Journal of the General Union of Arab Archaeologists
https://jguaa2.journals.ekb.eg/

Maritime and Underwater Cultural Heritage
in the Arab Region 9/2

The Origin of Using Dovetail Joints in Ancient Egyptian Boats and Ships

Article 6

Marwan Mady
Inspector of Underwater Antiquities/Ministry of Tourism and Antiquities, Egypt
marwan_fathy89@yahoo.com

Article Info: Received 31-12-2023;revised 13-05-2024; accepted 26-05-2024.
Available Online 01-06-2024

Recommended Citation

MADY, M.: «The Origin of Using Dovetail Joints in Ancient Egyptian Boats and Ships», *Journal of the General Union of Arab Archaeologists* 9/2, 2024, 91-103.
Doi: 10.21608/jguaa2.2024.259784.1163

THE ORIGIN OF USING DOVETAIL JOINTS IN ANCIENT EGYPTIAN BOATS AND SHIPS

ABSTRACT

[AR] **أصالة استخدام مفصلات ذيل الحمامة في السفن المصرية القديمة**

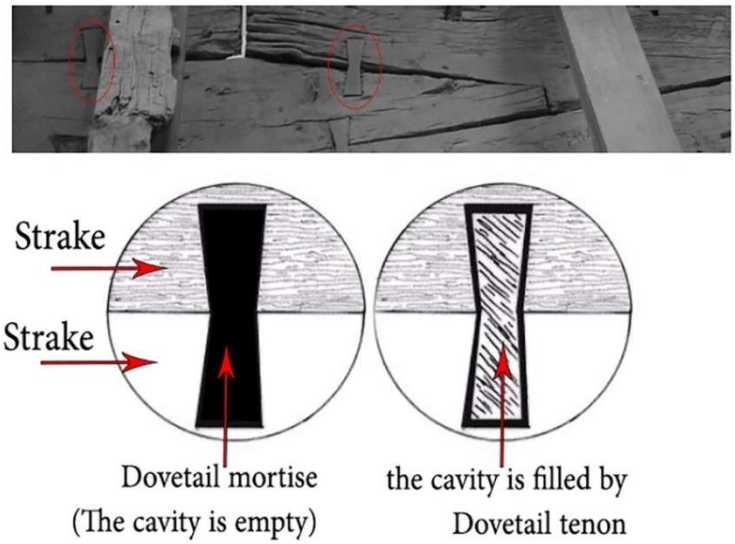
شهدت الحضارة الفرعونية تنوعًا في صناعة السفن طبقاً للوسط المائي الذي أبحرت فيه السفينة سواء نهر النيل أو البحرين الأحمر والمتوسط، بالإضافة إلى المسطحات المائية مثل البحيرات والقنوات. كان لبناة السفن خصائص خاصة في طرق ربط وتجميع ألواح المراكب، إحداها تُسمى ذيل الحمامة. على الرغم من ظهور طريقة ذيل الحمامة في الاثاث والتوابيت المصرية القديمة في العصور المبكرة، إلا أنها ظهرت لأول مرة في صناعة السفن فى الدولة الوسطى فى سفن دهشور، والتي كثر الجدل بين العلماء حول ماهية استخدام تقنية مفصلات ذيل الحمامة بالدُسرة أم بالخياطة في تلك السفن، حيث اختلفت أراء العلماء حول أصلية استخدام هذه التقنية؛ بعضهم يعتقد إن ذيل الحمامة استُخدم مع الخياطة وأن ما يوجد في الوقت الحاضر من دسُر ما هو إلا تجديد أَضيف بعد اكتشاف السفن في أوائل القرن الماضي عوضاً عن الخياطة، والبعض الأخر يعتقد أنه استُخدم مع الدسُر منذ القدم. مع مطلع القرن الحادي والعشرون، اكتشف علماء الآثار البحرية ألواح سفن تعود إلى فترة الدولة الوسطى في كهوف مرسى وادي جواسيس على ساحل البحر الأحمر، وعلى أحد هذه الألواح ظهرت نقر مفصلات ذيل الحمامة. تناقش هذه الورقة البحثية ماهية طريقة ذيل الحمامة في ربط ألواح السفن وأهميتها، وتستعرض اختلافات آراء العلماء حول استخدامها مع الخياطة أم الدسُرة، وتقديم ملاحظة الباحث التي تؤكد وتُحسم الجدل حول استخدام تلك المفصل مع الخياطة ام الدسُرة في سفن دهشور اعتماداً على مقارنتها بما ظهر في ألواح السفن من مرسى وادي جواسيس.

[EN] Ancient Egyptian civilization experienced a variety of ships designed for different bodies of water, including the Mediterranean, the Red Sea, and the Nile River, as well as lakes and canals. Shipbuilders used special fastening methods to assemble their ships, such as the use of dovetail joints. While the dovetail technique was applied in ancient Egyptian furniture and coffins, it was first observed in the Egyptian shipbuilding of Dahshur boats in the Middle Kingdom. The antiquity of dovetail joints with ligatures or tenons in Dahshur boats has long been debated by archaeologists. Thus, different theories have been presented on the originality of using dovetail mortise with ligatures or tenons. Some authors believed that it was originally used with ligatures, but tenons were modified after the boats' discovery in the early 20th century, while others argued that it was used with tenons from ancient times. In the early 21st century, archaeologists discovered the dovetail technique in ship timber at Mersa / Wadi Gawasis on the Red Sea, dating back to the Middle Kingdom. This paper aims to explore the significance of the dovetail technique in ancient Egyptian shipbuilding, as well as the various theories on its use with tenons or ligatures. It presents the author's analysis and observation to resolve the controversy about its use in Dahshur boats, based on a comparison with the ship timbers of Wadi Gawasis.

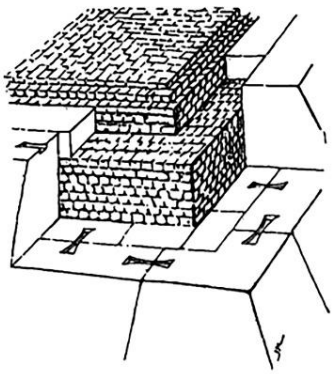
KEYWORDS: Assemblage, dovetail, tenon, shipbuilding, boats, ships, maritime archaeology, Middle Kingdom.

I. INTRODUCTION

First, what is the significance of the dovetail? It is a method of fastening used to assemble the hull planks to provide transverse reinforcement. This technique is embedded within the inner surfaces of the planks and consists of two components: the dovetail mortise and the dovetail tenon. The latter is a solid wooden piece, composed of two trapezoidal shapes meeting at their summits and positioned within the cavity of the former, which is divided into two sections at the seams of the planks **[FIGURE 1]**. The complete joint is used to secure the connection between each pair of planks from their internal surface[1]. The dimensions of the dovetail tenon are equal to those of the two parts of the dovetail mortise. Although the dovetail technique was observed in ancient Egyptian furniture and coffins in the fourth dynasty and was employed to join the blocks of the pyramid of Senwosret III[2] **[FIGURE 2]**, it initially appeared in the Egyptian shipbuilding of Dahshur boats in the Middle Kingdom[3].



[FIGURE 1]: Dovetail mortise and tenon joints © Drawing and photo used with the permission of P. Creasman. CREASMAN 2005: 13. Modified by the author.



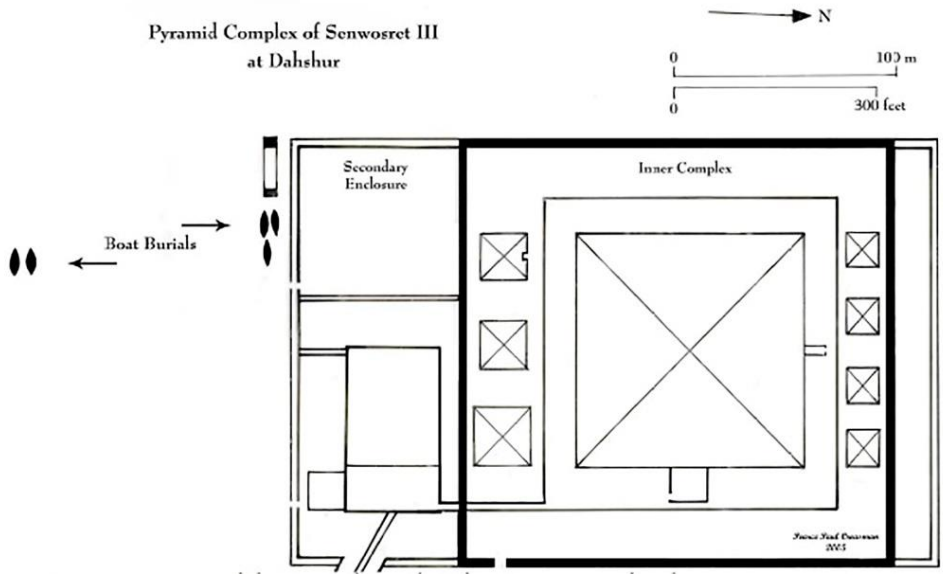
[FIGURE 2]: The pyramid blocks were connected by dovetail mortise and tenon © Drawing by De Morgan. DE MORGAN 1895:48, FIG.108.

[1] MCGRAIL 2004: 38; CREASMAN 2010:116.
[2] HALDANE 1984:100-101; DE MORGAN 1895: 48, FIG.108.
[3] WARD 2000: 93; CREASMAN 2005: 11.

II. ARCHAEOLOGICAL EVIDENCE

1. Dahshur Boats

Dahshur boats were discovered by Jaques De Morgan on the southeastern side of the southern wall of the funeral complex of the pyramid of Senwosret III in Dahshur **[FIGURE 3]**. They were dated back to 1850 BC[4]. Four assembled boats were found and divided into two groups, with a distance of one hundred meters. Two of these boats were initially kept in the Egyptian Museum in Cairo. However, they were relocated to the Sharm El-Sheikh Museum in 2020. The remaining two boats can be found in the Chicago Museum and the Carnegie Museum in the United States. Regrettably, the location of the fifth boat at the site remains unknown. All the boats are of similar size, featuring a rounded shape and constructed using arched brick-shaped planks. This design allowed the even distribution of stress across the hulls, and they were specifically designed to be Nilotic boats[5].



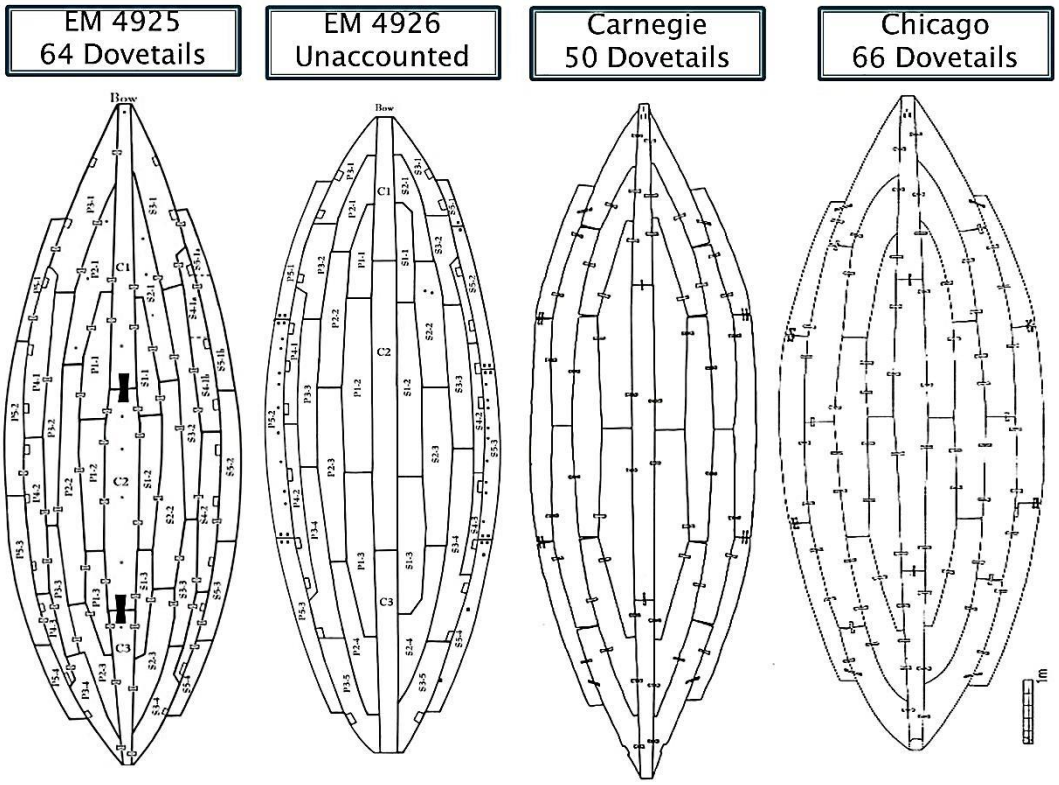
[FIGURE 3]: A plan shows the pyramid complex and the discovered boats in Dahshur © Drawing by Creasman. Drawing used with the permission of P. Creasman. CREASMAN 2005: 10.

2. Assemblage of the Dahshur Boats

The hull planks were firmly fastened using deep mortise and tenon joints, as the primary method of fastening in the Dahshur boat. These joints were arranged in transverse rows as internal frames, with every two joints placed in pairs at 5-15 cm from each other, while the distance between each pair was 25-60 cm[6]. Lashing methods were used in specific areas, such as between the ends of the bulwark strakes and the sheer strakes. Additional lashing was utilized to bind the extremities of the bow and stern strakes[7]. Dovetail joints were a common feature in Dahshur boats, with dovetail tenons measuring 13-17 cm long, 5 cm wide at the widest point, 3 cm at the narrowest point, and 2 cm deep. These joints were distributed at 70-100 cm from each other, with each

[4] HALDANE 1984: 3; WARD 2000: 84; ABD EL-MAGUID 2009: 59.
[5] MCGRAIL 2004: 37-38; CREASMAN 2010: 120-121,123.
[6] HALDANE 1984: 23-24; WARD 2000: 90, 92, 97; BELOV 2019: 107.
[7] CREASMAN 2010: 121.

half dovetail mortise measuring 8.5 cm long at the middle of the ship and 6.5 cm long towards the extremities of the boat. Additionally, bitumen was used by shipbuilders to fill the joints and seams to prevent any leakage[8]. The number of dovetail joints varied across the four boats: EM 4925 had 64 joints, EM 4926 had an unknown number, the Carnegie boat had 50 joints, and the Chicago boat had 66 dovetail joints[9] **[FIGURE 4]**.



[FIGURE 4]: Distribution and number of dovetail joints in each boat; Chicago and Carnegie boats. © Drawing by Ward. Drawings used with the permission of Cheryl Ward. HALDANE 1984: 14-49; EM 4925 and EM 4926 boats © Drawing by Creasman. Drawings used with the permission of P. Creasman. CRESMAN 2005: 48, 91; assembled and modified by the author.

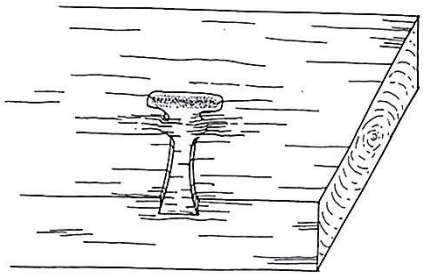
The originality of the dovetail tenon has been a subject of inquiry for a considerable period. Some scholars believe that the dovetail tenons are not original and were added as modern modifications after the excavation of the boats. In opposition, others argue that they are an original technique developed in shipbuilding during the Middle Kingdom.

3. Different Opinions on Dovetail Joints

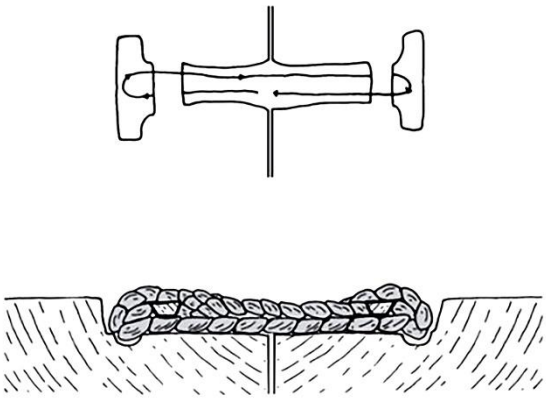
De Morgan[10], the discoverer of the boats, did not mention dovetails or lashing in his reports but reported the concealed mortise-and-tenon joinery between hull planks. Forthingham[11] pointed out that the boats needed repairs before being moved to the museum, and the hull planks were fixed with dovetail dowels and wooden treenails. Moreover, Reisner[12] observed that the Dahshur hulls were assembled using mortise and

[9] HALDANE 1984: 56-57, 100; Creasman 2005: 63; ABD EL-MAGUID 2009: 65; CREASMAN 2010: 123.
[10] DE MORGAM 1895: 82.
[11] FORTHINGHAM 1895: 72.
[12] REISNER 1913: XXIII.

tenon and tied planking. Although he could not confirm the use of dovetail with tenon or lashing, he believed that most dovetail tenons in these boats are modern. Clarke[13], on the other hand, described the state of the ship in the Egyptian Museum and stated that they were in bad condition, and it is difficult to distinguish between the old and new repairs in the boats because they were repaired after the discovery. Ward[14] believed that dovetails were used with ligatures in the original case, and those dovetail tenons were a recent modification, following the discovery of the boats in the last century. She noticed the shallowness of the dovetail mortises and interpreted the erosion in the edges caused by ligatures. She found the oval shapes of a few mortises **[FIGURE 5]**, well cut and located in the Carnegie hull, and these mortises were the bases of the ligature channels that escaped modification **[FIGURE 6]**. She presented proof that all the dovetails in all the hulls were modern and the assemblies were located in the same places as the ligature points in the Lisht planks **[FIGURE 7]**.



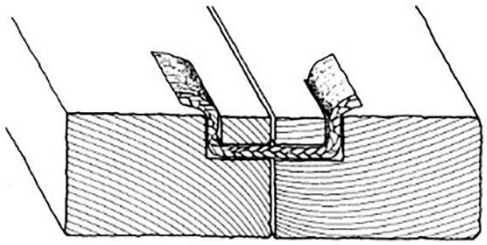
[FIGURE 5]: The oval shape of the Carnegie boat motivated Ward to think that they were used with a ligature © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 94, FIG. 43.



[FIGURE 6]: Ward's theory regarding the utilization of lashing as opposed to dovetail tenons for the assemblage of the Dahshur boats © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 95, FIG.44.

[13] CLARKE 1920: 7.

[14] HALDANE 1984: 101; WARD 2000: 93-94.

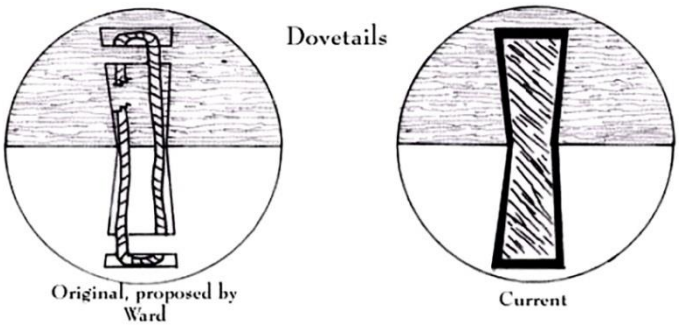


[FIGURE 7]: Lashing by single stitching or a single point in the Lisht timbers © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 118, FIG.63a.

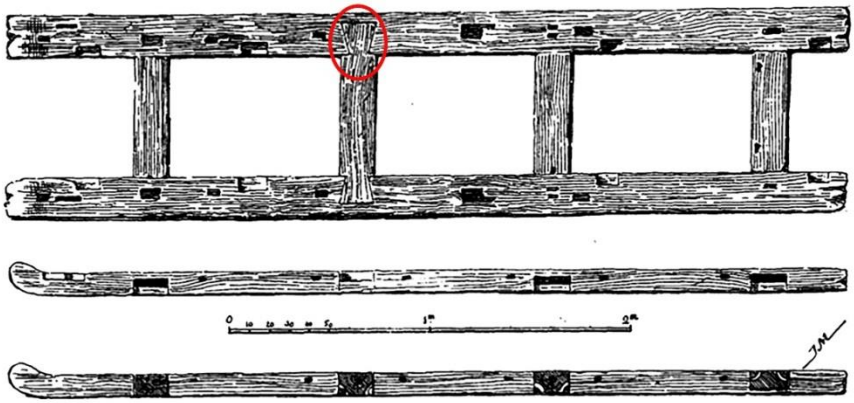
Steffy[15] thought that shipbuilders did not use lashings for edge joinery below the waterline in Dahshur boats, and the lack of frames seemed strange. However, the construction provided enough structural integrity for travel on the Nile. The tenons and mortises provided substantial bottom support, but secure dovetail fastenings or lashings still seemed necessary internally to prevent the planks from separating. McGrail[16] agreed with Ward and believed that the arrangement of the large tenons into mortises in all strakes, even if they were unpegged, could have ensured the hull.

Creasman[17] presented an alternative perspective, arguing that the fastening method was original, with dovetail tenons filling their respective mortises and conforming to the same Egyptian measurements (digit and palm) used in mortise and tenon joints. The dovetail tenons were approximately two palms long, 3 digits at the widest edge, and 2 at the narrow edges. The Cairo boats exhibited jagged edges resulting from ancient chisels, with no evidence of smooth edges caused by lashing straps. In contrast to the evidence found by Ward in the Carnegie boat **[FIGURE 8]**, there was a lack of proof regarding the presence of ropes or animal skin. Upon comparing the dovetail in the ships' timber of Wadi Gawasis, Creasman observed that it exhibited an opposing position on each side of the board, similar to the discovery of numerous half-dovetail tenons. This finding suggested a clear association between these tenons and the ship components[18]. Additionally, Creasman noted the existence of dovetail mortise and tenon joints in all four boats, despite variations in their numbers, suggesting their originality[19]. The discovery of three sledges with the boats, each containing at least one dovetail mortise tenon joint **[FIGURE 9]**, denoted the shipbuilders' familiarity with this fastening method. Creasman speculated that this technique might have been imported from countries conquered by the kings of the 12th dynasty, or it could have been a rapidly abandoned evolution, which explained its rare use in ship construction.

[15] STEFFY 1994: 35-36.
[16] MCGRAIL 2004: 38.
[17] CREASMAN 2005: 119-124.
[18] CREASMAN 2010: 117.
[19] ABD EL-MAGUID 2009: 68.



[FIGURE 8]: Comparison between Creasman's theory on using dovetail tenon and Ward's theory on using lashing © Drawing by Creasman. Drawing used with the permission of P. Creasman. CREASMAN 2005: 13, FIG.9.



[FIGURE 9]: A sledge was discovered with the Dahshur boats, probably used to carry the boat, bearing a dovetail tenon, see the red circle © Drawing by De Morgan. DE MORGAN 1895: 83, FIG.204.

In contrast, Abd el-Maguid[20] argued that De Morgan, the discoverer of the boats, did not mention or refer to the dovetail joints in his report. He only acknowledged the presence of mortise and tenon joints. Furthermore, Abd el-Maguid commented on Forthingham's note, which was published four months after the discovery, and did not consider it as evidence of the use of dovetail joints. He proposed that during the interim period, the boats might undergo some repairs, as Clarke realized that these ships were repaired after their discovery, due to their transfer to the museum. Abd el-Maguid supported Ward's theory because she had the opportunity to closely examine the hull planks of the Carnegie boat in the United States. In his opinion, after the discovery, the ligatures were replaced with tenons. However, the discovery of the Wadi Gawasis segment, which was analysed for the first time, revealed two opposite dovetail mortises on the inner face, suggesting that dovetail joints were likely used only between the first strake and the central strake. This was due to the hydrodynamics of the boat, which would cause the dovetails to break in the remaining strakes, necessitating the use of lashings instead of tenons[21].

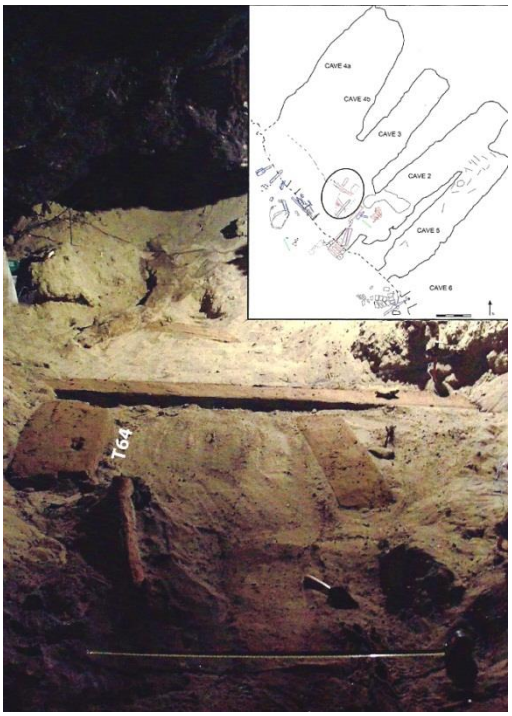
After presenting these contradicting viewpoints, a question arises as to whether the dovetail tenons observed in the Dahshur boats were ancient or a recent modification. Additionally, the significance of Wadi Gawasis ship timber in the context of shipbuilding will be considered.

[20] ABD EL-MAGUID 2009: 66-69.

[21] ABD EL-MAGUID, M. (Alexandria Library), interview by author. 17/05/2018.

4. T64 Hull Plank Segment

T64 segment was discovered in Cave 3 at Mersa/Wadi Gawasis, dating back to the Middle Kingdom, based on the information provided by a wooden box discovered in SU25 (strategic unit 25) in WG32 (Wadi Gawasis 32) near Cave 6. The box had an inscription referring to Amenemhet IV, the ruler of Egypt from 1786 to 1778 BC. In addition, the pottery and ceramics found in the caves referred to the Middle kingdom[22]. Furthermore, it exhibited noticeable resemblances to the boat construction techniques employed in the Middle Kingdom like those observed in Dahshur boats and Lisht timbers[23]. Mersa/Wadi Gawasis and its caves were constructed to facilitate state expeditions from Koptos to Punt. The ships were built at a shipyard along the Nile in Koptos, dismantled for transportation across the Eastern Desert, and then reassembled at the Red Sea harbors for their voyages **[FIGURE 10]**. T64 shed light on an ancient Egyptian technique for fastening ships, which could be compared to the method used in the construction of Dahshur boats. T64 referred to a section of plank that archaeologists have identified as being part of a ship's hull planks. It belonged to the first strake that was fastened to the keel[24]. It contained valuable information about the fastening methods employed, including pegged and unpegged deep and double mortise-and-tenon joints. Additionally, there was evidence of a ligature for copper strips and two opposite dovetail mortises on the inner face of the plank like in Dahshur boats[25] **[FIGURES 11-12]**.



[FIGURE 10]: T64 segment is lying along the length of Cave 3, with the permission of K. Bard & Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. ZAZZARO & CALCAGNO 2012: 77.

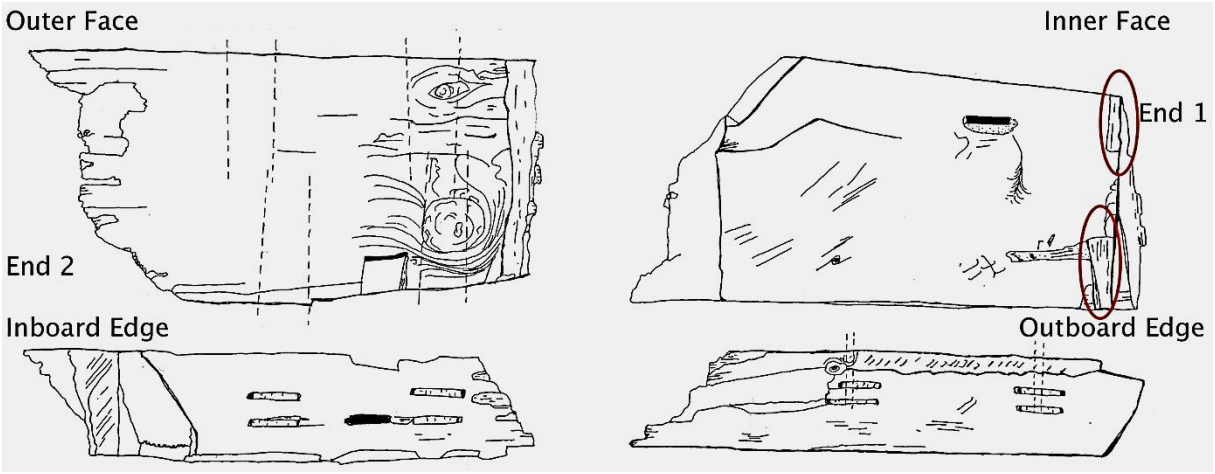
[22] MAHFOUZ & PIRELLI 2007: 47; PERLINGIERI 2007: 27-28; WARD et al. 2010: 389; FATTOVICH & BARD 2012: 23; MADY 2020: 2.

[23] WARD 2007: 137.

[24] Its dimensions are: 106 cm long; 50.5 cm wide; 22.5 cm thick.

[25] WARD & ZAZZARO 2010: 27-31,33-36,38,40; WARD et al. 2010: 387-388; MADY 2020: 2.

[FIGURE 11]: T64 segment shows two opposite dovetail mortises in the inner face of the plank, see the red circle. With the permission of K. BARD and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. ZAZZARO & CALCAGNO 2012: 79.



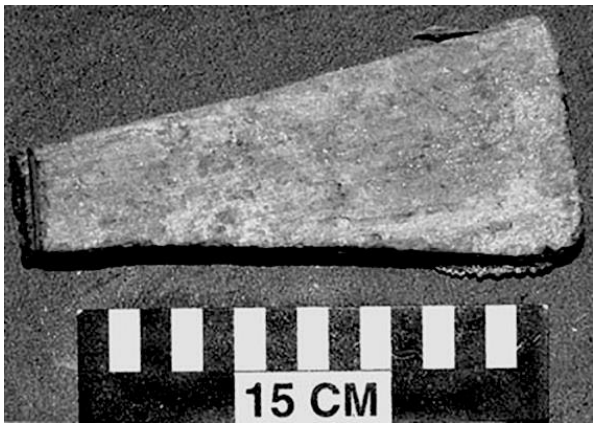
[FIGURE 12]: An illustration shows some fastening methods and the dovetail mortises, see the red circle ©Drawing by Ward. Drawing used with the permission of Cheryl Ward and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO; WARD et al. 2010: 388, FIG.1.

These dovetail mortises are the primary focus of this research. As noted by Creasman and Abd el-Maguid, there are similarities in the position of the dovetails when compared to Dahshur boats. This T64 segment served as the second piece of evidence of dovetail joints in shipbuilding in the Middle Kingdom. Ward and Zazzaro[26] compared the beams in Dahshur boats and those in Wadi Gawasis. They discovered similarities in the square holes found at each end of the beams. Furthermore, they observed that the beams in Wadi Gawasis were larger, indicating that they belonged to larger vessels. The author compared the dovetail mortise and tenon in Dahshur boats and the T64 segment.

[26] WARD & ZAZZARO 2010: 32,35.

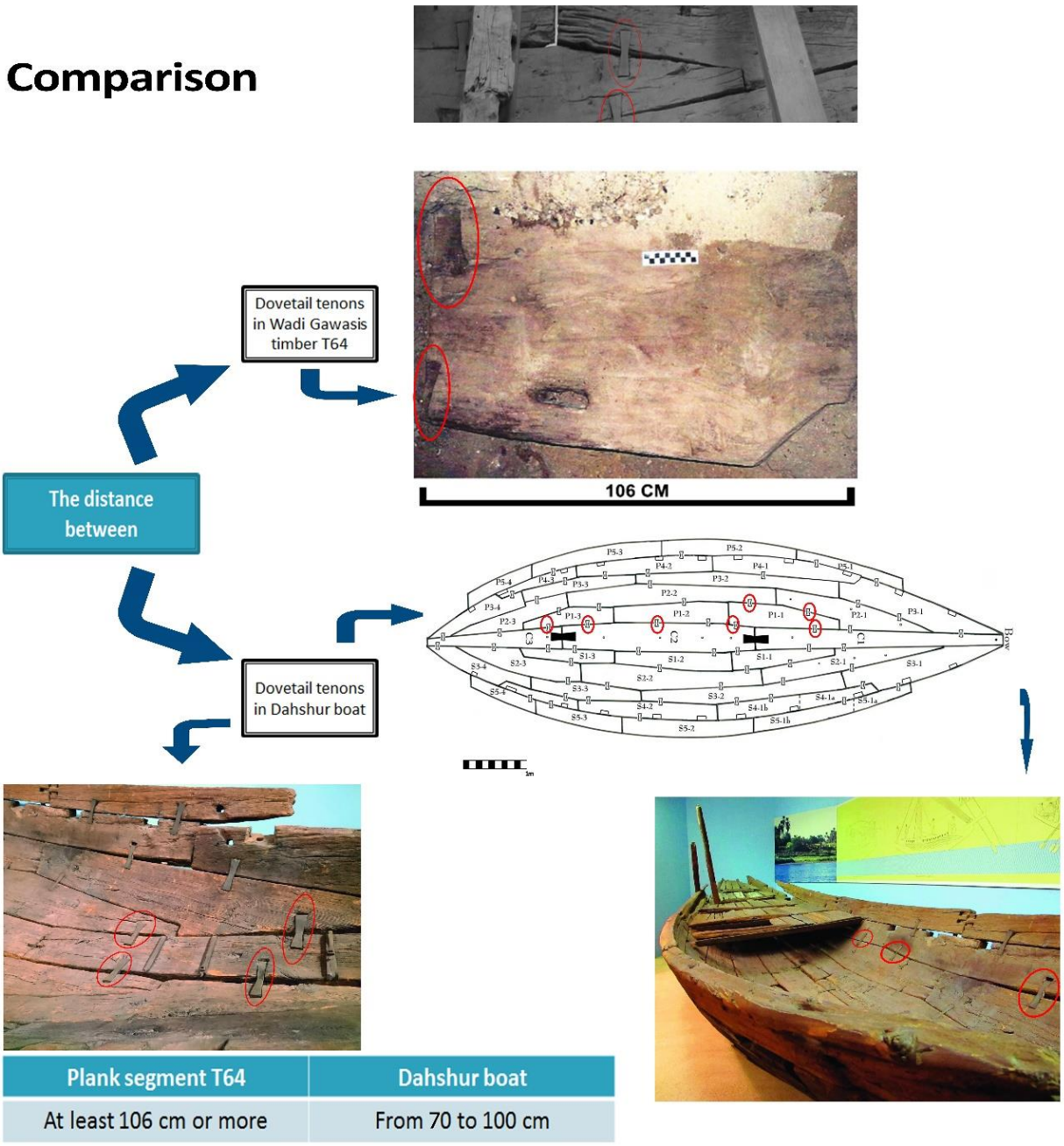
III. COMPARISON

The T64 segment occupied a position within the first strake of the ship, either forward or aft[27] with dimensions, as the author noted above. When compared to the Dahshur boat, the planks in the forward and aft sections of the first strake ranged from 160 cm to 186 cm long, with a minimum width of 7 to 12 cm and a maximum width of 24 to 30 cm. The thickness at the outboard edges was 9 cm and at the inboard edges, it was 9.5 cm[28]. The half dovetail mortise measured 14.5 cm long, leading to an estimated full length of 28-30 cm. It had a width of 3.4 - 6.5 cm and a depth of 3.8 cm. In contrast, the half dovetail mortise in the Dahshur boat had an estimated length of 7.5 cm from a full length of 13 - 16.5 cm. Its width at the narrow midpoints was 1.5 - 2 cm, while at its widest point, it measured 4 - 5 cm. The depth was 2 cm[29]. A total of 15 half-dovetail tenons were found near Cave 3, one of which corresponded to those in the T64 segment and measured 15 cm long[30] **[FIGURE 13]**. The dovetails in the Dahshur strakes were spaced approximately 70 cm apart at the extremities of the hull and 80 - 100 cm apart in the middle, these dimensions elucidated that the T64 segment might belong to a ship bigger than the Dahshur boat twice as Ward reached the same result when compared between the beams of Wadi Gawasis and Dahshur. According to Creasman's observation of the similar opposite dovetails in T64 and Dahshur boats supported the hypothesis that dovetail tenons were an original fastening method and not a later modification. Another observation by the author, reinforcing this possibility was the presence of only two opposite dovetails at the end of T64, with no others along the remaining 106 cm segment **[FIGURE 14]**. This finding indicated that the distance between those dovetails and the other dovetails in the missing part of the plank must be 106 cm or more, compared to the distances between dovetails in Dahshur boats, ranging 70-100 cm apart[31]. It reflected the desire of the shipbuilders to use the dovetails in the large distances between each other.



[FIGURE 13]: A half dovetail tenon which corresponds to the measurement of dovetail mortise in T64; © With the permission OF K.BARD and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. WARD & ZAZZARO 2010: 38.

[27] WARD et al. 2010: 387-389.
[28] CREASMAN 2005: 49.
[29] HALDANE 1984: 57; STEFFY 1994: 33; CREASMAN 2005: 63,105.
[30] CREASMAN 2005: 122; CALCAGNO & ZAZZARO 2007: 31-33; WARD & ZAZZARO, 2010: 37-38; WARD et al. 2010: 387; ZAZZARO & CALCAGNO 2012: 70.
[31] HALDANE 1984: 26; Creasman 2005: 105.



[FIGURE 14]: Cresman's observation in addition to the author's observation about the use of dovetail Tenons in both Dahshur boats and T64 in the wide distances © photos and drawing used with the permission of P. Creasman. CREASMAN 2005: 13; PETERS et al. 2017: 100 © a photo of T64 used with the permission of K. Bard. ZAZZARO & CALCAGNO 2012:79. Figures were assembled and modified by the author.

IV. CONCLUSION

After analyzing the position of T64 in the first strake, it is confirmed that dovetail mortise and tenon were used not only between the keel and the first strake but also connected between the first and second strakes like in the case of Dahshur boats. Shipbuilders desired to use dovetails in a large space between each other, as the author noted above, reflecting two points that probably interpreted the large spaces; the first point was that dovetails probably played a secondary role in securing the hulls, which were already secured by deep mortise and tenon from the internal edges; the second point was that even though the dovetail had the same importance in securing like mortise and tenon joints, they were probably spaced so far from mortise and tenon joints to avoid the weakness of the planks caused by digging a large part from the plank thickness. After presenting different perspectives and opinions and drawing comparisons and analyses between the available pieces of evidence, along with the author's observation, it could be confirmed that dovetail tenons were used on Dahshur boats as an original fastening method and not a modern modification in the last century after the excavation.

ACKNOWLEDGMENT

I would like to thank Dr./ Cheryl Ward, Kathryn Bard, Paul Creasman, Mohamed Abd el-Maguid, and Chiara Zazzaro for their invaluable aid and encouragement. I wish to express my gratitude to the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO for their significant contributions to the missions at Mersa/Wadi Gawasis, which have resulted in substantial findings and information that have played a crucial role in my research.

BIBLIOGRAPHY

ABD EL-MAGUID, M.: «Recherches sur la construction navale antique en Méditerranée orientale de l'Égypte pharaonique à la fin de l'antiquité: Étude archéologique», *PhD Thesis,* Faculté des Lettres/Université de Provence, 2009.

BELOV, A.: *Ship 17: A Baris from Thonis-Heracleion,* Oxford (Oxford Centre for Maritime Archaeology Monograph 10) 2019.

CALCAGNO, C. & **ZAZZARO**, C.: «Mersa/Wadi Gawasis 2006–2007», *University of Naples «l'Orientale» & Italian Institute for Africa & Orient Boston University*, 2007.

CLARKE, S.: «Nile Boats and Other Matters», in *Ancient Egypt and the East*, edited by PETRIE, F., 2-9, 40-51, London((Harrison & Sons, Printers) 1920.

CREASMAN, P.P.: «The Cairo Dahshur Boats», MA Thesis, Texas (A & M University) 2005.

CREASMAN, P.P.: «A Further Investigation of the Cairo Dahshur Boats», *the Journal of Egyptian Archaeology* 96/1, 2010, 101-23.

DE MORGAN, J.: *Fouilles à Dahchour*: *Mars-Juin 1894*, Vienne (Adolphe Holzhausen Imprimeur de la Cour I. & R. et de l'Université)1895.

FORTHINGHAM, J.: «Archaeological News: Summary of Recent Discoveries and Investigations», *American Journal of Archaeology and of the History of the Fine Arts* 10/1, 1895, 65-73.

FATTOVICH, R., & BARD, K.A.: «Archaeological Investigations at Wadi/Mersa Gawasis, Egypt: 2006–2007, 2007–2008 and 2009 Field Seasons», in *The Red Sea in Pharaonic Times: Recent Discoveries along the Red Sea Coast.,* edited by TALLET, P. & MAHFOUZ, E., 21-26, Cairo (Institut français d'archéologie orientale) 2012.

HALDANE, C. W.: «The Dashur Boats», MA Thesis/Texas A & M University, 1984.

MADY, M.: «The Emergence of using Pegs in Securing Tenons in Mortises by Ancient Egyptian shipbuilders», *Maritime Archaeology Graduate Symposium* 29th – 31st March 2019, Honor frost foundation, 2020.

MCGRAIL, S.: *Boats of the World: From the Stone Age to Medieval Times*, Oxford (Oxford University Press) 2004.

PETERS, E. & **ROBERTS**, C. & **CREASMAN**, P.: «Recent Research on the «Carnegie Boat» from Dahshur, Egypt», *Journal of Ancient Egyptian Interconnections* 16, 2017, 99-103.

REISNER, G. : *Models of Ships and Boats,* Catalogue général des antiquités du musée du Caire, Le Caire, 1913.

STEFFY, R.: *Wooden Ship Building and the Interpretation of Shipwrecks*, 3rd ed., College Station (Texas A & M University Press) 1994.

WARD, C. & **ZAZZARO**, C.: «Evidence for Pharaonic Seagoing Ships at Mersa/Wadi Gawasis, Egypt», *International Journal of Nautical Archaeology* 39/1, 2010, 27-43.

WARD, C.: *Sacred and Secular: Ancient Egyptian Ships and Boats,* Philadelphia (The University of Philadelphia for the Archaeological Institute of America) 2000.

WARD, C., **ZAZZARO**, C. & **ABD EL-MAGUID**, M.: «Super-sized Egyptian Ships», *International Journal of Nautical Archaeology* 39/2, 2010, 387-89.

WARD, C.: «Ship Timbers: Description and Preliminary Analysis», in *Harbor of the Pharaohs to the Land of Punt,* 135-50, Napoli, 2007.

ZAZZARO, C. & **CALCAGNO**, C.: «Ship Components from Mersa Gawasis: Recent Finds and their Archaeological Context», in *the Red Sea in Pharaonic Times*: *Recent Discoveries along the Red Sea Coast,* edited by TALLET, P. & MAHFOUZ, E., 65-85, Cairo (Institut français d'archéologie orientale) 2012.