NATURAL AND CULTURAL STRATIGRAPHY OF 'AYN AS-SAWDA, AL-AZRAQ WETLAND RESERVE: 2007 EXCAVATION REPORT AND DISCUSSION OF FINDS

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Introduction

The drying of the 'Ayn as-Sawda Pool, located inside the al-Azraq Wetland Reserve, exposed a series deposits and a wealth of prehistoric artifacts. Survey and excavations carried out in 1997 recovered artifacts of ages ranging from Lower Paleolithic to the Epipaleolithic and Neolithic (Rollefson *et al.* 1997). The excavations produced large amounts of faunal remains in association with Lower and Middle Paleolithic tools, including extinct species (Dirks *et al.* 1998). Species such as *Elephas namadicus*, an extinct species of elephant closely related to the Asian elephant (*Elephas maximus*) was one of the most interesting finds, as well as a series of animals associated with savanna biomes (Dirks *et al.* 1998). To understand the habitat of the fauna better, the environment in general, and the means of subsistence of prehistoric populations, this study aimed at (1) dating cultural deposits, and (2) recovering microbotanical information (pollen and phytoliths). Samples for OSL dating were processed at the Radiation Dosimetry Laboratory at Oklahoma State University. Pollen and phytolith samples are being processed at the Applied Geoarchaeology and Paleoecology Laboratory at the Geography Department at Oklahoma State University. The collection of samples for dating and microbotanical studies involved a detailed classification and description of sedimentary units and zones, a task that was accomplished in June 2007.

This report presents the description of sedimentary units of two excavation units (AS-1 and AS-2) and a preliminary interpretation of local environmental events and their correlation with events recorded in other regions of Jordan and their relation with Marine Isotopic Stages (MIS) in the Late Pleistocene.

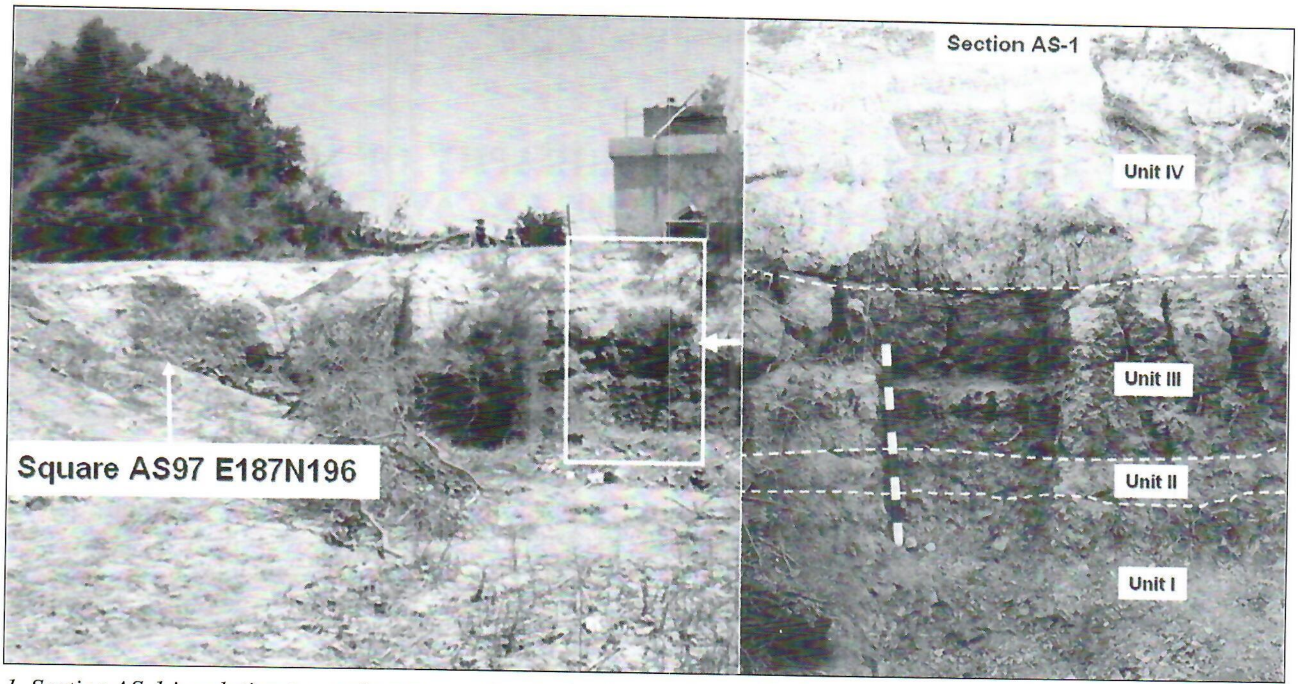
Section AS-1

Section AS-1 is located on the northern side of the pool, three meters east of square AS97 E187N196, excavated by Phil Wilke in 1997 (**Fig. 1**). The exposure was cleaned by removing 20-50cm of the section face. A 35-cm pit was dug into the floor of the pool to expose a larger section of the lowest sedimentary unit. The total depth of the section is 3.03 meters. Nineteen sedimentary/soil zones were defined and grouped into four stratigraphic units (**Fig. 2**). Zones usually designate a single deposit or event, and/or a soil horizon. Units encompass a series of zones of similar origin (e.g., lacustrine, alluvial, aeolian facies, as well as cultural layers). Given the proximity to P. Wilke's square AS97 E187N196, it was possible to correlate strata between this square and the sedimentary zones of section AS-1.

Eighteen samples for microbotanical remains were taken from this section (**Fig. 2**). Three samples for dating using the Optically Stimulated Luminescence (OSL) method were collected using 20cm-long tubes to keep sediment in the dark. Each set of OSL samples was accompanied by samples of the same sediment for dosimetry and water content. OSL samples were collected from the middle of zone 12, the top of zone 4, and the top of zone 2.

Test Pit AS-2

This test pit had 100 x 100 centimeter area with a depth of 23cm (**Fig. 3**). This pit was opened on a promontory at the center of the 'Ayn as-Sawda Pool where Middle Paleolithic material and fragments of partially fossilized bone were exposed. The purpose of test pit AS-2 was to test if the ground level of this promontory corresponds to Unit II in section AS-1 and stra-



1. Section AS-1 in relation to previous excavation in the 'Ayn as-Sawda Pool and stratigraphic units. Left side picture was taken from the approximate location of test pit AS-2.

tum IX in square AS97 E187N196 and to search for the top of the green clay.

At 5, 10 and 20 cm depth *in situ* lithics and bone were found. The diagnostic lithic material recovered from test pit AS-2 is predominantly Middle Paleolithic (**Fig. 4**). Two ash pits containing burned bone were identified at depths 5-15cm, 5 to 18cm, and 5 to 23cm (**Fig. 3**). The deepest part of the ash pit in the SE corner of the excavated area had an oxidized layer. Given the consistency and apparent sedimentary characteristics, the layers of ash, gravel, lithics and bone are correlative with P. Wilke's Stratum IX, and with zones 3 and 4 in section AS-1. The pit was stopped once the sterile green clay layer was reached. Samples for phytoliths were collected from the ash pits for information on the type of fuel used in the fires and as a means of correlation with Unit II in section AS-1.

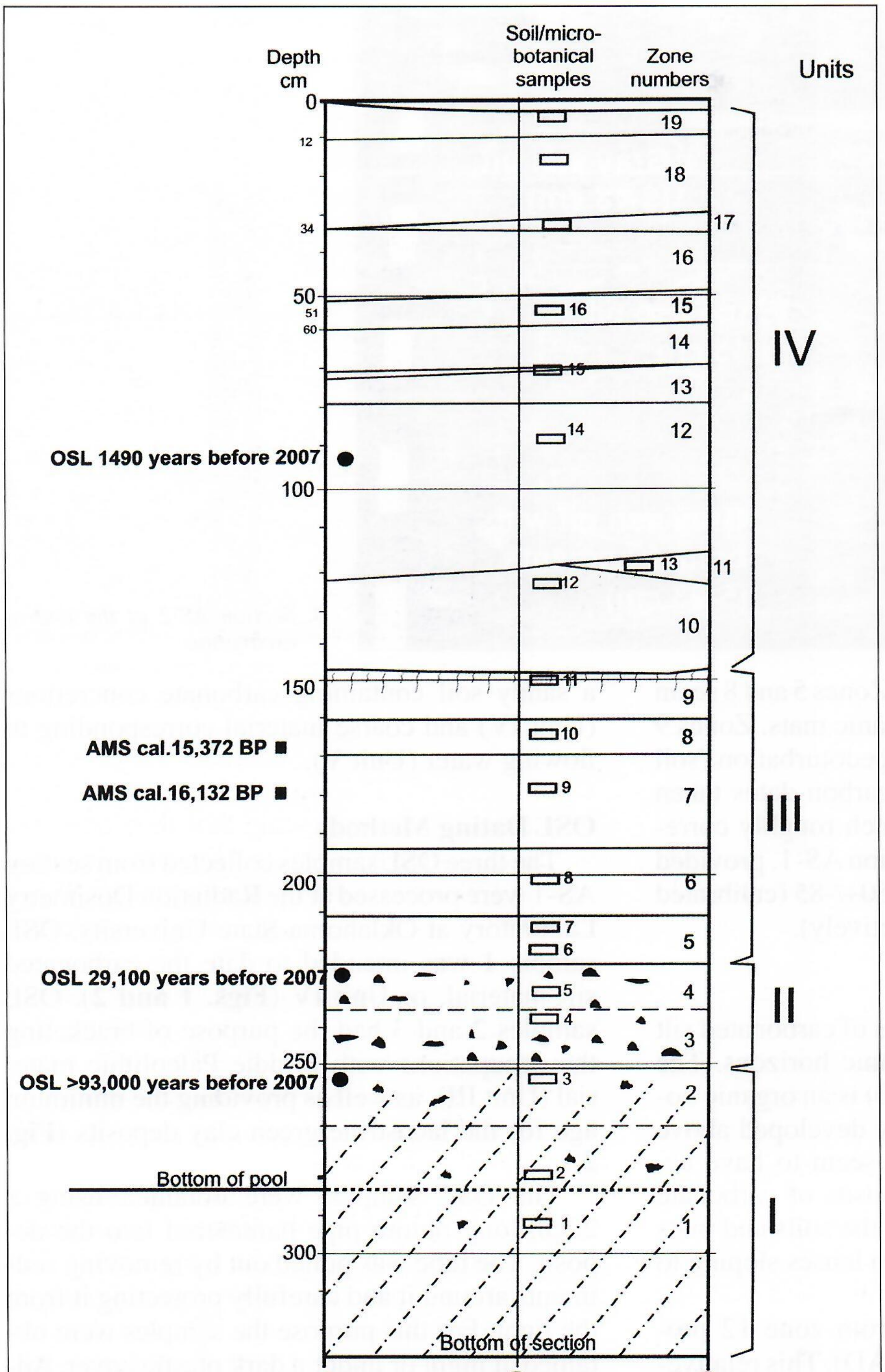
Stratigraphic Units in Section AS-1

Unit I (Zones 1-2)

This unit corresponds with a layer of compact green clay. Its pale green color seems to indicate the presence of bentonite, suggesting a rather deep lake environment. The two sedimentary zones of this unit represent two facies of green lacustrine clay. Zone 1 contains only a few small fragments of rock. Zone 2 includes embedded fragments of rock, all of which are unworked flint. The edges of these rock fragments are sharp, suggesting that they have not been transported by streams. Given the presence of a flint-rich rock outcrop twenty meters SW of the site, inside the pool basin, it is possible that these fragments are colluvial material that made it to the lake bed by means of gravity or perhaps by hominids mining the outcrop for flint. The age provided by OSL dating of the top of zone 2 suggests that Unit I is older than 93 ka BP.

Unit II (Zones 3 and 4)

This unit comprises two zones with predominantly cultural sediments. Zone 3 is predominantly a deposit with ash with fragments of flint and green clay. Zone 4 is predominantly ash, silt, gravel, lithics and bone. These two zones correlate with stratum IX of P. Wilke's 1997 square. Lithics in this stratum were predominantly Middle Paleolithic, although a few Upper Paleolithic specimens were also recovered. An OSL date from the top of zone 3 provided a date of 29.1ka BP. Unit II also correlates with the layer excavated in test pit AS-2. The correlative stratum IX was also rich in faunal remains, some of which contain a number of ungulates (cf. Dirks *et al.* 1998). Therefore, the microbotanical data from this layer will complement the



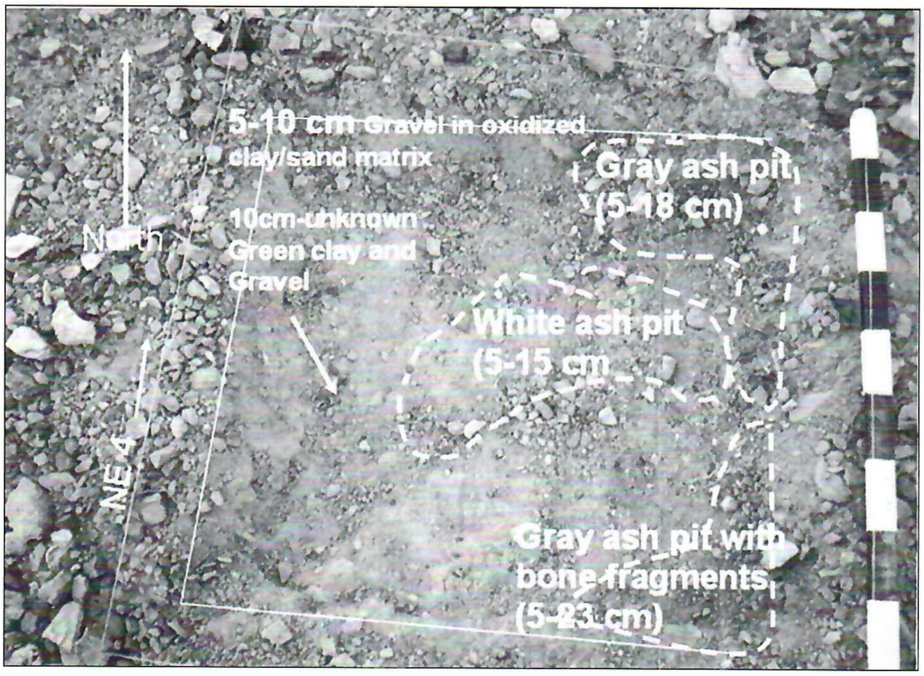
2. Section AS-1 stratigraphic units.

ecological picture of this occupation layer.

Unit III (Zones 5 to 9)

This unit is represented by a series of black mat layers, which here are grouped into six major zones based on consistency, color, pedogenic development, and the presence or absence of ash. Zone 5 is a peat deposit that grades up into a compact ash. Zone 6 is an organic mat deposit, similar to the layers above, but without shells and fragments of carbonates. Zone 7 is an organic mat with very firm consistency. Zone 8 is an ashy deposit similar to zone 5, but with shell fragments and root marks. Zone 9 is an organic mat with carbonates and small shell fragments.

Unit III represents the presence of a wetland



3. *Section AS-2 at the end of excavation.*

deposit abundant in organics. Zones 5 and 8 seem to indicate burning of the organic mats. Zones 9 and 10 and indicate signs of pedoturbation (soil formation). Two AMS radiocarbon dates taken in 1997 from stratum IV, which roughly correspond to zones 7 and 8 of section AS-1, provided ages of 13,200+/-95 and 13,850+/-85 (calibrated 15,372 and 16,132 BP, respectively).

Unit IV (Zones 10 to 19)

This unit comprises a series of carbonated silt deposits alternated with organic horizons. The bottom of the deposit (zone 10) is an organic horizon of a paleosol apparently developed above water. The rest of the zones seem to have accumulated as alternating deposits of carbonate and thin black mats. Some of the soils and mats in the carbonated deposit form lenses sloping to the west.

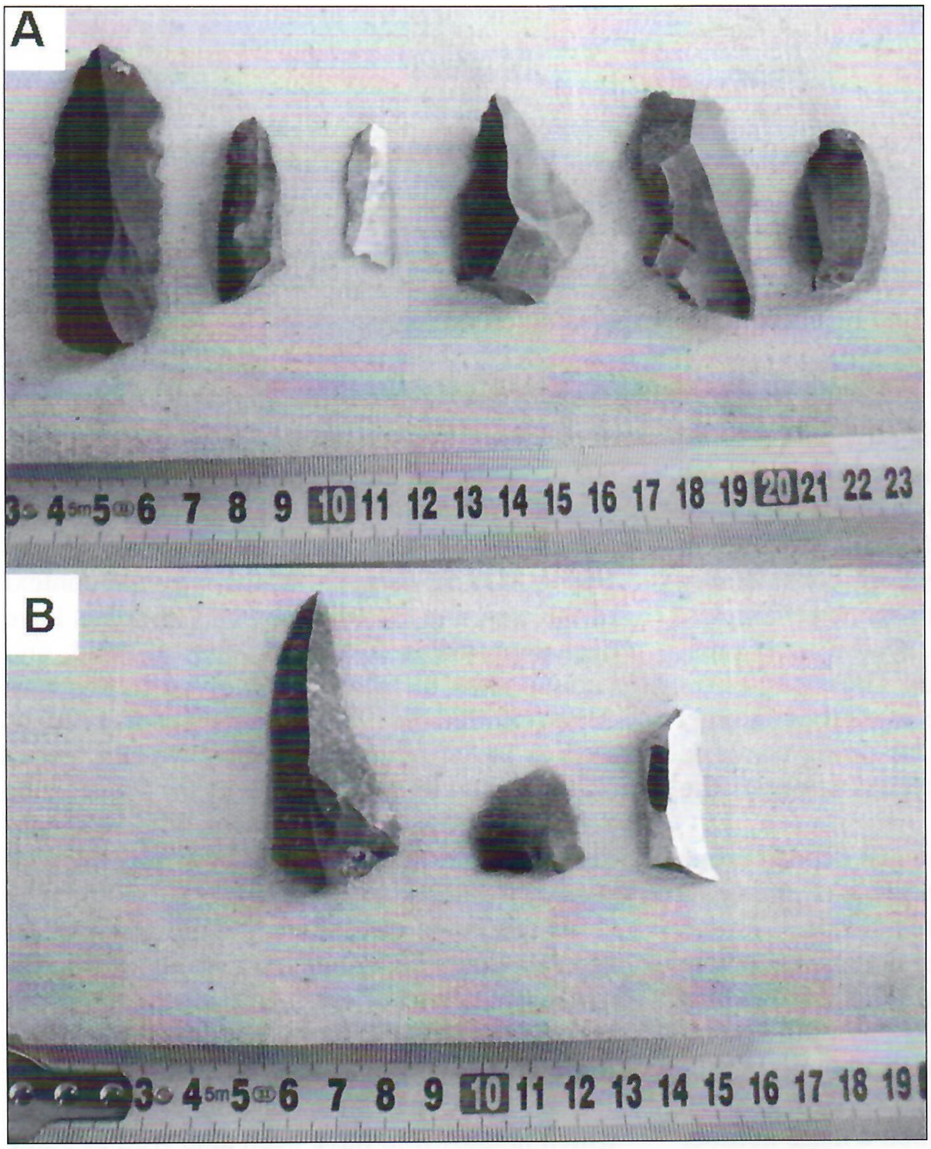
The OSL date obtained from zone 12 produced an age of 1490 BP (517AD). This relatively recent age suggests that most of the top white deposits (Unit IV) were laid behind the Roman-to-Early Islamic dam. Unlike the nearby ʻAyn Qasiyya pool, the ʻAyn as-Sawda pool is located inside the perimeter of the wall that demarcates the Roman-Islamic pool. This explains why the top deposits of ʻAyn Qaṣiyya are remarkably different from those of ʻAyn as-Sawda. According to Richter *et al.* (2007), the corresponding topmost sediments at ʻAyn Qaṣiyya consist of a sandy soil containing carbonate concretions (Unit IV) and coarse material corresponding to flowing water (Unit V).

OSL Dating Methods

The three OSL samples collected from section AS-1 were processed at the Radiation Dosimetry Laboratory at Oklahoma State University. OSL sample 1 was intended to date the carbonated silt material, or Unit IV (**Figs. 1 and 2**). OSL samples 2 and 3 had the purpose of bracketing the occupations with Middle Paleolithic material (Unit III), as well as providing the minimum age for the lacustrine green clay deposits (**Fig. 2**).

The OSL samples were obtained using a 20cm long plumb pipe hammered into the deposit. The tube was pulled out by removing sediments around it and carefully protecting it from the light. For this purpose the samples were obtained at night or under a dark plastic cover. Additional samples for dosimetry measurements and water content were obtained from the sampled layer and the layers above and below.

Measurements were obtained using a Risø TL/OSL-DA-15 reader, Risø National Laboratory, with a bialkali PM tube (Thorn EMI 9635QB) and Hoya U-340 filters (290-370 nm). The built-in $^{90}Sr/^{90}Y$ beta source gives a dose rate of 102.8 mGy/s. Optical stimulation was carried out with blue LEDs (470 nm), deliver-



4. (A) Lithic material from Test Pit AS-2, depth 5-10cm (B) Material from Test Pit AS-2, depth 10-20cm.

ing 31 mW/cm² to the sample. The heating rate used was 5°C/s.

The following measurement procedure was for all samples

1. Give dose D_i
2. Preheat at determined temperature for 10s to remove unstable signals
3. Stimulate with blue LEDs for 100 s at 125°C, measure OSL signal L_i
4. Give test dose, 15-20% of expected dose
5. Preheat at determined temperature for 10s to remove unstable signals
6. Stimulate with blue LEDs for 100s at 125°C, measure OSL signal T_i
7. Return to 1

The ages for the samples are calculated by dividing the dose by the dose-rate. The results are listed in **Table 1**.

Pollen and Phytoliths

Eighteen samples for pollen and phytolith analyses were collected from section AS-1 (**Fig. 2**) and three samples from the ash layers in test pit AS-2 (**Fig. 3**). The study is supported by collections of pollen and phytoliths from all the vegetation types in Jordan filed at the Applied Geoarchaeology and Paleoecology Lab at Oklahoma State University. The study of phytoliths included collection of soil and specimen samples in a vast area inside and outside the wetland

At this point only two of the eighteen samples have been processed for pollen and phytoliths. A sample from zone 4, Unit II, which is a layer containing Middle Paleolithic artifacts and

Table 1: OSL dates from section AS-1

Sample	Dose (Gy)	Dose rate (Gy/ka)	Age (ka)
AS-1-middle of zone 13	1.21±0.19	0.812±0.034	1.49±0.24
AS-1-top of zone 4	78.7±4.1	2.70±0.14	29.1±2.2
AS-3-bottom of zone 2	> 255±57	2.137±0.077	> 93

Equivalent dose, dose rate and resulting age for the samples. Reference point for the ages is the year 2007 AD.

bone, contained an assemblage of pollen types typical of grasses, chenopods, Asteracaeae, and Rhamnaceae shrubs. Although desert taxa such as Chenopodiaceae and *Artemisia* are present in this sample, their numbers are considerably lower than those recorded in modern samples. Aquatics such as *Typha* sp. (cattail) are present but in very small amounts. Grass phytoliths are not abundant, but more numerous than in regional modern contexts. The strong presence of undetermined shrub phytoliths suggests the presence of woody plants.

A sample from the organic mat deposit (zone 8, Unit III) produced a large number of grass pollen (approximately 85% of the sample). *Typha*, *Juncus*, Cyperaceae and other aquatic taxa were also common, as well as typical Saharo-Arabian desert Chenopodiaceae. Grass phytolith assemblages in this deposit show large amounts of bulliforms, which are abundant in aquatic grasses. The assemblages also contained a large number of plateau saddles typical of *Phragmites australis* and *Arundo donax*, both of which grow in the wetland reserve today.

Processing, counting, and proper statistic interpretation of all 18 samples for pollen and phytoliths will provide more information on the vegetation types associated with the natural and cultural deposits of section AS-2. It is expected that phytoliths will provide information on grass types (cool versus warm season grasses) as well as aspects related to fire and herbivory effects on the landscape.

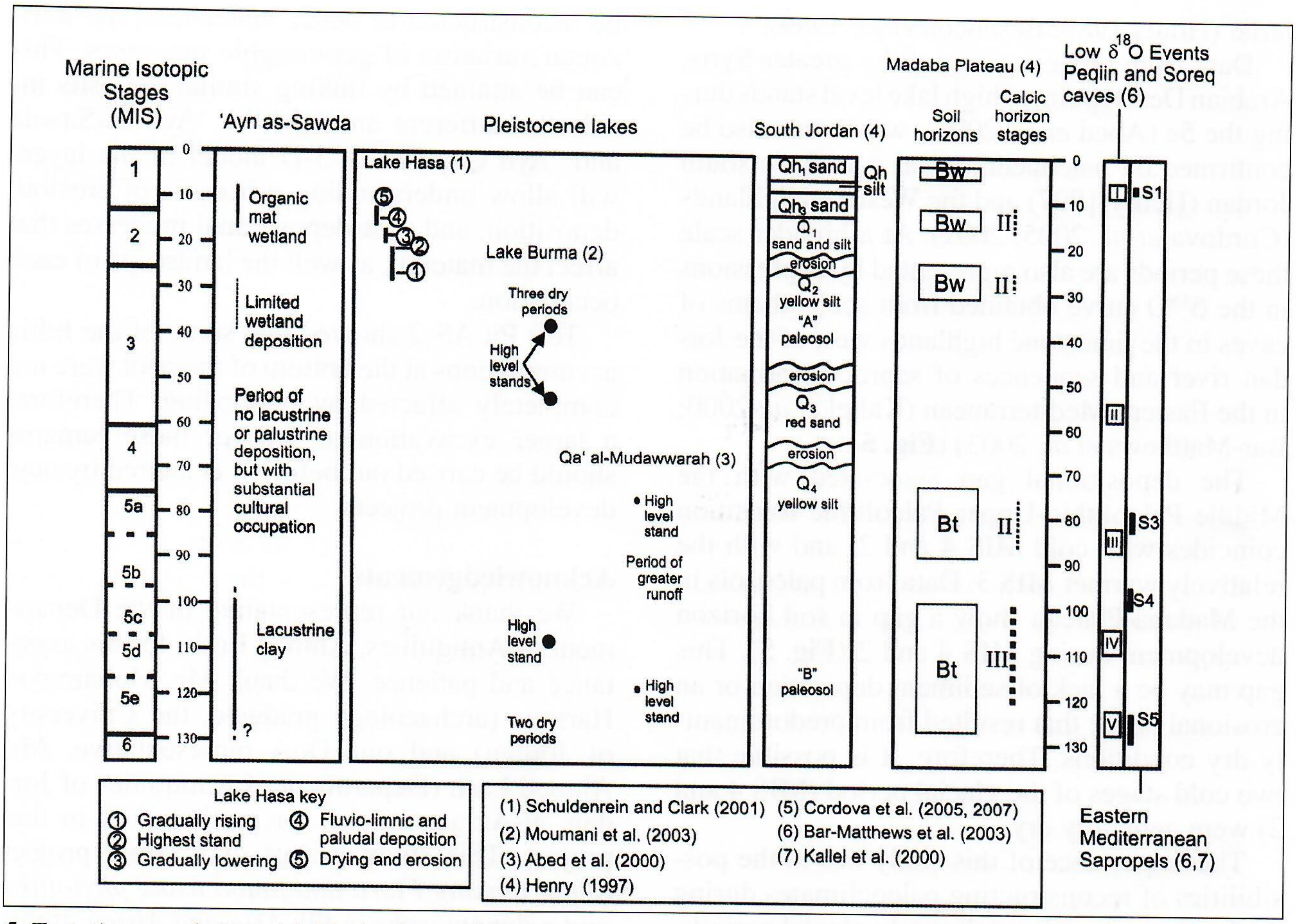
Interpretation of Finds

The sedimentary sequence excavated in the 2007 season at 'Ayn as-Sawda exposes the geomorphological history of the site during the past 100ka, although events are separated by long depositional gaps. The bottom of the sequence has a deposit of green clay in which fragments of rock increase towards the top. The minimum age of 93ka places the top of the clay deposit within MIS 5c (**Fig. 5**). In the regional context of the al-Azraq Basin, green clay deposits have been reported in C-Spring, 'Ayn al-Asad, and various sites in Wādī al-'Unqiyya in northern Azraq (Rollefson 1983; Besançon *et al.* 1989) as well as in the nearby 'Ayn Qaṣiyya (Richter *et al.* 2007). Its broad presence in the Pleistocene deposits and its association with Middle Paleolithic material are suggestive of a 'plenipluvial' period (Besançon *et al.* 1989).

At this point we assume that the green lacustrine clay may be associated with the extraordinarily wet period of the interglacial, or MIS 5e, as suggested by data from other localities in the Jordanian and Arabian deserts (Sanlaville 2002). The sequence may have continued into MIS 5c, which is known to have been also wet, as some evidence in the Levant suggests (**Fig. 5**).

Zones 1 to 3 represent a full lake that gradually dries out. The green clay with gravel (zone 2) indicates a lake with low influx of rock fragments delivered by the wadis emptying into the lake. However, most of the rocks are flint from the nearby outcrop exposed inside the pool. Therefore, it is possible that the flint source might be the nearby outcrop, either by means of erosion or deliberate mining. Zone 3 marks the total exposure of the lakebed and a relatively rich environment for hominid/human occupations.

Unit II (zones 3 and 4) represents the total drying of a lake and its further occupation by groups using Levallois lithic technology and later by groups using lithic technologies typical of the Upper Paleolithic. OSL dates bracket this



5. Tentative correlation with Marine Istope Stages (MIS) and regional paleoenvironmental events.

cultural layer between 29.1ka and 93ka, which are consistent with the Middle and Upper Paleolithic material of P. Wilke's stratum IX and the equivalent deposit in test pit AS-2. Throughout this period there is no evidence of lacustrine transgressions, suggesting long dry conditions.

The organic wetland deposit of Epipaleolithic age (Unit III) is interpreted as a wetland similar to the modern reed area inside the al-Azraq Wetland Reserve. The wet conditions of the deglaciation (roughly between 18,000 to 13,000 years BP) may have been the cause for the formation and persistence of this organically rich wetland. A similar deposit with similar lithic assemblages was reported for the nearby 'Ayn Qaṣiyya, also located inside the Azraq Wetland Reserve (Richter *et al.* 2007). Ash layers embedded in the Epipaleolithic wetland deposit suggest episodic burning of the wetland vegetation (zones 5 and 8).

The top layers of unit IV correspond to a highly carbonated silt deposit with layers of organic mats containing macroscopic remains of *Typha* sp. (cattail) and *Arundo donax* (reed grass) leaves, suggesting the presence of aquatic vegetation. Because of its location inside the Roman wall and the late date, this deposit may be associated with the construction of the water installation built during the Roman period.

Significance of this Study for the Middle Paleolithic

Geoarchaeological interpretation of sections AS-1 and test pit AS-2 and their ^{14}C and OSL age assays provide an overview of sequences of deposition and occupation for the latest part of the Middle Paleolithic. The green clay deposit under this occupation seems to correlate with a plenipluvial originally proposed by Besançon *et al.* (1989). Although the plenipluvial can be placed in MIS 5e to 5c, absolute dates are needed to determine the exact chronological extent of the lacustrine transgressions that may have resulted from high moisture levels. The importance of this clay in al-Azraq is that in several localities it has been associated with Middle Paleolithic material (Hours 1989; Besançon *et al.* 1989).

Data from other regions of the greater Syro-Arabian Desert point to high lake level stands during the 5e (Abed *et al.* 2000), which can also be confirmed by paleopedological data from south Jordan (Henry 1997) and the Western Highlands (Cordova *et al.* 2005, 2007). At a broader scale these periods are also represented by depressions in the $\delta^{18}O$ curve obtained from speleothems of caves in the limestone highlands west of the Jordan river and sequences of sapropel formation in the Eastern Mediterranean (Kallel *et al.* 2000; Bar-Matthews *et al.* 2003) (**Fig. 5**).

The depositional gap associated with the Middle Paleolithic-Upper Paleolithic transition coincides with cold MIS 4 and 2, and with the relatively warmer MIS 3. Data from paleosols in the Madaba Plateau show a gap in soil horizon development during MIS 4 and 2 (**Fig. 5**). This gap may be a lack of sediment deposition or an erosional phase that resulted from predominantly dry conditions. Therefore, it is possible that two cold stages of the glacial period (MIS 4 and 2) were generally dry.

The importance of this study lies in the possibilities of reconstructing paleoclimates during the last interglacial and the early glacial periods, which coincide with the late Levallois phases, particularly the ones associated with Tabun-C and Tabun-B types.

Conclusions and Recommendations

The stratigraphic analysis of natural and cultural sediments at AS-1 and the new set of OSL dates complement the information obtained by P. Wilke in square AS97 E187N196 in 1997. The paleoecological information obtained through pollen and phytoliths will be useful for placing the faunas associated with these deposits in their ecological context.

The most important aspects of this sequence lie in the nature of sediment deposition and paleoclimates during the last interglacial (MIS 5e) and the early glacial (MIS 5d-5a) as being relatively wetter in contrast with the drier middle glacial (MIS 4), interstadial MIS 3 and late glacial MIS 2. Another important aspect of the deposits in ʻAyn as-Sawda lies in the importance of the organic mat developed during the early and middle Epipaleolithic, which suggests wet conditions.

The paleotopography of each layer needs to be reconstructed to better understand the horizontal variation of geomorphic processes. This can be attained by linking similar deposits inside the different areas of the ʻAyn as-Sawda and ʻAyn Qaṣiyya. A 3-D model of the layers will allow understanding processes of erosion, deposition, and post-depositional processes that affect the material, as well the landscape of each occupation.

Test Pit AS-2 showed that some of the lithic accumulations at the bottom of the pool were not completely affected by bulldozing. Therefore, a larger excavation to recover these remains should be carried out before it is altered by new development projects.

Acknowledgements

We thank our representative of the Department of Antiquities, Ahmed Lash, for his assistance and patience. We thank Mr. Mohammad Hartoqa (archaeology graduate, the University of Jordan) and our DoA representative, Mr. Ahmed Lash (Department of Antiquities of Jordan, al-Azraq Office), for participation in this project. This study is part of a larger project titled: *Linking Flora and fauna using phytoliths and palynomorphs in SW Asia and Africa*, funded by an NEH-ACOR grant.

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