Charred plant macroremains (seeds, fruits) and phytoliths from villa E12.10 at Amara West, a pharaonic town in northern Sudan

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Abstract. Th s paper presents macrobotanical (seeds, fruits) and phytolith data from an elite house in a pharaonic town in northern Sudan. Amara West, occupied between 1300 and 1000 BC, was founded as the administrative centre of occupied Upper Nubia. Villa E12.10was situated in an extramural suburb and featured well-preserved food processing installations with associated charred macrobotanical remains. A range of archaeobotanical datasets provide complementary categories of information about plant use in different areas of the villa.

Keywords: charred macroremains, phytoliths, Sudan, Upper Nubia, New Kingdom

1. Introduction

1.1 Amara West

The New Kingdom (c. 1550–1069 BC) control of Upper Nubia, upstream of the second Nile Cataract, was characterized by the foundation of walled towns, provided with temples, administrative buildings, and housing areas, including those at Dokki Gel, Tombos, Kerma, Sesebi, Soleb, and Sai (Edwards 2004; Smith 2003). Under the reigns of Seti I and Ramses II (c. 1294–1213 BC), considerable investment was made in founding further towns, notably those of Aksha and Amara West, while large temples were also constructed in Lower Nubia, most famously that of Abu Simbel.

Amara West, located between the second and third cataracts on the north bank of the Nile as it fl ws east after Sai Island (Fig. 1), was the administrative centre of Upper Nubia, known as Kush, during the thirteenth and twelfth centuries BC. Excavations by the Egyptian Exploration Society (Spencer 1997, 2002) in 1938–39 and 1947–50 revealed a decorated sandstone temple and a formal residence with *in situ* inscriptions naming holders of the title 'Deputy of Kush', the highest administrative position in the region.

Since 2008, a British Museum research project (www.britishmuseum.org/AmaraWest) has been investigating the nature of ancient lived experience at the site, through excavating residential areas and two contemporary cemeteries. The excellent preservation of houses, storage

Figure 1. Map showing location of Amara West. (Map: Claire Thorne.)

magazines, and other buildings, both inside the walled town and beyond, allows a detailed consideration of how neighbourhoods developed across time, and of the role of individual, household, and external agencies in shaping this built environment (Spencer 2014, 2015). While the architecture and artefact assemblages are consistent with those found in Egypt proper, a circular building (E12.11) represents a rupture with pharaonic architecture, instead reflecting long-standing Nubian traditions (Spencer 2010). Pottery is mainly Egyptian in style and technology (Spataro et al. 2014), but handmade Nubian cooking pots are one of the most commonly found vessel types, and there is a notable increase in the proportion of such vessels during the twelfth century BC. Through the generosity of the National Corporation of Antiquities & Museums, it is possible to export archaeological samples to undertake analyses in laboratories at the British Museum and collaborating universities. This includes archaeobotanical material that is being used to study plants used for food, fuel, and craft activities (Ryan et al. 2012).

The town was originally founded on an island adjacent to the north bank of the Nile. The failure of a channel north of the town has been dated to the late second millennium BC; this failure may have been one of the primary factors that led to the abandonment of the settlement (Spencer et al. 2012). Land suitable for agricultural exploitation would have been reduced, and accumulations of windblown sand in the settlement would have become increasingly problematic. Nonetheless, the cemeteries were still being used for burials into the ninth century BC (Binder 2011; Binder et al. 2011), long after pharaonic Egypt had lost control of the region. Since the eighth century BC, and continuing until the present day, all major settlements are on the opposite river bank.

This paper presents a detailed comparison of the charred macroremains (seeds, fruits) and phytolith data from a villa (E12.10) outside the town walls.

1.2 Villa E12.10

An area of extramural buildings outside the sandstone west gate of the town was identified through magnetometry survey in 2008 (Spencer & Hay 2012). Several structures could be identified as villas on the basis of similarities with the plans of elite houses at such sites as Tell el-Amarna. At the time of writing, one villa has been fully excavated (E12.10) (Spencer 2009), while excavation has commenced in a villa to the south (D12.5). Preservation across villa E12.10 is uneven. Nearly 2 m of architecture is preserved in Room 13, but the brickwork is heavily truncated at the northern end through wind erosion. Sondages through the floors of three rooms revealed that the villa is founded upon a layer of rubbish characterized by 19th Dynasty pottery; thus this building, and perhaps other large houses in the extramural area, represents a later development in the town layout. Villa E12.10 follows the broadly tripartite division of elite Egyptian houses (Spence 2004), as shown in Figure 2, with a front area comprising an entrance porch (13), courtyard (7), and food processing suite (9–10), followed by a middle area with a broad room (5) set around a hearth, and stairs (4) to the roof or upper storey. The most private inner zone comprises a square room (2) with a low bench against the back wall, as well as two side rooms, including one with a bed alcove (3). The rear part of the house (rooms 1, 2, 3, 5) is characterized by the use of brick pavements underneath the clay floors; rooms 2 and 8 are further distinguished by the application of whitewash to the mud plaster that coats the walls.

Considerable provision was made for food storage and processing facilities. The courtyard, almost certainly unroofed, was provided with five storage bins along its western side. Raised up on schist slabs (presumably to reduce the threat from vermin), these cuboid bins were coated in mud plaster and provided with schist bases sealed with white plaster (Fig. 3). Immediately to the south of these bins was a doorway providing access to two rooms. Room 9 housed four side-by-side emplacements (Feature 2012) for quernstones, constructed from brick, stone, and mud plaster. These provided a setting for individuals to grind cereals (and perhaps other material), squatting over a quernstone, with the resulting products falling into a plastered basin along the south side of the room. The room to the south (10) was provided with seven cylindrical clay ovens with flue holes near their bases (Figs. 3 and 4). These are broadly contemporary, suggesting considerable capacity for bread production.

At nearly 400 m² in area, the ground floor of this house falls within the top 10 per cent of house sizes at Tell el-Amarna (Tietze 1985). However, given the remote location of Amara West, controls on display of wealth and prestige through house architecture (whether explicit or implicit) may have been less restrictive than at a royal residence city. The principal expense in constructing such a dwelling was time and labour, as materials (mud, sandstone, schist) were all locally available. Furthermore, the artefact assemblage from the villa was consistent with that found in much smaller dwellings (of 70 to 150 m²) inside the town wall, and the villa showed no noticeable increase in the number of luxury items, such as calcite, faience, or copper alloy objects.

Figure 2. Plan of villa E12.10. (© Trustees of The British Museum.)

Figure 3. Villa E12.10 showing storage bins in Room 7 (foreground), the grinding emplacement in Room 9 (back, central) and ovens in Room 10 (back, left). (© rustees of The British Museum.)

Figure 4. Oven from Room 10. (© Trustees of The British Museum.)

2. Methods

2.1 Sampling rationale

Phytoliths and charred macroremains can provide complementary evidence, and combining analyses is useful for cross-checking trends. Each dataset preserves information about different suites of plant parts. The macrobotanical remains from Amara West have been preserved through charring. Charred seeds can most commonly be used to identify a wider range of taxa than phytoliths, but the latter preserve information about less robust plant parts that do not frequently survive charring, such as leaves and stems. The phytolith record can also provide evidence for plants where charred material has been entirely turned to ash. Phytoliths are formed when monosilicic acid (H_4SiO_4), present in groundwater, is absorbed by plants and deposited as opaline silica, most commonly within or between epidermal plant cells (Piperno 2006). They are abundantly formed in certain monocotyledonous plants, especially grasses, sedges, and palms. They are also formed within various groups of dicotyledonous plants. Phytoliths are released into sediments through both burning and decay. Sediment samples were taken by the excavators during the 2009 fi ld season, with a focus on the well-preserved charred deposits in the southern areas of the building. The sediment samples were processed by a combination of dry sieving and fl tation to retrieve the charred plant remains during the 2011fi ld season and exported to the British Museum for identifi-

Table 1. Context descriptions.

Context	Archaeological sample (AS) number	Room	Description
2022	AS15	E12.10.9	Deposit in easternmost part of grinding table 2012
2025	AS16	E12.10.9	Fill from part of grinding table 2012
2026	AS17	E12.10.9	Fill from part of grinding table 2012
2083	AS 18	E12.10.9	Fill from part of grinding table 2012
2084	AS 18b	E12.10.9	Fill from part of grinding table 2012
2092	AS19	E12.10.9	Floor in SW corner by basin 2093
2016	AS3	E12.10.9	Ash layer, possible location of a fi e, against the north wall
2128	AS26	E12.10.10	Charcoal and sandy layer in oven 2035
2182	AS42	E12.10.10	Ash layer in oven 2040
2130	AS28	E12.10.10	Ash deposit in oven 2031
2104	AS23	E12.10.10	Ashy layer in oven 2081
2042	AS 22	E12.10.10	Ash layer in SW corner
2113	AS 24	E12.10.11	Ash and sand layer
2044	AS 9	E12.10.7	Sediments from storage bin
2155	AS 275	E12.10.5	Fill of hearth 2155
2098a	AS 274	E12.10.8	Ash on floor 209
2098b	S 276	E12.10.8	Floor 2098

cation; further sediment samples were exported for phytolith analysis at the British Museum. Descriptions of the sample contexts are provided in Table 1.

2.2 Charred seed sampling and analysis procedures

The charred seeds were recovered through a combination of dry sieving and fl tation (discussed below). The average sample size processed was between 2 and 4 litres. Simple bucket fl tation was used due to limited water availability (water was available for 1 to 2 hours a day from one shared tap).

The charred samples were analysed at the British Museum using a low-power binocular microscope, Leica MZ APO (×10 to ×80). A variable pressure scanning electron microscope (VP-SEM), Hitachi S-3700N, was used to further examine selected ancient and modern specimens. The samples were mounted on a scanning electron microscope (SEM) stub using Leit-C Plast carbon cement (a proprietary brand of conductive material with low outgassing properties that is suitable for SEM use). They were examined, uncoated, using the VP-SEM to observe the fi e detail of the crucial diagnostic anatomical features. An accelerating voltage of 15 kV was used on most occasions, but sometimes this was raised to 20 kV or lowered to 12 kV, depending on the condition of the sample. For optimal visualization of diagnostic cellular detail, the working distance varied from 23.5 mm to 11.3mm, as dictated by the individual sample being examined. To eliminate surface charging on non-conducting samples, the chamber pressure (whose unit of measurement is indicated by Pa, being the abbreviation for Pascal) also varied according to the state of preservation of each sample. The highly sensitive, five-segment BSE detector on the VP-SEM enabled detailed interrogation and imaging of the topography of the samples from different orientations and, where necessary, using low accelerating voltages. The 3D mode, rather than the Compositional mode, produced maximum surface topography information.

Identifi ations of taxa were made using modern reference material as well as reference works (Andrews 1956; Boulos 1999, 2000, 2002, 2005; Braun & Burgstaller 1991; Täckholm 1974). Minimum numbers of individuals (MNI) were recorded for grains and chaff. Spikelet forks and glume bases were counted as individual units, but for the purposes of calculations the results were combined into a total glume base figu e (with each spikelet fork equating to two glume bases). MNI were also recorded for wild taxa where possible, with two exceptions. Several whole *Acacia* seeds were present. Fragmented *Acacia* seeds were easily identifi d, but as it was not possible to calculate MNI, these instances were recorded as 'x' to illustrate presence. Occasionally, whole figs survived in charred form; examples of fruit fle h were recorded as 'x', indicating presence.

2.3 Charred seed preservation in relation to sample processing method

After a period of experimentation it was found that greater numbers of items survived via dry sieving than via fl tation (Table 2) and that this observation was particu-

Table 2. Summarized comparison of fl ated and dry sieved villa samples from processing experiments.

	2083		2025		2026	
	Dry sieve	Flot	Dry sieve	Flot	Dry sieve	Flot
Wheat grain	1	0	6	0	2	
Spikelet fork	80	7	23	4	14	1
Glume base	68	9	68	28	32	6
Barley grain	6	0	2	0	16	2
Barley rachis	33	3	16	0	16	4
Total items	***449***	***209***	***403***	***244***	***384***	***100***
Litres processed	**2**	**2**	**2.5**	**2.5**	**2**	**2**

larly applicable to cereals (found in sieve sizes > 0.5 mm). Spikelet forks also survived more frequently in the dry sieved samples (Fig. 5), whereas glume bases were more common in fl ated samples. The destruction of charred macroremains in water may relate to aridity and also perhaps to salt crystal dissolution. SEM images of glume bases from fl tation samples clearly show disintegration (Figs. 6a and 6b). Such disintegration has previously been recorded at Wadi Kubbaniya by Hillman, Madeyska & Hather (1989).

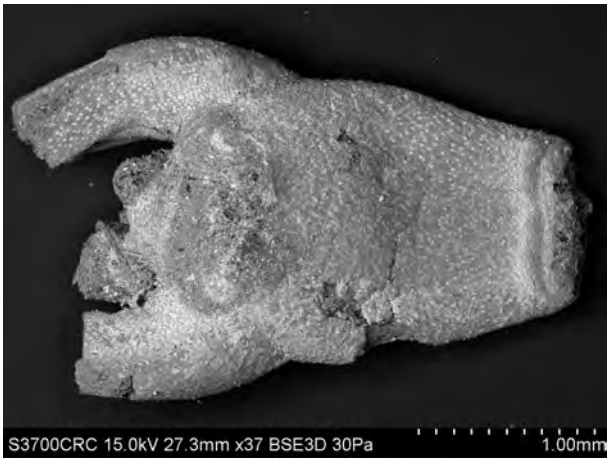

Figure 5. Backscattered electron (BSE) image of an emmer wheat (*Triticum dicoccum*) spikelet fork from a dry sieved sample (oven context 2130). (Image: C.R. Cartwright; © Trustees of The British Museum.)

In contrast, fl tation was still the best option for the smallest size fraction (0.3–< 0.5 mm). The grain size distribution of the sediments, which often contained a high

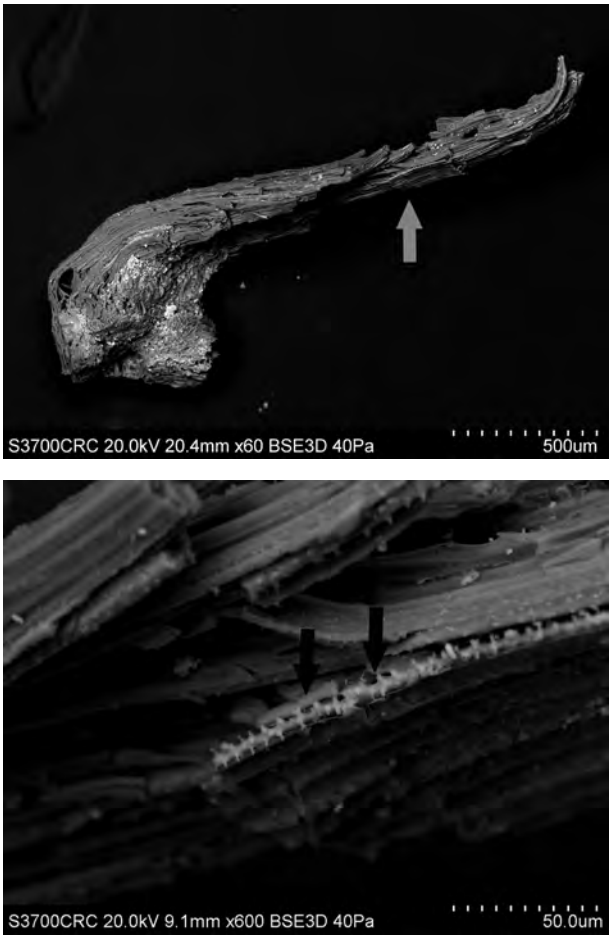

Figure 6. (a) BSE image of an emmer wheat (*Triticum dicoccum*) glume base from fl tation sample; (b) detail showing dendritic phytoliths. (Images: C.R. Cartwright; © Trustees of The British Museum.)

proportion of silts and small sands, meant that for many samples, large quantities of sediment became trapped in the 0.3 mm sieve. Th s makes it difficult to retrieve seeds, as large volumes of small sand particles need sorting. Th s sorting is also time consuming, allowing only small portions to be sorted in comparison with the fl ts (for the same amount of time invested). In addition, identification of charred items can be hampered by dirt. In some instances more items per sample were derived from dry-sieved samples than from the equivalent fl t samples, but in other instances the reverse was true. Th s difference relates most probably to the sedimentary composition of the original sample; it is easier to extract seeds from the 0.3–0.5 mm dry fractions of samples dominated by charred items compared with more sandy or very ashy samples. Furthermore, a greater diversity of taxa was retrieved from the fl ts (0.3–0.5 mm) because it was possible to sort through a larger proportion or even all of the

sample, due to the time constraints involved in sorting through the dry sieve 0.3 mm fraction.

2.4 Phytolith sampling and analysis procedures

Phytoliths were extracted from sediments through a series of laboratory steps to remove carbonates, organics, clays, and other non-siliceous elements following methods outlined by Rosen (2005). Phytoliths were mounted onto slides and analysed using a light-transmitting microscope (Olympus BH-2). Typically 300 morphotypes were counted per slide at ×400 magnifi ation.

3 Results

3.1 Macroremains

The charred seeds and other items present are detailed in Table 3. Results are shown for each archaeological context. The table includes original sample volumes, total actual numbers of items, and total numbers of items per litre for each sample. Since samples were dry sieved, as an alternative to showing fl t volumes, total charred content was estimated using comparison charts for visual estimation of percentage composition (Bullock et al. 1985; Terry & Chilinger 1955),a geological method sometimes employed in geoarchaeology (Ryan et al. 2011). Actual counts were converted to numbers per litre of sediment, and the frequency (ubiquity) for each taxon was also calculated.

Cereal grains and crop processing by-products were the most frequently represented botanical remains in the charred assemblages. The cereals present were identifi d as *Triticum dicoccum* Schrank (emmer wheat) and *Hordeum vulgare* subsp. *vulgare* L. (six-row hulled barley), the latter identifiable from well-preserved rachis internodes as well as the ratio of twisted to straight grains. There were high proportions of cereal crop processing by-products in relation to grains and high proportions of barley grains in comparison to wheat grains.

Other food plants present in very small quantities included *Lens culinaris* Medik. (lentil) and *Cucumis* sp. (a genus that includes melons). The taxon with the largest number of seeds, and which was present in the greatest frequency among samples analysed, was *Ficus sycomorus* L. (sycomore fig). High numbers of fig 'seeds' (drupelets) almost certainly refl ct the large numbers within individual figs. Whole fig fruit (syconium) fragments were also present. Wild plants, of which many were too charred for identifi ation, include *Acacia* sp., *Glinus lotoides* L. (Molluginaceae family), Trifoliaea (a Fabaceae tribe that includes clover), and the Portulacaceae family. Cyperaceae (sedges) identifi d were *Fimbristylis* sp. (fi bry) and *Cyperus* sp. (flatsedge). The relatively high numbers of *Fimbristylis* most probably refl ct the high level of silicifi ation of these nutlets.

3.1.1 Macroremain results by room

Room 9 (grain processing room): Cereal grains and chaff were abundantly present in samples analysed from different areas of the grain processing structure (Feature 2012), but were absent from fl or sample 2092 and present in low amounts from the ashy fl or deposit 2016. Samples from the emplacements for querns across Feature 2012 were dominated by chaff, with greater proportions from wheat than from barley. Barley and wheat grains were present in each, and very small numbers of wild grass caryopses were present in two of the three samples. Other seeds present in Room 9 included *Ziziphus spina-christi* (L.) Willd. (Christ's thorn) and *Lens culinaris*. The three samples from Feature 2012 also contained *Ficus sycomorus* 'seeds' and various other categories of small seeds, including sedges.

Room 10 (oven room): All of these samples were from ashy deposits within or near ovens. The cereal assemblages from rooms 9 and 10 were similar, with some possible slight differences (Fig. 7). Wheat grains were only present within one oven sample, and overall there were higher proportions of barley chaff in Room 10 in comparison to Room 9. There were also greater numbers of small wild grass caryopses in the Room 10 samples. Samples also contained other categories of small seeds, including sedges and *Ficus sycomorus*.

Room 11(small room adjacent to the oven room): The sample, although it was taken from a sandy/ashy deposit, contained no charred seeds.

Room 7 (courtyard): The storage bin sediment sample analysed contained no charred seeds.

Rooms 5 and 8: The two fl or samples, one of which was ashy, contained no charred seeds, and hearth deposit 2155 contained only very small numbers of seeds.

3.2 Phytoliths

Table 4 shows the numbers per gram sediment of the different types of phytoliths present. For most of the histograms discussed below, relative percentages were calculated for different morphologies. Th s is because numbers of phytoliths per gram sediment are affected by the variable sediment components of different context

Table 3. Charred seed counts per litre of sediment. x = present.

Archaeological sample no.	**16**	**17**		**19**	**3**	**22**	**23**	**26**	**28**	**24**	**9**	**274**	**276**	**275**	
Context no.	2025	2026	2083	2092	2016	2042	2104	2128	2130	2113	2044	2098a	2098b	2155	
Litres processed	2.5	2	2	1.5	1	4	3	4	4	3	2	1	3	3	
Proportion charred content	12%	7%	20%	2%	12%	40%	35%	45%	30%	2%	0%	1%	1%	5%	
Total items per litre	126	86	137.5		33	207.3	580.7	155.8	198.3					8.6	
Total items in sample	316	172	275		33	829	1742	623	793					26	
n per litre sediment															**Ubiquity**
Cereals															
Hordeum vulgare (grain straight)		1	1.5			0.25	1.3	1	0.25					0.3	*
Hordeum vulgare (grain twisted)	0.4	3	1			1	0.7		0.25						*
Hordeum vulgare (grain indet.)	0.4	6	0.5		1	2	3.3		0.25						*
subtotal *Hordeum vulgare* (total grain)	***0.8***	***10***	***3***		***1***	***3.25***	***5.3***	***1***	***0.75***					***0.3***	***64%***
Hordeum vulgare (rachis)	6.4	8	16.5		3	25	44	5.5	20.25					1.3	64%
Triticum dicoccum (grain)	2.0	2	0.5				0.7							0.3	36%
Triticum dicoccum (spikelet fork)	9.2	7	40		3	19	42.7	1.5	39.25					0.6	†
Triticum dicoccum (glume base)	27.2	16	34		1	24	13.3		91.5					1.3	64%
Cereal (grain indet.)	2	1	2		1	2	2.3	2	0.5					1	64%
Cereal culm nodes	0.4					4	1.3								21%
Pulses															
Lens culinaris							0.3							0.7	14%
Large legume	0.4		0.5												14%
Fruits															
Ficus sycomorus ('seed')	72.8	28	30		22	79	402	116	34						57%
Ficus sycomorus (whole fruit frags.)			x					x							14%
Cucumis sp.			2												7%
Ziziphus spina-christi			0.5					0.25							14%
Wild/weed															
Poaceae caryopses (small indet.)	0.4	0.5	2		1	14	0.6	11	2						57%
cf. *Phalaris* sp.	0.8														7%
Lolium cf. *perenne*							0.3	0.5							14%
Poaceae culm node						4			2						14%
Acacia sp. (seed)	0.4						1								
Acacia sp. (seed fragment)	x				x	x	x								29%
Small legumes cf. Trifolieae						4	1.3								14%
Cyperus sp.		1													7%
Fimbrystylis sp.	3.2	9				8	5.3		4						36%
Corchorus sp.			2			1		0.5							21%
Glinus lotoides		1					32		4						21%
Indet.															
		2	4			19	27.3	17.25						3	43%

* Combined under subtotal *Hordeum vulgare* (total grain); † Combined under *Triticum dicoccum* (glume base).

Table 4. Phytolith counts per gram of sediment.

Archaeological sample no.	15	16	17		19	3	23	26	28	42	24	9	274	276	275
Context no.	2022	2025	2026	2084	2092	2016	2104	2128	2130	2182	2113	2044	2098a	2098b	2155
n per gram sediment															
Single cells															
Smooth LC[M]	8175	5915	7102	8921	3172	8673	9240	1951	23561	7279			4650	1152	687
Sinuate LC[M]		539							3534	1456					172
Echinate LC[M]		3586	6391				3593	1170		5095	6577				69
Dendritic [G]	13387	1076	4971	10903		4336	26180	5852	51834	14557	75637		1033		
Dendriform [G]										1098					
Trapezoid sinuate/crenate [G]			710												
Papillae [G]		896	1597	2974			774	967	2356	1456	4385				
Keystone bulliform [G]		179		2459	4758		253		1472						102
Bilobate SC[G]		717		991			1027								
Polylobate SC[G]															
Cross SC[G]										728					
Saddle SC[G]	1487	359	5681			2168				3639					
Saddle topped trapezoid SC[G]							513								
Rondel SC[G]	7437	3944	5681	3965		2168	10267	780	8246	8007	8769				137
Indet. SC[G]	16350		3551				2567								240
Rod smooth LC[M]	4462		1420	3469			1540		3534	2911					
Assymetrical LC[M]		359	5681	6938			2053	2341	7068		5481				343
LC with projections on one side [M]			7812	6865	6345	6505	1282	1560	4712		4385				618
Stomata [M]						1084		184							0
Hair - indet.	3676	5737	22015	17841	15862	21682	13347	5852	41231	9825	18635		14984	6915	1305
Bulliform [M]	12631	7889	13493	9912	12690	5420	7187	3511	8246	7279	6206		6717	5762	1511
Cones cf. sedge	4462	3764	2307				4620	1170	1178	728	4385		517	1440	0
Globular decorated indet.			2900			8673		4281		1456			1033		275
Globular echinate cf. palm	14870		2130	1982		6505	5136	3902	2356	9462	3289		3100		206
Globular rugulose cf. palm			710							728					
Dicot elongate [D]			353						884	1456				864	278
Tracheids [DM]	2975	1434				3202	1790		2356		6577				
Single polyhedral [D]	19337	6095	7812	2974			513	4292	10602	5823	25212		2067		1442

Irregular psilate [DM]	15618	3227	4261	7930		8673	1540	390	1178	2911			7750	4610	480
Irregular scrobiculate [D]			1775			4336				990				6339	
Irregular scalloped [D]													517	576	
Tabular scrobiculate [DM]					3172	1084									
Tabular facited edges [DM]			533	505											
Multicells															
Indet. monocot [M]	23799	5464	9232	13876		19875	9240	8974	68326	8189			8220		936
Silica skeleton smooth LC[M]	4282								8540						
Silica skeleton sinuate LC[M]		863	1346				1396								
Silica skeleton echinate LC[M]															
Silica skeleton with rondels SC[G]	2854	144					1625		2062						
Silica skeleton with grass stomata [G]									3534						
Silica skeleton with bilobates SC[G]	1427														
Silica skeleton with saddles SC[G]		215	2051				1396		1178	2736					
Cereal straw/rachis	2975	383					2781	780	10602	337	2035				
Bulliforms [M]	1487	575	12072	2817					2650	6551					202
Silica skeleton assymetrical LC[M]										1368					
Palm multicell		1150	2130	939		28910	3250	3511	1178	2184			470		65
Silica skeleton cf. sedge	1427	288	352	939		1807	1396		2356	674					131
Non ID grass husk silica skeleton (C_3)	5950	1150	673			1807	3251	2340	11780	1368	17294				
Wheat husk silica skeleton		1438	673				2324	780	10602	674	3052				
Barley husk silica skeleton		288					927	1561	5890	2042	5087				
Wild grass husks (C_3)		288				3614	469			674					
Polyhedron multicell (woody dicot leaf)	11900	6902	5681	9912		7227	2324	3902	20027	4779	25433				226
Tracheid multicell [D?]			1420						4712		1525				

[M] = monocot; [G] = grass; [D] = dicot; LC = long cell; SC = grass short cell

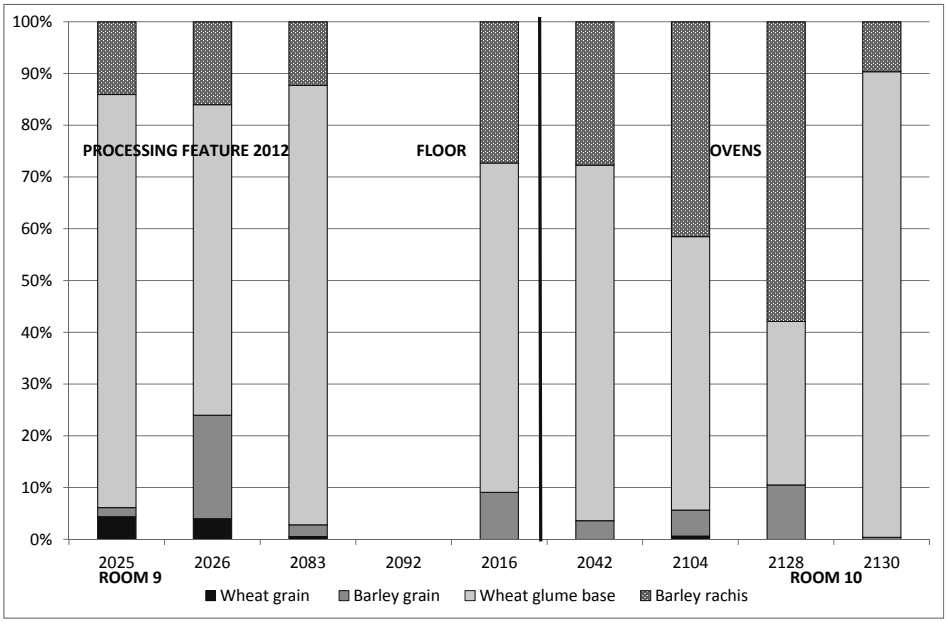

Figure 7. Histogram comparing the charred cereal assemblages from rooms 9 and 10.

categories. However, it is also useful to consider numbers per gram sediment, since percentages sometimes can over-inflate the importance of very small phytolith numbers in samples with low phytolith content.

3.2.1 Single cell phytoliths

A summary of single cell phytoliths, aggregated into monocot, dicot, and palm categories, is shown in Figure 8. These categories are present across all of the samples, but they display some differences in relative proportions and quantities. Sediments from context 2044 (the storage bin in Room 7) had no single cell phytoliths. High relative proportions of dicot phytoliths in comparison to monocots were noted in contexts from rooms 8 and 5, and also in 2092 and in 2016 from Room 9. Palm (globular echinate) phytoliths were intermittently present across the samples. Proportions of different types of grasses are examined in more detail in Figure 9, which compares the relative proportions of different types of grass 'short-cells'. No grass short-cells were present in samples 2092 (Room 9) and 2044 (Room 7) and the two samples from Room 8. Overall, rondel phytoliths (most frequently found in C_3 pooid grasses, which include cereals) were present in the largest proportions and found in 11 contexts. Saddle forms (most frequently found in chloridoid C_4 grasses) were present in more moderate relative proportions and

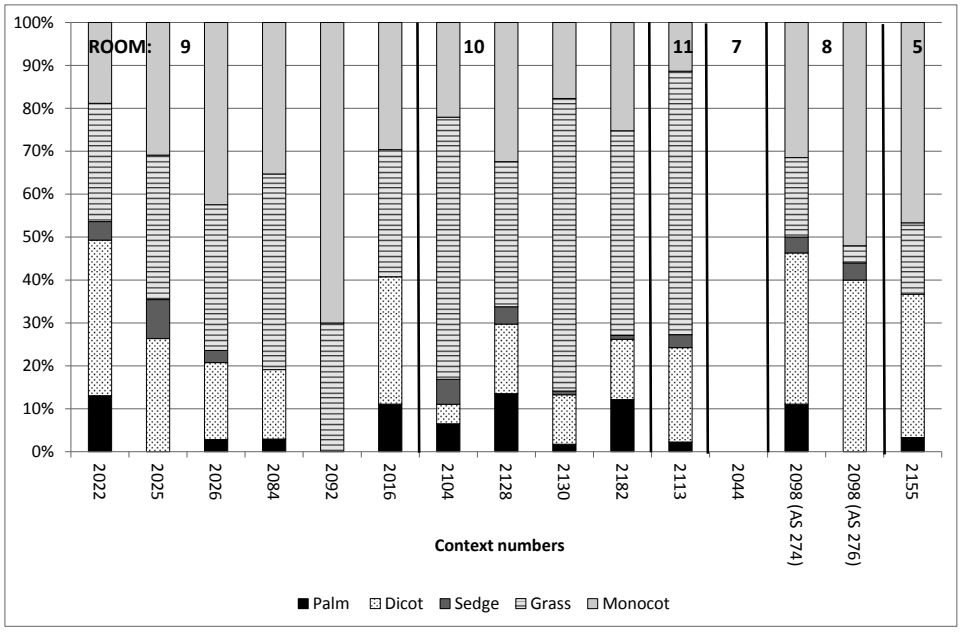

Figure 8. Histogram comparing relative abundances (%) of single cell phytoliths.

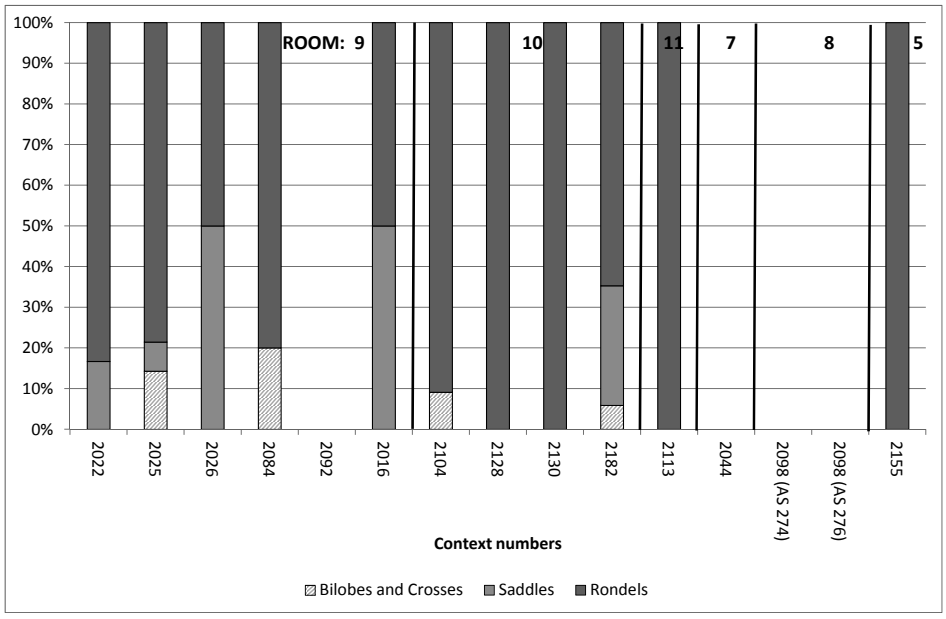

Figure 9. Histogram comparing relative abundances (%) of different grass 'short-cells' phytoliths.

quantities, in fewer samples, but in similar proportions to rondels in samples 2026 and 2016 from Room 9. Bilobate and cross forms (found in panicoid C_4 grasses) were present in the lowest proportions and fewest samples. The histogram in Figure 10 compares numbers of husk single cells (incorporating papillae and dendritic cells [Fig. 6b]) between samples. Grass husks are discussed in more taxonomic detail for the multicell record below; however, the single cell record can provide insight into the presence of grass husks in cases where multicells are not present (for instance, because they are disarticulated). Husk single cells were present in the ashy contexts from rooms 9, 10, and 11and low/absent in rooms 5, 7, and 8.

3.2.2 Multicell phytoliths

Figure 11a shows a summary of the main categories of multicells present, comparing relative abundances (%) of leaf/stem phytoliths, total husks (cereals + wild + unidentifi d), and palm and dicot leaf (polyhedrons) (Fig. 12). Sediments from contexts 2092 (Room 9), 2044 (Room 7), and 2098 (AS 276) (Room 8) contained no multicell phytoliths. In the other samples, leaf and stem phytoliths

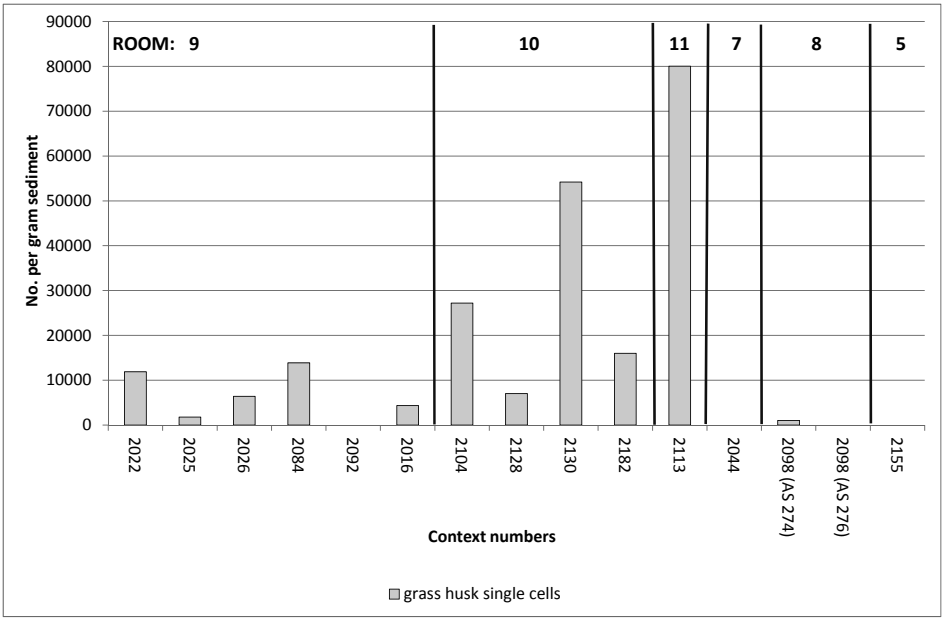

Figure 10. Histogram comparing numbers per gram sediment of grass husk single cell phytoliths.

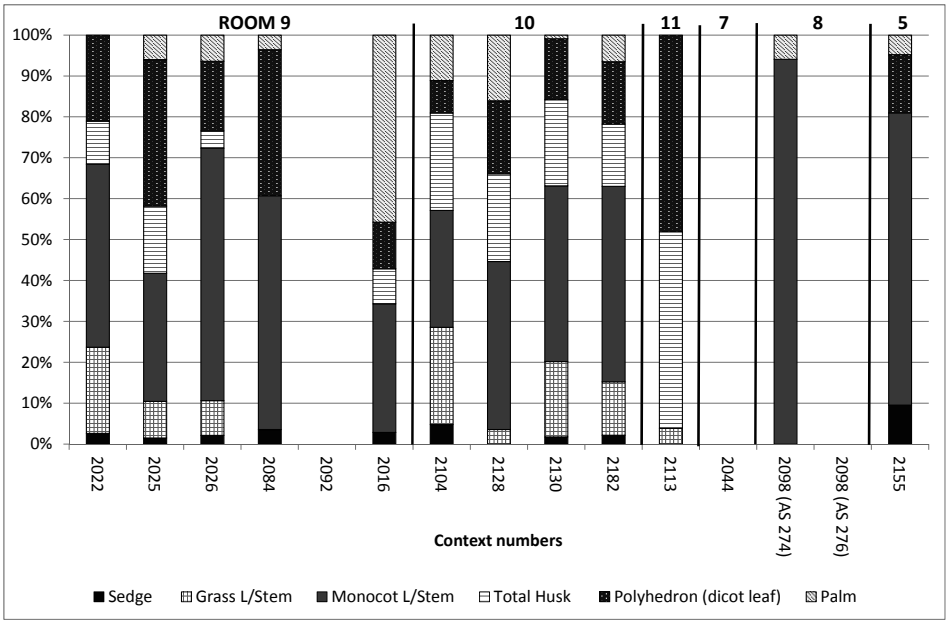

Figure 11a. Histogram comparing relative abundances (%) of multicell phytoliths.

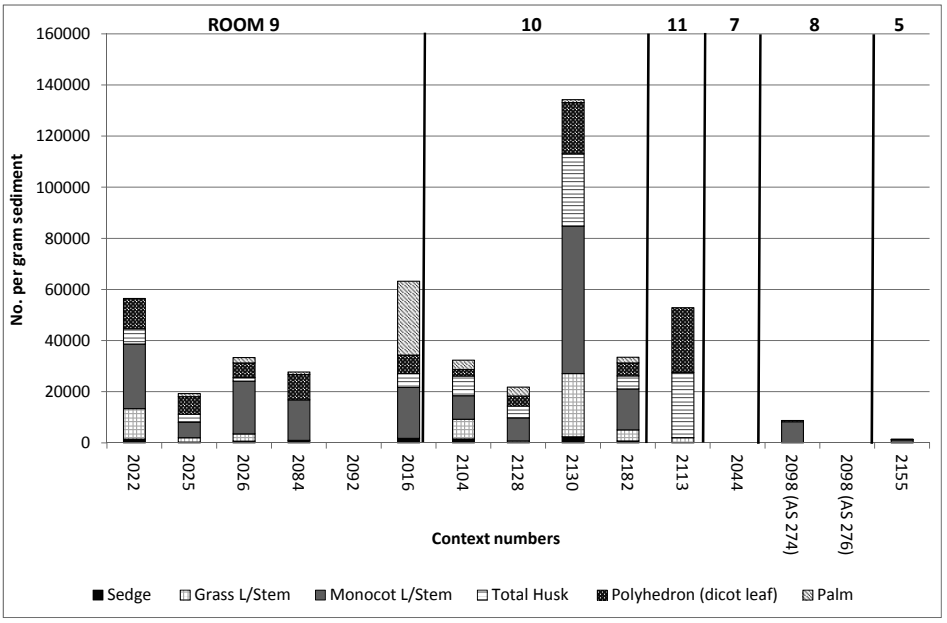

Figure 11b. Histogram comparing numbers per gram sediment of multicell phytoliths.

were ubiquitous. Husks were variably present, with the largest relative proportions and occurrence in samples from the oven room and the possibly related ashy deposit in adjacent Room 11,whilst rooms 5, 7, and 8 had no husk multicells present. Proportions of palm and dicot leaf phytoliths were variable among contexts, with ashy fl or deposit 2016 (Room 9) having the highest proportion of palm multicell phytoliths. Several samples had moderate to high proportions of dicot leaf phytoliths, especially context 21B (Room 11).Figure 11bshows the numbers of multicell phytoliths per gram of sediment, and thus more clearly shows the small numbers of phytoliths in some samples, for instance, in that from ashy context 2155. Grass husks in the multicell record were categorized as wheat (Fig. 13), barley, non-identifiable (C_3), wild (C_3), or panicoid. The relative proportions (%) among these categories are shown in Figure 14.

No grass husk multicell phytoliths were present in the samples from rooms 5, 7, and 8. Within Room 9, proportions of husk multicells varied; two samples had high proportions from wheat, one contained small proportions from barley, two had no husk multicells, and one con-

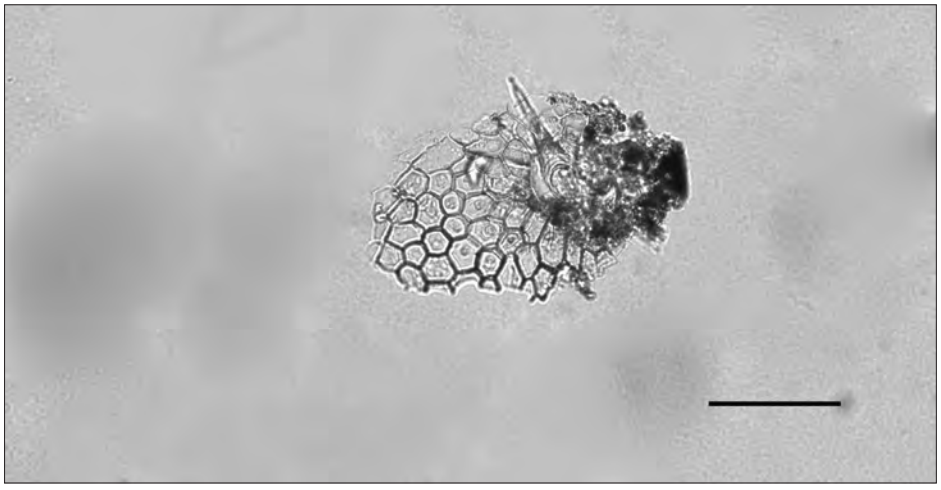

Figure 12. Multicell phytolith cf. dicot leaf from oven context 2130, scale bar 100 microns. (Image: P. Ryan; © Trustees of The British Museum.)

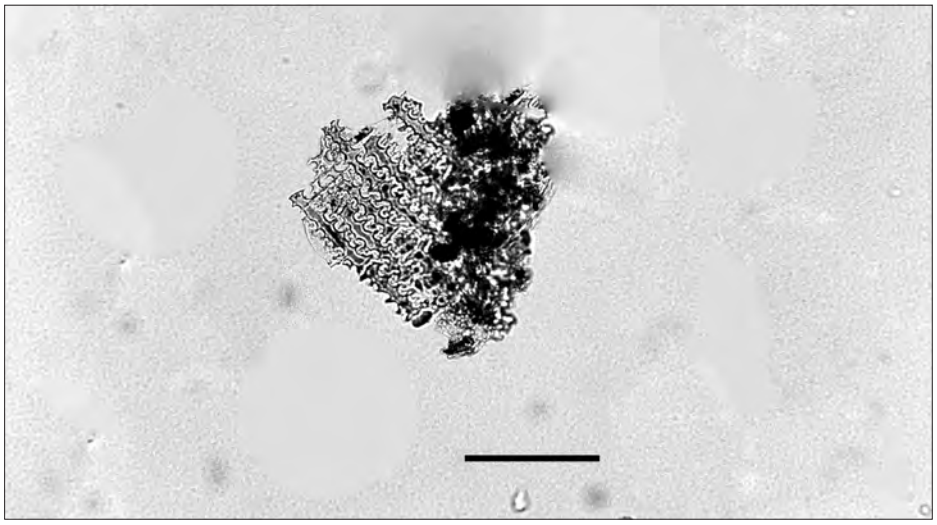

Figure 13. Multicell phytolith cf. wheat husk (*Triticum* sp.) from oven context 2130, scale bar 100 microns. (Image: P. Ryan; © Trustees of The British Museum.)

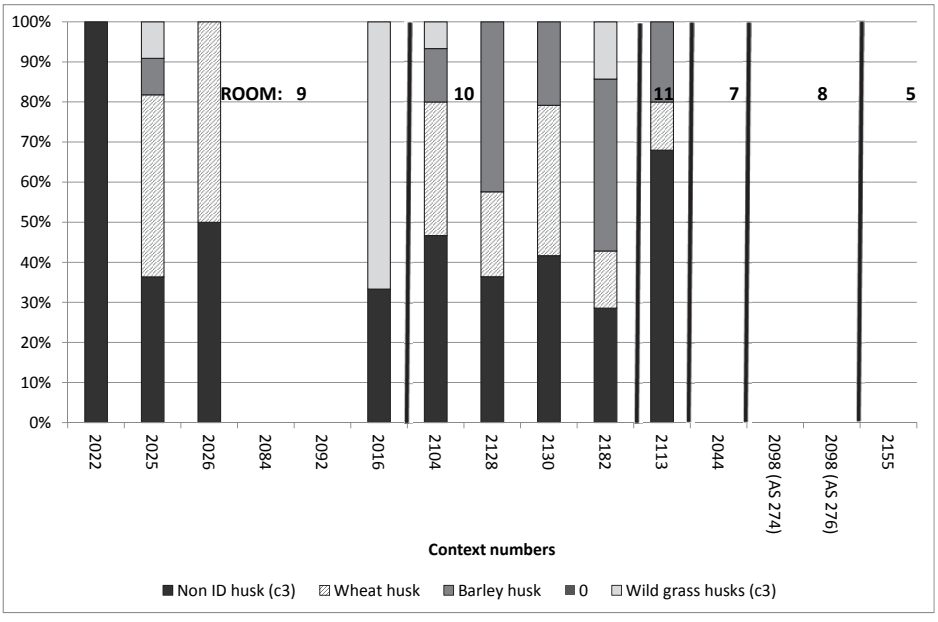

Figure 14. Histogram comparing relative abundances (%) of grass husk multicell phytoliths.

tained unidentifiable husk forms. In contrast, wheat and barley husk phytoliths were present in all of the samples from Room 10, and the ashy sample from Room 11had a similar composition to that of Room 10. Two samples from Room 10 and one from Room 9 contained small proportions of wild grass husk phytoliths, and one sample from Room 9 was notable for having the highest proportion of wild grass husks (which were from C_3 grasses), in combination with zero cereal phytoliths.

3.2.3 Phytolith results by room

Room 9 (grain processing room): Several differences were observed among the different samples analysed from Room 9, and between these samples and those from the other villa rooms. In comparison with all the other samples analysed, samples from 2055 and 2056 (different areas of emplacement for grinding stones 2012) had the highest relative proportions of wheat husk phytoliths, whilst ashy fl or sample 2016 had the highest relative proportions of phytolith multicells from wild grass husks and also from palms. Floor context 2092 forms a further contrast within Room 9, being the only sample to have no phytoliths from grass husks and no multicell phytoliths.

Room 10 (oven room): All of these samples were from ashy deposits within or near the cylindrical ovens. The overall phytolith compositions among samples were similar, with only slight variations. All contained phytoliths from monocot leaves/stems, dicots, palms, and cereals. Two also contained phytoliths from wild grasses (which included pooid grass husk multicells and single cells from C_4 grasses of uncertain plant part).

Room 11(small room adjacent to the oven room): The grass husk composition of ashy context 21Ɓ was similar to deposits analysed from Room 10. However, there were differences among proportions of other phytoliths present. Only small proportions of monocot leaves/stems were present, in contrast with comparatively high proportions of dicot leaf phytoliths.

Room 7 (courtyard): The sample analysed from a storage bin context in courtyard Room 7 did not contain any phytoliths.

Rooms 5 and 8: In the single cell record, these samples contained mainly dicot phytoliths and morphologies identifiable only as monocot. Fewer grass single cell phytoliths were identifi d than in the other samples, and grass husk single cells occurred in only one sample (2098), and in negligible numbers. Small numbers of multicells were present in two of the samples (ashy fl or sample 2098 and hearth 2155), and these were dominated mainly by morphologies identifiable as monocot leaf/stem, with smaller proportions from palms, and in the hearth sample, also from sedges and woody dicot leaves.

4. Discussion

4.1 Comparison of macroremains and phytoliths

The macroremains have enabled the identifi ation of a wider range of plant taxa, whilst the phytoliths have provided information about certain plant parts less frequently identifi d in the macrobotanical record, such as leaves and stems. Diagnostic husk phytoliths are found in the lemma, palea, and glume (no phytoliths are present within grass seeds). Both datasets have provided information about cereals and wild grasses. Sometimes the presence of barley chaff does not correlate as clearly as that of wheat between the datasets because barley rachises (the stems within the cereal ear) do not produce husk phytoliths, but, rather, phytoliths associated with cereal stems. Wild C_3 grasses were identifi d in both the macrobotanical and phytolith record. However, generally, small wild grass caryopses were often very highly charred in the macrobotanical record from the villa; here the phytolith record provided additional information about the types of wild grasses present. Small quantities of C_4 grasses were noted in the phytolith record from the villa, particularly from chloridoid grasses, but also (more occasionally) from panicoid grasses. Th s is interesting, as chloridoid grasses are generally more arid-adapted (Twiss 1992). Occasional charred chloridoid grass seeds have also been identifi d in deposits analysed from other buildings at Amara West. Phytolith information also provided plant evidence for contexts where few or no charred macroremains had survived (notably the ashy deposit in Room 8) and confi med in other instances the absence of plant remains (such as in the storage context).

Processing Room 9 and oven Room 10 were notable for the presence of abundant cereal remains, particularly chaff, possibly refl cting the activities of crop processing and the burning of crop processing waste. Some possible differences between the grain processing structure contexts (Room 9) and the oven room (Room 10) were noted. Both sets of deposits contained, overall, similar quantities of charred wheat chaff per litre sediment. However, both the phytolith and charred record showed greater relative proportions of chaff from wheat than from barley within deposits from the grain processing structure contexts (Room 9) in comparison with deposits from the

oven room (Room 10). In addition, wheat grains were recovered with greater frequency from the grain processing structure than from the ovens, whilst one of these grain processing samples also had the highest numbers and relative proportions of barley grains. One of the two Room 9 fl or samples had low/absent plant content in both the macro- and microbotanical record. The other sample, which was ashy, contained few macroremains, but the phytolith data indicated comparatively high relative proportions of both wild grass husks and palms. The burnt wild grasses from the fl or in the processing room possibly represent a distinctive episode and location of burning crop-cleaning debris. The high relative proportion of multicell phytoliths from palms also marked this fl or deposit as distinct from the other ashy deposits. Charred cereal remains around the processing feature may also relate to parching; however, experimental work in Egypt suggested that the process of parching prior to de-husking was not required due to aridity (Nesbitt & Samuel 1996). Another possibility is that ash was spread around quern settings deliberately, although the potential purpose of this is unclear. Miller (1987) has argued that, because ash has insecticidal properties, ash found beneath saddle querns at Tell el-Amarna may have been deliberately spread for this purpose.

The presence of wheat chaff in processing Room 9 and oven Room 10 suggests that emmer was stored in spikelet form. During threshing of hulled cereals the ears are broken down into individual spikelets. They can be stored in this form, but they then require a second processing stage to release the grains from the husk. For emmer wheat, the by-product of this second processing stage comprises light, papery lemmas and palea parts and more robust spikelet forks (or individual glume bases), and it is these parts that survive in the charred record. In contrast, during threshing, barley breaks into spikelets consisting of grains within a tightly fused lemma and palea, and segments of barley rachis. Thus, the presence of barley rachis segments is more ambiguous than that of wheat husk chaff (glume bases/spikelet forks). Barley rachis chaff may have been deliberately collected off-s te to serve as tinder for fi e-lighting. Another possibility is that barley ears were harvested and stored in ear form. Barley may also have been associated with dung. Much of the barley was well preserved and would not have survived well after animal digestion, so perhaps cereal remnants were incorporated into dung deposits in animal pen fl ors through trampling. Dung pellets have been identifi d in some charred deposits on the site, but pellets have not been recovered (so far) from the villa samples—though this may refl ct burning temperatures rather than real absence. Barley remains may also derive from their processing for food; some grains displayed hull (lemma and palea) removal, and barley grains were recovered from all the grinding emplacement samples. It is interesting that there were slight differences in proportions of barley to wheat chaff between rooms 9 and 10, suggesting some possible different routes into these contexts for wheat and barley.

In both rooms 9 and 10, phytoliths from monocot leaves/stems (including grasses and sedges), woody leaves, and palms most probably derived from the ashy remains of fuel. Some of the small wild seeds (including the grasses) may have entered the record with leaves/stems in connection with fuel or may have been present as crop weeds. An ashy context from Room 11(near oven Room 10) was analysed for comparison with the oven deposits. Although no seeds were preserved in the ash, it did contain cereal phytoliths and, in contrast to the oven deposits, high proportions of phytoliths from woody leaves and a few from monocot leaves/stems. All this suggests the fuel was of a different composition and that these ashes were not necessarily spread from the adjacent room.

The sample from the storage bin sediments (Room 7) was sterile in both datasets, indicating the deposit was purely wind-blown sand and suggesting that the bin had been emptied prior to abandonment. Such a practice would fit within the broader picture of careful abandonment suggested by the comparatively few artefactual fi ds and clean fl ors of the villa. The samples analysed from rooms 5 and 8 contrasted with those analysed from other rooms. Cereals were absent in the record from Room 8, and Room 5 contained negligible numbers of charred cereals and no evidence of cereals in the phytolith record. Phytoliths present in these two rooms probably derived principally from burnt fuel. The southern part of the building seems to be more associated with cereal processing, with ashy samples from the north area of the villa predominantly refl cting only fuel remains. The hearth in Room 5 would have been one of the focal points to life in the house, providing heat for cooking and warmth. The archaeobotanical record thus confi ms interpretations based on the architectural layout and presence of features.

4.2 Comparison with other site contexts

The villa analyses form part of a pilot study and of ongoing research into the archaeobotanical evidence from smaller houses within the north-western part of the town (E13.3-N and E13.3-S); a circular building (E12.11); and other samples, such as from roofi g fragments (Ryan et al. 2012; Ryan & Spencer 2013). There are no burnt

buildings on-site, and charred plant remains most probably represent fuel and other plant materials connected to cooking or debris. Exceptions include desiccated fragments of textile and basketry and wood artefacts preserved in cemetery contexts. Preservation via desiccation in later time periods (in cemetery contexts) may relate to increased aridity. Overall fi dings were similar to samples analysed from other site contexts, but there are also some initial distinctions. So far, there is also a greater proportion of barley to wheat in the smaller houses, E13.3-N and E13.3-S, particularly in the chaff record (45% wheat, 55% barley), whilst another notable difference was the presence of flax seeds in E13.3-S (Ryan et al. 2012). Some other taxa present elsewhere in the charred macrobotanical record but not yet identifi d in the villa include *Hyphaene thebaica* Mart. (doum palm), *Citrullus lanatus* (Thunb.) Matsum & Nakai (watermelon), and the closely related wild relative *Citrullus colocynthis* (L.) Schrad. (colocynth).

A key difference between the villa and the smaller houses seems to be that storage bins were not present in the latter. It is possible that the smaller houses received cereal supplies either from the larger houses or from storage magazines under the centralized control of the town administration and then maybe kept them in perishable storage containers. The different proportion of wheat to barley grains and chaff between the villa and smaller houses may also suggest variable household access to cereal resources. However, some differences in charred cereal assemblages may be context-related, since the charred deposits analysed from the smaller houses are so far all from ovens and hearths. Differences may also refl ct varied taphonomic pathways for grains and chaff in relation to, for example, crop processing debris collection and disposal practices or fuel use. Some of the smaller houses in the town that are contemporary with the villa (E13.4, E13.5, E13.6) were provided with suites of cylindrical ovens and grinding emplacements, though on a smaller scale than at villa E12.10. All houses were provided with a circular hearth, but other approaches to foodways are evident within the town. Houses E13.3-N and E13.3-S seemed to have shared a space that housed ovens and grinding emplacements. Th s space (E13.13) was accessible from the front door of each house; such an organization has implications in terms of privacy and social interactions within the ancient town. Villa D12.5 (currently being excavated), to the south of and of similar scale to villa E12.10, was also provided with a food processing suite, though it was arranged differently: a long room with three circular silos for possible grain storage, followed by rooms dedicated to grinding emplacements and ovens. One silo is provided with a mud plaster fl or; the other is paved with schist and coated in white plaster, perhaps suggesting differential use patterns.

4.3 Diet and plant use at villa E12.10 in the context of New Kingdom Egypt

The evidence thus far suggests that the cereals were Pharaonic winter crops. Bread and beer were staple Egyptian foods and were also common ritual offerings (Samuel 2001). There is not yet any evidence for local African grass exploitation, and this is clear in both the macrobotanical and phytolith record. However, analyses from new buildings or site levels at Amara West may alter this picture. Low numbers of pulses found at Amara West fit with similar observations elsewhere in New Kingdom Egypt (Murray 2000; Stevens & Clapham 2010).

Circular structures interpreted as ovens and features interpreted as grinding emplacements at Amara West are both similar to those excavated in Egypt, including at Tell el-Amarna (Samuel 2000). Like at Amara West, there is also evidence for storage facilities within various categories of elite homes at Tell el-Amarna (Kemp 1994). In contrast, the villas at Amara West were not situated within a walled compound, which, at Tell el-Amarna, included external subsistence activity areas such as circular grain silos, kitchen areas, and animal pens (Kemp 2006: 327-329). There are no stone mortars (for cereal de-husking) at Amara West such as those found at the workmen's village at Amarna or Deir el-Medina in Egypt (Samuel 2000); it is possible that wooden implements were used instead.

5. Conclusions

The different lines of archaeobotanical data are useful for cross-checking results and providing different categories of information about plant use. Archaeobotanical remains from Amara West are contributing to a better understanding of the late second millennium to early fi st millennium BC in Nubia (Ryan et al. 2012). The identifi ation of wood, charcoal, and textile fibres from the cemeteries and settlement is ongoing, and the phytolith and seed record will be usefully combined with the charcoal data for a fuller view of fuel exploitation and differences in fuel use among individual ovens and hearths. Future aims also include further comparison between the villa and other site areas, with excavations ongoing both inside the walled town and in the extramural suburb. Temporal analyses will be important for investigating the

impact of increasing local aridity on agriculture and plant use strategies.

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