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Ancient Monuments Laboratory
Report 70/97

THE INVESTIGATIVE CONSERVATION OF THE LEAD FISHING WEIGHTS FROM HOLME FEN CAMBRIDGESHIRE

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Summary

An assemblage of 538 lead fishing weights and associated fragments recovered from excavations carried out at Holme Fen Site 2 in Cambridgeshire was subjected to investigative conservation. Thirty-nine of the weights were found to be much more extensively corroded than the rest and eleven of the weights retained traces of associated net fibres. Analytical work established that the differences in condition were not due to compositional factors and alternative causes are discussed. The net fibres present were identified as being of animal origin, possibly cattle.

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The investigative conservation of the lead fishing weights from Holme Fen Cambridgeshire

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An assemblage of 538 lead fishing weights and associated fragments recovered from excavations carried out at Holme Fen Site 2 in Cambridgeshire was subjected to investigative conservation. Thirty nine of the weights were found to be much more extensively corroded than the rest and eleven of the weights retained traces of associated net fibres. Analytical work established that the differences in condition were not due to compositional factors and alternative causes are discussed. The net fibres present were identified as being of animal origin, possibly cattle.

Introduction

The excavation carried out at Holme Fen Site 2 by the Fenland Archaeological Trust in 1991 yielded some 13,000 artefacts, including an assemblage of 538 lead weights and associated fragments which are the subject of this report. The site contained two small mounds with associated dense artefact clusters and was situated on the southern side of the former Whittlesey Mere, on the eastern edge of a small peninsula. The lead weights were clustered particularly around and just off the north-eastern side of mound 1, identified as Carter's Cote (approximately 50% of the weights), and across mound 2, Prices Cote (approximately 10%).

The conservation strategy

Conservation work on these lead finds was carried out at the Institute of Archaeology, University College London in 1993/4, by Adrian Tribe, English Heritage Contract Conservator, South and East England. The conservation strategy that was followed is outlined in the following paragraph.

The finds were packaged on site by Fenland Archaeological Trust staff in 1991. An assessment of the lead weights was carried out by V. Fryer (Finds Researcher) in 1992 which concluded that this unique collection was worthy of further study. Her report referred to the fragile and unstable state of some of the finds and included recommendations that 23 of the weights should be cleaned for illustration purposes and that net/line fibres found to be present within several of the weights should be identified. The Conservator was contacted at the end of the Assessment Phase by the Cambridge Archaeological

Unit, to whom the post-excavation responsibilities had passed, and requested to carry out the conservation work proposed in the assessment report. The lead finds were examined visually, with details and observations being recorded on a computer database. A dedicated dBASE programme, MAP2HELPER, was used for this work. Following assessment, all the finds were repackaged to maximise their chances of long-term preservation. A total of 104 weights were selected to undergo treatment or investigative conservation. Once this work was completed the objects were transferred to V. Fryer and then to the Cambridge Archaeological Unit, together with the documentation produced during the conservation work, in readiness for deposition in the receiving museum in 1995.

Examination and X-radiography

Visual examination of the weights and associated items showed that out of 538 objects, 39 exhibited signs of greater corrosion than the rest, generally in the form of more extensive creamy brown powdery corrosion products and greater brittleness and cracking. Of these, 32 were recovered from and to the north east and east of Mound 1, 3 from and to the east of Mound 2 and 4 from the hinterland of Mound 1 (Figure 1). The remaining 499 items were found to be in fair to excellent condition, generally having just a light covering of creamy brown corrosion products over a dull grey surface. X-radiography, using a *Faxitron* x-ray cabinet and *Kodak Industrex CX* film, was carried out on one tubular weight that appeared to have a small iron encrustation on its side (UCL X-RAY NO: EH0168). This confirmed the presence of an iron protrusion, although its exact form could not be determined.

Eleven of the weights (nine rolled, two re-used) were found to contain traces of net fibres within them, preserved in all but one case as fibres rather than by being replaced by corrosion products.

Assessment and selection

The objectives of the conservation treatment and research work were:

- To try to determine the reason for the differences in condition between the 39 badly corroded items and the remaining lead weights and fragments.
- To identify, if possible, the net fibres found to be present with 11 of the weights.
- To clean for illustration purposes 23 weights representative of the types present in the assemblage.

In relation to these objectives, a total of 104 items were selected to undergo treatment and/or investigative conservation.

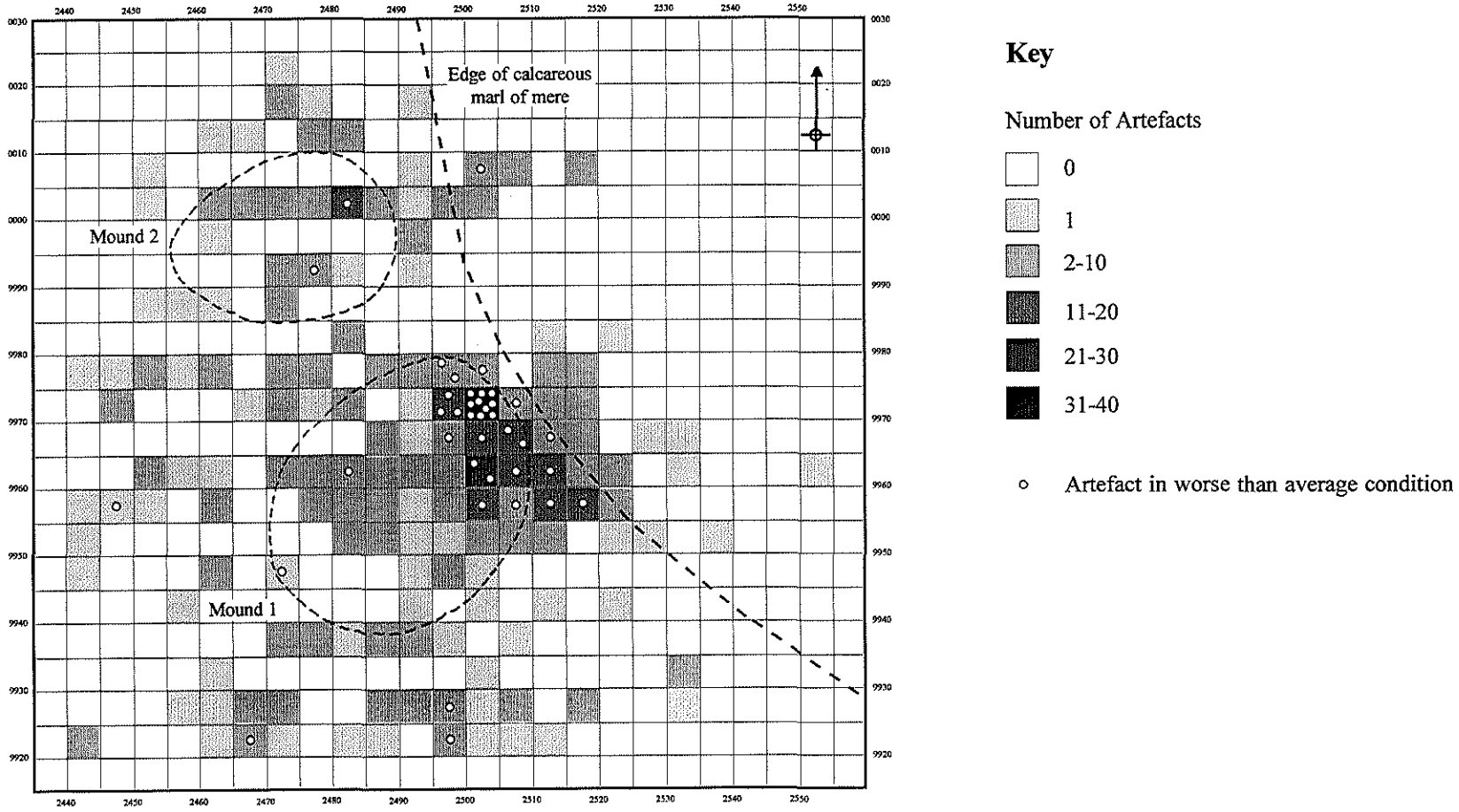


Figure 1 Distribution of the lead artefacts at Holme Fen Site 2

Treatment and investigative conservation

Cleaning for illustration

The weights that were selected for illustration were mechanically cleaned to remove adhering soil and any loose corrosion products, although 28 rather than 23 were cleaned due to ambiguities in their identification, having been specified in the Finds Specialist's Assessment Report by grid square number rather than by small find number.

Investigation of the corrosion differences

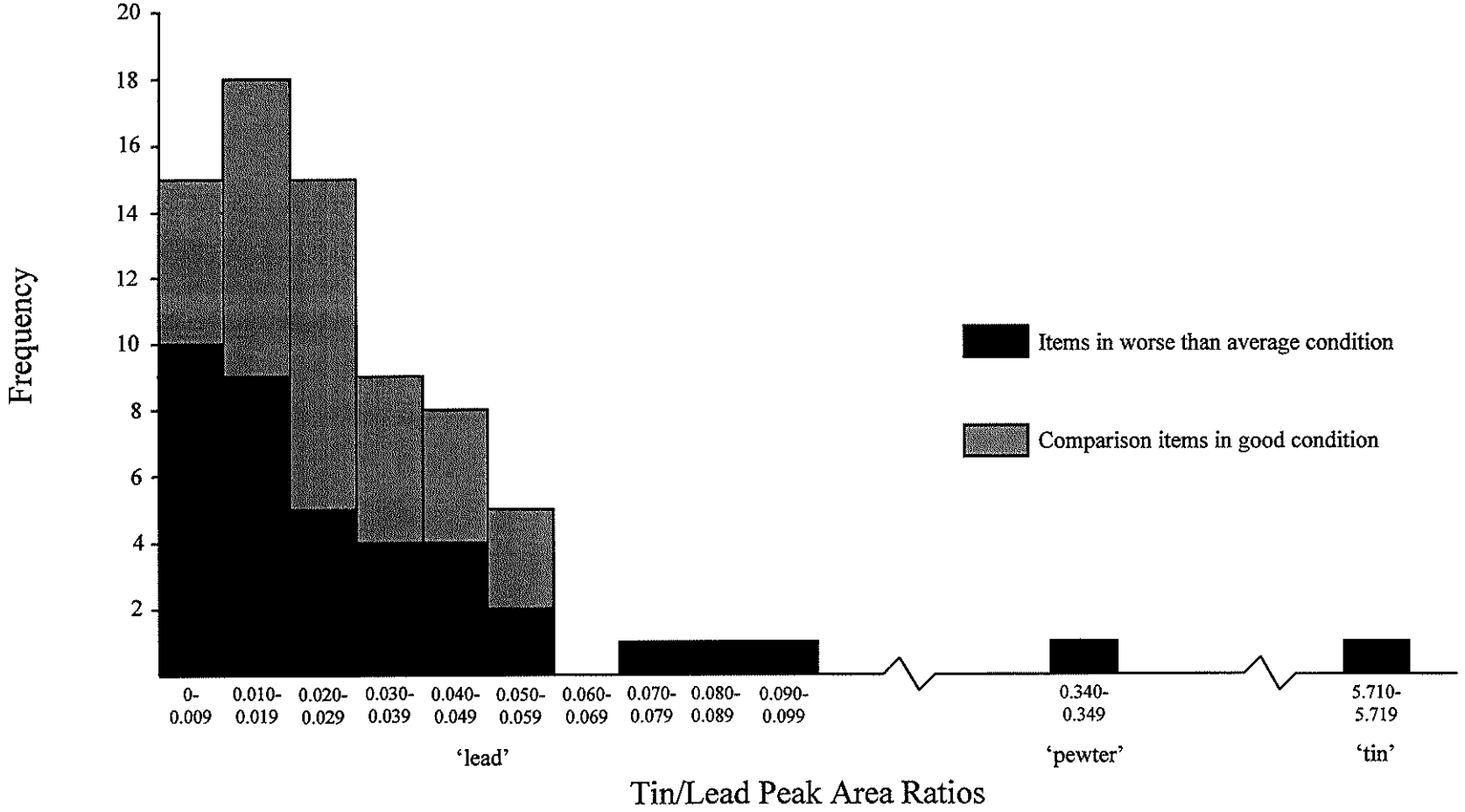
As the more extensively corroded objects were recovered from the same locations as many that were found to be in much better condition (Figure 1), it was first thought that the degree of corrosion could be related to composition. To test this hypothesis, X-ray fluorescence (XRF) analysis was carried out on these objects, together with 36 others that were in much better condition. As far as possible each more extensively corroded weight was paired with a less corroded weight recovered from the same grid square (given in brackets in the following text). Computer software linked with the XRF unit was used to measure the area of the major fluorescence peak for both tin and lead, the only metals definitely found to be present in the objects. This enabled tin/lead peak area ratios, indications of the proportions of tin and lead present, to be measured and compared.

Figure 2 shows the results of this analysis. It can be seen that in all but two cases, no more than small amounts of tin were present in the objects, designated 'lead' in Figure 2, and that there appeared to be no direct relationship between composition and condition. In two of the more corroded items significantly higher tin contents were noted. SF8109 (2495/9970) could be seen to be a fragment of a pewter spoon handle and is labelled 'pewter' in Figure 2. SF10113 (2480/0000) was found to have an extremely high tin content, in fact with lead present only as a very minor constituent, and is therefore identified as 'tin' in the Figure.

When the pewter and tin items are removed from the calculations, the average figures for the tin/lead peak area ratios for the remaining more extensively corroded items and the 36 lightly corroded finds are almost identical: 0.027 and 0.026 respectively. Thus compositional differences among these lead weights were not significant and could not explain the different degrees of corrosion observed.

Attention was therefore turned to the corrosion products themselves, with samples being taken from nine of the lead weights, as well as from the pewter and tin objects, for X-ray diffraction (XRD) analysis, carried out by M. Ward, Ancient Monuments Laboratory, English Heritage. A crystalline substance found to be present inside weight SF2644 was also sampled for XRD analysis. The results are shown in Table 1.

Figure 2 Tin/Lead X-ray fluorescence peak area ratios of 75 weights and other items.



Sample & Object Condition	Main Phase	Small Amounts	Trace Amounts	Other Phases	Comments
SF2644 (2495/9950). Good.	Gypsum	-	-	-	Crystalline substance within rolled weight. Cerussite and Hydrocerussite from the lead were also detected.
SF8149 (2465/9920). Good.	Hydrocerussite	-	Cerussite	Also traces of Lead metal and Massicot	-
SF8150 (2465/9920). Poor.	Cerussite	Hydrocerussite	-	-	-
SF7469 (2475/9990). Poor.	Cerussite	Hydrocerussite	-	-	-
SF7470 (2475/9990). Good.	Hydrocerusiite	-	Cerussite	Also traces of Lead metal and Massicot	-
SF10113 (2480/0000). Poor.	Cassiterite	Possibly Galena	-	-	`Tin' object fragment
SF8109 (2495/9970). Poor.	Cassiterite	Possibly Galena	-	-	`Pewter' spoon handle
SF8194 (2495/9975). Poor.	Cerussite	-	Hydrocerussite	Possibly Microcline (but only one line was visible)	One line of Cerussite was more intense than it should have been
SF8198 (2495/9975). Good.	Cerussite	-	Lead metal	A number of underlying amorphous peaks	-
SF10263 (2500/9970). Good.	Cerussite	-	Lead metal	A number of underlying amorphous peaks	-
SF10265 (2500/9970). Good.	Equal amounts of Cerussite and Hydrocerussite	Massicot	Lead metal	-	-
SF12232 (2500/9970). Poor.	Equal amounts of Cerussite and Hydrocerussite	Either Gypsum or Brushite	-	-	XRF analysis gave no positive support for sulpher (in Gypsum) or phosphorus (in Brushite) because of strong lead interference
SF12239 (2500/9970). Poor.	Hydrocerussite	Litharge	Cerussite	-	-

Mineral names mentioned in the table: Brushite - $CaPO_3(OH)_2{\cdot}H_2O$ Cassiterite - SnO_2 Cerussite - $PbCO_3$ Galena - PbS Gypsum - $CaSO_4{\cdot}2H_2O$ Hydrocerussite - $Pb_3(CO_3)_2(OH)_2$ Lead oxide (Litharge or Massicot) - PbO Microcline - $KAlSi_3O_8$

Table 1 X-ray diffraction phase analysis of corrosion products found on 13 lead items

Some differences in the corrosion products present on the lead items were revealed, but no definite correlation between the extent of corrosion and the identity of the corrosion products could be discerned, although it is possible that XRD analysis on a larger number of samples may enable such a correlation to be identified.

Lead oxides, lead carbonate and basic lead carbonate are all corrosion products that can be expected on lead objects recovered from archaeological contexts. The oxides (and to some extent the carbonate and basic carbonate) can form protective surface layers that considerably reduce the subsequent rate of corrosion. This present study appears to show that the differences observed in the condition of some of the lead weights compared with the majority were simply due to differences in the degree of corrosion rather than differences in metallic composition or in the types of corrosion products formed. It may be that in the more extensively corroded weights some physical factor or factors caused the disruption of protective corrosion layers, thus allowing further attack to take place due to reactions with peat soil constituents such as humic acids. The intermediate corrosion products formed by the action of weak organic acids on lead are soluble and would not therefore have been revealed by XRD analysis, although ultimately the basic carbonate is formed, which was detected on some of the more corroded weights.

An alternative explanation is that very localised and transitory increases in soil water content and acidity, and changes in soil water composition, may have caused corrosion rates to increase in these objects. The soil pH during medieval times on the very edge of the Mere cannot be determined with any certainty, partly because the extent of the Mere is known to have varied according to the season in that period. The 1983 Soil Map of England and Wales describes the soil of the Mere itself as extremely calcareous and the surrounding peat as very acid. The survival of fish bones in an excellent state of preservation among the peat surface soil would appear to indicate that the pH at this site has been quite consistently neutral or alkaline rather than acid, and the presence of lead carbonate as a corrosion product on some of the lead weights would also support this hypothesis as it is soluble in acid environments.

The most usual tin corrosion product, tin oxide (cassiterite), was shown to be the principle corrosion product present on the tin item and on the pewter spoon fragment. Although lead is a baser metal than tin in the galvanic series and might be expected therefore to corrode in preference to tin when in contact with it, in natural environments tin-lead alloys usually bear both tin and lead corrosion products, mainly lead carbonates and tin (IV) oxide, with the latter often predominating due to the greater solubility and mobility of these lead compounds (Turgoose 1985, 24).

The crystalline substance found inside weight SF2644 was shown by XRD analysis to be gypsum (calcium sulphate, $CaSO_4 \cdot 2H_20$). It is not known why this material was present.

Identification of the preserved net fibres

Fibre traces were found to be present inside eleven of the weights, although in one case this was not at all certain. The material that was commonly used in medieval times for making fishing nets was twine made from the bast fibres of the hemp plant (*Cannabis sativa L.*) (Steane & Foreman 1988, 162). East Anglia was a major source of hemp during this period, with, for example, some 15% of sown acreage in the Norfolk Fens being of hemp by the 16th century (Godwin 1967, 45). It would seem reasonable to assume therefore that the fishing net fibres found in these weights were those of hemp. However, examination of samples using stereo microscopy, transmitted light microscopy and scanning electron microscopy indicated otherwise (carried out by the author and by A. Cselik, Ancient Monuments Laboratory, English Heritage). The predominant fibre present was identified as being of animal origin, possibly cattle (Cselik, pers. comm.). Observations are summarised in Table 2. An example of the fibres from SF529 is shown in the scanning electron micrograph in Figure 3.

As shown in Table 2, the characteristics of the cordage used in making the fishing net could be at least partially determined in seven cases. In four of these the cord was clearly seen to consist of more than one thread, and in each of these the threads were Z-plied. In the five cases where the twist direction of the threads could be seen, they were always S-twisted. The most substantial cord was found inside weight SF8229, with a diameter of c.7mm and a surviving length of 35mm, consisting of three threads each with a diameter of c.3.5mm (Figure 4). In three cases, SF529, SF9742 and SF10986, the cord used clearly consisted of two threads. The cord diameters were c.3mm, c.4mm and c.2.5mm respectively, with the thread diameters being c.1.5mm, c.2mm and c.1.5mm respectively. In two instances, SF1360 and SF8133, the cord appeared to consist of just one thread, although in both cases degradation was extensive and details were unclear. The latter may possibly have had a diameter of c.2mm.

The recovery of considerable quantities of pottery from the site (jugs, cooking pots, broad shallow bowls) appears to indicate that at least some activity was being carried out at the fishing platforms beyond simply the landing of catches. It is known from medieval documentary sources that fishermen used to lay their nets out to dry on the shore of Whittlesey Mere (Darby 1974, 30). Considering also the large number of apparently re-worked weights that were recovered, it is not unreasonable to suggest that a certain amount of net repair work was probably taking place at the site. In fact, the appearance of the cord in SF9742 may suggest that this weight was deliberately cut from the net, presumably prior to the net being repaired, but was lost or discarded rather than being re-used (Figure 5). The fact that not one fish hook was found may indicate that the bulk of the fishing activity was carried out using nets rather than lines, although obviously the latter is not ruled out.

WEIGHT	CORD	THREADS	FIBRES
SF529	2 Threads, Z-ply. Diameter c.3mm. Surviving length c.12mm.	S-twisted. Diameter c.1.5mm.	Animal fibres: diameter c.0.05-0.14mm, medulla varied from continuous to interrupted or fragmental, varying in diameter from a quarter to two thirds of the total fibre diameter. Scales irregular waved mosaic? Some vegetable fibre bundles present?
SF1360	1? Thread. Diameter ≤3mm. Surviving length c.8mm.	S-twisted.	Fibres very degraded, diameter c.0.08-0.13mm. No detail discernable.
SF8133	1 Thread. Diameter c.2mm. Surviving length c.12mm.	-	Fibres very degraded. No sample taken for detailed microscopic examination.
SF8215	-	-	Only one or two fibres visible - possibly just root hairs? No sample taken for detailed microscopic examination.
SF8229	3 Threads, Z-ply. Diameter c.7mm. Surviving length c.35mm.	S-twisted. Diameter c.3.5mm.	Animal fibres: diameter c.0.07-0.14mm, medulla interrupted or fragmental, approximately one third of the total fibre diameter. Scales not visible. Some vegetable fibre bundles present?
SF8230	2? Threads. Diameter ≤3mm. Surviving length c.12mm.	-	Fibres very degraded. No sample taken for detailed microscopic examination.
SF8533	-	-	Fibres were received in a separate bag, completely disaggregated. Animal fibres: diameter c.0.07-0.12mm, medulla interrupted or fragmental, approximately one third of the total fibre diameter. Traces of a scale pattern present - irregular waved mosaic? Some vegetable fibre bundles present?
SF9742	2 Threads, Z-ply. Diameter c.4mm. Surviving length c.13mm.	S-twisted. Diameter c.2mm.	Animal fibres: diameter c.0.1-0.15mm, medulla fragmental, approximately one quarter to one third of the total fibre diameter. Scales visible but insufficient to discern any pattern. Some vegetable fibre bundles present?
SF10986	2 Threads, Z-ply. Diameter c.2.5mm. Surviving length ≤ 14mm.	S-twisted. Diameter c.1.5mm.	No sample taken for detailed microscopic examination.
SF11606	-	-	Some degraded fibres present. No sample taken for detailed microscopic examination.
SF11726	-	-	Very few fibres present. No sample taken for detailed microscopic examination.

Table 2 Fibre traces associated with 11 lead weights

Figure 3: Scanning electron micrograph of fibres from inside weight SF529

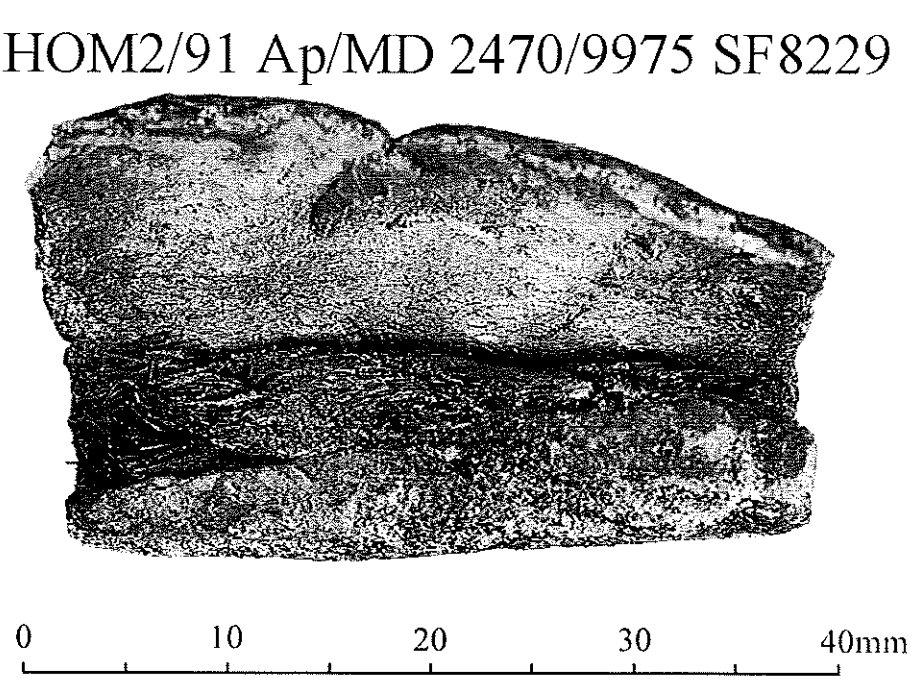


Figure 4: Remains of fishing net cord inside weight SF8229

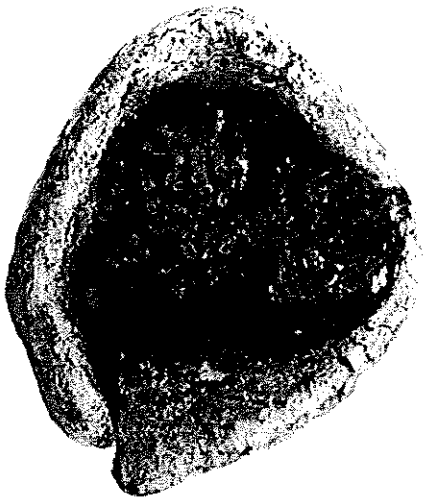


Figure 5:
End view of weight SF9742 showing cut? fibres

Packaging and storage

The weights and fragments were packed in individual pierced polyethylene bags and placed inside air-tight polyethylene boxes. To maintain a relative humidity (RH) below 35%, well-pierced polyethylene bags of silica gel were placed in each box, with an RH indicator strip positioned in such a way as to be visible without the lids having to be removed. With rigorous curation these conditions can be maintained indefinitely and the finds should remain stable.

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