ARCHAEOLOGY AND ENVIRONMENT OF THE DEAD SEA PLAIN: PRELIMINARY RESULTS OF THE SECOND SEASON OF INVESTIGATIONS BY THE JOINT LA TROBE UNIVERSITY/ ARIZONA STATE UNIVERSITY PROJECT

Phillip C. Edwards, Steven E. Falconer, Patricia L. Fall, Ilya Berelov, John Czarzasty, Christopher Day, John Meadows, Cathryn Meegan, Ghattas Sayej, Thomas K. Swoveland and Michael Westaway

Introduction

The 'Archaeology and Environment of the Dead Sea Plain' project, directed by Phillip Edwards, Steven Falconer and Patricia Fall, conducted its second joint field seasons at Ẓahrat adh-Dhrā' (ظهـــرة الذراع) in January and February 2001.[1] The Ẓahrat adh-Dhrā' region is located near the south-eastern corner of the Dead Sea, between al-Mazra'a village (المزرعـــة) to the west and the Jordan Valley margin to the east, on the low-lying and hyper-arid Dead Sea Plain (**Fig. 1**). The project is currently investigating the cultural and natural history of the Dead Sea Plain from the latest Pleistocene through the Holocene, by combining geomorphological and palaeoenvironmental studies with archaeological investigations of sites representing two of the region's most significant eras of prehistoric agricultural intensification; namely the Pre-Pottery Neolithic A (PPNA) and Middle Bronze Age (Edwards *et al.* 2001). The earlier of the two periods is represented by the site of Ẓahrat adh-Dhrā' 2 (ZAD 2), dating to 9,600–9,300 BP (9,100-8,550 calibrated years BC); and the second by Ẓahrat adh-Dhrā' 1 (ZAD 1), an unusual Middle Bronze Age village (ca. 2000-1600 BC) situated only 200 metres from ZAD 2.

This report begins with a synopsis of the geoarchaeological survey by Christopher Day, begun in order to provide palaeolandscape contexts for both ZAD 1 and ZAD 2 and the palaeoenvironmental core data. It continues with an account by Patricia Fall and Tom Swoveland of the ongoing AMS, isotope, varve, and palynological analyses of sediment cores obtained from the Lisān Peninsula (اللسان) in 2000, proceeds to a description of the sec-

1. The project's 2001 field seasons were made possible by the kind cooperation of Dr Fawwaz al-Khraysheh and the Department of Antiquities of Jordan. The project is an ASOR affiliate, and we thank the staff of ACOR in 'Ammān for their help and hospitality.

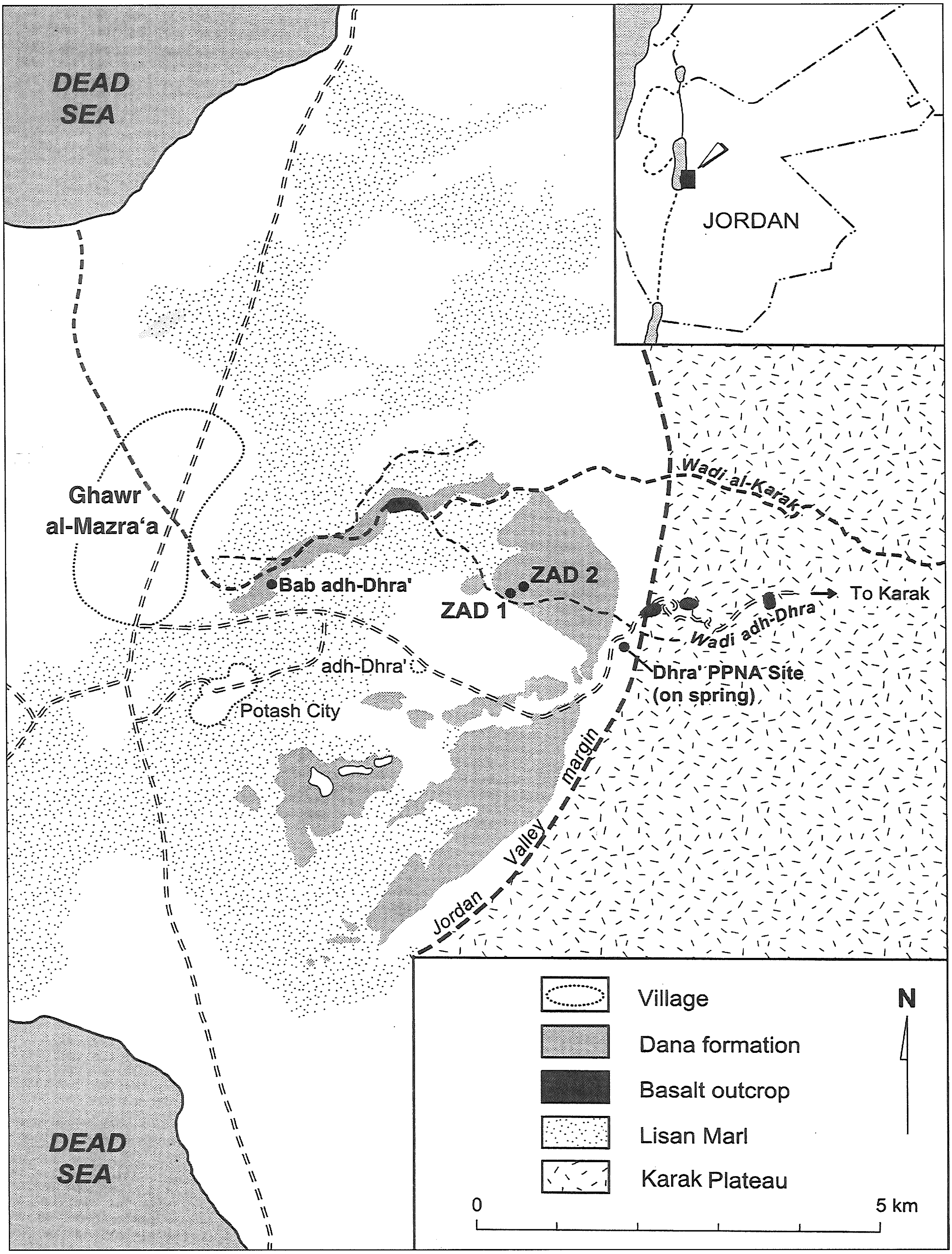
The site of ZAD 2 was excavated by the La Trobe University (LTU) team between January 16 and February 13 under Permit No. 2001/ 3. The La Trobe University team consisted of Phillip Edwards (director), Rebecca Brodie (excavation supervisor), Matthew Chamberlain (excavation supervisor), Rudy Frank (surveyor and photographer), Christopher Day (geoarchaeologist), Ali al-Khayyat (Department of Antiquities representative and excavation supervisor), John Meadows (archaeobotanist), Ghattas Sayej (excavation supervisor and lithics analyst), Zvonka Stanin (excavation supervisor), Michael Westaway (excavation supervisor and physical anthropologist) and Abu Faisal (cook). Six local workmen: Salim Salim al-Hubeiri, Bassam Khalil, Juma'a Khalil, Ibrahim Khalil, Khalid Khalil and Salman Salame, were employed in the excavation, as well as our donkey 'Umm Sabr II'.

We thank Dr Lutfi Khalil, Dr Maysoon al-Nahar, and their students for their kind cooperation in processing some of the ZAD 2 finds in the Department of Archaeology at the University of Jordan.

The 2001 Arizona State University (ASU) ZAD 1 survey crew consisted of Steven Falconer (director and ceramic analyst), John Czarzasty (surveyor), Ilya Berelov (ceramic analyst and surveying assistant) and Ahmed al-Tawahiyeh (Department of Antiquities representative). Our thanks go to our representative Mr. Tawahiyeh. Special thanks go to Hanan Hamdan for her wonderful dinners and to Umm Ashraf for handling our laundry.

Major funding for the excavations at ZAD 1 and ZAD 2 was provided by a Large Grant from the Australian Research Council (ARC) for 1999-2001 and a Research Grant from the Wenner-Gren Foundation for Anthropological Research. Funding for the sediment coring on the Lisān Peninsula was provided by a Research Grant from the National Geographic Society. We are grateful to both the Australian Institute of Nuclear Science and Engineering (AINSE - Special Grant 99/158S), and the La Trobe University Small 1999 ARC Small Grants Scheme for funding that enabled the AMS radiocarbon dating program for ZAD 2.

Both LTU and ASU crews are very grateful to the Jordan Valley Authority (JVA) and its Secretary-General Awadies Serpikian for its continuous support in providing us with accommodation in the JVA housing compound at Ghawr al-Mazra'a. Thanks are due to Khalil Hamdan, the Department of Antiquities Inspector for the Ghawr aṣ-Ṣāfī region for his help, and JVA staff member Na'il Habashne for his aid in maintaining the services in our house. Many thanks are due to Associate Professor Ziad al-Sa'ad, Director of the Institute of Archaeology and Anthropology at Yarmouk University and Dr Gerrit Van der Kooij of the Leiden University Faculty of Archaeology for the generous loan of house and excavation equipment from the Dayr 'Alla Research Station, and to Mr Ahmed Faris for facilitating its loan there; also thanks to Dr Stephen Bourke and the University of Sydney for lending us excavation equipment from Pella. Finally, thanks go to the ever-dependable Ahmad Faris for providing neighbourly hospitality, logistical help, and storage space for our project.



1. The Ẓahrat adh-Dhrā' sites (ZAD 1 and ZAD 2) in the Dead Sea Plain, Jordan, and other key sites and localities.

ond season of excavations of ZAD 2 by Phillip Edwards and then to the comprehensive surface architectural survey of ZAD 1 by Steven Falconer and John Czarzasty. It also includes progress reports on the analysis of excavated materials: the flaked and ground-stone lithics (Ghattas Sayej), plant macrofossils (John Meadows) and human bones (Michael Westaway) from ZAD 2; and the pottery (Steven Falconer and Ilya Berelov) and plant macrofossils (Patricia Fall and Cathryn Meegan) from ZAD 1.

Christopher Day's geoarchaeological work concentrated on the major Ẓahrat adh-Dhrā‘ region, situated between the al-Karak Road to the east and the roughly triangular area bordered to the west by the merging channels of Wādī al-Karak (وادي الكرك) and Wādī adh-Dhrā‘ (وادي الذراع). Surprisingly for a region with such a high archaeological profile, this particular area, which we have also christened the 'ZAD Triangle', appears to have never been made the subject of any previous comprehensive archaeological survey.

The Geoarchaeology of Ẓahrat adh-Dhrā‘ – the 'ZAD Triangle'

The location of a PPNA hamlet and an MB village (ZAD 2 and ZAD 1) on the arid and dissected Ẓahrat adh-Dhrā‘ plain represents two rare examples of settlement and agriculture in this region at critical junctures in the developmental trajectories of the Southern Levant. The aim of geoarchaeological investigation in the ZAD Triangle was to address several local and regional questions about the nature and rate of landscape change and adaptation to the peculiar geological setting and resources of Ẓahrat adh-Dhrā‘. The evidence from two seasons of investigation implies a history of settlement and land use in an environment more benign than is suggested by the present badlands and deeply incised wadis that surround both sites.

This work involved reconnaissance survey of the regional geology — currently available at only 1:50,000 scale — and interpretation of local geomorphology by which archaeological visibility and past land use might be reconstructed. Several new sites were recorded during the course of the survey. Their distribution and dating will greatly assist our understanding of the timing of landscape change at Ẓahrat adh-Dhrā‘. One specific and ongoing geoarchaeological issue at ZAD 1 is whether two large boulder walls at the northern and southern ends of the site were natural or human-made structures. Further, a sequence of low terraces in the channel of Wādī adh-Dhrā‘ below ZAD 1 which contain fine charcoal horizons was sampled in 2000. The prospect that this material might be a source of off-site colluvium was also investigated during the 2001 program.

Geological and Geomorphological Survey

A comprehensive geological survey revealed better resolution of the Dana Conglomerate Formation (DCF) and its relationship with overlying Pleistocene gravels. The lithological differences and landform development within the DCF provide data about past landscapes, land use and the survival of archaeological remains. The Dana Conglomerate (**Fig. 1**) outcrops at Ẓahrat adh-Dhrā‘ as a series of monoclines that dip gently to the southeast, capped by resistant silicified black cherts. Less resistant reddish and white sandstone units are exposed on the plains to the east of ZAD 1 and ZAD 2 but these are blanketed by Pleistocene gravels which thicken to the south beneath ZAD 1. Indurated sandstone beds some 1m thick outcrop near ZAD 2, above which the softer sandstones form a dissected badland terrain. Wādī adh-Dhrā‘ is a permanent stream and has incised some 20-30 metres below the level of neighbouring smaller wadis, exposing long sequences of the conglomerate and sandstone units within the DCF. Dissection also appears to be controlled by the Pleistocene gravels — the product of earlier outwash fan deposition from Wādī adh-Dhrā‘ at the Jordan Valley edge — which form a cap above the softer sandstones. According to the geological handbook for the region (Khalil 1992), the Dhrā‘ Plain is also shaped by several faults, one of which is continuous through Wādī adh-Dhrā‘. The presence of a small doleritic basalt dyke some 300 metres upslope from ZAD 1 and ZAD 2 provides evidence that tectonic and volcanic activity — which is associated with this fault further east — continues through Ẓahrat adh-Dhrā‘.

The Boulder Fields at ZAD 1

Investigation of the substantial alignments of boulders at both the southeast and northwest ends of ZAD 1 revealed that they were composed of silicified limestone, commonly sub-rounded, with dissolution pitting and honeycomb weathering. Some large boulders have become fragmented due to weathering. The issue about whether this alignment of boulders is a natural or human-made feature remained unresolved during the first season. The fact that no similar arrangement of large boulders existed anywhere else on the plain seemed to suggest that the boulders were transported from elsewhere. Excavation in and around the boulders, however (Falconer, in Edwards *et al.* 2001), seemed to indicate that they were set firmly within undisturbed natural gravels, suggesting a natural feature. Further survey during 2001 noted a similar wall built from the same material on the north bank of Wādī al-Karak about 1km away, providing a local analogue for such a construction.

During geological mapping the presence of large limestone boulders (erratics) was noted scattered throughout the valleys in the mid and upper parts of the hills immediately behind ZAD 1 and ZAD 2. Limestone is not part of the Dana Conglomerate, hence dispelling any notions that this material outcrops in the area immediate to ZAD 1. The scatters of erratics were traced almost to the Jordan Valley edge and are the product of material breaking from the ASL (Amman Silicified Limestone) unit which outcrops in dramatic vertical sheets (flatirons) some 2km to the east of the sites.

Large fragments of ASL, mobilised during erosion or tectonic episodes, form coarse debris flows and accumulate as lag deposits at the break of slope and on the near plain. It is a preliminary suggestion that such lag deposits have been the source of large stone for both wall construction and building material. ZAD 1 appears to lie at the end of a valley within which large erratics have been confined. This is supported by the observation that the DCF is a poor source of building stone, with construction activities at Ẓahrat adh-Dhrā‘ instead enabled by the appropriation of plentiful scatters of limestone. The concentration of large boulders as terminal lag material could reasonably have been rearranged as a substantial wall or territorial marker.

Colluvial Terraces at Wādī adh-Dhrā‘

The presence of multiple charcoal horizons within fine-grained sand and silty terrace deposits up to 3m thick on the northern side of Wādī adh-Dhrā‘ below ZAD 1 was attested during the first season. While undated, the fine lamination and cross bedding, and the succession of charcoal horizons suggested that these colluvial deposits might be a potential source of ancient cultural material. During the second season, charcoal within a colluvial section below ZAD 1 was sampled for dating. The exposure at this sampling site was extended to a depth of 215cm, revealing further thin charcoal horizons and silty material above basal cobbles. However, during final preparation of this section for description, a piece of black plastic was found embedded within the cobbles at about 200cm below the modern terrace surface, demonstrating the recent age of the sediments. The deposition of over 2m of alluvium or colluvium in recent times provides a clear example of the rapid rate of aggradation of sediment and complexity of deposition within these arid-land wadis. Up to four phases of deposition were recorded in the exposure with fine organic silty material (local colluvium) and continuous thin charcoal horizons separated by thick sequences of fine sandy silt (alluvium). The latter commonly contained evidence of cross bedding and fine lamination.

Landscape Archaeology

The region of Ẓahrat adh-Dhrā‘ between Wādī al-Karak, Wādī adh-Dhrā‘ and the Jordan Valley margin (the ‘ZAD Triangle’) appears to have remained unsurveyed in any systematic fashion. Reference to various past archaeological surveys in the region appear for the most part to have focused in and around Bāb adh-Dhrā‘ (باب الذراع) and further south (Rast and Schaub 1981), or to the north of Wādī al-Karak (Worschech 1985) or to the west (McConaughy 1981). However survey reports do not appear to have reviewed the ridge under discussion. During the second season four new major archaeological sites were discovered in the course of the geological mapping program:

a) A substantial limestone wall (mentioned above) constructed from large boulders some 100m above a parallel lower wall of smaller boulders on the northern bank of Wādī al-Karak, about 1km north of ZAD 1. Several curvilinear walls and internal structures were noted with a scatter of possibly Bronze Age pottery throughout, but most prominent on a hillock above the upper wall.
b) A rectangular enclosure about 80m x 150m, bounded by a loose and sparse scatter of cobbles and chert fragments on a gentle plain south of Wādī al-Karak and north of black chert hills in the northern part of Ẓahrat adh-Dhrā‘.
c) A square enclosure, about 80m x 80m, located 300m to the northeast of ZAD 2 on a flat plain. Some 10 to 15 small stone features (3.5 x 1.5m) are aligned around the western and southern perimeters.
d) A landscape of curvilinear walls, straight walls, square structures, round walled enclosures (up to 26m in diameter) and 10 to 15 twin-chambered burial cairns extends over terrain rising from Ẓahrat adh-Dhrā‘ east of the black chert range, about 500m northeast of ZAD 2. Pottery scatters suggest a Chalcolithic to Early Bronze date range.

The accurate survey and dating of the multi-period settlement of the region immediately surrounding ZAD 1 and 2 will greatly enhance the understanding of the land use history and chronology of landscape change of the Dhrā‘ Plain. The relationship and date of these other features to local landforms, particularly the evidence of truncation, will provide better resolution to models of the timing and phases of erosion in and around ZAD 1 and ZAD 2.

Future Questions

(a) The Dead Sea level fluctuations modelled by Donahue (1985), and Frumkin and colleagues (1994), are yet to be fully reconciled with the archaeological timing of erosion through ZAD 1 and 2. Future work will involve a collation of previous interpretations of climatic and Dead Sea level change with new palaeoenvironmental data from the 2000 coring operation (see Fall and Swoveland, below) and the 2002 geomorphological survey.

(b) Air photographic interpretation of the region will greatly assist geological and geomorphic interpretation.

(c) The sequence and distribution of settlement and land use on the Dhrāʿ Plain has yet to be mapped and dated. This has considerable potential for constructing a chronology of landscape change at ZAD 1 and 2. Future work will include a regional survey of these features at Ẓahrat adh-Dhrāʿ.

The results of the 2001 geo-archaeological survey have placed the PPNA and MB sites in a better regional geological and geomorphological context. On a gentle plain at the fringe of the Jordan Valley both settlements benefited from the perennial spring-fed Wādī adh-Dhrāʿ, and abundant sources of flint, and natural tumbles of building stone concentrated in break of slope lag deposits, were available for opportunistic use as town walls and building stone. The Dana Conglomerate Formation and structural features have produced a landscape of differential weathering shaped by phases of incision, the chronology of which will be better understood by a regional examination of both environmental data and wider settlement distribution.

(CD)

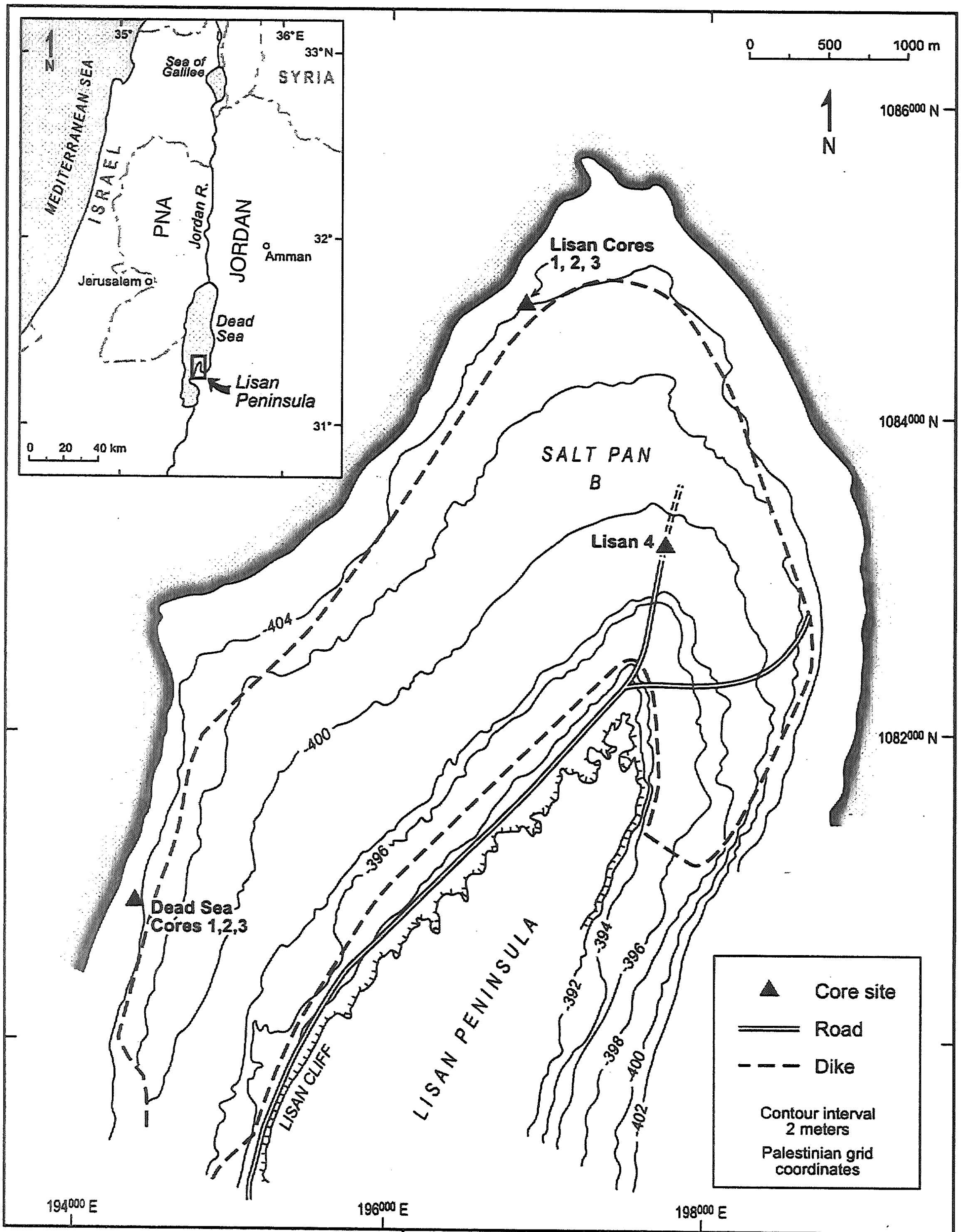
Palaeoenvironmental Investigations on the Lisān Peninsula, Dead Sea

An important aspect of the Archaeology and Environment of the Dead Sea Plain Project is to explain the sporadic settlement history on the Dead Sea Plain and the interaction of these human settlements with their past environmental landscape. Both ZAD 1 and ZAD 2 at approximately 160 metres below mean sea level lie adjacent to the ancient Pleistocene shoreline of Lake Lisan (70,000-11,000 years BP). As part of our ongoing investigations to interpret the palaeoclimate and past environments of this hyperarid region, Arizona State University (ASU) collected eight sediment cores from four localities on the north-western end of the Lisān Peninsula in January and February 2000 **(Fig. 2)**. Four of the cores (Dead Sea Cores 1-3 and Lisan Core 3) were collected with a hand-operated, piston corer (a 5cm diameter Livingston corer). The four deepest cores (Lisan 1, 2, 4, and 6) and the top 5m of Lisan Core 3 were collected with a truck-mounted, rotary drill rig operated by the Natural Resources Authority, Hashemite Kingdom of Jordan.[2] The sediments are composed of up to 30m of laminated carbonate and detrital deposits. Eleven AMS ages **(Table 1)** reveal that the uppermost 18m span approximately the past 20,000 years BP (uncalibrated radiocarbon years before present). Carbon and oxygen isotope analyses of carbonate layers from varved sediments show changes in lake chemistry and hydrology of Pleistocene Lake Lisan (Swoveland 2001). Our focus for this report is based on Lisan Core 3 (691-1225cm depth) that covers the latest Pleistocene interval, from 20,000 to 12,000 years ago.

Lisan Core 3 was collected near the foreshore of the Dead Sea on the Lisān Peninsula about one metre above the modern water surface that lies 404m below sea level. Lisan Core 3 was chosen for analysis because it represents the least distorted (due to recovery by a piston corer) and most continuously laminated sediments that cover the latest Pleistocene. The top 5m of Lisan Core 3 were recovered with the mechanized rotary drill rig in order to penetrate the uppermost halite and dense aragonite layers. Sediments below this depth were recovered with the hand-operated piston corer. A maximum depth of 1225cm was reached with the Livingston corer. After being shipped in wooden core boxes to the Paleoecology Laboratory in the Geography Department at ASU, Lisan Core 3 was sectioned lengthwise to observe the depositional varves. Each core section was photographed with a high-resolution digital camera in 15cm long overlapping images to produce an electronic gallery image for the entire core.

Lisan Core 3 is comprised of laminated sediments consisting of alternating white carbonate and dark grey-green detrital laminae **(Fig. 3)**. Three wood macrofossils embedded in the laminae show that Lisan Core 3 spans the period from 20,000 to 12,000 BP **(Table 1)**. The white carbonate layers

2. We thank the Arab Potash Company and the Natural Resources Authority of Jordan for facilitating the drilling on the Lisān Peninsula; Bruce Howell who assisted PLF and SEF in collecting Lisan Core 3; Dr. Paul Knauth and Mr. Stan Klonowski of Arizona State University's Department of Geological Sciences Stable Isotope Lab for analysing the isotope samples; Dr. Tom Groy of ASU's Department of Chemistry for support in the XRD analysis; Dr. Hamdallah Bearat of ASU Center for Solid State Sciences for assistance interpreting the XRD data; and Emily Prud'homme who helped section and photograph the cores and produced the digital gallery images.



2. *Map of the northern end of the Lisān Peninsula showing coring locations. Gallery images of the cores shown.*

in the core were sampled approximately every 15 centimetres for mineral and isotope analyses. X-Ray Diffraction (XRD) was used to determine the carbonate mineral phases throughout the core. XRD showed that the white layers were comprised mainly of aragonite, with trace amounts of gypsum, anhydrite, calcite, and salts. Carbon and oxygen isotopes were analysed from 24 individual aragonite laminae. $\delta^{13}C$ data are presented as parts per thousand ($^{o}/oo$) relative to the PDB (Peedee Belemnite) Standard. $\delta^{18}O$ data, presented as parts per thousand ($^{o}/oo$), were converted from PDB by ASU's Department of Geological Sciences Stable Isotope Lab, and are expressed relative to Standard Mean Ocean Water (SMOW).

Palaeoclimatic Interpretation Based on Lisan Core 3

Carbon isotopes demonstrate variability in car-

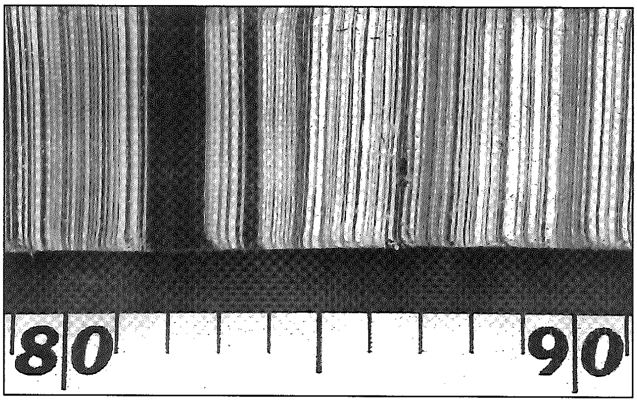
***Table 1:** AMS age determinations from Dead Sea and Lisan Cores.*

Core	Depth (cm)	Age (uncalibrated yr BP)	Laboratory Number	Calibrated Age (95% probability) Stuiver et al. 1998
Dead Sea 3	8.5	1440 ± 40	Beta-160106	AD 550-660
Dead Sea 3	26	1590 ± 40	Beta-160107	AD 400-560
Dead Sea 3	45	1690 ± 40	Beta-153581	AD 250-430
Dead Sea 3	108	1820 ± 40	Beta-153582	AD 100-260 and AD 290-320
Dead Sea 2	361	7030 ± 50	Beta-155306	BC 6000-5790
Dead Sea 2	512	5020 ± 50	Beta-155307	BC 3960-3680
Lisan 2	1461	15,190 ± 50	Beta-156767	BC 16,510-15,850
Lisan 2	1673	18,690 ± 60	Beta-156768	BC 20,730-19,770
Lisan 3	698	12,460 ± 40	Beta-153583	BC 13,490-12,220
Lisan 3	1067	17,990 ± 60	Beta-155308	BC 19,900-18,970
Lisan 3	1186	19,020 ± 70	Beta-156766	BC 21,150-20,120

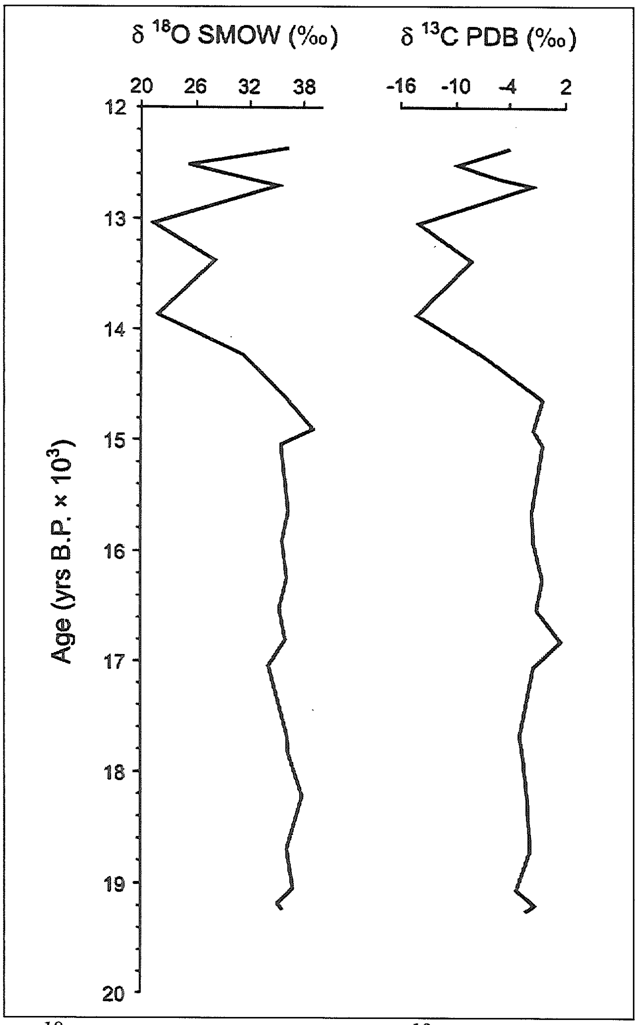
bon dilution and enrichment in the Dead Sea and are used as proxies for precipitation and/ or fluvial run-off to the basin. $\delta^{13}C/^{12}C$ ratios with higher ^{13}C values (-7.2 to 1.8 PDB) than the modern Jordan River (-7.2 PDB) (Stiller and Magaritz 1974) are interpreted as enriched. Dilution values vary from –14.2 to –7.2 PDB. Carbon isotopes from Lisan Core 3 show considerable enrichment for the period between 20,000 and 14,500 BP, as would be expected for a hypersaline lake (**Fig. 4**). Samples with ^{13}C values more dilute than the modern Jordan River are found after 14,000 BP. These dilution events are interpreted to represent the influx of organic material into Lake Lisan following an influx of water from runoff, flooding, and glacial melt water from the upper watershed of the Jordan River (the mountains of Lebanon).

Oxygen isotopes are used to provide relative temperature values. Enrichment and dilution of ^{18}O are interpreted using Jordan River water as a modern analog. Katz *et al.* (1977) reported an average ^{18}O value for the Jordan River of -2.9 SMOW (-7.2 PDB). ^{18}O for Lisan Core 3 (**Fig. 5**) shows the same enrichment and dilution seen in the ^{13}C data (**Fig. 4**). Between 20,000 and 14,500 BP the water of Lake Lisan is enriched in ^{18}O. Although absolute temperature values for the Dead Sea could not be assigned, this section of the core is interpreted to represent a relatively cold, stable period. Based on dilution of 18O starting about 14,500 BP, the temperature of the Dead Sea rose dramatically. More extreme temperature fluctuations are interpreted for the period between 14,500 and 12,300 BP.

Carbon and oxygen isotopes from Lisan Core 3 reveal that the late glacial climate of the Dead Sea region was relatively cold and dry with very little organic matter washed into Lake Lisan. This cool, dry interval ended about 14,500 years ago when precipitation and runoff into the lake basin increased greatly. This interpretation supports the recent study of stratigraphic sections in the Dead Sea area by Abed and Yaghan (2000) that hypothesizes that the climate during the Late Glacial Maximum



3. *Close-up of varves in Lisan Core 3.*

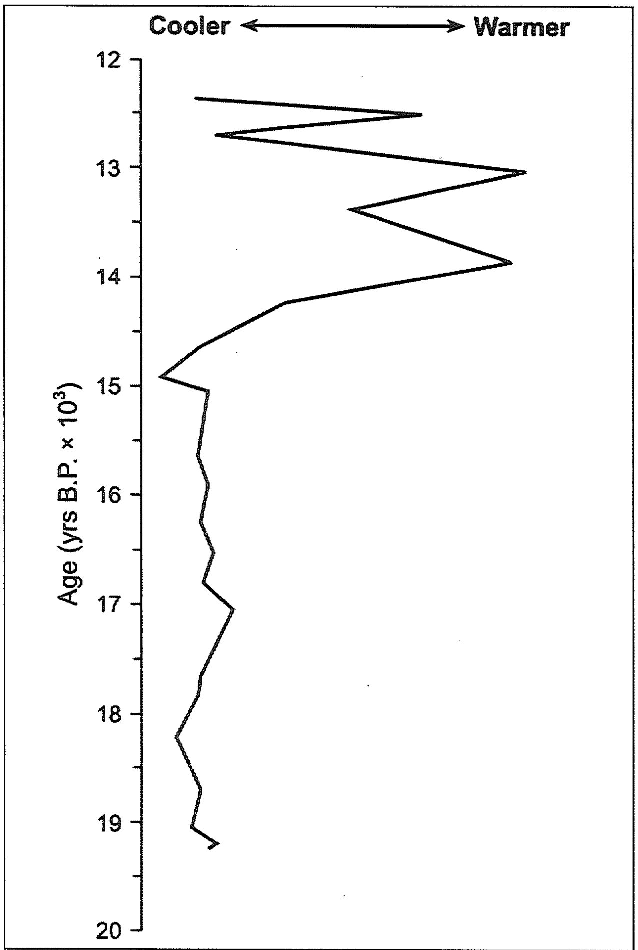


4. *$\delta^{18}O$ SMOW (°/oo, left column) and $\delta^{13}C$ PDB (°/oo, right column) from Lisan Core 3 (data from Swoveland 2001).*

(LGM) was cool and dry. No evidence for a pluvial climate during the period from 20,000 to 14,200 years ago, as suggested by Neev and Emery (1995), is seen in the Lisan Core 3 isotope data.

The cold and dry period identified in Lisan Core 3 between 20,000 and 14,500 years ago coincides with the Early Epipalaeolithic Period (20,000 to 15,000 BP) when the landscape was dominated by open steppe vegetation (Baruch and Bottema 1999) with Mediterranean forest refugia along wadis of the northern Jordan Rift Valley (Edwards 2001). During the Middle Epipalaeolithic (15,000 to 13,000 BP) locally moist environments continue along the Jordan Valley (Edwards 2001). Our results agree with palynological studies from the al-Ḥūlah Basin (حوض الحولة), in the upper elevation watershed of the Dead Sea, that show that deciduous oak forests expanded between 14,500 and 12,500 years ago in response to a warmer and wetter climate (Baruch and Bottema 1999). After about 12,500 years ago the climate of the region deteriorated, with dry conditions returning in the southern Levant (Baruch and Bottema 1999; Yasuda *et al.* 2001) as forests became more restricted and steppe lands expanded. Stream incision due to a lowering of base level began in the Late Epipalaeolithic (12,000 to 11,000 BP) when settlement sizes increased (Edwards 2001).

Ongoing AMS, isotope, varve and palynological analyses of both the Pleistocene and Holocene portions of the cores from the Lisān Peninsula will allow us to illuminate human interaction within the



5. *Relative temperature based on $\delta^{18}O$ SMOW (°/oo) from Lisan Core 3 (data from Swoveland 2001).*

context of the palaeoenvironmental landscape of the Dead Sea Plain and the greater Jordan Rift Valley.

(PLF and TKS)

A Second Season of Excavations at the PPNA Site of Ẓahrat adh-Dhrā' 2 (ZAD 2)

La Trobe University carried out a second season of excavations at ZAD 2 from January to February, 2001. The first season in late 1999 demonstrated ZAD 2 to be a small mound about two metres thick and 2,000 square metres in area. During that period, portions of three structures (Structures 1, 2 and 3) were excavated. Charcoal samples from successive phases of occupation in Structure 3 yielded three radiocarbon determinations of 9,490±50 BP (OZE 605); 9,440±50 BP (OZE 606) and 9,470±50 BP (OZE 607), indicative of a short-lived site.

The 2001 program succeeded in excavating Structures 1, 2 and 3 through to the underlying natural sediments; excavating a larger area of deposits in Structure 2, excavating a secondary burial in Squares I-J25, and beginning the excavation of Structure 4 in the northern part of the site **(Fig. 6)**. Several new radiocarbon samples also were obtained.

Structure 1 (Square E28)

Structure 1 is a small, round stone hut located on the western edge of the settlement **(Fig. 6)**. In the first season, a series of interleaved, red and dark grey deposits (Loci 1-18), which appeared to represent refuse tip lines, were excavated below it in Square E28. This sondage was continued in the second season (Loci 19-26), demonstrating a gradual decrease of artefact density with depth, until natural Dana Conglomerate Formation sediments (Locus 24) were encountered at 1.20m below the surface **(Fig. 7)**. While no artefacts were found in the DCF, the remains of a child's skull were found dug into a small pit (Locus 25), some 10cm deep into the natural layers **(Figs. 7, 8)**. The skull survived mainly as an endocast of sediment supplemented by a partial covering of thin cranial bone fragments, surmounted by a little molded dome of mud. Underneath this arrangement a number of loose, deciduous teeth were discovered.

Depth of Deposits in Structure 2 (Squares K22 – L23)

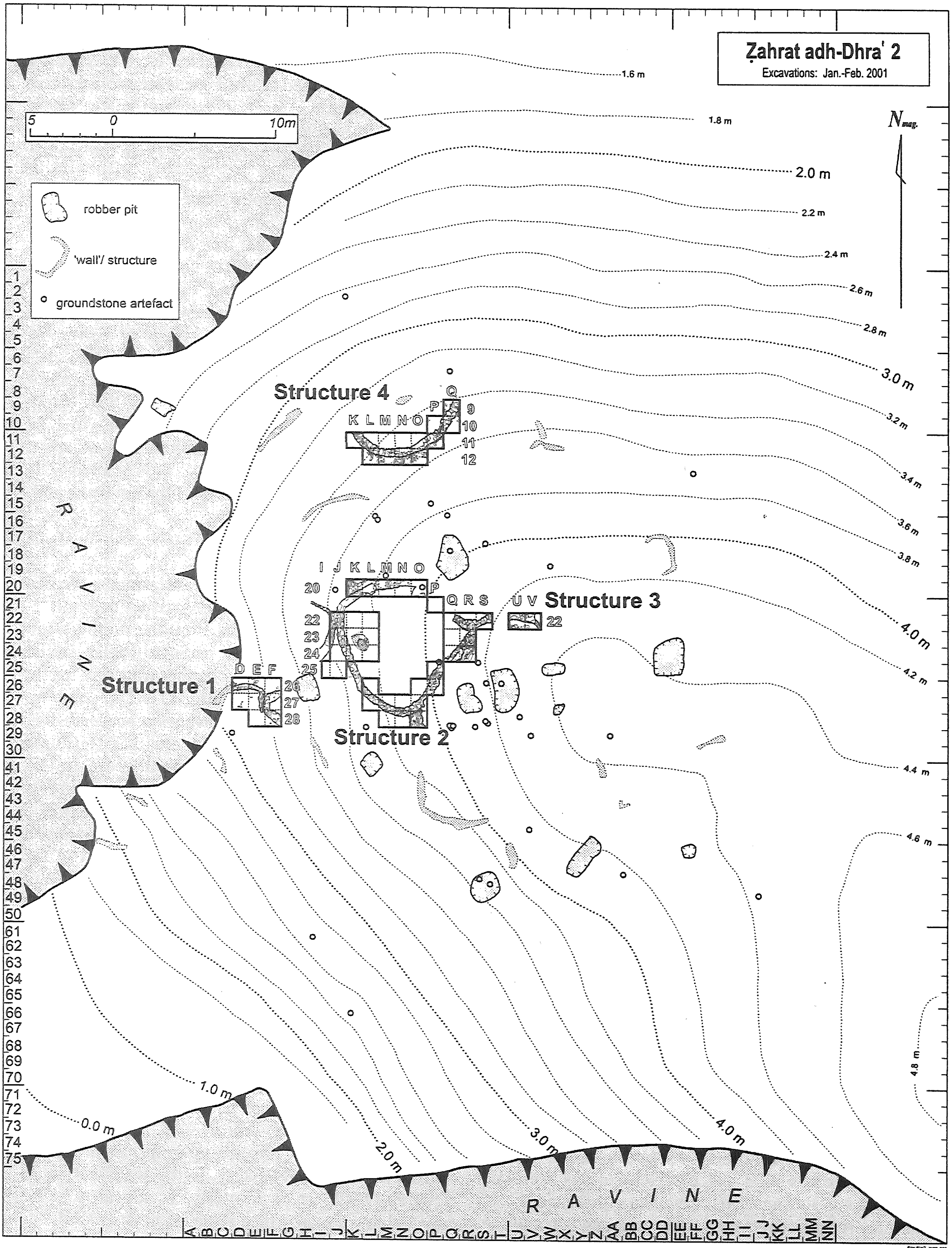
The first season of excavations showed Structure 2 to be associated with a plastered floor (Locus 3.1) and an interior hearth (F.4) set with stones and plaster in Squares K22 – L23. Excavations were extended here during 2001, revealing three additional superimposed floors between Locus 3.1 and the natural, some 60cm below **(Fig. 9)**. The next floor (Locus 4.1) encountered below Locus 3.1 was varied in character **(Fig. 10)**, changing from a hard plastered surface in the south to softer brown sediment in the north. The two regions were divided by a low, single coursed wall of stone, mudbricks and mortar (Feature 3 = F.3). The hearth (F.4), which was covered by Floor 3.1, proved to be founded on an underlying third floor (Locus 5.1). In the course of excavations beneath this locus a new feature (F.2) emerged: a U-shaped stone platform abutting the main wall (F.1). This was probably an earlier hearth and it rested on the fourth floor (Locus 6.1). The bottom of the wall (F.1) was associated with this lowest fourth floor, and final excavation revealed a six-coursed, double-rowed, well-mortared limestone wall standing to a height of 0.8m. No foundation trench was discovered at its base, although hard mortar and a number of stones associated with the base of the wall may have functioned to stabilize it. Finally, excavations in K22 reached the natural Dana Conglomerate at about 90cm below surface sediments. This (Locus 7.1) consisted of a shelf of hardened, lithified Dana sediment sloping up to the north.

Lateral Extent of Structure 2

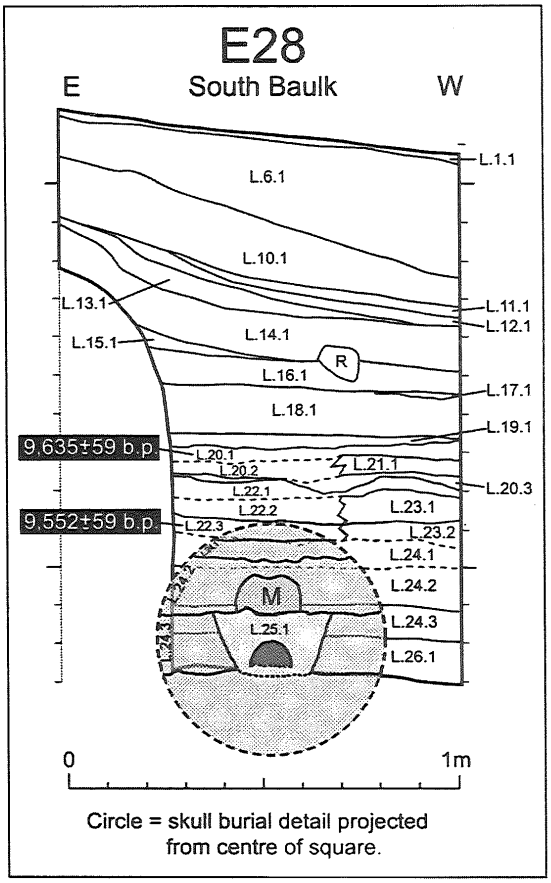
During the first season, excavations revealed that Structure 2 possessed a long curvilinear stone-wall arc (F.1), which curved from the northwest in Square J22 to the southeast in Square K24. In the second season this wall was further traced to reveal an entire walled enclosure **(Fig. 11)**. The southern and eastern parts of the excavations proceeded in 18 squares (L26 – S22). In Squares L26 – O, the structure curved sharply around to the east. In this sector, where the wall was dug to the uppermost floor (Locus 5), the six-coursed wall reached a height of 80cm in Phase 1 alone. A single-coursed stone wall (F.8) was found running from F.1 to the south in Squares N/O –28, apparently connected to it at a later date **(Fig. 11)**. Squares O26 – S22 saw F.1 straightening as it ran towards the northeast.

In the north, Feature 1 also ran sharply to the east through Squares K20 to O20. Square O20 touched on the edge of another human burial, inside the fill of Structure 2, which was left unexcavated. An old clandestine excavation pit precluded clarification of any further continuation of the wall to the northeast, but excavations in Square P19 demonstrated no linkage of the northern and eastern parts of the curvilinear wall, indicating the placement of a door or opening in this area. This is considered especially likely as the wall-section in Squares Q/R22 stops abruptly. It appeared to be finished to a squared face rather than destroyed.

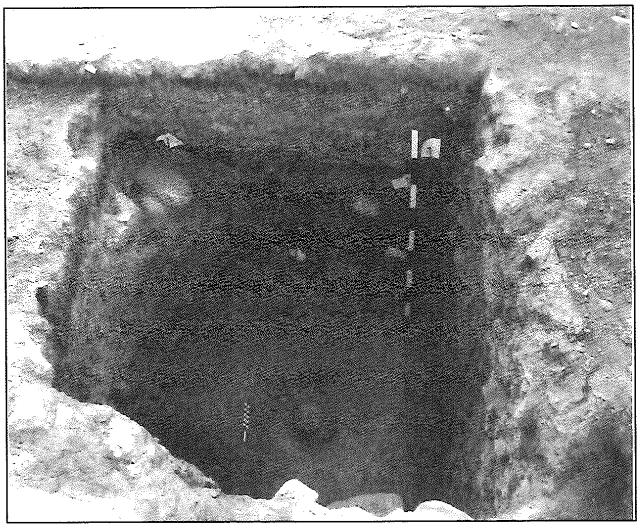
In summary, Structure 2 has proved to be a most unusual design, appearing as a constricted 'tear-



6. Site plan of ZAD 2.



7. South baulk section of Square E28 in Structure 1, ZAD 2.



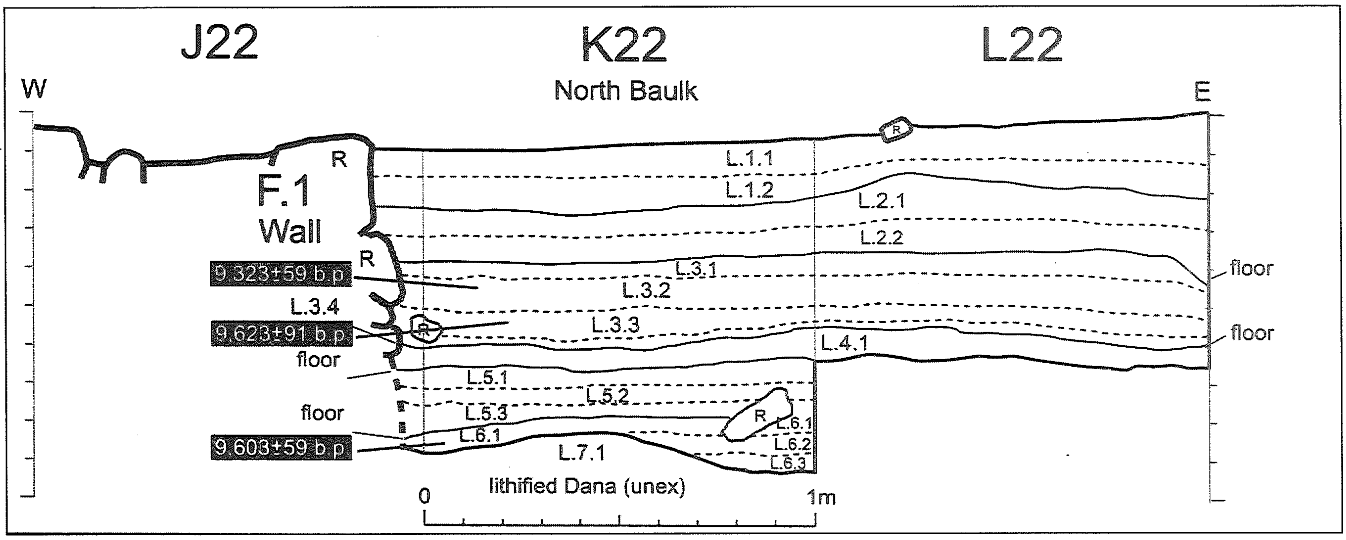
8. View of infant skull burial in Locus 25, Square E28 of Structure 1, ZAD 2.

drop'-shaped structure which opens to the east, with its major axes measuring some 7m in length **(Fig. 12)**. A further surprise is that the eastern wall of Structure 2 appears to swing round to the southeast to continue as Structure 3, though this awaits clarification by further excavation.

The Communal Burial in Squares I-J-K25

A second wall (F.2) abutted F.1 in Square J22 and curved away in the opposite direction (to the southwest). In 1999, a small cairn of stones (F.3) was discovered, positioned in the interstices between the two walls near the south baulk of Square J24, and this overlay some large fragments of a human cranium. Further excavation showed that F.3 marked the northern end of a complete human skull that emerged in the baulk. This burial (F.5) was excavated in 2001 **(Fig. 11)**. Traces of at least three humans were excavated in the burial. The one which belonged to the skull (see Westaway, below) was by far the most complete of them.

No burial pit was visible at any stage of the excavations. The bones were embedded in dark and friable ashy deposits throughout, and deposited in fill on or near to the uppermost floor between the two structures. Several large rocks based around the skull form a continuation of the small cairn (F.3) first discovered in Square J24. The burial



9. North baulk sections of Squares J/K/L22 in Structure 2, ZAD 2.

10. View southward to Floor 4.1 in Squares K22-L23 of Structure 2, ZAD 2.

continued west of Square I25, in the direction of a clandestine excavation pit. Many artefacts were recovered from the shallow deposits, the most notable being a small stone phallic figurine **(Fig. 13)**.

Structure 3 (U-V22)

In the first season, two squares (U-V22) were positioned at the summit of the site in order to investigate the deepest deposits of the site. In Locus 2.1, about 40cm below the surface, a hearth (F.3) rich in charcoal was found associated with a floor. This capped the underlying Structure 3 which consisted of a curvilinear wall stepped down to the north, curving east to west from Square V22 to U22, with the interior floored surface some 25cm below the exterior one. Excavations in the second season were designed to determine whether Structure 3 overlay an earlier structure or not, and in any case to excavate to natural sediments.

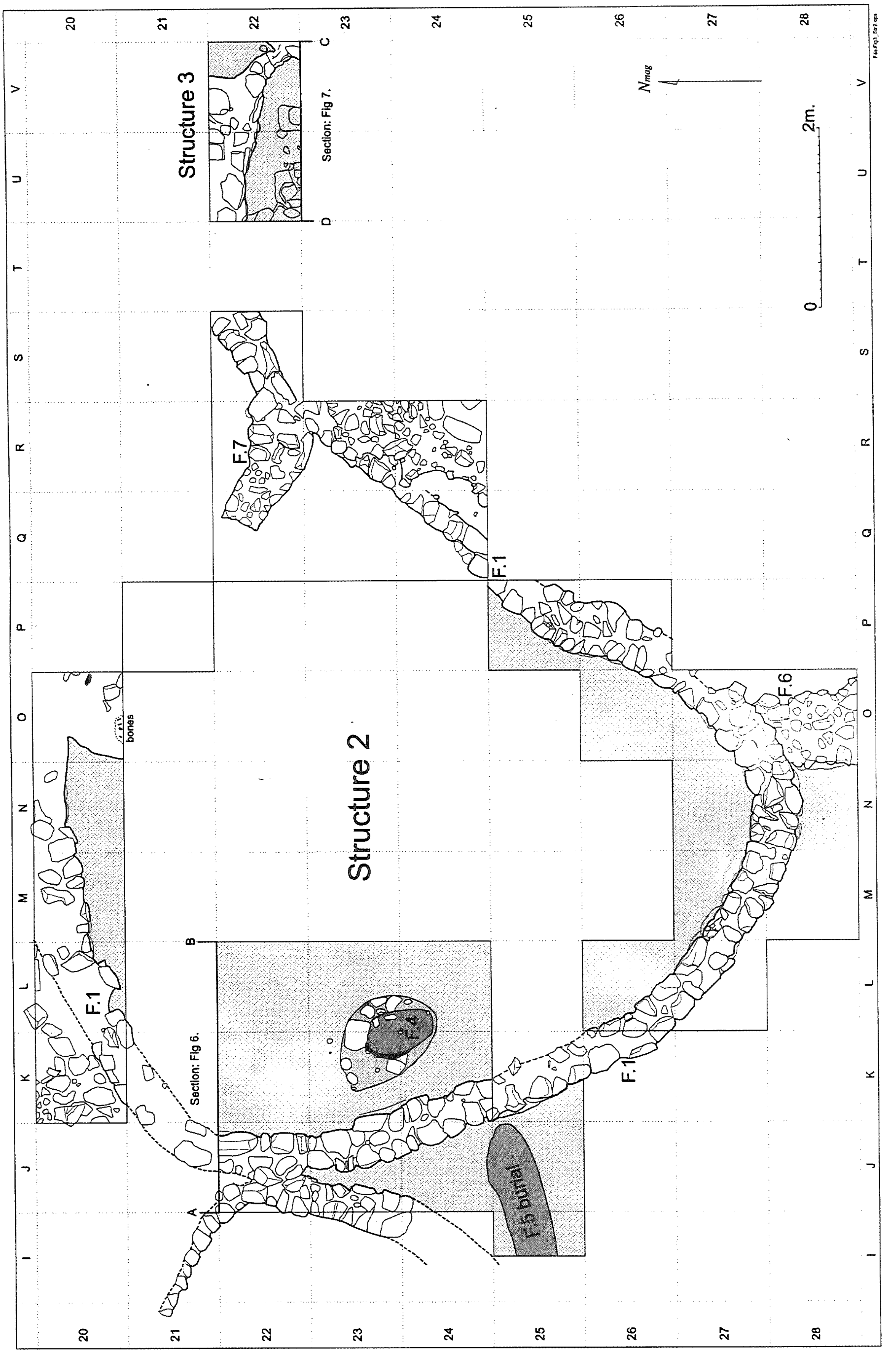
Only two thin layers (Loci 7.3 and 7.4), including the basal floor of Structure 3 (Locus 7.4), had to be removed before the season's goal was achieved **(Fig. 14)**. Below these layers the sterile Dana sediment (Locus 7.5) was encountered and dug down 45cm without further architectural finds appearing. Like Structure 2, the base of the main wall (F.1) was not set into a foundation trench, but was laid on a mortar base. The Structure 3 wall was dismantled in Square V22, showing that the stones were set into copious, hard mortar layers. This left a patch of exterior surfaces to be excavated from the small, triangular area in the northeast corner of V22. Two sharply defined and superimposed white plaster floors were encountered here, one associated with the external base of F.1.

Structure 4 (Squares K11 – Q10)

Clearance of Structure 4, located in the northern part of ZAD 2, was initiated in the second season. Excavation in thirteen squares tracked a large curvilinear wall segment (F.1) running in a northwest to southeast direction **(Figs. 15, 16)**. Excavations in Squares P10-11 and Q10 indicated the wall to be but one course thick, with a maximum height of 0.25m and width ranging from 0.55–0.68m, sitting on a thin layer of small pebbles and rocks. Hence, subsequent excavation was directed laterally wherever this horizon was encountered. Numerous stones were missing from the wall in Squares O11 and O12, and a large amount of tumble was scattered on its southern, exterior side. In Squares L-O11 on the interior of Structure 4, the single wall course was associated with a cobblestone floor composed of pebbles and small stones set into a coarse, grayish plaster. All of these strands of evidence support the conclusion that Structure 4 is much less well preserved than its more southerly counterparts, and this is attributable to its position near the edge of the mound where deposits are thinner.

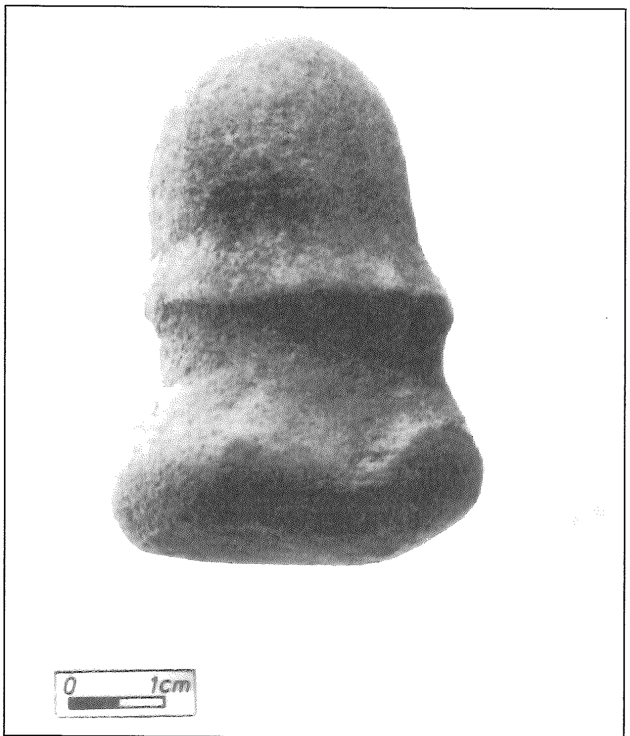
Summary of ZAD 2 Architecture

The 2001 excavations confirmed and extended the evidence previously obtained in 1999, and demonstrated that ZAD 2 was a short-lived settlement of round and teardrop-shaped stone huts, containing only one major constructional phase. Where we have excavated, the structures appear to be curvilinear ones whose external walls adjoin other structures. Despite the tightly clustered series of radiocarbon dates, it is not necessarily the case that all of the structures were planned and built at



11. Structures 2 and 3 in the southern part of ZAD 2.

12. Aerial view of Structure 2, and Structure 3 in bottom right, after the second season of excavations at ZAD 2.



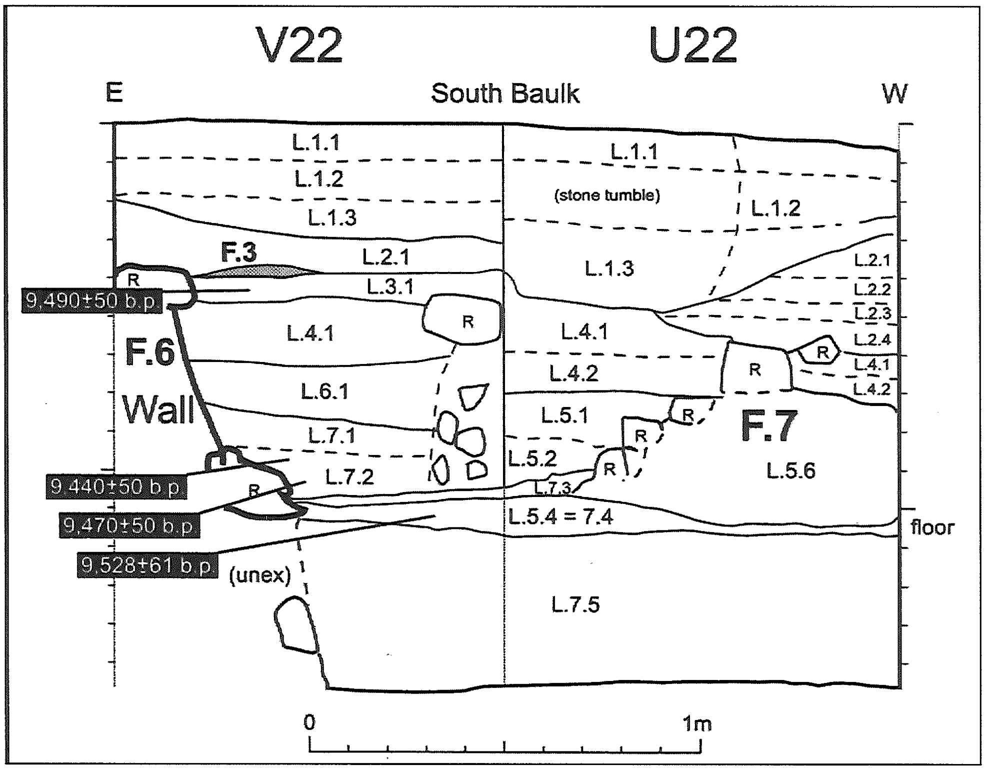
13. Small stone figurine (RN 010036) found in the J25 burial west of Structure 2, ZAD 2.

one time. Rather, there is some evidence in the way that Structure 2 seems to 'onlap' Structure 3, and the later exterior walls abutting Structure 2 (e.g. F.6) to suggest that the huts were added to laterally over time. Within individual structures there are multiple floor phases — up to four in the case of Structure 2. Structures 1, 2 and 3 were dug through to sterile deposits at about 1m below the surface, showing that the low rise of the mound (ca. 1-2m) is partially natural.

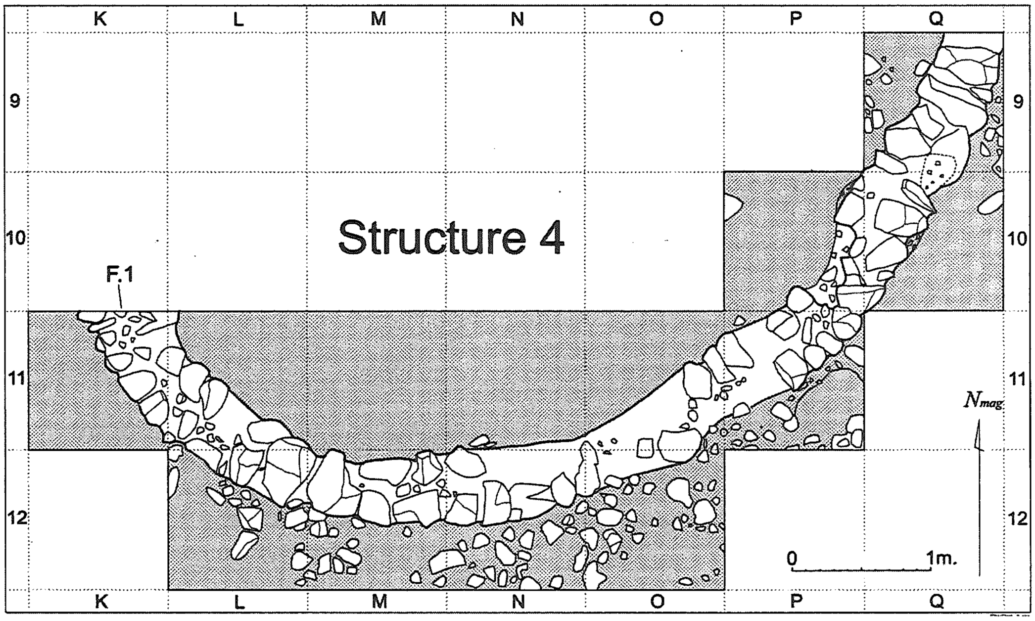
The architecture is notable for its regularity and high standard of construction, and can currently be counted among the more substantial architectural arrays for the PPNA period in Jordan. It is difficult to find exact parallels to ZAD 2's array of adjoining round, oval and teardrop-shaped stone huts, but it does recall another late PPNA architectural complex at Jurf al-Aḥmar in northern Syria (in Phase I on the eastern mound; Stordeur 1999: 140).

Various Artefacts and Materials from ZAD 2 in 2001

The most unusual find from the 2001 excavations was a small figurine made of an undeter-



14. South baulk sections of Squares U/V22 in Structure 3, ZAD 2.



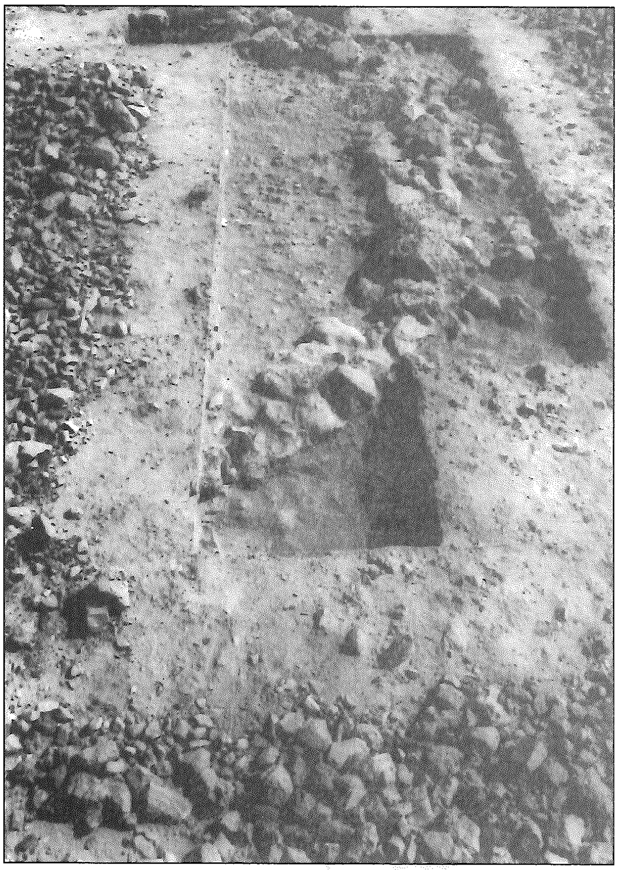
15. Structure 4 in the northern part of ZAD 2.

mined stone (**Fig. 13**), found in the J25 burial (RN 010036). More malachite fragments, some facetted, a red (coral?) bead, Dentalium shells and retouched lithics, a complete basalt pestle (RN 010065) and a cuphole mortar (010069) numbered among other prominent finds.

Stratigraphy and Chronology of Ẓahrat adh-Dhrā ʻ 2

Six additional AMS radiocarbon dates from ZAD 2 have been acquired after the second season, augmenting the three obtained from the first season (**Table 2**). All samples were run on small and chunky wood charcoal fragments, which are abundant in almost every excavation context throughout the site. The few specimens that have as yet been identified (pers. comm. Patricia Fall) derive from the branches and twigs of pistachio (cf. *Pistacia* sp.) trees. Notably, pistachio and fig are virtually ubiquitous in all loci at ZAD 2 in the floated archaeobotanical material (see Meadows, below).

In Structure 1, the date of 9,552 ± 59 BP (Wk-9455) comes from the lowermost occupation layer



16. *View eastward over Wall (F.1) and cobblestone floor of Structure 4, ZAD 2.*

of Square E28 (Locus 22.3),and overlies the infant skull remains dug into the Dana Conglomerat (**Fig.** 7). A date of 9,635 ± 59 BP (Wk-9633) comes from Locus 20.1, some 15-20cm higher than Locus 22.3. According to the method of Gillespie (1982), which is based on that of Ward and Wilson (1978), the two dates are statistically indistinguishable. The calculated value of the Test statistic T is 0.520, which is less than the tabled value of Chi-Squared (3.841) for one degree of freedom at the 0.05 level, indicating a 95% probability that the two ages share the same true mean age.

Structure 2 yielded three superimposed AMS dates. The first is 9,323 ± 59 BP (Wk-9444) that comes from a deposit (Square L23, Locus 3.2) underlying the uppermost floor (**Fig. 9**). The next date of 9,623 ± 91 BP (Wk-9568) comes from the layer (Square K22, Locus 3.3) immediately underlying Wk–9444. The final date of 9,603 ± 59 BP (Wk-9447) is from the earliest and lowest of Structure 2's four floors (Square K22, Locus 6.1). The statistic T for the three means is 3.783, less than the Chi-Squared Value (5.991) for two degrees of freedom at the 0.05 level, indicating a 95% probability that the three dates are statistically indistinguishable.

For Structure 3, a fourth date of 9,528 ± 61 BP (Wk-9570) can now be added to the trio obtained

***Table 2:** Radiocarbon age determinations from ZAD 2.*

Provenance	Date (uncal. BP)	Laboratory Code	Calibrated date (95.4% probability) OxCal. version 3.4
Structure 1 Sq. E 28, Loc. 20.1	9,635 ± 59	Wk-9633	9,230 – 8,790 BC
Structure 1 Sq. E 28, Loc. 22.3	9,552 ± 59	Wk-9445	9,250 – 8,650 BC
Structure 2, Sq. K 22, Loc. 6.1	9,603 ± 59	Wk-9447	9,220 – 8,790 BC
Structure 2, Sq. K 22, Loc. 3.3	9,623 ± 91	Wk-9568	9,240 – 8,740 BC
Structure 2, Sq. L 23, Loc. 3.2	9,323 ± 59	Wk-9444	8,750 – 8,330 BC
Structure 3, Sq. U 22, Loc.5.4	9,528 ± 61	Wk-9570	9,200 – 8,600 BC
Structure 3, Sq. V 22, Loc. 3.1	9,490 ± 50	OZE 605	9,150 – 8,650 BC
Structure 3, Sq. V 22, Loc. 7.2	9,440 ± 50	OZE 606	9,150 – 8,550 BC
Structure 3, Sq. V 22, Loc. 7.2	9,470 ± 50	OZE 607	9,150 – 8,600 BC

from the first season (**Fig. 14**). Wk-9570 is from the lowermost floor of Structure 3 (Square U22, Locus 5.4). Only a thin layer (Locus 7.3) separates this date from the overlying ones of 9,440 ± 50 BP (OZE-606) and 9,470 ± 50 BP (OZE-607), both on Floor 7.2 of Square V22,whicharein turn overlaid by the date of 9.490 ± 50 BP (OZE-605) underlying the uppermost floor (Square V22, Locus 3.1). 'T' for the four means is 1.358, less than the Chi-Squared (7.815) for three degrees of freedom at the 0.05 level, indicating a 95% probability that the four dates are statistically indistinguishable.

Together, the suite of radiocarbon dates shows a strong degree of concordance. Indeed, T calculated for eight of the nine dates (minus the most recent one of Wk-9444, 9,323 ± 59 BP) is 11.605, less than the tabled value of Chi-Squared (14.067) for seven degrees of freedom at the 0.05 level, indicating a 95% probability that the eight ages share the same true mean age. Only when Wk-9444 is added in does this concordance break down, giving a T-value of 21.942, which exceeds the tabled value of Chi-Squared (15.507) for eight degrees of freedom at the 0.05 level.

ZAD 2 is now a well-dated Pre-Pottery Neolithic A site. The single constructional phase across the site and the suite of concordant dates point to a short-lived settlement. Just a single date (9,323 ± 59 BP) suggests that the settlement persisted for more than about a century, and, at the outside, ZAD 2 spans the period from 9,600 to 9,300 BP.

The Implications of ZAD 2 for the Transition between the PPNA and the PPNB

In view of recent uncertainties about the nature of the passage from the PPNA to the PPNB in Jordan (Kuijt 1997; Rollefson 2001), the dating of PPNA ZAD 2 to 9,600 – 9,300 BP is a most extraordinary outcome, because the site slots neatly into the time frame of 9,600 – 9,200 BP proposed for the 'Early PPNB' (EPPNB) period (Rollefson 1989; 2001). The EPPNB in Jordan was advanced on the basis of such a phase in Syria, as attested at Tall Aswad (De Contenson 1989). However, the putative EPPNB in Jordan has hitherto entirely lacked any dated or excavated archaeological sites to fill it. Moreover, the PPNA at Jericho and Netiv Hagdud persists until 9,300 BP, and because of these considerations and the fact that socio-cultural, architectural and economic shifts towards sedentism and farming in Syria are known to precede the same transitions in the southern Levant, Kuijt (1997) has argued strongly against the EPPNB's existence in Jordan and for an extension of the PPNA in Jordan until ca. 9,300 BP.

On the uncalibrated radiocarbon scale, ZAD 2 now provides conclusive evidence for an extension of the PPNA in the southern Levant till 9,300 BP, and conversely, the site militates against the existence of the EPPNB in Jordan. Nonetheless, the employment of uncalibrated radiocarbon dates *per sé* is problematic in this regard, because uncalibrated dates do not represent true sidereal time. In particular they are ambiguous in the period from 9,600 to 9,400 BP which coincides with a marked 'flat spot' on the dendrochronological calibration curve (Edwards and Higham 2001). For example, calibration of the ZAD 2 dates (ranging ca. 300 years) leads to a greatly expanded calibrated time slice, from 9,250 BC to 8,330 BC, or nearly a thousand years.

In so far as the uncalibrated chronology is accepted, the extension of the Jordanian PPNA down to 9,300 BP is not just a matter of changing the chronological borders a little. It also highlights the transition in Jordan between the late PPNA of 9,300 BP and the large MPPNB settlements after 9,200 BP as a more acute scalar shift than we have previously realized. For the Dead Sea region, the contrast is best exemplified by the gulf between tiny ZAD 2 and the massive architectural elaboration of MPPNB (from ca. 9,000 BP) Wadi Ghuwair I (Najjar 2001). In view of the prior PPNB developments in the north, it now becomes increasingly difficult to derive the MPPNB village solely from the small late-PPNA hamlet of ZAD 2-type, and increasingly likely that strong influences from the northern Levant were introduced around 9,200 BP, just as economic changes such as the introduction of livestock herding (Martin 2000) later were.

(PCE)

The Lithic Technology and Typology of ZAD 2: results from the second season

The results of the second season of excavations show that ZAD 2 has an abundant flaked stone assemblage in flint, supplemented by a few pieces of quartz and obsidian, and a diverse groundstone assemblage made from basalt, limestone and sandstone. Geo-archaeological fieldwork in the ZAD Triangle indicates that all sources of raw material, besides the obsidian, are local (pers. comm. C. Day 2001). The Dana Conglomerate Formation which surrounds ZAD 2 contains massive veins of flint cobbles, used through time as flint quarries (Edwards *et al.* 1998), and this inexhaustible supply of ready flint lies only a 10-minute walk from the site. Furthermore, flint pebbles originating in the Dana Conglomerate veins wash down through Wādī adh-

Table 3: Lithic artefacts in Structures 1-4, ZAD 2.

Structure 1		**Structure 2**		**Structure 3**		**Structure 4**	
Debris	2,622	Debris	56,870	Debris	5,224	Debris	21,856
Debitage	102	Debitage	4,924	Debitage	205	Debitage	1,345
Tools	4	Tools	359	Tools	24	Tools	130
Sub-totals (Total= 93,665)	**2,728**		**62,153**		**5,453**		**23,331**

Dhrā' and are widely scattered over ZAD 2 and in its vicinity.

When relatively equal excavation volumes are considered, the majority of lithics came from the uppermost layers of ZAD 2, with lithic density decreasing noticeably with depth. This pattern probably relates to natural deflation, whereby the surface lithics have been concentrated in the upper layers over time, due to the steady winnowing of fine surface sediment. Beside the 52,959 pieces found during the first season of excavation (Edwards *et al.* 2001), the second season yielded a total of 93,665 specimens, recovered from Structures 1-4 (**Table 3**). Structure 1 provided 2,728 specimens of debitage, debris and retouched tools. Structure 2, which is the largest excavated area, supplied 62,153 pieces whereas Structure 3 had 5,453 and finally Structure 4 yielded 23,331 specimens.

Flaked Stone Technology

The second season produced a few burnt lithics, probably due to incidental burning of lithics associated with hearths, as was observed during the first season (Edwards *et al.* 2001). Macroscopic evidence for flint heat treatment during manufacturing is very limited, and shows that heat treatment was not a preferred technique (Sayej 2001).

The 'Debris' (or angular shatter) class at ZAD 2 consists of 92.4% of the total amount of recovered lithics and this category is divided between chips (84.2%) and chunks (15.8%, **Table 4**). This large amount of debris in comparison to other sites such as Netiv Hagdud 70.3% (Nadel 1997: table 4.1) and Wādī Faynān وادي فينان (WF16) 60.3% (Mithen *et al.* 2000: tables 2-3) reflects the easy availability of raw materials and indicate that the flint knappers of ZAD 2 produced most of their tools on site. The 'Debitage' class comprises 7% of the total recovered lithics at ZAD 2 and are divided as: cores (3.5%), flakes (71.8%), bladelets (23.3%), blades (0.9%) and core trimming elements (0.5%, **Table 4**). This percentage is much less than what is recorded from both Netiv Hagdud: 27.2% (Nadel 1997: table 4.1) and from Wādī Faynān: 37.6% (Mithen *et al.* 2000: table 2-3). It is quite intriguing to note that these proportions for the various sites differ so much. For example, Dhrā' is as equally close as ZAD 2 to the Ẓahrat adh-Dhrā' flint quarries.

Core analyses demonstrate three different sizes: small (<30mm), medium (30-70mm) and large (>70mm), made from flint (brown 80.8%, grey 15.7% and black 3.5%). The great majority of them (199) belong to the 'medium' size class, with 17 in the 'large' and 13 in the 'small' size categories. The smaller sizes might result from a deliberate strategy to produce small size tool-blanks, or exhaustion of the larger cores. The majority are pyramidal or conical single platform cores (107), while 25 have two platforms, 23 have multiple platforms and for 74 of them, the platforms are missing. The average scars on these cores are 5 scars for each core and the majority have scars of flakes (131) whereas (98) cores are predominantly blade/bladelet scars. Remains of both burnt and heat-treated cores are very limited, with only 11 cores burnt and 4 showing signs of heat treatment. Additional to the small scars resulting from platform trimming, 78 cores were further retouched and used as tools.

The existence of cortex on both cores and many flaked elements supports the idea that the local cobbles provided the main source for flaking flint elements. With regard to the cores, 43 have 30-100% coverage, 114 cores <30% coverage, and 72 cores do not have any. These high percentages tally with the proportions noted on the local flint sources by Edwards *et al.* (1998). The predominantly brown flint colour of the cores is also reflected in the Ẓahrat adh-Dhrā' quarries, with other colours present in lower frequencies.

Typology

As a contrast to the PPNB assemblages where bladelet blanks generally dominate retouched tool components (cf. Bar-Yosef 1981; Rollefson 1989), ZAD 2 has retouched tools almost equally manufactured from flakes (53%) and from blades and bladelets (47%), which is a typical PPNA pattern (Belfer-Cohen 1994). The second season, like the first (Edwards *et al.* 2001) produced many typical PPNA tool types **(Table 4)** such as Beit Ta'amir

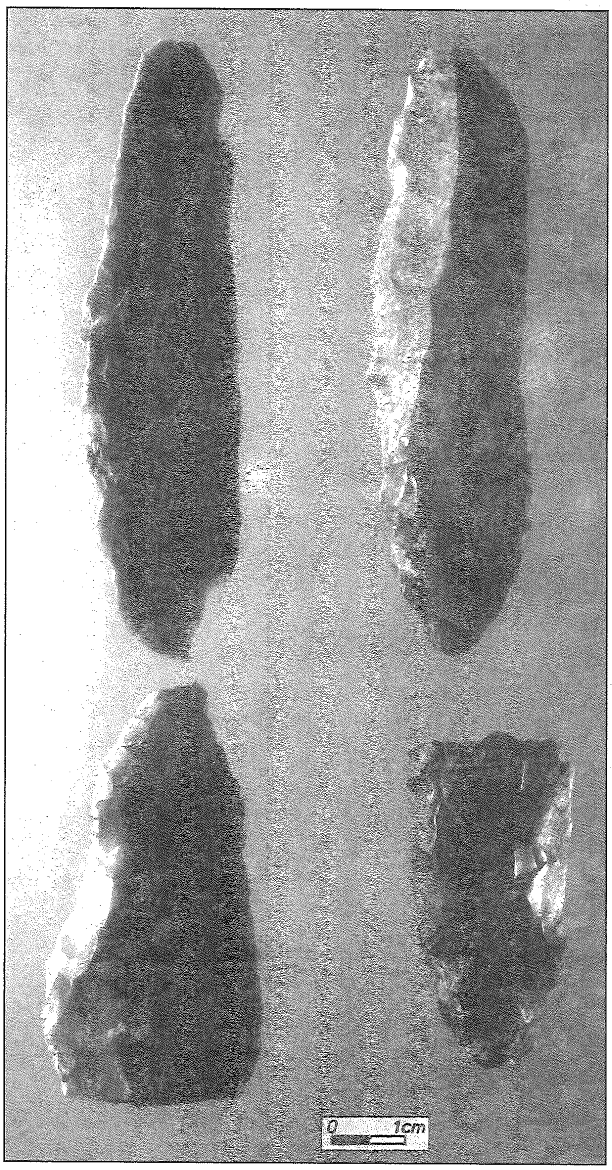
Table 4: *Debris, debitage and retouched tool totals for Structures 1–4, ZAD 2.*

	Types	N	%	Total	%
Debris					
	Chips	72,882	84.2		
	Chunk	13,690	15.8		
	Subtotal			86,572	92.4
Debitage					
	Cores	229	3.5		
	Flakes	4,724	71.8		
	Blades	61	0.9		
	Bladelets	1,531	23.3		
	Core trimming elements	31	0.5		
	Subtotal			6,576	7.0
Tools					
	Scrapers	38	7.4		
	Burins	5	1.0		
	Retouched blades	26	5.0		
	Beit Ta'amir blades	2	0.4		
	Retouched bladelets	123	23.8		
	Backed tools	7	1.3		
	Projectile points	3	0.6		
	Hagdud truncations	36	7.0		
	Notches	42	8.1		
	Retouched flakes	142	27.5		
	Borers	42	8.1		
	Picks	22	4.2		
	Axes	14	2.6		
	Hand axes	1	0.2		
	Intermediate	1	0.2		
	Multiple tools	4	0.8		
	Ouchtata	1	0.2		
	Truncations	5	1.0		
	Varia	3	0.6		
	Sub-totals			**517**	**0.6**
	Totals			**93,665**	**100**

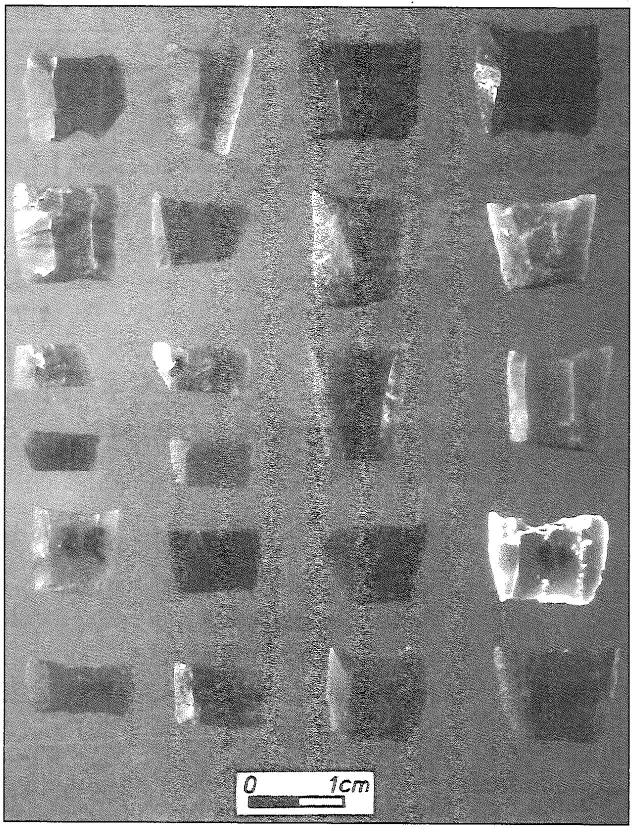
sickles (**Fig. 17**), Hagdud truncations (**Fig. 18**), bifacially flaked adzes, borers (**Fig. 19**), scrapers, notches, burins — but only a few broken El-Khiam points and other atypical projectile points (**Fig. 20**).

In contrast to other contemporaneous sites, ZAD 2 has a very low proportion of projectile points, and this raises many questions concerning the nature of its economy (Sayej n.d.). At ZAD 2 they constitute only 0.6% of the retouched tools, and most of them are broken, whereas at Dhrā‘ they make up 53.5% (Kuijt 2001; Kuijt and Mahasneh 1998: table 3), 24.3% at WF 16 (Mithen *et al.* 2000: table 2), and finally 3% at Netiv Hagdud (Nadel 1997: table 4.12). These results suggest that hunting was not a major preoccupation for the inhabitants of ZAD 2, whereas the quantities of ground stone equipment and botanical remains imply an emphasis on plant food processing. However, if projectile points had only symbolic or ritual status, then such purely functional conclusions may be inaccurate. Furthermore, some perishable materials may also have been used for hunting.

Both ZAD 2 and Dhrā‘ completely lack microliths (specifically lunates), while WF 16 has 25.4% (of retouched tools) and Netiv Hagdud has 13%. Because microliths were part of the continuity in



17. *Beit Ta'amir sickles from Structures 2 and 4, ZAD 2.*

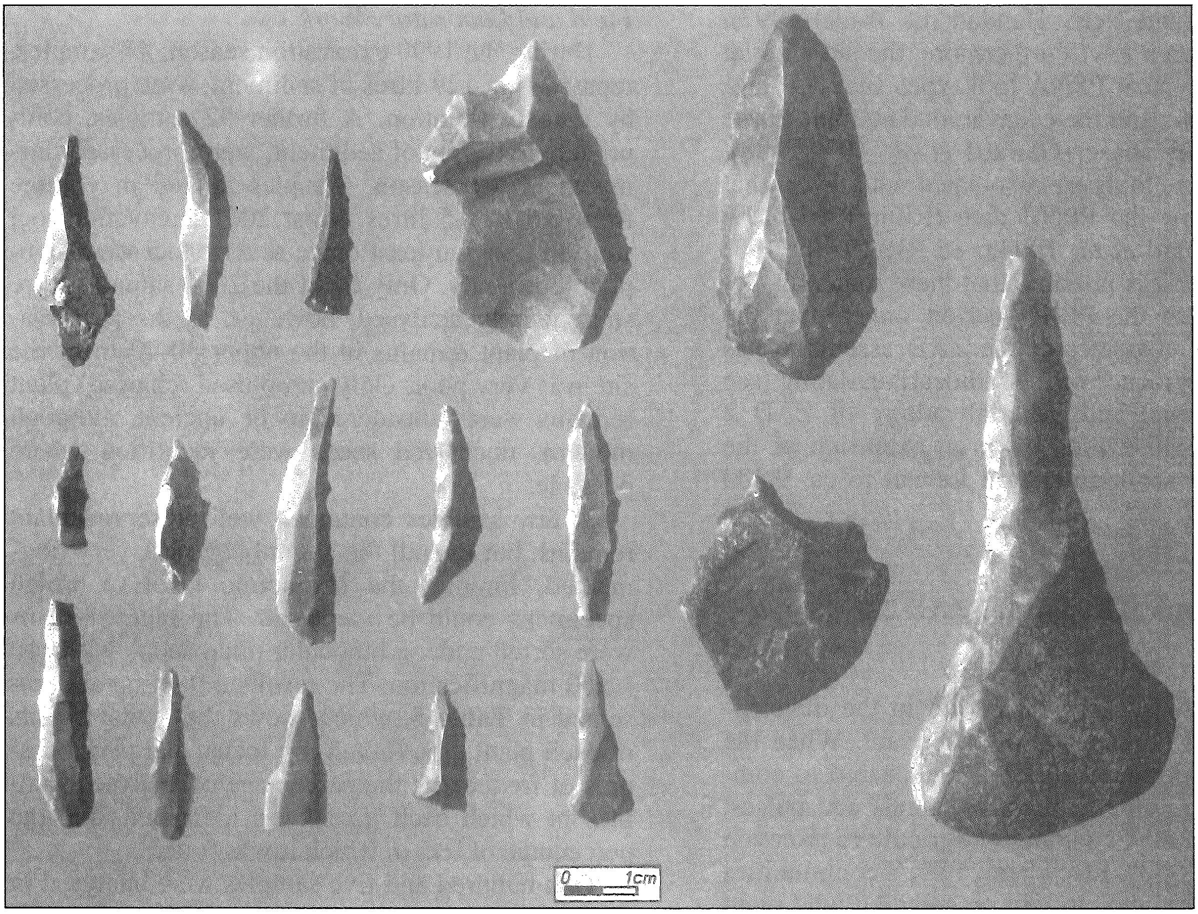


18. *Hagdud truncations from Structures 2 and 4, ZAD 2.*

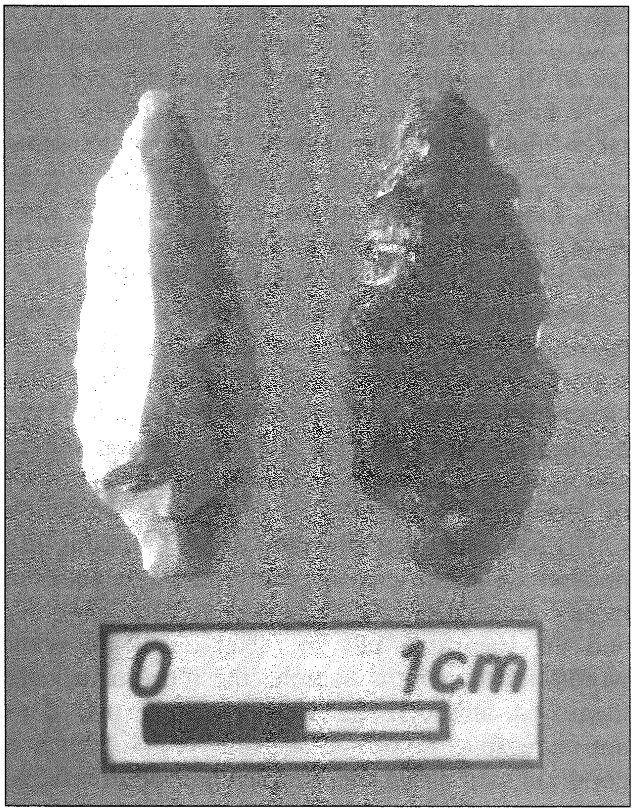
flint knapping technologies between the late Natufian and the early Neolithic periods (Nadel 1998: 8), the question arises as to whether Netiv Hagdud and WF 16 date to an earlier phase within the PPNA than Dhrā' and ZAD 2. Subject to the limitations discussed above on the interpretive potential of calibrated radiocarbon dates (see Edwards, above), the published dates give some support to this hypothesis. On the other hand, Dhrā' has 53.5% of its retouched tools identified as projectile points, which indicates an emphasis on hunting, and so functional explanations may also complicate the picture. Therefore, several explanations can be suggested:

1) If the two sites are contemporary, then Dhrā' may have supplied ZAD 2 with meat and the gathered products from the highlands such as pistachio nuts and figs, whereas ZAD 2 supplied the cultivated products to the inhabitants of Dhrā', such as barley and lentils.
2) If ZAD 2 is a little bit younger than Dhrā', as the dates so far suggest, then ZAD 2 with its extensive tracts of irrigable flat land, might represent a successor site to Dhrā'.
3) If there was no connection between the two sites whatsoever, then it is possible that ZAD 2 was a seasonal site, with an emphasis on crop growing (see Meadows, below), and that its inhabitants moved to the highlands during the hot dry season to practice foraging (Edwards and Higham 2001; Sayej n. d.; Sayej 2001).

The second season of excavation also yielded 36 Hagdud truncations, which form 7% of the recovered retouched tools (**Fig. 18**). These tools have steep retouch on distal and proximal ends and none of them show any sign of being either burnt or heat-treated. Three specimens are partially broken, from either misuse or incidental breakage. Flint was the only raw material exploited for this type of tool and 78% of these were brown flint (28 specimens), followed by grey (6 specimens or 17%) and black (2 specimens or 5%). The combination between both seasons of excavations have yielded a total of 61 Hagdud truncations, which is to date, the second largest amount recovered in the Southern-central Levant after Netiv Hagdud (63 specimens; Nadel 1997: 111).



19. Borers from Structures 1, 2, 3 and 4, ZAD 2.



20. Projectile points from Structures 2 and 4, ZAD 2.

Groundstone Artefacts

The remains of 6 pestles, including a complete one, were found during the second season of excavation, made from sandstone (3), basalt (2) and limestone (1). A hammer stone made from limestone and one cuphole mortar made from sandstone were also recovered. No querns were found in deposits during this season, contrary to their abundance on the surface of the site. In contrast to the surface collection of 35 groundstone specimens (Edwards *et al.* 2001), those recovered during the second season of the excavations were much fewer in quantity and poorer in quality.

Concluding Remarks

While the chronological status of the Khiamian and Sultanian phases of the PPNA are currently the subject of some debate, it is clear already that the techno-typological features of the ZAD 2 assemblage lack any of the PPNB characteristics such as bipolar naviform cores, regular heat treatment, Jericho points, Byblos points and Amuq points (cf. Bar Yosef 1981), and do show strong connections to many dated PPNA sites such as Dhrā‘ (Kuijt 2001; Kuijt and Mahasneh 1998), WF 16 (Finlayson and Mithen 2001; Mithen and Finlayson 2000; Mithen *et al.* 2000), and Netiv Hagdud (cf. Nadel 1997), just to mention a few. Furthermore, the site of Jilat 7 has some typical PPNA tool types such as Hagdud truncations and the excavators dated this phase to the EPPNB phase (Garrard *et al.* 1994a: 88). However, these tools are associated with layers that are well below the PPNB date (Kuijt 1997: 199; see also Garrard *et al.* 1994a: 85-91; 1994b: 193) and therefore, it is possible that these materials belong indeed to the PPNA period rather than the EPPNB. The character of the ZAD assemblage is PPNA. The evidence of the radiocarbon dating (see Edwards, above) and material culture of ZAD 2 provide decisive evidence for an extension of the PPNA in the southern-central Levant to ca. 9,300 BP.

(GS)

Archaeobotanical Report for ZAD 2

Background

The PPNA is a critical period in the development of food production in the Levant. When the PPNA was defined at Jericho, it appeared to coincide with the domestication of cereals and pulses, and thus with the beginning of agriculture (Kenyon 1979; Hopf 1983). Elsewhere, PPNA communities apparently continued to rely on gathered wild plant foods for their subsistence (Garrard 1999: table 3). Experimental work (Hillman and Davies 1990) has shown that the mutations that define the domestic varieties of cereals, while occurring naturally, could only become dominant under certain methods of cultivation, and would be selected against by the harvesting of naturally occurring wild stands. In order for the plant domesticates to become established, therefore, there must have been a period of 'pre-domestication cultivation', in which the wild ancestors of the domestic crops were intentionally cultivated. For certain species, that period may have coincided with the PPNA. The research questions that informed the archaeobotanical investigation of ZAD 2 therefore included:

1) Did the site depend entirely on foraging, or were certain species cultivated?
2) Were any cultivars wild or domestic forms?
3) Could 'pre-domestication cultivation' be identified from the plant remains, and distinguished from foraging and agriculture?
4) How would the plant economy of a 'pre-domestication' site differ from that of a true farming village?

Preliminary results of the first season were recently published (Edwards *et al.* 2001). This report combines those data with the results of the second season of excavation.

Field and Laboratory Work

During the 1999 excavation season, 41 samples, representing 129 litres of sediment, were processed by manual flotation. A further 92 samples, comprising 264 litres of sediment, were processed during the 2001 season. Samples ranged in volume from 0.5 to 6.5 litres. Most 2001 excavation loci were sampled at least once; several loci were sampled repeatedly. Only 64 of the 2001 samples were subsequently analysed, however, as the preservation of plant remains in the upper 30-40cm of the site was very poor. Only carbonised (charred) plant remains were considered to be ancient, although modern, uncharred seeds were identified where possible.

A few samples contained well-preserved plant remains, but overall the assemblage was very fragmented, limiting the taxonomic level to which specimens could be identified. The plant remains were sorted under a binocular microscope with x10 – x50 magnification. The results of sorting are presented in **Table 5**, which shows the actual counts of each plant type (taxon) by locus, and two measures of frequency: the percentage of analysed samples in which each taxon was identified, and the percentage of loci in which it was found.

One hundred and five samples were analysed in the two seasons. For the purpose of this report, data from all samples with the same locus number in adjoining squares were combined. This effectively reduced the number of samples to 39, corresponding to the number of distinct archaeological contexts from which archaeobotanical samples were taken and sorted. Repeatedly sampling the same context, without combining data from those samples, can create false patterns of frequency (Popper 1988). The least biased measure of frequency is the percentage of loci in which each taxon occurs.

No significantly variant patterning can be detected, either horizontally or vertically. Locus diversity (the number of identifiable taxa in each locus) is directly related to richness of deposit. There is a high correlation (0.77) between locus diversity and richness (the number of identifications per litre of sediment in each locus), a higher correlation (0.79) between locus diversity and total count (the number of identifications per locus) and an even higher correlation (0.85) between locus diversity and the logarithm of the total count. In other words, the larger the sample, the more taxa were identified, although the number of new taxa does not increase as rapidly as the total count. This is a good indication that the samples are representative of the taxa that might potentially be recovered, since every increase in sample size results in fewer

Table 5: Archaeobotanical remains from ZAD 2 by locus, for the 1999 and 2001 seasons.

Structure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Locus	02	05	06	08	10	11	12	13	14	15	16	17	18	20	21	22	24	25
samples	5	1	4	1	2	1	2	1	3	2	1	1	2	1	1	3	1	1
volume (L)	20	4	16	4	8	4	8	4	8.5	8	4	4	8	1.5	4	6.5	0.5	0.5
wheat (*Triticum* sp.) grain	1	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
wheat spikelet fork	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
wheat glume base	.	.	.	.	.	.	2	.	1	1	.	.	.	.	.	.	.	.
'wild' barley (*Hordeum* sp.) grain	.	.	.	.	.	2	3	.	1	2	.	1	1	.	.	.	.	.
'domestic' barley grain	.	.	.	.	.	.	3	.	.	.	.	.	.	1	.	1	.	.
barley grain indet.	1	.	.	.	.	.	1	2	2	2	1	.	.	.	.	2	.	.
barley lateral floret base	.	.	1	.	1	7	84	25	33	18	8	6	6	1	.	9	3	.
'wild' barley rachis internode	1	.	.	.	.	.	2	.	1	2	.	1	1	.	.	1	.	.
'domestic' barley rachis	.	.	.	.	1	.	1	.	1	1	.	.	.	.	.	.	.	.
indet. barley rachis	.	.	.	.	.	3	11	1	1	3	.	2	2	.	.	5	1	.
cereal grain fragments	34	3	20	15	18	50	180	40	31	87	9	19	20	6	1	11	2	.
cereal culm node	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
cereal culm base	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
lentil (*Lens* sp.)	1	.	2	.	.	.	2	2	2	1	1	1	.	.	.	1	.	.
pea/vetch (Vicieae) type	1	.	2	.	1	1	1	2	2	4	1	5	1	.	.	5	.	.
grass pea (*Lathyrus*) type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
indet. pulse fragments	56	4	54	6	20	24	50	75	69	96	35	50	27	1	1	9	6	.
Pistacia sp. fragments	1	.	1	1	1	20	21	3	15	44	12	15	13	.	4	24	5	.
cf. *Pistacia* fragments	34	4	16	50	23	210	260	60	299	780	270	225	365	.	62	199	44	2
fig (*Ficus* sp.) seeds	13	1	3	.	1	12	17	12	40	191	28	58	21	2	1	32	12	2
Aizoon hispanicum	m	m	m	m	m	m	m	m	m	m	m	2	1	.	m	1	.	.
Carthamus/Centaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asteraceae indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium sp.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Silene sp.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Heliotropium sp.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Arnebia/Lithospermum	.	.	.	.	.	.	.	.	m	.	.	.	.	.	m	1	.	.
Salsola sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodiaceae	1	.	.	m	1	1	1	1	1	.	4	.	1	.	.	.	.	.
Carex type	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Cyperaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
small-seeded legumes indet.	1	.	2	.	.	.	3	1	2	.	.	.	1	.	1	.	.	.
Onobrychis sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Onobrychis pod fragments?	.	.	.	.	.	.	.	.	.	5	1	2	1	.	.	12	.	.
Geraniaceae 'twist'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bupleurum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ornithogalum-type	.	.	.	.	.	.	1	.	.	.	.	1	.	1	.	1	.	.
Liliaceae indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Malva sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago sp.	.	1	.	.	.	m	.	.	6	3	4	3	1	.	.	2	1	.
Bromus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stipa sp.	.	.	.	.	.	1	3	.	1	2	.	.	.	.	.	.	.	.
Avena sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avena/Stipa awn fragment	.	.	.	.	.	.	1	.	4	4	3	2	3	.	1	2	.	.
Setaria type	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
grass bulbil - cf. *Poa* sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
small grass - sharp apex	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
small grass - blunt apex	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
grass seeds indet.	m	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
grass seed fragments	.	.	.	.	.	3	8	5	6	11	.	.	1	.	.	4	.	.
Solanaceae indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Verbena sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thymelaea?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
unknown - Cyperaceae?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
indeterminate seeds	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	10	2	.
total identifiable	20	2	11	2	5	29	139	47	102	249	57	88	46	7	4	88	19	2
identifiables/L	1.0	0.5	0.7	0.4	0.7	7.3	17.4	11.7	12.0	31.2	14.2	22.1	5.7	4.7	0.9	13.6	39.0	4.0

Table 5: (continued).

Structure	2NW	2NW	2NW	2NW	2NW	2SE	2SE	2SE	J25	N28	N28
Locus	02	03	04	05	06	02	03	04	03	03	04
samples	3	10	5	4	4	2	4	5	3	2	2
volume (L)	11	21.5	13.5	9	9.5	6.5	12	15.5	7	3	2
wheat (*Triticum* sp.) grain	.	.	.	.	.	.	.	2	1	.	.
wheat spikelet fork	.	.	.	.	.	1	1	.	.	.	.
wheat glume base	.	3	.	.	.	3	9	4	2	.	.
'wild' barley (*Hordeum* sp.)	.	1	.	.	.	2	1	9	.	.	.
'domestic' barley grain	.	.	2	.	.	1	.	5	.	.	.
barley grain indet.	1	1	1	.	.	.	1	13	.	.	.
barley lateral floret base	.	40	24	12	4	14	60	81	5	2	1
'wild' barley rachis internode	.	3	2	1	.	1	6	4	.	1	.
'domestic' barley rachis	.	2	.	.	.	.	.	5	.	.	.
indet. barley rachis	1	9	6	2	.	7	20	14	.	1	.
cereal grain fragments	54	18	5	3	2	113	284	403	1	.	.
cereal culm node	1	.	.	.	.	.	.	.	.	.	.
cereal culm base	.	.	.	.	.	.	.	.	.	.	.
lentil (*Lens* sp.)	.	.	.	.	.	4	9	5	1	.	.
pea/vetch (Vicieae) type	1	6	.	.	1	5	20	20	2	.	.
grass pea (*Lathyrus*) type	.	.	.	.	.	.	2	.	.	.	.
indet. pulse fragments	32	52	13	1	.	90	200	182	62	1	.
Pistacia sp. fragments	5	37	35	9	1	41	224	276	15	5	3
cf. *Pistacia* fragments	163	1060	670	434	17	2257	8976	10300	918	73	114
fig (*Ficus* sp.) seeds	1	25	21	7	2	13	150	76	2	.	2
Aizoon hispanicum	m	13	1	m	m	1	25	64	m	m	m
Carthamus/Centaurea	.	.	.	.	.	.	.	7	.	.	.
Asteraceae indet.	.	.	.	.	.	2	12	.	.	.	.
Cerastium sp.	.	.	.	.	.	.	.	.	.	.	.
Silene sp.	m	.	.	.	.	.	.	.	.	.	.
Heliotropium sp.	m	.	.	.	.	.	.	.	.	.	.
Arnebia/Lithospermum	.	.	.	.	.	.	.	.	.	.	.
Salsola sp.	.	.	.	.	.	.	.	1	.	.	.
Chenopodiaceae	.	m	m	.	.	4	3	3	.	.	.
Carex type	.	.	.	.	.	.	.	.	.	.	.
Cyperaceae	.	.	.	.	.	.	1	.	.	.	.
small-seeded legumes indet.	1	.	1	.	.	.	3	5	.	.	.
Onobrychis sp.	.	.	1	.	.	.	.	.	.	.	.
Onobrychis pod fragments?	.	.	.	.	.	.	.	3	.	.	.
Geraniaceae 'twist'	.	.	.	.	.	.	1	.	.	.	.
Bupleurum sp.	.	.	.	.	.	1	1	.	.	.	.
Ornithogalum-type	.	.	.	.	.	2	2	2	.	1	.
Liliaceae indet.	.	1	.	1	.	.	.	.	.	.	.
Malva sp.	.	.	.	.	.	1	.	.	1	.	.
Plantago sp.	.	.	.	.	.	.	.	.	.	.	.
Bromus sp.	.	1	1	.	.	.	.	.	.	.	.
Stipa sp.	.	1	1	.	.	.	12	8	.	.	.
Avena sp.	.	3	.	.	.	.	1	1	.	.	.
Avena/Stipa awn fragment	.	3	3	1	.	2	9	20	6	.	1
Setaria type	.	1	.	.	.	1	24	24	.	.	.
grass bulbil - cf. *Poa* sp.	.	.	.	.	.	.	8	59	.	.	.
small grass - sharp apex	.	.	.	.	.	5	14	5	.	.	.
small grass - blunt apex	.	1	.	.	.	.	.	.	.	.	.
grass seeds indet.	.	1	1	.	.	3	3	21	.	.	.
grass seed fragments	.	21	2	2	.	20	37	55	5	.	.
Solanaceae indet.	.	.	.	.	.	.	.	1	.	.	.
Verbena sp.	.	.	.	.	.	.	1	.	.	.	.
Thymelaea?	.	.	.	.	.	.	2	.	.	.	.
unknown - Cyperaceae?	.	.	.	.	.	.	212	344	.	.	.
indeterminate seeds	.	36	13	4	.	56	200	117	7	7	.
total identifiable	8	164	85	32	7	152	905	1029	36	13	5
identifiables/L	0.7	7.6	6.3	3.6	0.8	23.4	75.4	66.4	5.2	4.3	2.6

Table 5: (continued).

Structure Locus	3 02	3 03	3 04	3 05	3 06	3 07	3 08	3 09	3 10	3 11	total (ancient)	frequency %samples	frequency %loci
samples	2	1	3	9	1	6	3	1	1	1		N=105	N=39
volume (L)	2	1.5	4.5	13.3	0.75	7.5	5	3	3	3.5	256		
wheat (*Triticum* sp.) grain	.	.	1	.	.	.	.	.	.	.	6	7	10
wheat spikelet fork	.	.	.	.	.	.	2	.	.	.	4	3	8
wheat glume base	.	.	.	.	.	2	1	.	.	.	26	21	26
'wild' barley (*Hordeum* sp.)	.	.	.	.	.	2	.	1	.	.	26	17	31
'domestic' barley grain	.	.	.	3	.	.	.	.	.	2	18	14	21
barley grain indet.	.	.	1	.	.	.	.	.	.	.	29	15	31
barley lateral floret base	.	.	2	25	.	10	23	30	7	10	544	72	77
'wild' barley rachis internode	.	.	.	5	.	.	2	.	.	.	33	23	41
'domestic' barley rachis	.	.	.	.	.	.	.	.	2	.	13	10	18
indet. barley rachis	1	.	.	8	.	2	6	12	1	2	120	47	59
cereal grain fragments	6	1	11	34	1	32	25	6	9	15	1568	76	90
cereal culm node	.	.	.	1	.	.	.	1	.	.	4	4	10
cereal culm base	.	.	.	.	.	.	.	.	.	.	1	1	3
lentil (*Lens* sp.)	.	.	1	.	.	.	1	.	.	.	33	20	33
pea/vetch (Vicieae) type	.	.	1	.	.	.	.	.	.	.	80	30	41
grass pea (*Lathyrus*) type	.	.	.	.	.	.	.	.	.	1	3	3	5
indet. pulse fragments	.	.	4	7	.	3	1	3	1	1	1173	67	82
Pistacia sp. fragments	.	1	.	16	1	.	5	7	2	5	845	67	85
cf. *Pistacia* fragments	7	4	23	339	7	47	138	144	38	27	27554	96	97
fig (*Ficus* sp.) seeds	.	.	2	12	.	4	5	1	1	1	767	77	79
Aizoon hispanicum	m	m	m	m	m	m	1+m	.	m	m	108	18	23
Carthamus/Centaurea	.	.	.	.	.	.	.	.	.	.	7	2	3
Asteraceae indet.	.	.	.	.	.	.	.	.	.	.	14	4	5
Cerastium sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Silene sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Heliotropium sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Arnebia/Lithospermum	.	.	.	m	.	m	m	m	.	m	1	1	3
Salsola sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Chenopodiaceae	.	.	.	.	.	.	.	.	.	.	21	13	21
Carex type	.	.	.	.	.	.	.	.	.	.	1	1	3
Cyperaceae	.	.	.	.	.	.	.	.	.	.	1	1	3
small-seeded legumes indet.	.	.	.	1	.	.	1	1	.	.	24	17	33
Onobrychis sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Onobrychis pod fragments?	.	.	.	.	.	.	.	1	1	.	26	10	15
Geraniaceae 'twist'	.	.	.	.	.	.	1	.	.	.	2	2	5
Bupleurum sp.	.	.	.	.	.	.	.	.	.	.	2	2	5
Ornithogalum-type	.	.	.	.	.	.	.	.	.	.	10	10	21
Liliaceae indet.	.	.	.	.	.	.	.	.	.	.	2	2	5
Malva sp.	.	.	1	m	.	.	.	.	.	.	2	3	8
Plantago sp.	.	.	.	.	.	.	1	.	.	.	22	10	21
Bromus sp.	.	.	.	.	.	.	.	.	.	.	2	2	5
Stipa sp.	.	.	1	4	.	.	.	4	1	2	41	22	33
Avena sp.	.	.	.	1	.	.	.	.	.	.	6	5	10
Avena/Stipa awn fragment	.	.	.	5	.	.	1	1	2	1	68	32	54
Setaria type	1	.	.	.	.	.	.	.	.	.	52	12	15
grass bulbil - cf. *Poa* sp.	.	.	.	1	.	.	.	.	.	.	68	7	8
small grass - sharp apex	.	.	.	.	.	.	.	.	.	.	25	8	10
small grass - blunt apex	.	.	.	1	.	.	.	.	.	.	2	2	5
grass seeds indet.	.	.	1	2	.	.	.	.	.	.	34	11	21
grass seed fragments	.	.	.	6	.	2	3	4	2	3	195	37	51
Solanaceae indet.	.	.	.	.	.	.	.	.	.	.	1	1	3
Verbena sp.	.	.	.	.	.	.	.	.	.	.	1	1	3
Thymelaea?	.	.	.	.	.	.	.	.	.	.	2	1	3
unknown - Cyperaceae?	.	.	.	.	.	.	.	.	.	.	556	7	5
indeterminate seeds	.	.	.	8	.	.	1	5	1	1	455	38	41
total identifiable	3	0	12	81	0	20	46	59	17	20	3613		
identifiables/L	1.5	0.03	2.7	6.1	0.1	2.7	9.3	19.5	5.8	5.8	14.1		

Table 5 : (continued).

Notes:

1. all identifications are somewhat uncertain, due to fragmentary nature of remains; counts and frequencies include probable and doubtful identifications.
2. unless specified, plant part identified was a seed (broadly defined).
3. m = modern (not included in count or frequency results).
4. 'total identifiable' includes all taxa except: cereal grain fragments, pluse fragments, grass seed fragments and modern remains; total includes *Pistacia* fragments divided by 100 (estimated number of fragments per whole nut).
5. 'frequency % sample' is the percentage of samples analysed containing that taxon.
6. 'frequency % loci' is the percentage of loci containing that taxon.
7. Structure 2 (north-west) includes Squares J 22, J 23, K 22, K 23, L 22 and L 23; Structure 2 (south-west) includes Squares M 27, N 27, and O 27
8. J 25 samples came from a burial feature against the outside wall of Structure 2 (north-west).
9. N 28 samples were from deposits against the outside wall of Structure 2 (south-east).

additional taxa. The richest and most diverse loci are floor deposits on the south-eastern side of Structure 2. Some loci in Structure 1 are also relatively rich and diverse.

The most frequently identified food plant was pistachio (*Pistacia* sp.), with nutshell fragments in almost every locus with identifiable plant remains. Nutlets (seeds) of wild fig (*Ficus* sp.) were almost as widespread. Barley (*Hordeum* sp.) was also ubiquitous, but wheat (*Triticum* sp.) was identified in only a third of loci. Cereal grain fragments that were too broken to identify further were found in most loci. Three types of pulses — lentil (*Lens* sp.), a pea/ vetch type (Fabaceae Sect. Vicieae) and a grass pea type (cf. *Lathyrus* sp.) — were identified. There were pulse fragments in most loci. Most of the indeterminate pulse fragments probably belong to either the pea/ vetch or grass pea types, as fragments of lentil are more readily identifiable in cross-section. Lentils were found in only a third of loci.

Grasses other than wheat and barley (*Avena* sp., *Bromus* sp., *Poa* sp., *Stipa* sp., *Setaria* sp. and others) were common, with seeds, seed fragments or awn fragments in two-thirds of all loci. At least one grass taxon was identified in every locus with over 20 identifications. It is surprising that plants with little known food value were found so frequently, in the absence of domestic animals (whose dung, when burnt for fuel, can contribute fodder and pasture species to archaeobotanical assemblages). Nevertheless, even the broad category of non-cereal grass remains was represented in only about half the samples, compared to the 94% of samples with some cereal remains. The difference may reflect usage; it is possible that cereals were stored for year-round use, while other grasses were not.

All other plant taxa are less frequent. A third of loci include very small numbers of small-seeded legumes, while between a fifth and a quarter of loci include charred seeds of *Aizoon hispanicum*, *Ornithogalum*-type, *Plantago* sp. and Chenopodiaceae. No other taxon occurs in more than three loci. Two adjoining loci in Structure 2 contained over 500 seeds of an unknown type, possibly a species of Cyperaceae.

In summary, every locus sampled with a dozen or more identifications produced evidence of four categories of plant foods: cereals (barley and/ or wheat), pulses (lentil, pea/ vetch and/ or grass pea), pistachio and fig. Pistachio nutshell, which was probably used for fuel, may be over-represented. Likewise, the fig seeds recovered could, conceivably, have come from a single fruit. It is the regularity with which fig and pistachio remains were found that suggests they were staple foods, together with cereals and pulses.

Environment at Ẓahrat adh-Dhrā' during the PPNA Period

The ongoing analyses of pollen and charred macrobotanical remains from the project's core data (see Fall and Swoveland, above) will provide the best evidence of past regional vegetation for the Ẓahrat adh-Dhrā' region. Plant macrofossils gathered from our archaeological sites may also contribute to the study of the wider region's vegetation history; though they are highly selective in nature.

Wood charcoal is the preferred indicator of local vegetation, as the least-effort principle militates against long-distance transport of firewood. With relatively few tree species in Jordan, wood identification can also be more taxonomically specific than seed identification. Known food plants, such as fig and pistachio, are less indicative of local vegetation than are wild plants without food value, because it is assumed that foragers would travel further to collect highly valued species. At ZAD 2, three taxa were found both in the modern seed bank and as charred macrofossils: *Aizoon hispanicum*, Chenopodiaceae (e.g., *Suaeda* sp.) and *Arnebia/ Lithospermum* sp. The last was rare in the charred assemblage and occasional in the modern seed bank. The chenopod family is often treated as an indicator of arid, saline conditions, as many of its members thrive in such environments; chenopods were uncommon in both the modern and ancient flora. On the other hand, *Aizoon*, also an indicator of arid or saline conditions, was ubiquitous in the modern seed bank, and relatively common (108 seeds, in 23% of loci) in the archaeobotanical remains. Single (and questionable) examples of *Silene* sp. and *Heliotropium* sp. were also found in both the modern and ancient flora.

These taxa suggest an early Holocene environment similar to today's. The non-cereal grasses, however, tell another story. While none can be identified to species level, their abundance and diversity, and the near-absence of grass seeds in the modern seed bank (one uncharred grass seed was noted) suggest that the early Holocene vegetation of the Dhrā' Plain was significantly different.

The larger grass seeds (*Stipa* sp., *Avena* sp. and/ or *Bromus* sp.) may represent steppe vegetation, rather than desert. Awn and grass seed fragments were found in a small majority of loci. Awn fragments of *Avena* and *Stipa* are indistinguishable. Sections of caryopses lacking features that might have identified them as *Stipa, Avena* or *Bromus* were classed as grass seed fragments. Based on the relative frequency of the three genera, most of the indeterminate fragments are probably from *Stipa*. A second grass category consists of bulbils, rather than seeds, which match those identified by Kislev (1997) as *Poa* cf. *bulbosa*. These were found in only three loci. A third group includes the smaller grass seeds, some of which could be identified as *Setaria* sp. Most of the 79 small grass seeds were from the same loci as the bulbils. The bulbils and small grass seeds are weak indicators of past vegetation, due to their relative scarcity and inexact identification.

A number of other taxa were identified, including some that might be considered weeds at later sites, such as Asteraceae indet., *Silene* sp., small-seeded legumes, *Ornithogalum*-type, *Malva* sp., *Plantago* sp. and *Verbena* sp. Whatever their role at ZAD 2, these taxa are poor environmental indicators. Two seeds, tentatively identified as *Thymelaea* sp., may reflect steppe conditions.

In summary, the limited palaeoenvironmental evidence in the assemblage suggests less arid conditions in the PPNA than prevail at present. Kislev (1997) reached a similar conclusion, based on the range of species found at Netiv Hagdud. Steppe vegetation requires annual rainfall of at least 150mm. The modern vegetation around ZAD 2, however degraded by overgrazing, receives only 50-100 millimetres per annum (Al-Eisawi 1985).

Wild Food Resources

Nutshell fragments are ubiquitous at ZAD 2, occurring in almost every locus with identifiable plant remains. All were assigned to *Pistacia* sp. A single, whole nut recovered during the 1999 season appears to be of *Pistacia atlantica*. Fragments deemed to be diagnostic included a section of the rim around the hilum. The vast majority of fragments lacked diagnostic features, but were consistent with *Pistacia*. The only tree fruit identified was *Ficus* sp. Both trees may have grown in sandstone gorges a few kilometres east of the site, at more than 600 metres above sea level (Kürschner 1986: 55). Both are widely reported from prehistoric sites in Jordan (Neef 1997).

Pre-Domestication Cultivation

Barley, wheat and the pulses were probably cultivated at ZAD 2. The evidence is ambiguous, due to the poor preservation of most of the remains, but it has been argued that morphologically wild barley was cultivated (Meadows n.d.). This may, strictly speaking, be referred to as "non-domestication cultivation" (Hillman and Davies 1990: 168), as there is no evidence that the cultivation methods employed at ZAD 2 favoured the evolution of the domestic form of barley.

The defining characteristic of domestic cereals is that their ears, or spikes, do not spontaneously disarticulate at maturity (a highly disadvantageous mutation in the wild, but one which is selected for under certain methods of cultivation). In wild cereals, individual spikelets break off as soon as the grains within them ripen, leaving smooth abscission scars at the point of attachment between the rachis internodes. In domestic forms, the rachis internodes do not separate cleanly at the point of attachment. In theory, then, rachis internodes may be identified as domestic or wild, provided that the abscission scar is preserved. In reality, a minority of rachis internodes of wild cereals will have rough abscission scars if the grain is not allowed to ripen completely before harvesting (Kislev 1989). Moreover, wild cereals often grow as weeds of domestic crops. Early farming sites, therefore, tend to produce both wild- and domestic-type internodes.

At ZAD 2, wild-type barley rachis internodes outnumber the domestic type (32 definite and 2 probable wild types, versus 4 definite, 7 probable and 2 dubious domestic types). Most (121) barley rachis internodes could not be assigned to one type or the other, because the abscission scar was not preserved. Most of these, however, are narrow and have sturdy lateral floret bases, characteristics of wild barley (van Zeist and Bakker-Heeres 1982: 204). Over 500 fragments of lateral floret bases were also found. After allowing for the poorer preservation of the ZAD 2 remains, these proportions are similar to those obtained at Netiv Hagdud (Kislev 1997: table 8.1), where Kislev attributed all the chaff to wild barley. The barley chaff, therefore, is probably all of the wild variety.

No intact cereal grains were recovered. Of the 73 cereal grain fragments that could be identified as barley, 40 were complete enough for the thickness and breadth of the grain to be measured. When plotted, these measurements fall into two groups, the dimensions of which correspond to those of wild and domestic barley grains identified at other Neolithic sites in Jordan (Colledge 1994: fig. 4.6). Of the 40 grains, 15 had been identified as wild barley on morphological grounds, 16 had been identified as 'domestic' and 9 could not be classified as wild or domestic grains. All 16 'domestic' grains fell into the size group corresponding to domestic barley, while 14 of the 15 'wild' grains fell into the 'wild' size group; the indeterminates fell mainly into the lower end of the 'domestic' size group. On the basis of grain size and morphology, therefore, both wild and domestic barley appear to be present at ZAD 2.

The combination of wild barley chaff and 'domestic' grains at ZAD 2 invites two explanations: either 'domestic' chaff is missing from the assemblage, or the large domestic-size grains grew on plants with wild-type rachis. As both grains and chaff were derived from all areas of the site, the former explanation is highly implausible. Instead, it appears that one type of chaff is associated with two size groups of grain. The likely explanation is pre-domestication cultivation, perhaps supplemented by gathering of wild barley from natural stands. In this case, it is assumed that conscious selection of seed had already led to a cultivated variety of barley with larger, rounder grains, before domestic-type chaff had become established.

The remains of wheat are too few and too poorly preserved for comparable measurements to be obtained. The location of ZAD 2 suggests that the wheat was cultivated, as wild emmer is not found in southern Jordan, but its relative scarcity may imply that it was a 'weed' of the barley crop, rather than a crop in its own right.

Two aspects of the pulses suggest that they were also cultivated. Firstly, pulse fragments are roughly as abundant as cereal fragments, and occur in almost as many loci. This implies a similar pattern of storage and usage. Secondly, the pulse taxa at ZAD 2 are indistinguishable from those that were later domesticated — lentil, pea *(Pisum sativum)*, bitter vetch *(Vicia ervilia)* and grass pea. These are the same pulse taxa found at Netiv Hagdud. The mutations that characterise domestic pulse crops (loss of seed dormancy and pod indehiscence) are not observable in carbonised seeds (Kislev and Bar-Yosef 1988; Ladizinsky 1989). Nevertheless, the evidence is inconclusive. Pulse cultivation (and indeed domestication) at ZAD 2 is possible, but unproven.

It is assumed that the cereals and pulses were grown close to the site, taking advantage of the availability of flat land and the perennial flow of the Wādī adh-Dhrā'. Indeed, the establishment of ZAD 2, 2km west of a pre-existing PPNA site at the spring of Dhrā' (Kuijt and Mahasneh 1998), may reflect the adoption of food production, as the new site was further away from the natural habitat of the principal food plants (cf. comments in Sayej, above).

Comparison to Other Sites

The ZAD 2 assemblage is, to a good approximation, a sub-set of the better preserved assemblage analysed by Kislev (1997) at Netiv Hagdud. This is evident in both the food and non-food plants common at the two sites. Taxa that were rare at Netiv Hagdud, such as almond (*Amygdalus* sp.), acorn (*Quercus* cf. *ithaburensis*) and grape (*Vitis* sp.), are absent at ZAD 2. At both sites, barley remains greatly outnumber those of wheat, and lentils are outnumbered by vetch types (Vicieae). Barley chaff at both sites is predominantly of the wild type. Barley grain measurements from Netiv Hagdud were not published, but wheat grains were identified as wild emmer *(Triticum dicoccoides)*. At both sites, fig and pistachio were the main fruit and nut taxa. Common non-food species at both sites include *Aizoon, Avena, Stipa, Poa* and *Plantago*; others (e.g., *Malva*) are rare at ZAD 2 but more common at Netiv Hagdud.

The PPNA archaeobotanical assemblage from 'Irāq ad-Dubb (عراق الدب) (Colledge 1994), which may be earlier than ZAD 2, presents some similarities and differences. Again, fig and pistachio are the main fruit and nut taxa, although almond was also found consistently. Two or three pulse types include lentil, vetch/ grass pea and broad bean. Wheat and barley occur in most samples. Grains and chaff of both wild and domestic barley were identified. The wheat may be wild einkorn *(Triticum boeticum)*, which would be considered a cultivar on biogeographical grounds. 'Irāq ad-Dubb is probably a 'pre-domestication cultivation' site, although the evidence is ambiguous.

Cereal domesticates have also been identified in the PPNA at Jericho (Hopf 1983) and Tall Aswad, near Damascus (van Zeist and Bakker-Heeres 1982). Jericho is difficult to compare to the other sites, as plant remains were collected by hand, rather than by flotation. The resulting assemblage is small and unrepresentative. At Aswad, by contrast, a large and diverse assemblage was obtained, and it apparently includes domestic emmer wheat *(Triticum dicoccum)*, but not wild einkorn. In contrast to ZAD 2 and Netiv Hagdud, glume wheat chaff is abundant in the PPNA at Aswad (Phase I). On the other hand, Aswad has 'domestic' barley grains with 'wild' barley chaff, just as ZAD 2 does, indicating "an intermediate stage between the wild and fully domesticated forms" (van Zeist and Bakker-Heeres 1982: 204). Aswad also relied on the collection of figs and pistachios.

Pre-domestication cultivation may impose limits on community size that do not apply once domestic varieties are grown (Meadows n.d.). This is because the time available to harvest wild cereals is short; the ears of wheat or barley shatter as they ripen. Foragers can extend the harvest season by exploiting wild stands of cereals at different altitudes, because these would not ripen simultaneously. More sedentary cultivators of wild-type cereals, however, risk having their entire crop ripen at the same time, and being unable to harvest it all before the ears shatter, if their labour-force is too small. With domestic cereals, the harvest is the most labour-intensive time of the year (Russell 1988). Without domestic varieties, it seems unlikely that a sedentary community could grow enough cereals to feed itself. This is reflected in the continued reliance on gathered foods, as well as barley, at ZAD 2 (0.2ha) and Netiv Hagdud (1.5ha). PPNA Jericho and Aswad are larger (ca. 4ha), but apparently had domestic wheat.

(JM)

The Human Remains (Homo 1) in the Communal Burial (Squares I-J-K/ 25)

This report concerns the cranium of the first encountered individual in Square J25 *(Homo 1)*. It is limited to a discussion of some of the cranial material, as other cranial and post-cranial material is still in the process of being cleaned and reconstructed. *Homo 1* was buried on a slight angle, with the anterior portion (the face) buried straight down facing into the ground. The mandible and atlas were articulated with the cranium at the time of burial, indicating that there was at least some level of articulation of the individual when it was buried.

The fragile nature of the cranium meant that its removal from the matrix saw it break into numerous fragments. Very little was preserved of the maxio-facial region other than some small fragments of alveolar bone around the remaining teeth. The outline of the mandible, however, could clearly be made out *in situ*. Before removal the cranium was carefully cleaned and documented so as to identify any significant morphological or pathological features. No obvious pathologies were noted in the remains.

While *in situ*, it was noted that the individual had a pronounced supraorbital ridge and reasonably well developed mastoid processes. Morphologically these are considered male characters, although it is difficult to provide a definitive statement of sex from skeletal remains in the absence of the innominate bone. However, a number of additional characters were observed in the laboratory that indicate the remains might be those of a male. In the occipital bone, a reasonably well developed inferior nuchal line and external occipital protuberance suggested considerable muscle attachments. The masseteric tuberosity was, on the other hand, not well developed which suggests that the stresses of mastication were not particularly heavy.

Establishing the age of cranial material in such a fragmentary state is problematic. The cranial sutures were not obliterated suggesting that the individual was not an old man. It was noted that the different bones of the cranium had come apart at the coronal, sagittal and lambdoidal sutures. Considerable wear on the occlusal surfaces of the teeth was recorded, however, the cusps were not worn flat on all teeth and features such as regular fissures were still apparent in at least one tooth (the left maxillary second premolar). The condition of the sutures and degree of occlusal wear would indicate that the individual was an adult.

An unusual pattern of wear was identified in the first left maxillary molar. It consisted of a very severe pattern of wear on the lingual portion of the tooth which climbed steeply to the regular height of the occlusal surface on the buccal side. It may be associated with some kind of task or activity; however, in the absence of adjacent teeth and the alveolar structure it is difficult to say.

In the posterior mandibular dentition there is considerable alveolar resorption, which suggests that the last two molars on each side may have been lost due to some activity-related mechanism. There is no evidence of infection of the alveolar region, and therefore pathology is unlikely to be the cause of tooth loss, unless all evidence has healed. The unusual occlusal wear pattern on the left side maxillary M1 most likely has some relationship with this, however, the absence of evidence for the supporting tooth structure makes it difficult to explain this unusual pattern of wear.

(MW)

Mapping Survey at Ẓahrat adh-Dhrā' 1, 2001

Field operations at Ẓahrat adh-Dhrā' 1 (ZAD 1) between January 2 and 14, 2001 involved intensive remapping of all visible archaeological features on the ridge between Wādī al-Wa'īda (وادي الوعيدة) (which forms the northern bank of ZAD 1) and Wādī adh-Dhrā', and along the south bank of the Wādī adh-Dhrā'. This work was guided by the original site map drawn in 1994 by George Findlater and updated in 1999 by Rudy Frank (Edwards *et al.*1998; 2001: fig. 11), as well as the architecture revealed by the 1999/ 2000 excavations at ZAD 1.

A theodolite survey gathered data from over 1200 points to create a stone-by-stone map of 45 architectural features, including single- and multiple-room rectilinear structures, linear stone alignments, and curvilinear stone enclosures **(Fig. 21)**. During the 1999/ 2000 season, 21 excavation units of various sizes sampled 9 structures (Structures 36-44) and 6 potential midden localities (see discussion in Edwards *et al.* 2001). Among the architectural features at ZAD 1 are several alignments and structures on the south bank of the Wādī adh-Dhrā' with associated Middle Bronze Age potsherds, demonstrating that the settlement originally extended south of the modern wadi. Our mapping also incorporated the boulder fields cross-cutting the southeastern and northwestern ends of ZAD 1, with elements of the northwestern boulder field on both the north and south sides of Wādī adh-Dhrā'. Topography was mapped over the main site area between Wādī al-Wa'īda and Wādī adh-Dhrā', as well on three low alluvial terraces along the north bank of Wādī adh-Dhrā'. Terrace 2, below Structure 37, was the setting for Units Y and Z, excavated during the 1999/ 2000 season, while Terrace 3, below the southeast end of ZAD 1, was the site of stratigraphic investigation in 2001 (see Day, above).

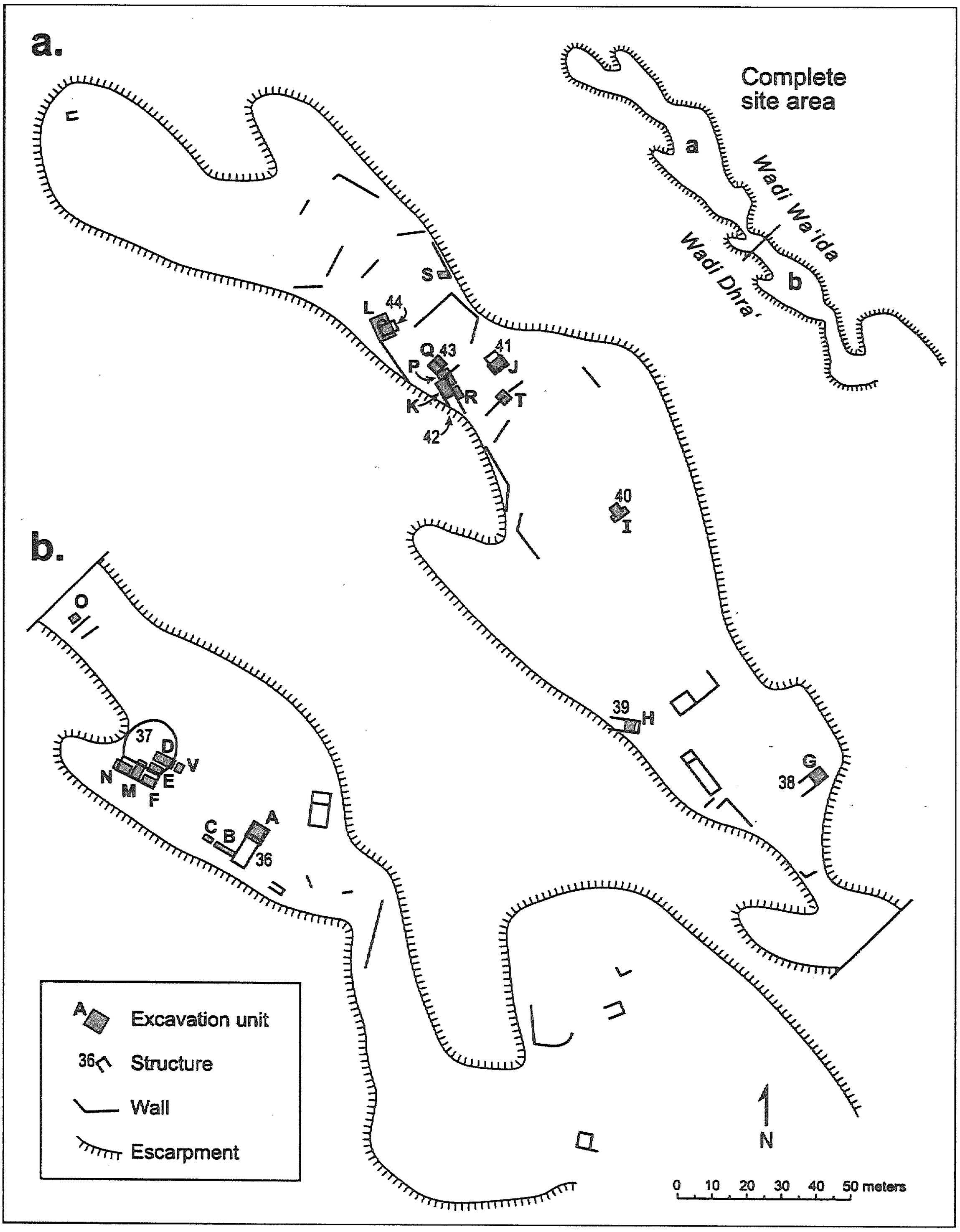
Pedestrian reconnaissance for our mapping also revealed a large rectangular hilltop enclosure (Structure 33) overlooking ZAD 1 from the southern edge of Wādī adh-Dhrā'. The outer walls of this structure measure roughly 50 x 40m, surrounding a central open area, with a series of square rooms along the south wall. A gap in the centre of the south wall suggests apossible entry or gateway. All surface pottery associated with this complex appears to be Middle Bronze Age, but shows intriguing contrasts to the pottery from the ZAD 1 excavations (see Falconer and Berelov, below). Approximately 100 metres farther east along the south edge of Wādī adh-Dhrā', a 20m-long wall associated with Roman/ Byzantine pottery provides our only example of a post-Middle Bronze Age archaeological feature in the immediate vicinity of ZAD 1.

(SF and JC)

Ceramic Sampling along the South Bank of Wādī adh-Dhrā'

Reconnaissance along the south bank of Wādī adh-Dhrā' included selective surface collection of ceramics, as well as a general mapping of the Structure 33 architectural complex. The pottery along the south bank, including Structure 33, like that at ZAD 1, dates uniformly to the Middle Bronze Age. Roman/ Byzantine pottery found approximately 100 metres east along the south bank of the Wādī adh-Dhrā', including corrugated jar body sherds and an example of terra sigillata ware, provide the only evidence of post-Middle Bronze Age occupation in the area.

The Structure 33 ceramics feature many types recovered in the 1999/ 2000 excavations, supplemented by several forms previously absent from ZAD 1. As we found during our previous work, serving vessels are extremely rare, but include an example of a concave, disk-based bowl (cf. Cole 1984: plate 20k, l, n). Cooking pots again include hand-built, straight-sided, coarse ware vessels with appended rope molding (cf. Cole 1984: plate 23; Falconer 1995: fig. 10a), but these are accompanied by globular cooking pot sherds with plain everted rims (cf. Cole 1984: plate 26; Falconer 1995: fig. 10b). Most notably, the Structure 33 surface pottery shows a striking predominance of jar sherds, whereas the ZAD 1 excavated assemblage had an unusual abundance of cooking pots. The jar forms feature a variety of simple to moderately elaborated everted rims (cf. Cole 1984: plates 32, 33) and characteristic flat bases (cf. Cole 1984: plate 37a-d). Another striking contrast is seen in the relative abundance of jar loop handles (Cole 1984: plate 38a, b; plate 44), which are absent altogether in the previously excavated assemblage. Among the Structure 33 samples is one example of



21. Results of the 2001 mapping survey of ZAD 1.

a double loop jar or jug handle (cf. Cole 1984: plate 29a).

Pottery from the south bank of Wādī adh-Dhrā', including Structure 33, seems generally contemporaneous with the assemblage excavated at ZAD 1. The straight-sided cooking pots and simple jar rims can be accommodated easily within Middle Bronze IIA assemblages from a variety of sites (e.g., Tall al-Ḥayyāt تل الحيّات Phases 5-4), while the globular cooking pots, disk-based bowl, and double-handled jar suggest occupation into Middle Bronze IIB (e.g., comparable to Tall al-Ḥayyāt Phase 3). No jar or bowl forms are sufficiently elaborated to suggest manufacture in Middle Bronze IIC. The distinctions between the pottery excavated at ZAD 1 and that collected from Structure 33 may also point to functional differences between these two major, and apparently contemporaneous, components of ZAD 1. A possible ethnographic parallel may be seen in the hilltop compounds of modern land owners that overlook agricultural villages and seasonal encampments on the Plain of Dhrā'.

In contrast to the evidence from Structure 33, the ceramics collected farther west along the south bank of Wādī adh-Dhrā' fit the general characteristics of the assemblage excavated on the main site of ZAD 1 in 1999/ 2000. Once again, cooking pot sherds are more frequent and jar handles are absent. This pattern again suggests that the domestic settlement of ZAD 1 originally extended over a larger expanse now dissected by the Wādī adh-Dhrā' and that the distinct nature of Structure 33 merits its own functional interpretation.

(SF and IB)

The ZAD 1 Middle Bronze II Ceramic Assemblage

Isolated from other MB II sites of the same period, and situated in an inhospitable environment, ZAD 1 is an unusual, single-phase MB site with a distinctive ceramic assemblage. A description of ongoing work on the excavated ceramic assemblage is given below, with emphasis on progress in reconstructing whole vessel numbers from fragmentary sherd evidence. Additionally, some evidence suggests that ZAD 1 was seasonally occupied, and so it is important to focus on data relating to the use and abandonment cycles of the site. Ongoing analysis of the ZAD 1 ceramic material has revealed a number of patterns that contribute to our understanding of these aspects.

Assemblage Composition

The ceramic assemblage is restricted to a few vessel types only (Berelov 2001a; Edwards *et al.* 2001). Cooking vessels are most abundant (63%), augmented by a smaller number of jars (36.5%), bowls and juglets (<1%). There are no vessels with handles found in the ZAD 1 excavation areas, which is very unusual for MB sites, although some have been found at Structure 33 which overlooks the main site from the south bank of Wādī adh-Dhrā' (see Falconer and Berelov, above).

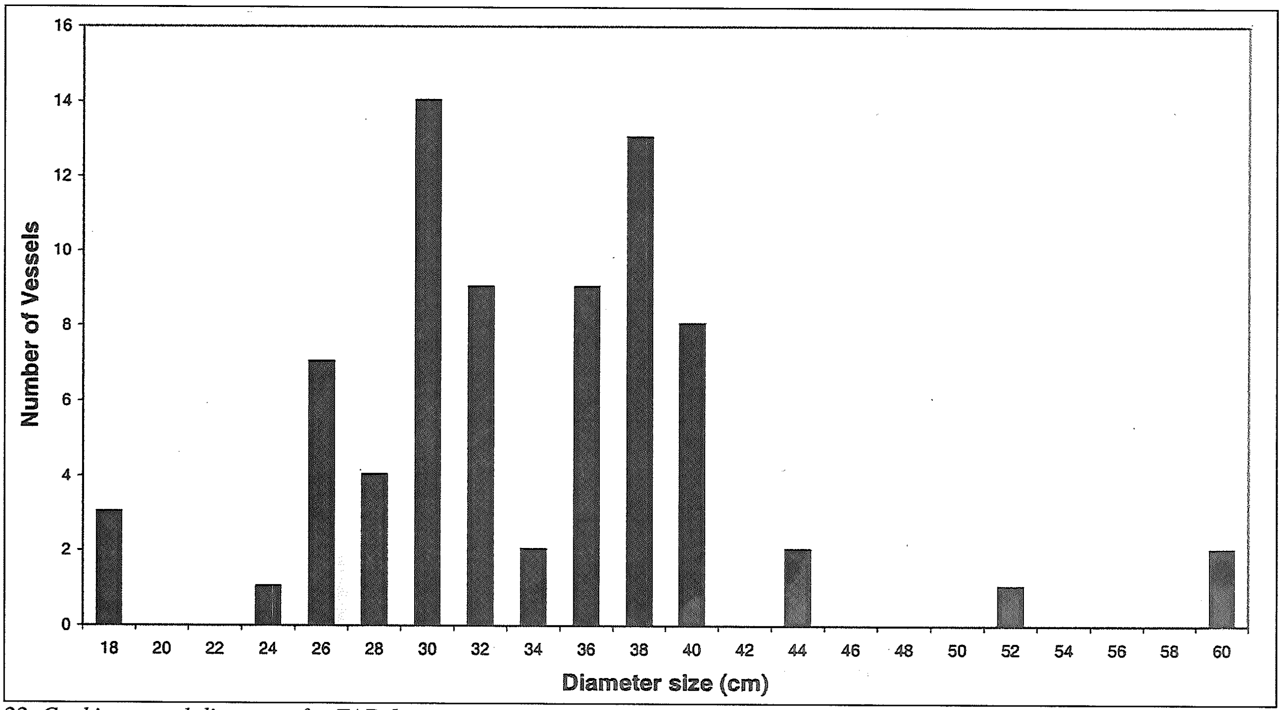
Raw sherd counts reveal that the ZAD 1 ceramic assemblage is made up predominantly of cooking vessels. Analysis has shown that the ZAD 1 cooking vessels break into smaller fragments than any other class of vessel, thus inflating their number in sherd counts. However, because cooking pots have smaller surface areas than jars, calculations show that cooking pots were more abundant than jars at ZAD 1 (**Table 6**). Ethnographic evidence (Longacre 1985), as well as technological considerations (Rye 1981), suggest that cooking pots, in general, are highly visible because of their high breakage rates, and hence their frequency of replacement is often high. Hand-built MB II cooking vessels were poorly made, and their angular design made them susceptible to frequent breakage (Edwards 1993). In addition, and contrary to initial estimations (Edwards *et al.* 2001), cooking vessels at ZAD 1 do vary substantially in size (**Fig. 22**). Cooking pot sherds show a bimodal distribution of rim diameters, suggesting small (<34cm in diameter) and large (>34cm in diameter) size classes.

A range of sizes is found throughout the structures. Five vessels provided complete profiles, enabling the reconstruction of their dimensions, which in turn assisted recalculation of vessel class proportions, using Orton and colleagues' (1997) *Estimated Vessel Equivalent* (EVE) measure. The total surface areas of the five vessels were calculated and averaged, giving an EVE figure. Following this, the surface area of all cooking vessel sherds was summed, and divided by the EVE. The aim was to estimate relative frequencies of vessel classes with greater accuracy than those calculated from raw sherd counts. The EVE method was applied to all classes (**Table 6**), since vessel profiles were reconstructed for all classes of vessels. Jars showed some range in diameter size (**Fig. 23**), particularly in Structure 33, which shows a bimodal distribution of small (<17cm in diameter) and large (>17cm in diameter) jars. The rest of the site shows a unimodal distribution of jar rim diameters.

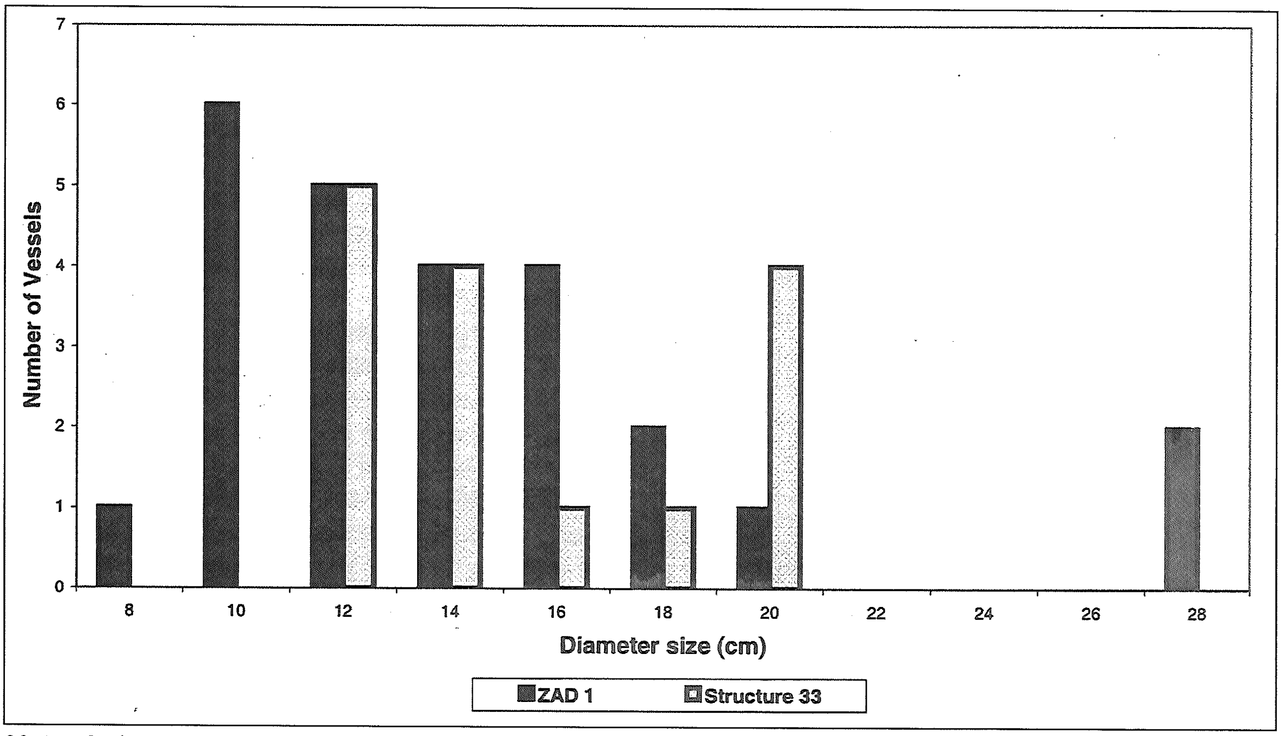
Jar surface areas and volumes show patterns different from those based on rim diameters. Two complete jar profiles and three partial profiles were reconstructed. Current data suggest that jars with diameters of about 10cm could be attributed to a smaller size category distinct from jars with diameters of between 12cm and 15cm. The latter catego-

Table 6: *Relative proportion of ZAD 1 vessel classes calculated from Estimated Vessel Equivalent (EVE) measure.*

Vessel type	Total Surface Area (cm^2)	EVE (cm^2)	Minimum No. of Vessels	Assemblage Proportion (%)
Cooking pots	38,585	3,520	11	60
Jar	34,523	5,360	6.5	35
bowl	229	420	0.6	3
juglet	159	420	0.4	2



22. *Cooking vessel diameters for ZAD 1.*

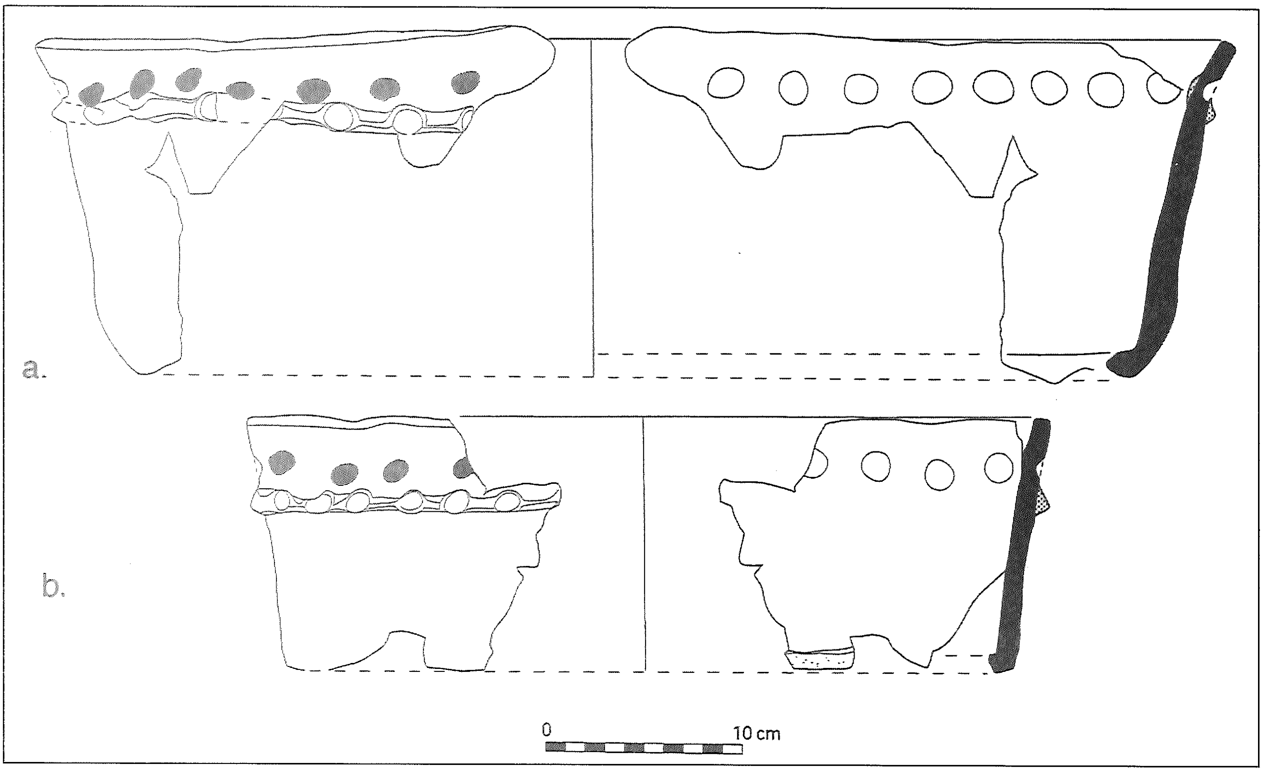


23. *Jar diameters for ZAD 1.*

ry is defined by medium sized jars of approximately 45cm in height and may belong to a class of larger jars or a distinct functional type of vessel. Jars with diameters of 18cm and more were not recovered in restorable condition. Finally, jars at ZAD 1 have a high number of mend holes, reflecting a strategy of curation. Small vessels such as bowls and juglets make up only 5% of the assemblage based on EVE calculations, and are restricted to the large Structures 37 and 42 (Fig. 21).

Typology

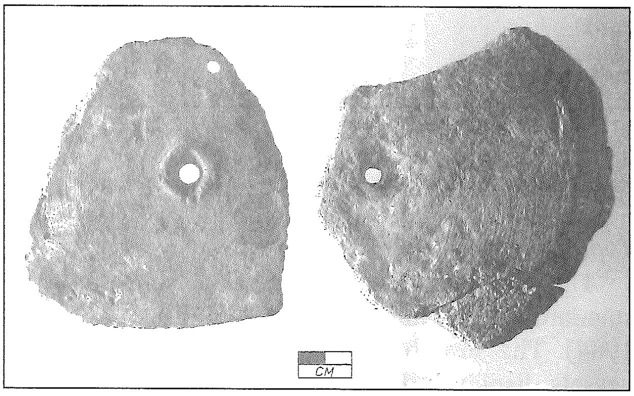
The cooking vessels at ZAD 1 conform to a standard type common in the MB IIA/ IIB (Cole 1984). The straight sided, hand-built, coarse-ware vessels display little variation at ZAD 1, generally maintaining a slight eversion, with the rope molding decoration substantially lower than the rim



24. Cooking vessels from ZAD 1.

(**Fig. 24**). Thumb impression decoration is always present and positioned above the rope molding and below the rim. The ZAD 1 cookers are generally larger than similar vessels found elsewhere (see for instance Fritz and Kempinski 1983).

Jars are generally squat and bulbous, without handles. Similar vessels are found at MB IIA/ IIB sites further to the north and have been linked to the opening phase of the MB II (Beck 2000; Cole 1984). Rim profile elaboration is minimal, the most common type constructed by the execution of one fold for thickening. There is no evidence at ZAD 1 to suggest that the lower half of the vessel was completed on a fast wheel. Current data supports the use of the fast wheel for the rim and upper dimensions of the body only. Two jar bases with perforations made before firing were excavated at ZAD 1 (**Fig. 25**) from Structures 37 (Locus N001) and 42 (Locus K019). Jars of this sort are known from the tombs of Dayr ʻAyn ʻAbāṭa دير عين عباطة (Politis 1997), as well as sites in Syria (Curvers and Schwartz 1997).

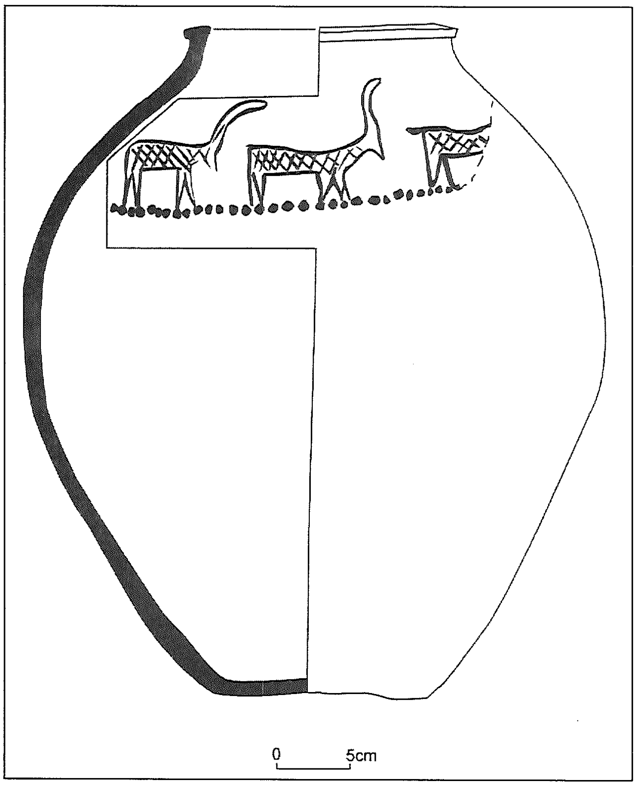


25. Perforated bases from ZAD 1.

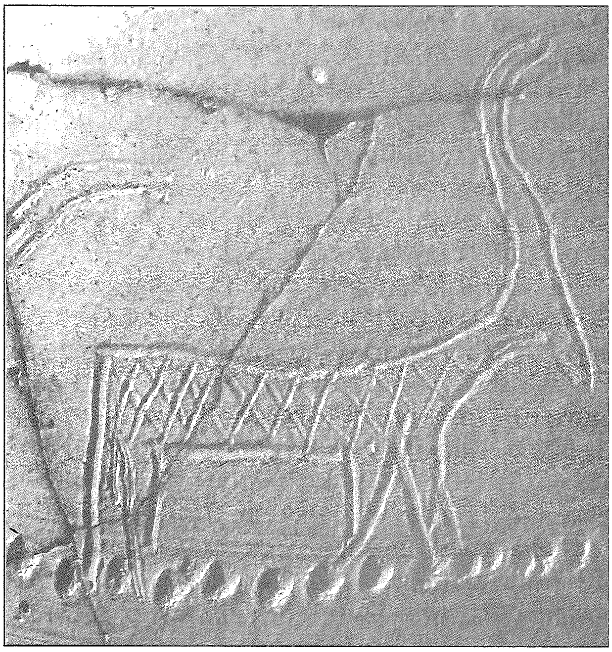
A unique jar, bearing a series of incised antelope motifs on the shoulder of the vessel, was found in Structure 42 (Locus K019) during the first season of excavations (Edwards *et al.* 2001) and can now be presented after its recent reconstruction[3] (**Figs. 26, 27**). Morphologically, this type of jar is commonly attested in the Middle Bronze Age (Gerstenblith 1983). The jar measures 47cm in height and has a maximum diameter of 40cm. The lower half of the vessel has been formed on a cone, whilst the upper portion was thrown on a wheel. A light cream slip was applied to the vessel over its variably coloured fabric; the latter ranging from Very Pale Brown (Munsell 10YR 8/2) to Light Greenish Gray (Gley 2 8/5GY). The rim is thickened and hammerhead-shaped in section, measuring 15cm in diameter.

The decoration of the pot is idiosyncratic, bearing a motif of nine antelope incised on the shoulder on the vessel. The animals follow one another, in procession, from left to right. The position of the head varies in each of the nine animals, with some

3. Many thanks go to Jo Atkinson of the Nicholson Museum at the University of Sydney for conserving the 'Antelope Jar'.



26. The 'Antelope Jar', ZAD 1.



27. Detail of the 'Antelope Jar', ZAD 1.

inclined further towards the ground, others looking ahead and up. Hoof prints are represented by punctate impressions below the animals in a continuous fashion. It was first suggested that the animals in the motif represented oryx. This however seems unlikely given the forward orientation of the horns. It is therefore more appropriate to describe the animals as antelope. The nearest known parallel to the 'Antelope Jar' is a small jar recovered out of context at the nearby EBA site of Bāb adh-Dhrā', which has a single ibex incised on the shoulder (Saller 1965: 153).

Implications for the Middle Bronze Period

The nearest Middle Bronze II settlements to ZAD 1 are Tall Msās (تل مساس) (Fritz and Kempinski 1983) and Tall al-Milḥ (تل الملح) (Kochavi 1967), 50-55km to the west, and Tall Nimrīn (تل نمرين) (Flanagan and McCreery 1990), 60km to the north. The typology of cooking vessels from these sites suggests that they are later than ZAD 1. They feature hand-built, straight-sided cooking vessels that are smaller than those found at ZAD 1, and display a pronounced inversion which the ZAD 1 vessels lack. In addition, vessels from the later sites are distinguished by the position of the rope molding decoration, which sits flush on the rim. Although a combination of thumb impressions, perforation, and rope decoration is found at Tall al-Ḥayyāt (Falconer 1995), inverted rims combined with a high rope molding placement seems to occur in MB IIB and MB IIC (Cole 1984: 64, fig. 16) only. The latter features belong to a later typological development, which suggests that ZAD 1 is indeed earlier, and should be placed in MB IIA-MB IIB. There are no vessels at ZAD 1 that should be attributed to MB IIC.

If these MB settlements are later than ZAD 1, it implies that the latter is chronologically as well as geographically isolated from other sites of the same period. This possibility increases the importance of any connection between ZAD 1 and the MB II cemetery of Dayr 'Ayn 'Abāṭa (Politis 1997), located 25km to the south of Ẓahrat adh-Dhrā'. The two sites are connected by the presence of jars with perforated bases. Since such jars have been linked to beer production (Curvers and Schwartz 1997), their presence at ZAD 1 together with large quantities of barley (see Fall and Meegan, below) attest to the pre-requisites for the production and consumption of beer at the site. Further, the presence of these jars in the Dayr 'Ayn 'Abāṭa tombs is significant as it indicates that a ritual significance was ascribed to them, and also suggests a possible cultural connection between the cemetery and ZAD 1 (Berelov 2001b).

Further evidence for the cultural distinctiveness of the Ẓahrat adh-Dhrā' region is suggested by ZAD 1's 'antelope jar' and its only known parallel, the generically similar 'ibex jar' from Bāb adh-Dhrā'. The two jars imply some cultural continuity on the Dead Sea Plain from the EBA to the MBA, since this decorative scheme in not known elsewhere in the southern Levant.

Refuse and Site Function

Structures 37, 41, 42, and 44 yielded floors with clusters of broken cooking vessels associated with cooking fires, which represent examples of 'primary refuse' (Schiffer 1972). Eight partially restorable cooking vessels were excavated from the structures, though their friable fabrics precluded the possibility of total restoration.

All size categories of cooking vessel occur in the western room of Structure 37. The other structures contain a narrower size range of rim diameters (between 30cm and 40cm). In four cases in Structure 37 (Loci N001/ N012), Structure 41 (Locus J023), Structure 42 (Locus K019), and Structure 44 (Locus L023), cooking vessel sherds were recovered in clusters associated with floors and ashy soil. These cooking vessels ranged greatly in size from diameters of 28-60cm in the case of Structure 37, and 32-36cm in the cases of Structures 41, 42, and 44. Their largely intact condition and great quantity suggests that they were not highly valued, and were cached from season to season.

One juglet, resting against the lower part of Wall E001 in Structure 37, was recovered intact but for a small fragment detached from the rim. The eastern room of Structure 37 also produced two incomplete jars, their lower halves unrestorable. The western room produced one complete jar and a smaller jar, which retained less than 50 per cent of its original form.

The ceramic evidence reveals distinguishable patterns relating to architecture, generally linked to the size and complexity of structures. Three types of structure are represented at ZAD 1: Horseshoe-shaped Room, 1-Room, and 2-Room. Three Horseshoe-shaped Rooms (Structures 38, 39, and 40) were excavated, but these contained no restorable items. Structure 5, in particular, contained a high Maximum Number of Vessels of between 65 and 94 vessels, often represented by single sherds. Two 1-Room structures were excavated at ZAD 1: Structures 43 and 44. Only Structure 44 contained restorable pottery in the form of two cooking vessels. The 2-Room Structures 36, 37, 41, and 42 contained most of the restorable vessels (particularly jars), and produced high densities of refuse on floors at 137.7 sherds/m^3 in Structure 37, 115.3 sherds/m^3 in Structure 41, and 63.2 sherds/m^3 in Structure 42 (**Table 7**).

Only Structure 37 produced more than one clear floor (Loci F010, F013, F015, and F020), and more than one phase of architecture (Walls F001, F018 and F019). In all but two structures (Structure 38 and the western room of Structure 37, Loci N001/ N012) occupational debris associated with floors produced much higher sherd densities than any other context type (**Table 7**).

Discussion

The ceramic material and its depositional context suggest a number of factors relating to site use and function. There is reason to believe that the ZAD 1 jars served a variety of functions, if one is to judge from the variety of rim types and sizes, perforated bases, and curious lack of handles. Furthermore, there are no intact jars, implying that jars were highly curated because of their value (for a comparative example, note Frankel and Webb n.d.). High rates of recycling (and by extension, of curation) are demonstrated by the large number of mending holes on jar sherds. The practice of drilling holes in broken jar sherds for mending is widely attested in the ethnographic literature (Deal 1998).

Variability in cooking vessel size across the site may likewise reflect a variety of functions for the vessels. On the other hand, the difference in vessel size may equally reflect differences in household unit size. This is suggested by the fact that Structure 37, which is the largest at ZAD 1, also contains the greatest variation in cooking vessel size, including the largest vessel which measures 60cm in diameter.

Seasonal exploitation of ZAD 1 is in part supported by the archaeobotanical evidence (see Fall and Meegan, below). This notion is also advanced by Falconer (in Edwards *et al.* 2001) on the basis of stratigraphic evidence in the form of a series of surfaces segregated by windblown sediments in Structure 42, Unit K. If ZAD 1 was a seasonal site, then cooking vessels were left as site furniture (cf. Binford 1981) while usable items such as jars, bowls, and juglets were removed. This proposition is likely given the high numbers of restorable cooking vessels and the absence of primary or *de facto* refuse for every other ceramic class (with the exception of one almost complete juglet). Longacre (1985) has argued ethnographically for a short life expectancy of cooking vessels. However in practice they are often under-represented (Frankel and Webb, in press; Edwards 1993), in contrast with the jar material. Interestingly, sites like Marki-*Alonia* in Cyprus and Pella/Ṭabaqat Faḥl (طبقة فحل) in Jordan which show a lower than expected volume of cooking vessel material, are not seasonal. Sedentary sites like these, as well as Tall al-Ḥayyāt in the north Jordan Valley, are generally associated with more frequent removal of household refuse to secondary contexts (Falconer 1995).

At ZAD 1, differences in sherd densities across depositional contexts are instructive. Occupational

Table 7: Sherd density for various excavation contexts, ZAD 1.

Structure	Late Fill	Surface	Exterior	Bin	Court-yard	N = Exc. (m3)	area
1	23.2	137.7	28.8		21.9	53.9	
2	7.6	11.9	4.		-		24.3
3	7.5	-	13.8		-		6.9
4	5.7	52.5	-.		-		7.3
5	22.3	125.7	3.5		-		9.6
6	1.7	115.3	0.9		-		22.3
7	2.6	63.2	10		-		28.6
8	2.0	102.6	39.7	33.3	-		13.8
9	1.7	56.6	11.5		-		6.1
Site Mean	8.3	83.2	14.0	33.3	21.9		172.7

debris associated with floors shows very high densities of sherd deposition, whereas later room fill and exterior contexts have the lowest sherd densities **(Table 7)**. No middens were identified during the excavations at ZAD 1. These differences suggest that the site was intensively used during short seasonal visits. Ethnographically, several cases show that non-sedentary people generally do not practice removal of refuse from residential areas as regularly as sedentary populations (Graham 1993; Joyce and Johannessen 1993).

(IB)

Macrobotanical Remains from Ẓahrat adh-Dhrā‘ 1

Macrobotanical remains were recovered using a non-random sampling strategy during the winter 1999/ 2000 excavations of the Middle Bronze Age village of Ẓahrat adh-Dhrā‘ 1. Sediment samples were collected from all areas exhibiting evidence of burning or carbonised seeds, especially hearths, pits, and surfaces. Approximately 353 litres of sediment from 123 samples were processed using water flotation. Seventy-five samples (averaging 3.8 litres each, totalling 240 litres) contained carbonized seeds and are reported below.

The plant macrofossils were sorted and identified with a binocular microscope at ASU. Seed identifications are based on external morphology and comparison with seed identification manuals (e.g. Martin and Barkley 1961), reports from prior excavations (Lines 1995; van Zeist and Bakker-Heeres 1982; 1984), and reference material at ASU's Laboratory of Paleoecology. The seeds were sorted and identified by Cathryn Meegan and form the basis for her Master's Thesis (Meegan n.d.).

The plant remains identified from ZAD 1 **(Table 8)** have been divided into six major categories: cultivated cereals, orchard crops, cultivated legumes, field weeds, wild taxa, and unidentified (unknown weed and wild seed taxa). The main cultivated taxa at ZAD 1 are hulled 2-row barley *(Hordeum distichum)*, fig *(Ficus carica)*, and grape *(Vitis vinifera)*. Other cereal types include naked barley *(Hordeum vulgare* var. *nudum)*, emmer wheat *(Triticum dicoccum)*, and bread wheat *(T. aestivum)*. Field weeds comprise the largest category of plant taxa recovered from ZAD 1. The field weed taxa, totalling 41.7% of the total number of seeds, include *Aizoon*, *Chenopodium*, *Malva*, *Rumex*, and several types of Papillionaceae. Wild taxa comprise 4.16% of the total seed assemblage; unknown seeds (most likely non-cultigens) make up 29.01%. Wild or weed plants account for about 75% of the assemblage.

The majority of the identified cereal grains are hulled barley (75.8% of the identified cereal grains), with naked barley (6.8% of cereal grains), emmer wheat (9.1%), and bread wheat (8.3%) present in relatively small amounts (Meegan n.d.). This suite of cereal grains is indicative of irrigation agriculture. The ratio of barley to wheat at an archaeological site can provide an estimate of the relative use of these cereals and provide environmental information. The barley to wheat seed ratio for

Table 8: *Macrobotanical Remains from ZAD 1 (data from Meegan n.d.).*

				Seed Count	Density Ratio *	Relative Frequency
Cultigens				447	2489	25.1 %
	Cereals			222	1236	12.5 %
		Barley		132	735	7.4 %
			Hulled 2-row Barley	100	557	5.6 %
			Naked Barley	9	50	0.5 %
			Undiff. Barley	23	128	1.3 %
		Wheat		28	156	1.6 %
			Emmer Wheat	12	67	0.7 %
			Bread Wheat	11	61	0.6 %
			Undiff. Wheat	5	28	0.3 %
		Und. Cereal		62	345	3.5 %
	Orchard Crops			189	1053	10.6 %
			Fig	130	724	7.3 %
			Grape	59	329	3.3 %
	Legumes			36	200	2.0 %
			Garden Pea	28	156	1.6 %
			Horsebean	7	39	0.4 %
			Bitter Vetch	1	6	0.1 %
Non-Cultigens				1332	7417	74.9 %
	Field Weeds			742	4132	41.7 %
	Wild Taxa			74	411	4.2 %
	Unknown			516	2874	29.0 %
	TOTAL			**1779**	**9906**	**100.0 %**

ZAD 1 is 4.71, similar to ratios found at the Early Bronze IV sites of Bāb adh-Dhrā‘ (6.2:1; see McCreery 1980), and Tall Abū an-Ni‘āj تل ابو النعاج (3.3:1; Fall *et al.* in review). Interestingly, the ratio for ZAD 1 is quite different from the ratio of 0.9:1 found at the Middle Bronze Age village of Tall al-Ḥayyāt in the northern Jordan Valley (Lines 1995; Fall *et al.* in review). Hulled varieties of barley are generally used as animal fodder, while naked forms may be used for food (Zohary and Hopf 1988). The predominance of hulled barley suggests that pastoralism played a significant role in the economy of ZAD 1. Barley also requires less water than wheat, is more tolerant of saline soils, and is less susceptible to insect infestation due to its shorter growing season (Zohary and Hopf 1988). Indeed, McCreery (1980) found high concentrations of boron in wheat and barley grains from Early Bronze Age Bāb adh-Dhrā‘, suggesting high salinity in the soils of the Dhrā‘ Plain.

Fig and grape are relatively common at ZAD 1; olive seeds are notably absent. Fig seeds are abundant in Bronze Age sites along the Jordan Rift Valley. A pattern of abundant grape and barley seeds is found in Bronze Age sites throughout the driest portions of the Southern Levant (Fall *et al.* in review). In contrast, substantial amounts of olive seeds suggest linkage to the development of urban markets (Fall *et al.* 1998). The lack of olive seeds suggests that ZAD 1 was not linked to the Middle Bronze Age regional markets.

(PLF and CM)

P.C. Edwards
I. Berelov
J. Meadows
G. Sayej
Archaeology Program
La Trobe University
Victoria 3086
Australia

S.E. Falconer
P.L. Fall
J. Czarzasty
C. Meegan
T.K. Swoveland
Department of Anthropology
Arizona State University
Box 872402, Tempe
AZ 85287-2402
USA

C. Day
Yung shue Wan
Lamma Island
Hong Kong

M. Westaway
National Museum of Australia
GPO Box 1901
Canberra
A.C.T. 2601
Australia

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