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ORIGINAL ARTICLE

The earliest finds of cultivated plants in Armenia: evidence from charred remains and crop processing residues in pisé from the Neolithic settlements of Aratashen and Aknashen

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Abstract Analyses of charred remains and impressions of chaff in pisé (mudbrick) from the Neolithic sites of Aratashen and Aknashen (sixth millennium cal B.C.) situated in the Ararat valley in Armenia demonstrate that naked barley and possible naked (free-threshing) wheat together with emmer and hulled barley were common. Two lesser known crucifers, *Camelina microcarpa* (false flax) and *Alyssum desertorum* (alyssum) were found in the form of crop processing residues. These were frequent in the pisé, indicating their use perhaps as an oil source. *Lens culinaris* (small-seeded lentil) and *Vicia ervilia* (bitter vetch) were recovered both as carbonized seeds and from crop processing residues in the pisé. False flax and bitter vetch were less common than alyssum and lentil. Two charred pips of *Vitis vinifera* (wild vine) were recovered, suggesting the early use of vines in the region. Flotation samples alone would have provided limited data; examination of crop processing residues used for tempering pisé provided important evidence of the plant economy at these two sites.

Keywords Neolithic · Caucasus · Early farming · Cereals · Oil plants · Wild plant use

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Introduction

Prior to the present study there has been little systematic sampling of sites in the region, and published results concerning crop plants are limited to a small number of finds (Lisitsina 1984; Gandilyan 1997). The aim of this work was therefore to gain for the first time evidence for the agricultural economy in the Ararat valley during the Neolithic.

Aratashen and Aknashen are the earliest known agricultural settlements in the Republic of Armenia (Avetisyan et al. 2006), and they are the only Neolithic sites to have been sampled for plant remains. The sites are situated in the Ararat valley, on the banks of the rivers Kassakh and Sev-Jur (tributaries of the Arax), at an altitude of 850 m a.s.l. (Fig. 1) and are separated by only 5 km. Aratashen (N 40° 08′ 08.2″, E 44° 14′ 05.3″) is located 5 km southwest, and Aknashen (N 40° 06′ 05.8″, E 44° 17′ 38.9″) about 6 km south of Vagharshapat, the ancient capital. Both sites are low mounds or tells (*blur* in Armenian). The excavated structures consist of circular daub buildings constructed in pisé (mudbrick). Larger structures are interpreted as houses, the smaller ones as ovens (*tonir* in Armenian) or storage structures (see Fig. 2).

The site of Aratashen has 2.5 m of stratigraphy, with two archaeological levels: I (upper) and II (lower). Level I was about 1 m thick and level II about 1.5 m. Radiocarbon dates indicate that the earliest level (II) dates to the first half of the sixth millennium cal B.C. Level I falls between middle of the sixth and middle of the fifth millennium cal B.C. (see Table 1). The upper levels of the site were destroyed by recent terracing works. Preliminary results at Aratashen have been published (Badalyan et al. 2007).

The Aknashen stratigraphy is 4 m deep. It is divided into 5 levels. Levels 1–4 of the site belong to the Pottery

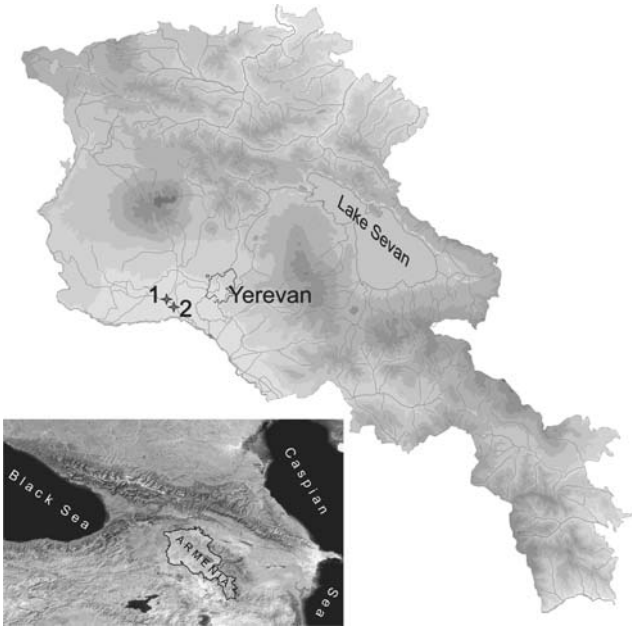

Fig. 1 Site location map. Aratashen 1, Aknashen 2

Neolithic period. The earliest level, 5, at Aknashen dates to the beginning of the sixth millennium cal B.C. (see Table 1; Badalyan et al. 2007).

At both sites numerous finds of querns, mortars, stone tools and obsidian sickle blades provide evidence of crop processing activities.

The sites are situated on a plain in the Ararat valley which slopes towards the river Arax. The climate of the area is continental with cold dry winters with an average temperature in January of −6°C. Spring is moist, while summers are hot and dry with an average temperature of 25°C. Autumn is dry and mild. Annual rainfall varies between 200 and 300 mm. Irrigation is practised in the region today and there is no dry farming (Baghdasaryan 1962). Prior to human impact the vegetation was probably a steppe with scattered deciduous trees and gallery forests along the rivers.

Material and methods

Sampling was carried out during the excavation and pisé was systematically sampled from the buildings. Charred and mineralized seed remains were recovered by flotation using a 0.3 mm mesh size. The sediment was wet-sieved using a 1 mm mesh size. The flotation samples came from hearths, floors, pits, etc. Approximately 510 l of sediment were processed at Aratashen (15 samples), and 780 l at Aknashen (72 samples; see Table 2). The average volume of the samples was 10–20 l. The charred remains represent less than 1% of the processed sediments; they were better preserved at Aknashen compared to Aratashen probably because of the depth of the sediments. The pisé was generally very fragile except in cases where it had been burned. Charred material was also found trapped in the hardened burnt pisé. Occasionally we consolidated the pisé with diluted water-based emulsified acrylic resin to conserve the remains.

The total number of identifications for each taxon, both charred and mineralized, is given in Table 2. For the impressions approximate frequencies are given. The identifications were made using the comparative seed collections at the Institute of Botany of the National Academy of Sciences of Armenia and the relevant literature (Maysuryan and Atabekova 1931; Kats and Kats 1946; Dobrokhotov 1961; Takhtajyan and Fedorov 1972; Gandilyan 1980; Dorofeev et al. 1976, 1979; Lukjanova et al. 1990; Terrell and Peterson 1993; Zohary and Hopf 2000; Takhtajyan 1954–2001; Jacomet 2006a). Nomenclature for cultivated plants follows Zohary and Hopf (2000, traditional classification), and for weeds and wild plants Czerepanov (1995) and Takhtajyan (1954–2001).

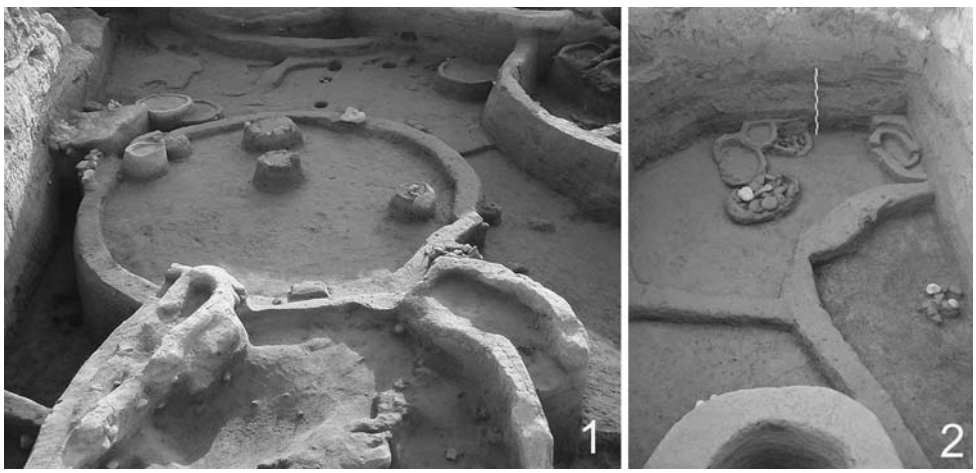

Fig. 2 Photos showing the excavated pisé structures at Aratashen 1 and at Aknashen 2

Table 1 Radiocarbon dates from the two sites

Level	Material	Sample N°	B.P.	cal B.C. (1 σ-range)	cal B.C. (2 σ-range)
Aknashen					
3	Charcoal	Ly-13664	6350 ± 70	5470–5260	5475–5084
4	Charcoal	AA-68559	6868 ± 40	5796–5712	5840–5669
4	Charcoal	UGAMS-02293	6550 ± 50	5610–5470	5620–5370
5	Charcoal	AA-68560	6930 ± 44	5845–5743	5903–5724
5	Charcoal	UGAMS-02292	6900 ± 50	5840–5720	5890–5660
5	Charcoal	AA-68561	7035 ± 69	5990–5871	6024–5753
5	Charcoal	Ly-13665	6920 ± 55	5840–5720	5980–5660
Aratashen					
IIa	Bone	Ly-2269	6660 ± 60	5632–5537	5663–5481
IIa	Charcoal	Ly-2268	6820 ± 55	5741–5657	5811–5627
IIb	Antler	AA-64175	6948 ± 73	5895–5742	5988–5713
IId	Charcoal	AA-64176	6821 ± 46	5735–5664	5791–5631
Iid	Charcoal	AA-64178	6866 ± 49	5809–5707	5848–5658
Iid	Charcoal	AA-64177	6913 ± 49	5839–5737	5905–5711

Results

572 items of charred and mineralized remains were identified from Aratashen, and about 70 samples of pisé (we use this term for all types of building earth) were examined for impressions which were left by the chaff temper (Table 2). 2991 items of charred and mineralized remains were identified from Aknashen and 90 fragments of pisé were examined (Table 2).

37 taxa were identified from samples at Aknashen and 16 from Aratashen (Table 2). Most taxa were identified from charred remains. However, examination of the pisé provided useful additional information. Plant impressions at both sites consisted of cereal chaff, including spikelet bases, glumes, stems, rachis fragments, grains and leaf fragments, etc. Capsules of *Alyssum* and pods of lentils were also common. Almost all the pisé examined contained plant impressions of cereal chaff and/or capsules of *Alyssum*. Some impressions were not identifiable. The impressions occasionally contained charred remains indicating that the pisé had been burned. The best preserved impressions were found in the burnt pisé. The number of impressions of cereal chaff varied from a few to several hundred for each fragment of pisé examined. Impressions of grains were rare because it was the chaff that was used as a tempering medium in the pisé and the grains would have been removed during winnowing. Of the charred material some caryopses were puffed and the outer layers were damaged. Many of the grains were broken and lacked the embryo.

The following cereals were identified from impressions and charred remains from flotation samples (Table 2). Grains resembling those of naked wheat (Fig. 3, 1–3) were common in the flotation samples and impressions of glumes resembling those of free-threshing wheat were found in the pisé. However, because only one free-threshing rachis fragment was identified and the grains are difficult to distinguish from emmer when charred at high temperatures in the dehusked state, we cannot exclude the possibility that a large proportion of these grains was emmer (Braadbaart 2008). At sites where naked wheat was positively identified, both chaff and grains were present, for example at Shortughai (Willcox 1991). With regard to the ploidy level at Shortughai there were hundreds of well-preserved rachis segments which were identified as hexaploid. For the Aratashen material no identification was possible.

Triticum dicoccum was identified from charred grains (Fig. 3, 4) and also from impressions of spikelet bases in the pisé. Two grains resembling *T.* cf. *monococcum* (single-grained einkorn) (Fig. 3, 5) were found; however these could be small grains of emmer.

Charred barley grains were more frequent than those of wheat. Impressions of barley were found in the form of threshed internodes showing the median and two lateral spikelets (triplet in Fig. 4, 17) with bases of both the palea and the lemma. These are typical products from threshed naked six-rowed barley (Janushevich 1976). A few well preserved grains of *Hordeum vulgare* var. *coeleste* (naked barley) (Fig. 3, 6 and 7) with the rounded form and dorsal folds from Aratashen and Aknashen confirm this identification. Hulled barley (Fig. 3, 8–9) was also present.

Two species of pulse, *Lens culinaris* ssp. *microsperma* (small-seeded lentil) (Fig. 3, 10–15; Fig. 4, 18–22) and *Vicia ervilia* (bitter vetch) (Fig. 3, 16) were recovered from both sites in the form of charred seeds. Lentils were also

Table 2 Plants identified from Neolithic settlements of Aratashen and Aknashen

Levels			Aratashen		Aknashen				
			I	II	1	2	3	4	5
Number of samples			10	5	1	6	25	5	29
Volume of processed sediment in litres			160	350	4	38	302	50	384
Total identifications (excluding impressions)			572		2,991				
Total identifications (excluding impressions)			38	534	8	98	951	58	1,876
Densities of charred items per litre of sediment			1	1	1	2	3	1	5
Number of pisé fragments examined			12	58	8	38	17	10	17
Triticum naked type	glumes	pisé	+	++	++	+	++	–	–
		pisé + c	–	4	–	1	–	–	2
	grains	flot	1	10	–	1	19	2	28
	rachis	pisé	–	1	–	–	–	–	–
T. dicoccum		pisé	–	++	–	–	–	–	–
	spikelets	pisé + c	–	2	–	3	1	–	–
	glumes	pisé	1	++	–	–	–	–	–
		pisé + c	–	2	–	5	–	–	–
	grains	pisé + c	–	2	–	–	1	–	–
		flot	3	15	–	–	1	–	1
T. monococum	grains	flot	–	–	–	–	–	–	2
Triticum sp.	grains	flot	–	3	–	3	32	2	22
Hordeum vulgare	grains	flot	4	14	–	2	15	2	43
H. vulgare var. *coeleste*	triplets	pisé	–	++	–	–	–	–	–
	lemma/palea	pisé	–	++	–	1	–	–	–
	grains	pisé	–	–	–	–	–	1	–
		pisé + c	1	10	–	4	1	–	2
		flot	–	40	–	–	–	–	4
H. vulgare (hulled)		pisé	–	–	–	–	–	–	2
	grains	flot	–	3	–	–	–	–	–
Cerealia	chaff	pisé	+++	+++	+++	+++	+++	+++	+++
	grains	pisé + c	–	–	–	2	–	–	–
	grain frags	flot	15	31	3	21	552	35	516
Lens culinaris	pod	pisé	+++	++	+++	++	3	+	++
		pisé	1	3	–	–	–	–	–
		pisé + c	–	2	–	–	–	–	–
	seeds	flot	4	9	–	–	44	5	88
Vicia ervilia	pod	pisé	–	1	–	–	–	–	–
	seeds	flot	–	1	–	–	2	–	12
cf. *Vicia* sp.	seeds	flot	–	–	–	2	7	2	53
Fabaceae (*Pisum* ?)	seeds	flot	–	–	–	–	6	–	–
Camelina microcarpa		pisé	+++	+++	+	–	+++	–	–
	capsule	flot	–	–	–	1	16	–	7
	seeds	flot	–	–	–	1	–	–	4
Alyssum desertorum	capsule	pisé	+++	+++	++	+++	+++	+++	+++
	seeds	pisé + c	5	–	–	–	–	–	–
Vitis sylvestris	pips	flot	2	–	–	–	–	–	–
Amaranthus cf. *retroflexus*	seeds	flot	–	3	–	46	136	5	187
Chenopodium cf. *album*	seeds	flot	–	20	–	1	–	–	45
Rumex cf. *crispus*	nutlets	flot	–	–	–	–	3	–	173
Polygonum aviculare	nutlets	flot	–	–	–	–	–	–	1

Table 2 continued

Levels			Aratashen		Aknashen				
			I	II	1	2	3	4	5
Capparis spinosa		flot	–	7	–	–	1	–	1
	seeds	pisé + c	–	–	–	–	–	–	1
Elaeagnus sp.	stone	flot	–	–	–	–	1	–	–
Celtis sp.	stones	flot	–	1	–	–	1	1	3
Bolboschoenus maritimus	nutlets	flot	–	350	–	1	–	1	1
Monocotyledones	stems	pisé	–	–	2	–	+	–	–
Bromus sp.	grains	flot	–	–	–	–	1	–	10
Poaceae	grains	flot	–	–	–	1	6	–	1
Astragalus sp.	seeds	flot	–	1	–	–	–	–	–
Medicago/Melilotus	seeds	flot	–	–	–	–	–	–	7
Fabaceae (*Sophora ?*)	seeds	flot	–	–	–	–	2	1	2
Fabaceae spp.	pod	pisé	–	–	1	–	–	–	–
	seeds	flot	–	–	–	–	30	–	–
Thlaspi sp.	seeds	flot	–	–	–	–	–	–	1
cf. Brassicaceae	seeds	flot	–	–	–	–	–	–	11
Buglossoides arvensis	nutlet (min)	flot	–	–	–	1	31	–	631
Lithospermum officinale	nutlet (min)	flot	–	–	–	–	–	–	5
Boraginaceae	nutlet (min)	flot	–	–	–	–	2	–	–
Galium sp.	mericarp	flot	–	–	–	–	1	–	2
Convolvulus arvensis	nutlet (min)	flot	–	–	–	–	5	–	–
Calystegia sepium	nutlet (min)	flot	–	–	–	–	–	–	1
Hyoscyamus cf. *niger*	seeds	flot	–	–	–	–	29	–	–
Cyperus sp.	nutlet	pisé + c	1	–	–	–	–	–	–
cf. *Carex* sp.	nutlets	flot	–	–	–	–	2	–	2
Caryophyllaceae	seed	flot	–	–	–	–	–	–	1
cf. Rosaceae sp.	fruits	flot	–	–	–	–	–	–	4
Dicotyledones	leaves	pisé	–	–	2	1	–	1	–

Counts of identifications from the impressions in pisé are arbitrary and not exhaustive. Here we give an indication. + = <10; ++ = 10 to 100; +++ = >100

min mineralized, *pisé + c* carbonized from pisé, *flot* flotation, *pisé* indentification from impression in pisé

identified from impressions of pods and seeds. Charred bitter vetch was rare at Aknashen and only one impression of a pod was found in Aratashen (level II, str. 22).

Impressions of capsules from two wild species of crucifer were common at both sites. These consisted of *Alyssum desertorum* (desert alyssum) (Fig. 4, 3–4, 25–26) and *Camelina microcarpa* [=*Camelina sativa* ssp. *microcarpa*] (a species of false-flax) (Fig. 4, 1–2, 23–24).

Two charred *Vitis sylvestris* (grape) pips were found during the 2001 excavations at Aratashen (level I, UF87). The morphology of the pips resembled that of pips from wild vines (see Fig. 4, 5). Wild vines are still found growing in the lower and middle mountain forest zones of northeast and southeast Armenia. (Takhtajyan 1954–2001).

Seeds and fruits of wild/weed plants were common; these are discussed below (see Fig. 4 and Table 1). Non-charred bio-mineralized nutlets of *Celtis* sp. (hackberry) were found at both sites and one charred stone of *Elaeagnus* sp. (oleaster) was present at Aknashen.

Discussion

Chaff impressions from cereals, pulses and crucifers found in the pisé from the two sites represent crop processing residues that were used as temper. Cereal chaff has been very commonly used as tempering material in many parts of the world including Armenia, from the early Neolithic to the present day. Pods of lentils and bitter vetch are less commonly used.

The presence of processing residues of *Alyssum* and *Camelina* is of particular interest. The impressions consisted exclusively of the separated valves of the capsules. This strongly suggests that the capsules had been broken to

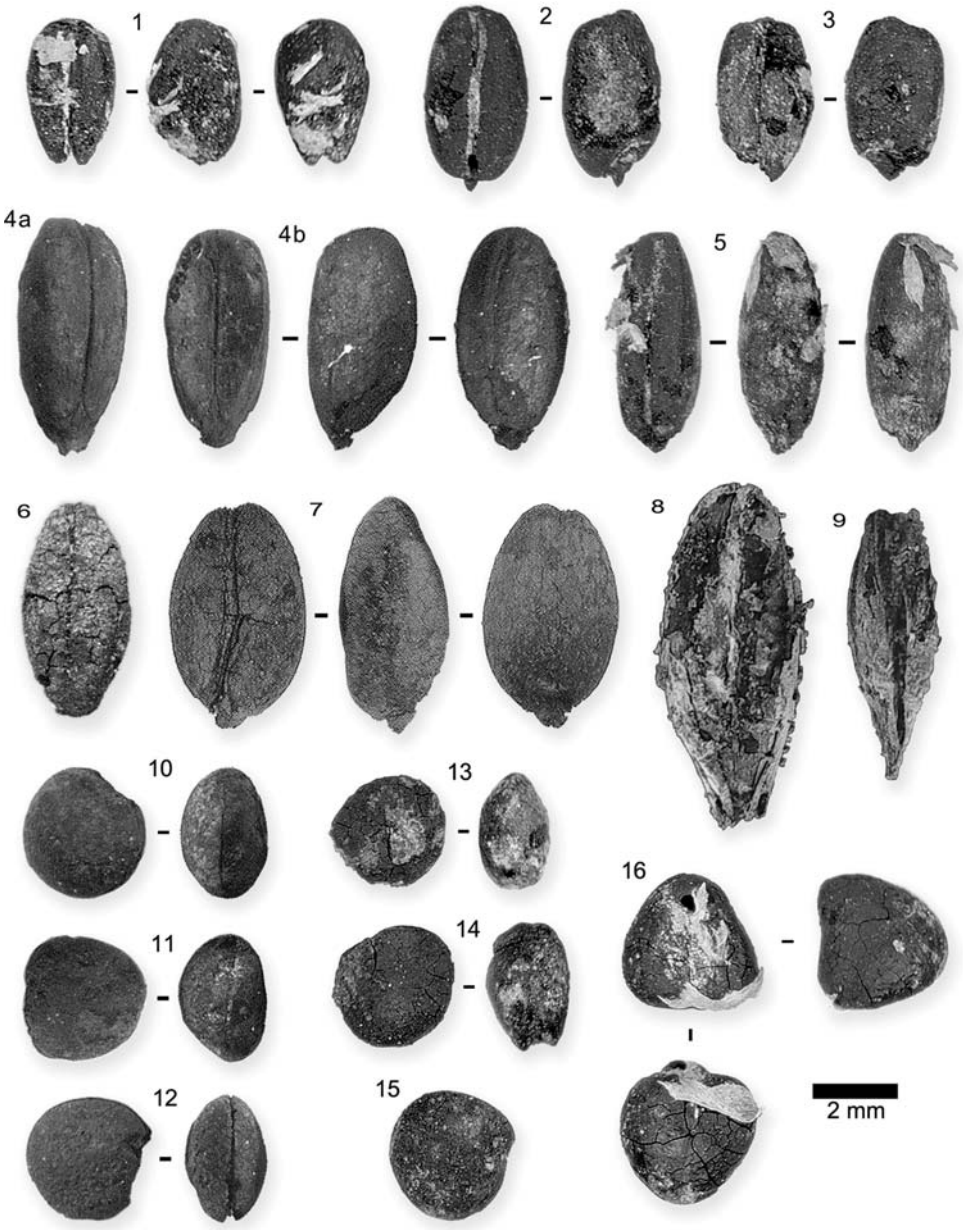

Fig. 3 Charred cereal grains and pulse seeds from Aratashen and Aknashen Neolithic settlements. *1–3* naked wheat; *4* emmer (the grains 4a and 4b were recovered from a single spikelet in the burnt pisé); *5* possibly single grained einkorn; *6,7* naked barley recovered from pisé; *8,9* hulled barley (from pisé); *10–15* lentil; *16* bitter vetch. Archaeological contexts: *Aratashen, Level II*—4 (K06); 6 (UF324); 10,11 (UF291); 12 (UF341). *Aknashen, Horizon 5*—1,3 (Sond. A, UF10, F6); 2,5 (Sond. A, UF12); 8,9 (Sond. A, UF14a); 13–15 (Sond. A, UF10, F5); 16 (Sond. A, UF13a, Str.1); *Horizon 3*—7 (Tr.4, UF6)

release the seeds during threshing. The seeds and the chaff would have been separated by winnowing. These plants have seeds with high oil content. The very high concentrations of *Alyssum* and *Camelina* processing residues suggest that these plants, usually considered wild plants, were either gathered or cultivated at Aknashen and Aratashen for their seeds. The high frequencies of these two taxa in a wide range of samples indicate that they were important economic plants. A few complete carbonized capsules of *Alyssum* were found at Aratashen (Level I, UF94, Fig. 4, 3–4). Common oil plants such as flax, poppy or *Carthamus tinctorius* (safflower) were absent, suggesting that *Camelina* and *Alyssum* may have replaced them. *Camelina* cf *sativa* seeds were found in large quantities at the Urartian site of Karmir-Blur (seventh-sixth centuries B.C.) where they were used for oil production (Tumanyan 1944). This is the first time *Alyssum* has been found associated with an oil-producing cultivar.

Camelina sativa has been used traditionally in the region for a long time (Stoletova 1930). *Alyssum* was also found in concentrations at the early Neolithic site of Dja'de in Syria, suggesting that it may have been used there as well (Willcox et al. 2007); also from central Europe, in lake dwellings there are high frequencies of crucifer seeds which may have been used as oil plants (Schlichtherle 1981; Maier 2001). Wild crucifers were also found in a storage context at Neolithic Çatalhöyük in Turkey (Fairbairn et al. 2007).

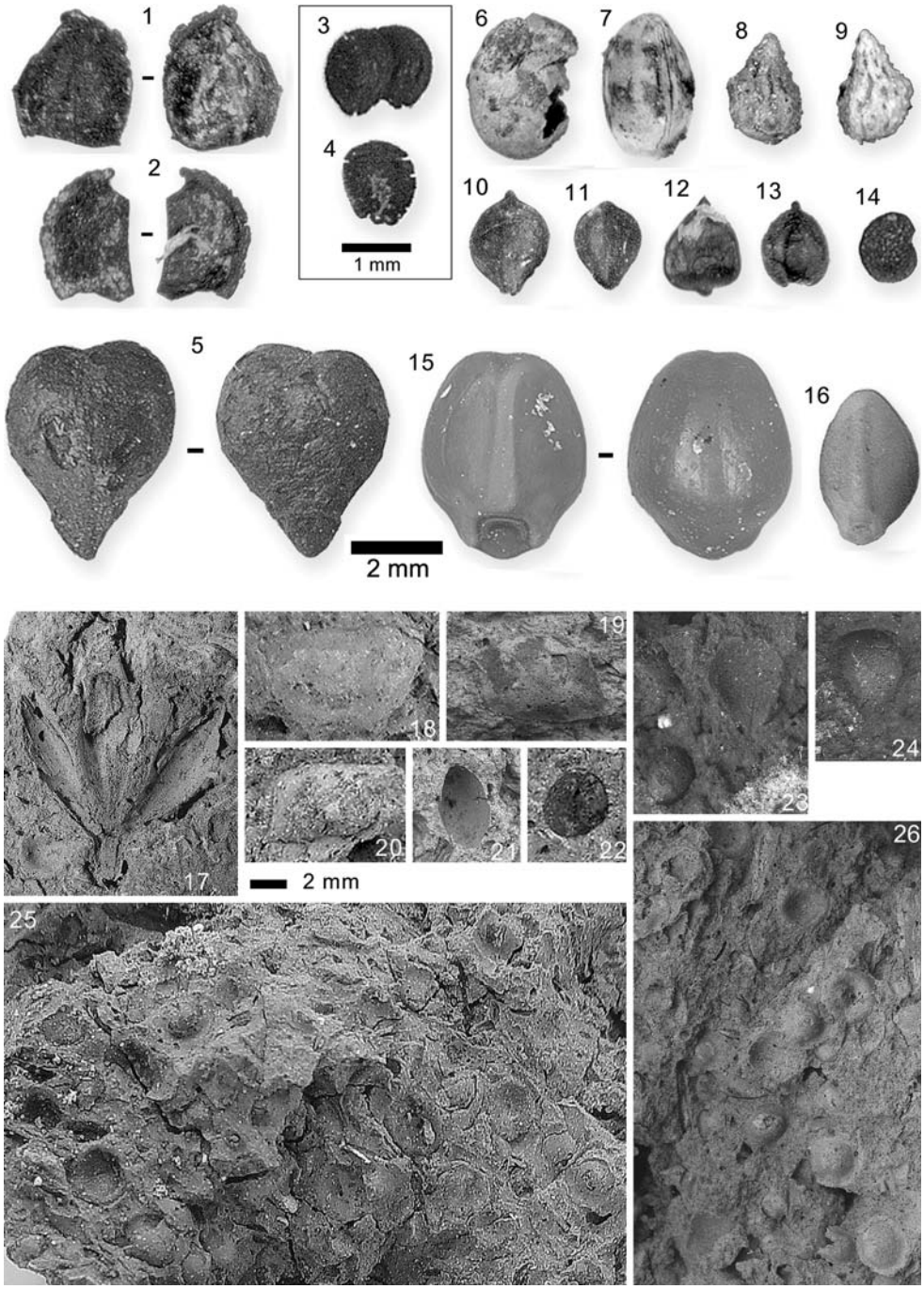

Fig. 4 Seeds and plant impressions from Aratashen and Aknashen Neolithic settlements. *1,2* Charred capsule fragments of *Camelina microcarpa*; *3,4 charred seeds of Alyssum desertorum* (from pisé); *5* charred *Vitis sylvestris*; *6* mineralized seed of *Capparis spinosa*; *7 Lithospermum officinale,* mineralized; *8,9 Buglossoides arvensis* mineralized; *10,11* charred nutlets of *Bolboschoenus maritimus*; *12,13* charred nutlets of *Rumex crispus*; *14* charred seeds of *Hyoscyamus niger*; *15* mineralized nutlet of *Calystegia sepium*; *16* mineralized nutlet of *Convolvulus arvensis*. *17–26* impressions in pisé: *17* triplet of naked six-rowed barley; *18–20* lentil valves; *21,22* lentil seeds; *23,24 Camelina microcarpa* capsule valves; *25,26 Alyssum desertorum* capsule valves. Archaeological contexts: *Aratashen, Level I*—3,4 (UF94); 5 (UF87); *Level II* —10,11 (Str.48); 17 (K06); 19,20,22 (str. 25); 21 (str. 22); 23,24 (K02); 26 (UF273, str.19). *Aknashen, Horizon 1*—18 (Tr.1, UF4); *Horizon 3*—14,16 (Tr.2, UF6); *Horizon 5*—1,2,8,9,12,13,15 (Sond. A, UF12); 6,7 (Sond. A, UF14, Str.2); 25 (Sond. A, UF9)

Naked wheat and barley, emmer, lentil and bitter vetch have been found on other prehistoric and medieval sites in Armenia (Gandilyan 1997; R. Hovsepyan, in preparation). These crops together with wild grape, recovered from Aknashen and Aratashen, are known from other Neolithic sites in the Caucasus (Nergul 1960; Lisitsina and Prishchepenko 1977; Lisitsina 1984; Janushevich 1984; Wasylikowa et al. 1991; Zohary and Hopf 2000). Naked wheat and barley are not frequent components of Near Eastern Neolithic cereal assemblages, which are dominated by emmer and hulled barley (Nesbitt 2002). In central Europe free-threshing wheats were common during the Neolithic (Maier 1996; Jacomet 2006b, 2007). In the western Mediterranean a similar assemblage, with high frequencies of naked barley and wheat has been identified at Neolithic sites in Spain (Buxo 2007).

Wild plants found at the sites come from various habitats. Weeds of cultivation were an important group, consisting of *Convolvulus, Galium, Rumex, Brassica, Bromus, Chenopodium, Amaranthus, Lithospermum, Polygonum, Thlaspi*

and *Calystegia*. Another group of taxa, which includes some of the same species, consisted of ruderals such as *Hyoscyamus niger* and species of *Rumex, Chenopodium, Amaranthus* and *Polygonum,* which would have grown near the settlements (Fig. 4, 7–16). These taxa can be found growing in the region today.

The hygrophilous plants such as *Bolboschoenus maritimus*, *Carex* sp. and *Cyperus* sp. (all in the Cyperaceae family) would have grown on the flood plain of the rivers not far from the sites. They could have come from animal dung used as fuel; charred sheep/goat coprolites were found at Aratashen (Level II, Str. 48).

Four hackberry stones and one oleaster stone were identified. Two species, *Elaeagnus angustifolia* L. and *E. orientalis* L. (oleaster) and two of *Celtis caucasica* Willd. and *C. glabrata* Stev. ex Planch (hackberry) occur in the region today (Takhtajyan and Fedorov 1972). It is probable that trees and shrubs have been greatly reduced as a result of human impact. Hackberry fruits have been used since the Palaeolithic period in Armenia; for example, they were found at the Hovk-1 cave in the Ijevan region (Hovsepyan in prep.).

Woody plants such as *Celtis* and *Eleagnus* combined with identifications of charcoal (H. Pessin, personal communication) which include Chenopodiaceae type, *Acer* sp., *Phragmites* sp., *Populus* sp., *Quercus* sp. (deciduous), *Tamarix* sp. and *Amygdalus* sp. provide evidence of the surrounding vegetation (Badalyan et al. 2007). *Quercus, Celtis* and *Amygdalus* must have grown much nearer the site in the past, but pressure from agriculture, grazing and wildfires have led to a reduction in the tree cover in this area since the Neolithic.

A combination of poor preservation and less sampling at Aratashen compared to Aknashen makes any comparison between the two sites hazardous. However their plant economies appear to have been similar.

Conclusions

The Neolithic sites of Aratashen and Aknashen are characterized by naked barley and possibly naked wheat and emmer. Hulled barley was also present. Einkorn may have been present, perhaps as a weed. Pulses, small-seeded lentil and bitter vetch were also cultivated. Both sites provide evidence, for the first time, of the use of two wild crucifers, *Alyssum* and *Camelina*. *Alyssum* has not previously been reported as an economically important plant. We suggest that these two plants may have been used for the oil in their seeds. Two carbonized grape pips found at Aratashen represent an early find of this species which is rare during this period.

This study gives some hints as to how Neolithic agriculture in Armenia differs from other areas. The presence of naked barley and two unusual oil plants demonstrate a distinct regional development. However these results are based on a small number of samples from only two sites. The information we have for the vine (two seeds), or *Elaeagnus* (only one identification) and naked wheat (only one rachis fragment) illustrates the need for more solid data to consolidate the interpretations. This need can only be satisfied by further sampling of a wider range of sites.

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