

Pre-Dynastic Iron Beads from Gerzeh, Egypt

Sir Flinders Petrie (1914/5) and G. A. Wainwright (1932) described two groups of 'Iron Beads' that had been found in Pre-Dynastic graves at Gerzeh, 70km south of Cairo. Both authors claimed that the beads were of Pre-Dynastic date (about 3000 BC) and that, at the time the beads were discovered, they were the most ancient iron artefacts ever recorded. A technical study of several examples of the beads revealed only that the composition was entirely of limonite (a hydrated iron oxide). There was no remaining metallic iron.

All of the 'iron beads' from this collection, now at the Petrie Museum at University College London, are thoroughly corroded (Fig. 1). Only three beads remain; Nos. 10,738 through 10,740. Their dimensions are roughly 15–16mm in length and variable in diameter with 12mm, 5.5mm and 3mm. The weights are approximately 1 gramme. Reportedly, these beads formed part of a necklace in which metallic iron cylinders had originally alternated with precious and semi-precious stones. Petrie (1914/5) claimed that these beads were made by 'flat-hammering' small pieces of metallic iron which were then bent into cylindrical shapes. Gowland and Bannister (1927) agreed. Based upon folds, or creases, observed along the cylindrical axis, the beads appear originally to have been metallic iron (Fig. 1). This phenomenon is characteristic of folding metallic iron and not drilling through a mineral specimen of brittle, inflexible limonite.

In an early metallurgical study of the beads, Gowland (1927) reported that an analyzed bead consisted of 78.7% of ferric oxide and 21.3% combined water. However, Desch (1929) reported that another one of the beads contained 92.5% iron and 7.5% nickel. Such a composition would be typical for meteoric iron. Wainwright (1932) emphasized this to be 'proof positive' of the meteoritic origin of the iron metal. Nevertheless, Desch (1929) did not give any indication of the analytical method used, nor did he describe the corrosion state of his sample. These results, presented as weight percentages of iron and nickel, are presumably normalized from analysis of the remaining corrosion products. The meteoric origin of the iron used for these beads is accepted as plausible by Buchwald (1975) based upon corrosion models suggesting greater loss of nickel than iron under

such burial conditions. Reworked meteoric iron is the interpretation usually accepted today as the explanation for the occurrence of metallic iron artifacts from such early archaeological sites. A rare alternative source of native metallic iron in Egypt is very unlikely indeed.

Due to the archaeometallurgical significance of these corroded iron beads, small samples, up to about 0.5mm, were scraped from the surface of the smallest of the beads and mounted for electron probe microanalysis (EPMA) in the Department of Mineral Resources and Engineering at Imperial College, University of London.

Microscopy documented that the corrosion products taken from the surface consisted mainly of porous, hydrated iron oxide (limonite). This mineral encloses small, rounded sand (quartz) grains (Fig. 2). These identifications were confirmed with EPMA. Despite careful search, no metallic iron or common slag minerals were observed. The rounded quartz grains most likely derive from the burial environment having been incorporated into the greater volume of the corrosion products.

Numerous microanalyses of small areas, measuring about 20 x 20 microns, were made on the polished section of the corrosion products. These areas were selected to characterize the iron oxide corrosion products, without inclusion of the quartz grains. The weight percent range of elemental compositions based upon eleven analyses are as follows:

51–59% Fe
0.0–0.2% Ni
0.03–0.5% Cu
2.0–4.0% Si
0.1–5.0% Ca
0.0–0.5% Na
0.0–0.3% P
0.0–0.2% K
0.1–2.2% Cl

Traces of Ti, Ag and Au were also noted. The concentra-

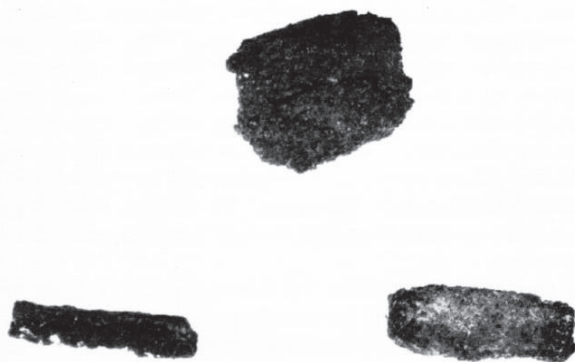


Fig. 1. Three 'iron' beads from the Pre-Dynastic grave at Gerzeh now in the Petrie Museum collections. The narrowest bead shows clear indications of having been bent into a cylindrical shape. (Actual size)

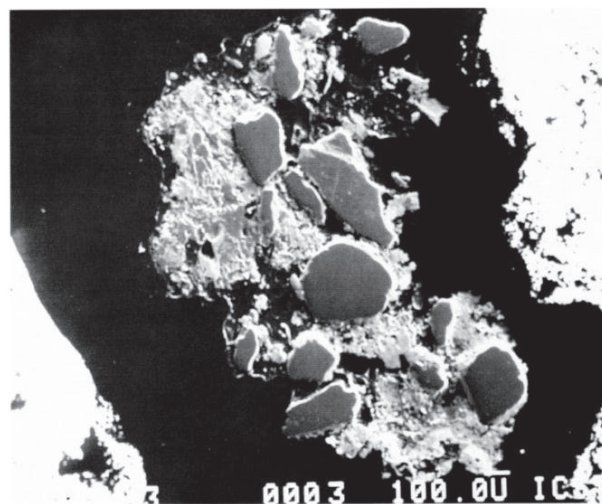


Fig. 2. Photomicrograph from the electron microprobe of the corrosion products from the analyzed bead. The image shows the quartz grains surrounded in the matrix of iron corrosion products.

tions of iron, along with the low totals, are characteristic of limonite. The ranges for Ni and Cu are most significant.

The concentration range for nickel is much lower than that indicated from the earlier analyses by Desch (1929). While the new analytical results would not completely rule out the possibility of meteoric origin (Photos, 1989), the lower concentrations below 0.2% Ni do certainly decrease the strength of the argument. Although both sets of analyses were done on corrosion products, the earlier set by Desch did include a larger sample; most likely the whole bead. To resolve this matter, a new metallographic section across one of the remaining beads would be required. This could confirm or reject the hypothesis that the bead was originally metallic. Micro-analysis may also discover any remaining metallic iron within the corrosion products.

It is important to establish the origin of this Pre-Dynastic iron metal and this is where the observed copper range in the corrosion products is important. It is uncertain whether any copper or copper alloy artefacts were also in the same grave with the beads. If the copper is, indeed, a component of the original iron metal, then the implication would be that the iron may be a by-product from copper smelting. Again, a section would be necessary to establish the distribution of copper within the iron corrosion products. Investigations of copper in corroded iron artefacts from Timna by Gale et al. (1990),

simply report the presence of copper based upon X-ray fluorescence analysis (XRF). Chronologically, these 'iron beads' from Pre-Dynastic Egypt would be comparable to the Late Chalcolithic or Early Phase of metallurgical activities in Rothenberg's (1990) table for the Sinai-Arabah. At this time, copper smelting was conducted using iron ore flux, which could be the actual source of the smelted iron.

El Sayed El Gayar

References

- Buchwald, V. F. 1975. *Handbook of Iron Meteorites*, Vol. 2, Berkeley. University of California Press.
- Desch, C. H. 1929. *Reports on the metallurgical examination of specimens for the Sumerian Committee of the British Association*. Reports of the British Association for the Advancement of Science.
- Gale, N. H., Bachmann, H.-G., Rothenberg, B., Stos-Gale, Z. and Tylecote, R. F. 1990. The Adventitious production of iron in the smelting of copper. In B. Rothenberg, ed. *The Ancient Metallurgy of Copper*. London. IAMS. 182-91.
- Gowland, H. and Bannister, C. O. 1927. *Ancient Egyptian Metallurgy*. London. Chas. Griffin.
- Petrie, W. M. F. 1914/5. *Ancient Egypt Journal*, 12-23.
- Photos, E. 1989. The question of meteoritic versus smelted nickel-rich iron: archaeological evidence and experimental results. *World Archaeology*, 20, 3: 403-21.
- Rothenberg, B. 1990. *The Ancient Metallurgy of Copper*. London. IAMS.
- Wainright, G. A. 1932. Iron in Egypt. *Journal of Egyptian Archaeology* XVIII: 3-15.

Analytical Investigation of Crucible Steel Production at Merv, Turkmenistan

According to the early Islamic texts, three methods are described for indirect production of steel (*fuladh*) as discussed by Allan (1979) and al-Hassan and Hill (1986). The most common, traditional method is solid state carburization of wrought iron. There are many variations on this method. It is also known as 'case hardening' or in other instances 'cementation'. This is a diffusion process in which wrought iron is packed in crucibles or a hearth with charcoal, then heated to promote diffusion of carbon into the iron to produce steel. Alternatively, another indirect method uses wrought iron and cast iron. Although there has been some uncertainty on the translation of the word *daus* in Islamic texts, the cast iron interpretation is generally accepted (Allan, 1979). In this process, wrought iron and cast iron may be heated together in a crucible to produce steel by 'fusion'. This is also called a 'visco-liquid diffusion process' (Needham, 1958) and may operate below the melting point of true cast steel (Smith, 1960). A third indirect method to produce steel is partial decarburization of cast iron or a high carbon steel bloom. Again, there are variations of this method, but generally it is considered very difficult to control (see Rostoker and Bronson, 1990). Outside the Islamic textual evidence, inadvertent direct production of steel during bloomery iron smelting represents another possibility, but it is not considered here in the context of an indirect or multi-stage process to routine production of steel. A detailed account of the many variations is presented by Rostoker and Bronson (1990). It is against these three main methods for indirect steel production, this preliminary report concerns the

archaeometallurgical evidence and its interpretations for early Islamic times at Merv, Turkmenistan.

The archaeometallurgical investigations at the Islamic site of Merv represent only one aspect of an international collaborative project under the direction of Dr Georgina Herrmann and Dr K. Kurbansakhatov. The organizations involved in the International Merv Project are the Institute of Archaeology, University College London, YuTAKE (the South Turkmenistan Multi-Disciplinary Archaeological Expedition), Turkmen Academy of Sciences, Ashgabat, and the Institute for the History of Material Culture, St Petersburg.

During the 1993 season at Merv, two areas with surface concentrations of crucible fragments, green 'glass' fragments and slagged furnace fragments have been located in the survey in area MGK 7.F.II. The scatter of pottery around and within the archaeometallurgical remains in MGK 7.F.II at Merv is predominantly dated as Early Islamic, perhaps 8th or 9th century AD, by the archaeological team. A small-scale excavation was conducted in the 1994 season (Fig. 1) by Dr K. Kurbansakhatov, D. Connolly, St. J. Simpson, Ann Feuerbach and other members of the International Merv Project.

Fragments of crucibles, furnace wall and tuyeres, as well as the glassy slag, were collected from the metallurgical dumps by Dr J. Merkel for technical investigation in the Wolfson Archaeological Science Laboratory at the Institute of Archaeology, UCL. The analytical work is undertaken, in part, as supervised M.Sc. research in archaeometallurgy by Ann Feuerbach. The metallurgical