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Assessment of residues from Helston, Clodgey Moor (HCL22-23)

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Dr T.P. Young

Abstract

This report details a small collection of archaeometallurgical residues (24.2kg, 255 pieces) derived from excavations at Clodgey Moor, Helston, Cornwall. Of this, 23.4kg (241 pieces) derive from the remains of a single bloomery iron smelting furnace of later Iron Age date.

The assemblage, and in particular the large slag block remaining in situ *in the base of the furnace, provides an almost unparalleled level of detailed information about the construction and use of the structure.*

The basal chamber of the furnace was approximately 320mm in diameter. It was accessed via a frontal arch on the north side that narrowed from 280mm internally to 215mm on the outside of the furnace. Outside the arch, a narrow channel turned immediately eastwards with no significant provision for any tapped slag. The arch was blocked during a smelt by a large central block of metamorphic rock, overlain by a second block and by a slag block from a previous smelt. The furnace was blown from the east side, by bellows of unknown form.

The basal chamber of the furnace was packed with large wood fragments prior to a smelt. During the smelt slag flowed into the spaces in the basal chamber, forming a porous 'furnace bottom' (probably of approximately 14kg). A small amount (approximately 1kg) of the descending slag leaked through the gaps in the blocking of the arch and chilled as tapslag on the external face of the blocking. The cooling of this slag outside the furnace is interpreted as coincidental, rather than as a deliberate tapping of the slag.

At the end of the smelt, the iron bloom was dislodged by the use of a chisel applied vertically to the region immediately in front of the blowhole.

A small quantity of quartz-bearing goethite ore was recovered. Minor iron-bearing mineralisation is known in areas close to Helston, although no detailed petrology of these ores has been recorded in the literature; a source in these areas appears likely.

The furnace shows features compatible with its later Iron Age date – a period when smelting furnaces became markedly smaller than had been previously. Some parallels may be drawn with the use of the 'sunken shaft' furnaces of eastern England..

Elsewhere on the site a small assemblage of poorly-preserved iron smithing slag was recovered from contexts associated with Roundhouse RH1. These need not necessarily be from the same phase of ironworking as the furnace.

Contents

Methods

Background

This assessment was commissioned by Bryn Morris of South West Archaeology Ltd. The materials described and assessed here arise from excavations undertaken on land at Clodgey Moor, Helston, Cornwall (site code HCL22-23). The site lies on the Mylor Slate Formation of Devonian age. Alluvium lies within the valley a short distance to the east.

Assessment

All submitted materials were examined visually in November/December 2025, using a low-powered binocular microscope where required. They have been catalogued (Table 1) and assessed. No instrumental analysis has been undertaken.

Results

General

The submitted assemblage comprised a total of 24.2kg of material (255 pieces). Of this, 23.4kg (241 pieces) derived from fill (198) of Furnace [197] (including 23.3kg (147 fragments) of hand-picked pieces and 446g (94 fragments) from sample <2>. This material was entirely formed of residues associated with bloomery iron smelting.

A further 14 pieces (786g) derived from 4 separate contexts ((246), (297), (309) and (315). The fragment from (246) was also a smelting slag and those from (297) were low-grade iron ores, but the material from contexts (309) and (315) were residues from iron working (smithing).

Details

Iron smelting residues: The main block of slag (Figure 1) from fill (198) of Furnace [197] measures 425 x 310 x 150mm and weighs 17.6kg. The mass is not entirely slag, for it contains two large sub-angular blocks (apparently of a micaceous metamorphic rock). The larger block measures 180 x 150 x 110mm and weighs an estimated 6.4kg. The smaller piece is apparently a thin sliver, representing the base of a block resting on the larger one and slightly further into the furnace at approximately the mid-point of the furnace arch. At a similar level on the west side of the arch, there is a block of slag 'burr' in an inclined orientation. The two pieces of rock and the slag 'burr' appear to have been placed as a blocking of the furnace arch. This interpretation suggests that the slag component of the main block weighs approximately 10.9kg (subtracting an estimate weight from the total to account for the granite and slag placed blocks).

The collection of isolated fragments from context (198) includes 1.2kg of fragments (43 pieces) certainly associated with the in-situ block and a further 4.6kg (194 pieces) that are less definitely associated with the in-situ block. The total residue produced in the final smelt in the furnace was therefore likely to have been between 12.1kg and 16.8kg. The furnace fill (198) also produced one fragment of a relatively high-grade goethite ore (41g). Context (297) (a fill of ditch [296]) produced three fragments of low-grade ore (45g).

The current version of the plan of Furnace [197] depicts a granite block on either side of the furnace bottom (incorrectly labelled as 'slag bloom'). Close inspection of images IMGP4757 and IMGP4788 shows significant differences to this plan. In particular, the eastern granite block appears much larger on the photographs than it does on the plan and it has a planar junction with the adjoining slag; the western granite block is less clear and may be simply deeply vitrified furnace wall. A labelled interpretation of the main block is presented alongside IMG4757 in Figure 2 and an amended version of the figure is used in Figure 3 to illustrate the furnace layout.

The basal chamber of the furnace was approximately 320mm in diameter. It was accessed via a frontal arch that widened from 215mm to 280mm into the furnace. The eastern granite block forms the margin of the arch, in addition to extending into the furnace below the likely blowhole location.

The face of the slag block adjacent to the eastern granite forms a planar, non-wetted surface 250mm in length approximately 80mm in depth. This surface preserves a lobate surface which has scattered embedded grains from the degraded granite, forming the face to a vertical sheet of slag. This sheet is continuous with the flow slag forming a tapslag-like flow that descended from above close to the upper block of rock, with flows then passing both outwards onto the top of the lower block of rock and also passing inwards to form the inner part of the vertical sheet. A 600g detached block shows that the outward flow of slag passed around the west side of the arch blocking and descended 80mm to the inclined floor of the external pit, extending 80mm outwards onto the rising pit.

Inwards of the flowed slag and the arch-blocking, the furnace bottom comprises a mass 270mm long and 320mm wide. This mass comprises slags containing the moulds of a coarse wood pit-packing. These slags are in the form of variably amalgamated flow slags, commonly pale grey, with a slightly waxy lustre. In some areas the flow slags comprise a richly-coloured very dark brown glass. A few areas towards the west side of mass show a very smooth, gently fuel-dimpled top, but the eastern part of the cake has a largely fractured upper surface, exposing the internal wood moulds. Behind the inner half of the non-wetted vertical slag sheet a complex void suggests a rectangular-sectioned bar or chisel has been hammered through the hot slag cake, creating the void and deforming the base of the cake outwards. The bar appears to have been approximately 16mm x 10mm. These features probably derive from removal of a bloom of 140mm to 150mm in diameter.

The opposite (western) side of the furnace arch has a 45mm-wide zone of slag between the large block of rock and the furnace wall, against which it shows a vertical non-wetted, lobed, slag face with a thin veneer of adhering fired clay. The base of the gap filled by this slag was an inclined surface, covered in a scatter of granite-derived crystals and probable flow-slag fragments, that became overlain by flowed slag.

The base of the furnace bottom slag mass is formed by descending dimpled slag prills forming an open structure around voids that are probably moulds of timber-packing, but which are too open structured to preserve the wood surface. The fine-scale prills descend to close to a bowl-shaped surface, but very few of the prills actually reach this surface (although many of the detached slag fragments recorded separately may have originated here).

A visually similar small (13g) fragment of a flow of 'tapped' slag in narrow flows was recovered from ditch terminus context (240).

Behind the dense slags within the gap between rock and wall on the west side of the furnace, lies a void 70mm across and 10mm wide, separating the dense slag from the more friable slags in the furnace bowl. It is unclear whether this is a planar wood mould or if it is a fracture that opened on the line of the rear face of the stone block, as a result of the deformation induced by the extraction of the bloom.

Iron ore: two small fragments (total 41g) from (198) are probably pieces of a single broken ore piece (Fragment #22 of the collection). The ore texture is variable, with a dominance of fibrous veins, probably of botryoidal goethite in one section, but an abundance of quartz crystals in another. The presence of what appears to be neomorphic quartz suggests that this is not a bog iron ore, or other low-temperature superficial product.

Context (297) produced 45g (3 pieces) of a low-grade iron ore. They appear to show veins, probably of goethite, within a brownish host. There are later superficial black micro-botryoidal veneers, likely also to be of goethite.

The finds spreadsheet lists a further large (2.2kg) fragment of botryoidal goethite ore from context (323), but unfortunately this was absent.

Iron smithing residues: several large fragments of smithing hearth cakes (SHCs) and numerous small, but compatible, fragments, were recovered from contexts (309) and (315).

Context (309) (not described in the supplied documentation, but [308] and [310] are associated with Roundhouse RH1) produced nine pieces of slag (Fragments 104 to 112):
- three small fragments of low-density slags (weighing 8g)
- two weathered fragments, locally rusty, of moderately dense slag, but with few surviving surface features, weighing 31g.
- a weathered slag lump (apparently an SHC) showing dense slag attached to the hearth wall, which appears either to have collapsed on to the top of the SHC or, less likely, to have formed the base of an over-hang. or forms base of protrusion).
- a fragment from the lip of a dense plano-convex slag bowl, almost certainly an SHC. It has a lobe of slag attached to the outside of an otherwise dimpled/prilly lower surface. It weighs 133g.
- a fragment of strongly lining-influenced slag, weighing 32g, probably a peel from the hearth wall. It comprises a sheet of low density grey (glassy?) slag, with charcoal moulds and impressions on top. There are patches of vesicular FAS, locally with green glass, om the underside.
- a 124g piece comprising a quadrant of thin slag sheet, c.60mm radius, with a maximum of 20mm thickness. This is probably a fragment of a small, thin SHC.

Context (315) (a fill of ring gully RH1) produced a single highly-weathered SHC fragment, weighing 200g and probably constituting much of the SHC (Fragment 102). The piece had a thick weathering crust obscuring the surface, but a recent fracture exposed a cross-section showing a thin (c. 8mm) basal crust, overlain by 20mm of a charcoal rich (mostly moulds) slag.

Interpretation

Furnace [197]: The furnace is markedly different from the slightly earlier furnaces known elsewhere in SW England. These are much larger, with a wide frontal arch, the floor of which slopes uniformly down in the bowl-shaped cut of the furnace base (Young 2016a, 2016b, 2016c, 2022, 2023, 2025a). Similar furnaces are known elsewhere in southern Britain from the Early to Middle Iron Age (Young 2020, 2024; Young & Anelay 2025).

The plan and images of the present furnace show that, not only is it small, but it has an unusual, asymmetric, plan (Figures 2, 3).

The greater thickness of heat-altered clay adjacent to the granite block on the east side of the furnace suggests that the air blast was located on this side. The blowing wall was supported by the basal granite block – which appears to have been around 300mm in length according to the photographs and also supported the east side of the frontal arch. The furnace was approximately 320mm across in front of the air blast (and the basal chamber of the furnace was probably of a similar length). The opposite side of the furnace shows an indurated zone, indicating that high temperatures extended across the full width (the

images are less convincing of the existence of a second granite block on that side).

The furnace narrows towards the frontal arch, which appears to be approximately 215mm wide on the outside and aligned at around 110° to the blowing wall. The narrow external hollow continues to curve to the east (i.e. back towards the location of the bellows), with no significant provision for any tapped slag. The cooling of some flow slag outside the furnace is interpreted as coincidental, rather than as a deliberate tapping of the slag.

In use, this arch was blocked by a series of stone and slag blocks to a depth into the hearth of around 150mm. The height of the arch and its blocking remain unknown. The elements present within the main slag block total 150mm, so the arch must have been taller than this.

The relatively small size of the furnace and the low volume of slag, together with the use of stone, both in the blowing wall and in the temporary arch blocking, are all features that set the furnace apart from other examples in the SW of England.

The radiocarbon date for Hazel charcoal from the furnace (cal. BC 390-340 / 320-200) suggests a 3rd century BC age is most likely. A reduction in iron smelting furnace size in southern Britain in the period between the 4th and 2nd centuries BC has been recognised (Young in prep.). The present site would appear to lie early in this period but is more similar to the furnaces of the later Iron Age than the earlier.

There is some crossover in design with the furnaces of the earlier Iron Age, including the evidence for an incompletely sealed furnace arch. It has been argued that in the earlier furnaces this would have permitted bloom manipulation (e.g. Young & Anelay 2025). In a furnace as small as that described here such a process would be of reduced utility.

The dating of the furnace would overlap with that for the furnaces at Crawcwellt West, Gwynedd (Crew 1998). These furnaces share their small size with the present example. They have a simpler structure without stone blocks but have a similarly narrow frontal arch. At Crawcwellt, the use of a clay arch blocking is assumed – which does not appear to have permitted slag leakage as seen at Helston.

A rather better parallel for the function of the furnace would be in the 'sunken shaft' furnaces of eastern England. These were termed the 'Wakerley-type' in the East Midlands (Jackson & Ambrose 1978; Hall 2008), but are now also recognised in SE England, where this term has not been applied (Girbal 2019; Barker *et al.* forthcoming). This group of furnaces has a furnace arch that is usually entirely below ground level, and which faces out into a pit with very limited access, rising sharply in front of the arch. Slag passes through the arch to cool partially in the external part of the pit, but this does not appear to have been conducted as a slag-tapping process, and the flow may have remained below a fuel bed. The pit is usually deeper in this group than appears to be at Helston (assuming that it is not highly truncated), but there are striking similarities.

The ore source: the site lies at a considerable distance from the nearest known Iron Age smelting sites (21km from Threemilestone, Gossip 2021, Young 2007, and its ore sources for instance) and even further from the major ore sources in the area of the Perran Lode (Brooks 2011; Dines 1956; Nowakowski & Quinnell 2011; Young 2023, 2025) and thus a different ore source would appear likely.

Dines (1956) describes two groups of iron-bearing mineralisation in the Helston area: firstly (p. 243), ores apparently associated with the fault bounding the Lizard Complex. Locations include Wheal Fenwick (p. 243), near Mullion, 8km S of Helston. Secondly a belt of iron bearing lodes in the ground between the fault and the Carnmellis Granite. These include (p. 270-271) Brogden Iron Mine (1.5km SE of Constantine, 7km ENE of the present site) and a trial for iron on Gweek Downs (just over 2km E of the present site). A cluster of locations that have yielded evidence for iron mineralisation (mainly in the form of siderite) lie in a zone running SE from Porthleven Harbour, approximately 3km SW of the site (p. 241-242). To the north, further iron ores (including a specular ore) occur in the area of North Lovell mine, approximately 5.5km NE of the site.

The potential presence of iron ores on Gweek Downs and of iron in the lodes east of Porthleven raise the possibility of a relatively local iron source, although the Brogden Iron Mine is not far distant.

The smithing: the occurrence of smithing slags in two contexts apparently associated with RH1 is not closely indicative of age, with blacksmithing SHCs of the size suggested here being known from Iron Age onwards. Although the assemblage is very small, one of the SHC fragments is suggestive of a large example and thus the activity tentatively appears to be blacksmithing rather than the working of raw blooms. The smithing might, therefore, be of an entirely different age to that of the bloomery furnace.

Further work

This assessment has demonstrated the detailed information that can be extracted from the residues and structure of Furnace [197]. The furnace occurs in an area without previous evidence for Iron Age iron production. The evidence garnered thus far has the potential to be further enhanced by investigation of the iron ore employed, since this is likely to currently undocumented. Characterisation of the ore would also have the potential to allow detailed investigation of the chemistry of the furnace – allowing construction of a mass balance, a key component in the estimation of the productivity of the furnace.

Such an investigation could involve analysis of two samples of iron ore (the ore from the furnace and the lower-grade ore from elsewhere on site), samples of a suite of slags from the furnace (5 samples) and o the wall cermaic (1 sample). It is also recommended that efforts are made to obtain samples of ore from the Brogden Iron Mine, Porthleven and Gweek Downs areas, to attempt to constrain the source of the ore employed (although this may not be possible, depending upon the survival of mine waste).

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Figure Captions

Figure 1. Photographs of the upper (left) and lower (right) surfaces of the main slag block from Furnace [197]. The frontal arch is the top of the block as illustrated.

Figure 2. A labelled interpretation of the main slag block from Furnace [197], showing the features described in the text. The arrows indicate the direction of slag flow through the blocking of the frontal arch. IMG4757 is presented alongside for ease of comparison of these features with the structure of the furnace itself.

Figure 3. Amended version of the supplied figure illustrating the iron smelting furnace and its setting, locally modified to integrate the evidence from the residues, and from the site photographs, with the drawn version. The extent of the slag block close to the S and SW side of the furnace is not well-constrained, but many of the loose fragments probably derive from this area.

Table 1: catalogue of submitted materials. Weights in g.

C	bag	fragments	Item wt	Item no.	Description
198			17600	1	main block (for description see text)
198	fragments		596	1	foot of wall flow, arising from somewhat convex wall and flows out onto dished base; fits outer face of stone block
			63	1	fragment of fine, small tapslag flow
			506	40	flow slags with wood/charcoal moulds
			23	1	natural stone
198	1 of 11	1 to 10	217	1	dark glassy amalgamated flow slag with fuel/wood moulds
			757	1	wall contact region, pale ceramic, in front lie slags with probable wood moulds, highly vesicular
			88	1	pale grey glassy lobate slags attached to pale grey ceramic
			110	1	deep glassy layer, dense but very finely vesicular
			135	1	grey glassy lobate flow slags, dense
			28	1	rusty lobate nub of low-density vesicular slag
			116	1	pale grey glassy flow slags with large wood impression (50mm square)
			147	2	brown vesicular slag with wood impressions - similar to in-situ block
			51	1	low density vesicular rounded slag nub with dark surface
198	2 of 11	11 to 20	215	1	fragment from sheet of flow lobed slag, poorly developed lobes, internally vesicular, pale; from a slag puddle?
			123	1	fragment with highly vesicular slag, over glassy slag on grey ceramic
			32	1	fragment of flow lobed pale grey slag with large lithic (?) clasts
			135	1	narrow pale grey runner of slag; resembles tapslag but no reddening of surface
			34	1	pale grey slag, with wood mould; non wetted lobes on much of basal surface, but with also some indurated grey ceramic
			71	1	curious sub-cubic lump of low-density highly vesicular slag with maroon slightly lobed surface

			83	1	smoothly lobate pale grey slag surface, with vesicular slag internally; wood/fuel contacts on flow surface
			81	1	irregular angular fragment of slag containing charcoal clasts
			54	1	dense, broadly lobed slag nub with gravel particles on base
			51	1	low-density greenish grey glassy slag, with FAS and ceramic clasts
198	3of 11	22 to 30	308	8	moderate-density flow slags; some well-formed, prilly; others with fuel moulds, typically pale grey, waxy lustre
			72	2	rusty lumps - either corroded slag or mixed slag/iron
			17	1	very eroded low-density vesicular slag sheet - probably a lining slag
		22	41	2	broken piece of quartz-bearing goethite ore
198	4 of 11	31 to 40	222	7	amalgamated flow slags around fuel/wood moulds, variable density
			84	2	fragments of tapslag-like flows, slightly maroon upper surfaces; non-wetted bases with granitic grain inclusions
			22	1	fragment of ball of clinker-like maroon-surfaced pale grey, waxy slag
			29	1	spall from surface of partially-melted fine-grained igneous(?) rock
198	5 of 11	41 to 50	209	8	fragments of grey amalgamated flow slag around fuel and wood moulds
			48	2	fragments of thin tapslag flows; maroon upper surface; granitic grains on base
198	6 of 11	51 to 60	70	1	dark surfaced tapslag-like flow; large granitic gains on the base
			18	1	irregular gravelly lining slag
			138	8	lower density flow slags; some well-formed, prilly; others with fuel moulds; typically pale gey, waxy lustre
198	7 of 11	61 to 70	139	9	fragments of grey amalgamated flow slags around fuel clast moulds,
			1	1	fine accumulation of charcoal dust in slag or accreted ash?
198	8 of 11	71 to 80	124	8	fragments of grey amalgamated flow slag around fuel clast moulds, one piece is from floor and shows grey ceramic between lobes
			15	2	fragments of slagged apparently rather kaolinitic pale ceramic

198	9 of 11	81-90	53	2	pale flowed(?) lining with dark surface; weathered
			12	2	ceramic fragments
			3	1	gravelly lining slag
			5	1	very weathered slag (?) with abundant fine charcoal
			30	5	small fragments of grey flow slag
198	10 of 11	91 to 98	17	7	dark flow slag, locally glassy, with margins of wood moulds locally
			2	1	small slag fragment with ceramic and granitic grain clasts
297	11 of 11	99-101	45	3	low grade ore fragments with goethite in a brownish host and black goethite(?) veneers (slot A)
315		102	200	1	highly weathered slag piece with iron weathering-crust and recent fracture; section shows c. 8mm thin crust, overlain by 20mm of charcoal-rich material - probably an SHC
240	terminus	103	13	1	margin of tapslag flow, maroon top, fine lows
309		104 to 112	8	3	small fragments of low-density slags
			31	2	weathered fragments, locally rusty of moderately dense slag, but with few surviving surface features
			200	1	weathered slag lump showing dense slag attached to wall which appears to have collapsed onto top of slag lump (or forms base of protrusion); most likely a smithing slag
			133	1	fragment from the lip of a dense plano-convex slag bowl; has a lobe of slag attached to outside of the otherwise dimpled/prilly lower surface; probably SHC
			32	1	appears to be a peel from the wall; a sheet of low density grey (glassy?) slag charcoal moulds and impressions on top; FAS regions (locally with green glass) below
			124	1	quadrant of thin slag sheet, c60mm radius, max 20mm thick, thin SHC fragment
198	<2>	113 to 120	174	9	flow slags around wood moulds, mostly rather dense

198	<2>	121-135	89	15	flow slags, varying from pale amalgamated to shiny dense prills - locally with dark glassy surfaces
198	<2>	136 to 150	52	15	small grey flow slag fragments
198	<2>		108	50	small fragments of grey flow slags; variously prilly, amalgamated, or with moulds
			0.8	1	glass slag droplet, bright brownish-black glass
			12	1	weathered granite
			10	3	rusty fragments, probably rough flow slags

Figure 1

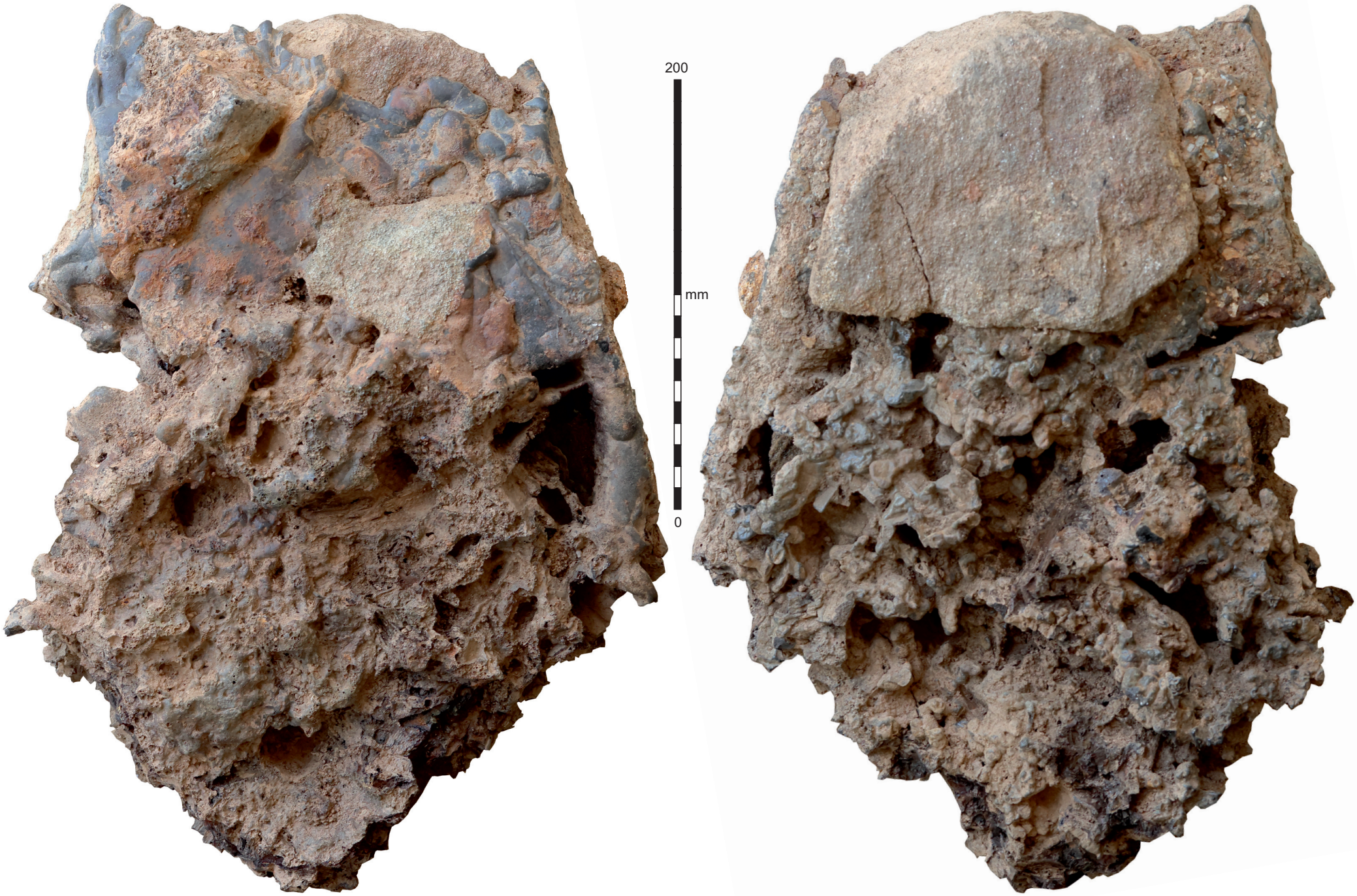


Figure 2

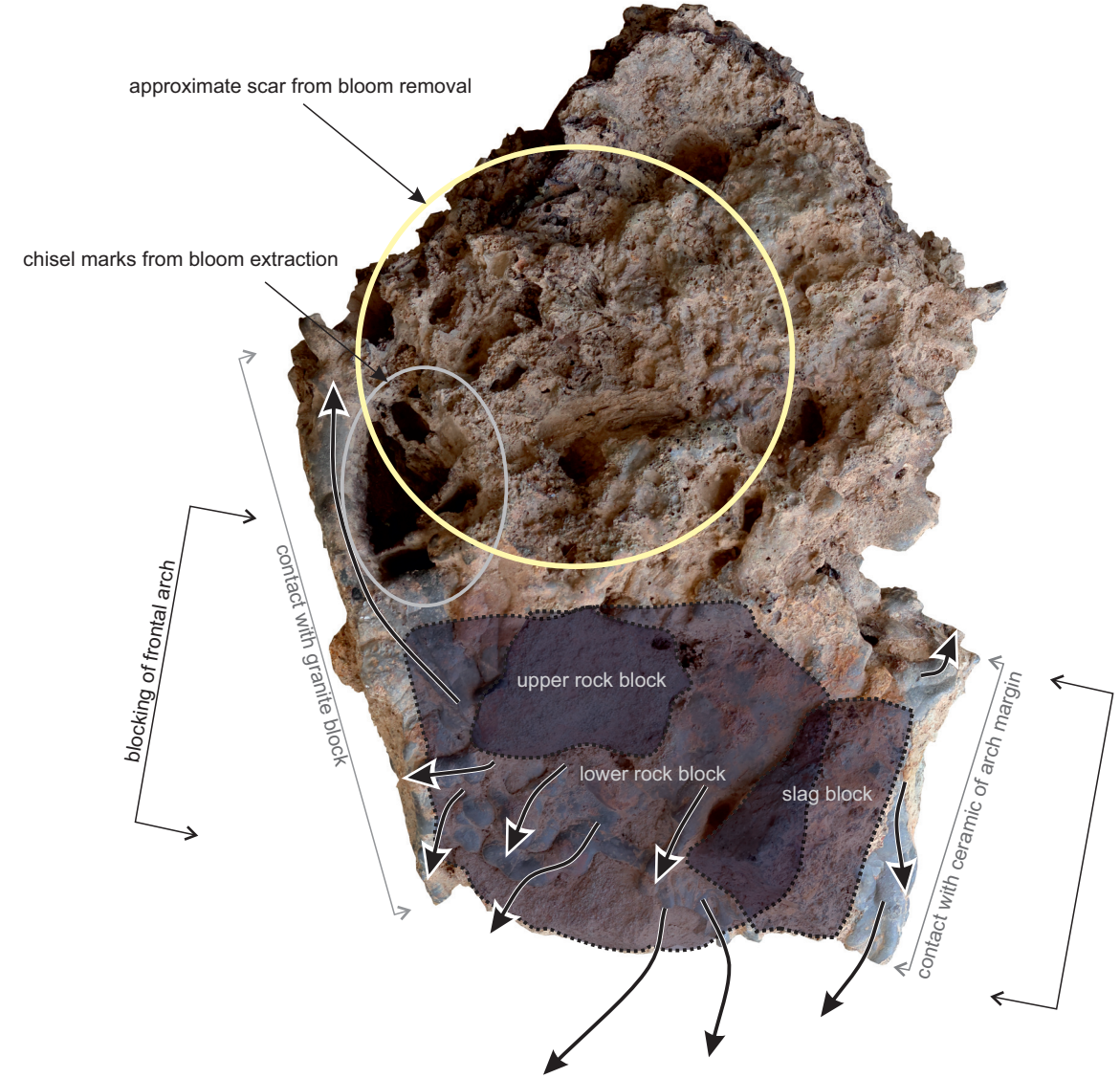
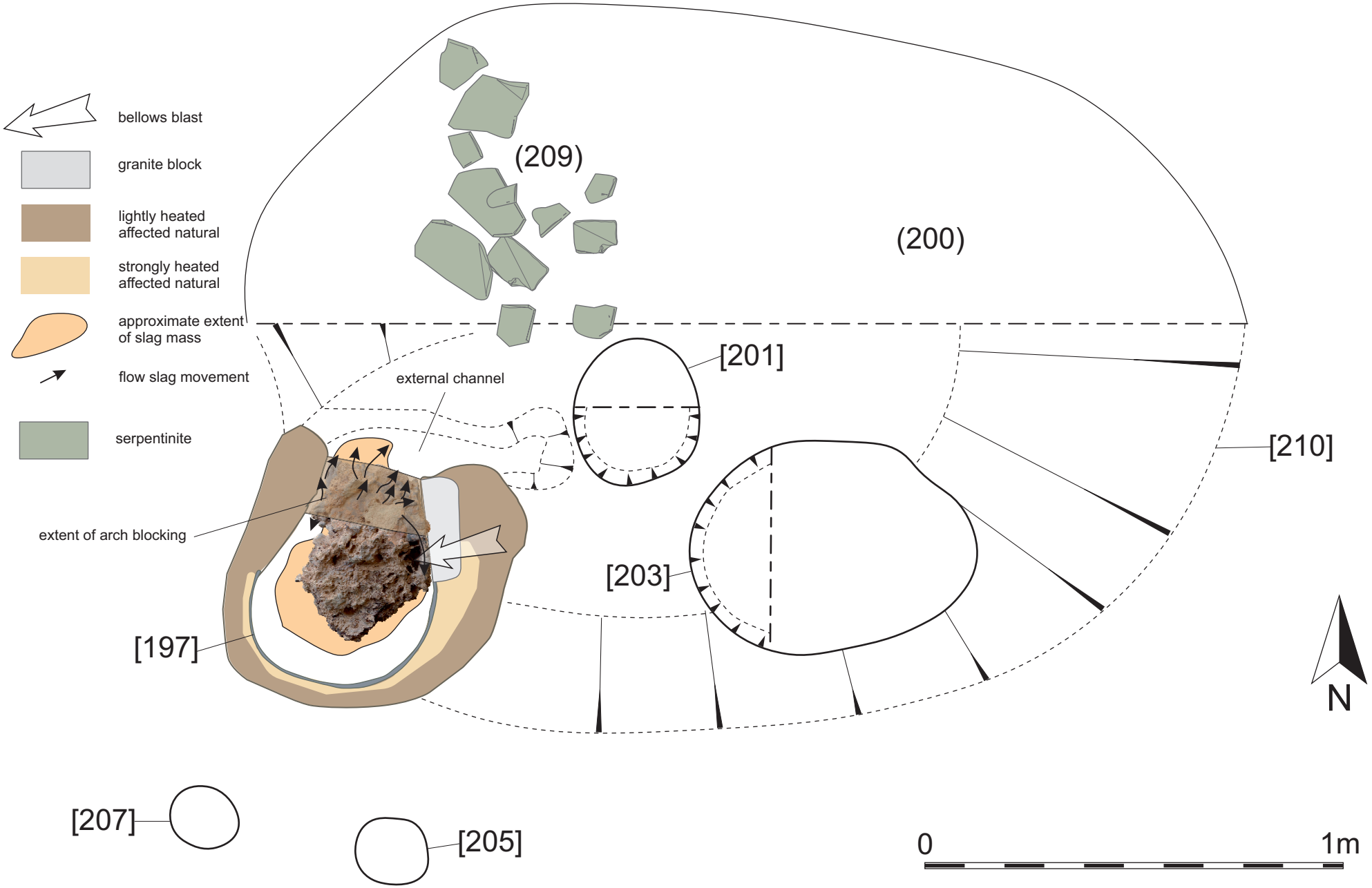

approximate scar from bloom removal
chisel marks from bloom extraction
blocking of frontal arch
contact with granite block
upper rock block
lower rock block
slag block
contact with ceramic of arch margin

Figure 3


bellows blast
granite block
lightly heated affected natural
strongly heated affected natural
approximate extent of slag mass
flow slag movement
serpentinite
(209)
(200)
[201]
external channel
[210]
extent of arch blocking
[203]
[197]
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