

SKOURIOTISSA:
INTERDISCIPLINARY STUDY OF THE ARCHAEOLOGY
AND ENVIRONMENT OF CYPRUS'
LAST OPERATING COPPER MINE

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Abstract

The scope of this project funded by the A.G. Leventis Research Programs of the University of Cyprus was to record the history, archaeology and ancient environment of the mine of Skouriotissa, and thus preserve this important aspect of Cypriot cultural heritage that has been severely damaged by one hundred years of modern exploitation. The mine of Skouriotissa, together with those of Mavrovouni and Apliki, are part of the mining region of Solea, which is located in the north-western foothills of the Troodos mountains. The mine of Apliki is, according to Lead Isotope Analysis, most probably the mine that generated the copper used to produce the vast majority of copper oxhide ingots found in Cyprus and abroad during the Late Bronze Age (16th – 12th century BC). In the Iron Age (from the 11th century onwards), the most enigmatic period of copper production on the island of Cyprus, the mines belonged to the kingdom of Soloi, one of the most prosperous on the island. In the Roman and Late Roman/Early Byzantine periods, mining and smelting at Skouriotissa reached an unprecedented scale. Slag, the waste from the smelting furnaces, accumulated in large heaps. They formed an impressive landmark, which eventually gave the name to the Monastery of Panagia Skouriotissa and then the whole area around it.

The Late Roman slag heaps of Skouriotissa were systematically recorded by the author, in collaboration with colleagues from other academic institutions within the framework of two interdisciplinary projects, namely, the “Troodos Archaeological and

Environmental Survey Project” and “CAMP: The Cyprus Archaeomagnetic Project: high resolution dating, magnetic characterization and archaeointensity correlation of major slag deposits in Cyprus and the Eastern Mediterranean”. But neither of these projects investigated the ancient mining remains at Skouriotissa. It is the first time that a project will actually focus on the mine rather than the slag heaps. It is also the first time that an effort has been made to systematically collect information on the archaeology and history of the mine from the State Archives, as well as from the archives of the mining company and people who worked there.

Introduction and Objectives

The scope of this project funded by the A.G. Leventis Research Programs of the University of Cyprus is to record the history, archaeology and ancient environment of the mine of Skouriotissa, and thus preserve this important aspect of Cypriot cultural heritage that has been severely damaged by one hundred years of modern exploitation. The mine of Skouriotissa, together with those of Mavrovouni and Apliki, are part of the mining region of Solea, which is located in the north-western foothills of the Troodos mountains (Ingham 1959: 140–155) (**Fig. 1**). The mine of Apliki is, according to Lead Isotope Analysis, most probably the one that generated the copper used to produce the vast majority of copper oxhide ingots found in Cyprus and abroad during the Late Bronze Age (16th – 12th century BC) (Gale 2011: 218). In the Iron Age (from the 11th century onwards), an enigmatic period of copper production on the island of Cyprus, the mines belonged to the kingdom of Soloi, one of the most prosperous of the island (Kassianidou 2013a: 57–58). In the Roman and Late Roman/Early Byzantine periods, mining and smelting at Skouriotissa reached an unprecedented scale (Kassianidou 2013^b: 126). Slag, the waste from the smelting furnaces, accumulated in large heaps (**Fig. 2**). They formed an impressive landmark, which eventually gave the name to the Monastery of Panagia Skouriotissa and then the whole area around it. Skoria or skouria is the Greek word for slag. In other words, the church is actually dedicated to the Virgin Mary of the slag. Most importantly, based on the size of the ancient slag heaps that dominate the landscape, it is believed that in Antiquity this area probably produced more than 50% of the total amount of copper produced on the island (Constantinou 2007: 339). In the 20th century, the three mines produced more than 85% of the total copper ore concentrate from Cyprus (Constantinou 1982: 15), and in the 21st century, 100% of copper metal exported from Cyprus has come from Skouriotissa, the only mine on the island still in operation today. This of course means that it is the mine with the longest history of copper production. The mining lease is currently held by Hellenic Copper Mines, a company that has designed an innovative, cost-effective and environmentally friendly copper extraction technique based on hydrometallurgy.

In the last fifteen years, the mine of Skouriotissa has produced annually 1000 to 5000 tons of copper of extremely high purity (99.999%) and has an annual export revenue in the order of 20-30 million euros (for more information visit the company's website <http://hcm.com.cy/site/>).

It is important to highlight that Skouriotissa is the only Cypriot mine that is specifically mentioned in the ancient sources. Galen, the well-known ancient doctor who came to Cyprus looking for minerals and plants with which he could produce medicaments (Michaelides 2011: 94), left an eyewitness account of the mining activities in the mines of Soloi (Kassianidou 2000: 747-749). The mine he is describing is most probably Skouriotissa. Another reference is found in a fragmentary text attributed to Pseudo Aristotle (Ph. 266). The text states the following:

Boukasa is a mountain with gold mines and is situated at the foot of the Troodos toward the northern parts of the island and in relation to the sea, it is on the west... It has various mines of gold and silver, and copper, and stypteria, split and white, and true stypteria. And sory and yeast of gold, and misy and khalkitis and other metals.

(Wallace and Orphanides 1990: 54)

Clearly *Boukasa* can only be Phoukasa, the copper ore bearing hill that has been exploited since Antiquity. The toponym is recorded on the first triangulated map of Cyprus prepared by Horatio H. Kitchener for the British Colonial Government between 1878 and 1883 (Shirley 2001). Apart from the toponym, Kitchener's map also notes the location of the Monastery of Panagia Skouriotissa and the slag heap (the Kitchener map can be found online in the website of the National Library of Scotland - the area of Skouriotissa is on Sheet 9 <https://maps.nls.uk/view/103246397>).

The Skouriotissa slag heap, which is the largest of the forty recorded on the island, was estimated to contain two million tons of copper slag. In the 1920s it covered an area of about 800m in length, 30-90m in width and 20m in height (Lavender 1962: 63) (**Fig. 3**). The reference in the ancient sources and the size of the slag heap, although currently greatly reduced because it has been extensively quarried in modern times, led the Department of Antiquities of Cyprus in 1991 to declare it an ancient monument of the First Schedule. The fact that the ancient sources often mention Cyprus' wealth in copper is what led an American prospector, by the name of Charles Godfrey Gunther, to come to the island in 1912 and to visit Skouriotissa (Rickard 1930: 287; Lavender 1962: 46-49). He soon started exploratory drilling and managed to discover one of the richest ore deposits on the island. In order to exploit Skouriotissa a new company was set up in New York City called the Cyprus Mines Corporation (CMC). The principal investor was an American, Seeley Mudd. Under the leadership of his son

Harvey S. Mudd, CMC expanded greatly not only in Cyprus but all over the world (for the history of CMC see Lavender 1962). The company stayed active on the island until the Turkish invasion of 1974, finally closing down all operations in 1976 (Constantinou 1992: 341-342).

Previous studies

It is only natural that since the 1970s, when archaeometallurgy was taking form as a new discipline of the field of archaeology, the slag heap of Skouriotissa attracted the attention of scholars working on the island. The mines and slag heaps were visited and sampled by Koucky and Steinberg, who tried to create a typology of Cypriot slags for use in the field (1982: 117). Zwicker together with his colleagues also sampled and analyzed a number of samples from Skouriotissa (Zwicker et al. 1972: 40). More importantly, in his effort to estimate the scale of copper production in Cyprus during different archaeological periods, Zwicker (1986: 96) collected charcoal and mining timbers from various locations, in order to date them by radiocarbon (^{14}C). Among these samples were three mining timbers, from the mine of Skouriotissa, and three charcoal samples, from the slag heaps (1986: 102-103; Kassianidou 2013^a: 73). Furthermore, the ore deposit and slag heap of Skouriotissa are often mentioned in the publications by the Oxford Group on Lead Isotope Analysis. Skouriotissa, together with the mines of Mavrovouni and Apliki, forms the so-called Solea axis ore deposits (Stos-Gale et al. 1997: 98), which are credited with being the source of copper for almost all copper oxhide ingots dating from the middle of the 15th century BC onwards (Gale 2011: 218). The overall impression one gets is that ancient activities at Skouriotissa had been well recorded by previous scholars. This, however, is not the case. All of these studies rarely gave information on the provenance of analyzed samples within a slag heap, which is a multi-stratified deposit built over several decades, if not centuries (Kassianidou 2004: 95). The Late Roman slag heap of Skouriotissa was eventually systematically recorded by the author together with colleagues from other academic institutions within the framework of two field projects, namely the “Troodos Archaeological and Environmental Survey Project (TAESP)”, directed by A.B. Knapp, M. Given, J. Noller and V. Kassianidou (Given et al. 2013^a; 2013^b) and “The Cyprus Archaeomagnetic Project: high resolution dating, magnetic characterization and archaeointensity correlation of major slag deposits in Cyprus and the Eastern Mediterranean (CAMP)”, directed by Thomas E. Levy, Lisa Tauxe, Rob Shaar, Erez Ben Yosef and Vasiliki Kassianidou (Ben Yosef et al. 2011; Shaar et al. 2015). Neither of these projects, however, worked on the mining remains. The modern mine was in full operation for the duration of both projects and therefore fieldwork there was not possible. Inspired by the work and projects carried out in other mining regions (for a recent overall review see O’Brien

2014, and for the scope of the field of mining archaeology see Stöllner 2014), the new Skouriotissa project was launched in order to rebalance the scales and finally, and for the first time, focus on the archaeology of the mine.

During exploitation of the ore deposit with underground galleries, the men working for CMC invariably came across ancient adits and galleries, and within them the tools of the ancient miners. Although more than a thousand years had passed since mining ceased at Skouriotissa, even the tools, which were made with organic materials (ropes, baskets, windlasses, ladders and wooden supports), were preserved remarkably well (Fig. 3). This is due to the burial environment, which was rich in copper minerals. Thanks to the interest of James Latimer Bruce, a mining engineer who served as the resident director of CMC from 1925 to 1935, the ancient galleries were noted in the plans of the mine and the objects found within them were collected. Bruce in collaboration with D.M. Creveling presented the information he gathered in a paper that was published in 1937, as an Appendix to the third volume of the “Swedish Cyprus Expedition”, a corpus recognized as the foundation of the field of Cypriot Archaeology. The paper entitled “Antiquities in the mines of Cyprus” includes information regarding ancient mining technology, plans and sections of the ancient adits, and photographs of the mining tools and the slag heaps. More than eighty years later, this remains the most comprehensive study of ancient Cypriot mines. It is extremely important as these remains have since been largely destroyed, because since the 1950s the ore has been extracted by the open cast method. This means that large machinery work from the surface down, removing not just the ore deposit but also the host rock. As a result, after the 1950s, the hills that once covered the rich cupriferous ore deposits and were riddled with ancient galleries and adits, were transformed into artificial lakes of substantial size (Fig. 4). At the same time, huge spoil heaps have been formed by the discard of crushed metal-poor waste or, more recently, for leaching the copper out of the ore (Fig. 5). These modern spoil heaps cover and dominate the landscape in all mining regions of the island. The scale of the disturbance is evident in aerial and satellite photographs. In the case of Skouriotissa, based on high-resolution satellite images available for interpretation in the Google Earth 3D globe environment, the size of the disturbed area is estimated around 500 hectares. Thus, in order to understand the pre-modern mining landscape and the topography of the area one has to search for information recorded in eyewitness accounts, reports, maps, photographs and aerial photographs predating opencast operations. And this has been a primary aim of the project.

Another aim of the project was to study the artefacts that were found in the mines and in the surrounding regions. The local villagers soon realised that the mining engineers and their spouses had a keen interest in Cypriot antiquities. Thus, they would bring objects that they found on their land (ceramic, glass and metal artefacts and

jewellery) to sell to members of CMC (Bruce 2016: 34). The most important objects were sold to or kept for the owner of CMC, Harvey Mudd, who acquired an important collection of Cypriot antiquities. Other members of the company such as Bruce also obtained their own collections of Cypriot antiquities and when they left Cyprus, they requested and received permission to export them. An important collection of mining tools was kept in the offices of CMC in Skouriotissa. This was inspected by Aggeliki Paschalidou – Pieridou, who submitted a report to the then Director of Antiquities A.H.S. Megaw (Kassianidou 2018^a: 591). When the company closed operations on the island in 1976, the collection was given to the Department of Antiquities. Some of the artefacts were used for the Archaeometallurgy display in the Cyprus Museum, which unfortunately has now been taken down.

Methodology

Because of the significant changes at Skouriotissa since open cast mining operations began in the 1960s, it was clear that we had to search for information that dated prior to that period and at a time when the landscape of Skouriotissa was still largely the same as it was in ancient times. To do this we turned to archive images (1950s, 1960s, 1970s 1990s) and recently acquired aerial and orthophoto images (the latest from airborne flights taken in 2014). Furthermore, throughout the duration of the project and until today, an effort was made to gather information from the State Archives and the archive of the Department of Antiquities. We have collected important information regarding the area of Skouriotissa, including a map produced in 1916 showing the slag heaps (SA 1/1036/1915). This is the earliest detailed map of the area that we know of. The search in the archives of the Department of Antiquities, especially the Photographic Archive, proved to be very important, as it enabled us to clearly identify the objects that formed the Mathiatis Hoard (Kassianidou 2018^a: 590-592). This is one of the most important Late Cypriot hoards, because it includes the largest number of oxhide ingot fragments, as well as other extraordinary metal artefacts. It was discovered by employees of CMC while working at the mine of Mathiatis North (Kassianidou 2018^a; 2018^b).

A hope that Bruce and Creveling had more photographs in their personal archives (apart from the ones they published in 1937), led to the search for members of their families who may have saved them. Thanks to the World Wide Web, the author was able to trace and get in touch with members of Bruce's family who live in different parts of the United States of America. Contact was first made with his daughter-in-law, Mrs Stevey Bruce, who lives in California and is now in her nineties. Mrs Bruce was at the time working on the history of the family's life in Cyprus and which she has since published (Bruce 2016). In 2014 during a visit to Los Ange-

les, the author was able to meet her and other members of the Bruce family who were kind enough to show albums with photographs taken by Bruce in Cyprus in the ten years that he was resident director of the Cyprus Mines Corporation (1925-1935). The photographs offer rare glimpses of the diverse mining community that lived and worked at the mine of Skouriotissa: the mining engineers were Europeans or Americans, while the miners and other workers came from the local villages (**Fig. 6**). It is truly a remarkable record of Cyprus between the two World Wars. The photographs also offer rare glimpses of the ancient industrial landscape prior to its destruction by the modern open cast operations, as well as of the ancient mines and smelting workshops.

This visit in many ways sparked the idea for the Skouriotissa project, as it became very clear that it would soon perhaps be impossible to trace the people who had a direct connection with this early modern history of the mine. It would thus be soon impossible to collect and safeguard the evidence. With funding by the current project and with the help of members of the Bruce family, whom I would like to sincerely thank, the photographs have been scanned and now form part of the archive that we have compiled for the history of Skouriotissa. The author was also fortunate to trace members of D.M. Creveling's family. He was actually the one who took most of the photographs that were included in the 1937 publication. His daughter had a large collection of negatives of her father's photographs, and she gladly sent them to the University of Cyprus for scanning and digital recording. Finally, an equally important photographic archive belongs to the descendants of Charles F. Jackson, who was the resident director of CMC at Skouriotissa from 1923-1925. His grandson, Dr William Everett, who recently published a book based on letters sent by his grandmother to other family members while the family lived in Cyprus, provided a copy of the archive for the project (Everett 2017).

In terms of the ancient mining remains, however, a major breakthrough was made thanks to the archive of Dr Oskar Kortan, an Austrian mining engineer who worked for CMC from 1954 to 1971. Between 1962 and 1964, Kortan produced accurate maps of Skouriotissa, which he included in his doctoral thesis (Kortan 1970: Anlage 5, Blatt 1-4). The thesis, as well as other important documents from his personal archive, have been donated to the University of Cyprus and have been digitized and are available online through the UCY Lekythos repository (<https://lekythos.library.ucy.ac.cy/handle/10797/24499>). Kortan, who had a keen interest and respect for Cyprus' ancient cultural heritage, painstakingly recorded with great accuracy the slag heaps, any ancient adits and ancient dumps and all sorts of other remains such as stone walls and features that were still visible in the 1960s. Very importantly, he recorded the exact location of 319 tombs – in other words a whole necropolis.

Results

Dr Athos Agapiou rectified Kortan's maps (1970: Anlage 5, Blatt 1-4) with the latest available high-resolution aerial orthophoto of the area taken in 2014, kindly provided for the needs of the project by the Republic of Cyprus' Lands and Surveys Department. The rectified map has been extremely important as it enabled him to geo-reference earlier hand-drawn plans published by Bruce indicating the location of ancient galleries and other features, and a detailed plan of the mine published by Cullis and Edge (1927: Plate II) in which the location of these features is also noted (Fig. 7). By combining the three sets of maps and plans, in a GIS platform, Agapiou was able to reconstruct the ancient topography of the mine (Fig. 8). Among the archaeological sites that we have been able to spatially place is the hitherto unknown necropolis that was recorded by Kortan. Unfortunately, this is currently completely buried under the leaching heaps of the modern mine (Kassianidou et al. forthcoming).

Similarly, using a set of aerial photographs of the area of Skouriotissa taken at different times (namely 1957, 1970 and 2014) for the Lands and Surveys Department, we have also been able to show how large the slag heaps once were and how extensively they have been destroyed over the last sixty years. Early reports on Skouriotissa, the map in the National Archive, as well as photographs from Bruce's archive, clearly show two spatially separated slag heaps. Thanks to the work done during the TAESP and CAMP projects, we now know that the one that is still visible today dates to the Late Roman/Early Byzantine period (Kassianidou 2013^b: 126; Manning 2013; Shaar et al. 2015: 8-10). As part of the current project, we have been able to absolute date a section of the other concentration of several smaller heaps, which have since been obliterated under the modern mine's spoil heaps (Kassianidou et al. forthcoming). The section was exposed in 2016, when the mining company opened a new road and we were invited to study it (Fig. 9). The section was cleaned and recorded by Dr Athos Agapiou with photogrammetry. Samples of slag and charcoal were then collected from the different layers of the section. Some of the charcoal samples were then chosen for radiocarbon dating, which revealed that this part of the slag heap dates at 95.4% probability between 172 BC and AD 21, in other words, to the Hellenistic-Roman period. This does not mean that this was the earliest phase of mining at Skouriotissa. A look at the earlier aerial photographs reveals that there was a great volume of slag higher up and closer to the ore deposit and mine that probably is of an even earlier date, contemporary perhaps with the wooden mine supports that show exploitation in the Iron Age (Kassianidou 2013^a).

Perhaps the most important and unexpected result of the Skouriotissa project has to do with the collection of Cypriot antiquities belonging to Harvey Mudd. His collection includes artefacts from the Mathiatis Hoard and one of only three complete

oxhide ingots that were ever found on Cyprus (Kassianidou 2009: 43) (**Fig. 10**). The archival work that was carried out during this project revealed the story behind the acquisition of this ingot (Kassianidou 2018^b: 219-221). When Harvey Mudd passed away, his family founded an engineering college in his memory, which they named after him – Harvey Mudd College. When his wife passed away, the family donated to the college his collection of Cypriot antiquities, including the oxhide ingot. One of the aims of the project was to create a digital catalogue of the artefacts and, therefore, the author wrote to the President of Harvey Mudd College in order to ask permission to study the collection. Professor Klawe responded immediately and at the same time informed the granddaughter of Harvey Mudd, Victoria, that someone from Cyprus was interested in the collection. After a few months of correspondence, Ms Mudd got in touch to say that the Mudd family together with the Board of Trustees of Harvey Mudd College had decided that they would like to return the collection of Cypriot antiquities to its place of origin. They believed that the University of Cyprus, an academic institution like Harvey Mudd College, would be the ideal new home for the collection. The Board of Directors of the University of Cyprus accepted the donation and in December 2018 the Rector of the University of Cyprus, Professor Constantinos Christofides, and the President of Harvey Mudd College, Professor Maria Klawe, signed the Deed of Gift in a ceremony attended by Ms Victoria Mudd and other members of the Mudd family, the author and the academic community of the college (**Fig. 11**). The collection consists of 360 artefacts made of clay, stone and metal of different periods (Coventry 1985). Apart from the oxhide ingot and the objects that once formed part of the Mathiatis Hoard, of note are a limestone head of a crowned female figure dating to the Classical period and two terracotta figurines. The artefacts have been catalogued and photographed in preparation for their return. The author has since been working with archaeological officers at the Department of Antiquities to repatriate the collection, which will be displayed in the Stelios Ioannou Learning Resource Center, the Library of the University of Cyprus. Furthermore, it will be used as a teaching collection for the students of the Department of History and Archaeology of the University of Cyprus. The aim is to produce a catalogue of the collection in print and in digital form.

Conclusions

The project entitled “Skouriotissa: Interdisciplinary study of the archaeology and environment of Cyprus’ last operating copper mine” and funded by the A.G. Leventis Foundation Programs of the University of Cyprus, has officially come to an end. The fact is, however, that the data, accumulated in the two short years of the project’s duration, is extensive and will provide material for many studies, which will be published in the future. The project was launched at a critical point in time, as many of the people

who had a first-hand knowledge of the mine as it was, before modern open cast mining operations, had already passed away. Nevertheless, we were successful in finding members of their families, who embraced the project and made available the archives that they still had in their possession. It has been an incredible journey and for this I would like to thank the members of the Bruce family, the Creveling family and the Jackson family. Furthermore, without the material provided by Dr Kortan much of the archaeology of the mine would have been completely unknown and lost. He has been a veritable gold mine of information. Finally, the most important result of this project is that a collection of more than three hundred ancient Cypriot artefacts will be repatriated, thanks to the generosity of members of the Mudd family, especially Victoria Mudd, and the good will of the Board of Trustees of Harvey Mudd College and its President, Professor Maria Klawe.

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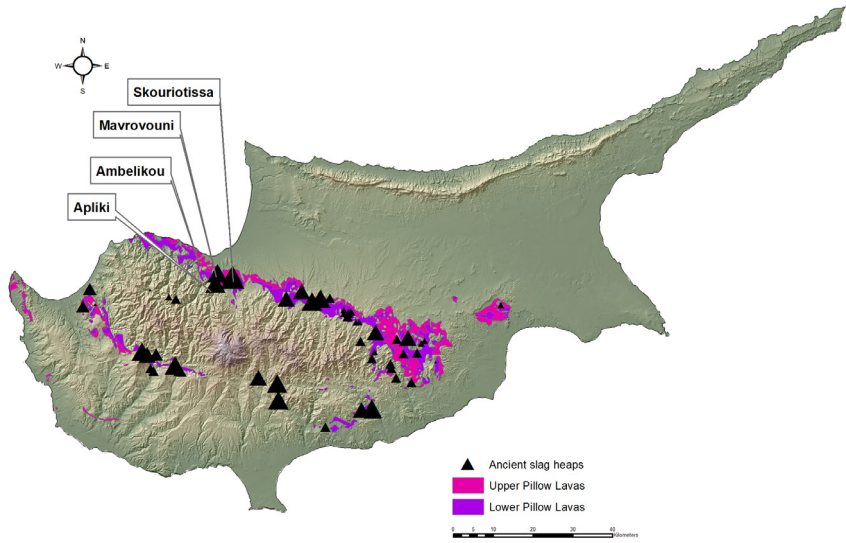


Fig. 1



Fig. 2



Fig. 3



Fig. 4



Fig. 5



Fig. 6

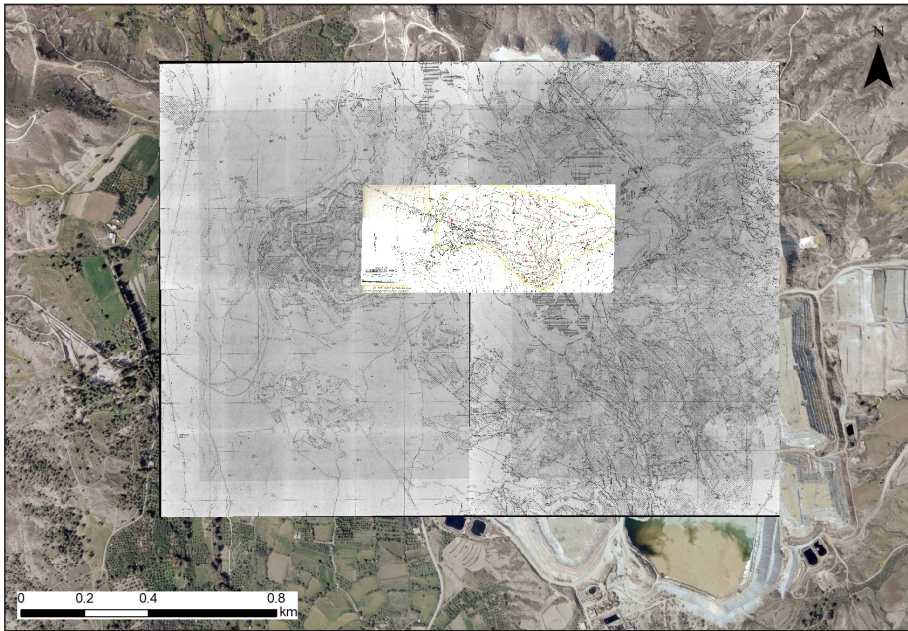


Fig. 7

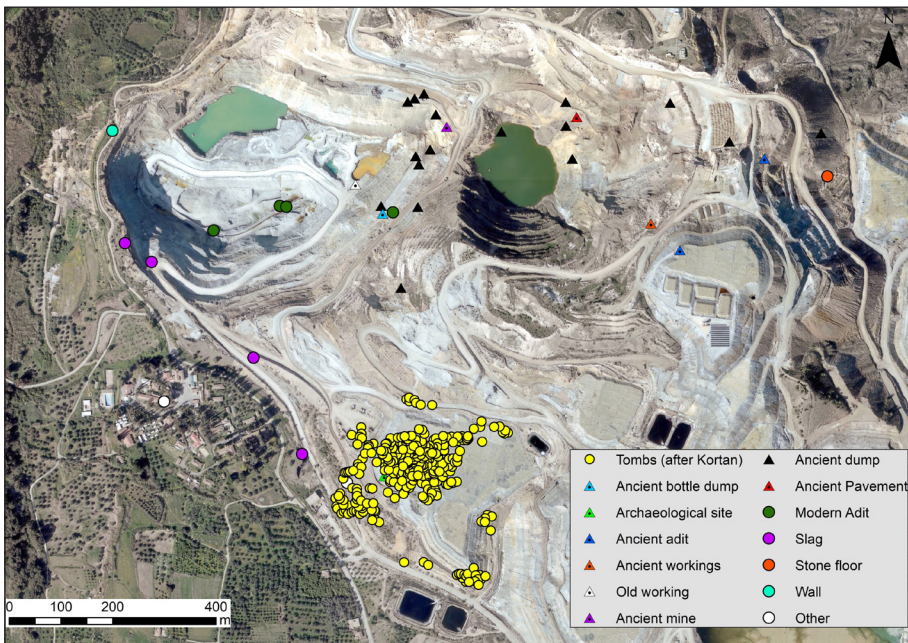


Fig. 8



Fig. 9



Fig. 10



Fig. 11

Legends to the figures

1. Map of Cyprus showing the Pillow Lava geological formation, the location of ancient slag heaps and the mines of the Solea axis (Produced by Vasiliki Kassianidou with digital geological data provided by the Cyprus Geological Survey)
2. The Late Roman/Early Byzantine slag heap of Skouriotissa.
3. Ancient basket from the collection of the Cyprus Mines Corporation and now in the Cyprus Museum
4. The Phoenix opencast mine at Skouriotissa
5. The Skouriotissa leach heaps and spoil heaps are visible from a great distance.
6. The Skouriotissa community gathered to celebrate sports day in May 1927. Photograph from the Bruce family archive.
7. The map published in Cullis and Edge (1927, Plate II) superimposed on the maps of Skouriotissa published by Kortan (1970: Anlage 5, Blatt 1-4), georeferenced and superimposed over the 2014 aerial photograph of the area. Map created by Dr Athos Agapiou.
8. Archaeological sites and points of interest including an ancient necropolis noted in the maps of Cullis and Edge (1927), Bruce (1937) and Kortan (1970) and placed on the 2014 aerial photograph of the area. Map created by Dr Athos Agapiou.
9. Recording the section of the slag heap within the mine of Skouriotissa.
10. The oxhide ingot in the Harvey Mudd College collection of Cypriot Antiquities.
11. The ceremony during which the Deed of Gift of the Harvey Mudd College collection of Cypriot Antiquities was signed by the President of the college Prof. Maria Klawe and the Rector of the University of Cyprus, Prof. Constantinos Christofides.

