The "Rope Cave" at Mersa/Wadi Gawasis

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Abstract

The site of Mersa/Wadi Gawasis (Egyptian Red Sea Coast) has been identified as the pharaonic harbor šȝww, which was used for sea-faring expeditions during the Middle Kingdom. The excavations recovered, among others, many shipping related objects (such as ship timber and anchors). Perhaps the most remarkable find, however, and unprecedented in the Egyptian archaeology is the cave in which shipping ropes are stored. Here, we present the analysis and offer suggestions for the function of these ropes.

Introduction[1]

The site of Mersa/Wadi Gawasis is located ca. 25 km south of Safaga, on the Egyptian coast of the Red Sea. The ancient occupation area extends across the northern coral terrace and slope of a dry river bed (*wadi*) and on the bay (*mersa*) to the northeast.[2]

In 1976 and 1977 Abdel Moneim Sayed conducted excavations in this area.[3] On the basis of the textual evidence, Sayed identified the site as the pharaonic harbor of *šȝww*, which was used for sea-faring expeditions to the land of Punt during the 12th Dynasty.

Since December 2001 the Joint Expedition of the University of Naples "L'Orientale" (UNO), the Italian Institute for Africa and Orient in Rome (IsIAO) and Boston University (BU) has investigated

[1] This paper is dedicated to the late Wallace Sellers of Lahaska, Pennsylvania (USA). Wallace Sellers was a friend and major supporter of the Mersa/Wadi Gawasis excavations 2003–2008. A financial investor by profession, he had a life-long interest in archaeology. In January 2004 Wallace visited the Mersa/Wadi Gawasis site and thereafter he followed our reports and excavation results with much interest and enthusiasm. The excavation team will always be grateful for his support—from the rather modest beginnings, when there was little to show at the site except for scatters of potsherds, to the major finds of the "Harbor of the Pharaohs to the Land of Punt."

[2] We, AJV and CZ, are grateful to Salima Ikram, Fredrik Hagen and Kathryn Bard for improvements in the English text and remarks on the organisation of the paper. We wish to express our gratitude to Rodolfo Fattovich and Kathryn Bard, directors of the UNO-BU project at Mersa/Wadi Gawasis and to all participants of the project who, in different ways, helped us in this study, but especially: Ksenija Brojevic, archaeobotanist; Carlos de la Fuente, photographer; Rainer Gerisch, archaeobotanist; Andrea Manzo, archaeologist; Pasquale Musella, conservator; Cinzia Perlingieri, ceramics analyst; Stefano Tilia, topographer, and Cheryl Ward and Edward Rogers, nautical archaeologists. We thank Fredrik Hagen for his insights into texts related to the topic, and Alan Clapham and Caroline Cartwright for their help regarding the identification of the plant fiber. We thank Lucy Skinner for her help with the preservation of the ropes. The UNO-BU project has been conducted with grants from the UNO, IsIAO, Ministry of Foreign Affairs (Rome), and generous contributions by Mr. Wallace Sellers and the Glen Dash Charitable Foundation, Woodstock, CT (USA).

[3] Abdel M. A. H. Sayed, "Discovery of the Site of the 12th Dynasty Port at Wadi Gawasis on the Red Sea Shore," *RdE* 29 (1977), 140–78; idem, "Discovery of the Site of the 12th Dynasty Port at Wadi Gawasis on the Red Sea Shore," in Walter F. Reineke, ed., *Acts of the First International Conference of Egyptology* (Berlin, 1979), 569–78; idem, "Observations on Recent Discoveries at Wadi Gawasis," *JEA* 66 (1980), 154–57; and idem, "New Light on the Recently Discovered Port on the Red Sea Shore," *CdE* 58 (1983), 23–37.

the site under the direction of Rodolfo Fattovich (UNO) and Kathryn Bard (BU). The recent archaeological investigations have revealed different areas of use and occupation at the site.[4] On the top of the terrace, ceremonial monuments, consisting of small mounds with chambers, platforms, and small huts, have been found. Production areas and workshops have been excavated at the lower part and at the base of the western terrace slope. Excavations in the *wadi* bed have revealed what was possibly the ancient shore and the landing place, based on the discovery of two anchors and the results of recent geological and geophysical surveys.[5]

Seven distinctive rock-cut structures and niches for stelae were discovered along the wall of the western coral terrace, below ca. 3 to 5 m of deposited sand. The main rock-cut compound, however, consisted of five caves.[6] Four caves (Caves 2, 3, and 4a/b) were originally carved into the terrace wall from the same natural rock shelter. The partial excavation of two caves (Cave 2 and Cave 3) revealed they were used at different times and that they were employed not only to dismantle and rework ship timbers, but also for food processing. During periods of inactivity they were most likely used as storerooms for nautical equipment and ship timbers.[7]

Cave 5 was discovered due to a natural opening at the rear of Cave 2, on the northwest wall, which was the result of collapse of the original wall between the two caves. The large number of rope coils found in Cave 5 earned it the nickname of the "Rope Cave." The present work is the final analysis of the contents of this cave.[8]

During the seven field seasons at Mersa/Wadi Gawasis, about 500 fragments of cordage, 70 of which have knots, were recorded,[9] excluding the ropes found in the cave. The cordage was fragmentary; the ropes' lengths vary from a few cm to 5 m. The focus of the present work, however, will be only on the ropes from Cave 5; the remains of ropes in Cave 2 will be mentioned only in passing.

Overview of Cordage Studies

The last ten years have seen an increased interest in the study of archaeological cordage, although the studies are largely limited to more recent periods of Egypt's history, i.e., the Roman period and

[4] Preliminary reports: Kathryn A. Bard with Rodolfo Fattovich, eds., "The Wadi Gawasis/Wadi Gasus, Egypt: a Preliminary Assessment," online at www.archaeogate.org (2001, visited 14 August 2008); Rodolfo Fattovich, ed., "Archaeological Investigation at Wadi Gawasis (Red Sea—Egypt) of the Italian Institute for Africa and the Orient (Rome) and "L'Orientale" (Naples)": December 2002–January 2003 Field Season," online at www.archaeogate.org (2003, visited 14 August 2008); Kathryn A. Bard with Rodolfo Fattovich, eds., "Mersa Gawasis (Red Sea—Egypt): UNO/IsIAO and BU 2003–2004 Field Season under Direction of Rodolfo Fattovich and Kathryn Bard," online at www.archaeogate.org (2004, visited 14 August 2008); idem, "Recent Excavations at the Pharaonic port of Mersa Gawasis on the Red Sea, 2004–2005 Field Season," online at www.archaeogate.org (2005, visited 14 August 2008); Rodolfo Fattovich with Kathryn A. Bard, eds., "Joint Archaeological Expedition at Mersa/Wadi Gawasis (Red Sea, Egypt) of the University of Naples "L'Orientale" (Naples, Italy), Italian Institute for Africa and the East (IsIAO), and Boston University (Boston, USA)—2005–2006 Field Season," online at www.archaeogate.org (2006, visited 14 August 2008); idem, "Mersa/Wadi Gawasis 2006–2007," online at www.archaeogate.org (2007, visited 14 August 2008). First 5-year report: Kathryn A. Bard with Rodolfo Fattovich, eds., *Harbor of the Pharaohs to the Land of Punt. Archaeological Investigations at Mersa/Wadi Gawasis Egypt, 2001–2005* (Naples, 2007). The introduction of the present paper draws from these reports as well as the participation of CZ during the last seven years.

[5] Duncan FitzGerald and Christopher Hein conducted geological investigations during the 2006–2007 and the 2007–2008 field seasons; Benjamin Vining conducted the geophysical survey during the 2005–2006 and 2006–2007 field seasons.

[6] We define the general term "cave" used here to mean natural cavities in the wall terrace that were extended by carving rooms ca. 20–24 m long.

[7] Kathryn A. Bard with Susan T. Childs, Rodolfo Fattovich, Elsayed Mahfouz, Andrea Manzo, Cinzia Perlingieri, Rosanna Pirelli, Cheryl Ward and Chiara Zazzaro, "Excavations," in Bard and Fattovich, *Harbor of the Pharaohs*, 38–77, esp. 61–68.

[8] Previous preliminary reports have been published, especially Chiara Zazzaro with Cheryl Ward, "Cordage from Cave 5," in Fattovich and Bard, "Joint Archaeological Expedition at Mersa/Wadi Gawasis," online at www.archaeogate.corg (2006, visited 14 August 2008); André J. Veldmeijer with Chiara Zazzaro, "The Rope Cave at Mersa Gawasis: a Preliminary Report," *AO* 5 (2007), 243–47; and Chiara Zazzaro, "Cordage," in Bard and Fattovich, *Harbor of the Pharaohs*, 190–94.

[9] Zazzaro, "Cordage."

later (studies include those from the sites of Berenike,[10] Quseir al-Qadim,[11] and, to a lesser extent, Qasr Ibrim,[12] as well as incidental isolated finds[13]). Cordage finds from contexts contemporary to Mersa/Wadi Gawasis are relatively rare,[14] and of these, few have been adequately published[15] (especially Deir el Medineh[16] and Amarna[17]). This emphasizes the uniqueness and importance of the Mersa/Wadi Gawasis finds. Several studies add to our understanding of cordage from a textual and/or iconographic perspective.[18] Additional information about cordage can be found in archaeobotanical reports, but these focus primarily on the materials of which the cordage is made.[19] Other important sources of information is anthropological in nature,[20] particularly in terms of ethnography,[21] and more general overviews of cordage can be helpful.[22]

[10] André J. Veldmeijer, "The Cordage," in Steven E. Sidebotham with Willemina Z. Wendrich, eds., *Berenike '96. Report of the Excavations at Berenike* (*Egyptian Red Sea Coast*) *and the Survey of the Eastern Desert* (Leiden, 1998), 237–52; André J. Veldmeijer, "The Cordage," in Steven E. Sidebotham with Willemina Z. Wendrich, eds., *Report of the 1997 Excavations at Berenike and the Survey of the Egyptian Eastern Desert, including Excavations at Shenshef* (Leiden, 1999), 257–76; idem, "Fishing Nets from Berenike (Egyptian Red Sea Coast)," *Trabajos de Egiptología* 3 (2004), 99–110; idem, "Archaeologically Attested Cordage. Terminology on the Basis of the Material from Ptolemaic Roman Berenike (Egyptian Red Sea coast)," *Eras* 7 (2005), online at http://www.arts.monash.edu.au/eras/edition_7/veldmeijerarticle.htm (visited 14 August 2008); idem, "Identifiable and Associated Cordage Examples from Berenike (Egyptian Red Sea Coast)," *AO* 3 (2005), 65–87; idem, "'Knotless' Netting in Ancient Egypt. A Reappraisal on the Basis of Archaeologically Attested Material from Berenike and Qasr Ibrim," *GM* 206 (2005), 91–102; idem, "The Cordage from the 2001–Season of the Excavations at Berenike (Egyptian Red Sea Coast): Preliminary Results," *AO* 4 (2006), 119–35; idem, "Knots, Archaeologically Encountered: a Case Study of the Material from the Ptolemaic and Roman Harbour at Berenike (Egyptian Red Sea Coast)," *SAK 35* (2006), 337–66; idem, "The Cordage from Berenike (1994–2000 Seasons): the Statistics." *AO* 6 (2008), 37–97; André J. Veldmeijer with Sigrid M. van Roode, "Carrier Netting from the Ptolemaic Roman Harbour Town of Berenike (Egyptian Red Sea Coast)," *AO 2* (2004), 9–25; Willemina Z. Wendrich with André J. Veldmeijer, "Cordage and Basketry," in Steven E. Sidebotham with Willemina Z. Wendrich, eds., *Berenike '95. Preliminary Report of the Excavations at Berenike* (*Egyptian Red Sea Coast*) *and the Survey of the Eastern Desert* (Leiden, 1996), 269–96.

[11] Fiona Handley, "Basketry, Matting and Cordage from Myos Hormos-Quseir al-Qadim. A Roman and Islamic Port Site," online at http://www.arch.soton.ac.uk/ (1999, visited 31 March 2008); idem, "Basketry, Matting and Cordage from Myos Hormos-Quseir al-Qadim. A Roman and Islamic Port Site," online at http://www.arch.soton.ac.uk/ (2000, visited 31 March 2008); Sue Richardson, "Basketry, Matting and Cordage from Myos Hormos-Quseir al-Qadim. A Roman and Islamic Port Site," online at http://www.arch.soton.ac.uk/ (2001, visited 31 March 2008); idem, "Basketry, Matting and Cordage from Myos Hormos-Quseir al-Qadim. A Roman and Islamic Port Site," online at http://www.arch.soton.ac.uk/ (2002, visited 31 March 2008); idem, "Basketry, Matting and Cordage from Myos Hormos-Quseir al-Qadim. A Roman and Islamic Port Site," online at http://www.arch.soton.ac.uk/ (2003, visited 31 March 2008).

[12] André J. Veldmeijer, "Netting from Qasr Ibrim," (in preparation); some notes in Willemina Z. Wendrich, *The World According to Basketry. An Ethno-Archaeological Interpretation of Basketry Production in Egypt* (Leiden, 1999).

[13] Daryl P. Domning, "Some Examples of Ancient Egyptian Ropework," *CdÉ* 52 (1977), 49–61.

[14] "Contemporary" to the Mersa Gawasis ropes; we take this rather widely, i.e., Old Kingdom through New Kingdom.

[15] Donald P. Ryan, "Old Rope. Who Cares about this Ancient Egyptian Technology?" *KMT* 4, 2 (1993), 72–80; Donald P. Ryan with David H. Hansen, *A Study of Ancient Egyptian Cordage in the British Museum* (London, 1987); André J. Veldmeijer, "A lot of Old Rope: Cordage at HK43," in Renée Friedman, ed., *Nekhen News Volume 18, Fall 2006* (London, 2006), 25; André J. Veldmeijer with Janine D. Bourriau, "The Carrier nets from a Burial at Qurneh," *JEA* 95 (*accepted*); Willemina Z. Wendrich, "Ancient Egyptian Rope and Knots," in J. C. Turner with P. van de Griend, eds., *History and Science of Knots* (Singapore, 1996), 43–68.

[16] Yvon J.-L. Gourlay, *Les Sparteries de Deir el-Médineh I. Catalogue des Techniques de Sparterie* (Cairo, 1981), esp. 21–25, 33–36; idem, *Les Sparteries de Deir el-Médineh II. Catalogue des Objects de Sparterie* (Cairo, 1981).

[17] Willemina Z. Wendrich, "Preliminary Report on the Amarna Basketry and Cordage," in Barry J. Kemp, ed., *Amarna Reports V* (London, 1989), 169–201, esp. 174–84.

[18] Ernest MacKay, "Note on a New Tomb (No. 260) at Drah Abu'l Naga, Thebes," *JEA* 3 (1916), 125–26; Emily Teeter, "Techniques and Terminology of Rope-Making in Ancient Egypt," *JEA* 73 (1987), 71–77.

[19] Elhamy A. M. Greiss, "Anatomical Identification of Plant Material from Ancient Egypt," *BIE* 31 (1949), 249–83; idem, *Anatomical Identification of Some Ancient Egyptian Plant Materials* (Cairo, 1957).

[20] Especially Nessim H. Henein, *Mari Girgis. Village de Haute-Égypte* (Cairo, 1988), esp. 130–53; 189–94.

[21] Wendrich, *The World According to Basketry,* 292–95; 298–300; 374–88 deals with the production of cordage and its subsequent use to make an object such as nets or bed matting.

[22] Especially Alfred Lucas and John R. Harris, *Ancient Egyptian Materials and Industries* (4th Ed.; London, 1962); André J. Veldmeijer, "Cordage Production," *Encyclopedia of Egyptology* (2009), online at http://www.humnet.ucla.edu (visited 24 September 2009).

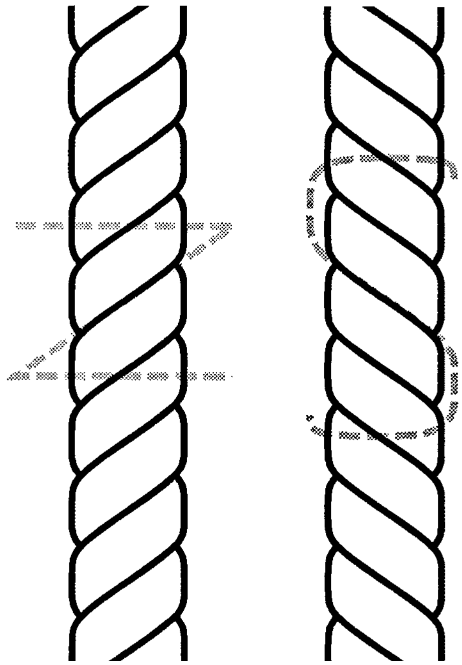

Fig. 1. Spinning and plying is visualized by means of the letters "Z" and "S"; the letter "I," not shown in the figure, refers to unspun strands. Figure by E. Endenburg/A. J. Veldmeijer.

Reports on cordage outside Egypt are scarce, which is partly due to unfavorable circumstances for preservation. Of these reports, the most important one concerns the cordage from Masada.[23] Cordage is frequently found associated with shipwrecks, but often as small scattered fragments of linear cordage whose function cannot be determined.[24]

Terminology

Various aspects of cordage have been described by Veldmeijer,[25] several of which need to be introduced shortly, viz. appearance ("how does it look") and application ("how is it used").[26] The appearance of cordage can be divided into three characteristics: twist/composition, diameter, and the Cord Index of Ply (CIP).[27] There are different ways to describe the twist and composition of cordage, but in all cases it involves the use of the letters "S" and "Z" to visualise the orientation of the spinning, plying and cabling (referred to as the cordage's twist, see fig. 1). We follow the system as discussed by Wendrich[28] and evaluated by Veldmeijer,[29] as opposed to the system used by Ryan and Hansen.[30] This means that the yarn[31] is presented by a small letter "s" or "z"; the ply by a capital "S" or "Z"; and cabled cordage by means of a capital letter between square brackets: "[S]" or "[Z]" (cabled cordage is not among the cordage in the "Rope Cave"). A number in subscript refers to the number of yarns and plies (its composition; fig. 2). Most of the cordage is made in such a way that the subsequent manufacturing levels have an opposite orientation, called "alternating" (fig. 2). This means for plies a twist of "sZ" or "zS." This is not only important for the interpretation of the production of cordage, but gives insight into the strength as well, because "alternating cordage ("zS" or "sZ") is

[23] Kathryn Bernick, "Masada Basketry, Cordage and Related Artifacts," in Joseph Aviram, ed., *Masada IV. The Yigael Yadin Excavations 1963–1965. Final reports* (Jerusalem, 1994), 286–317, esp. 304–17.

[24] The Bronze Age Shipwreck of Cape Gelidonya (ca. 1200 BC) yielded fragments of rope identified as *Phragmites* sp., see J. du Plat Taylor, "Basketry and Matting," in George F. Bass, ed., *Cape Gelidonya: a Bronze Age Shipwreck*, Transaction of the American Philosophical Society, New Series, vol. 57, part 8 (Philadelphia, 1967), 160–62, esp. 160–61.

[25] Veldmeijer, "Cordage Terminology."

[26] The rope does not show any signs of features, i.e., knots, loops, beginnings, kinks and snarls.

[27] Veldmeijer, "Cordage Terminology," Tab. 1. Note that the Cord Index of Cable (CIC) is not mentioned, as cabled cordage is not among the ropes from the "Rope Cave."

[28] Willemina Z. Wendrich, *Who is Afraid of Basketry; a Guide to Recording Basketry and Cordage for Archaeologists and Ethnographers* (Leiden, 1991), esp. 30–32; 33–47.

[29] Veldmeijer, "Cordage Terminology."

[30] Ryan and Hansen, "Cordage in the British Museum." William H. Charlton Jr., *Rope and the Art of Knot-Tying in the Seafaring of the Ancient Eastern Mediterranean* (M.A. thesis, Texas A&M University, 1996), esp. 12–14, discusses this topic in a comparable way as Wendrich and in the present work. However, his conclusion on left- and right-handed production of linear cordage is premature, cf. Veldmeijer, "Statistics."

[31] Not to be confused with the fibers from which a yarn is made. In small linear cordage, fibers cannot often be counted as they are too small (the same is true for string and threads of flax), but especially with thick linear cordage (ropes) the thick fibers are often counted and hence erroneously referred to as yarn; consequently, the rope is interpreted as cable, which, technically, it is not, cf. Lucas and Harris, *Ancient Egyptian Materials and Industries,* 134.

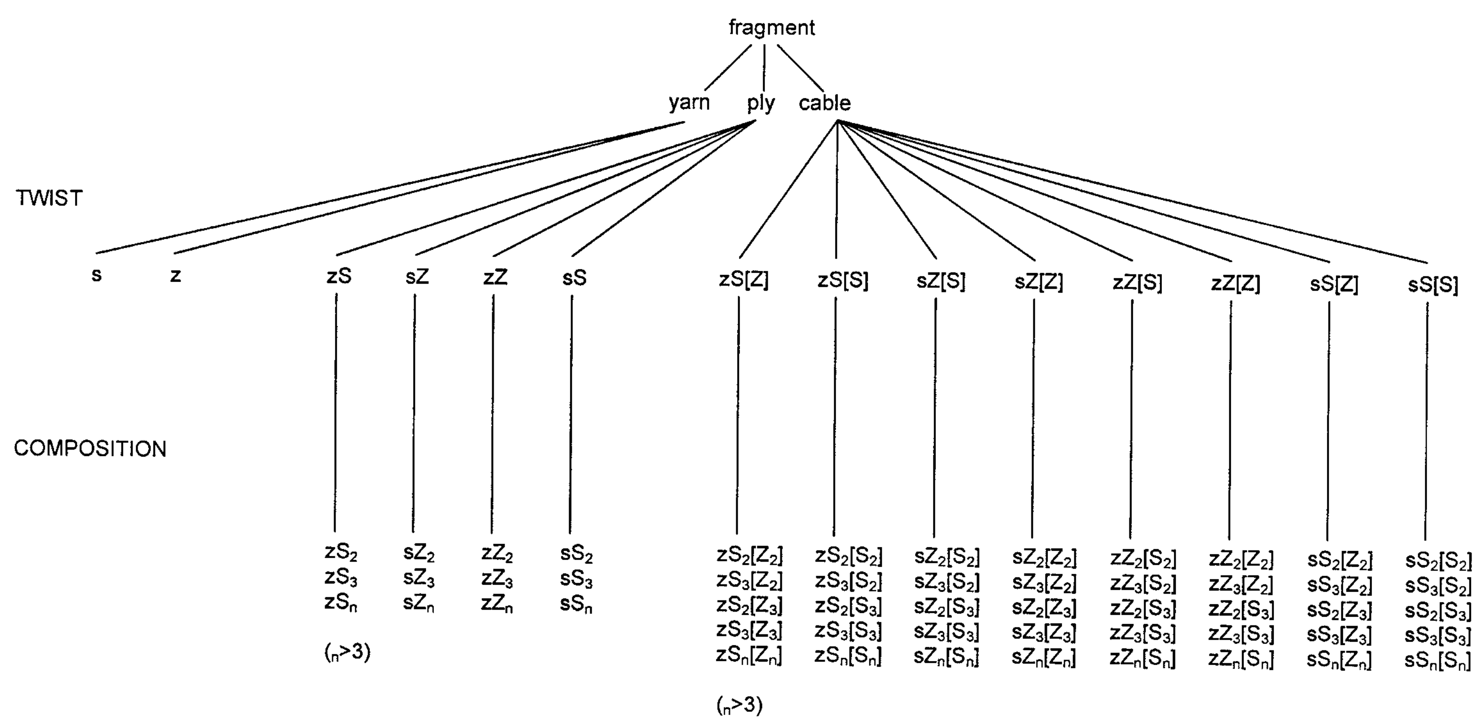

Fig. 2. Schematic rendering of twist and composition in cordage. Although the variety can be large, especially in cabled cordage, only one twist and composition was recorded for the ropes in the Mersa/Wadi Gawasis "Rope Cave." Adapted from Veldmeijer, "Cordage Terminology."

assumed to be stronger relative to non-alternating cordage ("zZ" or "sS"), because the alternation of a level locks the previous level"[32] (more on strength below).

The diameter, the second characteristic within the cordage's appearance, is an indication of its strength: cordage of which the largest diameter is less than 10 mm is referred to as "string," while those with a diameter of 10 mm or more are defined as "rope."[33] These terms are used regardless of the twist/composition. The diameter is used to calculate the CIP. The CI (Cord Index; the third characteristic) is "the ratio of the number of twists to the length and diameter of a yarn, string and rope. This ratio is expressed in a number between 0 and 100. The higher the CI, the tighter the rope has been made. This can give an indication of the quality of a rope."[34] The CIP expresses the tightness of a piece of plied cordage and determines how tight a piece of cordage is plied. Tightness not only determines the flexibility of cordage, but also gives an indication of its strength.

Specific functions (the aforementioned "application") for multiple use artefacts such as cordage, is difficult to determine, particularly when they are linear (i.e., pieces without characteristics, such as knots, that give additional information other than appearance) or without other associated artefacts. It is easier to determine the function of "associated cordage," pieces that are used in or with other artefacts. Since Cave 5, as far as we know, only contains ropes without features, we can refer to them as linear, but in this case identifiable linear cordage: "The term identifiable cordage is that for which the function may be determined, and gives more information about the fragment than the linear fragments provide. Through this it proves possible to determine a (possible) function of the particular piece."[35]

The association of cordage and the integration with other data from the excavation can give important information, even of linear cordage, making the artefacts here identifiable (see below for discussion on the context). The association of pieces with another artefact, regardless of whether its function is known or not, is regarded as "open-associated," as opposed to "closed-associated." Open-associated cordage is not an essential part of an artefact, but is, rather, associated with the artefact. Here, the open association comes from the unquestionable maritime nature of the site.[36]

Methods

The research was carried out *in situ* using basic measuring tools (a flexible measuring tape, a set of vernier callipers, a hand loupe (magnification ×20), a microscope, pincers and a set of brushes and blowers. The numbered coils were photographed in overview and detail and are included in the present work (fig. 4 and 6 resp.). In order to obtain a reliable average of the diameters as well as the CIP of a rope, several measurements were taken within one coil. Only the coils that could be identified were assigned numbers, hence the map (fig. 3) shows a picture of several coils with "empty" spaces in between. Figure 4 shows the actual situation with many remnants of coils (and isolated ropes?) scattered across the entire surface. However, as it was impossible to establish whether these were disintegrated coils and, if so, whether they belonged to one and the same coil or different ones. Therefore, they are not included in the analysis. The numbered coils were measured (Table 1).

[32] Veldmeijer, "Cordage Terminology."

[33] "Modern usage applies this term [i.e., rope] to cordage over 1 inch (2.54 cm) in circumference," Charlton, *Rope and the Art of Knot-Tying,* 151.

[34] Wendrich, "Amarna Basketry and Cordage," 173–74.

[35] Veldmeijer, "Cordage Terminology"; examples from Berenike in Veldmeijer, "Identifiable Cordage."

[36] For more on this, illustrated with an example, see Veldmeijer, "Cordage Terminology."

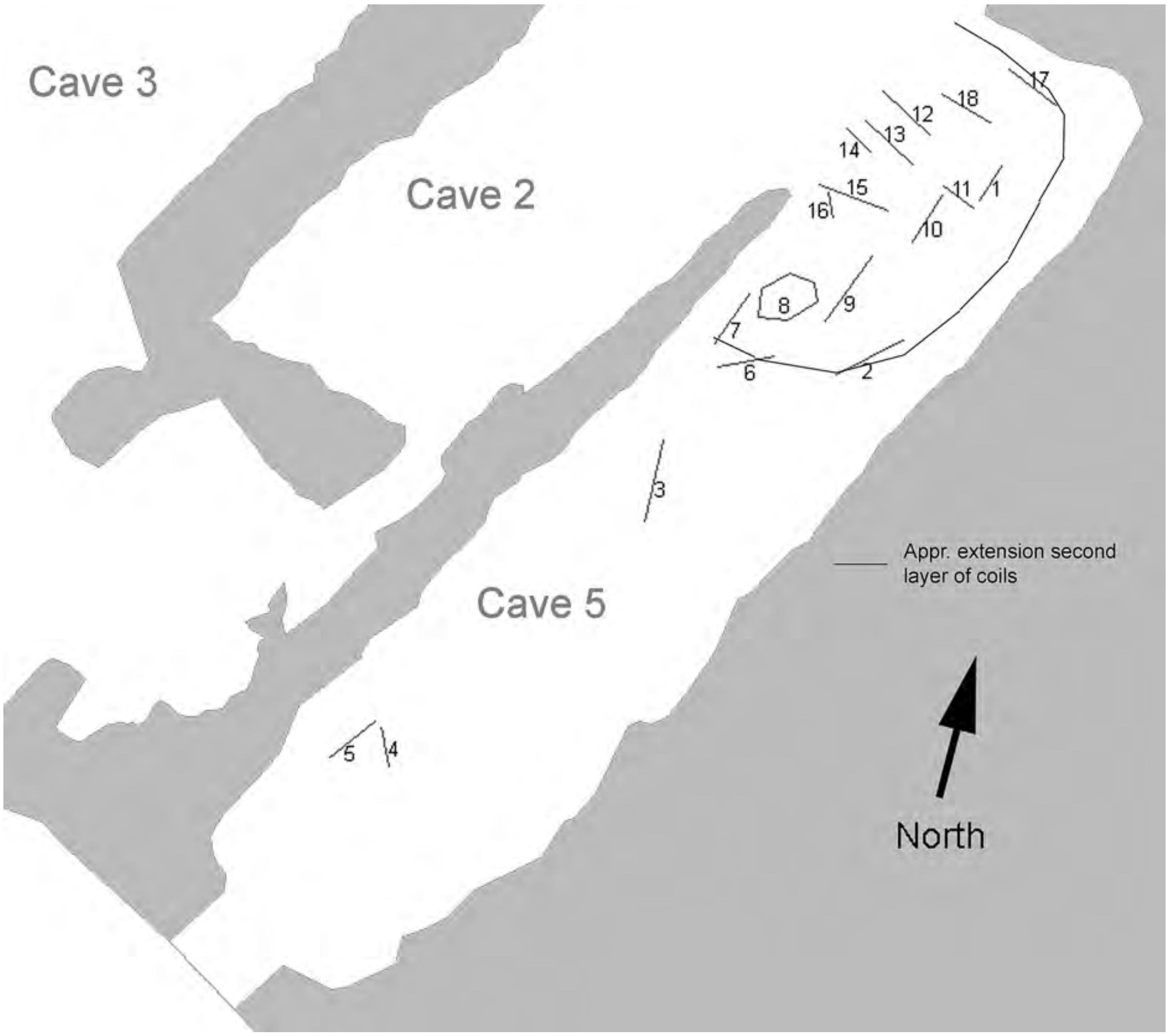

Fig. 3. Plan of the "Rope Cave" with the most intact coils, showing their orientation. Coil no. 2 is the most intact one; coil nos. 8 and 18 are piles of rope. The line roughly indicates the lower layer of coils. Map by S. Tilia (TreErre srl., Rome).

Comparison to pharaonic cordage is limited because most objects are isolated fragments from non-maritime contexts. Moreover, the context and date of these are not always clear. Among the few known examples are pieces of much thicker papyrus ropes from the Tura quarries, but the date of these is uncertain.[37] Moreover, the context suggests quite a different use than the Mersa/Wadi Gawasis ropes. The cordage from the Khufu boat[38] is much older than the ropes in Cave 5, but is useful nonetheless. Comparison with the Roman finds from Berenike and Quseir al-Qadim is only helpful

[37] Lucas and Harris, *Ancient Egyptian Materials and Industries*, 161.

[38] Mohammed Z. Nour with Zaky Iskander, *The Cheops Boats. Part I* (Cairo, 1960); Nancy Jenkins, *The Boat Beneath the Pyramid: King Cheops' Royal Ship* (New York, 1980); Paul Lipke, *The Royal Ship of Cheops: A Retrospective Account of the Discovery, Restoration and Reconstruction Based on Interviews with Hag Ahmed Youssef Moustafa* (Oxford, 1984).

Fig. 4. Overview of the "Rope Cave", looking towards the original entrance, which is now blocked by eolian sand. Photograph by C. de la Fuente, UNO/BU Project.

to a certain extent, mostly for a better understanding of the cordage's appearance rather than for explaining their function. The site of Ayn Soukha also yielded some burnt ropes with a thin diameter, connected to ship timbers and used for fastening. The archaeological assemblage from this site dates to the Old Kingdom.[39]

Cave 5: The "Rope Cave"

Plan of the cave

In general, at Mersa/Wadi Gawasis the cordage was found almost exclusively in excavation units on top of the slope along the western terrace, and in Caves 2 and 5. The deep deposits of soft sand and the dry condition of the caves' environment were important factors in the preservation of the cordage in this area of the site.

Cave 5 is 19 m long and has an almost rectangular plan (fig. 5), with a width of 3.75–4.10 m.[40] The ceiling is slightly vaulted with a central groove of 60 cm wide. It is 1.6 m high in the middle and 1.5 m high at the sides. The cave is entered through a collapsed wall between Caves 2 and 5 (arrow in

[39] Pierre Tallet, "Six campagnes archéologiques sur le site d'Ayn Soukhna, golfe de Suez," *BSFE* 165 (2006), 10–31.
[40] Bard et al., "Excavations," 38–77, esp. 67.

Table 1

Coil no.	Length coil (in cm)	Estimated total length (in m)	Width coil (in cm)	Ø yarn (in mm)	Ø yarn (average/largest difference)	Ø ply (in mm)	Ø ply (average/largest difference)	CIP formula	CIP (×100)	CIP (average)/largest difference)
1 (figure 6A)	123	12	39/34/34	10.6		25.4		3×10.6/54.6	58	
				11.7		27.2		3×11.7/54.4	65	
				10.6		26.7		3×10.6/55.6	57	
				12.3		24.8		3×12.3/53.2	69	
				10.3		24.0		3×10.3/51.5	60	
				10.7		26.2		3×10.7/50.0	64	
				11.0	11.0/2.0	26.2	25.8/3.2	3×11.0/52.6	63	62/8
2 (figure 6B)	137	23	47/41/48	5.8†		37.5		3×5.8/81.7	21††	
				17.2		31.8		3×17.2/62.1	83	
				16.8		31.8		3×16.8/69.0	73	
				15.6		33.2		3×15.6/73.0	64	
				13.7		31.0		3×13.7/72.1	57	
				13.8		33.2		3×13.8/80.7*	51	
				14.4		33.8		3×14.4/75.5*	57	
				16.3		32.0		3×16.3/69.7	70	
				14.4		37.9		3×14.4/70.9	61	
				14.8	15.2/3.5	30.2	33.2/7.3	3×14.8/67.2*	66	60/33
3 (figure 6C)	150*	>7.7	–	10.6		25.6		3×10.6/63.4	50	
				14.0		28.5		3×14.0/71.5	59	
				11.7		28.3		3×11.7/57.4	61	
				13.7	12.5/3.4	31.4	28.5/5.8	3×13.7/73.0	56	57/11
4 (figure 6D)	126*	17.5	-/35/-	10.7		24.6		3×10.7/42.1	76	
				12.2		26.5		3×12.2/50.5	72	
				11.7		26.3		–	–	

Table 1.—*continued*

Coil no.	Length coil (in cm)	Estimated total length (in m)	Width coil (in cm)	Ø yarn (in mm)	Ø yarn (average/largest difference)	Ø ply (in mm)	Ø ply (average/largest difference)	CIP formula	CIP (×100)	CIP (average)/largest difference)
				10.9		23.7		–	–	
				10.6		24.1		3×10.6/54.0	59	
				12.8	11.5/2.2	21.6	24.5/4.9	3×12.8/51.5	75	71/17
5 (figure 6D)	142#	?	–	10.8		24.6		3×10.8/50.1	65	
				11.9	11.4/1.1	27.9	26.3/3.3	3×11.9/51.1	70	68/5
6 (figure 6E)	–	?	–	11.2		26.6		3×11.2/69.9	48	
				13.0		27.3		3×13.0/66.5	59	
				12.4		30.5		3×12.4/67.7	55	
				9.9		27.5		3×9.9/57.8	51	
				13.2	11.9/3.3	25.5	27.5/5.0	3×13.2/56.0*	71	57/23
7 (figure 6F)	–	>10?	–	14.1		33.0		3×14.1/67.8	62	
				15.2		30.7		3×15.2/76.7*	59	
				13.5		32.6		3×13.5/72.4	56	
				13.8		35.4		–	–	
				15.5		37.3		–	–	
				14.5		34.4		–	–	
				15.7		33.0		3×15.7/67.2	70	
				13.4	14.5/2.3	30.4	33.4/6.9	3×13.4/80.2	50	59/20
8 (figure 6G)	138×135$^{\Delta}$	>10	–	11.5		27.2		3×11.5/58.7	59	
				12.0		25.8		3×12.0/69.2	52	
				14.0		29.2		3×14.0/65*	65	
				11.3		28.3		3×11.3/53.9	63	
				13.5		26.2		3×13.5/55.6	73	
				14.0		28.9		3×14.0/71.2	59	
				11.3		29.8		3×11.3/54.5	62	
				13.3	12.6/2.7	26.8	27.8/4.0	3×13.3/71.8*	56	61/21

Coil no.	Length coil (in cm)	Estimated total length (in m)	Width coil (in cm)	Ø yarn (in mm)	Ø yarn (average/largest difference)	Ø ply (in mm)	Ø ply (average/largest difference)	CIP formula	CIP (×100)	CIP (average)/largest difference)
9 (figure 6H)	–	>10?	–	12.3		28.9		3×12.3/68.2	54	
				13.0		28.1		3×13.0/64.2	61	
				15.3		31.8		–	–	
				13.6	13.6/3.0	33.2	30.5/5.1	–	–	58/7
10 (figure 6I)	140#	?	60*	15.6		33.9		3×15.6/79.2	59	
				15.7		32.6		3×15.7/74.5	63	
				15.5		32.9		3×15.5/79.5	58	
				15.7		34.2		3×15.7/72.6	65	
				15.5	15.6/0.2	33.0	33.3/1.6	3×15.5/71.0	65	62/7
11 (figure 6J)	83§	10	–	13.3		29.2		3×13.3/60.4	66	
				13.7		29.4		–	–	
				13.4	13.5/0.4	30.9	29.8/1.7	3×13.4/66.3	61	64/5
12 (figure 6K)	135#	20	43/43/–	12.1		31.4		3×12.1/64.2	57	
				12.9		31.2		3×12.9/62.4	62	
				12.2		28.0		3×12.2/61.7	59	
				11.8		28.1		3×11.8/63.9	55	
				11.7		25.6		3×11.7/64.8	54	
				12.7		27.1		3×12.7/58.0	66	
				11.5	12.1/1.4	26.3	28.2/5.8	3×11.5/54.8	63	59/12
13 (figure 6L)	150	15	34	11.6		25.9		3×11.6/63.4	55	
				11.6		24.9		3×11.6/67.0	52	
				11.1		24.1		3×11.1/71.5*	47	
				11.1		24.2		3×11.1/54.3	61	
				10.3		27.2		3×10.3/57.1*	54	
				12.2		25.7		3×12.2/56.8	64	
				10.8	11.2/1.9	24.9	25.3/3.1	3×10.8/51.8	63	57/14

Table 1.—*continued*

Coil no.	Length coil (in cm)	Estimated total length (in m)	Width coil (in cm)	Ø yarn (in mm)	Ø yarn (average/largest difference)	Ø ply (in mm)	Ø ply (average/largest difference)	CIP formula	CIP (×100)	CIP (average)/largest difference)
14 (figure 6L)	150#	15	–	13.4		31.8		3×13.4/77.0	52	
				16.2		33.0		3×16.2/78.8	62	
				18.0		34.4		3×18.0/67.3	80	
				15.2		33.6		3×15.2/67.7	67	
				15.6	15.7/4.6	34.6	33.5/2.8	3×15.6/73.6	64	65/28
15 (figure 6M)	–	?	–	12.8		25.8		–	–	
				10.8		27.4		–	–	
				11.4	11.7/2.0	26.5	26.6/1.6	3×11.4/47.1	73	–/–
16 (figure 6M)	120#	?	–	13.1		25.5		3×13.1/56.0	70	
				12.4		24.0		3×12.4/49.2	76	
				11.5		23.5		3×11.5/53.9	64	
				12.2		25.4		3×12.2/56.1	65	
				12.7	12.4/1.6	25.7	24.8/2.0	3×12.7/50.8	75	70/12
17 (figure 6N)	130	?	–	10.7		29.3		–	–	
				11.4		26.4		–	–	
				11.3		26.6		3×11.3/60.9*	56	
				12.4	11.5/1.7	31.8	28.5/5.4	–	–	-/-
18 (figure 6O)	–	?	–	15.9		34.4		3×15.9/84.6	56	
				15.7		35.0		3×15.7/69.3	68	
				14.3		32.3		3×14.3/81.3	53	
				15.0		35.6		3×15.0/74.8	60	
				16.7		37.0		3×16.7/79.0	63	
				13.9		29.4		3×13.9/66.3	63	
				12.7		29.3		3×12.7/51.9	73	
				15.8	15.0/4.0	38.4	33.9/8.1	3×15.8/87.8*	54	61/20

Table 1. Measurements of the ropes, including the identification numbers and reference to their images in the present paper (first column). Key: ✧ The estimations are the absolute minimal length; ∗ approximate measurement; # estimated length; Δ area; § visible length; † this measurement had not been used to calculate the average; the accompanying CIP (††) is a result of the deviating diameter of the yarn and also not included in the analysis (but see text).

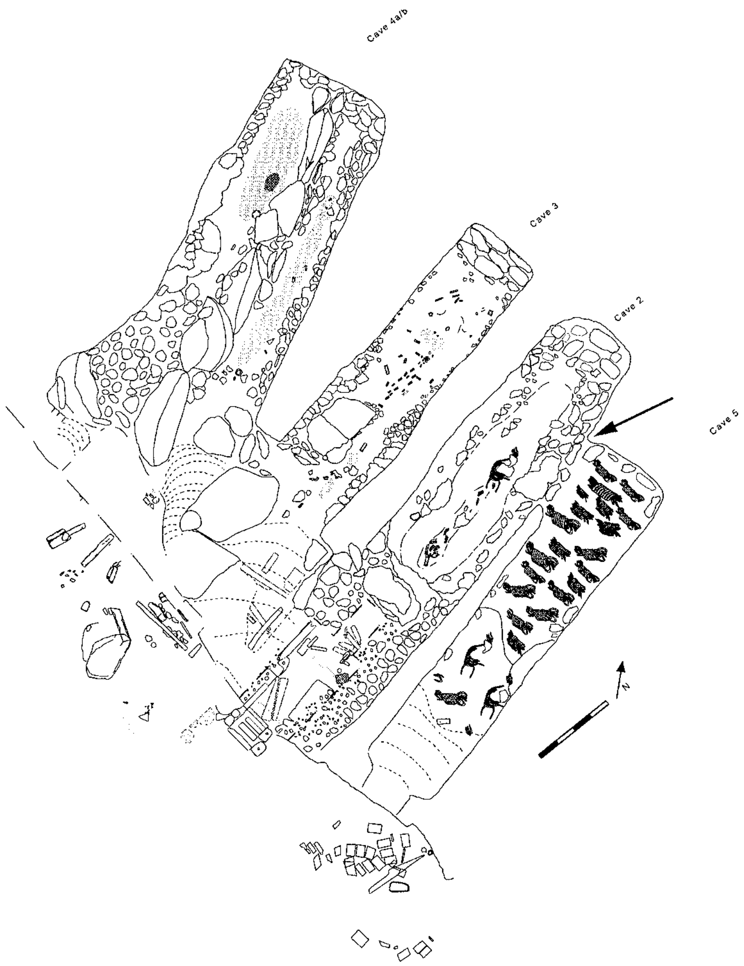

Fig. 5. Plan of Caves 2–6. Note the decreasing width of the wall between Cave 2 and 5. Plan by A. Manzo and C. Zazzaro.

fig. 5), as eolian sand covered the original entrance, that, in the present work is referred to as the "corridor." The wall between Caves 2 and 5 narrows towards the back of the caves.

In Cave 2, at about halfway along its length, a patch of fiber and pieces of ropes were found, together with some additional pieces of rope closer to the back of the cave. It is difficult to be certain whether the patch was a coil when deposited, but the amount of scattered fibers at least suggests a relatively large quantity of rope, and possibly a coil. The rubble of the collapsed wall partially covers the remains; this suggests that the wall collapsed after the ropes were deposited in Cave 2.

Deposition and storage of the ropes (figs. 3, 4, 6A–O)[41]

In Cave 5 the majority of the coils are deposited at the back of the cave (figs. 3, 4). There are at least two layers, the lower one, obscured by the top layer, extends in half a circle from the collapsed wall between this cave and Cave 2. The layer contains an estimated number of 10 coils, although the exact number could not be identified. Probes suggest the same kind of cordage there as in the top layer.

The top layer consists of 16 more or less complete coils, along with two big piles of ropes, possibly consisting of three or more coils (nos. 8 and 18; figs. 6G and O). Some ropes do not seem to have been deposited as longitudinal coils, such as coil 2 (fig. 6B), as their layout is different from the coils that have fallen apart. Instead, they might have been brought in as a jumble of rope or in a different shaped coil (these, together with the isolated ropes mentioned above, are also not included in the analysis).

Generally, coils laid in a single layer do not rest on others, although the partial preservation of some of the coils makes it difficult to interpret the depositional sequence. A preliminary scenario of the depositional sequence is possible by examining the relative positions of the ropes. One might expect the storage of the coils of rope to have occurred from the back of the cave to front, but there are indications that the storage was done in a less orderly manner. For example, coil no. 15 lies over

[41] With contributions on textual evidence by Fredrik Hagen.

no. 16, which means that no. 16, lying closer to the entrance, was deposited first. No. 13 lies over coil no. 14, which is a comparable situation as with coil nos. 15 and 16. No. 17 lies partially across the bunch of ropes, referred to as no. 18. Of the three coils against the opposite wall, only no. 11 has the same orientation as the one close to the corridor with Cave 2; the other two have the same orientation as the cave. Note that coil no. 1 lies on top of all other ropes, suggesting it was deposited as one of the latest. Furthermore, the row of coils at the corridor with Cave 2 are at right angle to the length of the cave (nos. 12–18) and must have been brought in first,[42] as the layer of coils, which are deposited against the opposite wall (nos. 1, 10 and 11), lie partially over them.

Towards the front of the cave, the number of coils decreases: it is tempting to suggest that the coils, which lie closer to the original entrance (nos. 2, 6–9), were deposited later. Even closer to the original entrance are coils nos. 3, 4 and 5. Coil no. 3 lies more in between coil nos. 2, 6–9, and nos. 4 and 5. The latter two have been moved from their original place and left at the eolian soil, now entirely blocking the original entrance. It seems that at some point, people came in and moved the coils, but discarded them before removing them from the cave. This means that either the entrance between Caves 2 and 5 did not exist at that time, or that the entrance to Cave 2 was not useable. It is difficult to believe that people crawled over the sand dune to store or retrieve the ropes, when a much easier entrance would have been available. It is not certain whether more coils were taken from the cave or not. Coil no. 4 lies partially over coil no. 5 and at right angle; it is the better preserved one of the two.

It is not possible to establish, from the archaeological context, whether all ropes were deposited in the cave together at the same time; the lowest layer could, in principle, have been deposited earlier. The sheer quantity of rope is in itself no argument against a single deposit, however, as considerable quantities of rope would have been necessary aboard a ship. A Ramesside papyrus in the Museo Egizio, Turin (the "*Giornale dell'anno 13*") lists a significant amount of rope in connection with materials for boats, including ropes specifically said to be "for the royal bark."[43] Similarly, a Ramesside ship's log (P. Turin 2008 + 2016) contains at least three entries where the ship picks up rope as part of its supplies on a journey down the Nile. The amounts involved are surprising; the best preserved entry records three ropes of 1000 cubits[44] in length, and twenty-seven (!) ropes of 500 cubits.[45]

Reliefs showing the transportation of coils of rope to ships complement such textual sources.[46] This type of coil might be similar to those depicted in tomb reliefs, such as a rope-making scene in the tomb of Khaemwaset (see below). Surprisingly, coils, such as those found predominantly in the cave, are not depicted. Possibly, the ropes were transported as circular coils, as depicted in scenes, and only tied across the middle just before putting them into the cave for storage. The larger ones, transported by two individuals with a pole on their shoulders,[47] might be the bigger coils, such as coil no. 2. Note, however, that in one case, two persons share a large length of rope, each one carrying half of the entire coil on his neck.[48]

Preservation

As Ward[49] states, the condition of the ropes, due to the long and slow desiccation in the constant environment have a freeze-dried appearance, although lacking in cellular integrity, which greatly

[42] I.e., of the top layer; obviously the semi circular lower layer were brought in before the top layer.
[43] Jac. J. Janssen, *Commodity Prices from the Ramesside Period* (Leiden, 1975), esp. 439.
[44] The length of a cubit fluctuated, but is roughly 52 cm.
[45] Jac. J. Janssen, *Two Ancient Egyptian Ships' Logs* (Leiden, 1961), esp. 84, 86–87, 90.
[46] For example, in the mastaba of Akhethetep, see Jacques Vandier, *Manuel d'Archéologie égyptienne. Bas Reliefs et Peintures scènes de la vie quotidienne*, Tome V, 2 (Paris, 1969), esp. fig. 322.
[47] Mastaba of Akhethetep, see Vandier, *Manuel d'Archéologie égyptienne*, fig. 323; mastaba of Ti, see Lucienne Épron with François Daumas, *Le Tombeau de Ti. Volume I,* MIFAO 65 (Cairo, 1939), esp. pl. 49.
[48] Vandier, *Manuel d'Archéologie égyptienne*, fig. 323.
[49] In Zazzaro, "Cordage," 194, n. 8.

reduced their stability. The thick layer of scattered fibers surrounding the layer of coils supports this observation. Moreover, as stated above, many coils have disintegrated and only a few are more or less complete. Even in some cases where the outer appearance suggests that the coil is (mostly) intact, the inner part has entirely crumbled, leaving an empty outer shell (for example, coil no. 4). This prohibited the excavation of the coils or even lifting them in order to weigh them.[50] The crumbling and disintegration of the ropes is caused not only by desiccation but also by insect activity. The rope is pierced by numerous small holes with diameters of about 1 mm.[51] This activity might not (only) be ancient, but modern, as experiments on paper left on the hole seems to prove.[52]

Dating

So far nothing within Cave 5 has thrown any light on the date of the ropes. However, archaeological investigations outside the cave can help in the evaluation of the date. As already mentioned, a deposit of eolian sand with remains of wooden boxes fills the original entrance to Cave 5. The excavations immediately outside the cave yielded similar boxes with painted inscriptions, two of which are dated to the reign of Amenemhat IV of the 12th Dynasty (ca. 1786–1777 BC).[53] On the other hand, several potsherds, which were found at the entrance of Cave 2 in an upper occupation phase (on top of a lower occupation phase, which clearly dates to the 12th Dynasty), date to the Early New Kingdom.[54] At that time people most likely removed part of the sand filling, including Middle Kingdom pottery, from Cave 2. This seems to coincide with the displacement of the coils in the entrance part of Cave 5 (especially coils 4 and 5, see fig. 3), and the deposit of the steering oar blades, which are tentatively identified as early New Kingdom (ca. 1550–1295 BC) as well.[55] Because the activities at the harbor were limited during the New Kingdom, together with the predominantly 12th Dynasty dates of material in the immediate vicinity of Cave 5, we suggest that the ropes should be dated to the 12th Dynasty (ca. 1985–1773 BC) at the earliest.

Manufacturing[56]

Short lengths of thin string could easily be made by rolling two bundles between the hands, as ethno-archaeological research shows.[57] The production of large quantities of rope, however, was a laborious and perhaps specialized job (see below), making good quality rope relatively expensive. Textual sources from the New Kingdom show prices of up to 1 *deben* of silver (equivalent to about two

[50] An alternative approach to estimate the weight is to make a coil, the possibilities of which are currently being explored.

[51] Similar preservation was seen in the material in Cave 3: "However, all of the spikelets were "hollow." Not a single emmer grain was preserved inside the spikelets. Several spikelets had a visible round whole [*sic*], indicating that the cereals were infested with pests. Numerous beetle exoskeletons were found with plant remains." See Ksenija Borojevic, "Archaeobotany," in Fattovich and Bard, "Mersa/Wadi Gawasis 2006–2007."

[52] Research into the kind of insect, its activity and how to deal with it, are currently being investigated by Lucy Skinner.

[53] Andrea Manzo, "Archaeology—Excavations. WG 32," in Fattovich and Bard, "Mersa/Wadi Gawasis 2006–2007"; Elsayed Mahfouz with Rosanna Pirelli, "Epigraphy—Wooden Boxes," in Fattovich and Bard, "Mersa/Wadi Gawasis 2006–2007."

[54] Andrea Manzo and Cinzia Perlingieri, "Finds—Pottery," in Bard and Fattovich, *Harbor of the Pharaohs*, 101–34, esp. 101–5.

[55] Chiara Zazzaro, "Nautical Evidence from the Pharaonic Site of Mersa/Wadi Gawasis: Report on two Steering Oar Blades," Ronald Bockius, ed., *Proceedings of the 11th International Symposium on Boat and Ship Archaeology, Mainz 24–28 September 2006* (Mainz, in press).

[56] With Egyptological contributions by F. Hagen. The material is discussed with "Features and identification of the ropes."

[57] Henein, *Mari Girgis,* esp. 190, fig. 2; Ryan, "Old Rope," 72–73; Wendrich, *The World According to Basketry,* esp. 298–300. An overview in Veldmeijer, "Cordage Production." Note that there is a large variety in composition (see Veldmeijer, "Cordage Terminology," table 2). The hand-rolling method results in an alternating twist. The archaeological record, however, also yields non-alternating twists, but the focus here is on alternating cordage, as these were the only ones found in the "Rope Cave."

cows) per 100 cubits for "very large and very good quality" (*ꜥꜣ sp-sn nfr-nfr*) rope destined for the royal bark. Lower quality rope was significantly cheaper at 1 *kite* (*ḳdt*) of silver (or less) per 100 cubits, i.e., only a tenth of "very good quality" rope.[58] It seems therefore reasonable to assume that stored ropes, being so expensive, would have been (re)used by the next expedition, rather than letting them remain unused in the cave.

The production of thick, heavy ropes, such as those found in the cave, must have involved various persons. The depiction of cordage production is not often shown in reliefs and paintings.[59] The tomb of Khaemwaset shows such a scene[60] and is discussed by Teeter.[61] Here the man pictured on the right spins the yarn by means of a tool with a weight. The man on the left is shown plying the two yarns, while the person in the center regulates the tension of the plying. After this was done, the third yarn would have been inserted.[62] The longer the rope, the more strength is required in order to produce the same degree of tightness. A constant tightness throughout the length of rope is of utmost importance, as lesser tightness means lesser strength. The weak spot thus created is more susceptible to breakage. This method is an important argument against the statement that cordage twisted in opposite direction is made by left- or right-handed people.[63]

Ropes could be manufactured to almost any length. Texts regularly record ropes of 500 cubits (over 250 m), and exceptionally even 1000, 1200, or 1400 cubits (over 700 m) in length.[64] It is difficult to imagine the production process of such large ropes without the help of a ropewalk ("rope-making machine"). In the Turin ship's log cited above the delivery of ropes is accompanied by that of *ỉsr*-fibers and *šmꜥt*-fibers, which has been thought to represent raw materials for rope-making.[65] This was implicitly dismissed by the latest editor of the text who translated *ỉsr* and *šmꜥt* simply as "rushes" and "sedge," respectively.[66] In fact, there is little evidence that the fibers were destined for rope-making, and certainly *ỉsr*-fiber appears elsewhere in the log without any association with rope,[67] and it may have been used for other things.[68]

[58] Janssen, *Commodity Prices*, 439.

[59] The most complete inventory is given by Charlton, *Rope and the Art of Knot-Tying*, 37–39.

[60] MacKay, "Note on a New Tomb." See also Jacques Vandier, *Manuel d'Archéologie égyptienne,* fig. 210, 1. The leather-making scene in the Theban tomb of Rekhmira (TT 100; see Norman de Garis Davies, *The Tomb of Rekh-mi-Reʿ at Thebes I and II* [New York, reprint 1973], esp. pl. 52) should be viewed with care as it seems to be a rope-making scene and as such out of place with the leather production part of the decoration; see also Stephanie Schwarz, *Altägyptisches Lederhandwerk* (Frankfurt am Main etc, 2000), esp. Katalog A, no. 17 [no page numbers]). However "the juxtaposition of scenes does not necessarily prove that the rope is made of leather" (Teeter, "Techniques and Terminology of Rope-making in Ancient Egypt," 72, n. 6). From an archaeological point of view it seems unlikely that they are making leather twined ropes (as suggested, for example, by Rosemarie Drenkhahn, *Die Handwerker und ihre Tätigkeiten im Alten Ägypten* (Wiesbaden, 1976), esp. 13, n. 28). To the best of our knowledge, these are not known archaeologically from pharaonic times. "Ropes" from animal hides as well as sinew are mentioned in the Coffin Texts, but one wonders if these are twisted ropes or strips of material; rawhide strips (e.g., axe lashing) and leather strips (e.g., in wheels of chariots) were used, but these were not twisted. Considering the fact that the scene is situated next to one showing the cutting of leather strips, possibly the men are straightening the leather strips. The coils, though similar in layout to those in the Khaemwaset scene, might be coils of leather strips.

[61] Teeter, "Techniques and Terminology of Rope-Making in Ancient Egypt." More on rope making scenes in Charlton, *Rope and the Art of Knot-Tying*, esp. 39–52 and on Khaemwaset, esp. 49–52.

[62] This is based on observations on the production of thin cordage. It is not unlikely that in the production of thick ropes, the third person (or the person already busy plying) was holding the third yarn and thus that the sZ_3 rope was made in one phase.

[63] See the discussion in Veldmeijer, "Statistics."

[64] Janssen, *Two Ancient Egyptian Ships' Logs*, 86; idem, *Commodity Prices*, 439. Other ancient sources, albeit not on Egyptian ropes, mention ropes up to a mile long, for example, Reginald W. Macan, *Herodotus I* (New York, reprint 1973 [1895]), esp. 53–54.

[65] Eric T. Peet, "An Ancient Egyptian Ship's Log," *BIFAO* 30 (1931), 481–90, esp. 488.

[66] Janssen, *Two Ancient Egyptian Ships' Logs*, 86.

[67] Janssen, *Two Ancient Egyptian Ships' Logs*, 70.

[68] In P. Anastasi IV, 13.10–11, for example, basketmakers (*ỉrw-ḥtp*) are said to use *ỉsr*-fibers in their work; see Alan H. Gardiner, *Late-Egyptian Miscellanies* (Brussels, 1937), esp. 50.1–2. Also Ricardo A. Caminos, *Late-Egyptian Miscellanies* (London, 1954), esp. 198–99.

Judging by the amount of work involved in making just one rope (including the harvest and preparation of the raw materials before spinning and plying[69]), as well as the necessary skill, rope-making might have been a (semi-) specialized craft. Additional support for this suggestion might come from the sheer quantity and quality (see above, cf. table 1) of the ropes found in the "Rope Cave." If the fibers delivered to the boat in the Turin ship's log were indeed raw material for ropes, the ropes may or may not have been manufactured on the boat. However, there are no known instances of a title "rope maker" (e.g., **ỉrw-nwḥ*), which could support the suggestion that it was not a separate profession, and that at least the final part of the process could be carried out by "sailors" (*wʿw*) themselves.[70]

The weight of the ropes in the "Rope Cave" is difficult to establish, as they are desiccated, delicate, and impossible to lift. However, some indications can be given. Macan[71], for example, estimated that a mile-long-rope (1,609 m), with a diameter of about 7 inches (17.78 cm), would weigh up to fifty pounds per foot (30.48 cm) of length. If we calculate according to this ratio, such a rope would weigh about eight pounds per foot of length. This seems too heavy, even for such a big rope, and obviously is too much for the Wadi/Mersa Gawasis ropes, as the diameter is much smaller. Moreover, in addition to the diameter and material used, the rope's weight also depends on the tightness of spinning and plying: stronger plying means more material per cm and thus heavier rope. Modern ropes of manila, which is made of the leaves of the plant *Musa textiles*, one of the most commonly used natural fibers nowadays, weigh up to 0.85 kg per meter for a 36 mm diameter rope[72]; this measurement seems more likely for the Wadi/Mersa Gawasis ropes.[73]

Features and Identification of the Ropes

Material[74]

Macroscopic observations that the ropes are not made of the most common materials used for making cordage in ancient Egypt (papyrus,[75] halfa grass or palm leaf)[76] are confirmed by examination under a microscope: the material used is grass.[77]

Which species of grass the rope is made from is more difficult to determine. Traditionally, most grass ropes have been identified as being of halfa grass. There are two species of halfa grass, *Desmostachya bipinnata* (L.) Stapf and *Imperata cylindrical* (L.) Raeusch, but it is unlikely to be either of these species as the rope is made from stems rather than leaves and the stems are woodier than those of

[69] See, for example, Veldmeijer, "Cordage Production" and references therein.

[70] There is a reference in Ostracon Turin 9598 to a sailor who is said to be "for the rope" (*ỉw=f r pꜣ nwḥ*), but this probably refers to the pulling (of a boat?) by ropes, rather than rope manufacture; see Georges Posener, "Ostraca inédits du Musée de Turin (Recherches littéraires III)," *RdÉ* 8 (1951), esp. 175.

[71] Macan, *Herodotus I*, 53–54.

[72] For example, http://www.traditionalropecompany.co.uk/index.htm, visited 23 June 2008.

[73] Interesting in this respect is the remark made by Steffy that the handling and storage of a line of great bulk would have been impractical for many of the smaller ships used in antiquity; see J. Richard Steffy, "Anchor Design," in George F. Bass with Frederick H. van Doornick Jr., eds., *Yassi Ada Vol. 1* (Texas, 1982), 142–43, esp. 143.

[74] With contributions about the identification and properties of the reeds by A. J. Clapham and C. R. Cartwright and Egyptological contributions by F. Hagen.

[75] Contrary to general belief, although papyrus was used for thicker cordage, it has never been used as extensively for making cordage as grasses and palm: its application seems to have been restricted mainly to the production of papyrus sheets. See also Lucas and Harris, *Ancient Egyptian Materials and Industries*, 130, 137.

[76] For an overview see Lucas and Harris, *Ancient Egyptian Materials and Industries*, 134–35.

[77] It is relatively easy to distinguish between the two families, Cyperaceae (sedges) and Poaceae (grasses) by examining the vascular bundles found in the leaves and stems. In the sedges the vascular bundles are composed of two xylem vessels which are capped by the phloem cells, while in the grasses there are three xylem vessels capped by the phloem cells. The desiccated rope fragment examined here showed the presence of three xylem vessels in the vascular bundles and therefore is of grass.

halfa grass. It is likely that the ropes are made from one of two other species of grass, the common reed (*Phragmites australis* (Cav.) Trin ex Steud) or the giant reed (*Arundo donax* L.). Both species produce tall stems of up to 6 m in height.[78] In the archaeological record, these reeds are applied for the same use[79] and there have been numerous finds from pharaonic tombs.[80] Its many uses include linings for Neolithic subterranean grain storage pits, fencing, crop shelters, plant and grapevine supports, baskets, and mats.[81] In particular, the culm (stem) was used for flutes, arrows, writing pens, furniture (including coffins), and roofing.[82] Basketry and matting could also be made of reeds. Accounts of cordage made of reeds are less numerous, but Brunton[83] mentions a reed rope from Predynastic times.

Today, the common reed can be found growing in the Nile region, including the Delta, valley and Faiyum region, the oases of the Western Desert, the Mediterranean coastal strip, all desert regions, the Red Sea coastal strip, and the Sinai Peninsula. The common reed is considered native to Egypt[84] and can be found abundantly in marshy and salty areas.[85] The giant reed has a similar distribution, but is not found on the Red Sea coastal strip.[86] According to Boulos,[87] the giant reed is a Mediterranean species that Springuel considers to have spread south through cultivation and naturalization.[88] It is thought to have been introduced into Egypt from Syria in ancient times.[89] The giant reed prefers slightly alkaline, heavy but well aerated moist soil, but can grow on sandy soil if the ground water is close to the surface.[90] With the evidence of the distribution of the two species of reed, it can be suggested that the most likely candidate for the rope is the common reed (*Phragmites australis*). It is possible that the common reed may have been found in abundance growing in the mangrove swamps which would have lined the Red Sea coastal strip in antiquity. The limited distribution of the giant reed in ancient times makes it a less likely candidate, considering the large amount of material necessary to make the ropes.

Transporting raw materials to the harbor from its vicinity and twisting them into ropes near the ships has the advantage that transporting the raw materials is much easier to do than transporting coils of rope.[91] The activity areas at the entrances of caves often shows the same plant remains as the ropes as well as fragments of ropes, together with wood debris. Possibly these cave entrances were chosen as working areas because of the humid environment: it would have been favorable for rope working as humidity makes the vegetable fiber easier to work (but see below for a possibly more important reason), as is suggested by a modern cave called "Grotta dei Cordari" (Syracuse, Italy),

[78] Lotfy Boulos, *Flora of Egypt. Volume 4. Monocotyledons* (*Alismataceae–Orchidaceae*) (Cairo, 2005), esp. 221, 223.

[79] Wendrich, *The World According to Basketry*: 148–49 and references therein.

[80] Irina Springuel, *The Desert Garden. A Practical Guide* (Cairo, 2006), esp. 135–37.

[81] Elhamy A.M. Greiss, "Anatomical Identification of Plant Remains and Other Materials," *BIE* 36 (1955), 227–36; Lucas and Harris, *Ancient Egyptian Materials and Industries*, 131.

[82] Greiss, "Anatomical Identification of Plant Material from Ancient Egypt," 255–56 and references therein. Also Lucas and Harris, *Ancient Egyptian Materials and Industries*, 131.

[83] Guy Brunton, *Mostagedda and the Tasian Culture* (London, 1937), 63.

[84] Boulos, *Flora of Egypt*, 222–23.

[85] F. Nigel Hepper, *Pharoah's Flowers. The Botanical Treasures of Tutankhamun* (London, 1990), esp. 35.

[86] Loutfy Boulos, *Flora of Egypt Checklist* (Cairo, 1995); idem., *Flora of Egypt*, 221–23.

[87] Boulos, *Flora of Egypt*, 221–23.

[88] Springuel, *The Desert Garden,* 135–37.

[89] Springuel, *The Desert Garden,* 135–37.

[90] Springuel, *The Desert Garden,* 135–37.

[91] Also cereals found at the site were most likely transported as spikelets from the Nile Valley (Borojevic, "Archaeobotany"), possibly in rope netting carried by two men. This kind of transport is often depicted in tombs; see, for example, the tomb of Menena (Manfred Gutgesell, "Economie en handel" in Regine Schulz with Matthias Seidel, eds., *Egypte, het Land van de Farao's* [Cologne], 371–76, esp. 375). Donkey transport was also used (as still nowadays; see Winifred S. Blackman, *The Fellahin of Upper Egypt. Their Religious, Social and Industrial Life Today with Special Reference to Survivals from Ancient Times*, Classic Reissues (Cairo, 2000), 173, 177, fig. 104, for an example from the beginning of the 19th century. The working and reworking of ship parts may be seen as additional evidence of production at the harbor.

where ropes were produced during the 17th century AD.[92] Common reed is a fast growing species and if harvested while the stems are still green, it is possible that the culms would have been flexible enough to be made into ropes.

There is still much uncertainty about the identification of ancient Egyptian plant names, but if the reference to *ỉsr*-fibers and *šmʿt*-fibers in the Turin ship's log cited above should be interpreted as raw material for ropes,[93] this could be a further example of identified plant names.[94] However, in most cases ropes for ships are said to have been made from *wḏ*,[95] which is widely accepted as referring to palm fibers.[96]

Composition (table 1; cf. figs. 6A–O)[97]

The composition of the ropes is without exception sZ_3.[98] Comparison as to preferences of composition is limited to material from much later contexts, as explained above. Moreover, we should bear in mind that the material differs from the commonly occurring materials from which the cordage at Berenike was made (halfa grass and palm). However, data on cordage made of reeds is largely absent. The dominant twist in the Berenike samples[99] was zS and the most important composition zS_2. The other twist, sZ, does occur and is more often used for cordage made of palm (especially palm leaf); the most often registered composition within the sZ twist was sZ_3. It is occasionally mentioned in literature that cordage with different twists are made by left- and right-handed people.[100] This hypothesis has been challenged the goat hair cordage from Berenike was almost without exception made in the sZ twist. According to Wendrich (personal communication), the properties of the material were and are the reason for the dominant sZ twist of goat hair rather than differences in female or male work, or left- and right-handed people.[101] Whether this might explain the prominence of the sZ twist with palm cordage is unanswerable for the time being, but the fact that, despite the higher percentage of sZ twist, most palm cordage is still made in the zS twist seems to suggest another reason.[102] Additional support for rejecting the left- and right-handed hypothesis is the fact

[92] Giulio Cappa with Carla Lanza, "Indagine preliminare sulle abitazioni trogloditiche a Monte S. Angelo," *Bollettino della Società Geografica Italiana* 4, 6 (1962), 3–13.

[93] As did Peet, "An Ancient Egyptian Ship's Log," 488, but see the discussion above.

[94] Janssen, *Two Ancient Egyptian Ships' Logs*, 86, identified *ỉsr* as "rush" (*Juncus acutus* L.), with reference to Vivi Täckholm with Mohamed Drar, *Flora of Egypt* Vol. II (Cairo, 1950), esp. 454–56.

[95] Janssen, *Commodity Prices*, 438.

[96] Victor Loret, *La flore pharaonique d'après les documents hiéroglyphiques et les spécimens découverts dans les tombes* (Paris, 1892 [2nd edition]); Ingrid Wallert, *Die Palmen im Alten Ägypten. Eine Untersuchung ihrer Praktischen, Symbolischen und Religiösen Bedeutung* (Berlin, 1962), 48–49. See too the discussion by Janssen, *Commodity Prices*, 438, where he retracts his earlier view of *wḏ* as a word for papyrus (Janssen, *Two Ancient Egyptian Ships' Logs*, 87), but note that Wolfgang Helck, *Materialien zur Wirtschaftsgeschichte des Neuen Reiches* (Wiesbaden 1961–1969), 815, finds the evidence inconclusive.

[97] "Composition" refers to the orientation and number of the subsequent levels of the piece; see Veldmeijer, "Cordage Terminology."

[98] Three s-spun yarns, twisted Z-wise (plied).

[99] Veldmeijer, "Statistics."

[100] Colin Renfrew with Paul Bahn, *Archaeology. Theories, Methods and Practice* (London, 1991), 383; Charlton, *Rope and the Art of Knot-Tying*, 14 are only two examples.

[101] See Veldmeijer, "Statistics" for additional arguments against left- and right-handed people, introducing cabled cordage into the discussion.

[102] Veldmeijer, "Statistics" notes: "It might be interesting to see whether the importance of this composition was with all palm cordage, or whether this was due to the use of the sZ_2 composition with one of the specific palm tree parts (fiber or leaf). Also, it might be interesting to see if one of the palm species, *H. thebaica* or *P. dactylifera,* showed a tendency to a larger quantity sZ_2 composed cordage or not. This, in turn, might shed light on the sZ_2 composed goat hair cordage. If one of the palm species or palm parts show a tendency to the SZ twist, this could be a strong indication that the properties of the material forced the rope maker to make the cordage according the SZ twist, as with goat hair. However, although no numbers are available about palm fiber/palm leaf/palm species, it seems doubtful that one of the features exhibited a similar emphasis on sZ_2 as goat hair."

that ropes such as the ones found in the "Rope Cave" were not made by the hand rolling method (see "production").

The majority of the cabled ropes from Berenike seems to have been made to lock the ply, rather than to create thicker cordage.[103] Moreover, there is a certain amount of cabled cordage that originates from baskets: the handles were usually cabled. Research on the Berenike cordage, as well as the study of isolated ropes (see below), suggest that, for thicker cordage, rope-makers preferred to insert a third yarn and/or increased the diameters, rather than cabling: the number of cabled ropes is lower than the number of plied ropes, even when not taking into account the fact that a part of the cabled ropes were actually basketry handles. The ropes from the Old Kingdom Cheops boat were also plied rather than cabled.[104] The reason for this preference might be that one needed strong but flexible ropes: in general, cabled ropes are less flexible.[105] At Berenike the sZ twist occurs slightly more often with ropes,[106] the reason for which cannot be satisfactorily explained: why did the rope makers not add another yarn to a zS_2 string or rope to increase the diameter rather than creating sZ twisted ropes when thick, heavy ropes were needed?

Measurements and CIP

Table 1 shows the measurements of the coils. They can be roughly divided into two groups. Group One, the larger group, consists of an average diameter smaller than 15 mm for the yarn, and smaller than 30 mm for the ply. Group Two ropes have a diameter larger than 15 mm for the yarn, and larger than 30 mm for the ply (coil nos. 2, 10, 14, and 18). The rope of one coil (coil no. 7) shows an average diameter close to 15 mm (14.5 mm) and still has an overall diameter larger than 30 mm, whereas the ropes of two coils (coil nos. 9 and 11) have smaller yarns (13.6 and 13.5 mm, respectively) and an overall diameter of about 30 mm (30.5 and 29.8 mm, respectively). The differences in diameter within one rope are very small for the yarn; the differences in diameter of the ply are somewhat larger, but still surprisingly small. The small differences indicate that the ropes suffered only slightly or not at all from loss of internal cohesion. The bigger differences in overall diameter (i.e., ply) confirm this, as generally these are the coils, which are less well preserved. The slight differences in diameter are an indication of the considerable skill of the rope makers. The relatively larger differences in diameter in bunches of rope no. 8 and coil no. 18, also suggest different coils, but this could be due to their state of preservation (see above). Cordage in an archaeological context is vulnerable to deterioration, resulting in a loss of internal cohesion. However, the larger the CIP (i.e., the tighter the yarns are plied), the less likely it is that the ropes will lose their internal coherence. As the plies unlock and the yarns fall apart, the measurements are increasingly less representative of the original diameter. An indication of the rope's original tightness can be obtained by measuring along the entire length at spots that were affected least: the CIP is lower at the ends of a linear piece as the ends are prone to loosening. Measurements are less reliable when the rope is bent or otherwise distorted;

[103] Veldmeijer, "Statistics."

[104] Nour and Iskander, *The Cheops Boats*. Other examples of thick ropes which are plied rather than cabled are the famous rope in the Egyptian Museum Cairo from Deir el-Bahri and the papyrus specimen in the Agricultural Museum Cairo; see Elhamy A. M. Greiss with K. Naguib, "An Anatomical Study of Some "Sedges" in Relation to Plant Remains in Ancient Egypt," *BIE* 37 (1956), 234–57, esp. 252–53. The cabled fragments from Deir el-Bahri described by Ryan and Hansen, *Cordage in the British Museum*, 11–14, figs. 7G, K, all have small diameters ("string" in the terminology used in the present work), or the fragment is a coincidental "rope"' (i.e., a piece of cordage that was made with a far smaller diameter originally and turned into a thicker one accidentally) as in the case of EA 43222. More on cabled cordage in representations in "Function of the ropes." Cabling, according to Damien Sanders (personal communication September 2008) "only becomes used for specific purposes with the advent of machinery in the later Middle Ages, and cables are only made to order when they are needed."

[105] Which is mainly due to the increasing Cord Index, see also "Strength."

[106] Veldmeijer, "Statistics."

this accounts at least in part for the differences in CIP.[107] In order to prevent the rope from losing its internal cohesion the ends can be knotted into a stopper knot (usually overhand knots[108]), but such knots have not been found in the ropes stored in Cave 5.[109] The CIP values show, as with the measurements of the diameters, a relatively small variation, suggesting a considerable degree of care (and/or experience) in producing the ropes.

The estimated length of the most complete, and seemingly also the largest coil, no. 2, is at least 30 m (see Table 1 for the less accurate estimates of the less well preserved coils).

Strength

Modern shipping ropes in Western societies are often made of synthetic fibers, which are extensively tested on pulling strength[110]: this is crucial in order to make the correct choice of rope for a ship, for example. Testing 4,000-year-old ropes is impossible and the only alternative would be to test modern cordage made using the ancient technology and the appropriate materials. However, such experimental testing is complicated and expensive, not the least because one needs controllable circumstances. There is, in other words, a severe lack of data on the pulling strength of ancient ropes. Various strategies to determine the ropes' original strength are currently being explored, but some preliminary working assumptions on the relative strength of (ancient) cordage can be made, as follows:

1) A piece of cordage with a diameter larger than 10 mm is stronger than a piece of cordage with a diameter less than 10 mm. However, there are limits regarding the use of a certain quantity of material because adding material increases the diameter, and this could render the rope too thick for its intended purpose.
2) An increase in the number of yarns increases the strength of the rope, hence the choice of a third yarn. This has another advantage: the third yarn locks the other two together (especially when it is inserted in a second production phase) and thus the internal cohesion of a rope increases. The insertion of even more yarn strands might further increase strength (although not necessarily so), but this has a negative effect on the ropes' flexibility, perhaps a good reason to limiting the number of yarns to three.
3) The tighter the rope is plied, the stronger the rope is, but this too reduces the flexibility of a rope. Moreover, up until a certain point, the CIP can increase but after that, it is likely to drop, simply because the additional amount of material prevents stronger twisting: the corpus from Berenike clearly demonstrates this.[111]
4) The preparation of the fibers before turning them into rope influences flexibility and strength. Bruised and beaten vegetable fibers (e.g., halfa grass[112]) are basically already damaged before the

[107] Because the length of three twists is used to calculate the CIP, the bent or otherwise malformed rope influences the result. Since the length of twists is not used in measuring the diameter, malformation is of much lesser influence. For detailed information on CIP see Wendrich, *Who's Afraid of Basketry,* 33–39.

[108] Veldmeijer, "Knots," 345–47 (including the references to Clifford W. Ashley, *The Ashley Book of Knots* (New York, 1993); cf. Wendrich, "Amarna Basketry and Cordage," 178–82; cf. Ryan and Hansen, *Cordage in the British Museum*, 29.

[109] This does not mean, however, that they were not there, as the ends might have been tucked in the coils. It is more likely that the ropes were used in such a way that the ends were tied, and thus there is no need for a stopper knot.

[110] Han Valk, *VOC-schip onder Zeil. Zeilmaken met Oog voor het Verleden* (Amsterdam, 1995), 36–38. Much information on strength of natural and synthetic fibers is available online: http://www.langman.com, http://www.caves.org/section/vertical/nh/50/knotrope.html, http://www.traditionalropecompany.co.uk (all visited 19 August 2008).

[111] Veldmeijer, "Statistics." But see the remark on shrinkage.

[112] Greiss, "Anatomical Identification of Plant Material from Ancient Egypt," 249–83; note, however, that this contrasts principally with Wendrich's ethno-archaeological observations; Wendrich, *The World According to Basketry*, 283, stating that the material was dried and wetted before use, but not bruised.

twisting starts: using them without this process means using stronger fibers. Note that the Mersa/Wadi Gawasis ropes from the cave do not show extensive preparation of the fibers.

5) Ropes, twisted in alternating twist, are stronger, because the first layer (i.e., yarns) is locked due to the opposite direction of the ply. As a consequence, they are less prone to loosening or falling apart and hence are stronger. The tightness increases by using wet material, which shrinks when drying and thus causes the fibers to cling together more tightly.[113] This might be the reason that rope-making was done in the caves, as seen in *Grotta dei Cordari* mentioned before.

To what extent formalized testing was carried out in antiquity is not known, but awareness of the factors that affect rope strength is apparent in the choice of its composition (sZ_3 rather than the more common sZ_2/zS_2), the amount of material (larger diameters) used, as well as the choice of material (the woody reed rather than halfa grass, for example).

Function of the Ropes

The function of the ropes can tentatively be determined by a study of the ropes, their archaeological context, as well as visual and textual evidence from ancient Egypt. The ropes do not show any obvious wear. This suggests that they have not been used (extensively), although one must remember that the degree of wear on a rope depends on its task. Moreover, spare ropes might have been aboard a ship to replace broken ones, or could have been brought to the cave and stored as back-ups for future use. The analysis of the context and associated materials might help in the interpretation of this find, but in most cases the function of string and rope cannot be identified with certainty: a piece of linear cordage can be used for many different things, or a single one repeatedly. However, the functions of some cordage, if made for a specific purpose, are limited, as is the case with the ropes in Cave 5. Figure 7 shows a theoretical graph based on diameter and CIP. Optimal function of the ropes occurs when they are used for the intended purpose for which they were made (II in fig. 7B; see below), but they will naturally be less suitable for tasks that require ropes that are less thick and strong, and this type of rope will increasingly not be used because it is simply too thick, heavy and inflexible (I in fig. 7B). For tasks requiring even stronger ropes, there will also be increasingly less application of this type of rope because it is not strong enough, but it might be used more often than on the other side of the optimum (also because the ropes can be combined; III in fig. 7B). An example, deliberately exaggerated, will clarify this. As will be argued below, we think the ropes were used as standing rigging,[114] or as a hogging-truss, the longitudinal ropes that were used to give structural cohesion to seagoing ships,[115] the purpose for which they were made. It might not be wholly unthinkable they were also used to tie an anchor. However, they would not be suitable for re-use in, for example, fish nets, or to repair broken sandals, because of their thickness and inflexibility. On the other end of the spectrum, however, a thinner rope might be better suitable as hogging-truss, although it would be more prone to breakage than ropes made for that specific purpose. An alternative, then, might be to use more ropes in order to lift the force on one rope and distribute it to all of them. This theoretical approach is, one should realise, more helpful with thicker and specially made

[113] Personal communication with A. J. Clapham (August 2008). A similar procedure is seen in the use of rawhide strips, for example, as used in axe lashing.

[114] The standing rigging or shrouds are a set of ropes of a sailing vessel supporting the mast from the sides.

[115] "The girt-ropes, of which there was one forward and one aft, were heavy cables passed right round the hull at bow and stern, primarily to provide a secure anchorage for the hogging-truss. This latter, which may be considered a substitute for the keel, was a stout cable, which fastened at either end of the girts, passed fore and aft over crutches practically the whole length of the ship, and was maintained at considerable tension," Raymond O. Faulkner, "Egyptian Seagoing Ships," *JEA* 26 (1940), 3–9, esp. 4–5 but see below for comments on cabled ropes in representations.

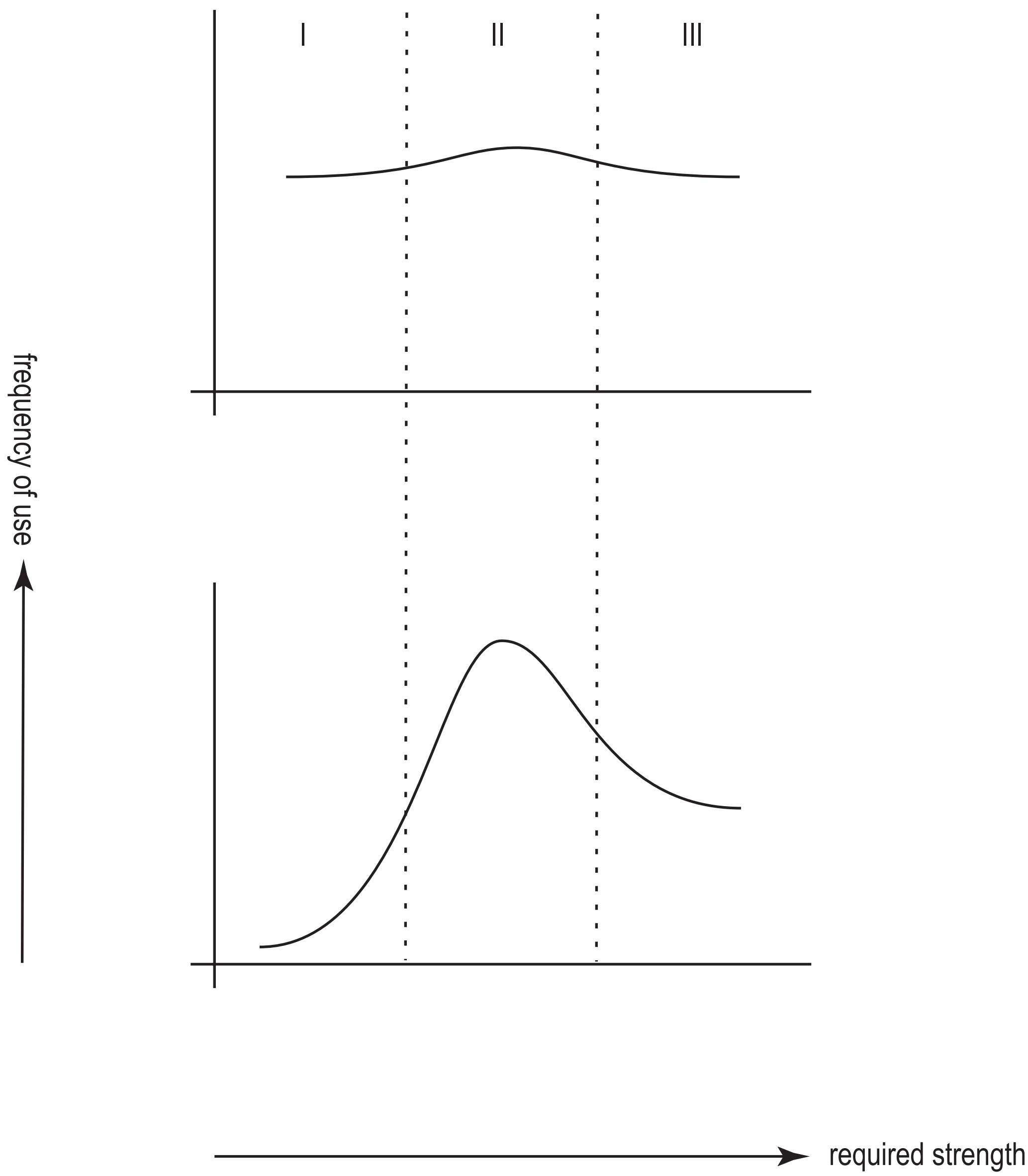

Fig. 7. Simplified graph to show the application of rope/string. The thicker a rope, the less often it can be used for tasks outside the task it was made for, especially for those requiring less thick ropes. Thinner ropes/strings are less specific and can be used for more tasks, hence a flatter curve.

A) The most often encountered string, zS_2 of average CIP and made of grass (based on the research of the cordage from Berenike; on the day-to-day use of zS_2 linear cordage see Veldmeijer "Statistics"). The small diameter and flexibility makes it suitable for many tasks; the optimum use is therefore almost non-existent.

B) The more specific a piece of linear cordage is (here: large diameters, lower flexibility), the less suitable it is for using in other tasks than that for which it is meant. It will (almost) never be used for tasks that requires string with a small diameter (I), and seldom, but more often, for tasks that require even stronger ropes (III). The optimum, i.e., the task for which it is specifically made, will show the main frequency of use (II).

cordage: thinner cordage can be used for more tasks (hence a flatter curve; fig. 7A). Note that it does not mean that cordage was not used for less suitable tasks.

Ancient Egyptian reliefs showing scenes of rope production appear mainly with scenes of boat building, certain agricultural scenes, or in conjunction with swamp environments.[116] Rope was essential for ancient Egyptian boats and ships for a variety of purposes: as standing rigging and running rigging,[117] for tying the oars and rudders, and to give structural cohesion (stitching) to the hull of the ship. For example, the hull in papyrus boats consisted of bundles tied together with rope, as shown in many tomb scenes. Rope was also used to fasten the wooden planks of the hull in larger boats, as archaeological evidence from the Cheops boat,[118] the Abydos boat remains,[119] the Lisht timbers,[120] and some planks from Mersa/Wadi Gawasis demonstrate.

Thus, interpretation of the excavated contexts at Mersa/Wadi Gawasis strongly indicates that cordage was used in maritime activities, including ship construction, as mentioned above.[121] Although the diameters of some of the ropes in Cave 5 are too wide to have been used in lashing, others might have been utilized for this. The ropes are too thick for fastening the steering oar and the rudder, but anchors have holes large enough to accommodate them and since there is no need for flexibility in anchor ropes, but because they do need to be strong, it cannot be excluded that ropes, such as those found in Cave 5, would have been used for this task. However, the sheer quantity of ropes in Cave 5 suggests another (additional?) function. One of these possible functions is as mooring rope, as shown in some reliefs and depictions,[122] but we still do not know where the mooring place was, or how boats and ships were moored at Mersa/Wadi Gawasis.

We can exclude the possibility that the ropes from Cave 5 were used in running rigging: they are simply too thick and heavy. The most suitable application for the ropes seems to be as a function requiring considerable strength to hold tension, such as the hogging-truss or standing rigging. The fact that all the coils have roughly the same estimated length (table 1) supports the hypothesis of the hogging-truss. The hogging-truss is variable in length, depending on the length of the ship. The ship remains found thus far allow us to reconstruct the maximal length of the ships at 14.4–20 m.[123] This would leave several meters at each end for tying the rope. However, since the hogging-truss runs above the deck with a curve, and is supported by forked stanchions, as shown in the iconography, less than 5 m would be available, which still might be enough to tie it conveniently. A possible stanchion was found at Mersa/Wadi Gawasis.[124] Its forked end is ca. 7 cm wide, large enough to hold two ropes of ca. 3 cm in diameter, which neatly fits the measured diameters of the ropes (table 1).

The hogging-truss is usually represented as the thickest rope on a ship. It appears in Old and New Kingdom representations of seagoing vessels and cargo boats, and in the relief of the Hatshepsut

[116] Teeter, "Techniques and Terminology of Rope-Making," 74. See also n. 59.

[117] The running rigging is a system of ropes to control or set the yards and sails.

[118] Nour and Iskander, *The Cheops Boats.*

[119] Cheryl Ward, "World's Oldest Planked Boats: Abydos Hull Construction," in Carlo Beltrame, ed., *Ship Archaeology of the Ancient and Medieval World* (2003), 19–23, esp. 20–21 and fig. 5.4.

[120] Cheryl Ward, *Sacred and Secular: Ancient Egyptian Ships and Boats,* New Monographs Series, No. 5 (Philadelphia, 2000), 111 and fig. 63a.

[121] See "Introduction."

[122] See, for example, Aylward M. Blackman, *The Rock Tombs of Meir. Volume I. The Tomb-Chapel of Ukh-hotp's Son Senbi* in Francis L. Griffith, ed., *Archaeological Survey of Egypt* (London, 1914–1953), plate IV. Another example is found in Davies, *Rekh-mi-re*, pls. 81 and 82.

[123] This is the maximal estimated length of ships navigating in the Red Sea, on the basis of ship timbers remains from Mersa/Wadi Gawasis. See Zazzaro, "Nautical Evidence."

[124] Cheryl Ward, "Ship Components," in Fattovich and Bard, "Joint Archaeological Expedition at Mersa/Wadi Gawasis." Cheryl Ward with Chiara Zazzaro, "Ship Evidence," in Bard and Fattovich, *Harbor of the Pharaohs*, 135–60, esp. 139, fig. 61.

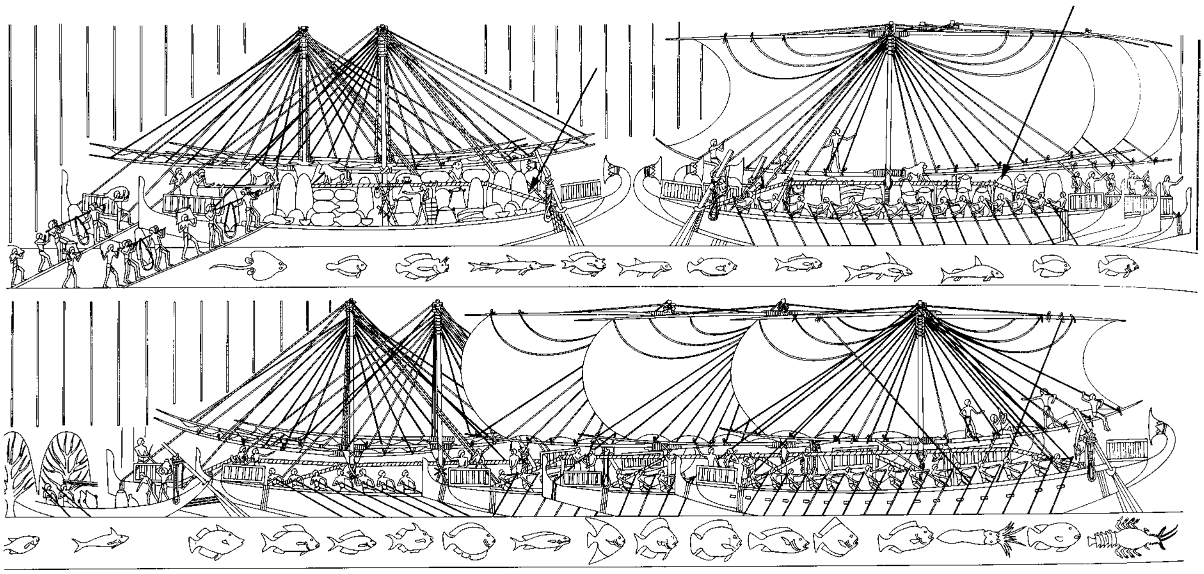

Fig. 8. Detail of the expedition to Punt from Hatshepsut's mortuary temple at Deir el Bahari. The arrows point to the hogging-truss (from: Walter-Friedrich Reineke, "Techniek en wetenschap," in Arne Eggebrecht, ed., Het oude Egypte [Bruna, 1986], 365–94, esp. 378).

obelisk barge. The hogging truss was employed to give longitudinal support to transport heavy loads, and, in the case of seagoing vessels, to resist the action of sea waves (fig. 8).

The earliest representation of a hogging-truss on seagoing ships can be found in the reliefs of the Sahure's funerary temple at Abusir. In this representation it seems that several ropes are twisted together in a hogging-truss to form a thicker cable.[125] Ships represented in the tomb of Khunes also show a hogging-truss that must consist of cabled rope.[126] We assume it very unlikely that the yarns are depicted, being plied into ropes on board.[127] In the Sahure's ships a pin is set between two ropes in order to tighten the cabling. However, according to Faulkner,[128] "In this ship the hogging-truss consisted of parallel strands of rope seized together at intervals, and was not "laid" after the manner of a cable." As explained, cabled ropes never seem to have been used because the ancient Egyptians preferred to increase the diameter, together with inserting an extra ply. Thick cabled ropes are not known from the archaeological record, but *if* this interpretation of the rope is correct (i.e., they are cabled), it might very well be that the ropes, as found in the "Rope Cave," were cabled aboard, possibly together with the fastening of the hogging-truss to bow and stern. This may have been done with the aid of tools (e.g., pin-like objects as seen in the depictions), inserted between the plies and turning it as seen in the Sahure reliefs.[129] Remarkably, the hogging-truss in the Sahure relief is

[125] Ludwig Borchardt, *Das Grabdenkmal Des Konigs Saꜣhu-re: Band II: Die Wandbilder* (Leipzig, 1913 [reprint Osnabrück, 1981]), pl. 13.

[126] Edward Morgan Rogers, *An Analysis of Tomb Relief Depicting Boat Construction from the Old Kingdom Period in Egypt* (M.A. Thesis, Texas A&M University, 1996.

[127] See above. It would result in very weak ropes. Moreover, yarns have no internal cohesion and would be difficult to handle, as seen in the scenes. The tightening of them would almost certainly result in breakage due to the low cordage index.

[128] Faulkner, "Egyptian Seagoing Ships," 5.

[129] Borchardt, *Das Grabdenkmal Des Konigs Saꜣhu-re,* pl. 13.

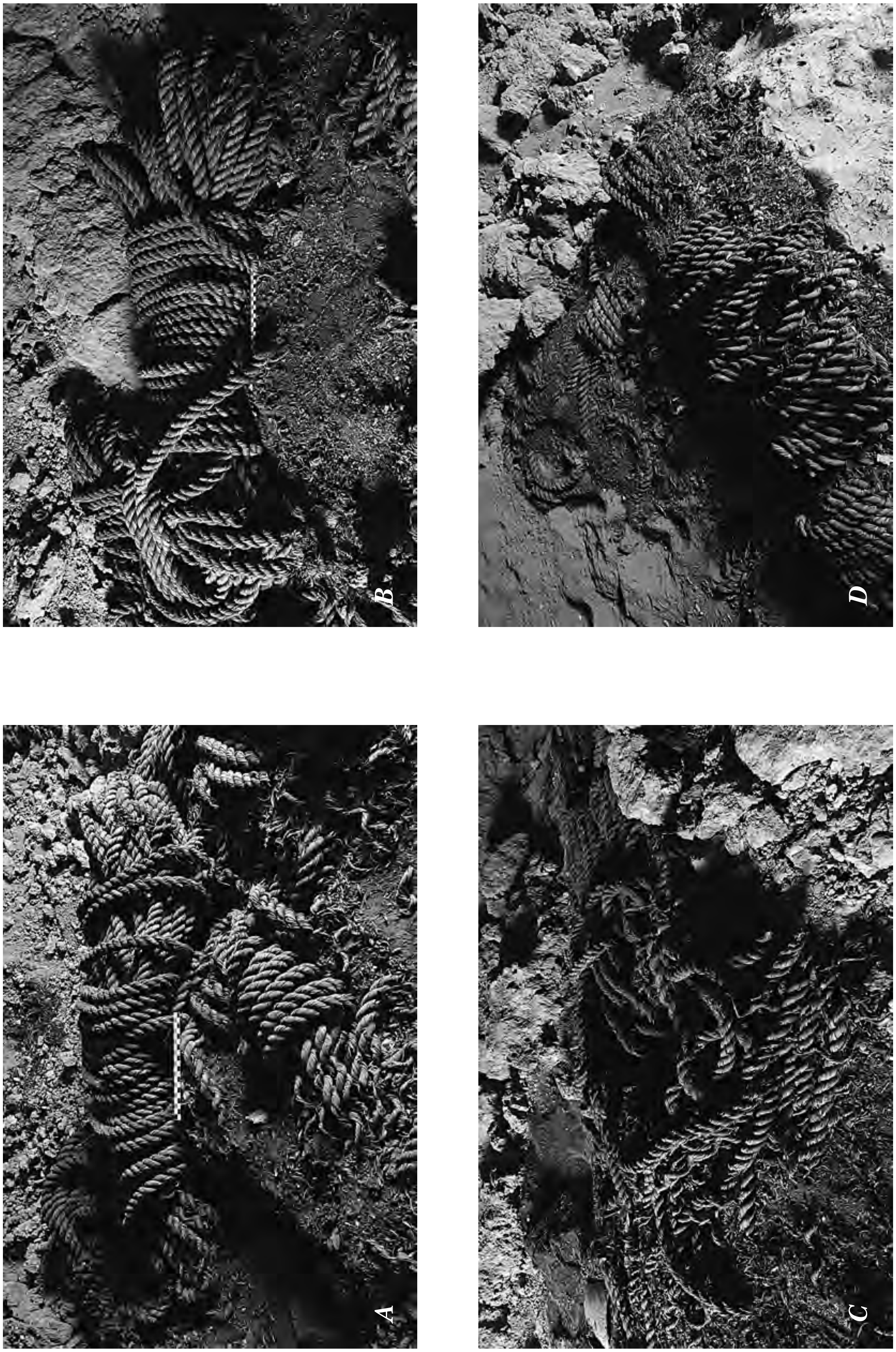

Fig. 6. The top layer consists of 18 recognisable coils (including two conglomerations of ropes, see text). These have been numbered (see fig. 3) to allow detailed research. A) No. 1; B) No. 2; C) No. 3; D) Nos. 4 (top) & 5 (bottom); E) No. 6; F) No. 7; G) No. 8; H) No. 9; I) No. 10; J) No. 11; K) No. 12; L) Nos. 13 (top) & 14 (bottom); M) Nos. 15 (top) & 16 (bottom); N) No. 17; O) No. 18. Photography by C. de la Fuente UNO/BU Project.

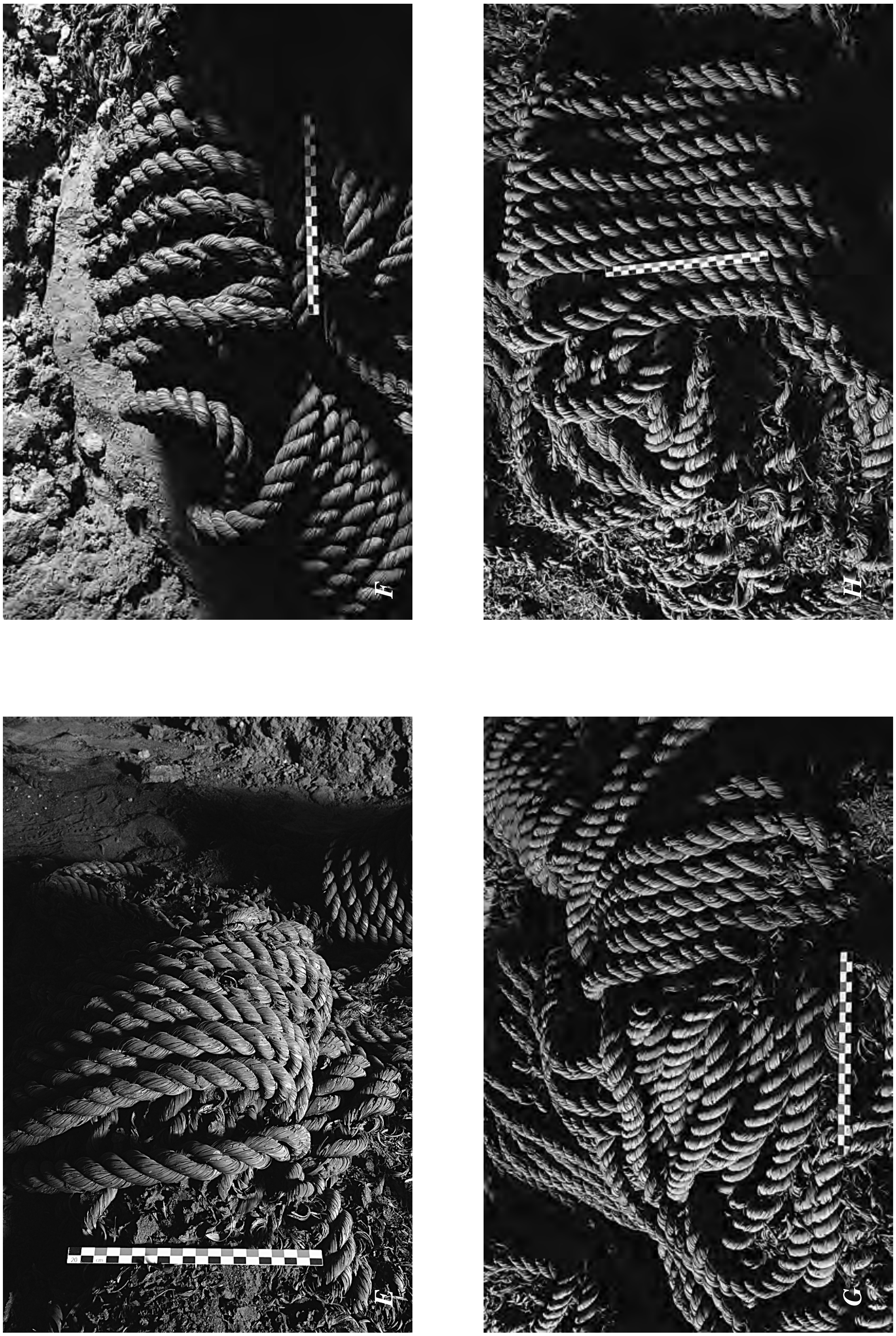

Fig. 6 E-F-G-H

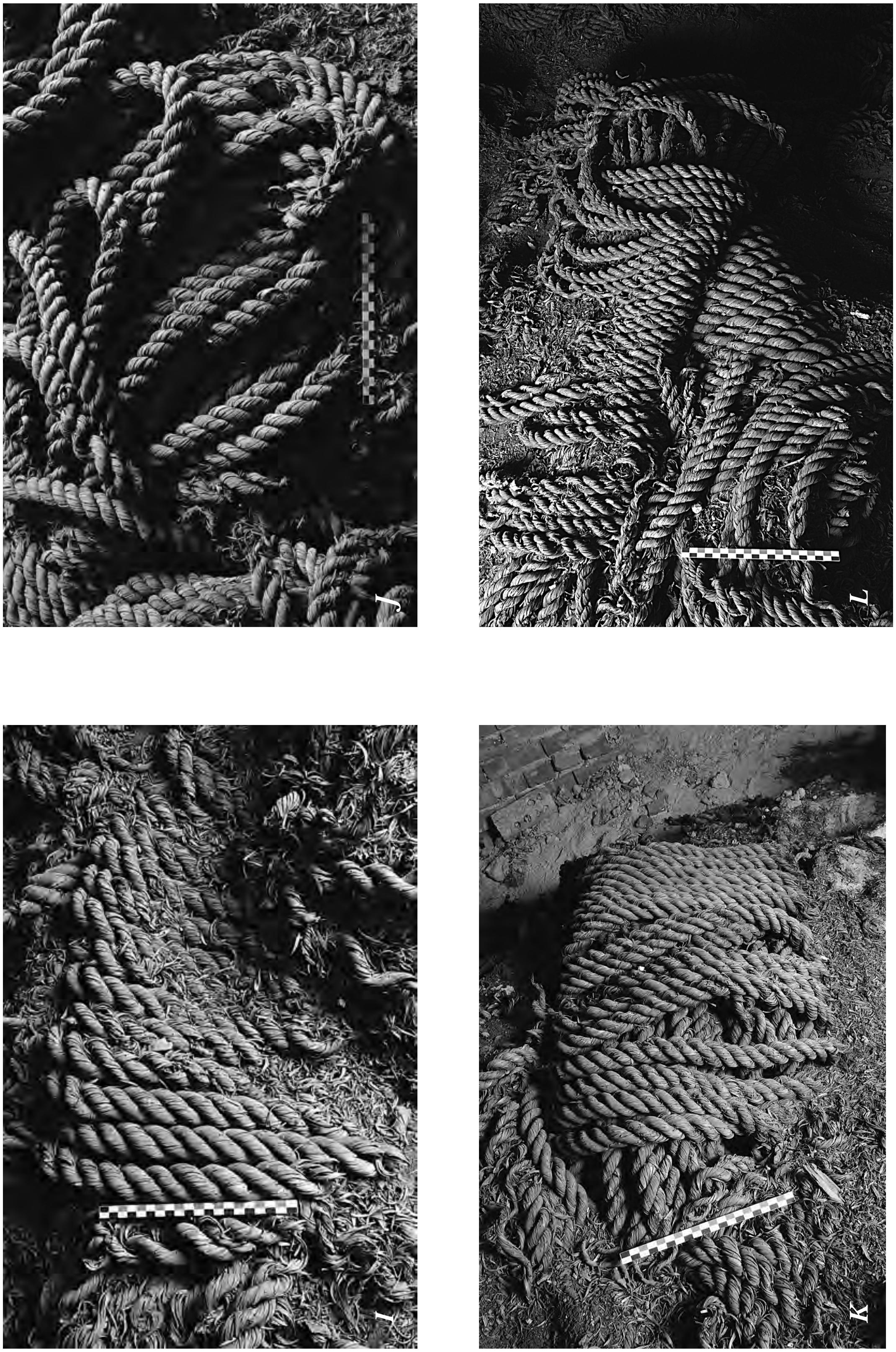

Fig. 6 I-J-K-L

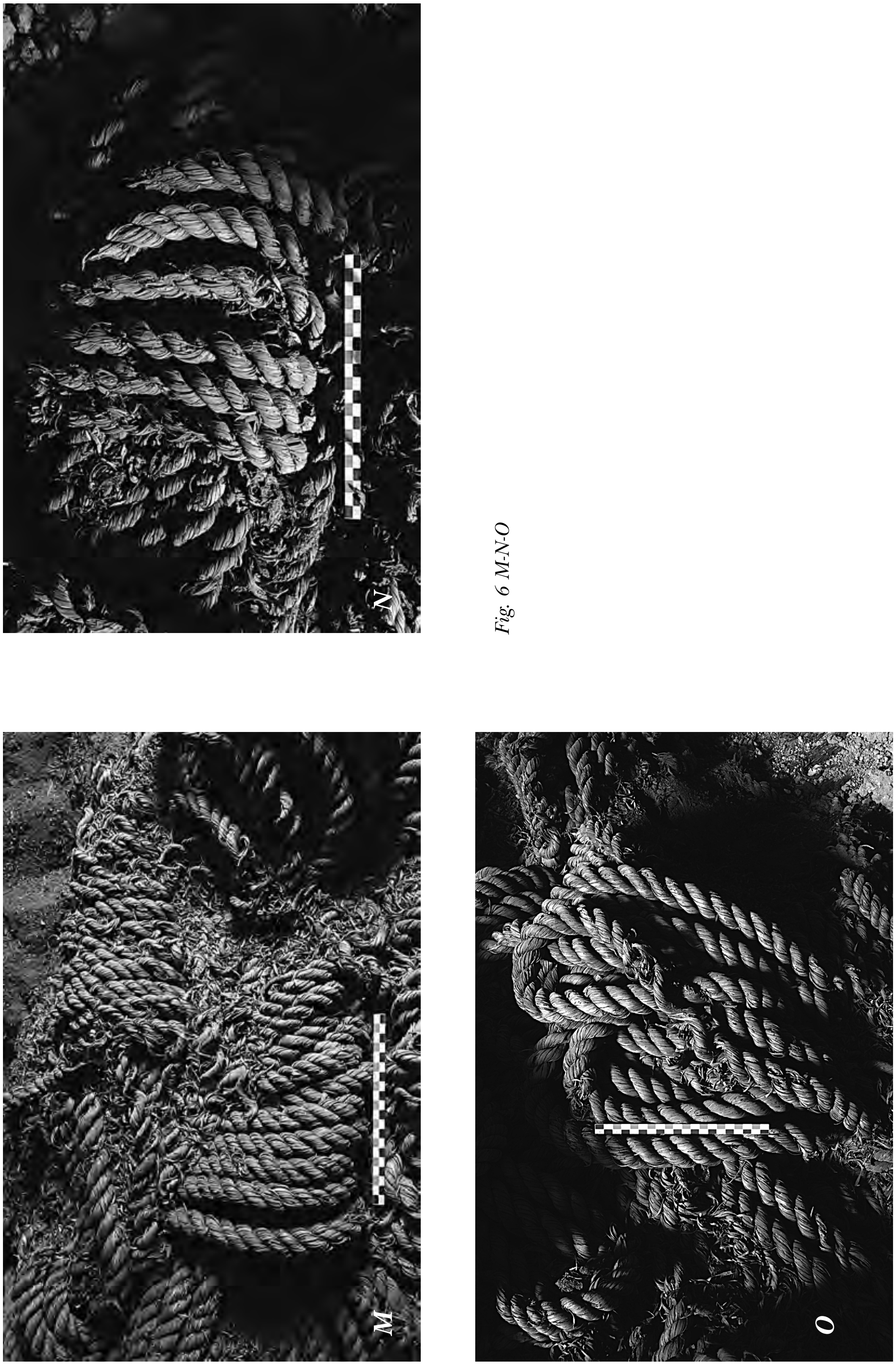

Fig. 6 M-N-O

depicted, partially, with the S-twist, whereas finds, including the Mersa/Wadi Gawasis ropes, suggest that usually strong, thick ropes are made in Z-twist. However, generally, if two plied linear pieces of cordage are cabled, it is in opposite direction (see "Terminology," fig. 2), resulting in the S-twist. Note that the other ropes represented in the reliefs of the Sahure ships are thinner and, in general, of the opposite orientation.[130] In the Hatshepsut Punt expedition scene[131] the hogging-truss is shown as a rope twisted in a different direction on two ships; both sZ and zS are drawn. Although there are indications that the depiction of twist is seemingly random rather than a truthful rendering of ropes,[132] the nearly[133] exclusive rendering of the hogging-truss in the S-twist might suggest it was depicted like that intentionally. Note also that the ropes, connecting the hogging-truss at bow and stern, are often (but not exclusively) drawn in the Z-twist. It is not entirely certain when the coils in Cave 5 were deposited, but assuming they were deposited together as explained, the quantity suggests they were the ropes for several ships, probably including coils of spare ropes to replace broken ones.

Note on Other Cordage Finds

Besides the ropes from the "Rope Cave," at least five different types of rope have been recorded at Mersa/Wadi Gawasis, which vary in diameter, composition and possibly material.[134] About two-thirds of this cordage consists of rope made of a thin fiber spun in an S or Z-direction and composed of a single strand, or of two yarns plied in an S-direction; the strand diameter is generally less than 7 mm. About one-third of the cordage consists of ropes with a fiber thicker than 2 mm, s-spun, and three yarns Z-plied; the strand diameter is generally from 7 mm to 30 mm.[135]

Summary

The ropes at the Mersa/Wadi Gawasis site are an extraordinary archaeological find without precedent in the ancient world. Their study is valuable for our understanding of both rope-making and seafaring in pharaonic Egypt. The strong, well-made ropes indicate a good working knowledge of strength and durability, and may suggest a (semi-) professional craft, despite the absence in texts of a term for "rope maker." The choice of the material, reed as opposed to halfa grasses (halfa grasses have been much used in ancient Egypt and must have been available in abundance in the vicinity of the harbor), confirms this conclusion: they were chosen for their strong, woody fiber. Other finds that might support this conclusion are the *Phragmites* ropes found with a Bronze Age shipwreck at Cape Gelidonya.

The Mersa/Wadi Gawasis ropes must have been produced by several individuals working together (in the absence of ropewalks), a suggestion that is supported by iconographic evidence. Specialized manufacturing and standardization of production have been recognized in other materials from the site with a nautical function, such as anchors and ship timbers. Evidence of cleaning and reworking ship timbers in the entranceway of Cave 2 suggests that some of the ship parts were modified or sal-

[130] Obviously it is not possible to give the exact indication of size on the basis of these scenes, but the difference in depicted size between the hogging-truss and the other cordage was apparently important. One wonders if the hogging-truss was depicted larger to emphasize its importance.

[131] Édouard Naville, *The Temple of Deir el Bahari III* (London, 1907–1913), pls. 72–75.

[132] There are many examples of depicted cordage in which the artist erroneously changed the orientation of the twist in one piece of cordage. This happens especially when the rope runs, for example, in a loop. This seems to support the randomness of the depiction of twist.

[133] The only exception being the partial rendering in the Sahure vessel.

[134] Zazzaro, "Cordage," 190–94.

[135] Zazzaro, "Cordage," 190–94.

vaged at the site, as well as stored there. Considering the fact that the necessary raw material for the ropes in all probability grew in the immediate vicinity of the site, it is likely that the ropes were made at the harbor, possibly in the caves themselves. This would reinforce the already suggested complexity of organization involved in seafaring expeditions departing from Mersa/Wadi Gawasis.[136]

Study of the ropes also supports the theory that the twist of cordage is influenced by the property of the material rather than the right- or left-handedness of the makers.

Based on the diameter, CIP, length and quantity of the ropes, their function would have been either as a ship's standing rigging, its hogging-trusses, or both. Although cabled ropes were not used in ancient Egypt for tying, and are limited to basket handles, etc., we cannot wholly ignore the possibility that several of these ropes were cabled aboard while installing the hogging-truss, as is possibly shown in reliefs. The "Rope Cave" at Mersa/Wadi Gawasis has proved important for our understanding of cordage and ship rigging in ancient Egypt, but due to its unparalleled nature, more finds properly excavated are needed to confirm or reject our conclusions.

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[136] Bard and Fattovich, *Harbor of the Pharaohs*, 239–53.