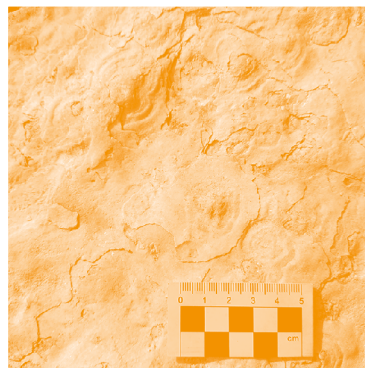


Analysis of the stone dressing technology used on anhydritic-gypsum building blocks discovered in the Blemmyan Necropolis at Berenike



Abstract: The Tool Marks Pattern Analysis method was applied to describe and analyze the stone dressing technology used in the production process of anhydrite stone blocks uncovered in the Blemmyan Necropolis and the Hellenistic-Roman Isis Temple precinct at Berenike. Based on the numerous diagnostic stone blocks collected during the 2023 and 2024 excavation seasons in the necropolis, it was possible to reconstruct their surface dressing process and compare it with parallel material found in the vicinity of the temple. The analyzed anhydrite blocks provide evidence of the stone blocks dressing technology used within three technological industries identified at the site, spanning the Hellenistic period, the Roman period, and Late Antiquity, when Berenike was conquered and inhabited by the nomadic Blemmyes from the Eastern Desert.

Keywords: Tool Marks Pattern Analysis, surface dressing, anhydrite blocks, technological industries, Hellenistic period, Roman period, Late Antiquity, Blemmyes

INTRODUCTION

Berenike, a Red Sea harbor located in Egypt's Eastern Desert [Fig. 1], was founded by Ptolemy II in the 3rd century BCE and has been excavated by the American-Dutch-Polish teams since 1994 (Wendrich et al. 2003; Sidebotham 2011; Sidebotham and Zych 2011; Zych 2017).

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Research conducted to date on the town's history—from its founding through the Roman Period—has revealed that Berenike was a harbor of international importance, benefiting primarily from long-distance trade with regions including the Mediterranean, Africa, Arabia, and India (Tomber 2008; Sidebotham 2011: 69). The recent discovery of epigraphic evidence indicates the presence of Eastern Desert nomads known as the Blemmyes in Berenike during Late Antiquity (Ast and Rądkowska 2020), and the results of excavations at the northwest necropolis suggest that it served as the burial ground for local elites of that period (Then-Obłuska 2024: 251–252, 268; Gwiazda, Zych, and Smagur 2025).

Archaeological investigations at this necropolis (dating to the late 4th–5th century CE) [see Fig. 1] have identified

two distinct types of burials: chamber tombs (N1/1–5, N2/1–7) and numerous shaft burials (Gwiazda, Zych, and Smagur 2025). The former are rectangular in plan and feature a cult chamber built in the form of a mausoleum, with an entrance in the east-facing front wall and a burial chest along the rear wall [see below, Fig. 3:e, h]. The latter consist of two main components: a superstructure in the form of a mastaba, often equipped with a cult niche [see below, Fig. 3:b, f], and a substructure comprising a chest dug into the ground [see below, Fig. 3:a, c, d]. Both types of burials were constructed primarily from calcareous coral, but also incorporate roughly cut stones of various rock types. In the case of the shaft burials in particular, large anhydritic-gypsum stone slabs were used to construct burial chests and cult niches.



Fig. 1. Location of the Blemmyan Necropolis and the Isis Temple at Berenike (PCMA UW | plan M. Gwiazda, M. Łuba, M. Wikorzak, and S. Popławski)

Analysis of the stone building material recovered during the archaeological excavations conducted at the necropolis in 2023 and 2024, using the Tool Marks Pattern Analysis method (TMPA, see

below), provided a unique opportunity to understand and propose a detailed reconstruction of the anhydritic-gypsum block dressing technology employed by local stonemasons at the time.

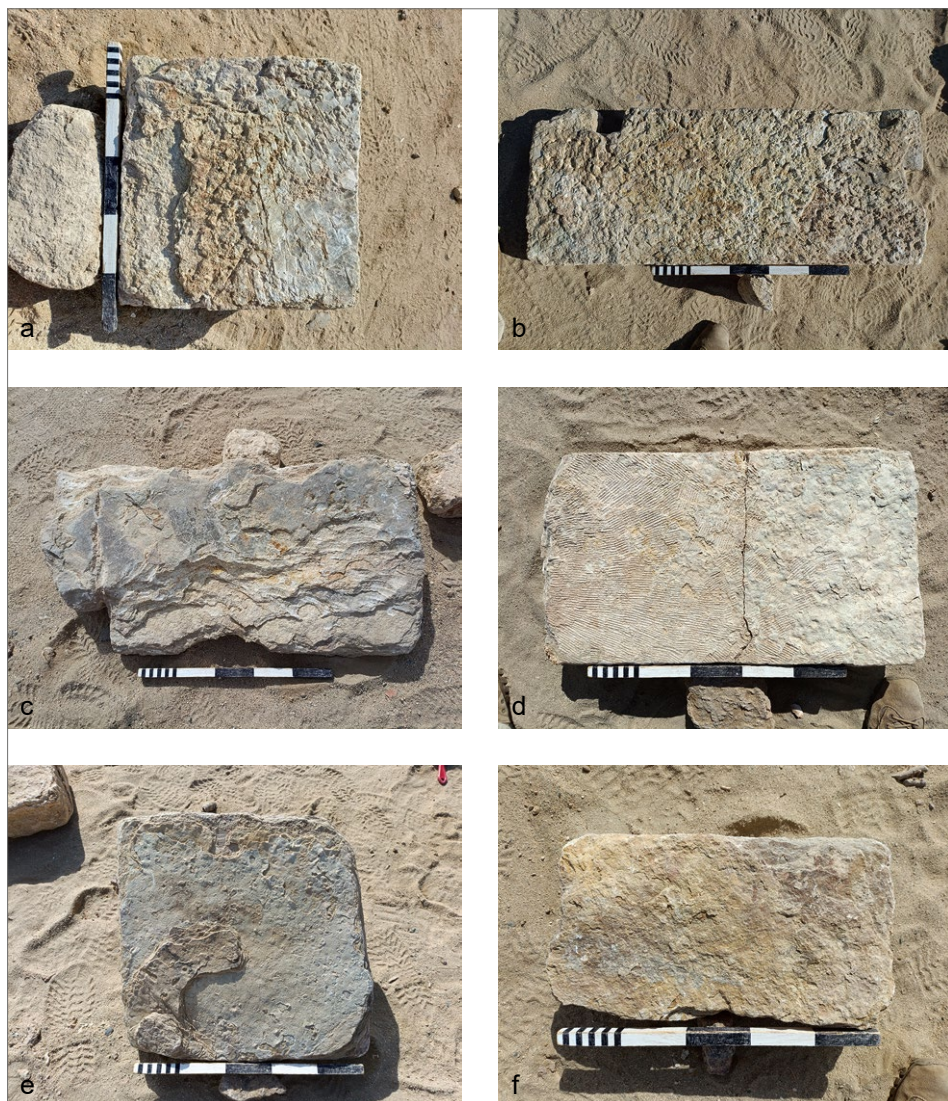


Fig. 2. Examples of examined anhydritic-gypsum blocks from the Blemmyan Necropolis: a, b – from loci 31 and 54, Trench BE24-173, Blocks 2 and 3; c – Trench BE23-160, Block 1; d – Locus 10, Trench BE24-158, Block 1; e, f – Locus 10, Trench BE24-158, Blocks 10 and 11; g – tomb in Trench BE24-175; h, i – blocks from the Isis Temple (PCMA UW | photos D.F. Wieczorek)

To enable such a description and to thoroughly analyze the newly recovered stone material, it was compared with blocks accessible in the block yard of the Hellenistic and Roman Temple of the Goddess Isis (approximately 1st century BCE–3rd century CE). The temple, located at the very center of the town and oriented along an east–west axis with its entrance



facing east, appears to be the largest — and likely the oldest— sanctuary in Benenike (Meredith 1957: 59–70; Hense 2017; Sidebotham et al. 2021: 17–19) [see Fig. 1]. Excavations to date have revealed that the temple complex comprised a walled forecourt, accessed through a main gateway, and the temple proper, featuring a pronaos and a central sanctuary flanked by rooms on both lateral sides. The temple was constructed using local anhydritic-gypsum blocks (Popławski et al. 2021: 387, 389, Fig. 1; Sidebotham et al. 2021: 22).

The dressed stone building material found at the site includes coral, anhydritic-gypsum, gypsum, and limestone blocks of various dimensions, all likely sourced from local quarries in the vicinity (Harrell 1996: 105–109; 1998: 121–131; Sidebotham et al. 2021: 21–22). In general, however, anhydritic-gypsum was primarily used for producing gypsum stone blocks for construction purposes. This material can be characterized as a hard, dense rock when freshly quarried; however, due to weathering, it becomes soft, powdery, and porous (Sidebotham et al. 2021: 22; Harrell 2024: 131–132, 365–367). Overall, it exhibits very poor resistance to atmospheric conditions and, consequently, tends to be in a generally poor state of preservation. In light of this, analysis of the material using the TMPA method proved exceptionally difficult to carry out.

DESCRIPTION OF THE MATERIAL

Two assemblages of stone material were examined. The primary research material comes from the Blemmyan Necropolis, while stone blocks from the Temple of

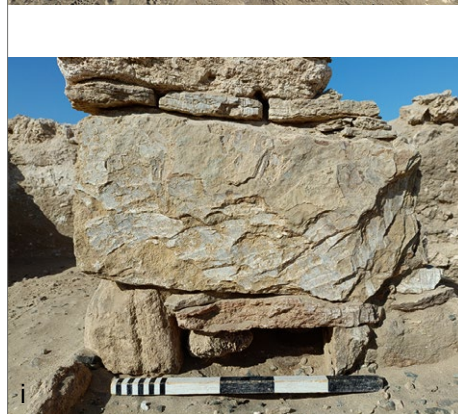
Isis were used as supplementary and comparative material.

In general, the stone material from the necropolis consists mainly of slabs of various sizes [Fig. 2:a–g]; however, they typically measure approximately 40 cm

× 55 cm × 12 cm. The same applies to the stone material from the temple, where the examined wall blocks measure about 22 cm × 42 cm × 38 cm and 20 cm × 60 cm × 36 cm [Fig. 2:h, i]. The slabs from the necropolis mostly originate from



Fig. 3. Stone slabs in sub- and superstructures of tombs in the Blemmyan Necropolis: a, b – shaft tomb in Trench BE24-165; c, d, f – Locus 10 in the Trench BE24-158; e, g – tomb in Trench BE24-175; h, i – tomb in Trench BE24-176 (PCMA UW | photos D.F. Wiczorek)



the substructures of shaft tombs and burial chambers, constructed in the form of chests, where they served as cladding [Fig. 3:a, c, e]. Others derive from the superstructures, forming architectural components of funerary niches [Fig. 3:f–i]. In some cases —though rarely— they also come from other architectural features, such as the interiors of chamber tombs.¹ The stone blocks from the temple [Fig. 3:h, i], although retrieved from the block yard located within the temple temenos, originally came from the temple's walls.

Out of several hundred slabs, blocks, and fragments recovered at the site, 27 diagnostic stone pieces were selected and analyzed: 25 from the necropolis [e.g. Fig. 4:a–g] and two from the temple [e.g. Fig. 5:h, i].

THE TOOL MARKS PATTERN ANALYSIS OF THE MATERIAL

The Tool Marks Pattern Analysis (TMPA) is an analytical method originally developed for the study of limestone building blocks. It was first applied to material dated to the 15th century BCE from the temples of Hatshepsut and Thutmose III at Deir el-Bahari in Egypt (Eighteenth Dynasty, New Kingdom).² The TMPA

- 1 For example, stone slabs were used as building material — either as part of a platform or offering altar identified in front of the grave chest in the tombs in Trenches BE24-158 and BE24-175 [Fig. 3:f, g], or as a structural element of the burial chest in the tomb in Trench BE24-176 [Fig. 3:h, i] (see also Gwiazda, Zych, and Smagur 2025).
- 2 This research is presented in the author's publication "Building Dipinti in the Temples of Hatshepsut and Thutmose III at Deir el-Bahari: Epigraphic and Technological Studies" (Wieczorek forthcoming a); see also the preliminary analysis of limestone building material from the 6th–7th century CE Church N₁ in Marea/Philoxenite (see Wieczorek forthcoming b).

method is based on the documentation and stratigraphic sequencing of various

types of tool marks —consisting of different forms of negatives³ and flake scars⁴— as

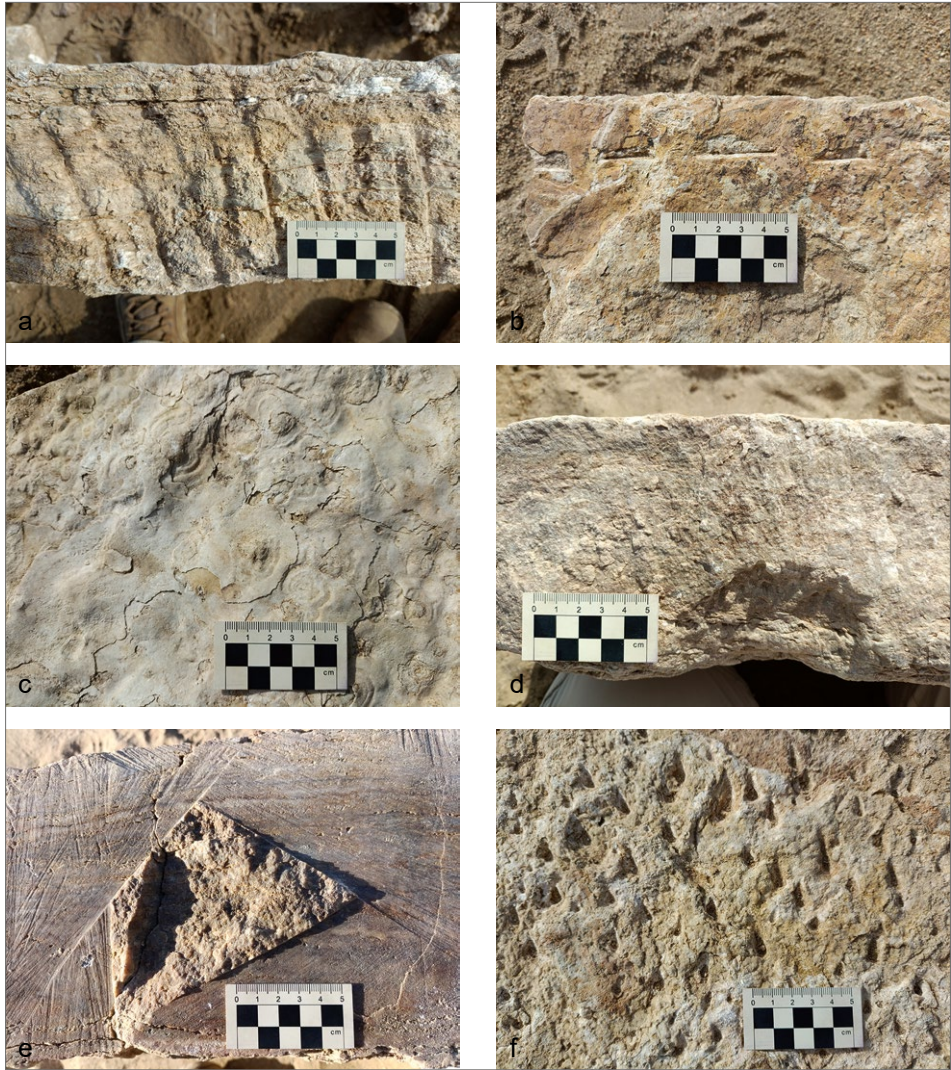
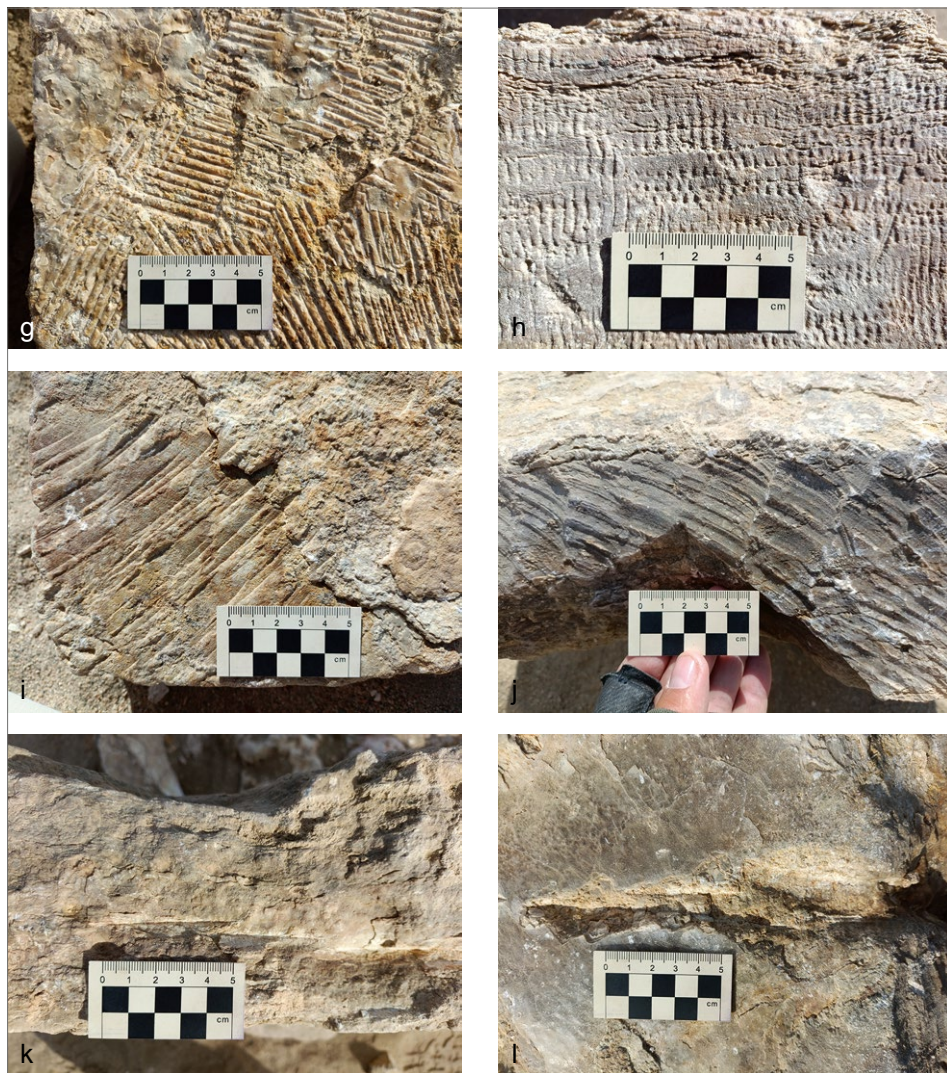


Fig. 4. Tool marks (negatives and flake scar types) recorded on stone material from the Blemmyan Necropolis: a – Neg. 3 mm: l (Trench BE24-173, Block 2, Face c); b – Neg. 20 mm: c (Trench BE24-173, Block 5, Face T); c – Neg. S (Trench BE24-165, Block 1, Face B); d – Neg. 3 mm: sl (Trench BE24-158, Block 5, Face B); e – Neg. Sw (Trench BE24-173, Block 6, Face c); f – Neg. 3 mm: s (Trench BE24-173,

- 3 The term “negative” should be understood as direct evidence of the use of a given tool, preserved in the form of an impression of its working edge on the dressed surface.
- 4 In the literature, it is also, though less commonly, referred to as a fracture detachment scar, describing the concavity left on the fracture propagation surface after the detachment of a flake (Shea 2020: 15).

well as associated deposits⁵ observed on the surfaces of all six faces of a stone block. This approach enables the reconstruction of the technological-production process of a given assemblage of

building blocks, divided into distinct phases. Based on the collected data, the morpho-technological features of the analyzed assemblage are distinguished and described, the types of tools used



Block 3, Face T); g – Neg. 40 mm (:9) ind (Trench BE24-158, Block 1, Face T); h – Neg. 40 mm (:12) ind (Trench BE24-173, Block 6, Face d); i – Neg. 40 mm: f (Trench BE21-44, Block 2, Face T); j – Neg. 40–50 mm: f (Trench BE24-158, Block 9, Face d); k – Neg. 40 mm: sp (Trench BE23-160, Block 1, Face a); l – Neg. 40 mm: c (Trench BE23-160, Block 1, Face T) (PCMA UW | photos D.F. Wiczorek)

⁵ In this case study, the term “deposit” refers to mortar preserved on the surface of the stone blocks.

during production are identified, and, through the comparison of block assemblages from different sites and time periods, features characteristic of specific historical phases can be determined and arranged in chronological sequence.

The analysis of the diagnostic stone material at Berenike revealed evidence falling into two primary categories: tool marks and deposits. For the building stone material from the necropolis (NM), this evidence is presented in *Table 1*; for the temple (TM), in *Table 2*.

The majority of the collected evidence consists of various types of tool marks, namely different forms of negatives and flake scars. These were created by the detachment of flakes using a range of tools during the technological-production process of the anhydritic-gypsum blocks — and, in some cases, much later, as a result of secondary dressing or post-depositional processes.⁶ In contrast, deposits such as mortar are significantly less frequently attested.

Table 1. Blemmyan Necropolis (NM) – surface dressing processes of anhydritic-gypsum building blocks

Phase	Operation stage	Category of evidence				
		Tool marks			Deposits	
		Negatives	Flake scar			
I	A	Neg. 3 mm	l	linear	—	
	1 B1 Quarrying	Neg. 20 mm	c	cutting		
		B2	Neg. S	S	split	
	2	A1	Neg. 3 mm	sl	shelly-linear	
		A2	Neg. S	S	split	
		B1 Initial dressing	Neg. Sw	Sw	saw	
B2			Neg. S	S	split	
3	Preparation dressing	Neg. 3 mm	s	shelly		
II	4 A Flattening dressing	Neg. 40 mm (:9-12)	ind	indented		
		B	Neg. 40-50 mm	f	flat	
	5	Setting	—			Dep. M M mortar
III	6 A Secondary dressing	Neg. 40-50 mm	f	flat	—	
		B	Neg. 40-50 mm	sp	splitting	
	C	Neg. 40-50 mm	c	cutting		
	7	Post-depositional processes	Damage	PD	damage	

6 Post-depositional damage will not be discussed in detail here, as it does not constitute direct evidence of the technology used in the production of the limestone building blocks.

Table 2. Isis Temple (TM) – surface dressing processes of anhydritic-gypsum building blocks

Phase	Operation stage		Category of evidence				
			Tool marks			Deposits	
			Negatives	Flake scar			
I	1	A*	Neg. 3 mm*	l*	linear*		
		B1	Quarrying	Neg. 3 mm	sl	shelly-linear	
		B2		Neg. S	S	split	
	2	Initial dressing	Neg. 10 mm	l	linear	*	
	3	Preparation dressing	Neg. 25–35 mm	sl	shelly-linear		
II	4 ₁	Flattening dressing	Neg. 30–40 mm	f	flat		
	5	A*	Setting	Neg. Sw*	Sw*	thick scratched*	
		B		–		Dep. M M mortar	
III	4 ₂	Flattening dressing	Neg. 30–40 mm	f	flat		
	6	Cutting cramp slot	Neg. 25 mm	sl	shelly-linear		
IV	4 ₃	Flattening dressing	Neg. 30–40 mm	f	flat		
	7	Planing dressing	Neg. Sm	Sm	thin scratched		
V	8	Relief decoration	RD	RD	relief decoration		
	9		ReU*	ReU	recarving		
VI	10	Post-depositional processes	Damage	PD	damage		

* – Hypothetical/reconstructed presence of a negative or flake scar within a given Phase and Operation stage.

As for the building stone material found in the Blemmyan Necropolis, the categories of evidence related to its dressing technology can be characterized as follows:

With regard to tool marks, five different types of negatives corresponding to the widths of the working edges of the tools were identified: 3 mm, 20 mm, 40 mm (with 9–12 teeth), 40–50 mm, and saw marks (Neg. 3, 20, 40 (:9–12 teeth), 40–50 mm, and Sw), indicating the use of various tool types [Fig. 4:a–l; Table 1].

Moreover, analysis of the tool marks allows for the distinction of nine different types of flake scars, each with characteristic morphologies:

linear (l) — deep and long descending gutter, tilted to the left, ending in a negative [Fig. 4:a];

cutting (c) — wide flake scar corresponding to the chisel's working edge, made vertically, spaced at 1.5 cm intervals [Fig. 4:b];

split (S) — almost completely flat, formed as a result of splitting [Fig. 4:c];

shelly (s) — shelly in form and deep, with an elongated, descending gutter ending in a negative [Fig. 4:f];

shelly-linear (sl) — shelly in form and deep, with a long, descending gutter ending in a negative [Fig. 4:d];

saw (Sw) — flake scars consisting of very numerous tiny scratches [Fig. 4:e];

indented (ind) — wide flake scar corresponding to the tool's working edge, completely covered by long grooves left by 9 or 12 teeth, ending in a negative [Fig. 4:g, h];

flat (f) — wide flake scar corresponding to the chisel's working edge, usually short and shallow in gutter, ascending and starting with a negative [Fig. 4:i, j];
splitting (sp) — wide flake scar corre-

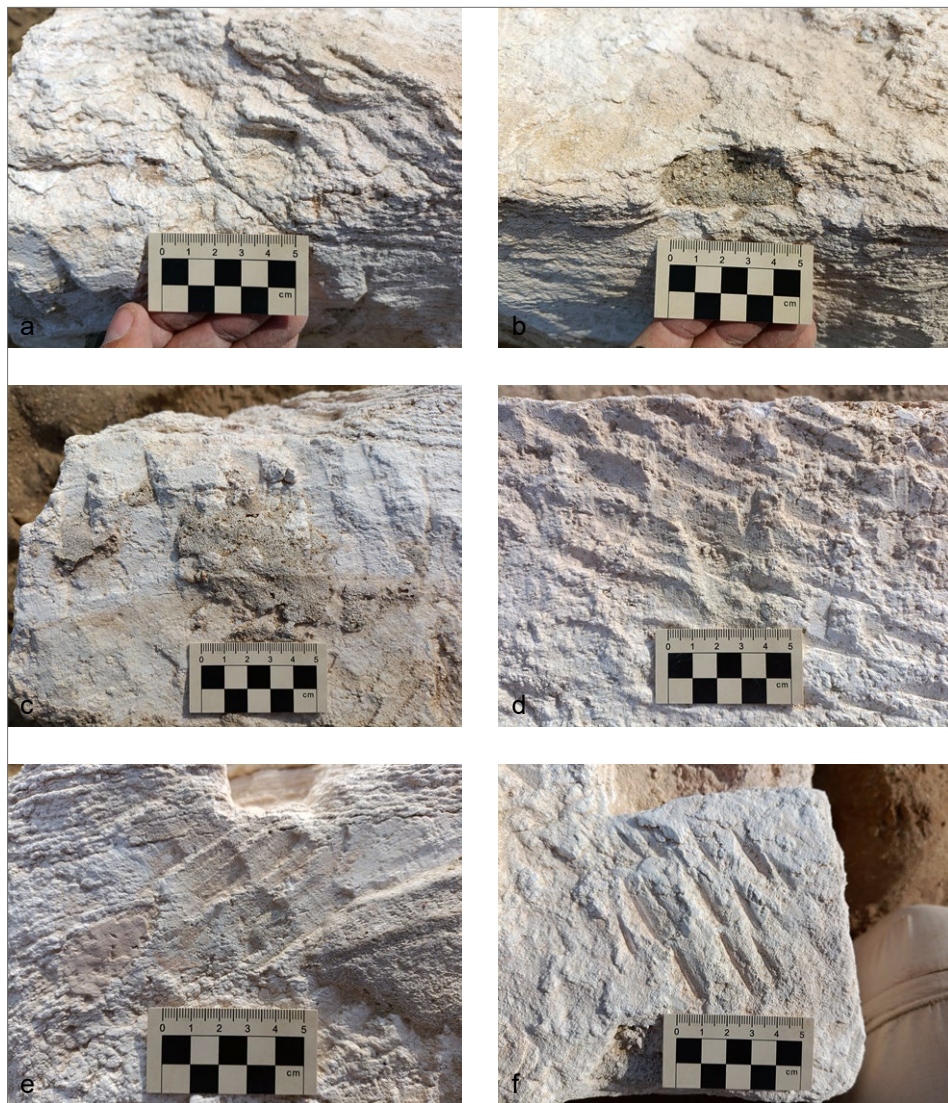


Fig. 5. Tool marks (negatives and flake scar types) recorded on stone material from the Isis Temple: a – Neg. 3 mm: sl (Block 2, Face c|T); b – Neg. 3 mm: S (Block 2, Face c|T); c – Neg. 10 mm: l (Block 2, Face c); d – Neg. 25 mm: sl (Block 1, Face b); e – Neg. 30–40 mm: f (Block 2, Face b); f – Neg. 30–40mm: f (Block 2, Face T); g – Neg. 25 mm: sl (Block 2, Face T); h – Neg. 40 mm: f (Block 1, Face a); i – M (Block 2, Face d) (Photos D.F. Wiczorek)

sponding to the tool's working edge, with short gutter arranged in a line and interscar ridges touching or overlapping [Fig. 4:k, l; see Table 1].

Only one type of deposit was identified (Dep. M), namely mortar (M) [see Table 1].

In the case of the building stone material originating from the Isis Temple,



the categories of evidence related to its dressing technology can be presented as follows:

Regarding tool marks, six types of negatives corresponding to the widths of the tools used were recorded, ranging from 3 mm, 10 mm, 25–35 mm to 30–40 mm (Neg. 3, 10, 25, 30, 35, 40 mm), indicating the use of various tool types [Fig. 5:a–i; Table 2].

In addition, within the tool marks, four distinct types of flake scars with characteristic morphologies were identified:

linear (l) — deep, straight, forming a long, descending gutter ending in a negative [Fig. 5:c];

shelly-linear (sl) — shelly in form and deep, usually with a long, descending gutter ending in a negative [Fig. 5:a, d, g];

split (S) — almost completely flat, formed as a result of splitting [Fig. 5:b; see Fig. 4:c];

flat (f) — flake scars corresponding to the chisel's working edge, usually short and shallow in gutter, ascending and starting with a negative [Fig. 5:e, f, h].

Only one type of deposit was identified (Dep. M), namely mortar (M) [Fig. 5:i; see Table 2].

IDENTIFICATION OF THE TOOLS USED

The vast majority of the identified tool marks (negatives combined with flake scars) provide unequivocal evidence of the so-called reduction technique, in which numerous flakes were detached during the technological-production process of shaping anhydritic-gypsum blocks (see Tables 1, 2: tool marks).



Fig. 6. Modern Egyptian toothed adze (*shahuta*), in use by stonecutter Sabr Ibrahim Hussein at Deir el-Bahari, 24.11.2024 (PCMA UW | photos D.F. Wiczorek)

Based on their characteristic morphology and strike direction—and, above all, when compared with the current state of knowledge concerning ancient soft stone dressing technologies—the observed tool marks can be interpreted as evidence for the use of metal tools in both block extraction and surface preparation (see generally Wright 2000; 2005a: 33–39, 43–56; 2009: 140–227; Fant 2008).⁷

Tool marks such as Neg. 4 mm: l (NM) likely resulted from the use of metal picks, or, in the case of Neg. 3 mm: l (NM), a metal adze-pick—both employed during the excavation of separation trenches immediately prior to the extraction of a stone block (Ginouvé and Martin 1985: 69–70, Pl. 6:5, 10; Wright 2005b: Figs 67, 88:a).

Similarly, traces such as Neg. 3 mm: s, 10 mm: l, 25–35 mm: sl (TM), and Neg. 20 mm: sp (NM), as well as 40–50 mm: sp, c (NM), may be attributed to a variety of pointed or flat metal chisels driven with wooden mallets (Ginouvé and Martin 1985: 71–72, Pl. 6:3, 6–8; Harrell 1998: 138–139, Pls 4–10; 2024: 74–77; Wright 2005b: Fig. 90:2).⁸

Surface-flattening marks—Neg. 40 mm: ind (NM)—consist of numerous narrow, elongated, and parallel scratches on the stone surface, clearly grouped in

7 For a general discussion of stone-dressing techniques in Egypt, see Clarke and Engelbach 1930: 5–22, 96–116; Arnold 1991: 41–47; Aston, Harrell, and Shaw 2000; Goyon et al. 2004; Wright 2009: 145–154, 164, 166; Harrell and Storemyr 2013: 21–26; Stocks 2023; Harrell 2024: 74–107. On Ptolemaic examples, see Röder 1965: 523; Arnold 1991: *passim*; Goyon et al. 2004: *passim*; Wright 2009: 151–156, 160–163, 167–168; Harrell and Storemyr 2013: 26–42; Laroze and Garric 2013; Stocks 2023: 67 and *passim*. For evidence from Roman times, see Orlandos 1968: 45–184; Bessac 1988: 47–52; Fant 2008; cf. Harrell and Storemyr 2013: 26–42; Wright 2009: 152–153, 155; Wootton, Russell, and Rockwell 2013: 1–10.

8 The use of chisels and mallets is well attested in both the archaeological and iconographic records for the Pharaonic and Ptolemaic periods (see, e.g. Arnold 1991: 264–265, Figs 6.7, 6.18, 6.19; Wright 2000: 64; Harrell and Storemyr 2013: 21–22, Figs 2, 3; Harrell 2024: 74–75, Figs 5.1, 5.2).

sets of 9 or 12. These were created using a claw or toothed tool, such as a claw chisel or a toothed adze resembling the modern Egyptian tool known as *shahuta* (for the claw chisel, see Ginouvès and Martin 1985: 72, Pl. 6:4; Harrell 1998: 139, Pls 4–10; Wright 2005b: Fig. 90:3; for the adze, cf. Orlandos 1968: 52, Fig. 41) [Fig. 6].

Finally, Neg. Sw (NM), a 2 mm-thick mark, can be unequivocally identified as the result of using a metal saw to cut

stone blocks into smaller pieces (Ginouvès and Martin 1985: 73; Bessac 1988: 45–46, Fig. 6; Arnold 1991: 266–267, Fig. 6.22; Laroze and Garric 2013).

The minority category of evidence consists of deposits (see *Tables 1, 2*: Dep. M), represented exclusively by mortar (M): a white limestone mortar mixed with various inclusions (Lucas and Harris 1962: 75; Goyon et al. 2004: 70; Harrell 2024: 132), used as a binding agent for the stone blocks.

STONE BLOCK SURFACE DRESSING PROCESS

Based on the recorded stratigraphic sequence of tool marks and deposits identified on the surfaces of diagnostic anhydritic-gypsum blocks—both at the Blemmyan Necropolis and in the Isis Temple—it was possible to reconstruct two distinct surface dressing processes. For the blocks uncovered at the Blemmyan Necropolis, six stages of the surface dressing process, used during the general technological-production procedure, can be identified. For the blocks from the Isis Temple, as many as eight stages were observed in a parallel process. Furthermore, the individual stages in both sequences can be grouped into three and five broader phases (Phases I–V), respectively. Phase III (NM) and Phase VI (TM) correspond to post-depositional processes.

SURFACE DRESSING PROCESS OF THE BUILDING STONE BLOCKS FROM THE BLEMMYAN NECROPOLIS

Phase I: raw material acquisition

This phase includes two stages of the surface dressing process and comprises four

technological (tech.) actions: 1:A, B1–2; and 2:A1–2, B1–2.

Stage 1 – quarrying

Directly linked to raw material acquisition, this stage involved the use of sharp picks to cut separation trenches, leaving characteristic linear flake scars on the stone surface (Neg. 3 mm: l) (tech. action 1:A) [see Fig. 4:a]. Additionally, at least one relatively flat split surface was created on a block during its extraction from the bedrock, either using the same tool or by subsequent cutting with a flat chisel (Neg. 20 mm: c; Neg. 3 mm: S) (tech. action 1:B1–2) [see Fig. 4:c];

Stage 2 – initial dressing

This stage involved the initial trimming and fragmentation of a large chunk of raw material, including the carving of wedge sockets to split the chunk. A sharp, pointed metal chisel (Neg. 3 mm: sl) (tech. action 2:A1–2) [see Fig. 4:d] and a saw (Neg. Sw) (tech. action 2:B1–2) were used, leaving large, relatively flat split surfaces on the stone block [see Fig. 4:e].

Phase II: formation of the stone block

This phase comprises the next three recorded stages and four technological actions: 3, 4:A–B, and 5.

Stage 3 – preparation dressing

At this stage, the roughly cut stone chunk was trimmed into a block of the desired shape and dimensions using a sharp, pointed metal adze-pick (Neg. 3 mm: s) (tech. action 3) [see *Fig. 4:f*];

Stage 4 – flattening dressing

This involved trimming the rough and uneven surfaces of the block to make them flat. The final surface preparation could take two forms: trimming with a metal toothed adze (Neg. 40 mm [9–12 teeth]) (tech. action 4:A) [*Fig. 4:g, h*; see *Fig. 6*]; or, if needed, trimming with a flat metal adze (Neg. 40–50 mm: f) (tech. action 4:B) [*Fig. 4:i*]. It should be noted, however, that most of the building blocks uncovered during excavation were never properly flattened;

Stage 5 – setting

This final stage involved placing the stone blocks in the masonry structure, where they were bonded using mortar (Dep. M), frequently applied to the upper surfaces. Interestingly, there is no evidence of the usual final dressing of the outer faces of the blocks visible in the masonry, which would have rendered them flat and smooth.

Phase III: post-depositional processes

This phase describes all damage (PD) observed on the surfaces of the blocks

— these are secondary in nature, whether of anthropogenic or natural origin. Although generally not directly relevant to the original surface dressing process, in this case the evidence appears exceptionally important for understanding both the history of the material and the site. It is likely associated with secondary dressing.

Thus, within Phase III, one operational stage and three technological actions—resulting in later post-depositional damage— can be identified:

Stage 6 – secondary dressing

This stage is associated with the reuse or adaptation of previously worked stone material. It involved three technological actions using flat metal chisels (tech. actions 6:A–C): trimming (Neg. 40–50 mm: f) [*Fig. 4:j*], splitting larger blocks (Neg. 40–50 mm: sp) [*Fig. 4:k*], and/or cutting them (Neg. 40–50 mm: c) [*Fig. 4:l*].

SURFACE DRESSING PROCESS OF THE BUILDING STONE BLOCKS FROM THE ISIS TEMPLE

Phase I: raw material acquisition

This phase possibly consisted of two stages in the anhydritic-gypsum stone surface dressing process, executed through four technological actions: 1:A*,⁹ 1:B1–2, and 2.

Stage 1 – quarrying*

This stage is associated with raw material acquisition. Sharp picks were used to cut separation trenches, leaving char-

9 Throughout the text, the asterisk (*) is used to indicate a hypothetical/reconstructed presence of a negative or flake scar within a given Phase and Operation stage.

acteristic linear flake scars on the stone surface (Neg. 3 mm: 1*) (tech. action 1:A*)¹⁰ [see *Fig. 4:a*]. In addition, wedge sockets were cut using a pointed metal chisel to facilitate extraction (Neg. 3 mm: sl) (tech. action 1:B1) [*Fig. 5:a*]. The extraction process resulted in at least one relatively flat split surface on the stone block (Neg. S) (tech. action 1:B2) [*Fig. 5:b*];

Stage 2 – initial dressing

This stage involved the preliminary trimming of the freshly quarried stone chunk using a pointed metal chisel (Neg. 10 mm: l) (tech. action 2) [see *Fig. 5:c*].

Phase II: formation of the stone block

This phase includes three recorded stages, executed through four technological actions: 3, 4,¹¹ and 5:A*–B:

Stage 3 – preparation dressing

The roughly cut stone chunk was further trimmed into a properly shaped and dimensioned building block using flat metal chisels (Neg. 25–35 mm: sl) (tech. action 3) [*Fig. 5:d*];

Stage 4₁¹¹ – flattening dressing

This step aimed to make the still uneven surfaces relatively flat using a flat metal chisel (Neg. 30–40 mm: f) (tech. action 4₁) [*Fig. 5:e*];

Stage 5 – setting

This stage concerned the final placement of stone blocks into the masonry. Once set, the blocks were first planed (tech. action 5:A*) using a metal saw (Neg. Sw*)¹² [see *Fig. 4:e*] along the side and base faces adjacent to the front face, in order to create the tightest possible joints. Subsequently, mortar (Dep. M) was applied (tech. action 5:B) to bond the positioned blocks [*Fig. 5:i*].

Phase III: top face formation

This phase includes two observed stages and their corresponding technological actions: 4₂ and 6:

Stage 4₂ – flattening dressing

This stage corresponds to the final flattening of the top face surface to prepare it for the next course of stone blocks. This was carried out using a flat metal chisel (Neg. 30–40 mm: f) (tech. action 4₂) [*Fig. 5:f*];

10 Although no metal pick tool marks (Neg. 3 mm: 1*) (tech. action 1:A*) were identified on the examined stone blocks—likely because they were removed during subsequent dressing—available sources (Ginouès and Martin 1985: 70, Pl. 65; Goyon et al. 2004: 142–156; Wright 2005b: Fig. 67; Harrell and Storemyr 2013: 32–40) leave little doubt that such metal picks were not used to extract the blocks from bedrock during the carving of separation trenches. For interpretation and dating of the dressing technology of the Isis Temple stone blocks, see discussion below.

11 The subscript numbers in Stage 4₁, 4₂, and 4₃ indicate that the same tool was used three times during the three different surface dressing phases and in three different technological actions (see discussion below).

12 Although no saw tool marks (Neg. Sw*) (tech. action 5:A*) were identified on the examined stone blocks—likely because such marks typically appear as tiny scratches and were not preserved due to the poor quality of the stone and harsh environmental conditions—available sources clearly indicate that saws were used to create joints between adjacent planed stone blocks (Laroze and Garric 2013). For interpretation and dating of the dressing technology of the Isis Temple stone blocks, see discussion below.

Stage 6 – cutting cramp slot

In this stage, cramp slots were cut into the flattened top face between two adjacent blocks using flat metal chisels (Neg. 25 mm: sl) (tech. action 6) [Fig. 5:g].

Phase IV: final dressing of the front face

This phase comprises two stages and their related technological actions: 4₃ and 7.

Stage 4₃ – flattening dressing

This stage involved the final flattening of the front face to create a smooth outer wall surface or to prepare it for relief decoration. This dressing left tool marks characterized by vertical flake scars formed by horizontally-driven chisels moving from top to bottom and right to left (Neg. 30–40 mm: f) (tech. action 4₃) [Fig. 5:h];

Stage 7 – planing dressing

This stage aimed to smooth the already flattened surface using stone grinders (Neg. Sm) (tech. action 7) [see Fig. 5:h].

Phase V: relief decoration

Although this phase naturally includes at least seven operational stages (Stupko-Lubczynska 2022: 87–90), in this study it has been condensed into a single Stage 8, simply to acknowledge its place within the overall surface dressing process, which is otherwise not the focus here.

Phase VI: post-depositional processes

The process concludes with post-depositional modifications, corresponding to all damage observed on the stone block surfaces, whether of secondary anthropogenic (ReU) or natural (PD) origin.

DISCUSSION

It should first be stated—and emphasized once again—that the analyzed stone material used for the building blocks is in a poor state of preservation due to weathering. As a result, the Tool Mark Pattern Analysis (TMPA) of the gypsum-anhydrite blocks was significantly limited and yielded only restricted information. Consequently, it was not possible to carry out a complete, standard analytical procedure using the TMPA method to gain full insight into the operational sequence involved in the general technological-production processes of both assemblages, based on all six faces of a single stone block (Wieczorek forthcoming a). Nevertheless, drawing on the collected evidence [see *Tables 1 and 2*], it was possible to

reconstruct a general picture of what these processes may have looked like by focusing on one face of a block at a time and describing the operational sequence involved in the surface dressing process. Moreover—and most significantly—it was possible to associate the analyzed stone blocks with specific dressing industries and to identify the likely timeframes of their production activities.

Referring to the observations made regarding the identified tool sets, several aspects stand out from both a technological and chronological perspective. First, two distinct tool sets were recorded in the tool marks on the two analyzed assemblages (NM and TM). Second, the composition of the tool sets differs. Third, particular attention is drawn to

the use of sharp, pointed tools, including metal picks (Neg. 3 mm: l (NM)), adze-picks (Neg. 3 mm: l (NM)), metal pointed chisels (Neg. 3 mm: s (TM); Neg. 10 mm: l (TM)), and metal toothed adzes (Neg. 40 (:9–12) mm: ind (TM)).

Regarding the recorded operational sequence of surface dressing processes of the gypsum-anhydrite blocks, it is important to note that the sequence encompasses the entire technological-production process — from raw material acquisition in the quarry to its reuse, abandonment, and post-depositional damage [see *Tables 1, 2*]. One of the most significant technological observations made is that all operations directly related to surface dressing differ substantially between the two assemblages. The blocks from the Blemmyan Necropolis were fully dressed during Phases I and II, that is, prior to being set into the masonry. In contrast, the blocks from the Isis Temple were dressed in two distinct stages — both before and after their placement— within Phases I–II and III–V, respectively. Furthermore, in the case of the Blemmyan Necropolis blocks, it is particularly noteworthy that the material shows evidence of secondary dressing and, therefore, reuse during Phase III (see below).

Based on the collected evidence and the observations presented above, it is reasonable to conclude that both assemblages of gypsum-anhydrite blocks can generally be associated with stone dressing technologies of the Hellenistic-Roman period. This is clearly indicated by the tool sets used, their specific selection, the presence of sharp-pointed tools, and the use of wedge sockets — technological features characteristic of

that period and not attested earlier (see Identification of the tools used, above). Moreover, the operational sequence of the surface dressing processes, as presented [see *Tables 1, 2*], makes it possible to narrow down their chronology and distinguish three distinct stone dressing industries within the material, each reflecting a different tradition of stone dressing technology. These are: (1) the Ptolemaic, (2) the Roman, and (3) the Blemmyan stone dressing industries.

The Ptolemaic industry is represented by the gypsum-anhydrite blocks found in the Isis Temple. As Table 2 clearly illustrates, the recorded surface dressing process strongly recalls Pharaonic soft rock dressing technology, combined with typically Ptolemaic methods (cf. part 4 above). This is evident in the selection of tools used: a wide variety of flat metal bar chisels (Neg. 25–40 mm) appears alongside sharp-pointed tools such as metal picks and chisels (Neg. 3 and 10 mm). The manner of their use (five types of flake scars), the presence of wedge sockets, and —most notably— the two-step technological-production process of stone dressing all reinforce this interpretation. In the first step (Phases I–II), the stone blocks were quarried and dressed into the desired shape and dimensions, but only on the base and side faces. In the second step (Phases III–V), the top face and, finally, the front face were dressed (cf. Clarke and Engelbach 1930: 99–100; Arnold 1991: 43–116; Goyon et al. 2004: 286; Wright 2009: 146–151; Wiczorek forthcoming a).

The Roman industry is clearly evidenced by the gypsum-anhydrite blocks uncovered in the Blemmyan Necropolis. According to the data presented in

Table 1, their surface dressing process exemplifies a purely Roman approach to soft rock dressing technology (cf. see Identification of the tools used, above). This is unambiguously demonstrated by the dominant use of metal sharp-pointed tools — namely chisels, picks, adze-picks (Neg. 3 mm), and a toothed tool, probably a toothed adze, *shahuta* (Neg. 40 mm: 9–12 teeth, ind.). The variety of flake scars observed (nine types), as well as the one-step technological-production process — where the blocks were entirely dressed prior to being set into walls (Phases I–II)— further confirms the Roman character of this industry (cf. Wright 2000: 113, and 110–128 *passim*).

The Blemmyan industry is attested by the same gypsum-anhydrite blocks found in the Blemmyan Necropolis (see above). Although these blocks were clearly dressed according to Roman soft rock dressing technology, detailed stratigraphic analysis of the tool marks and the reconstructed operational sequence reveals evidence of secondary dressing. This is confirmed by tool marks produced by flat metal adze-picks (Neg. 40–50 mm: f) [see *Fig. 4:j*] and chisels

(Neg. 40–50 mm: sp, c) [see *Fig. 4:k, l*], which are assigned to Phase III — post-depositional processes— Stage 6: tech. actions 6:A–C [see *Table 1*]. At this stage, the original stone blocks were split, cut, or trimmed into smaller pieces, primarily slabs, to achieve the desired shape and dimensions. It is also particularly noteworthy that the same type of blocks has been found in the vicinity of the Isis Temple, now scattered across the ground in the area [*Fig. 7:a, b*], clearly indicating their origin and confirming their reuse and secondary dressing within the necropolis. Furthermore, the dimensions of the slabs reused in the necropolis (e.g. approximately 40 cm × 70 cm × 12 cm) [*Fig. 2:d*] can be directly linked to the division of larger slabs (originally approximately 42 cm × 103 cm × 12 cm) into smaller pieces [*Fig. 2:b*].

To summarize the chronology of the material in question and compare it with its archaeological context, it seems reasonable to associate the three identified stone dressing industries with three distinct technological traditions — Ptolemaic, Roman, and Blemmyan— each corresponding to a differ-



Fig. 7. Examples of stone blocks located in the vicinity of the Isis Temple, dressed in the same manner as those examined in the Blemmyan Necropolis (PCMA UW | photos D.F. Wiczorek)

ent chronological horizon. The first, the Ptolemaic horizon, spans at least four centuries, from the 3rd century BCE to the 1st century CE.¹³ The second, the Roman horizon, relates to the period from the 1st to the 3rd century CE.¹⁴ The third, the Blemmyan horizon, should be associated with the presence of the Blemmyes in Berenike between the late 4th and 5th centuries CE (see Introduction). However, it must be clearly emphasized that these proposed time frames are only approximations, based on known historical events at the site. The actual duration of the technological industries—within one tradition or another—may have been, and most likely was, more extended.

As for the characteristics of the three identified stone dressing industries, they can be summarized as follows: the Ptolemaic industry appears to be the most technologically complex. It is characterized by the greatest variety of tools and the most intricate operational sequence. The Roman industry is clearly less com-

plex, with a significantly reduced toolset and an operational sequence limited to essential stages. The Blemmyan industry, by contrast, displays an extremely limited technological approach. The entire production process seems to have been executed using, at most, two types of tools (Neg. 30–40 mm: f=metal pick-adze and chisel; see above), which is quite surprising.

Overall, it appears that the complexity of stone dressing technology—and, consequently, the level of skill involved—gradually declined over time and nearly disappeared during the Blemmyan period. This observation aligns well with what is seen in Blemmyan architecture more broadly, where finely cut ashlar masonry gave way to irregular, rough-cut stonework. These later structures often incorporated locally collected irregular stone fragments or even corals, which are well attested in Berenike's urban and funerary architecture (see also Sidebotham et al. 2015: 306–316; Gwiazda, Zych, and Smagur 2025).

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¹³ Although the examined stone material should certainly be dated to the first half of the 1st century CE, based on the foundation date of the Isis Temple (Hense 2017: 137–138; Poplawski et al. 2021: 389–390; Sidebotham et al. 2023: 27).

¹⁴ The time frame provided spans from the Roman conquest of Egypt in 30 BCE to the period when the temple fell into disuse in the 4th century CE (Hense 2017: 137–138; Sidebotham et al. 2023: 28).

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