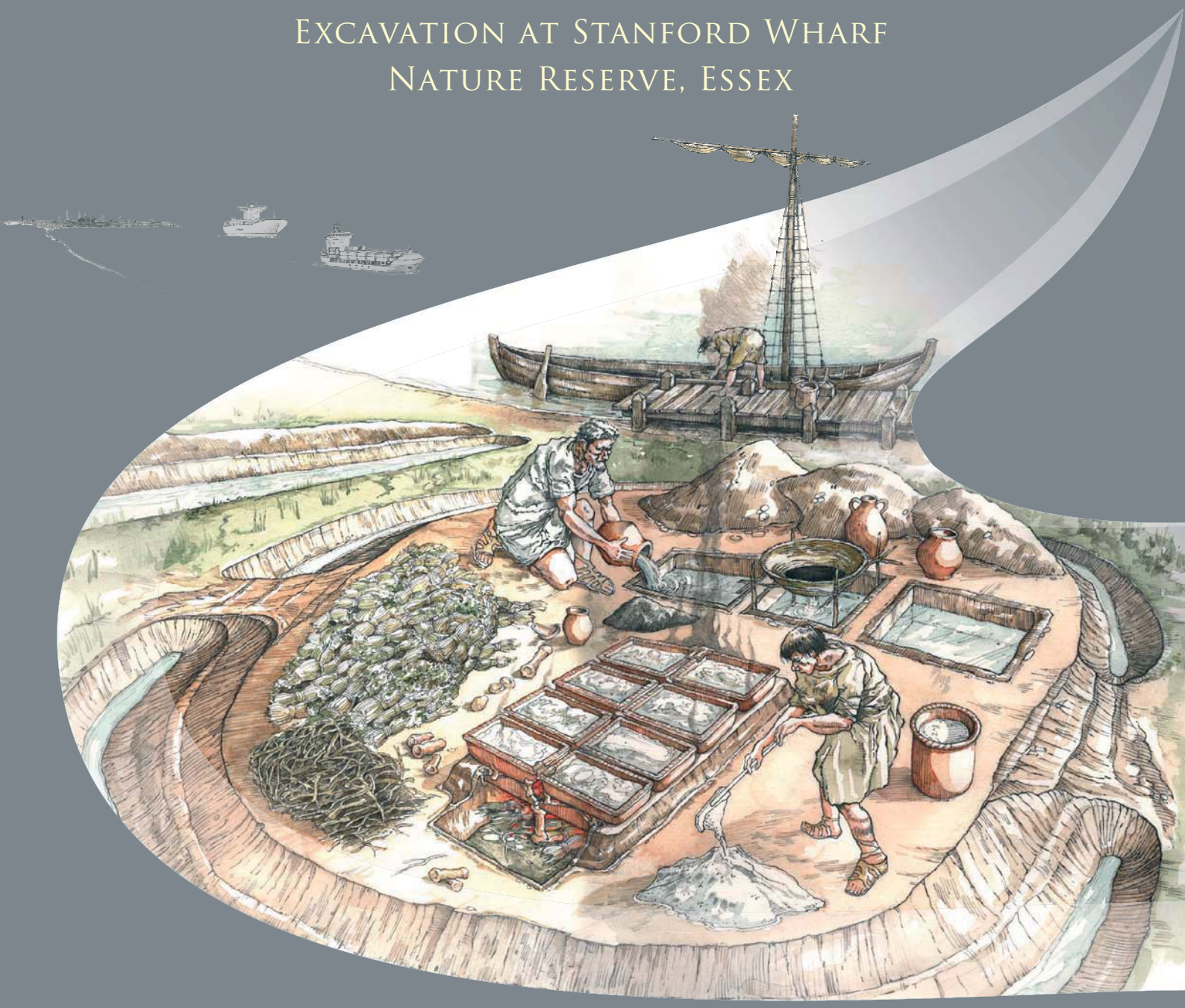
# London Gateway

## Iron Age and Roman Salt Making in the Thames Estuary

### Excavation at Stanford Wharf Nature Reserve, Essex



Specialist Report 6

Slag and High-Temperature Debris

by Lynne Keys

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*by Lynne Keys*

## Introduction

A small assemblage (just over 10.05kg) of slag and related high-temperature debris was recovered by hand during excavation and from soil samples processed afterwards; most was from Area A. For this report it was examined by eye and categorised on the basis of morphology alone. Each slag type in each context was weighed. Quantification data are given in Table 6.1 in which weight (wt) is shown in grammes; length (len.), breadth (br.) and depth (dep.) in millimetres.

## Discussion of the assemblage

Iron slag was a small proportion (704g) of the assemblage. Minute quantities of non-magnetic, silica-rich spheres may derive from Iron Age smelting but the lack of other bulk evidence argues against this. The diagnostic iron slags are those of secondary smithing. One smithing hearth bottom (a plano-convex slag cake which builds up in the hearth base) and 5g of hammerscale flakes and magnetic spheres were recovered (Table 6.2).

Hammerscale flakes are produced by ordinary hot working of a piece of iron (making or repairing an object), while the tiny magnetic spheres derive from high temperature welding used to join or fuse two pieces of iron. The more bulk slags are moved about, the less hammerscale is likely to remain with them. The quantities from the Stanford Wharf samples are so small they indicate that no intense smithing took place and the hammerscale was not near any focus of smithing.

Iron slag described as undiagnostic cannot be assigned to smelting or smithing either because of morphology or because it has been broken up during deposition, re-deposition or excavation. Less than a kilo of undiagnostic slag was recovered, lending support to the argument that no serious iron-working activity took place in the area. There is the possibility that larger smithing slags produced may have been removed for recycling on roads and as hard core elsewhere during the Roman period.

Other types of debris in the assemblage may derive from a number of high temperature activities – including domestic fires – and cannot be taken on their own to indicate that iron working was taking place. These include fired clay, vitrified hearth lining and cinder. Vitrified hearth lining comes from nearest the tuyère region (the region of highest temperature) of a hearth or furnace. Cinder is a very porous, highly vitrified material formed at the interface between the alkali fuel ashes and siliceous material of a hearth lining. If found in association with iron smelting and/or smithing slag these materials are almost certainly products of the process, but this is not the case here and other industries involving heat were taking place and could have produced them.

Fuel ash slag was the largest quantity of slag recovered (over 2.9kg). It is a very lightweight, highly porous, light coloured (whitish-grey to grey-brown) residue produced by a high temperature reaction between alkaline fuel ash and siliceous material such as a clay lining or surface. It can result from any high temperature activity where these two constituents are present, including domestic hearths, accidental fires (burning down of wattle-and-daub and thatched buildings), and even cremations. On its own it does not represent metalworking activity; only when associated with diagnostic evidence can it be so attributed (for further discussion on the subject, see Bayley 1985, 41; Henderson *et al.* 1987a; 1987b). Fuel ash slag is frequently found in quantity as large lumps on Iron Age sites, but any such pieces subjected to re-deposition and disturbance will quickly break up. Some fragments in the Stanford Wharf assemblage are so hard – almost stoneware-like – that they may include some saline element in their make-up.

Ferruginous concretions are made up of a re-deposition of iron hydroxides (rather like iron panning), enhanced by surrounding archaeological deposits, particularly if there is iron-rich waste present as a result of iron working. It forms the second largest group (2.6kg) of material submitted for examination as ‘slag’ but more likely indicates the presence of iron in quantity in some deposits. Support for this may be the many tiny non-slag iron flakes recovered by sampling during excavations; perhaps iron vessels or other sheet material were being used (and sometimes shaped) here.

**Discussion by period**

***Iron Age***

Area A layer 5849 contained small iron flakes and some broken pieces of flake hammerscale (total 0.5g). A layer of dumping (5024) in Area A produced 36g of iron-rich undiagnostic slag. Also in Area A, layer 5026 contained 6g of slag dribbles and small cindery runs.

***Roman***

Layer 1745 in Area A contained non-magnetic, silica-rich spheres (0.5g) which could be produced by smelting and, less often, iron smithing. The only smithing hearth bottom came from layer 6743 in Area A; it also contained a small quantity of undiagnostic iron slag. Area B feature 4786, fill 4787, contained some silica spheres in a residue mainly consisting of fuel ash slag.

***Middle Roman***

Layer 5735 contained small iron flakes, an iron nail and ferruginous concretions (total 5g), which may be waste from smithing or just iron and resultant corrosion products dumped here.

***Late Roman***

In Area B, fill 4065 of ditch 4063 produced non-magnetic silica-rich spheres, some cinder and fuel ash slag.

***Late Roman 1***

Fill 1021 of posthole 1022 in Area A contained a small quantity of non-magnetic, silica-rich slag spheres. Fill 5708 of enclosure ditch 5816 contained six pieces of undiagnostic slag weighing 112g.

***Late Roman 2***

In Area A layer 1007 contained tiny iron flakes. Layer 1018 contained 30g of undiagnostic iron slag. Fill 1525, feature 1526, contained 15g of undiagnostic iron slag. Layer 1626, a slot with burnt material, contained a tiny quantity (0.5g) of broken hammerscale flake, tiny iron flakes and burnt clay. Floor layer 5061 contained 106g of undiagnostic iron slag, probably re-deposited. Fill 6092 of tile-built hearth 6061 contained crushed iron dust, very occasional broken hammerscale flake, tiny iron

flakes, and a very small quantity of undiagnostic iron slag. There is not much, but it does suggest that structure 6090 could have been used for a one-off smithing event, perhaps involving shaping or repair of flat iron objects, such as iron heating pans. Layer 5795 (unit G5) contained 0.5g of microslags in the form of slag bubbles and broken spheres.

## References

Bayley, J, 1985 What's what in ancient technology: an introduction to high-temperature processes, in *The archaeologist and the laboratory* (ed. P Phillips), CBA Research Report **58**, London, 41-2

Henderson, J, Janaway, R C and Richards, J, 1987a A curious clinker, in *Journal of Archaeological Science* **14**, 353 - 365

Henderson, J, Janaway, R C and Richards, J, 1987b Cremation slag: a substance found in funerary urns, in *Death, decay and reconstruction* (eds A Boddington, A N Garland and R C Janaway), Manchester University Press, Manchester, 81-100

# Slag and High-Temperature Debris Tables

## TABLE 6.1: QUANTIFICATION OF THE SLAG AND HIGH-TEMPERATURE DEBRIS

| cxt | sam | slag identification | wt | len | br | dp | comment | pcs |
|---|---|---|---|---|---|---|---|---|
| 1002 | | iron nail | 17 | | | | with ferruginous concretion | |
| 1007 | 1334 | iron | 0.25 | | | | tiny flakes | |
| 1007 | | ash lump | 17 | | | | | |
| 1007 | | clay & iron | 414 | | | | | |
| 1007 | | ferruginous concretion | 1 | | | | | |
| 1008 | 1335 | copper oxide alloy run | 1 | | | | translucent, red, glassy | |
| 1008 | 1335 | heat magnetised residue | 4 | | | | fired clay, grit, iron flakes | |
| 1008 | | iron | 172 | | | | and ferruginous concretion | |
| 1008 | | iron | 194 | | | | with ash | |
| 1008 | | iron | 12 | | | | | |
| 1018 | | undiagnostic | 30 | | | | | |
| 1021 | 1009 | hammerscale | 0.5 | | | | tiny, non magnetic silica-rich spheres | |
| 1095 | | fired clay | 7 | | | | | |
| 1096 | | iron | 4 | | | | with ferruginous concretion | |
| 1215 | | ferruginous concretion | 406 | | | | | |
| 1215 | | iron | 66 | | | | | |
| 1217 | | ferruginous concretion | 13 | | | | | |
| 1227 | | fuel ash slag | 18 | | | | | |
| 1363 | 1236 | heat magnetised residue | 2 | | | | fired clay, grit | |
| 1363 | | fuel ash slag | 23 | | | | with fired clay | |
| 1375 | 1030 | mixed residue | 3 | | | | iron flakes, glassy green fuel ash slag | |
| 1410 | 1053 | ferruginous concretion | 14 | | | | | |
| 1415 | | fired clay | 40 | | | | and cinder | |
| 1415 | | fuel ash slag | 1 | | | | | |
| 1457 | 1062 | heat magnetised residue | 1 | | | | mostly tiny charcoal fragments | |
| 1495 | | bricatage | 36 | | | | | |
| 1495 | | cindery run | 0.5 | | | | | |
| 1495 | | fired clay | 67 | | | | or briquetage | |
| 1495 | | fuel ash slag | 13 | | | | | |
| 1525 | 1059 | undiagnostic | 15 | | | | | |
| 1531 | 1111 | cinder | 17 | | | | glassy black | |
| 1531 | | ferruginous concretion | 180 | | | | | |
| 1531 | | fired clay | 16 | | | | | |
| 1531 | | iron | 64 | | | | | |
| 1586 | | undiagnostic | 33 | | | | | |
| 1593 | 1330 | mixed residue | 387 | | | | fired clay, fuel ash slag | |
| 1593 | | fuel ash slag | 4 | | | | | |
| 1618 | 1320 | fuel ash slag | 554 | | | | | |
| 1626 | 1075 | hammerscale | 0.5 | | | | broken flake | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1626 | 1075 | heat magnetised residue | 0.5 | | | | tiny iron flakes, fired clay, grit | |
| 1674 | 1094 | heat magnetised residue | 1 | | | | fired clay, stones | |
| 1679 | | fuel ash slag | 4 | | | | | |
| 1680 | 1090 | fired clay | 1 | | | | | |
| 1680 | 1090 | heat magnetised residue | 1 | | | | fired clay, stones | |
| 1745 | 1117 | fuel ash slag | 7 | | | | | |
| 1745 | 1117 | slag spheres | 0.5 | | | | silica-rich, non magnetic | |
| 1745 | | fired clay | 7 | | | | | |
| 1784 | 1113 | cinder | 2 | | | | | |
| 1784 | 1113 | ferruginous concretion | 9 | | | | | |
| 1834 | 1115 | heat magnetised residue | 1 | | | | grit | |
| 1890 | 1121 | heat magnetised residue | 2 | | | | fired clay, stones | |
| 1890 | 1121 | heat magnetised residue | 2 | | | | fired clay, grit | |
| 1915 | 1137 | heat magnetised residue | 0.5 | | | | ashy charcoal | |
| 1958 | 1146 | cinder | 3 | | | | | |
| 1958 | | cinder | 2 | | | | | |
| 4065 | 4002 | heat magnetised residue | 1 | | | | microslag silica spheres, cinder, fuel ash slag | |
| 4240 | | fuel ash slag | 806 | | | | so vitrified as to be almost stoneware in composition | |
| 4240 | | fuel ash slag | 233 | | | | | |
| 4241 | | fuel ash slag | 30 | | | | | |
| 4245 | | fuel ash slag | 25 | | | | | |
| 4282 | | fuel ash slag | 58 | | | | very hard and vitrified | |
| 4292 | | fuel ash slag | 3 | | | | | |
| 4298 | | fired clay | 24 | | | | white clay with flattened surface | 2 |
| 4298 | | fuel ash slag | 30 | | | | highly vitrified | |
| 4298 | | vitrified hearth lining | 8 | | | | | |
| 4319 | 4030 | fuel ash slag | 203 | | | | very tiny pieces | |
| 4333 | 4011 | fuel ash slag | 4 | | | | | |
| 4333 | 4011 | vitrified hearth lining | 34 | | | | | |
| 4356 | 4024 | mixed residue | 198 | | | | fuel ash slag, fired clay, grit | |
| 4356 | 4024 | mixed residue | 81 | | | | fuel ash slag, fired clay | |
| 4358 | 4025 | fuel ash slag | 348 | | | | | |
| 4358 | 4025 | mixed residue | 219 | | | | fuel ash slag, tiny dribbles, cinder | |
| 4382 | 4028 | fuel ash slag | 78 | | | | | |
| 4407 | | fired clay | 32 | | | | with vitrified surface | |
| 4407 | | fuel ash slag | 72 | | | | highly vitrified | |
| 4430 | | fuel ash slag | 5 | | | | | |
| 4441 | 4035 | fuel ash slag | 63 | | | | | |
| 4445 | | fuel ash slag | 27 | | | | | |
| 4446 | | fired clay | 39 | | | | highly vitrified | |
| 4567 | | fuel ash slag | 3 | | | | | |
| 4600 | 4037 | waterlain deposit | 22 | | | | fired clay | |
| 4600 | | ferruginous concretion | 23 | | | | and cess | |
| 4600 | | fuel ash slag | 26 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4755 | 4098 | fired clay | 2 | | | | | |
| 4764 | 4099 | heat magnetised residue | 1 | | | | fired clay, tiny stones etc | |
| 4787 | 4106 | heat magnetised residue | 3 | | | | clay | |
| 4787 | 4106 | heat magnetised residue | 10 | | | | fuel ash slag, silica spheres, fired clay | |
| 4787 | | fuel ash slag | 63 | | | | vitrified and with glassy surface | |
| 4787 | | fuel ash slag | 92 | | | | so vitrified as to be almost stoneware in composition | |
| 5005 | | mixed residue | 33 | | | | fuel ash slag, fired clay, cinder | |
| 5024 | | fuel ash slag | 17 | | | | | |
| 5024 | | iron-rich undiagnostic | 36 | | | | | 2 |
| 5026 | | fired clay | 68 | | | | | |
| 5026 | | fuel ash slag | 8 | | | | | |
| 5026 | | slag dribbles & cindery runs | 4 | | | | | |
| 5039 | | ferruginous concretion | 75 | | | | with nail | |
| 5041 | 1162 | fired clay | 3 | | | | | |
| 5041 | 1162 | undiagnostic | 106 | | | | very ferruginous | |
| 5133 | | cinder | 5 | | | | | |
| 5133 | | fuel ash slag | 36 | | | | | |
| 5133 | | fuel ash slag | 12 | | | | iron-rich | |
| 5133 | | undiagnostic | 135 | | | | | 1 |
| 5133 | | vitrified hearth lining | 57 | | | | | |
| 5155 | 1165 | heat magnetised residue | 1 | | | | fired clay, stone grit; very ashy | |
| 5165 | | cindery runs | 3 | | | | | |
| 5250 | 1360 | heat magnetised residue | 1 | | | | fuel ash slag, fired clay, grit | |
| 5315 | 1200 | slag spheres | 1 | | | | silica-rich, non magnetic | |
| 5364 | 1189 | heat magnetised residue | 1 | | | | fired clay, grit | |
| 5434 | 1210 | fuel ash slag | 4 | | | | | |
| 5506 | | fuel ash slag | 22 | | | | | |
| 5532 | 1359 | waterlain deposit | 983 | | | | fired clay, fuel ash slag, tiny pebbles | |
| 5568 | | cinder | 1 | | | | iron-rich | |
| 5568 | | fired clay | 2 | | | | | |
| 5707 | | cinder | 3 | | | | | |
| 5708 | | ferruginous concretion | 34 | | | | | 1 |
| 5708 | | fired daub | 15 | | | | with whitewashed surface | |
| 5708 | | undiagnostic | 112 | | | | | 6 |
| 5735 | 1247 | iron | 5 | | | | iron nail, iron flakes, ferruginous concretion | |
| 5795 | 1254 | microslags | 0.5 | | | | slag bubbles & broken spheres | |
| 5835 | 1280 | fired clay | 1 | | | | | |
| 5849 | 1269 | mixed residue | 0.5 | | | | iron flakes & broken hammerscale flake | |
| 5849 | | mixed residue | 9 | | | | iron-rich undiagnostic, fuel ash slag, fired clay | |
| 5851 | 1303 | waterlain deposit | 26 | | | | mostly clay | |
| 5852 | | ferruginous concretion | 58 | | | | | |
| 5985 | | fuel ash slag | 0.5 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5985 | | fuel ash slag | 4 | | | | | |
| 5987 | | fuel ash slag | 1 | | | | | |
| 6052 | 1297 | heat magnetised residue | 7 | | | | fired clay, grit, very occasional tiny fragments of hammerscale flake | |
| 6092 | 1346 | heat magnetised residue | 10 | | | | iron flakes, fired clay, grit, tiny undiagnostic | |
| 6092 | 1346 | heat magnetised residue | 5 | | | | crushed iron dust, occasional broken hammerscale flake | |
| 6140 | 1317 | concretion around root | 112 | | | | | |
| 6140 | 1317 | ferruginous concretion | 3 | | | | | |
| 6140 | 1317 | fired clay | 27 | | | | | |
| 6150 | | fired clay | 7 | | | | | |
| 6192 | 1316 | fired clay | 19 | | | | | |
| 6236 | | cinder | 12 | | | | | |
| 6255 | | fuel ash slag | 8 | | | | | |
| 6259 | 1358 | ferruginous concretion | 1732 | | | | waterlain and concreted with pebbles | |
| 6530 | | ferruginous concretion | 4 | | | | | |
| 6669 | | cinder | 13 | | | | | |
| 6743 | | smithing hearth bottom | 135 | 80 | 65 | 30 | | |
| 6743 | | undiagnostic | 90 | | | | | |

## TABLE 6.2: SLAG TYPES, PROCESSES AND WEIGHTS

| process | slag type | Wt (g) |
|---|---|---|
| non-diagnostic | cinder | 58 |
| non-diagnostic | vitrified hearth lining | 99 |
| non-diagnostic | fired clay | 502 |
| non-diagnostic | ferruginous concretion | 2552 |
| non-diagnostic | fuel ash slag | 2906 |
| | | |
| smelting | non-magnetic slag spheres | 1.5 |
| | | |
| smithing | hammerscale | 4 |
| smithing | smithing hearth bottom | 135 |
| | | |
| undiagnostic | cindery runs | 3.5 |
| undiagnostic | slag dribbles | 4 |
| undiagnostic | iron-rich undiagnostic | 36 |
| undiagnostic | undiagnostic | 521 |

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