[Supplementary material]

Reconstructing an ancient mining landscape: a multidisciplinary approach to copper mining at Skouriotissa, Cyprus

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Archaeology of mining and current scope of discipline and practice

In the past, the archaeology of mining largely concentrated on the technology of mining and the physical mines (for example, see Healy 1978). However, in the last few decades the focus has widened. Stöllner (2014) describes the archaeology of mining and its modern foci as addressing the entire broader social, economic and landscape issues directly related to mining activities or the raw materials/products deriving from these activities (see e.g. Weisgerber 1989, 1990; Knapp *et al*. 1998; Hirt 2010; O'Brien 2015; Gosner 2016). This enhanced scope is evident in recent conference proceedings on mining archaeology with papers on a wide range of topics (e.g. Stöllner *et al*. 2003; Anreiter *et al*. 2010, 2013; Orejas & Rico 2012; Ben-Yosef 2018). Altogether, in the last few decades a considerable number of ancient copper mines have been discovered and investigated across the Old World (e.g. O'Brien 2015; Ben-Yosef 2018; and Table S1). A challenge in Cyprus and other loci is that modern open-cast mining has often largely obliterated the landscape of earlier mining activities. To clarify: opencast mining is open to the surface, with the ores removed from a large (and usually increasingly larger over time) open pit, rather than through underground workings (called adits when they are inclined and start from the surface and galleries when they are horizontal and underground; Thrush 1968: 769).

Table S1. Some (of many) examples of scholarship on ancient mines (versus primarily metallurgy) from the last few decades from Europe, the Mediterranean and Near East (but notably not Cyprus). For an extensive bibliography on ancient mining, visit the webpage of the Oxford Roman Economy Project: http://oxrep.classics.ox.ac.uk/bibliographies/mining_bibliography.

Country	Reference
Austria	Schibler *et al*. (2011); Stöllner & Oeggl (2015)
Greece	Conophagos (1980); Weisgerber (1988); Morin & Photiades (2012); Morin *et al*. (2012)
Ireland	O'Brien (2004)
Israel	Conrad & Rothenberg (1980); Avner *et al.* (2018); Langford *et al*. (2018)
Jordan	Weisgerber (2003, 2006); Hauptmann (2007)
Portugal	Cauuet (2004)
Romania	Cauuet (2014); Cauuet & Tamaș (2012)
Spain	Domergue (1990); Orejas & Sánchez-Palencia (2002); Hunt Ortiz (2003); Rico (2005); Fontanals *et al*. (2018)
UK	Crew & Crew (1990); Timberlake (2003), (2009); Timberlake & Marshall (2018); Williams & le Carlier de Veslud (2019)

Examples of scholarship on ancient mines and mining on Cyprus; and ancient sources

Scholarship on mines and mining on ancient Cyprus includes especially: Davies (1928–1930); Bruce (1937), (1948); Koucky & Steinberg (1974), (1982a), (1982b), (1989); Steinberg & Koucky (1974); Weisgerber (1982); Raber (1984); Constantinou (1992); Kassianidou (2000), (2004), (2013a), (2013b), (2013c). We note in the main text that samples of ancient slag from Cyprus were chemically analysed and the results published already from the later part of the nineteenth century (Terreil 1861; Gaudry 1863). Social history related to mining and colonial practice on Cyprus in the early twentieth century is discussed in (e.g.

Given 2005; Apostolides 2013).

It is clear that in both proto-history and ancient history (Classical through to the Early Byzantine period) Cyprus was associated with copper and the production of copper (Vryonis 1962; Muhly *et al*. 1982; Constantinou 1992; Kassianidou 2013c). This begins with mentions of Alashiya (which almost all scholarship associates with Cyprus or a part thereof) and copper in the second millennium BC (Knapp 1996; Knapp 2008: 307–13), and continues in the subsequent first millennium BC through classical era where there are several references to Cyprus associating it directly or indirectly with the production of copper (see Wallace & Orphanides 1990). These range from Homer (e.g. Odyssey 1.182-184: Wallace & Orphanides 1990: 1) onwards. Perhaps the most famous is Pliny *NH* 32.2–4, where the author says that "in Cyprus, where copper was first discovered" (Wallace & Orphanides 1990: 146–47). Particularly relevant text references are found for example in Wallace & Orphanides (1990: 54–55, 57–58, 63, 125–26, 131, 141–42, 149, 160, 161, 167, 223, 224, 225 & 227) from eight different ancient authors (note: a pdf scan of Wallace & Orphanides is available from: https://www.researchgate.net/publication/267509251_Sources_for_the_History_of_Cyprus_Greek_and_Latin_Texts_to_the_Third_Century_AD). For discussions of Iron Age and Hellenistic to Roman mining and copper production on Cyprus, see Kassianidou (2000, 2013a).

By the time of the re-discovery of the mines in the eighteenth to nineteenth centuries AD, it appears that even the memory of copper production on the island had been lost—at least among the villagers. Gaudry, the French geologist who published a memoir on the geology of the island in 1863, relates how villagers described to him the remains of volcanoes but in fact they were talking about the slag heaps. They mistakenly identified the slag as lava. He notes (Gaudry 1863: 180): "…les résidus des exploitations antiques forment de tels monceaux, qu'il est difficile, au premier abord, de ne pas les croire des produits de la nature".

Skouriotissa: name and *testimonia*

The most important testimony and descriptions of the mine of Skouriotissa (or perhaps Mavrovouni) are found in the books of the ancient doctor Galen who in 166 AD came to Cyprus in order to collect minerals for the manufacture of medicaments (Michaelides 2011). On several occasions, for example in *De Antidotis* (for the ancient text see Kühn (1827)), he refers to the director of the mines, a procurator (επίτροπος), appointed by Caesar (Kassianidou 2000). He also describes how the work is carried out by slaves who worked under difficult conditions *(de Simplicium Medicamentorum Temperamentis 9* (for the ancient

text see Kühn (1826)):

> *But to me, all the times I descended to the end of the tunnel where the warm and green- yellowish water was collected, the smell of the air, which smelled of khalkitis and copper rust, seemed to me to be stifling and oppressive. The taste of the water was the same. The naked slaves brought up the amphorae running, and they could not stand to stay there for a long time, but quickly ascended. Neither the lamps which were lighted on both walls of the tunnel in symmetrical spaces could stay lighted for a long time, but instead they were extinguished very quickly* (Wallace & Orphanides 1990: 227).

Sometimes there were fatal accidents: "They say that once in the past the entire tunnel collapsed and killed all of them and destroyed the passage" (Wallace & Orphanides 1990: 227).

Descriptions of Skouriotissa are also found in the books of travellers who visited the island in the early modern era. This is perhaps because they would find shelter in the monastery of Panagia (the Virgin Mary) Skouriotissa while travelling along the west coast and across the mountains to visit another famous monastery at Kykkos also dedicated to the Virgin Mary. One of the earliest references, from the Russian monk Barks' Kyi, who travelled around the island between 1734 and 1736, reads:

> *From there I walked for two hours crossing mountains and arrived at another monastery. In Greek this monastery is called Panagia Skouriotissa, that is, the Mother of God of the Rust, with this appellation coming from a rusty colored stone which is found in abundance in the mountains close to the monastery* (Grishin 1996).

Just two years later, the monastery was also visited by Richard Pococke, who wrote:

> *We went to the convent where the Bishop of Gerines [he means Keryneia, the town located on the North coast of the island beyond the Pendadaktylos or Keryneia mountain range] commonly resides. It is situated on the side of the hills where there are very rich iron mines which are not now worked* (Coghlan 1908).

Early books on the archaeology and history of Cyprus also mention Skouriotissa. According to Myres and Ohnefalsch Richter (1889): "The Panagia Skourgiotissa, 'Madonna of the Slag-Heaps' derives her epithet from the refuse heaps (σκουργιαίς scoriae) of copper mines still visible in the neighbourhood although deserted since Roman times". Sakellarios in a book published in 1890 on the geography, history and language of Cyprus discusses Skouriotissa

and the slag heap and states that on the hills there are ancient mining galleries still visible (Sakellarios 1890).

The significance of the Skouriotissa mine as a source of copper in the ancient world is highlighted by the observation drawn in the main text that around half of all the copper produced on Cyprus in antiquity came from Skouriotissa. Studies of copper oxhide ingots and work on ancient metals provenance by lead isotope analysis have likewise usually identified Skouriotissa and its region, the so-called Solea Axis in the northwest of Cyprus including the mines of Mavrovouni, Apliki, Ambelikou and Skouriotissa, as likely the dominant source of copper produced on Cyprus and exported in antiquity (e.g. Kassianidou 2009; Gale 2011).

The 'modern' history of the Skouriotissa ore deposit and mine began with its 'discovery' by Charles Godfrey Gunther (Bruce 1948; Time 1956). He visited the area of Skouriotissa for the first time in 1912, following the recommendation of the principal forestry officer A.K. Bovill (Lavender 1962: 61), and was struck by the size of the slag heap. In a history of the Cyprus Mines Corporation (CMC), Lavender (1962) recounts what was visible at the time of Gunther's visit. CMC was established in 1916 to exploit the rich copper ore deposits of the Solea valley and elsewhere. This was more than 1000 years after the last certain use. The principal investor and main stockholder was Colonel Seeley W. Mudd and later his son Harvey Seeley Mudd. Harvey Mudd College was founded and named in his memory and honour: https://www.hmc.edu/about-hmc/history/. The Cyprus State Archives hold a wealth of information about the early stages of activities by CMC including mine leases. In this way, after more than 1000 years, copper mining resumed at Skouriotissa.

H.H. Kitchener's survey of Cyprus

Digital scans of Kitchener's maps are now available online through the National Library of Scotland (https://maps.nls.uk/cyprus/) and the Sylvia Ioannou Foundation (https://geoprojects.hua.gr/kitchener/).

Lost necropolis at Skouriotissa

As shown in Figure 4, there is a now lost necropolis buried under modern leaching heaps at Skouriotissa. We lack any direct evidence about these tombs. However, the context and other finds in the areas give us some indications and point to a likely date for at least some of these tombs.

Some other tombs are known in the area of Skouriotissa. Max Ohnefalsch Richter excavated tombs in 1883 for the Cyprus Museum and some private individuals, and in 1885 for the

Berlin Museum (Reinach 1885: 352). These indicate an extensive Hellenistic to Late Roman necropolis in an area between the Monastery of Skouriotissa, Katydata and Linou villages. Some of the tombs contained only pottery, while others, which he and Myres presumed to date to the Roman/Late Roman period, contained significant numbers of glass objects, some of which were of high craftsmanship (Myres & Ohnefalsch Richter 1889; Ohnefalsch Richter 1893). According to Reinach (1885: 352), Ohnefalsh Richter excavated an enormous tomb near the monastery of Skouriotissa and the copper mines. The tomb had numerous niches and was 35 feet long. Near Linou he also excavated another necropolis of this date in which the tombs were entirely furnished with glass artefacts (Myres & Ohnefalsch Richter 1889). Clearly, these tombs were not the tombs of slaves that may have worked in the mines, but more likely related to the engineers and administrators who were in charge. Sakellarios (1890) mentions the existence of a necropolis extending over three hills north of the monastery of Skouriotissa. Unfortunately, no systematic excavations took place in this area apart from those of Markides (1916), who excavated around 100 tombs in the general vicinity of Skouriotissa and the nearby Katydata village ranging in date from the Middle Cypriot to the Hellenistic and Roman periods (Åström 1989). According to Åström (1989), Markides excavated nine looted tombs at the location of Apoti (sic) to the east of the monastery of Skouriotissa. One contained a Roman sarcophagus. A water supply system consisting of terracotta pipes connected to small tanks built of stone was also uncovered, in the same vicinity. Cadastral maps of the area, which record plots as well as the toponyms, reveal that the location of the tombs recorded by Kortan (1970) are in the vicinity of the toponym "Apotes". We may therefore suggest that that at least some of the lost tombs dated to the Roman period. Unfortunately, evidence from rescue excavations within the area of the mine in the last few decades are scarce or unpublished (Given *et al*. 2013a) but some recent rescue excavations by the Department of Antiquities of Cyprus in the wider area of Solea, including the nearby village of Katydata, have been have been published in the last few years (Georgiou & Karageorghis 2013; Georgiou 2014). The size of the necropolis hints to the population that once lived, worked and died at Skouriotissa. The scale of this population is not attested. But, since Strabo (Geography Book 3.2.10), referring to the work of Polybius (around 150 BC), states that 40 000 miners were working in the mines of Carthago Nova in Iberia, and Domergue (1990: 335) assesses this as a number that cannot be far from reality, it is possible that the work force at Skouriotissa was of a similar size.

Radiocarbon dating of a section of the Skouriotissa slag heap (Figure 9).

We obtained radiocarbon dates on six samples from the section of the slag heap shown in Figure 9 (see Table S2). These samples were processed and dated at the Groningen radiocarbon laboratory (Dee *et al*. 2020). Calibrated calendar dates ranges for these radiocarbon measurements with no modelling using OxCal (Bronk Ramsey 2009a) version 4.4.1 and IntCal20 (Reimer *et al*. 2020) are listed in Table S2. At 95.4% probability the dates all lie between 172 BC and AD 21 (158 BC to AD 7 at 68.3% probability). Since the deposit shown in Figure 9 appears to reflect a set of likely related industrial activities forming a discrete phase within the slag heap section (versus separate events spread out over a considerable period), it appears reasonable to model the dates as random events from within a uniform probability Phase in OxCal representing the overall period of these activities (Bronk Ramsey 1995; 2009a). We apply the OxCal Charcoal Outlier model to the dates on wood/wood charcoal to allow approximately for in-built age and the OxCal General Outlier model to the two dates on pinecone scales, which should plausibly belong to the year of deposition (Bronk Ramsey 2009b). An OxCal Date query and Interval query are applied to the Phase in order to estimate the date and duration represented for this overall Phase of activities (between the start and end Boundaries for the Phase). The model and outcomes are shown in Figure 10. The IntCal20 calibration dataset (Reimer *et al*. 2020) was employed with curve resolution set at 1 year.

Table S2. Radiocarbon (^{14}C) dates from slag section (Figure 9). For details on pretreatment, dating, calibration (using IntCal20; Reimer et al. 2020) and modelling (using OxCal v4.4.1; Bronk Ramsey 2009a & b).

Sample ID	GrM-	Material	Dated fraction	$\delta^{13}C$	SD	Radiocarbon age BP	SD	Cal age (BC/AD) 68.3% (left)	95.4% (right)
SP3/11-16	11846	Wood, *Pinus brutia*	Holocellulose	−25.44	0.13	2108	14	158–58 BC	172–52 BC
SP3/9-3	11847	Wood, *Quercus*, evergreen	Holocellulose	−25.55	0.13	2087	14	147–51 BC	158–47 BC
SP3/16-2	11844	Wood, pine cone scale	Holocellulose	−23.55	0.13	2035	14	49 BC–AD 7	89 BC–AD 21

SP3/16-26	11845	Wood, pine cone scale	Holocellulose	−24.18	0.13	2045	14	88 BC–AD 5	96 BC–AD 15
SP3/8-2	12599	Charred wood, *Quercus*, evergreen	Reduced carbon	−23.18	0.26	2094	18	150–53 BC	166–49 BC
SP/7-15	12600	Charred wood, *Quercus*, evergreen	Reduced carbon	−25.64	0.26	2093	18	149–53 BC	165–49 BC

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