limestone cobbles ca. 30-40cm long were used for construction material. The excavation showed that this barrage consisted of a straight front wall ca. 4m long and a semi-circular rear wall ca. 2m long, and that rubble was packed into a narrow space between the two (Figs. 20, 22). Both walls were a single-row wide and are preserved to the height of a single course. The volume of fallen stones scattered around, however suggested that they were originally a few courses higher. It is also conceivable that the front wall was originally a few meters longer. This barrage can also be defined as a small wadi barrier used for the reservation of drinking water. The addition of the semi-circular reinforcement wall, (though opposite in orientation), is reminiscent of the similar devices of Barrages 1 and 2. The masonry technique using large cobbles that were arranged in header bond at the forefront was also similar to the two upstream barrages. These similarities hint at the synchronism or, at least, technological consistency among the three barrages that were constructed along the same tributary wadi.

Aside from a Jafr blade found in a lower fill layer, no artifacts were unearthed from this barrage. Thus nothing can be said about the date of this barrage, except that the structural affinities noted above are suggestive of the synchronism with Barrages 1 and 2.

### Wādī ar-Ruwayshid ash-Sharqī Barrage 1 and 2

The site of Wādī ar-Ruwayshid ash-Sharqī,



20. Wādī Abū Ṭulayḥa Barrage 2 and 3: The plans and elevations.

or JF-0104 in our site registration code, is situated ca. 7km WNW of Wādī Abū Ṭulayḥa, again, in the middle of *Ḥamād*. Two small barrages were found at this site (Figs. 24-25). As with the barrage system at Wādī Abū Ṭulayḥa, this barrage system was also constructed along a small tributary wadi and kept a moderate distance (ca. 0.4km) from the main stream to the east. It is therefore likely that both barrage systems were constructed following the same stan-

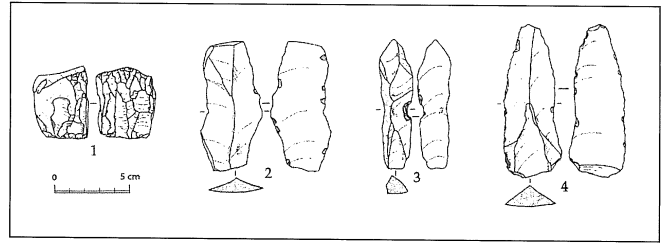
dard in terms of land choice. It is important to note, however, that unlike Wādī Abū Ṭulayḥa, this barrage system was not attended by a neighboring settlement. In order to double-check the excavation results from Wādī Abū Ṭulayḥa, the last few days of the 2006 spring field season were devoted to a brief investigation of the site. The excavations were conducted based on a 5m by 5m grid and locus system that was set up in accordance with the magnetic north. Since finds



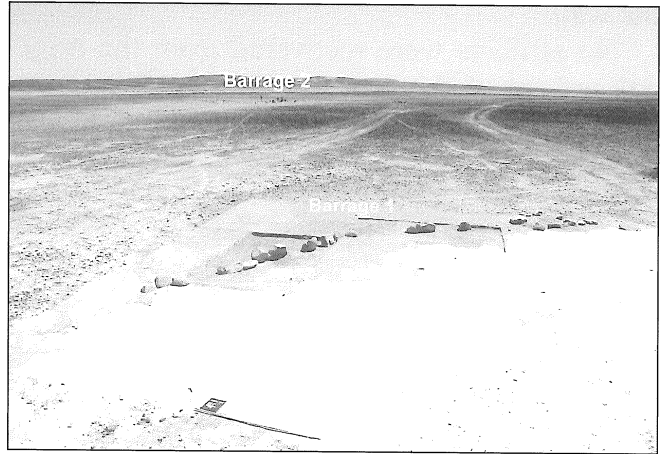
21. Wādī Abū Ṭalayḥa Barrage 2: A general view (from S).



22. Wādī Abū Ṭalayḥa Barrage 3: A general view (from SW).



23. Wādī Abū Ṭalayḥa Barrage 2 and 3: The finds.

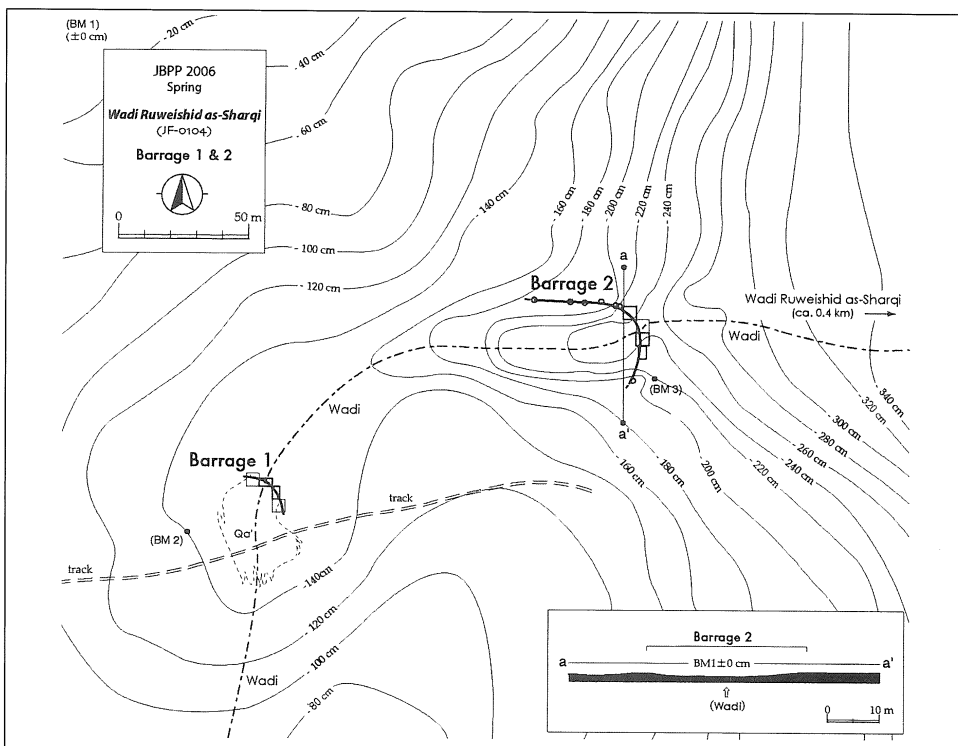


25. Wādī ar-Ruwayshid ash-Sharqī: A general view of the barrage system (from SW).

were very scarce again, excavated soil was not put through a sieve.

### Barrage 1

Barrage 1 was a small, slightly incurved, stone-built structure ca. 30m in total length and



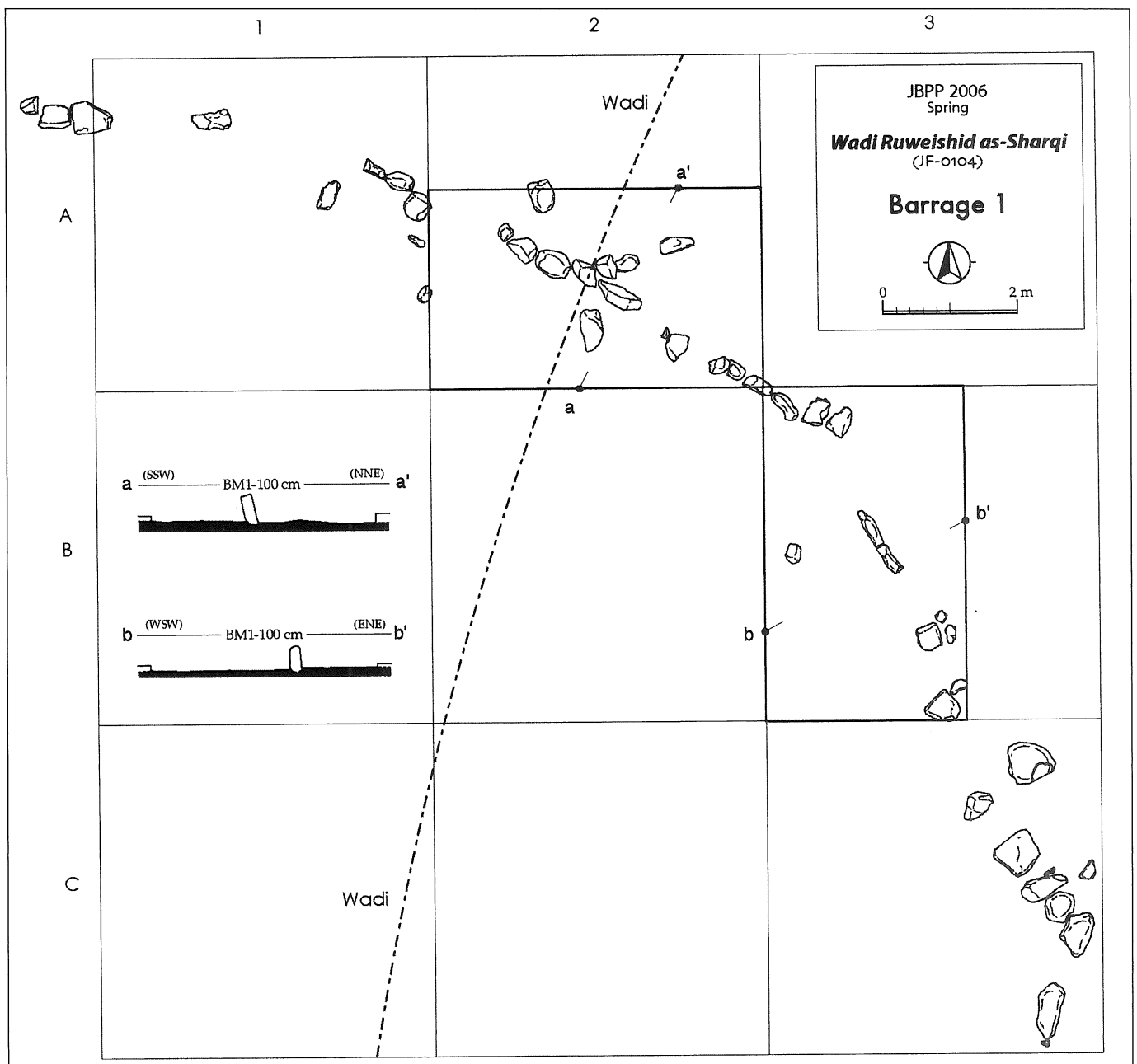
24. Wādī ar-Ruwayshid ash-Sharqī: A contour map of the barrage system.

located at an upstream plain of the tributary wadi (Figs. 26-27). It was simple in structure, being constructed with a single row and course of upright limestone boulders. In light of the scarcity of fallen stones scattered around the wall, it probably retained the original form. As with Barrage 1 at Wādī Abū Ṭulayḥa, a small playa was formed in a flooded area encompassed by the wall.

No artifacts were recovered from the original context of this barrage. It is notable, however, that a bilaterally notched stone weight was found among scattered stones around the wall



27. Wādī ar-Ruwayshid ash-Sharqī Barrage 1: A general view (from SE).



26. Wādī ar-Ruwayshid ash-Sharqī Barrage 1: The plan and elevations.



(Fig. 16: 2). It resembles the stone weights from Wādī Abū Ṭulayḥa Barrage 1 and its neighboring PPNB outpost, suggesting the synchronism.

### *Barrage 2*

This U-shaped structure, ca. 60m in total length, occupied a slightly dissected terrain ca. 150m downstream of Barrage 1. The excavation at the converging point revealed that a retaining wall ca. 1.5-2.0m wide was constructed; it leaned against an embankment ca. 1m high and a few meters wide (Figs. 28-29). Although the poor state of preservation made it difficult to clarify its original form, a protruded reinforcement wall similar to those attested at the Wādī Abū Ṭulayḥa barrage system was barely distinguished near the middle of the converging point. Again, a bilaterally notched stone weight was found at its right-hand corner (Fig. 30, Fig. 16: 3). In addition, traces of a washout were confirmed beside it, another episode reminiscent of Wādī Abū Ṭulayḥa Barrage 1.

Again, finds were very scarce. Special emphasis, however, should be paid to the fact that the bilaterally notched stone weight was incorporated into none other than the right-hand corner of the protruded reinforcement wall. This episode strongly suggests the synchronism with Wādī Abū Ṭulayḥa Barrage 1. In addition, two C-14 dates (1164±33, and 1195±33 uncal. BP) were obtained. One date is from a small hearth at the base of a pit-type tomb that was dug into (thus younger than) the wall of the converging point. The other, from Hearth-01, belonged to a lower fill layer. Both of these hearths fall within the time range of the early Islamic period and warrant the dating of the barrage to pre-Islamic times.

### **Summary and Discussion**

The investigation of this field season dealt with a total of five barrages, three at Wādī Abū Ṭulayḥa and two at Wādī ar-Ruwayshid ash-Sharqī. On the basis of excavated evidence, three major issues will be discussed below: the date, function, and archaeological implications of the five barrages.

### *Date*

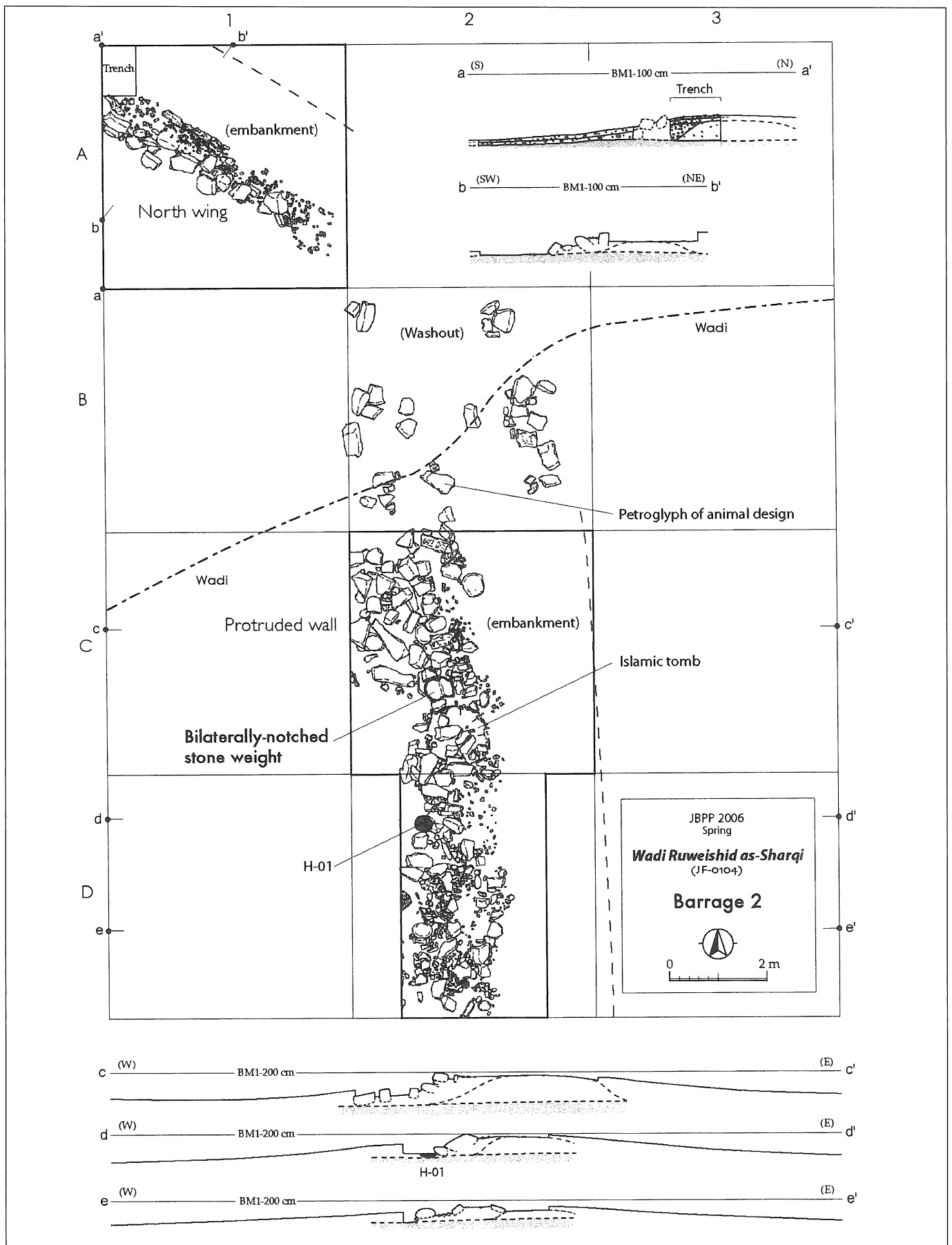
Barrage 1 at Wādī Abū Ṭulayḥa is the most informative. To begin with, the stratigraphical

correlation noted above supports the synchronism between the barrage and the neighboring LPPNB outpost. (Three C-14 data - 8409±41, 8464±51, and 8443±51 uncal. BP – are now available for the dating of the outpost.) Also, the co-occurrence of distinctive artifacts (i.e. bilaterally notched stone weights) from both sides corroborates the dating suggested above. Both the similarity in masonry technique and the total absence of settlement sites (with the only exception of the outpost) within a radius of a few dozen kilometers around the barrage may also argue for the dating. In addition, there is collateral evidence — the existence of Hismaic inscriptions inscribed only on the exposed surface of construction materials, the occurrence of early Islamic pottery sherds from fill layers, and the stratigraphical gap between the barrage and an early Islamic tomb — also contribute to narrowing down the date to some extent. Taken together, it is highly probable that the barrage can be dated to the same horizon as the neighboring LPPNB outpost.

Barrages 2 and 3 at Wādī Abū Ṭulayḥa, on the other hand, are difficult to date due to the deficiency of available evidence. The only clue is the technological affinity of Barrage 1. The existence of a semi-circular reinforcement wall, coupled with the frequent use of header bond technique at the forefront, seems to indicate that both of these were constructed concurrently with Barrage 1. It seems that the total absence of settlement sites around these two barrages (with the only exception of the PPNB outpost beside Barrage 1) is also in favor of the assumption suggested above.

The dating of Wādī ar-Ruwayshid ash-Sharqī Barrage 1 and 2 is less troublesome, because the occurrence of the bilaterally notched stone weights supports the synchronism with Wādī Abū Ṭulayḥa Barrage 1 and therefore its neighboring PPNB outpost. This is particularly the case of Barrage 2, because a distinctive artifact was unearthed from the same archaeological context as Wādī Abū Ṭulayḥa Barrage 1. Besides, two C-14 dates from Barrage 2 warrant its dating to pre-Islamic times.

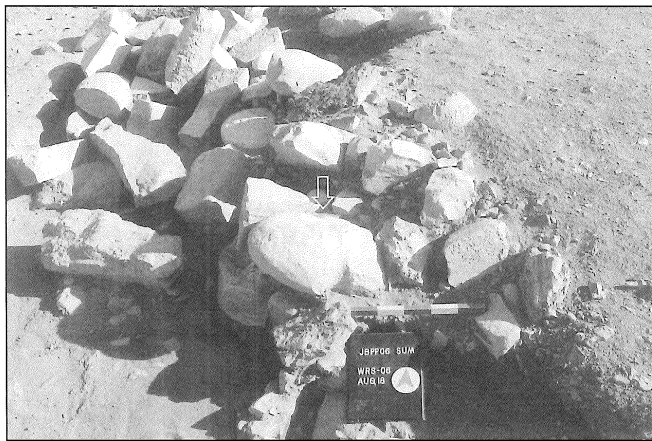
To summarize, Wādī Abū Ṭulayḥa Barrage 1 and Wādī ar-Ruwayshid ash-Sharqī Barrage 2 can be positively dated to the LPPNB period. Barrage 1 of the latter system is also probably



28. Wādī ar-Ruwayshid ash-Sharqī Barrage 2: The plan and sections/elevations of the wall at the converging point.



29. Wādī ar-Ruwayshid ash-Sharqī Barrage 2: A general view (from SE).



30. Wādī ar-Ruwayshid ash-Sharqī Barrage 2: A close-up view of the protruded reinforcement wall (from S).

assignable to the same horizon on the basis of the occurrence of the distinctive stone weight. Barrages 2 and 3 of the former system, on the other hand, are difficult to date, but the technological consistency noted above is likely to indicate the synchronism with the upstream barrage. It is therefore highly probable that the two barrage systems can be dated to the LPPNB period. Unfortunately, no direct C-14 data is available, but the opinion is inevitable in view of the nature of these barrages as extramural nonresidential structures.

### Function

Again, Wādī Abū Ṭulayḥa Barrage 1 provides a good starting point. In light of the location across a wadi and the V-shaped profile opening upstream, there is little doubt that this unique structure served as a barrage to collect seasonal runoff water of the tributary wadi. Both the arrangement of wall alignments following contour lines and the contrast in structural strength be-

tween the core part and the distal walls can also be understood within the same framework. It is also notable that while a considerable difference in elevation exists between the foundation course of the key wall and the peripheral walls, the elevation of the uppermost course presents less difference between the two. (Given that the wall of the converging point was originally a few courses higher, one might even say that the uppermost course was of uniform elevation.) In addition, the construction of the protruded reinforcement wall can be reasonably understood as an essential device that bore strong sideways water pressure on the converging point. It is therefore evident that Barrage 1 was constructed as a water catchment facility.

The question is: what is the specific use? Was this large barrage used for reserving drinking water? A series of circumstantial evidence casts doubt on this assumption. To begin with, the location at the flat permeable terrain is incompatible with reservoir use. This is particularly the case with the Jafr basin, which is characterized by both poor precipitation and a large evaporation rate. The use for an irrigation facility seems more likely; the frequency of reaping and grinding tools at the neighboring coeval outpost suggest the existence of a crop field nearby. Secondly, it is most unlikely that the annual precipitation in the Neolithic Jafr basin was sufficient to make dry farming possible, (as suggested by the total absence of coeval settlement sites other than the outpost at Wādī Abū Ṭulayḥa). This functional identification, if accepted, would explain why the barrage occupied the flat and permeable terrain at the eastern edge of the upstream plain, and why it was designed to produce a shallow extensive flooded area. Insights are also provided into the seasonality of the outpost; the harvest season of the cereal crop probably cultivated inside the barrage. This means that the outpost was used from spring to early summer (Fujii 2006a, 2006b). A series of floral analyses, now in progress, will hopefully provide specific evidence for the cereal cultivation using the basin-irrigation facility.

Barrages 2 and 3 at Wādī Abū Ṭulayḥa, on the other hand, can be defined as simple wadi barriers for reserving drinking water. The evidence comes from their location at a slightly dissected (thus easier to store water) valley in

the lower course. It is also suggestive that, unlike Barrage 1, construction happened at a stony impermeable terrain which included an exposed limestone bedrock layer. The simple yet sturdy structure is also consistent with the use as a cistern.

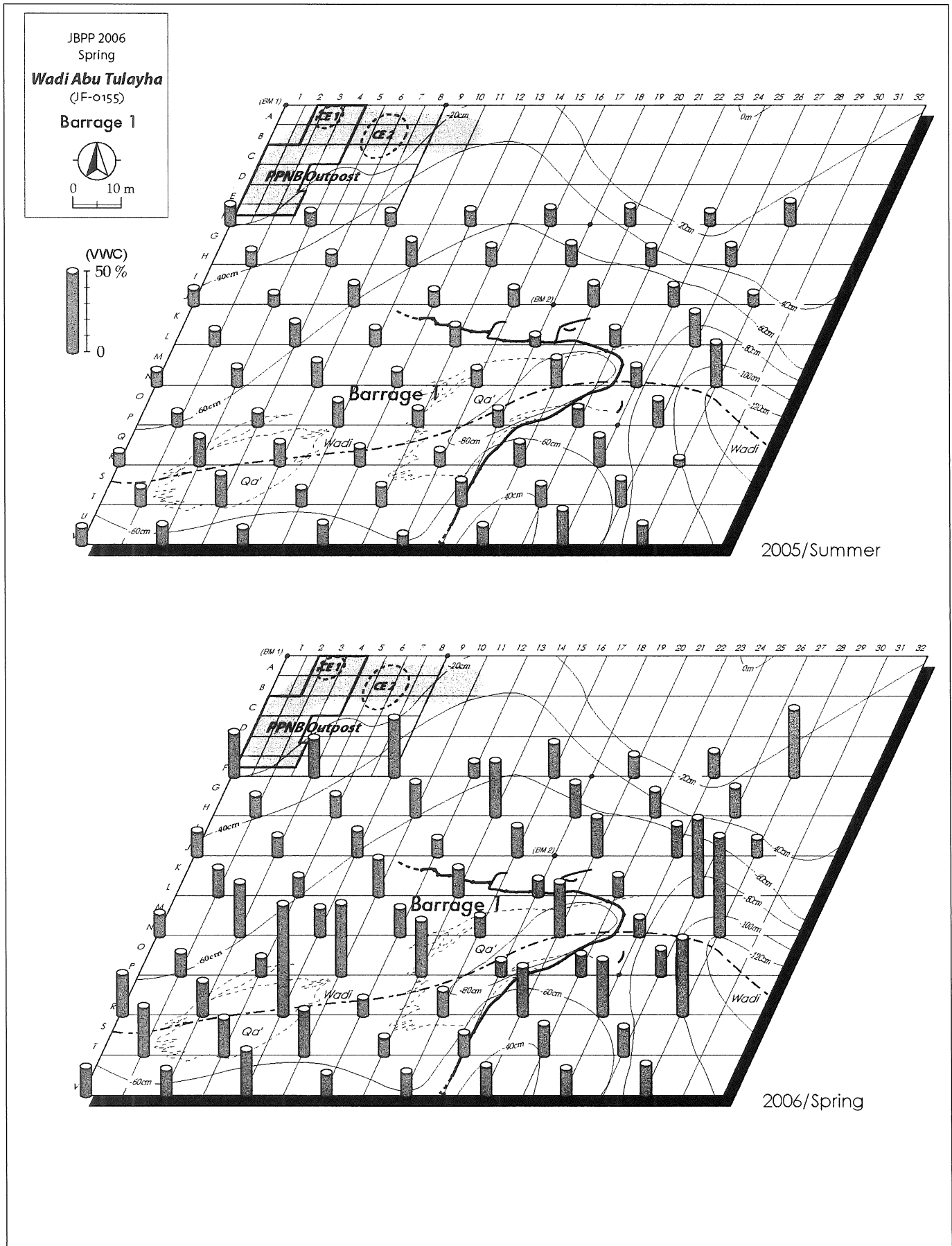
It follows that the LPPNB outpost at Wādī Abū Ṭulayḥa used two distinct types of water catchment facilities for different purposes. While the larger barrage constructed in the upstream plain was probably used for basin-irrigation, the two smaller barrages in the lower course served, most likely, as small cisterns for both the inhabitants of the neighboring outpost and their livestock. It seems that the combination of these two distinct types of barrages first enabled the seasonal (yet relatively long stays) at the outpost isolated in the flint-strewn desert.

Things are slightly different at Wādī ar-Ruwayshid ash-Sharqī, where the smaller barrage was situated in the upper course and the larger barrage was located in the lower course. Nevertheless, in view of its location at a flat permeable terrain, it is safe to say that Barrage 1, albeit smaller in scale, was used for a basin-irrigation facility. The frequency of gap between construction materials is also incompatible with the use as a reservoir. The same is true of Barrage 2, because the dissection inside the barrage is likely to have been vitalized after the wash-out of the converging point. It is most unlikely that such a large reservoir was constructed in the middle of *Ḥamād*, independent of a settlement. Thus, the use for a basin-irrigation facility seems more likely. The structural affinities to Wādī Abū Ṭulayḥa Barrage 1 also argue for this view. Why does the barrage system at Wādī ar-Ruwayshid ash-Sharqī consist only of irrigation facilities? Why does it lack in water storage facilities? Suggestive in this regard is the fact that unlike the Wādī Abū Ṭulayḥa barrage system, the area was not attended by a settlement. It is probably for this reason that the barrage system at Wādī ar-Ruwayshid ash-Sharqī was able to specialize in irrigation facilities. It is intriguing to hypothesize that the area served as an enclave field for the transhumants who made a round trip between a parent settlement to the west to the LPPNB outpost at Wādī Abū Ṭulayḥa.

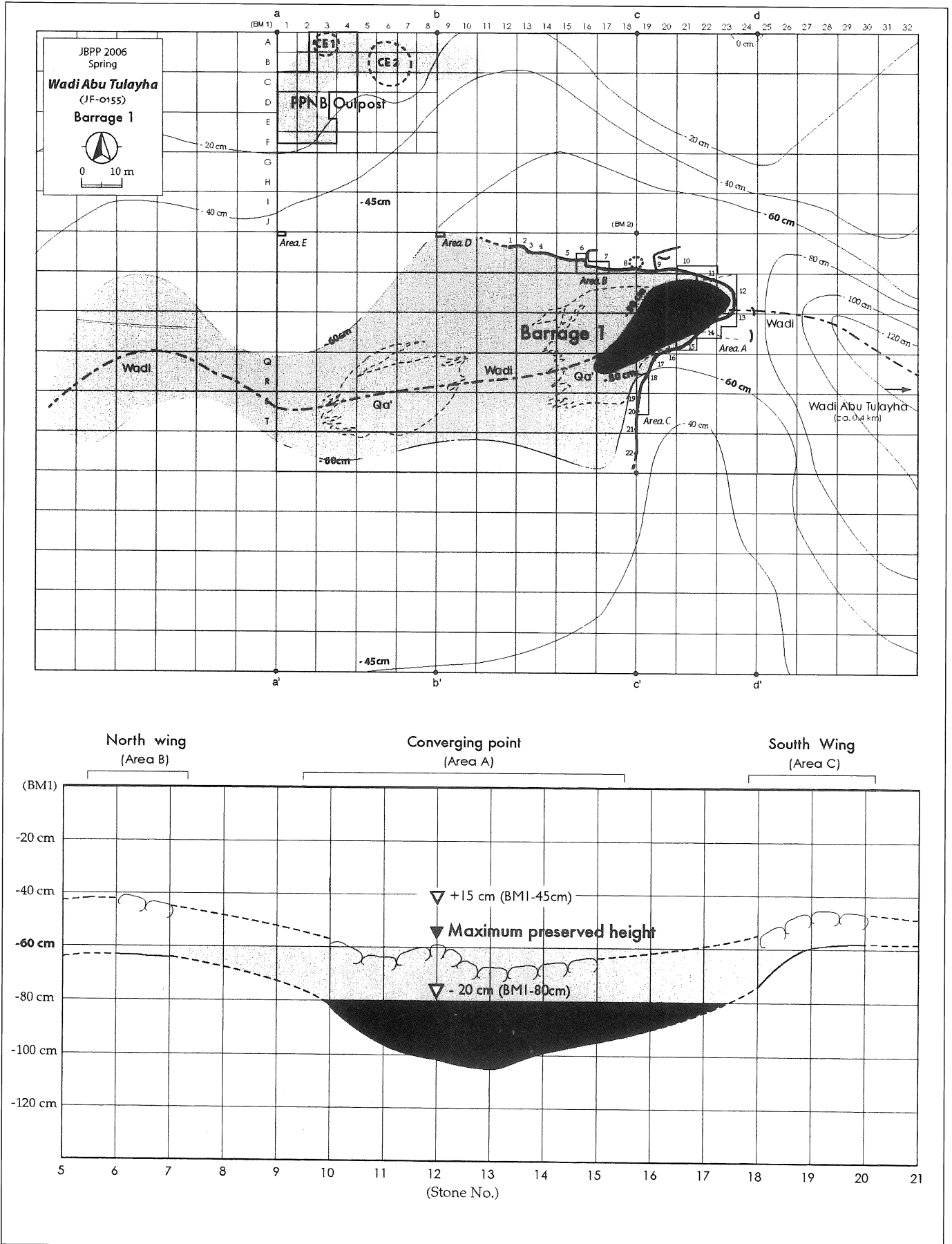
A question now arises: was the basin-irrigation (using such simple barrages) really effec-

tive in crop cultivation? In order to approach this issue, we measured soil humidity (VWC: volumetric water content) ca. 20cm below the present ground surface at Wādī Abū Ṭulayḥa Barrage 1, using Filed Scout TM TDR 300 Soil Moisture Meter (Spectrum Technologies, Inc.). The measurement was conducted twice: at 9:30 – 11:30 a.m. on September 10 in 2005 and 7:30-9:00 a.m. on March 31 in 2006. The measurements showed that the soil humidity in spring is a few times higher than that in summer (Fig. 31). It was unexpected, however, that the measured values in spring did not make a conspicuous contrast between the inside and outside of the barrage. This is partly because winter rain of that year was insufficient, and partly because the measurement in spring was conducted much later than the last winter rain. Otherwise, the contrast would have been more conspicuous. The PPNB existed under a humid climate. Results might have been more explicit with different weather conditions.

Another question concerns the area of arable land that the basin-irrigation facility produced. Again, Wādī Abū Ṭulayḥa Barrage 1 provides a useful data set. Since the surrounding terrain is very flat, the flooded area varies to a large extent depending on the water level of the barrage (Fig. 32). Providing the water level was ca. 20cm lower than the preserved wall height of the converging point, the barrage would have produced an arable land ca. 0.05 ha in size. Also, the water level equal to the preserved wall height would have provided arable land with an area of ca. 1ha. If it had been a few courses or ca. 15cm higher (this is highly conceivable in view of the volume of fallen stones around the wall), the flooded area would have been a few more times larger. Needless to say, the two theories are rough estimates based on the maximum wall height and must be discounted to some degree. It is also conceivable, however, that the infiltration of soil humidity into the surrounding plain offset or, possibly, outweighed the decrease suggested above. It is therefore safe to say that the barrage produced a sizable arable land in a year with a sufficient deal of precipitation. Likewise, Wādī ar-Ruwayshid ash-Sharqī Barrages 1 and 2 must have provided a small yet precious arable land area measuring less than 1 ha in area. On the other hand, the maximum pondage of Wādī



31. Wādī Abū Ṭalayha Barrage 1: Soil humidity (VWC: Volumetric Water Content).



32. Wādī Abū Ṭulayḥa Barrage 1: Estimated flooded area depending on water level.

Abū Ṭulayḥa Barrages 2 and 3 is estimated to be several meters. All these values, though far from satisfactory for a parent settlement to the west, seem to have been sufficient to sustain the livelihood at the seasonal outpost.

#### *Archaeological Implications*

In conclusion, the archaeological implications of the two barrage systems found in the Jafr basin will be briefly discussed. To begin with, the existence of the barrage system at Wādī Abū Ṭulayḥa corroborates the multiple subsistence strategy of the neighboring LPPNB outpost. It is now evident that the outpost was based upon a mixed economy that consisted of hunting (evidenced by the occurrence of wild animal bones and various hunting weapons), transhumance (evidenced by the existence of domesticated sheep and goats among faunal remains), and basin-irrigated agriculture suggested by the coexistence of the barrage system as well as the frequency of agricultural utensils. It seems that such a combination of distinct options first made it possible to establish and maintain the outpost in the middle of *Ḥamād*. This is not to say, however, that the basin-irrigated agriculture using the barrage was always successful. In light of the harsh environmental conditions of the Jafr basin, the crop field may often have changed into a mere pasture for their livestock especially in a dry year. Nevertheless, the frequency of agricultural implements such as querns and sickle blades seems to indicate that a substantial harvest was expected in a usual year. (To put another way, the decrease in yield point and/or the loss of yielding stability may have led to the abandonment of the fixed outpost and the consequent pastoral nomadization.)

The barrage system at Wādī Abū Ṭulayḥa also highlights the careful land choice of the PPNB transhumants. They chose neither the main stream whose seasonal runoff water was difficult to control nor minor wadis where sufficient water flow could not be expected. What they chose instead was the medium-scale tributary wadi that meets the two conflicting conditions: the ease of water control and the predictability of a certain degree of water flow. The same can be said about the Wādī ar-Ruwayshid ash-Sharqī barrage system, which was also constructed along a moderate-sized tributary wadi with a relatively

extensive drainage area. Nevertheless, what the establishment and maintenance of an agro-pastoral outpost in the arid periphery requires is not limited to the existence of an irrigated arable land. Another requirement, namely the procurement of drinking water for both the inhabitants and their livestock, should also be fulfilled. Thus the wadi concerned must be enough wide and flat to satisfy the first condition and, at the same time, enough narrow and more or less sloping to meet the second requirement. In this light, the wadi choice of the PPNB transhumants at Wādī Abū Ṭulayḥa makes sense, because the upstream plain provided an extensive arable land and the slightly dissected downstream valley was suitable for the construction of cisterns. This in turn explains the reason why they did not locate themselves along the tributary wadi of Wādī ar-Ruwayshid ash-Sharqī. It is probably because the area was lacking a dissected valley available for the construction of a storage dam.

To put it in a broader context, another archaeological significance of the barrage systems comes into sight. Noteworthy is their early date beyond the traditional perspective about irrigation facilities in the ancient Near East (Postgate 1992; Wilkinson 2003). To date, no clear evidence for irrigation facilities has been confirmed at Pre-Pottery Neolithic sites; the only exception is the two sites in the Jafr basin. Even in the Pottery Neolithic, the evidence is limited to several debatable examples in southern Mesopotamia and its surrounding areas (Oates 1969; Oates and Oates 1976; Hole 1977, 1987; Hole *et al.* 1969; Neerly and Wright 1994). Reliable evidence does not appear until the end of the Pottery Neolithic or the beginning of the Proto-literate period (Adams 1972, 1974, 1981; Hunt 1988). Thus the discovery of the two barrage systems in the Jafr basin requires a review of the history of irrigated agriculture in the ancient Near East. The same is true of wadi barriers for reserving drinking water. The existence of such easy-to-construct facilities has, for a long time, been assumed. However, such a simple feature hardly remains intact. Even if the facility happens to survive, the dating is difficult due to the deficiency of available evidence. Wādī Abū Ṭulayḥa Barrages 2 and 3 are the first to provide the specific evidence.

The two barrage systems also provide insight

into another dimension behind the prosperous PPNB farming society in southern Jordan. It is now evident that the LPPNB period in southern Jordan witnessed partial infiltration into arid peripheries such as the Jafr basin. The existence of the LPPNB outpost at Wādī Abū Ṭulayḥa clearly exemplifies this episode (Fujii 2006a, 2006b; Fujii in this volume). What is important is that, unlike the expansion into the Azraq/Jilāt area to the north (College 1994; Garrard *et al.* 1994, 1996), the infiltration into the Jafr basin is likely to have been based on a well-balanced mixed economy consisting of hunting, transhumance, and agriculture. However, in light of the limited precipitation in the basin, it is highly doubtful that dry farming familiar to the heartland was directly transplanted to the flint-strewn desert. Even if the rainfall of those days was much higher than that of the present, it is still questionable if dry farming was really successful. The total absence of PPNB settlement sites in the basin (with the only exception of the outpost at Wādī Abū Ṭulayḥa) corroborates this assumption. Then, what made the agriculture in arid peripheries possible? The finding of the two barrage systems provides a key to this question. The construction of irrigation facilities first enabled the early transhumants to found their stable outpost in the middle of *Ḥamād*. It is interesting to note that the establishment of the outpost coincided with the appearance of the 'LPPNB mega-site phenomenon' in southern Jordan (Gebel 2004).

Finally, it should be added that the finding of the barrage systems in the Jafr basin enabled us to recognize anew the potential of the arid land archaeology. It is precisely because they were isolated in the middle of desolate wilderness that such unique features remained intact. Such findings are hopeless in the heartland, because the evidence, if present, must have been thoroughly covered or erased through thousands of years of occupational history. In this sense, one should not underestimate the potential of arid peripheries. Sparse in distribution density as they are, desert sites may contain precious information unavailable in the heartland. The finding of the two barrage systems has attested to this.

### Concluding Remarks

The 2006 spring field season of the Jafr Basin

Prehistoric Project has shown that the LPPNB infiltration into the basin was based on the well-balanced mixed economy incorporating basin-irrigated agriculture as well as transhumance and hunting. The investigations also shed light on the purposeful land choice of the PPNB transhumants. Additionally, the finding of the two barrage systems in the Jafr basin has made it possible to enter an in-depth discussion regarding the social dynamics of the PPNB farming society in southern Jordan. As also suggested by a similar structure recently found at Wādī Badda (Fujii 2007), the PPNB hydrology seems yet to be exploited.

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