New evidence on metallurgical production during the Ptolemaic period in the ancient harbor of Berenike (Eastern Desert) in Egypt

Abstract: Recent excavations in the southwestern part of the embayment that served as the southern harbour of ancient Berenike uncovered, among others, a metallurgical furnace from late Hellenistic times. An analysis of this discovery in trench BE14/15-102 offers insight into metallurgical production taking place in the harbour zone in the last years of the Ptolemaic kingdom. The early Roman phase, as attested in this trench, indicates a restructuring of this part of the harbour and its new, changed function as an open-circulation area, probably with some wealthy residences nearby.

Keywords: Berenike, harbor, Late Hellenistic, metallurgical production, copper smelting, intaglio

The Ptolemaic and Roman port of ancient Berenike, on the Red Sea coast of Egypt, lies about 825 km south-southeast of Suez and approximately 260 km east of Aswan. It was one of the most important and essential ports of the Red Sea from the mid-3rd century BCE through the mid-6th century CE. The importance of this natural harbor lay in its location [*Fig. 1* inset], protected from the prevailing northern winds by a large peninsula that offered a safe landing place large enough for

Joan Oller Guzmán

Universitat Autònoma de Barcelona

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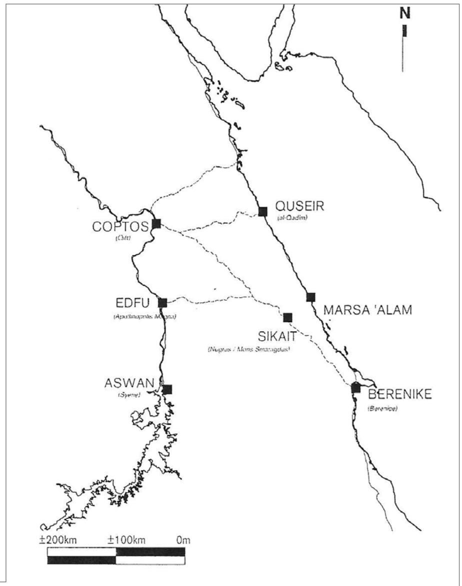
many commercial ships plying the Red Sea route to India. It was established as a shipping port by Ptolemy II Philadelphos in 275 BCE and during the Ptolemaic period it was used initially as a transfer station for imported wild elephants for the Ptolemaic army, as well as a major trading outpost for the Ptolemaic African commerce. Its position as an important trade emporium was cemented in early Roman times.

Archaeological work at the site started in 1994 and continued through 2001, under the direction of Steven E. Sidebotham from the University of Delaware and Wil-



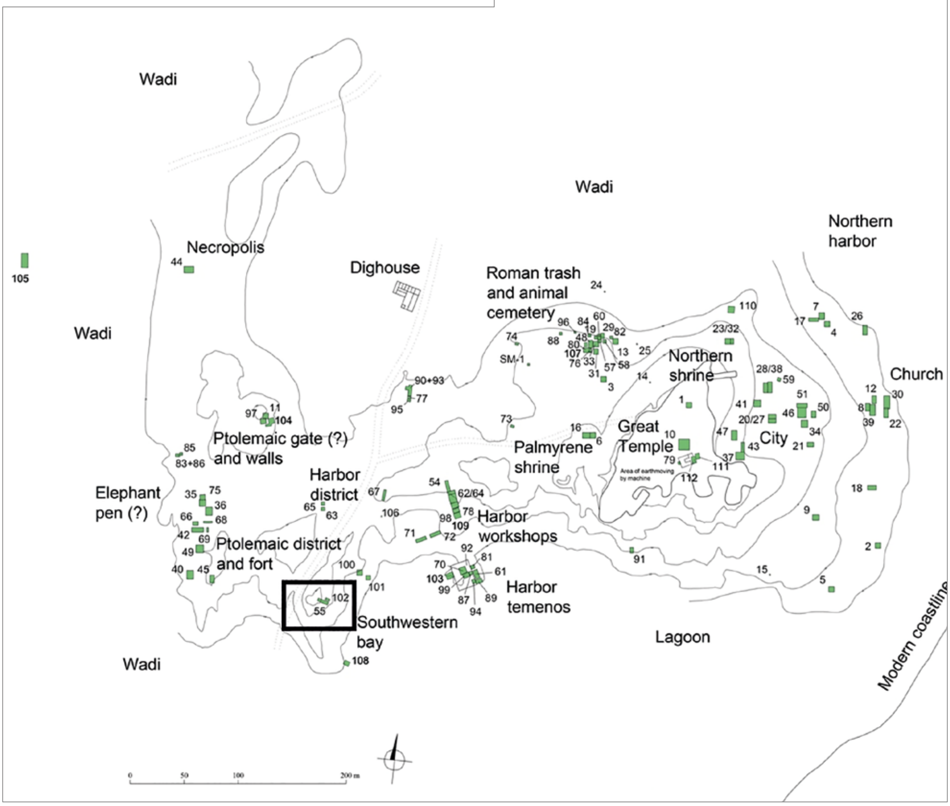


Fig. 1. The site of Berenike: location of trench BE14/15-102 indicated by the box; inset, map of Egypt with the location of Berenike (Berenike Project | plan R. Ryndziewicz; map in inset after Sidebotham et al. 2004).

helmina Z. Wendrich from Leiden University. The excavations paused for some years, until they were resumed in 2008, this time under the direction of Sidebotham and Iwona Zych from the Polish Centre of Mediterranean Archaeology, University of Warsaw. The author participated in the excavations in Berenike from 2013, digging in 2014 and 2015 trench BE-102 situated in the southwestern embayment [*Fig. 1*].[1]

TRENCH BE-102

Trench BE-102 is located in the southwestern part of the southern harbor of Berenike. This part started to be excavated in 2009, but remains barely known. In search of new data about the planning, development and chronology of this area, a trench was opened next to trench BE09-55, which had yielded the remains of a hardened platform related to a casemate-like structure, probably intended as a solid base for some kind of heavy-duty activities (Sidebotham and Zych 2011: 51). Trench BE09-55 also encompassed a fill deposit apparently related to an elite residential complex, implying that the area was turned into a trash dump late in its occupation (around the turn of the 2nd century CE through the mid-3rd) (Sidebotham and Zych 2011: 49–51). Opening trench BE-102 in 2014, the excavators sought to verify and augment this information and to learn more about the functioning of this particular section of the ancient emporium.

The trench started out 4 m long N–S and 2 m wide E–W, barely scrathing the surface in the first season and continuing full-scale in the 2015 season, reaching a depth of 1.80 m but not culturally sterile layers. Since the exploration of the trench was not continued, the results presented here are perforce preliminary in nature, and do not provide a complete chronological sequence for this part of the southwestern embayment which was where the southern harbor of Roman and perhaps Hellenistic Berenike before that was located. In spite of this shortcoming, the data from the excavation are of sufficient interest for gaining a better understanding of the development of this part of the town.

The levels recorded in the excavation relate to two main chronological phases. A review of the pottery finds indicates that most of the levels dug can be placed in the early Roman period, from Augustan times until the mid-1st century CE. The lowest identified levels are related to the late Hellenistic period, more specifically, the end of the 1st century BCE. These Ptolemaic layers are especially interesting because they offer insight into the evolution of this part of the harbor at a little known period in the history of Berenike. The present paper concentrates first on this earlier phase of the finds from trench BE-102, continuing with an interpretation of the functional changeover of this part of the southwestern embayment in the early Roman period.

1 For the site and the results of excavations to date see among many others: Sidebotham and Wendrich 1999; Sidebotham and Wendrich 2007; Sidebotham 2011; Sidebotham and Zych 2011.

LATE HELLENISTIC PHASE

A furnace identified as a metallurgical installation was identified thanks to abundant remains of metallurgical slag and crucibles as well as fragmentary bricks found in and around a circular structure of baked clay. Significantly, the feature was associated with charcoal and ash-rich levels, indicating its possible metallurgical character.

EARLY ROMAN PHASE

Metallurgical production ceased at the beginning of the 1st century CE and the area underwent a structural reorganization into an open space with free circulation. Walking levels—like locus *063*, which is a bed of gravel and small stones bonded in mortar or simple hardened clay surfaces—alternate here with brief periods of abandonment and evidence of repairs to these surfaces.

Large sandy deposits, crossing the trench downslope in the direction of the lagoon, could reflect major natural phenomena like flash floods, for example, as already observed in the neighboring trench BE09-55. These could be interpreted as evidence of a cooling and wetter climate in the area in later Roman period.

A remarkable quantity of pottery finds come from this phase, including local production for domestic use, containers and fine wares, such as Eastern Sigillata, and imported products from distant regions such as Parthia or Nabataea. Building materials, different types of metallurgical elements, glass fragments, faunal remains, etc. were also documented, noting their abundance in the abandonment fills following the early Roman phase and, like in trench BE09-55, reflecting a wealthy Berenikan elite. Nothing in the archaeological record from trench BE-102 suggests continued usage of this harbor area after the 1st, possibly the first half of the 2nd century CE.

The results of these two seasons of excavations in trench BE-102 are, as has been noted above, preliminary in nature, but the import of the discovery of the first metallurgical furnace in Berenike, especially in view of its late Hellenistic dating, justifies this exploratory study.

LATE HELLENISTIC PHASE: METALLURGY IN BERENIKE

The late Hellenistic layers reached in the trench were dated archaeologically to the second half of the 1st century BCE, thus giving greater insight into the little known evolution of Berenike's harbor from this period. The metallurgical furnace identified in these levels allows more details to be inferred thanks to the related materials.

FURNACE

The furnace in question is a circular feature, 1.10 m in diameter, made of hardened clay. Some fired clay bricks inside the feature would indicate the existence of furnace walls, while several gypsum stones located around the structure probably formed a base outlining this oven-like structure [*Fig. 2*]. The elements here

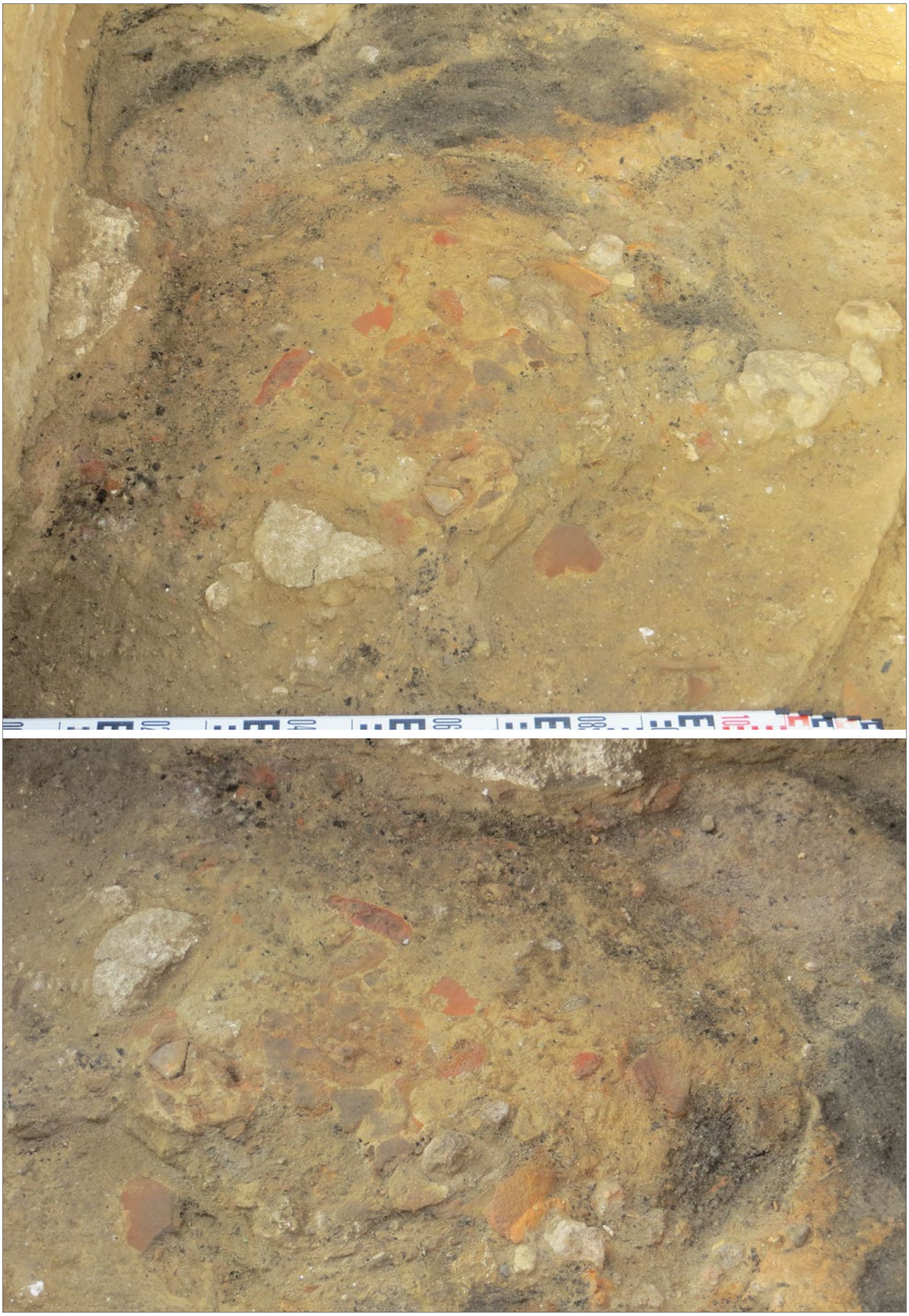


Fig. 2. Remains of a late Hellenistic metallurgical furnace: top, general view looking west; bottom, details of the structure looking south; note fragmentary gypsum blocks, which could be part of a stony base (Berenike Project | photo J. Oller Guzmán)

described correspond to a typical small furnace of the period: stony base, walls built of hardened clay and a small flue at the top for gases produced during combustion to escape (Domergue 2008: 172–173).[2]

Abundant deposits of ash and charcoal around the remains of the furnace [*Fig. 2*], and a remarkable quantity of slag and fragments of crucibles suggest the existence of a small metallurgical reduction furnace, which is operated during early stages of the metallurgical process when mineral combustion melts a specific metal. The process is very simple: a certain amount of ore mixed with fuel (usually charcoal) is introduced into the furnace chamber and ignited. The rising temperature gradually melts the mineral, separating the coveted metal from the sterile mineral part or gangue, which becomes slag in effect (Craddock 1995: 157ff.). To raise the temperature, a tuyère or pipe ensuring air flow is essential to increase the presence of oxygen needed to regulate the temperature, but no such tuyère has been identified in the material so far. Once the two substances have been separated, the metallic part is collected, whereas the slag is removed using various methods and techniques. The most common way is to have a small receptacle at the bottom of the furnace for the liquid slag to collect in and solidify after cooling. A more developed technique involves making a small exit hole at the bottom of the furnace wall, allowing the liquid slag gathering at the bottom of the chamber to flow out and solidify. The Berenike furnace rather did not have the exit-hole solution, because the slag flowing from such an aperture takes on various shapes reproducing its movement out of the furnace, namely, droplets and stringy forms collecting on the ground around the furnace (Rovira and Renzi 2010: 116). The slag from Trench BE-102, however, is typical "furnace slag", characterized by compact blocks that reproduce the hemispherical shape of the furnace floor on which they were formed (Rovira and Renzi 2010: 116) [*Fig. 3*].

CRUCIBLES

In the case of the Berenike furnace, finds of crucibles were apart from the slag remains, the source of information on what type of ore that could be reduced in this installation. Crucibles are vessels made of a refractory material, clay as a rule, used to collect material melted at high temperature. In ancient times, they were used either to collect liquid metal, to remelt different metallic items or to make alloys (Renzi 2010: 125). In this regard, it is important to distinguish the foundry crucibles, used to cast the liquid metal into moulds, from the so-called "oven-vessels", used for performing ore reduction. In the latter case, crushed metal (and whatever else is required by the recipe in the batch) is placed in a ceramic container and covered by charcoal, and this is loaded into the furnace. Several studies have sought to differentiate archaeologically between these two types of crucibles, focusing on their size, wall thickness, shape and pottery characteristics, etc. However, the extreme heterogeneity of this vessel category does not lend itself to establishing any definitive criteria of differentiation

2 In the case of the well-known copper smelting site of Agia Varvara/Almyras in Cyprus, the common dimensions assumed by researchers for furnaces associated with copper smelting, from the Archaic to the Hellenistic periods, were about 0.80 m high and 0.30–0.40 m in diameter (Fasnacht 2001: 130).

(Bayley and Rehren 2007; Renzi 2010: 135–137). Nevertheless, the fragmentary objects recovered from Trench BE-102 are more likely to be foundry crucibles based on their whereabouts near the furnace [*Fig. 4*].

FERROUS SLAG

Practically all of the slag residues inside these fragmentary crucibles turned out to originate from copper ore. Therefore, this particular furnace appears to have been intended for copper production.[3] Six drops of copper found in locus *048*, which is linked to the last operation of the furnace, points irrefutably to copper ore reduction. The liquid metal would subsequently be poured into the crucibles for further work.

Slag remains were also recorded in abundance in all the levels associated with the furnace, this being predominantly ferrous slag.[4] Many of these lumps

Fig. 3. Ferrous slag recovered from trench BE-102, including some of the typical "furnace slag" of hemispherical shape (Berenike Project | photo J. Oller Guzmán)

3 Copper production is one of the most ancient metallurgical activities documented in Egypt with evidence that can be taken back to 7000 BC (El Bassyouni and Moustafa 1994: 194). Even in the Eastern Desert this evidence can be traced at least to the Predynastic period with the example of the settlement in Wadi Dara, dedicated to the exploitation of copper ore (Castel, Mathieu, and Pouit 1997; Rothenberg et al. 1998: 4).

4 Based on data provided by Berenike Project team member and metal specialist Martin Hense, the total amount of slag recovered is 5200 cm^3 from the lower levels, 60% of this concentrated within the remains of the furnace.

retained a hemispherical shape, about 7–10 cm in diameter, resulting from the morphology of the furnace floor. It is not a problem that ferrous slag accompanies copper reduction because in the case of both copper and iron ore reduction the slag produced is characterized by the presence of both metals.[5] Therefore, a higher percentage of ferrous slag in the assemblage does not necessarily imply use of the furnace for iron reduction, but the crucibles and copper drops are a sure indication of a copper reduction process taking place. The presence of ferrous slag suggests the possibility of some iron ore reduction in this facility, but it would have been rather small-scale and time-consuming considering the rather small quantities involved. Iron production of substance would have produced a much larger quantity of slag discarded around the furnace.

METALLURGICAL FACILITY IN THE HARBOR – SUMMING UP

In conclusion, there seems to have been a small point of metallurgical production in this part of Berenike's southern harbor during the late Hellenistic period, that is, in the late 1st century BCE. The finds include a reduction furnace of copper ore and perhaps, to a lesser extent, iron ore. The interest of this discovery lies in the fact that in Berenike it appears to be the oldest metallurgical production area documented in an archaeological context,

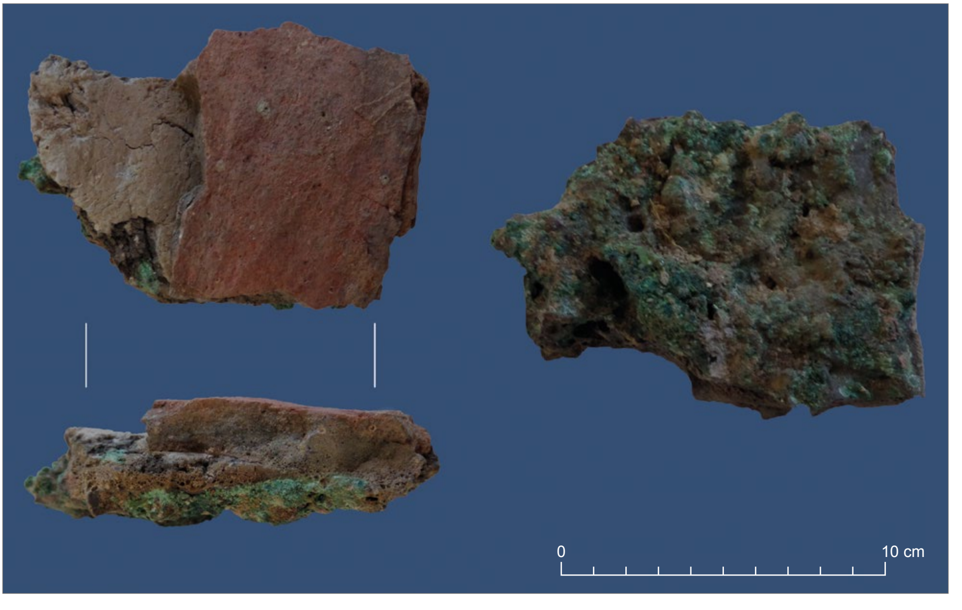


Fig. 4. Evidence of ore reduction found near the furnace: left, fragments of a crucible; right, remains of ferrous slag (Berenike Project | photos M. Hense)

5 This has indeed provoked a lively discussion among archaeologists regarding the beginning of iron metallurgy in several Mediterranean regions, because distinguishing between copper and iron reduction becomes quite complicated based solely on remains of furnaces and the slag produced during the reduction process (Fasnacht and Senn 2001: 132–133).

which evidently did not continue past the end of the 1st century BCE. It is obviously very difficult to extrapolate data about this production, nor establish its scale at this point. Remains of slag and crucibles similar to those from the furnace were found in overlying early Roman layers, which could suggest a continuity of metallurgical activities in this zone in Roman times, implying merely a different location for the actual production area in later times.

EVIDENCE FOR METALLURGICAL PRODUCTION IN BERENIKE

Metallurgical production in Berenike has been evidenced since the beginning of the excavations on site by finds of slag and crucibles related to copper and iron reduction (Hense 1995: 57). Most of these discoveries came from either surface finds or archaeological trenches, out of context or in Roman levels (Hense 1996: 225–226; Hense 1998). The clearest evidence of metallurgical activity in the city during the Ptolemaic period comes from trench BE00-40, which was excavated in the 1999/2000 season. Located in the western part of the site (some 80 m west of the embayment ridge where Trench BE-102 is located), the trench yielded several elements related to metallurgy: ferrous slag, charcoal, copper-alloy fragments, burned stone, pieces of lead, an ash deposit, a bloom fragment and a set of hearths worked apparently in the 2nd century BCE. The presence of lead documented in relation to the hearths suggested to the excavators an industrial form of the smelting of this metal, because the melting temperature of lead is very low and reduction can be achieved even using small hearths. The association, of course, is producing lead for ship repairs—feasible and in fact in high demand in a maritime harbor. However, no furnaces or copper slag were recovered from this trench (Sidebotham 2007: 37–44). Filling the picture is the discovery of some 95 kg in all of archaeological lead in trench BE00-36 located just 50 m north of trench BE00-40. Although no structure related to lead-smelting was uncovered in this trench, it seems clear that facilities for this type of activity had to be located nearby in this area, confirming lead-working in this part of the Ptolemaic town (Sidebotham 2007: 36–37).

The recovery of numerous copper elements from previously excavated Ptolemaic contexts on site have always implied the possibility of a local copper production, which however had not been archaeologically attested until now.

Other evidence that helps to contextualize this find are the copper deposits known to exist in the environs of Berenike, for instance, at Um Sukati. This site, located some 80 km northwest of Berenike, may have been one of the main sources of copper ore brought to the town in ancient times and, in fact, some extensive ancient mining works have been detected there (Hense 1995: 57; Botros 2003: 228). The presence of ancient settlements processing and smelting copper ore during the Ptolemaic period in the Egyptian Eastern Desert is well known thanks to sites like Abu Gerida, with mining shafts, copper slag and crucibles in an area geologically characterized by the existence of copper minerals (Abd el-Rahman et al. 2013: 13–15).

EARLY ROMAN PHASE

The early Roman phase in this trench is characterized by the absence of any kind of structure whatsoever. There is instead a sequence of several overlapping walking levels with various features, alternating-with apparently short episodes of abandonment or refurbishment.

OPEN SPACE

The walking levels show some compaction of the surfaces, indicating that they could have served as a passage between the different parts of the embayment [*Fig. 5*]. The most interesting and best preserved example is perhaps locus *063*, a surface made of a layer of gravel and small pebbles poured with mortar, reaching up to 10 cm in thickness [*Fig. 6*]. A block of local gypsum stone represents the sole documented evidence of a possible structure in the early Roman levels [see *Fig. 6*].

The absence of structures and the presence of several walking surfaces suggest that this was during the 1st century CE an open area with free circulation of people and goods. Considered in connection with the compacted surface from nearby trench BE09-55, which also seems to have been located in an open area (see Sidebotham and Zych 2011: 44, 48), the situation in trench BE14/15-102 helps to bring coherence to this part of the harbor in the early Roman phase.

SAND LEVELS

Another set of archaeological features that connect the two trenches are the large sand deposits crossing the trench transversely. They follow the downslope in the direction of the lagoon (generally southeast) and have yielded plentiful material in similarity to similar deposits from trench BE09-55. These sandy levels are clear evi-

Fig. 5. South baulk of the trench; note the different layers with walking surfaces (Berenike Project | photo J. Oller Guzmán)

Fig. 6. Walking level from the early Roman phase (locus *063*); arrow indicates gypsum stone in the baulk which could be the sole remnant of a structure from this phase (Berenike Project | photo J. Oller Guzmán)

Fig. 7. Sandy levels breaking through the different archaeological layers in the south baulk of the trench (Berenike Project | photo J. Oller Guzmán)

dence of natural phenomena causing heavy erosion in the area of the southern harbor. The data available being so limited, it is difficult to point to specific circumstances of climate change that could have effected these deposits, but it is clear from the homogeneous structure of these deposits that they had a natural origin.

Such episodes of perhaps natural disasters (for example, flash floods which are known to occur in this region in the winter seasons after heavy rainfall in the Eastern Desert mountains) imply a subsequent reconditioning of the affected areas. There is also other evidence testifying to the abandonment of this area, e.g., a deep hole, probably manmade, filled with clean sand in the northern part of the trench.

Interestingly, these levels have yielded an excess of artifactual material: pottery, building materials, metal elements, faunal remains, etc. The finds include also objects of elite status, such as imported terra sigillata vessels, a lamp decorated with erotic motifs, a small alabastron. The most remarkable find without doubt are small finely carved intaglios. The green chalcedony gemma bears a representation of a male figure riding a horse, a whip in his hand; the horse raises one of its forelegs [*Fig. 8* bottom]. The red carnelian gemma shows a robed female figure, standing, identifiable as a divinity, perhaps Demeter/Ceres or Fortuna [see *Fig. 8* above].

Fig. 8. Intagli from trench BE14/15-102: above, image of a robed female figure, carnelian (BE14-102/039/001); bottom, image of a horse rider, green chalcedony, with modern stamped impression on the right (BE14-102/005/001) (figures not to scale) (Berenike Project | photos S.E. Sidebotham)

The intaglios represent a category of small semiprecious gemstones that in antiquity were usually set in rings, often being used as personal seals (Casal Garcia 2002: 23–24). Both the material and the fine execution, requiring mastery of the gem-cutting craft, are a clear sign of luxury and therefore linked exclusively to the upper echelons of society. Both are dated to the second half of the 1st century BCE, a period associated with a growing trend of classicism in iconography coupled with a greater popularity of this type of ornament (Higgins 1980: 174; Lopez de la Orden 1990: 48).

Fine artifacts of this kind, found in deposition layers linked to some form of natural disaster, in this trench and the nearby trench BE09-55, which suggests a common source of these objects, can be linked to the house furnishing of the wealthy elites of Berenike. It remains to be seen where this material could have come from, whether from a destroyed structure or from some kind of rubbish dump formed more or less northwest of the two trenches, most likely on top of the embayment, which would have otherwise stopped all heavier material carried by the waterflow involved in the creation of these sandy levels.

Summing up, in early Roman times the site of metallurgical production from the late Hellenistic period was used as an open area with freely circulating people of presumably all professions to be expected in a harbor: traders, merchants, craftsmen, sailors, etc. Habitations of some kind, although not found directly in the trench, could have been located nearby. Moreover, the remnants of crucibles and slag found in early Roman contexts are surely proof that metallurgical production here had not ceased completely.

In turn, the objects apparently washed in with the sand deposits, which could reflect destructive flash flooding, are clear enough proof of the existence of wealthy households somewhere in the vicinity.

It seems quite unlikely that the area continued to be occupied beyond the 1st century CE or the first half of the 2nd century CE as indicated by finds from trench BE09-55 (Sidebotham and Zych 2011: 43–51), a chronological determination suggested also by excavations in other parts of the southwestern embayment (I. Zych, personal communication), indicating that after this time the harbor function was moved away from this part of the site.

CONCLUSIONS

To conclude, even though still unfinished, the excavation of trench BE-102 has yielded results that, combined with the findings from the previously excavated trench BE09-55, shed light on the functioning of the southern harbor of Berenike in the late Hellenistic and early Roman periods.

Foremost, the area has been proven to be a small metallurgical center on site, consistent with metallurgical activity known to have taken place west of the embayment, producing copper, lead and perhaps also iron, presumably for the needs of a funtioning harbor with its related functions of ship maintenance and repairs. The scale of this production cannot yet be determined, but its documentation even in this preliminary form is crucial to understanding the development of this part of the site.

Metallurgy apparently continued to be practiced in this part of the southwestern embayment even though the late Hellenistic furnace ceased to exist. The space inside the trench was evidently an open area, with people freely circulating in it. The continuity of production-related activities in this part of the embayment, especially in the last quarter of the 1st century CE, is thus confirmed.

The excavation has also confirmed what the findings from trench BE09-55 had already hinted at: episodes of some form of a natural phenomenon (possibly flash floods in the rainy season), responsible for washing in with the sand objects representing the wealthy Berenike elites. While the artifacts paint a picture of a luxurious existence with access to luxury items, their somewhat extraordinary findspot raises questions about urban planning in the southwestern part of the town.

Joan Oller Guzmán
https://orcid.org/0000-0001-5002-4914
Universitat Autònoma de Barcelona
joan.oller@uab.cat

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