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wall. Of course, these forms will be investigated in detail [illegible] structures in the corrosion products. Below the "fin" [illegible] honeycomb pattern in the glass[illegible] which appears similar [illegible] of other crucible base [illegible] descriptions of a character- [illegible] pattern in the slag (see Percy 1864) as well as striations in some glassy green slag fragments suggest incomplete fusion (see Smith 1960).

Crucible fragments are variable in thickness and condition but appear to represent a single type. Wall thickness ranges from 0.5–2.5 cm. Fragmented circular segments with a reconstructed outer diameter of 6–8 cm. and a thickness of about 0.5 cm. are interpreted as crucible lids. These fragments have a central perforation about 1 cm. in diameter and the outer edges exhibit evidence of a clay seal to a crucible wall. The use of a luted, perforated lid is a variation in accounts of traditional steel making in crucibles during the nineteenth century (see Bronson 1986; Rostoker and Bronson 1990). The thinner fragments and lids are interpreted as having been fired at high temperatures under reducing conditions. The thickest fragments have a light-coloured core and dark, reduction fired inner surfaces. Investigations of the refractory properties of the crucible fragments and furnace wall fragments will be undertaken in order to characterise the materials relative to their performance at high temperatures and to estimate the duration of firing. These would be important considerations for steel production.

Fragments of furnace wall consist of the local mudbrick but lined with crucible fragments on the interior. The inner surface is covered with a black, adhering layer of slag arising from high furnace temperature and fuel ash. It has not yet been investigated. The furnace wall fragments were about 5–10 cm. in length and 5–10 cm. in height. Several are interpreted as representing corner fragments. There are examples of crucible base fragments slagged onto a lower ceramic support (Pl. VIIId), which was placed on the furnace bottom. No exact joins have yet been made between the furnace wall fragments. Although none of the furnace wall fragments were *in situ*, it is possible to suggest rectangular furnace dimensions. This proposed reconstruction is influenced by the furnace descriptions included by al-Hassan and Hill (1986). Further assessment would require more extensive excavations

One large fragment of a tuyere was found along with the other metallurgical remains. It is well-fired with a large diameter of about 4 cm., but, as the ends are missing, it shows no evidence of direct contact with the other furnace wall fragments.

While these archaeometallurgical samples are attributed to crucible steel production, there remain many questions and lines of evidence to investigate. There are many samples still to section and analyse. Distinction between the three possible indirect methods (cementation, fusion or decarburisation) for crucible steel production at Merv would depend upon further discovery of minute fragments of raw materials in the glassy green slag or adhering to the crucible walls. Raw materials might include wrought iron with elongated slag inclusions, carbon impressions or components (such as rice husks in the later Indian examples presented by Lowe *et al.* 1991) or perhaps even cast iron coatings on wrought iron droplets. Final products such as ingots or fragments may not necessarily be conclusive to distinguish between fusion or cementation. For the interpretation of these archaeometallurgical specimens from Merv, the most salient observations relate to the abundant steel prills of variable carbon content in a relatively small amount of glassy green slag with a melting temperature of approximately 1250° C adhering to the inner wall of crucible fragments. Further excavations of the archaeometallurgical remains are anticipated.

Archaeobotanical Research in the Merv Oasis, by Mark Nesbitt

The presence of an archaeobotanist made possible the construction of a flotation machine, equipped with a pump. This resulted in the processing of far larger quantities of soil than had been possible in 1992, when water had to be raised by bucket from the canal. This in turn made it possible to respond to a kind invitation from Professor Maurizio Tosi to collect samples from the excavations at Tahirbaj Tepe.[9]

The Merv flotation machine is an adaptation of the Siraf machine (Williams 1973), working on the same principle in which carbon is separated from the soil matrix in water. The floating plant remains flow into a 0.5 mm. sieve (the minimum mesh that could be used here without clogging), the heavy silt and sand falls to the bottom of the tank, and other heavy items—especially bone and small artefacts—are collected on an internal 2.5 mm. mesh. As sample sizes at Merv are, of necessity, small (typically 10–20 litres) and portability is a major factor for equipment, a smaller machine than the usual 40-gallon oil-drum type was built. Constructed by a neighbouring workshop, it is a cube 40 cm. square, and was operated using water from the newly operational shower tank. Flotation rates of 50 litres/hour for normal samples and 20–30 litres/hour for exceptionally small or difficult samples are, in line with the small size of the tank, about half of typical rates for the Siraf machine. In general, samples disaggregated and floated well, although in about ten samples from Merv persistent clods of earth floated into the flot sieve, and six other samples from Merv had to be discarded where this problem was particularly bad.

Merv: Sample size was limited by the necessity to carry soil samples, as well as other dig equipment, some 300 m. from the excavation trench to the nearest point accessible by vehicle. In practice, three samples each of 15–20 litres was the daily maximum. Samples were taken from as wide a range of contexts as possible, including all pits and hearths. In all 1,074 litres of soil from 100 samples, representing sixty-two discrete deposits, were recovered from the 1992 and 1993 seasons. Particular effort was devoted to floating the entire contents (323 litres) of the shallow pit consisting of units 299 (upper fill) and 333 (lower fill), which was rich in bone and carbon.

Preliminary figures for carbon, bone and ceramics density, calculated from the heavy residues, are shown in Table 2 and Fig. 2. Despite the small number of samples from some deposit types, and incomplete data sets (some samples collected on the final day of excavation could not be fully processed), some interesting patterns are already apparent. In terms of carbon density, the samples clearly fall into three classes: low—floors, make-up, and mud-brick; medium—refuse and pits; high—hearths and burnt areas.[10] These results are consistent with those from other sites and are important for two reasons: firstly, they indicate that the excavator's assessment of deposit types is broadly correct (hence the consistent figures; secondly, the low amounts of carbon in the mudbrick-derived material (i.e. the three low density deposit types) suggests that old mudbrick is not an important source for the charred plant remains at the site, and that therefore most of the plant remains are essentially contemporary with the excavated architecture.

There is much less of a distinction in pottery and bone densities between refuse areas and mudbrick derived floors and make-up, suggesting that residual pottery may form a high proportion of refuse deposits, and that pits may be a more reliable source of pottery for dating purposes. More detailed analysis depends on increasing the number of sampled deposits, especially the low density types which are currently under-represented.

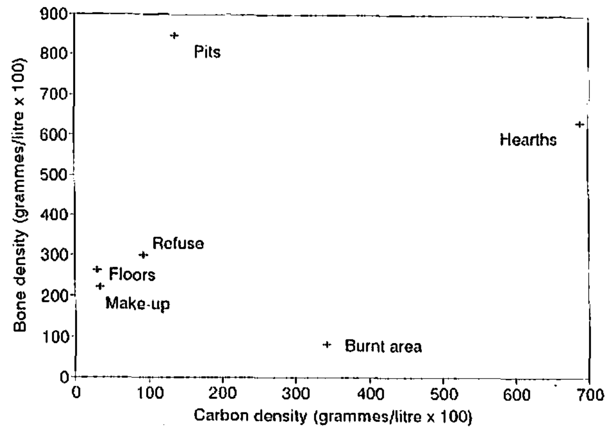

Fig. 2. Average carbon and bone densities in different context types. Mudbrick samples have been excluded as bone densities are not year available. Note that densities have been multiplied by one hundred to make more manageable numbers.

All the carbon samples were quickly scanned: of the sixty-two deposits, thirty-seven contained charred seeds. Simple presence/absence for each deposit has been used to assess relative abundance of the different crop species (see Table 3).

TABLE 3

	Number of seed-containing deposits (n=37)	% presence
Cotton	28	76
Hulled barley	17	46
Bread wheat	14	38
Lentil	9	24
Pea	3	8
Grape	3	8
Hackberry	3	8
Melon/cucumber	1	3
Broomcorn millet	1	3
Peach	1	3
Almond	1	3

TABLE 2

Deposit type	Number sampled	Carbon density (g./litre x 100)			Bone density g./litre x 100)			Ceramics density g./litre		
		n.	n. productive	density	n.	n. productive	density	n.	n. productive	density
Hearths	18	17	17	689	10	8	634	11	8	9
Burn areas/ashes	5	5	5	342	3	3	83	3	1	3
Pits	6	6	6	137	6	5	847	6	5	17
Refuse deposits	15	14	14	93	13	13	299	13	13	5
Make-up	7	7	7	34	6	5	222	6	5	6
Floor	7	6	6	30	6	6	263	6	6	5
Mud-brick	4	4	4	16	0	-		0	-	

Densities of carbon, bone and ceramics in flotation heavy residues (n. = number of deposits for results were obtainable n. productive = number of those deposits with more than zero contents;

Weed seeds are present in 65% of the deposits; wheat and barley chaff in 11% and dung in 2%. The high proportion of samples containing weed seeds means that ecological studies will be possible.

The abundance of cotton strengthens the interpretation made in the 1992 preliminary report that most of the plant remains derive from burning dung and cotton sticks. The abundance of cotton in the samples is not, therefore, a direct reflection of its economic importance: at such a large urban site food plants such as wheat and barley must have been most important. It is also likely that wheat and barley are over-represented because of their presence in dung. The difference in abundance between lentil and pea is more likely to reflect a difference in economic importance because these are both pulses, and should therefore be subject to the same preservation biases. The fruits known from Merv now include peach (one charred stone), grape and a probable almond. Several uncarbonised fruits were found during excavation, but crumbled to dust prior to consolidation.

Even taking into account the factors favouring preservation, cotton is still an important crop: its sheer ubiquity in the samples argues for a widespread presence on site. It is present in both Late Sasanian and Arab-Sasanian samples. Wheat, barley and lentil can be considered staple food crops; the relative importance of grape, pea and millet is uncertain. The presence of millet—only as a single grain—adds another summer-season crop to cotton and cucumber. Millet is common in the Near East and adjacent areas from at least the Iron Age (Nesbitt and Summers 1988), and it is surprising that it is not more common here.

The main results of the seed analysis have been to confirm the conclusions drawn on the exceptionally rich single sample discussed in last year's report (Nesbitt 1993), in particular the importance of cotton. It is hoped that flotation in 1994 will result in a longer sequence of samples, especially from MGK: 5, which will enable us to look at the possibility of change through time. Further flotation may well also produce new evidence of those crops present at very low frequencies, such as millet and melon/ cucumber.

An extensive vegetation survey of the Merv area was completed, focusing on the extensive shrubby growth, especially in areas affected by the rising water-table caused by the Karakum canal. The oasis vegetation was compared to that at the Repetek nature reserve, which contains relatively dense desert woodland. While the dominance of cotton monoculture has greatly reduced the potential for ethnographic or ecological studies of irrigation agriculture in the oasis, most village houses still use traditional cooking techniques and ovens, and there is a great deal of local knowledge of the fuel properties of different woody species. Ethnographic work with Akmohammad Annaev carried out on this, and other medicinal and food properties of wild plants, is of obvious applicability to understanding our charcoal and dung assemblages.

Tahirbaj Tepe: The recent Italian excavations at Tahirbaj Tepe, a prehistoric site in the north of the oasis, have aimed at obtaining a good stratigraphic sequence of pottery and radiocarbon dates for the Iron Age. Initially defined in the 1950s by Professor V. M. Masson's excavations at Yaz Tepe, the Yaz sequence runs from the later part of the Late Bronze Age through to the late Iron Age (mid-second to mid-first millennium B.C.). This period has been divided into three phases on the basis of pottery types, with the earliest, Yaz 1, dominated by handmade pottery. Ten flotation samples were taken on 27 September and floated at Merv. Two samples were particularly rich: sample 5 from a Yaz 2 burnt destruction level, contained dung, hulled barley and broomcorn millet. Sample 9 (Yaz 1), from a black lense deep within a structural platform, contained spherical dung pellets (from sheep or camel?), many weed seeds (some with dung attached), hulled barley grains and broomcorn millet.

Although Tahirbaj Tepe today lies well north of the Murghab river delta, archaeological evidence indicates that in the Iron Age river waters would have reached the site. The plant remains presumably result from local cultivation. Comparative material from other sites is limited to Merv and the nearby Bronze Age (early second millennium B.C.) site of Gonur Tepe (Miller 1993). At Gonur Tepe plant remains were recovered by 2 mm. dry-sieving, and the absence there of millet seeds is therefore not necessarily significant. Crops that were present include much hulled barley, little free-threshing wheat and emmer wheat, many lentils, little chickpea, pea and grass pea, much grape and few plums.

The range of plant remains from Tahirbaj is too limited for detailed comparison, but several interesting points emerge. Firstly, cotton seeds are absent from both Tahirbaj and Gonur. Introduction of cotton into the area must have taken place at some point between the late Iron Age and the late Sasanian period. Barley is the most frequent cereal at all three sites, while broomcorn millet is present in the area from at least the Iron Age onwards. Lentils are the most abundant pulse, both at Gonur and Merv. There is evidence for shortage of wood fuel in the abundance of dung in samples from all three sites. If the Parthian gap can be filled, either at Merv itself or elsewhere, the prospects for studying long-term agricultural change in the Merv oasis are encouraging. Clearly, despite modern (or ancient) salinisation, preservation of charred plant remains is not a problem in this region.

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[2] The principal contributors to the Research Design were St John Simpson, David Tucker and Glynn Barratt.

[3] The work was carried out under the Excavation Permit No. 16/377 of Dr. S. D. Loginov and was directed jointly by S. D. Loginov and St John Simpson. The team consisted of R. Hobbs, V. Zavyalov and N. Smirnova, joined for part of the season by A. B. Nikitin and M. Kotchoubeev. A. Fisher, M. Nesbitt, N. Savvonidi assisted towards the end of the season. V. Ossipov tragically died on the third day from a heart attack.

[4] Bailey (1992: 38, 44–5) described how in Tashkent earlier this century cotton seed oil was used to fill saucer lamps that were lit with the help of twisted cotton wool wicks.

[5] Early Islamic pottery was noted here during a visit in 1993.

[6] The team consisted of St John Simpson, V. Zavyalov, N. Savvonidi and up to six workmen.

[7] Finger-marked mudbricks have been recovered from a number of earlier YuTAKE excavations at Merv, notable MGK Trench 2 (Usmanova 1963: 176), the south-western fortifications (Tashkodjaev 1963: 104, fig. 6) and the so-called "castle" on the southern circuit of the MEK walls (Filanovich 1959: Usmanova 1963: 50–1).

[8] We would like to acknowledge the valuable advice from Dr. I. Freestone, T. Lowe, Dr. B. Gilmour, Professor H.-G. Bachmann and others on the investigation of the remains.

[9] Archaeobotanical work benefitted greatly from assistance by Kathy Judelson and Akmohammad Annaev in building the flotation machine and from Merv excavation staff in carrying bags of soil over long distances with little complaint. At Tahirbaj Tepe the director of excavations, Dr. Cattani Maurizio, gave active assistance in sampling.

[10] Deposit types have been defined as follows: hearths—clearly defined, small areas of *in situ* burning; burn areas/ashes—large spreads of ashes, mostly thought to be *in situ*; pits—clearly defined; refuse deposits—areas with higher than normal densities of bone; make-up—relatively sterile soil used to level up surfaces; floor—floor surfaces and associated underlying layers; mud-brick: individual mudbricks, and one sample of bonding material which proved to be similar in character.