

McDONALD INSTITUTE MONOGRAPHS

An Age of Experiment: Classical Archaeology Transformed (1976–2014)

Edited by Lisa Nevett and James Whitley



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with contributions from
Susan E. Alcock, Giovanna Ceserani, Alexandra Coucouzeli, Thomas W. Gallant, Michael Given, Jonathan M. Hall, Paul Halstead, Sturt W. Manning, Ian Morris, Lisa Nevett, Robin Osborne, Sara Owen, Gillian Shepherd, David B. Small, Jeremy Tanner and James Whitley

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Chapter 12

The Materiality, Monumentality and Biography of Copper Slag on Cyprus

Michael Given (University of Glasgow)

Cyprus has been famous for its copper since at least the time of Pliny the Elder (*Natural History* 34. 2). It is a curious feature of this reputation, however, that almost all that copper was in fact exported or has since been melted down, apart from the tiny proportion of weapons, coins and statues that survive in museums and storerooms. What is left, though, are some 4 million tons of copper slag from the production process, spread across the island in at least 85 slag heaps and making up probably the densest distribution of such metalworking remains in Europe (Constantinou 1992, 69; Stos-Gale *et al*. 1998, 235–6). After, arguably, masonry, copper slag is the commonest material surviving from antiquity.

In spite of this, copper slag has often been curiously neglected, other than being used as a proxy for technological processes. Like garbage, excrement and uncultivated land, it has all too often been rejected as mere 'waste'. And yet copper slag is a rich, dense and highly connected material. Like soil (Boivin 2004; Salisbury 2012) and middens (McNiven 2012), slag is material culture. As such, it plays an active, lively role in the material and social world, thanks to its unique properties, arrangements and contexts.

This article celebrates the lively role of slag by engaging with examples from across Cyprus, ranging from the Iron Age to the Late Roman period. It starts with the materiality of individual slag cakes, and the elaborate entanglement that connected slag with other materials, humans and the environment (see also Gallant, this volume; Whitley, this volume). When aggregated into the massive slag heaps of Late Roman Cyprus, slag takes on a unique grandeur and monumentality. The complex structuring of the slag heaps and the buildings they swallow up expresses the rhythm of the physical interactions of materials and humans in the copper production process, both within the furnace itself and across the wider landscape and much of the Mediterranean.

The complexity of these associations and collaborations means that slag cakes have lives of their own, which continue to unfold and develop millennia after they were first tapped out of their furnaces in molten form. The flows that characterize the solidified surface of the slag cake also express the constant material and social transformations of metallurgy itself. These are most evident in the dramas that surround the production process: the spatial and thematic convergence of Iron Age copper production and religious practice; the imperial scale, organization and devastation of copper production in the Roman Empire; and the Christian martyr cults that grew up round the mines of Cyprus and Jordan.

Ancient metallurgy is constituted by the lively roles of materials and processes, by dramas and biographies, and by ongoing flows of materials and identities. The copper itself is an absence, something exploited and removed by an external power, leaving only the slag to continue the connections and flows.

Slag

Slag is glorious. Copper slag from Iron Age to Roman Cyprus is characteristically rich and dense, often a deep matt black, sometimes with shades of dark chocolate brown or manganese purple or silver-grey. The flows and runnels of its molten state pick their way across the surface, inviting your fingers to touch and follow them. If you pick up a complete slag cake, its density makes it surprisingly heavy; you feel its presence and properties very directly in your arm muscles.

Just like metal (Killick & Fenn 2012, 562; Ryzewski 2013, 354), slag has a very real and powerful materiality that invites a sensual engagement going beyond any functional or technological character. It demands that we feel its properties and follow

the ingredients and social processes that together constitute its materiality. And unlike metal, it has an intriguing ambivalence. Is it an artefact or natural? Waste or resource? Liquid or solid?

A complete slag cake had a very marked impact on those who tapped, carried, stacked and reused it (Fig. 12.1). A typical example from the Roman period is 42 cm long, 62 cm wide and 17 cm thick, with a weight of about 55 kg (Kassianidou *et al*. 2003b, 91). In shape slag cakes tend to be roughly circular or elliptical, often with a raised point at one end where you can see the flow down from the hole in the furnace where the slag was tapped out (Georgakopoulou & Kassianidou 2013, 238). Underneath, a smoothly curving belly echoes the shape of the shallow pit into which the slag was tapped. This tapping separates the slag from the matte, the intermediate product of primary smelting, before secondary smelting transformed it into black copper. In earlier examples, such as from the small Late Bronze Age smelter of Politiko *Phorades*, you can even see the shape of the ingot of matte underneath the slag, removed by the smelters once it had all cooled (Knapp & Kassianidou 2008, 144). In the Iron Age to Roman period, the liquid slag was tapped out, leaving the matte or copper to solidify in the bottom of the furnace. Sometimes the slag from several furnace runs was tapped into the same pit, making characteristic layered slag cakes (Koucky & Steinberg 1982; Georgakopoulou & Kassianidou 2013, 238).

To dismiss slag as merely 'black' misses a whole world of material colour (Young 2006, 173). Closer inspection shows that the matt black is complemented by a range of deep browns and reds, blues and purples, silvers and greys. To the archaeometallurgist, and, we can presume, the ancient smelter, these are clues to the chemical composition and firing process, as well as ongoing exposure and weathering. Flecks of light green can appear on the surface, produced from the weathering of exposed copper prills; these are less common in Late Roman slag cakes, where the more efficient smelting process leaves less than 1 per cent of copper in the slag (Georgakopoulou & Kassianidou 2013, 240). The old simplistic distinction of red 'Phoenician' slags and black 'Roman' has been long



Figure 12.1. *Slag cake from Skouriotissa, c. 60 cm wide. The molten slag was tapped out of the furnace from the bottom left. (Michael Given)*



Figure 12.2. *Gossan at the modern copper mine of Mitsero* Kokkinopezoulas. *(Michael Given)*

discredited, and is due more to weathering during the slag's later life (Stos-Gale *et al*. 1998, 237).

When we probe more deeply into the slag's material properties, we find many more colours bound up in it, each with their own affordances and agencies (Young 2006, 181). A vital agent here is the flux, which gives the colour and so much else to the slag cake. Flux lowers the melting point of the slag: at the firing temperature of 1100–1200°C, this makes it less viscous, so it can separate more easily and more fully from the copper, and flow out the tapping hole more readily (Constantinou 1992, 64–5; Kassianidou & Van Lokeren 2003, 226; Rapp 1998, 179–81). By the Late Roman period, the most commonly used and effective flux was manganese, usually found in the mining areas as umber, a rich brown compound of manganese and iron oxides long used as a pigment in, for example, Cypro-Archaic bichrome pottery (Constantinou 1992, 54; Kassianidou 2013, 50). A more concentrated effect could be given by using the small black nodules of manganese concretions, produced by the weathering of these umbers. Either way, these fluxes give the resulting slag distinct tinges of a deep metallic blue (Kassianidou & Van Lokeren 2003, 223).

Working backwards from the smelting to the mining and prospection of the ore itself, colour was key to the locating of the secondary enrichment zones, where the leaching of copper sulphates created enriched ores such as chalcopyrites with more than 15 per cent copper (Constantinou 1992, 54–7). As these sulphates began to leach down, the iron was precipitated out, forming characteristic gossans or 'ironhats' that sat above the bodies of enriched ores (Fig. 12.2). The iron reacted with the air to form a riot of strident yellows, crimsons, oranges and pinks, easily identifiable to the ancient prospector and already pointing towards the chain of processes and transformations that would ultimately result in the slag cake.

The characteristic of tapped copper slag that appeals most directly to the senses is the ropy, dribbling texture of its upper surface (Fig. 12.1). When the smelters judge that the smelt is finished, they unblock the tapping hole that passes through the clay furnace wall; the liquid slag runs out and fills the pit, each successive dribble flowing and solidifying across its predecessors. The flows and patterns depend on the viscosity of the liquid slag, which in turn depends on the flux and firing temperature. The less viscous and

more liquid slag, Koucky and Steinberg's 'blocky' type (1982, 118), has a smoother surface, interrupted by occasional ridges and trenches and gas bubbles. A good example of this is the slag from Mitsero *Kokkinoyia*, dated by pottery and radiocarbon dating to the Archaic and Classical period, where the flows are present but rather subdued, with long gas vesicles parallel to the surface (Kassianidou & Van Lokeren 2003, 221).

In the more viscous 'ropy' type (Fig. 12.1), the flows are elaborate and exuberant, often clinging to the side of the furnace to form an L-shaped slag in the corner of the furnace and the pit (Koucky & Steinberg 1982, 118–19). These include the later manganese-rich slag which used umber or manganese nodules to decrease the viscosity, making the slag more liquid, and are characteristic of Late Roman slag heaps such as Mitsero *Kouloupakhis* (Kassianidou *et al*. 2003b, 88, 91) and Skouriotissa (Georgakopoulou & Kassianidou 2013, 240). This is a petrified viscosity, but still very much visible and tangible, still apparently flowing. As we will see, these flows and fluxes are one reason why slag is so good to think with.

In our culture of shopping malls, tarmac and soft play areas, we live in 'smoothed-over space', alienated from the sensory world of materials and their very particular, striking properties. Industrial ruins can confront us with the material world afresh, engaging our bodies and senses as we pick our way through the rubble and twisted, often unidentifiable debris (Edensor 2005, 314, 24). It is not just industrial ruins that do this for us, I would argue, but industrial waste. The finished objects, the coins and lamps and imperial busts, bring with them a sense of completion and closure. For archaeologists, they reduce the whole field of interpretation to a narrow functionalism and a shallow assignation of social status. Slag, by contrast, forces us to engage with the materiality and sensuality of the whole production process, before, during and after the actual smelting.

What are the sounds of slag, for example? The production of slag has a powerful, hypnotic rhythm, a steady, continuing collaboration of hissing air, clay pipes, crackling charcoal and human muscles. For some seven hours (Kassianidou 1998, 236; Rothenberg 1996, 173–4), alternate feet pump the bellows and feed the furnace, the air forced through the tuyères into the throbbing roar of the furnace. Experimental smelting shows that pumping 60 times a minute works well (Merkel 1990, 107), once every two heart beats for a fit 20-year old. For the human body working hour-long shifts, this is an intimate engagement with the apparatus, materials and incipient slag: it 'requires not so much physical strength as coordination, stamina and a good feeling for what is happening inside the furnace' (Fasnacht *et al*. 2000, 104; see also Ryzewski 2013, 355).

And then there is the smell. The worst is the roasting, when the ore has been sorted and crushed and is burnt in great heaps to remove the sulphur from the sulphide ore. Systematic survey of the mine at Agrokipia *Kriadhis* showed a Late Cypro-Geometric roasting heap, unsurprisingly well away from any settlement or more labour-intensive smelting operation (Kassianidou *et al*. 2003a, 74). But the smelting was not kept at a distance, particularly in the Roman period, when slag heaps are routinely recorded adjacent to settlements. At Ayia Marina *Mavrovouni*, the landscape was configured so the daytime anabatic winds from the north blew the sulphur dioxide fumes directly onto the workers' living and eating quarters (Graham *et al*. 2013, 192). Heavy metal pollution is well known round Roman-period copper smelting sites (Pyatt *et al*. 2000; Pyatt 2001), and this is presumably why food was brought in from agricultural hamlets and estates downriver, rather than grown on the fluvial terraces round Mavrovouni itself (Graham *et al*. 2013, 198).

But can we so easily denigrate the smell of smelting as pollution? Or, like waste, could it have had more positive, generative qualities? Certainly, the doctor Galen who visited the Roman mines near Soloi in AD 166 describes the 'stifling and oppressive' air in the tunnels where medicinal solutions were collected (*De Temp. Fac. Simp. Med*. 9, in Wallace & Orphanides 1990, 227), and Strabo notes the tall chimneys to remove the acrid smoke from silver smelting in Spain (Strabo 3.2.8; Kay 2014, 47). But Galen is also interested in the smoke from the firing; he scrapes off the soot, the materialization of that smell, from the roof of the cave (*De Temp. Fac. Simp. Med.* 9, in Wallace & Orphanides 1990, 226). The smell is part of the generative process, that produces slag, matte and the rhythms of material and human collaboration. Perhaps, as Doonan and colleagues suggest, that is why the smelting of Late Cypriot II Maroni was done in the midst of the settlement, to diffuse the potent material aura of that transformation amongst those who depended on it for their sense of community, identity and place (Doonan *et al*. 2012, 56).

This dependency constitutes another important element of the materiality of slag. A slag cake encapsulates all the technical processes, organizational structures and social relations that produced it in the first place and continue to change and develop during the slag cake's ongoing life. Smelting is certainly a social process (Knapp 2013, 54); but much more than that, it generates a dense entanglement where materials and humans become closely dependent on each other (Hodder 2011). Clearly slag needs the bellows to

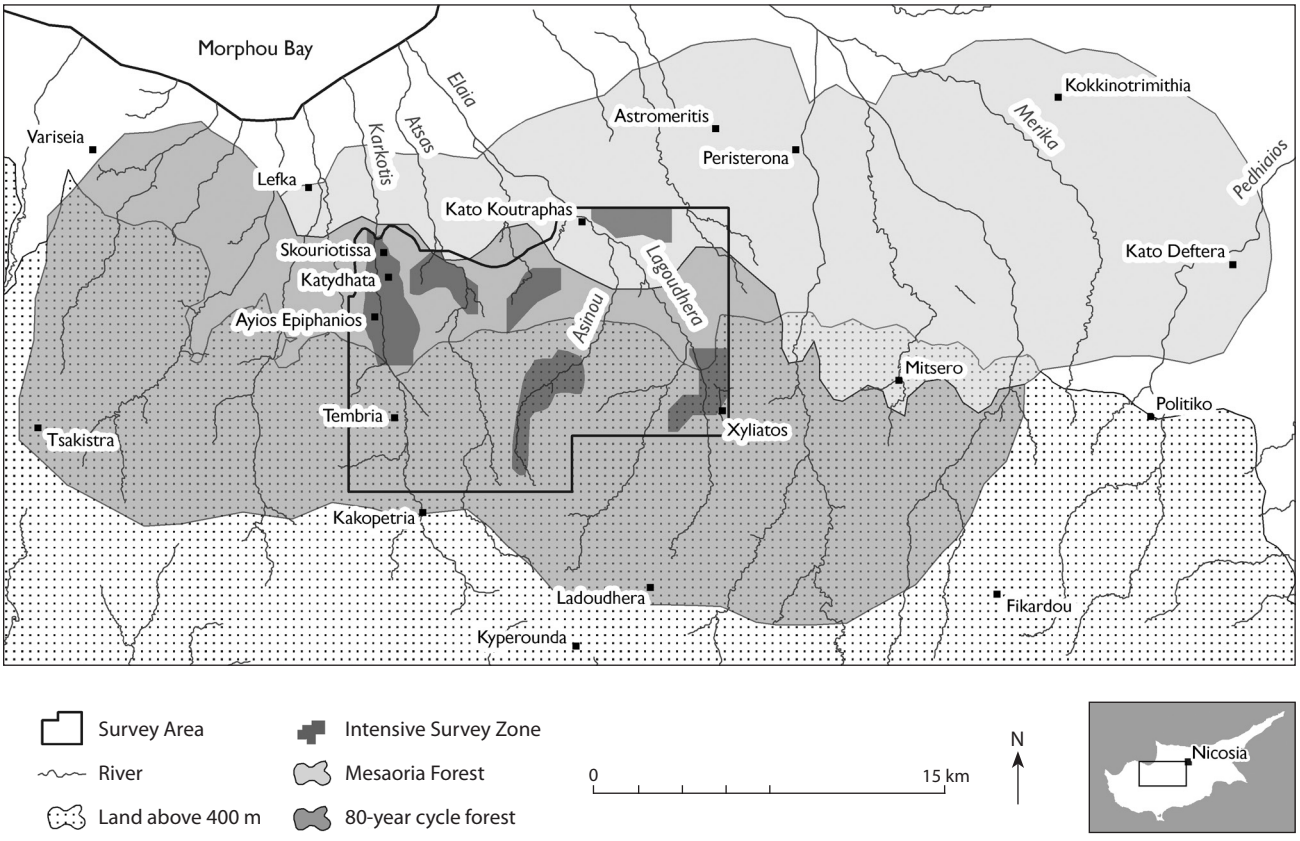


Figure 12.3. *Northern Troodos mountains with TAESP survey area and suggested area where charcoal could be harvested on an 80-year cycle to support the mines of Skouriotissa (Noller & Unwin 2013, 319). (Luke Sollars)*

come into being, along with the human operator. Slag needs the ore, charcoal and flux that give it its origins, the workers who produce and deliver it, the clay and stones that make up the furnace. Conversely, there can be no matte or copper without slag, and thanks to the structure of the slag heap, as we will see, each slag cake becomes the foundation of the next smelt, or the wall of the next furnace.

This entanglement stretches further than Hodder's mutual dependence of humans and human-made artefacts (2011). The materiality of slag encompasses the geological and hydrological processes that produced the ore and flux, the compressed air forced through the bellows, the soil in which the *Pinus brutia* grew to supply the charcoal, the river that laid down the sediment which formed the clay for the furnace lining. These environmental processes are vital players in the intricately interwoven tangle of connections and dependencies that constitutes a slag cake (Edgeworth 2011, 133–4; Given 2013; Ingold 2012).

Slag is the culmination of a large and complex industrial network connecting these processes with the very specific properties of a wide range of materials and elaborately organized teams of workers and animals. The Troodos Archaeological and Environmental Research Project (TAESP), for example, mapped not just the mining and smelting operation of the Late Roman period but also charcoal production in the Troodos foothills (Noller & Urwin 2013, 314–20) and food production in the adjoining plains and valleys to support the workers (Boutin *et al*. 2013, 149–50; Given *et al*. 2013, 49) (Fig. 12.3). Even the relatively small slag heap at Ayia Marina *Mavrovouni* must have required some 660,000 donkey journeys for bringing in the charcoal alone (Graham *et al*. 2013, 182).

As well as embracing the whole procurement and production process, the entanglement of slag extends down the line to the consumption of the copper. Anthony Snodgrass was one of the first to point out that one of the characteristics of the so-called Iron Age is its systematic and widespread use of bronze (1982, 287; see also Muhly & Kassianidou 2012, 134). It was first used for vessels, statues, jewellery and decorative fittings, and then for coins as well, continuing through into the Hellenistic and Roman periods (Fasnacht 1999, 181; Kassianidou 2000, 747). The 100-m wide Iron

Age slag heap of Sia *Anoyia*, for example, produced something like 30 tons of copper, the work perhaps of a team of 30 people over several years. This would have made some 330,000 small objects, distributed presumably across the island and beyond (Fasnacht 1999, 181). Under the Ptolemaic and Roman empires, the connections proliferate across the Mediterranean (Kassianidou 2000, 751–3). According to Pliny the Elder, for example, Cypriot copper was used for minting the small-denomination *as* coins (*Natural History* 34.2.4); these were used across the Roman empire, including for paying the troops.

Slag, then, is more than a waste product, and more than the sum of its ingredients. The ore, charcoal and flux, along with the environmental processes and human skill and labour that went into its production, give it very specific properties, which in turn impact on the world of materials, natural processes and living beings around it. Their mutual dependence involves the slag cake in a rich and dense entanglement across the island and beyond, from the gathering of the ores and fluxes to the daily use of the artefacts ultimately created by the separation out of the slag.

Slag heap

Slag has a presence not just as individual cakes or fragments but as ensembles or assemblages which in the form of slag heaps interact with structures, society and the wider landscape. These slag heaps have their own grandeur and monumentality. This can be explored at different scales, from the slag heap's own structure and contents, to the effects of its monumentality on the people working, living or passing nearby, to its active role in the landscape and across the island.

Like middens, manuring scatters and other such deposits, slag heaps are not just random garbage (Halstead, this volume). They are internally differentiated and intricately structured; they have patterns and meanings deriving from the materials and practices that go into them (Garrow 2012; McNiven 2012). It is all too easy to ascribe the term 'symbolic' to such structuring (Barrett & Ko 2009, 290), where the patterns and materials are made into proxies for something merely human and social. But slag and the structures it comprises have a very real material presence; they encapsulate very specific activities and entanglements. Compare the ashmounds of Neolithic South India, for example: the rhythm of activities that go into their ongoing formation, such as the burning and dumping of animal dung, is directly expressed in the patterning of their layers and deposits (Johansen 2004, 315).

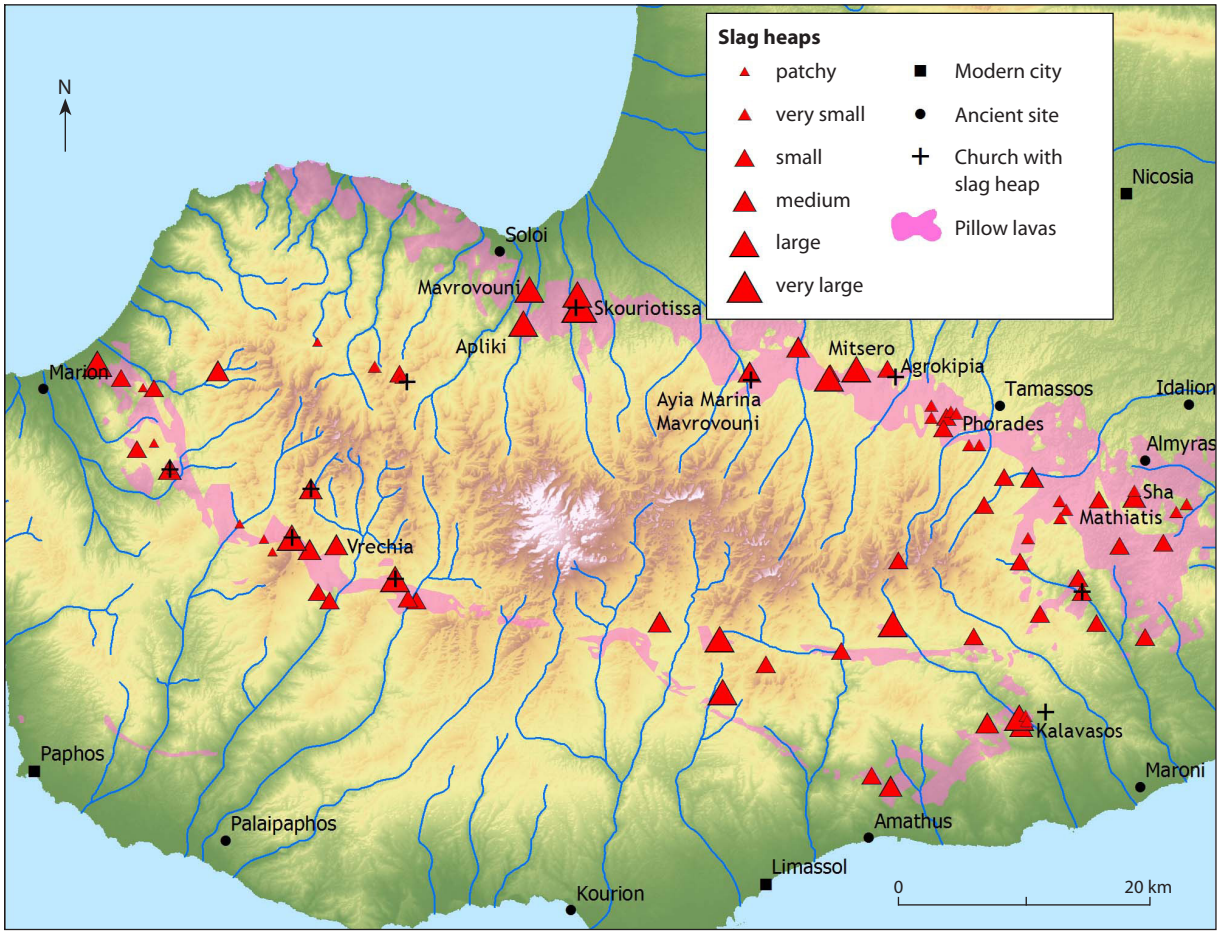
The archaeologist's task is to detect and interpret those rhythms. For the slag heaps, this is most easily done in the great sections created by twentieth-century quarrying for road metal. Far from being homogeneous, these sections show a rich diversity and intricacy of rhythmic activity: smelting, dumping, smashing, sorting, heaping, retaining. Each furnace was constructed on the remains and slag cakes of its predecessors, creating series of horizontal floors as the rhythm of successive smelts gradually built up the internal structure of the slag heap. This can be seen, for example, in the Roman slag heaps of Mitsero *Sykamies* (Given *et al*. 2003, 101–13) and Skouriotissa *Vouppes* (Boutin *et al*. 2013, 121) (see Fig. 12.4 for a map).

Another set of rhythms comes, surprisingly, from the smashing up of much of the slag. Examination of many of these slag heap sections shows that the hard and heavy slag cakes were broken up into fragments as small as a few centimetres, sorted by size, and then carefully tipped onto the existing heap in specific locations. This formed characteristic sloping layers, often with complete slag cakes placed along the top of the layer (Fig. 12.5) (Boutin *et al*. 2013, 121–5). In earlier periods the slag was crushed in order to extract remaining copper (Hauptmann 2007, 245–6), but by the Roman period the process was so efficient that the slag contained less than 1 per cent of copper. Although some slag might have fractured while cooling (Koucky & Steinberg 1982, 118–19), it is clear that this widespread and large-scale phenomenon of breaking and crushing the slag was explicitly for the creation of stable, well-structured slag heaps that provided secure working surfaces for ongoing generations of smelting (Georgakopoulou & Kassianidou 2013, 238; Kassianidou & Van Lokeren 2003, 223).

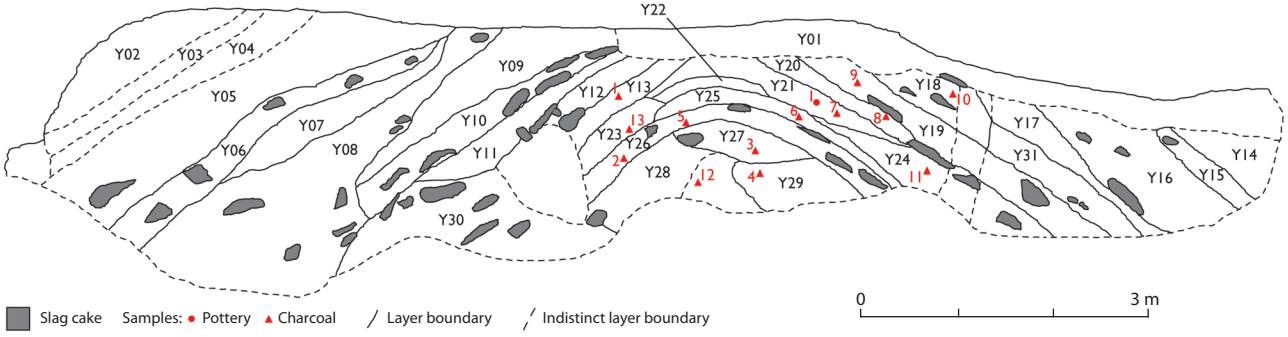
This ongoing care and maintenance is a regular, probably daily activity that becomes a core element of the relationship between people, their labour and the materials of copper production, and directly produces the elaborate structure of the slag heap (Gibson 2007, 78; Johansen 2004, 324–5). It is even more strikingly seen in a Late Roman glacis-like retaining wall at

Figure 12.4. *(Opposite above) Map of western and central Cyprus, showing slag heaps, churches associated with slag heaps, and sites mentioned in the text. Slag heap data from Stos-Gale et al. 1998, 238–9. Sizes of slag heaps are indicative only; Skouriotissa (the only 'very large' slag heap) has roughly the same volume as the rest put together. (Michael Given)*

Figure 12.5. *(Opposite below) Section of Late Roman slag heap of Skouriotissa* Kitromilia. *(Drawing: Thomas Tselios; photograph: Chris Parks)*


Slag heaps
patchy
very small
small
medium
large
very large
Modern city
Ancient site
Church with slag heap
Pillow lavas
N
Nicosia
Soloi
Mavrovouni
Skouriotissa
Apliki
Marion
Mitsero
Agrokipia
Ayia Marina Mavrovouni
Tamassos
Idalion
Phorades
Almyras
Sha
Mathiatis
Vrechia
Kalavasos
Paphos
Maroni
Palaipaphos
Amathus
Limassol
Kourion
0
20 km




Y22
Y01
Y02
Y03
Y04
Y05
Y06
Y07
Y08
Y09
Y10
Y11
Y12
Y13
Y20
Y21
Y25
Y23
Y26
Y27
Y28
Y29
Y30
Y18
Y19
Y24
Y17
Y31
Y16
Y15
Y14
0
3 m
Slag cake
Samples: Pottery
Charcoal
Layer boundary
Indistinct layer boundary

Skouriotissa *Vouppes* made out of complete slag cakes turned upside-down: in a particularly sensitive use of the form of the slag cakes, their sloping sides, formed by the side walls of the pit into which they were tapped, forms the outer sloping surface, while their upper and lower surfaces provide a stable horizontal layer to support the next course above them (Boutin *et al*. 2013, 130).

Slag heaps are composed of much more than slag itself and its associated materials of furnace walls, furnace lining, charcoal and crushed ore. Roman-period slag heaps such as Skouriotissa *Vouppes* are rich in fragments of table wares and transport amphorae, many of them imported, cooking and utility wares, tiles, water pipes and stone tools (Boutin *et al*. 2013, 131–2). They also contain entire buildings, swallowed up by the slow advance of the slag and incorporated into the heap. These are a regular feature of Roman-period slag heaps. A particularly good example can be seen at Skouriotissa *Vouppes*, where a stone structure with plastered walls was associated with extensive pottery, glass, bone and an iron nail (Boutin *et al*. 2013, 128–9). Other striking examples are Mitsero *Kouloupakhis*, with a building nearly 2 m high (Kassianidou *et al*. 2003b, 85–8) and Kalavasos *Skouries*, where the slag engulfed what was conceivably a Cypro-Classical sanctuary (Kassianidou 2013, 67). The structure and materiality of the slag heap, then, have incorporated generations of labour and community life.

It is precisely this incorporation that gives slag heaps their monumentality. There is also their sheer size, of course: Skouriotissa *Vouppes*, admittedly by far the biggest on the island, is some 800 m long, 30–90 m wide and up to 20 m high, and contains about 2 million tons of slag (Boutin *et al*. 2013, 114). But monumentality has a much wider and richer reference than a big building built to impress. Monuments such as Scottish Mesolithic middens are constructed over time, even generations, by ongoing routines of daily practices and specific activities which are repeated at 'persistent places' (Cummings 2003, 7; Warren 2007, 116). Those mundane activities may not even have been originally intended to create an imposing structure, but that is certainly the effect, particularly when the materials are very durable, like slag (Joyce 2004). A monument, then, is a structured accumulation of materials which play active and ongoing roles in their material world and human society (McNiven 2012).

This approach works particularly well for the Cypriot slag heaps, as we know the mundane activities in some detail: building and stoking the furnaces, lighting the fires, pumping the bellows, tapping out the slag, smashing it and dumping it, constructing the next furnace: each slag cake contains these activities and conveys the memory of them to the next generation of smelters. A large slag heap holds thousands of such episodes (Kassianidou 2011, 545): their material residue at Skouriotissa accumulated over at least four centuries, from the third to the seventh centuries AD (Boutin *et al*. 2013, 123–30)

As Johansen neatly demonstrates with the Neolithic ashmounds of South India, the density of meaning of such monuments comes not just from their size and their materiality but from their position in relation to the viewer, their clarity of form (Johansen 2004, 319–20). The massive slag heap at Skouriotissa *Vouppes* is linear, lying more or less north-south and parallel to the Karkotis Valley on whose eastern flank it lies. It is sufficiently raised up above the valley floor that the dense black of its 800-m side is clearly visible across the fertile and well-watered agricultural estates that produced food for its workers. Even the narrower southern end is clearly visible from 5 km up the valley, particularly as the steep sides resist the accumulation of sediment and the growth of vegetation. The contrast with local buildings of the Roman period was striking: the largest contemporary building in the area was probably the sixth-century basilica at Soloi, the city 8 km to the north-west that controlled the mine. Based on the figures given for the internal colonnades, the basilica stood some 9 or 10 m high (des Gagniers & Tinh 1985, 50–1, Pl. X), dwarfed by the 20-m height of the Skouriotissa slag heap.

The sight of the slag heap, along with its acrid smell and the rhythm of pumping the bellows and smashing the slag, carried different associations to different people. At one level, the slag heap's monumentality expressed the power and control of the Roman and Byzantine empires. The Roman empire needed the mines to continue minting coinage to make up for the empire's chronic trade deficit (Mattingly 2011, 167), while after the sixth century the Cypriot mines were, along with Pontus and Georgia, the principal source for the imperial statues and busts that disseminated the ideology of the Byzantine Empire (Savvides 2000, 140), as well as, presumably, the more mundane copper pots and pans of daily cooking.

For most people experiencing the slag heaps of Iron Age to Late Roman Cyprus, their major association was with the sheer labour that had constructed them. We know from Galen that there were slaves working at Skouriotissa or nearby Mavrovouni in the second century AD (*De Temp. Fac. Simp. Med.* 9; Wallace & Orphanides 1990, 227), though much of the mining and smelting at Roman mines was sufficiently technical to require skilled waged labourers (Mattingly 2011, 190–1). Either way, the sheer volume of both slag and labour that had accumulated over the generations of

their work was abundantly clear. Another indication of the massive scale of this labour comes from Polybius' estimate of 40,000 workers at the silver mines at Carthage in the second century BC (34.9.8–9; Kay 2014, 45). There is no chemical signature for blood and sweat in copper slag, but the labour of workers and slaves is a key component of the monumentality of these slag heaps.

The life of slag

The active presence of slag does not stop dead after it has been removed from the pit and dumped on the slag heap. As with all kinds of waste, slag has a rich continuing biography, which has been almost entirely neglected in the scholarship. This is no mere 'afterlife', appended to the production process as an incidental curiosity, but an expression of the ongoing flow of form and relationship that constitutes the world of materials and living beings (Ingold 2012, 435).

The villages which integrated both agriculture and mining into their identities in the first half of the twentieth century clearly demonstrate the ongoing life of slag. Katydhata, for example, 1 km south of Skouriotissa, was closely tied to the Cyprus Mines Corporation which exploited Skouriotissa in the 1920s; its inhabitants combined their small-scale agriculture with new employment in the mines (Boutin *et al*. 2013, 99; Given 2005). The village's agricultural landscape is characterized by terrace walls made of slag cakes, and there are walls built of slag in the village itself. The cluster of family-owned threshing floors on the outskirts of village, overlooked by the towering spoil heaps of the mine, has retaining walls made of slag cakes (Boutin *et al*. 2013, 100–2).

The same can be seen elsewhere, with vineyard terrace walls marked by recurrent slag cakes in Vrecchia (Stos-Gale *et al*. 1998, 261), house walls built out of slag in Agrokipia (Sakellarios 1890, 201), and, perhaps most strikingly, slag cakes from the nearby Roman slag heap at Kouloupakhis used to mark a 1920s threshing floor in Mitsero (Fig. 12.6) (Given 2004, 127). As with all prominently displayed spolia (Kinney 2006), these pieces create memories and identities, and their positioning in the landscape of agricultural practice helps to negotiate the tensions between the old agriculture and the new mining (Given 2005, 54–5).

Slag was also valued because of its material properties, especially its strength and hardness. At a local scale, it was used in the nineteenth and twentieth centuries for the paving of country roads (Stos-Gale *et al*. 1998, 241, 61). In the late nineteenth and early twentieth centuries slag was quarried systematically by the colonial Public Works Department. In 1915 the President of the Municipal Council of Nicosia was very clear on the properties of slag: 'The covering of the town streets with the said dross is advocated by the solidity of the mixture, as well as by the absence of dust when strong winds blow' (SA1/961/1915, Red 2). By the 1950s, slag was being used on an industrial scale to supply iron and silica for cement manufacture. Between 1957 and 1962, for example, 14,082 tons of slag from Kalavasos were sold by the Hellenic Mining Company to the Cyprus Cement Company near Moni (Bear 1963, 190).

These various extraction activities left huge sections in slag heaps such as Skouriotissa for archaeometallurgists to record and analyse. In 1991 Skouriotissa was formally declared an Ancient Monument (Boutin *et al*. 2013, 115), and across the island slag has entered a new and particularly active stage of its life, thanks to the work of archaeologists and archaeometallurgists (e.g. Bachmann 1982; Ben-Yosef *et al*. 2011; Georgakopoulou & Kassianidou 2013; Kassianidou 2003).

There is more to the biography of a material such as slag than the continuing story of its active life. Slag is so much more than a mere proxy for technological processes. To approach the *slagness* of slag means following all the transformations that it acts out through its life, from the gathering of the ingredients to the tapping out of the molten mixture to the hardness underpinning the threshing sledge or ox-cart. These transformations are vital for understanding not just metallurgical processes but the flows and fluxes that constitute all materials. Materiality, in this understanding, is not form imposed by human intention onto inert, 'brute' matter, thus producing the artefact, but ongoing flux and form-taking activity (Ingold 2012, 432–4). Rather than looking for the final product or artefact, our task is to follow these fluxes and transformations throughout their ongoing lives.

Slag can offer something to this theoretical debate. Being incidental to human design, unlike the bronze coin or arrowhead or imperial bust, it bypasses the need to separate form from matter. The flows and transformations are very literal: the solidified slag cake is an ongoing expression of the flows of molten slag that filled the pit and dribbled across what was becoming the surface. In the materiality of the slag lives the interaction with the heat and charcoal and flux in the furnace, the running slag meeting the surfaces of the pit, blows from the hammer in the hands of the worker, the scratching of the sharp chipped stones under the threshing sledge.

When philosophers Deleuze and Guattari critique the 'matter-plus-form' conception of materiality, where brute material is given presence by human design and agency, it is striking that they take metallurgy as their

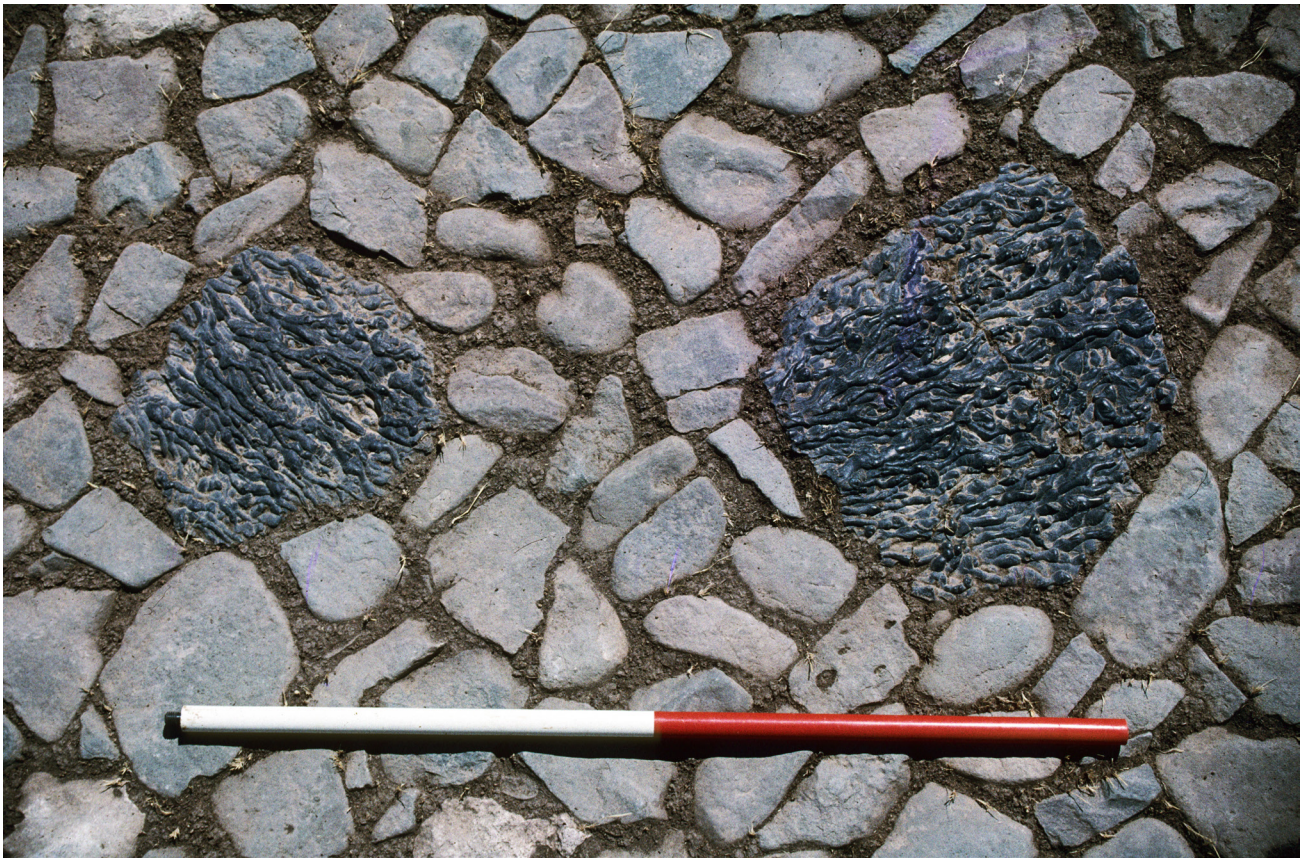


Figure 12.6. *Threshing floor at Mitsero* Kato Alonia*, paved in the 1920s, with two slag cakes. (Michael Given)*

demonstration (Deleuze & Guattari 1987, 404–15). For them, metallurgy is not a strictly sequential *chaine opératoire* of stable physical states, but continual material variation and interaction between heat, human gestures and materials. Ingold glosses this rhythmically as an 'unbroken contrapuntal coupling of a gestural dance with a modulation of the material' (2012, 434). So the properties of materials are not unchanging, chemical attributes, but histories of particular interactions and changes, that come out in the practice of working with them (Ingold 2012, 434–5; Ryzewski 2013, 359–60).

Flux, in the form of umber or manganese oxide, gives the molten ore greater fluidity at lower temperatures, to aid its transformation into matte and slag and to smooth the flow of the slag out of the furnace. Similarly, metallurgy is itself a flux, giving a greater penetration with other materials and lives. It is the flux of society, endowing it with a whole range of interconnections and flows: across the Mediterranean, between different chemical states, among the lives of slaves, specialists, foremen, managers, visitors. The slag is the visible expression of that flow, the coupling of the 'gestural dance' and the constantly transforming materials. Slag is the continual becoming produced by this dance of agency (Pickering 2008) which encompasses the materials, workers, the conditions. Slag *is* the flow.

Slag and sanctuary

All this is not just an academic construct. Flows of materials and gestural dances were hugely important in past understandings of the world, and can be clearly seen in the constellation of metallurgical dramas surrounding smelting and slag. These dramas are very evident in the writing of the Roman doctor Galen, who visited Skouriotissa or nearby Mavrovouni in AD 166 (*De Temp. Fac. Simp. Med.* 9; Wallace & Orphanides 1990, 226–8; Kassianidou 2011, 540–1). He focuses on the transformation of materials through different processes, resulting in a rich if challenging terminology for all the material variants. The manager of the mines fires *kadmeia* on an open fire for him, and he scrapes the soot off the roof of the cave as *pomphylox*. Similarly, *khalkanthos* remains 'in the stage of transformation' into *khalkitis* for over 20 years. Most dramatically, the naked

slaves ran down through a low and suffocating tunnel to collect the 'green-yellowish thick and warm water', so that the dissolved copper salts could be extracted for medicinal purposes and for a whole new series of bodily transformations. The 'stifling and oppressive' air extinguished the lamps, and on one occasion a tunnel had collapsed and killed the slaves. Galen's text is rich in transformation at a variety of levels.

One of the best ways of understanding ancient conceptions of flows and transformations associated with copper production is through the expressions of world view in associated religious practice. There is now an established literature examining the connections between copper production and religion in Late Bronze Age Cyprus (Kassianidou 2005; Knapp 1986; Spigelman 2012); there is much less for the Iron Age, Hellenistic and Roman periods (but see Kassianidou 2013).

The Cypro-Archaic city of Tamassos has a clear spatial association between copper smelting and the sanctuary, though as with the Late Bronze Age this does not necessarily mean that the temple actually controlled the copper production (Kassianidou 2005). The whole process of smelting, refining and casting was carried out in a workshop connected to the Ashtart temple by a corridor (Buchholz 1973, 362–3; 1987, 177). Slag was also found in the temple *bothroi*, where discarded dedications were disposed of, and in the area of the altar (Buchholz 1987, 177; Zwicker 2000, 197). Could slag, this ongoing expression of transformation, have been dedicated to the goddess of the generation of life? As with many Late Bronze Age examples of such associations, the scale of the copper production here is very small, though encompassing the entire process. Doonan and colleagues suggest for Late Bronze Age Maroni and other similar sites that the aim was not so much efficient production using economies of scale, but the staging of a metallurgical drama: this could be perhaps seen but certainly heard and smelt by visitors to the sanctuary and neighbouring residents, thus helping to create a sense of community and perhaps structuring social relations between those involved (Doonan *et al*. 2012, 53–6).

Even after going through Ulbrich's catalogue of Iron Age sanctuaries (2008, 263–478), the list of Iron Age sanctuaries with associated copper production is a small one (helpfully reviewed in Kassianidou 2013). The kouros sanctuary in the palace at Amathous has an apparent furnace with an ashy layer and copper slag (Petit 2002, 291–3). There is a pit filled with 'clearly votive' slag and topped with a bull skull in front of the entrance to the sanctuary of Peristeries at Polis (ancient Marion), as well as more slag in *bothroi*, again possibly votive (Smith 1997, 84, 90–1; Smith *et al*. 2012, 175, 8). The sanctuary at Kition *Bamboula* has a smelting working workshop as part of the complex, with the main altar mediating the passage between workshop and temple (Karageorghis 1976, 111–12). Because most published sanctuaries were discovered in the nineteenth century, when the focus was on statuary rather than 'waste' products, this is likely to be a very incomplete list. What is clear is that the transformative character of copper production was highly meaningful in religious term, and that this was explicitly expressed in the dedication of slag.

There is also a certain amount of evidence for religious practices at the mines and smelting sites themselves. The Archaic mine and smelting workshop of Ayia Varvara *Almyras* has a rock-cut chamber some 3 m across, clearly not a tomb, with a limestone statuette of a ram and two terracotta human figurines (Fasnacht 1999, 180; Fasnacht *et al*. 1996, 99–102). The Sydney Cyprus Survey Project found a statuette of Ashtart in association with a slag heap at Agrokipia, though the heap has been very disturbed and the stratigraphy is not clear (Kassianidou *et al*. 2003a, 70, 74); another figurine was noted in association with the Agrokipia slag heaps in the 1920s (Davies 1928–30, 75). There are also two examples of slag heaps incorporating earlier sanctuaries, though the stratigraphy is not clear enough to tell whether the sanctuaries were contemporary with the earlier phases of smelting. The sanctuary under the slag heap at Mathiati *Mavrovouni* seems to have been dedicated to a warrior deity, judging by the figurines (Karageorghis 1984, 962–5), while that at Kalavasos *Skouries* was a stone built structure with several figurines, probably dating to the Cypro-Classical period (Kassianidou 2013, 67).

Clearly, the details of the rituals associated with smelting are lost to us, other than the dedication of slag and the multisensory experience of smelting and refining going on adjacent to the sanctuary. There are, however, some very intriguing structural parallels between Iron Age ritual and the smelting process. The key moment of the smelting operation comes when the tapping hole in the side of furnace is unplugged and the molten slag pours out to form the slag cake. This act of pouring was, in the form of libations, central to Iron Age religion and funerary cult in Phoenicia and Cyprus (Markoe 2000, 122). Libations were carried out with a wide variety of elaborate vessels such as *phialai*, *rhyta* and *kernoi*, along with a whole range of jugs (Lightbody 2013, 148, 91). It was also enacted by miniature figurines on the shoulders of fifth–fourth-century BC jugs, who hold a tiny jug, connected by a piercing to the body of the main jug; these last may have been specifically associated with the Cypriot goddess of fertility (Vandenabeele 1998, 36–7). The ever-flowing

dribbles and runnels on the surface of slag dedicated in the sanctuary continue that pouring in perpetuity.

Slag's eloquence in expressing transformation is also very much in keeping with Iron Age religion, particularly given the centrality of the vegetation god who dies in early summer and along with the earth itself is dramatically brought back to life with the first rains of the winter. This annual cycle of transformation was celebrated by rituals focusing on trees, such as dancing around them, carried out certainly by terracotta figurines and presumably by humans as well (e.g. Karageorghis 2006, 217; Young & Young 1955, 39–41). It also resulted in a wide range of 'tree of life' representations being used in ritual practice (Bushnell 2008; Lightbody 2011). Judging again by the terracotta figurines, masks were used in ritual to express and enhance these transformations; the figurines are shown just at the point of taking off or putting the mask on (Given 1991, 88–90, 95–6; Karageorghis 2006, 159–61). In just the same way as the flowing surface of the slag, caught in the moment of transition, the focus is firmly on transformation.

The key transformation of Iron Age religion was that of death to life, and the creation of new life from old; this principle is normally referred to in the secondary literature as 'fertility'. Enabling this was the role of the Great Goddess of Cyprus, variously termed Cypria, Paphia, the Lady, Aphrodite, Ashtart or Hathor (Serwint 2002; Ulbrich 2005, 199–200). For humans to receive this new life for their crops, their animals and themselves, they needed to give a token sample in exchange. At Tamassos, for example, the sanctuary of the Great Goddess, conventionally termed 'Ashtart/Aphrodite', has dedications of bowls containing olives and grain, jugs and amphorae for oil and wine (Buchholz 1974, 565; Buchholz 1978, 169–70, 219), and bones of sheep, goats and oxen, as well as other domesticated and wild animals (Buchholz 1973, 343–4; Buchholz 1978, 171).

What is interesting is that these dedications have the same distribution as the slag: in the sanctuary, round the altars, and in the *bothroi*. For the Late Bronze Age, Kassianidou argues that copper was just one aspect of production that was supported by the Goddess (2005, 133–5). Judging by the dedications in sanctuaries such as Tamassos, that was clearly the case for the Iron Age too. Along with mother-and-baby figurines, the first fruits of the harvest, and the annual resurrection of the vegetation, copper slag is a vivid demonstration of the transformative power of the gods.

A very different kind of metallurgical drama comes with the growth of Christianity. In the persecutions of the early fourth century AD, we hear from hagiographers such as Eusebius considerable detail about the sufferings of the Christian martyrs who were sent to the mines of Phaeno in southern Jordan (Mattingly 2011, 188–9). As the Christian community grew, it developed its own house churches and appointed its own bishop, until the Christians at Phaeno were purged by the emperor Maximinus in AD 311 (Eusebius, *Martyrs of Palestine* 13.1–3; Mattingly 2011, 189–90). Their leaders were executed, the elderly or infirm were decapitated, and the rest were distributed round the mines and quarries of Cyprus, Lebanon and Palestine. By the sixth century this gave rise to a considerable martyr cult at Phaeno, with probably five churches and monasteries acting as focuses for pilgrimage (Mattingly *et al*. 2007, 315–16; Mattingly 2011, 183).

We know of at least one Cypriot saint who was condemned to the copper mines. According to the sixteenth-century *Martyrologium Romanum*, which is based on sixth-century sources, Saint Spyridon bishop of Tremithus was condemned to work in the mines of Cyprus under Galerius (AD 305–11) (Hill 1940, 238, 48). What is interesting from an archaeological point of view is the common association of churches with slag heaps (Fig. 12.4). Six are noted by Stos-Gale and colleagues in their catalogue of slag heaps across the island (Stos-Gale *et al*. 1998, 238–9, 41, 61–2), to which I would add Agrokipia (Davies 1928–30, 299), the church of St George in Drapia (Jeffery 1918, 353), the destroyed church of Ayios Kyriakos at Ayia Marina *Mavrovouni* (Graham *et al*. 2013, 187), and the monastery of Panayia Skouriotissa adjacent to the slag heap of the same name (Boutin *et al*. 2013, 135–6). Further field research is very likely to find more examples.

Panayia Skouriotissa is of particular interest because of its name: 'skouria' means slag, and so the monastery is dedicated to 'Our Lady of the Slag'. There is clearly a Late Roman settlement on the site of the monastery, and a surviving fresco suggests that there was a church in the fifteenth century, even though the monastery itself was not built until 1716 (Boutin *et al*. 2013, 135–6). What is clear is the direct association between the church and the slag heap. Were these slag heaps witnesses of the martyrdom of the saints, and so a focus of pilgrimage? The juxtaposition with the churches is suggestive, and unlike the mines themselves they are visually striking, monumental and, until the advent of the bulldozer, virtually indestructible. As with the terrace walls and threshing floors, and the dedications in the sanctuaries, these churches provide one more demonstration of the ongoing life of slag.

Conclusion

In very broad terms, this article has addressed the materiality, monumentality and biography of copper slag. Rather than cherry-picking examples and

squeezing them into the theoretical mould, however, I would argue that the relationship between the slag and the theory is a two-way dialogue. The nature of slag challenges the archaeological theorist: is it artefact or natural? Solid or liquid? Waste or resource? Active or inert? Archaeological theory in general needs more material input and challenges from the data (Knappett 2012, 201), and slag is particularly good to think with.

For workers and residents round the great copper mines and slag heaps of Iron Age to Late Roman Cyprus, the actual copper was extracted, removed, a biography cut short. It gives the agency to exploitative state or colonial powers, and continues the scholarly myth of Cyprus as a long line of foreign occupations.

Far from being negative and harmful, 'waste' and 'dirt' can show action, production, prosperity, life; as the Dogon prayer has it, 'May god turn your courtyard very dirty' (Douny 2007, 315). So I would propose that Cyprus is celebrated as much for its slag as its copper. As well as being more accurate, this carries within it the richness of the material and social character of the island, along with the local identities, the flows of material, and the metallurgical dramas. These flows and biographies never die, as the slag continues to transform itself and play its lively role in the world.

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'SA1' refers to colonial-period minute papers preserved in the State Archives, Nicosia. Copyright remains with the Government of Cyprus.

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