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Agricultural development in western Central Asia in the Chalcolithic and Bronze Ages

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Abstract. This paper lays out archaeobotanical evidence of cereals and fruits from 5th-2nd millennium B.C. sites in Turkmenistan (Anau, Gonur) and Uzbekistan (Djarkutan). Our current research program (1989-present) focuses on systematic recovery of botanical remains in their stratigraphic context. The cereals from these sites include *Hordeum vulgare* L. ssp. *vulgare* (6-row barley) and *Triticum aestivum* L. s.l. (bread wheat). The presence of plump grains of 6-row barley and bread wheat may indicate that small-scale irrigation was practised at Anau as early as the Chalcolithic period. The possibility is also raised that these plump-grained types may have come from the east rather than through northern Iran. Fruit pit remains of *Vitis vinifera* L. (grape) and *Pistacia* (pistachio) make their first significant appearance in Bronze Age deposits.

Key words: Barley - Wheat - Grape - Pistachio - Irrigation

Introduction

At the beginning of this century, western Central Asia was considered a center for the origins of plant domestication (Vavilov [1926] 1951). Wheat and barley phytolith remains and casts in bricks from the 1904 excavations at Anau provided evidence of Chalcolithic agriculture (Schellenburg 1908). There was no reason to think that plant domestication began there (Pumpelly 1908, p 67), but there was no evidence for earlier developments, either, until the Neolithic site of Jeitun was excavated. At Jeitun, located less than 50 km from Anau and in the same foothill zone, Harris et al. (1996) reported west Asian domesticates, primarily *Triticum monococcum* L. (einkorn), but also *T. dicoccon* Schrank (emmer), hulled and naked Hordeum vulgare L. (6-row barley) and two grains of *Triticum aestivum*, a "hexaploid-type" wheat. Thus, we now know that farming began in western Central Asia thousands of years before the Anau sequence began. The Jeitun Neolithic and Anau Chalcolithic occupations do not overlap in time, however, and while some archaeologists recognize stylistic continuities, there are important differences between these occupations, which are separated by several hundred years (F. Hiebert, personal communication). That is, the cultural relationship between the people of Jeitun and Anau is not clear.

Some time between the earliest attested agriculture at Jeitun and the settlement of Anau, farmers living north of the Kopet Dag increasingly grew crops that are often associated with irrigation in an arid environment: varieties of 6-row barley and hexaploid bread wheat. For example, at one late Neolithic site, Chagylly Depe, the archaeologists report, in addition to *Hordeum distichum* (L.) Alef., two hexaploid wheats (*Triticum vulgare* and *T. compactum*) (Masson and Sarianidi 1972, p 42), but the researchers do not cite a botanical report. By the Chalcolithic, these last had become the predominant cereals. During the Bronze Age, they continued to form the subsistence base, even as populations moved into radically different environments in the desert. Perhaps the most obvious Bronze Age innovation is the appearance of fruits and nuts.

This paper is based on recently excavated plant remains from three sites, Anau, Gonur, and Djarkutan (Fig. 1, Table 1). Most of the crop and food seeds come from mixed samples of rubbish deposits. Aside from some burnt grave offerings from Djarkutan, the remains were not intentionally burned. Rather, they became charred accidentally, presumably as remnants of food-processing or in dung fuel.

Methods

A manual flotation system (Minnis and LeBlanc 1976) was used to retrieve plant remains from Anau and Djarkutan; the author and Nathaniel Harrison did the flotation at Anau, Fredrik Hiebert did the flotation at Djarkutan. In addition to soil samples, the contents of three previously excavated bowls were examined. At Gonur, high winds prevented the archaeologists from floating the samples. Instead, Katherine M. Moore hand-picked charred material caught in a 2 mm sieve, so only fairly large items were recovered.

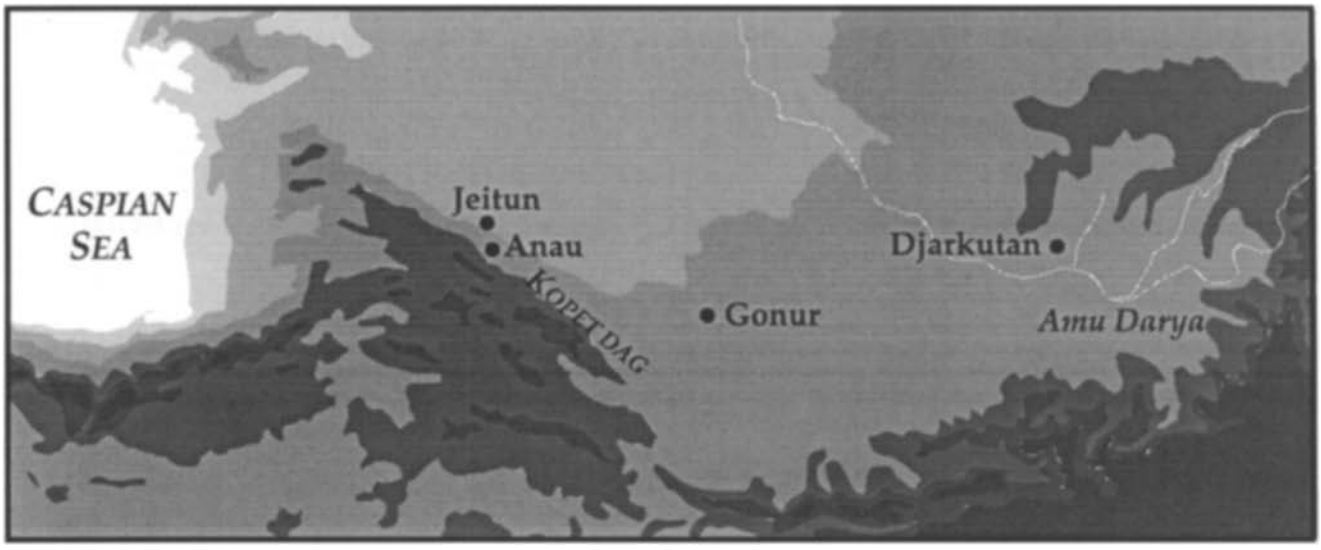

Fig. 1. Chalcolithic and Bronze Age sites mentioned in text

The environmental and archaeological setting

Modern day precipitation at Anau, Gonur and Djarkutan is under 230 mm/year, which is low for reliable dry-farming of cereals. All three sites are, however, well-situated to take advantage of surface water using traditional small-scale irrigation methods. These technologically simple systems provide the model for reconstructing ancient agricultural practices. Along the foothills of the Kopet Dag, irrigation depends on gravity flow, with agricultural fields situated along alluvial fans which extend into the arid zone from rivers originating in the Kopet Dag and Pamir mountains. Because these systems are spatially limited by accessibility to the inland river deltas, they form the basis of the "oasis civilizations" of the Bronze Age (Hiebert 1994). It is suggested below that the origins of this technology can now be pushed back to the Chalcolithic at Anau.

Anau, lying just north of the Kopet Dag, provides the oldest remains considered here. In antiquity, Anau would have been situated on the alluvial fan created by the Anau Su. The site of Anau is comprised of three mounds, two of which are at present under investigation. Anau North (4500-3000 cal B.C.) dates to the Chalcolithic, and Anau South (3000-1700 cal B.C.) dates to the Bronze Age. Ongoing work by F. Hiebert and K. Kurbansakhatov is giving us a nearly continuous, well-dated pottery sequence that spans the cultural periods known locally as Anau IA and Namazga I (Kurbansakhatov 1985) to Namazga VI (Hiebert 1995).

Archaeobotanical remains at Anau North came from soil samples cut in 1997 from the baulk of Kurbansakhatov's earlier excavation in the north mound. Most of the flotation samples from the north mound can be related directly to the architectural plans of that excavation. Traditional area excavations were carried out on Anau South. In both areas wood charcoal was abundant.

The modern vegetation has changed, especially since the construction of the Karakum canal over 50 years ago. Population increase following the construction of the canal led to the cutting of the mountain woodlands. *Juniperus* (juniper) woodland would have covered the lower slopes (Kamakhina 1994, p 145). Today scattered trees such as *Celtis caucasica* (hackberry), *Ficus carica* L. (fig), *Cerasus microcarpa* (=*Prunus microcarpa*, little cherry) and *Ailanthus altissima* (tree of heaven) grow. On the piedmont are stands of *Calligonum* sp. and chenopodiaceous shrubs such as *Haloxylon* sp. To the north, these shrublands gradually turn to desert. Cutting across these east-west bands of vegetation is riparian vegetation characterized by thickets of *Tamarix* sp. (tamarisk), *Populus pruinosa*, *P. euphratica*, and *Elaeagnus orientalis* (Popov 1994, p 183).

Table 1. Relative quantities of cultigen/food taxa seeds. Symbols: +=1-25; ++=26-100; +++=250-750 (most quantities are estimates based on weight equivalents of whole seeds).
Sources: Anau North (report in prepation); Anau South (Harrison 1995); Gonur (Miller 1993); Djarkutan (report in preparation)

Taxon	Anau North	Anau South	Gonur	Djarkutan flot	Djarkutan bowls
number of samples	42	17	12	17	3
Hordeum vulgare	+++	+++	+++	+++	>2000
Triticum aestivum	++	++	++	-	-
T. aestivum/durum	-	-	-	+	++
T. "sphaerococcum"	-	+	+	-	-
T. cf. *dicoccum*	-	-	+	-	-
Cicer	-	-	+	-	-
Lens	-	-	++	++	-
Pisum sp.	-	+	+	-	-
Pistacia vera	-	-	-	+	-
Vitis	?	+	++	++	-
cf. *Malus*	-	-	+	-	-
cf. *Prunus*	+	.	+	.	.

Fig. 2. *Hordeum vulgare* subsp. *vulgare* (barley) from Anau North

The archaeobotanical assemblage allows us to reconstruct the woody vegetation near Chalcolithic Anau. First, the ratio by weight of charred seeds to wood is low, usually less than 0.05, which strongly suggests that wood fuel was available (see Miller 1984). Second, most of the identified charcoal (80%, N=168) comes from *Tamarix*. The other types include *Populus*, *Juniperus* and Chenopodiaceae. This suggests the setting into which we can put the Anau farmers - they cleared the thickets along the river for their fields.

Like Anau South, the sites of Gonur and Djarkutan had Bronze Age deposits. Gonur is located in the Murghab delta in the Margiana region of Turkmenistan and Djarkutan is on an alluvial fan of the Surkhandarya river in the north Bactria region of Uzbekistan (Fig. 1). Both are roughly contemporary representatives of the Bactria-Margiana Archaeological Complex of the early second millennium B.C. The samples from Gonur came from a stratified trash (rubbish) deposit excavated by Fredrik Hiebert as part of a larger excavation by Victor Sarianidi (Hiebert 1994; Miller 1993). The remains consisted primarily of mixed burned trash that includes wood, seeds, and dung. At Djarkutan, Hiebert dug some of the material from old excavations with guidance from the original excavator, Timur Shirinov. In addition, a few unfloated charred seed concentrations deposited as grave offerings have been examined.

Cereals

Samples from Chalcolithic Anau provide few whole cereal grains (in 41 of the 42 samples there were a total of 84 barley and 28 wheat grains), and even most of those are poorly preserved. The *Hordeum* (barley) grains in one sample (ANN 97.078), though numerous, are puffed, distorted, and largely unmeasureable; nevertheless, the 200 whole grains seem to be plump, with a mean length to breadth ratio [L:B] of 1.6 [N=63, SD=0.28]), and most are rounded in cross-section. This sample and others have barley internodes with three robust pedicels (Figs. 2, 3). For that reason many of the grains are probably naked 6-row barley, though the hulled and 2-row types could be present.

In addition to barley, there is some *Triticum* (wheat) (Fig. 4). Cultivated wheat specimens cannot be assigned to species or subspecies solely on morphological grounds; identification of charred archaeobotanical remains is even more problematic. Many archaeobotanists

Fig. 3. *Hordeum vulgare* subsp. *vulgare* (barley) internodes from Anau North. Although the grains do not show obvious twisting, most of the internodes have three sturdy pedicels

Fig. 4. *Triticum aestivum* s.l. (wheat) from Anau North

list "species" which in effect are morphological types. In this article, various authors' own designations are mentioned; unless otherwise noted, it seems reasonable to assume that *Triticum aestivo-compactum* Host and *T. sphaerococcum* Percival respectively refer to small, plump, and nearly spherical seeds, based on the archaeobotanists' assessment of grain shape. With regard to the Anau North material, the wheat grains are mostly unmeasurable. They appear to be fairly plump, which suggests a naked grain; the internodes support an identification as *T. aestivum* s.l. following criteria suggested by Hillman (unpublished): many of the reasonably intact examples are "conspicuously shield-shaped", they have deciduous glume bases, the nodes are "weakly-developed", and some examples have "longitudinal lines near the outer edge of the convex face" of the rachis internode.

Bronze Age samples from the south mound at Anau were examined by Nathaniel Harrison and Wilma Wetterstrom. They found mostly hulled 6-row barley, some naked barley, and relatively plump wheats designated *Triticum aestivum* L. (including compact grains) and *T. sphaerococcum* Percival (Harrison 1995); some of the recognizable wheat rachis material fits the broad description for *T. aestivum* s.l. mentioned above, according to personal observation, so it is perhaps safest to think of the Anau wheat as that type. Earlier, Schellenburg (1908) reported wheat from what he called the "*Triticum vulgare*" group based on phytoliths and 2-row barley ("*Hordeum distichum*") from both phytoliths and casts in brick samples that he examined. According to Arlene M. Rosen (personal communication), Schellenburg based his identifications on "silica skeletons (silicified sections of epidermal tissue) which are composed of many fossilized cells rather than a single phytolith cell", and that at least distinguishing wheat and barley from phytoliths in epidermal tissue is not difficult (Rosen 1992).

At both Gonur and Djarkutan, the primary cereal in the samples was a very plump 6-row barley. Gonur had the hulled and naked varieties; one sample had an average L:B ratio of 1.48 (N=12) (Miller 1993). At Djarkutan, the grave offerings consisted of the naked type, which predominated in the occupation debris samples as well.

One of the most striking aspects of the wheat and barley from the Central Asian sites discussed here is the overall impression that the grains were plump (that is, rounded in cross-section and with relatively low L:B ratios). Unfortunately, there were few measurable grains, but pulling together published data for the Near East and South Asia, the Anau grains, both wheat and barley, seem to fall at the plump end of the spectrum. For example, 52 out of 63 barley grains measured had a L:B ratio of less than 1.7 (range: 1.27-2.50, ANN 97.078). An even greater proportion of the measured barley from Djarkutan was similarly plump (152 of 173 grains, range 1.19-2.27, bowl 1).

Wheat constituted a relatively small proportion of the identified cereal; approximately 85-90% of the identified cereal remains from Anau North and South, Gonur, and Djarktan occupation debris was barley, as was 99% of the grain from the Djarkutan bowls. Gonur and Djarkutan had *Triticum aestivum* s.l. The wheat tended to be plump. At Gonur, the appearance of 12 grains is consistent with a sphaerococcoid wheat (L:B of two measurable grains is 1.1 and 1.2). Six measurable Djarkutan wheat grains had L:B ratios of 1.1 to 1.5. Unlike the earlier Neolithic assemblages from Turkmenistan, emmer and einkorn grains were so few that they seem to be weed inclusions rather than crops.

The Bronze Age samples from Djarkutan contained a few grains of *Setaria* sp. or *Panicum* sp. (millets) There is no particular reason to think that they were cultivated.

Irrigation and drought resistance

Six-row naked barley and plump forms of bread wheat may be associated with irrigation in this area. For example, Jack Harlan (1968) observed that in areas where both 2-row and 6-row barley are grown, it is the 6-row that will be irrigated. Harry Harlan (1914, p 29) noted that for any given barley variety, irrigation affects grain width more than length, so plumpness can be caused by irrigation. In general, loose glumes and plump grain shape seem to be associated with each other; naked grains are not constrained by glumes, so they tend to have higher L:B ratios than hulled varieties. For example, at Yarym-tepe I in Iraq, the range of average L:B ratios for naked barley grains is 1.30-1.74, and for hulled grains is 1.83-2.27 (Bakhteyev and Yanushevich 1980).

It might be that similar trends affect free-threshing wheats, though measurements for archaeological specimens of *Triticum aestivum* are not available. Some modern irrigated free-threshing wheat grains from the Kur river basin in southern Iran had lower L:B ratios than that of unirrigated wheat from the same area (Miller 1982, pp 107, 392). Helbæk (1969, p 408) considered *Triticum aestivum* to be "indicative of irrigation", and

the compact forms of hexaploid wheat (*T. compactum* and *T. sphaerococcum*) tend to be drought tolerant (E. E. Saari, personal communication.).

What cultural and natural forces might have encouraged the use and development of these characteristics? Presumably, if growing conditions are suitable, people prefer naked grains because they are easier to process for food. Under irrigation, the grains get larger, but length is fairly stable. Therefore, any increase in mass would be expressed in greater breadth and thickness of the seeds, so the seeds get plumper. From the plant's point of view, a plump seed could confer a selective advantage. With irrigation, the plant has enough water, but the seed, only loosely encased in its glumes, would be more exposed to aridity. A rounder, more spherical seed would have less surface area than a long one of the same mass, and so would retain moisture better. (Note, however, that there is no reason to presume that all irrigated grains are plump.)

Possible sources of the plump forms

Bread wheat and 6-row barley had been cultivated in Turkmenistan for centuries by the time Chalcolithic Anau was occupied. In considering possible sources of the particular varieties of hexaploid wheat and 6-row barley varieties found at Anau, Gonur, and Djarkutan, however, it is useful to review what is known. Originally domesticated in the Near East, emmer, einkorn, free-threshing wheats and barley soon spread to south Asia. Hexaploid bread wheat is a hybrid between *Triticum turgidum* L. and *Aegilops squarrosa* (Zohary and Hopf 1994, p 47) and so could not have developed until the west Asian tetraploid came into contact with *A. squarrosa*. This *Aegilops* is native to the lands from the west of the Caspian, across northern Iran and Central Asia to Kazakstan and Pakistan; based on DNA evidence for different populations of *A. squarrosa,* a current view is that this hybridization occurred southwest of the Caspian Sea (Zohary and Hopf 1994, p 52).

Costantini (1984) has commented on the compact aspect of both the wheat and the barley from south Asia beginning in the Neolithic at sites such as Mehrgarh in Pakistan. Seed measurements from Loebanr 3 (Pakistan) that illustrate that his idea of "compact" shape include L:B ratios of 1.47 for 11 *Triticum sphaerococcum* and of 1.54 and 1.55 for naked 6-row barley (Costantini 1987). He has identified naked wheat in earliest Mehrgarh Pakistan, though it is not clear whether it is the tetraploid or hexaploid type (Costantini 1984). If tetraploid, it would suggest that at least some hexaploid bread wheat could have originated in the east. If the Mehrgarh wheat is hexaploid, it suggests that there was a very rapid spread of that type from west Asia. Grains so small and round that Costantini is willing to call them *Triticum sphaerococcum* occur as early as Mehrgarh level III, which the excavator (Jarrige 1987) dates to about 6500 B.P. (c. 5500 cal B.C., well before the Anau samples). Samples from later phases at Mehrgarh include increasing quantities of such grains (see also Costantini and Biasini 1985).

Thus, prior to its appearance in Turkmenistan, naked wheat, most likely to be *Triticum aestivum* s.l., is known in both west and south Asia. Given the chronological and possible cultural gap between Jeitun and Anau, one might ask: did those plump, naked hexaploids arrive from northern Iran with settlers or through trade, or rather, might they have reached Central Asia from Afghanistan or Pakistan across the mountains following the valleys of the Amu Darya tributaries (Fig. 1). A third possibility is that the character of plumpness, for both wheat and barley, developed in place; the recent discovery of small amounts of 6-row barley and possible bread wheat from Jeitun (Harris et al. 1996) make this a possibility that cannot be dismissed.

Fruits

Today, Central Asia is well known for its fruit - *Vitis vinifera* L. (grape), *Malus domestica* Borkh. (apple), *Cydonia oblonga* P. Miller L. (quince), *Prunus armeniaca* L. (apricot), *Prunus domestica* L. s.l. (plum), *Prunus dulcis* (Miller) D.A. Webb (almond), and many others are widely grown. Archaeological recognition of fruit growing is not easy because the shape of fruit pits and seeds changes slowly or not at all under cultivation. Even before we can infer that fruit was cultivated, however, we have to find evidence for its use. Other researchers report fruit remains from sites of the late second millennium B.C. In the sites I have examined, the earliest tree seeds encountered are *Celtis* from Chalcolithic Anau. As is commonly the case with this type, the seeds are mineralized, not charred. *Celtis* does have an edible fruit, so it could have been eaten. In addition, there were a few fragments of some nutshell and a *Prunus*-like seed along with a single small fragment that might be from *Vitis* (grape).

Fig. 5. *Vitis vinifera* (grape) from Djarkutan

The first clear evidence for the use of fruit comes from the Bronze Age. The most widespread type is *Vitis vinifera* (grape). Wild grape grows in Turkmenistan, but its absence from Chalcolithic Anau and earlier sites suggests the fruit of the wild vine was not used. Though the grape might have grown wild along rivers, it could only have been grown under irrigation at Anau, Gonur, and Djarkutan. Grape appears in a number of samples at the three sites in small amounts. The seeds are mostly plump, and there are also some pedicels (Fig. 5). Although Stummer's (1911) measurements suggest that grape pips with a low length to breadth ratio are wild, many modern varieties in the Near East and Central Asia also have plump seeds (personal observation). Kroll (personal communication) observes that only cultivated varieties produce undeveloped pips; one such type from Djarkutan is illustrated here (Fig. 5). The archaeological specimens therefore suggest that the use of grapes, and probably also their cultivation, extends as far back as the beginning of the second millennium B.C. in western Central Asia. Soon-to-be-analyzed samples from the 1997 excavation at Anau South have grape seeds from early Namazga V levels. These seeds push fruit cultivation back to the mid-third millennium cal B.C.

Pistacia vera L. (Fig. 6), which is the pistachio of commerce, makes an appearance at Djarkutan. Aside from a few scattered fragments, the seed component of a hearth sample was almost entirely pistachio shell. By weight, the total of fragments could have come from as few as ten nuts. *P. vera* is a component of the mountain forests. It was probably first cultivated in Central Asia, and except for two nuts from Tepe Yahya, Iran, it is unknown in the Near East until classical times (Zohary and Hopf 1994, p 180). It is too soon to say whether the nuts were gathered from the wild or were cultivated.

Fig. 6. *Pistacia vera* (pistachio) from Djarkutan

In addition to the grape and pistachio, Bronze Age Djarkutan had a few fragments of a fruit pit (fruitstone). Gonur had two whole *Prunus* pits that compare well to plums that are grown today. Gonur also had a single seed that may be *Malus* (apple).

These data show that there is little evidence for the use of fruits and nuts before 1500 B.C. It does, however, seem likely that grape was grown.

Conclusions

First, the cereals from Anau, Gonur, and Djarkutan consist primarily of 6-row barley, probably the naked variety; next in importance is bread wheat. Second, the grains of both barley and wheat are remarkably plump, at least compared to those from sites in Turkey and Syria. Climate, crop choice and the shape of the grains point to the likelihood that irrigation was practised. The plumpness of the grains, so reminiscent of Neolithic and later remains from south Asia, suggest that region should be considered as a possible source of the varieties; as more sites intermediate in time and space are excavated, this issue will undoubtedly be clarified. Finally, fruit remains from western Central Asia appear at least as early as the beginning of the second millennium B.C.

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