ANCIENT EGYPTIAN HULL CONSTRUCTION

A Dissertation

by

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Submitted to the Office of Graduate Studies
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 1993

Major Subject: Anthropology
ANCIENT EGYPTIAN HULL CONSTRUCTION

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ABSTRACT

Ancient Egyptian Hull Construction. (May 1993)

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Nautical archaeological resources from ancient Egypt provide the most complete picture of boatbuilding traditions in the ancient world before the Classical period. Models, representations, economic and religious texts, and more than 20 wooden hulls allow us to trace the development of nautical technology in Egypt between 5,000 and 2,500 years ago. Although contact with Nubia, Palestine, and Syria is attested from the beginnings of the Early Dynastic Period, the idiosyncrasies of Egyptian hull construction, when viewed in light of later Mediterranean traditions, imply independent development and persistent use of native techniques to fasten planks and create stable, sturdy hulls.

By studying how Egyptian hulls were built, and where they fit into the fabric of society, we can gain some sense of the complex solutions to practical problems faced by Egyptian shipwrights. Whether swift warships, giant cargo carriers, elaborate wooden imitations of papyrus rafts, or heavily laden seagoing vessels, Egyptian watercraft incorporated design and technological features as complex, and durable, as those of the more visible stone monuments of ancient Egypt.
ACKNOWLEDGEMENTS

Many people contributed their time and resources to the research described in this dissertation. I am particularly grateful to the institutions and individuals who encouraged, permitted, and assisted me in the recording of Egyptian hulls or documentation for hulls in their care: the Anthropology Section of Chicago’s Field Museum of Natural History; James B. Richardson III, David Watters, Diana Craig Patch, and other staff at the Carnegie Museum of Natural History; Dieter Arnold and members of the Metropolitan Museum of Art Egyptian Expedition; Ahmed Kadry, Shawki Nakhla, and Mohammed Saleh of the Egyptian Antiquities Organization; Elie Rogers and Peter Miller of the National Geographic Society; and David O’Connor and members of the Expedition to Abydos, University Museum, University of Pennsylvania.

My dissertation committee patiently advised me and shared their experience with me as this work was written. To J. Richard Steffy, George F. Bass, Frederick H. van Doorninck, Sylvia Grider, Daniel MacGillvray, and Richard Vrooman, my thanks and appreciation. Thanks also to Claudia LeDoux and Clyde Reese, for unfailing assistance.

Discussions with Paul Lipke, Mark Lehner, Shelley Wachsmann, Fred Hocker, Mike Fitzgerald, Steve Vinson, and Douglas Haldane provided me stimulating arguments for and against some of my ideas. I am grateful also to Douglas Haldane, Margaret Lynch, Michael Fitzgerald, George Bass, Fred van Doorninck, and J. Richard Steffy for their comments on earlier versions of this work.

The College of Liberal Arts Technology and Society Dissertation Award allowed me to devote myself to the research and writing of the dissertation for a year. It would be unwritten without this support. I also would like to recognize the financial assistance offered to me during these years by Robert and Elise Haldane, the Nautical Archaeology Program, Steve Ward, and Douglas Haldane.

My parents, Richard and Elizabeth Ward, have constantly supported and encouraged my pursuit of archaeology; I could not have persevered without them. Doug, David and Duncan Haldane, Steven and Kathryn Ward, and my family of friends also provided emotional sustenance at crucial times. To all of you, my love and thanks.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Ships as Symbols</td>
<td>1</td>
</tr>
<tr>
<td>Environment, Culture, and Economy in Ancient Egypt</td>
<td>4</td>
</tr>
<tr>
<td>Dynastic Egypt</td>
<td>9</td>
</tr>
<tr>
<td>Resources, Labor, and Power</td>
<td>11</td>
</tr>
<tr>
<td>Conclusions</td>
<td>18</td>
</tr>
<tr>
<td>II NATURAL RESOURCES</td>
<td>26</td>
</tr>
<tr>
<td>Native Genera</td>
<td>26</td>
</tr>
<tr>
<td>Imported Genera</td>
<td>33</td>
</tr>
<tr>
<td>Conclusions</td>
<td>38</td>
</tr>
<tr>
<td>III TOOLS AND WOODWORKING</td>
<td>47</td>
</tr>
<tr>
<td>Tools</td>
<td>47</td>
</tr>
<tr>
<td>Cordage</td>
<td>56</td>
</tr>
<tr>
<td>Early Woodworking</td>
<td>58</td>
</tr>
<tr>
<td>Conclusions</td>
<td>68</td>
</tr>
<tr>
<td>IV EARLY DYNASTIC HULLS AT ABYDOS</td>
<td>78</td>
</tr>
<tr>
<td>Other Evidence for Early Watercraft</td>
<td>82</td>
</tr>
<tr>
<td>Conclusions</td>
<td>84</td>
</tr>
<tr>
<td>V KHUFU I</td>
<td>89</td>
</tr>
<tr>
<td>Discovery</td>
<td>89</td>
</tr>
<tr>
<td>Reconstruction of the Hull</td>
<td>90</td>
</tr>
<tr>
<td>Hull Construction</td>
<td>107</td>
</tr>
<tr>
<td>The Purpose of Khufu I</td>
<td>112</td>
</tr>
<tr>
<td>Chapter</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>VI</td>
<td>KHUFU II</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td></td>
<td>Catalogue</td>
</tr>
<tr>
<td></td>
<td>Analysis and Conclusions</td>
</tr>
<tr>
<td>VII</td>
<td>ROCK AND BRICK BOATS OF THE OLD KINGDOM</td>
</tr>
<tr>
<td></td>
<td>The Rock-Cut Boats of Khafra</td>
</tr>
<tr>
<td></td>
<td>The Rock-Cut Boats of Khufu</td>
</tr>
<tr>
<td></td>
<td>Conclusions</td>
</tr>
<tr>
<td>VIII</td>
<td>THE LISHT TIMBERS</td>
</tr>
<tr>
<td></td>
<td>Archaeological Background</td>
</tr>
<tr>
<td></td>
<td>Timber Characteristics</td>
</tr>
<tr>
<td></td>
<td>Frames and Transverse Timbers</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
</tr>
<tr>
<td></td>
<td>Conclusions</td>
</tr>
<tr>
<td>IX</td>
<td>A PLANKED MODEL BOAT FROM LISHT</td>
</tr>
<tr>
<td></td>
<td>Analysis and Conclusions</td>
</tr>
<tr>
<td>X</td>
<td>THE DASHUR BOATS</td>
</tr>
<tr>
<td></td>
<td>Dimensions and Shape</td>
</tr>
<tr>
<td></td>
<td>Structural Components</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>Repairs</td>
</tr>
<tr>
<td></td>
<td>Analysis and Conclusions</td>
</tr>
<tr>
<td>XI</td>
<td>THE LATE PERIOD BOAT AT MATARIA, CAIRO</td>
</tr>
<tr>
<td></td>
<td>Hull Construction</td>
</tr>
<tr>
<td></td>
<td>Conclusions</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>Page</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>XII CONCLUSIONS</td>
<td>250</td>
</tr>
<tr>
<td>Principle Features of Egyptian Hull Construction</td>
<td>252</td>
</tr>
<tr>
<td>Reuse and Disassembly</td>
<td>254</td>
</tr>
<tr>
<td>Egyptians Hulls and Seafaring</td>
<td>257</td>
</tr>
<tr>
<td>Ancient Egyptian Hull Construction</td>
<td>259</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>263</td>
</tr>
<tr>
<td>APPENDIX 1</td>
<td>276</td>
</tr>
<tr>
<td>APPENDIX 2</td>
<td>277</td>
</tr>
<tr>
<td>APPENDIX 3</td>
<td>279</td>
</tr>
<tr>
<td>VITA</td>
<td>284</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Ritual procession from the Qustul incense burner</td>
<td>4</td>
</tr>
<tr>
<td>1-2</td>
<td>Simplified drawing of a shipbuilding scene from the tomb of Nefer and Ka-Hay</td>
<td>16</td>
</tr>
<tr>
<td>3-1</td>
<td>Examples of stone tools from Badari</td>
<td>48</td>
</tr>
<tr>
<td>3-2</td>
<td>Distribution of adze blades by length</td>
<td>51</td>
</tr>
<tr>
<td>3-3</td>
<td>Old Kingdom coffin EM 28038</td>
<td>60</td>
</tr>
<tr>
<td>3-4</td>
<td>Planks from Tarkhan</td>
<td>62</td>
</tr>
<tr>
<td>3-5</td>
<td>Fastenings used in the Tarkhan planks</td>
<td>64</td>
</tr>
<tr>
<td>3-6</td>
<td>Ivory model EM 86169, 17 cm. long</td>
<td>67</td>
</tr>
<tr>
<td>3-7</td>
<td>UC 17156 and UC 17162</td>
<td>69</td>
</tr>
<tr>
<td>3-8</td>
<td>Upper timbers of a frame from Lisht</td>
<td>70</td>
</tr>
<tr>
<td>4-1</td>
<td>Working plan of the Abydos hull</td>
<td>79</td>
</tr>
<tr>
<td>4-2</td>
<td>Profile of Abydos Boat 10</td>
<td>80</td>
</tr>
<tr>
<td>4-3</td>
<td>a) Small plaque of a hull b) &quot;The ships of the king&quot; on a seal from Abydos</td>
<td>81</td>
</tr>
<tr>
<td>4-4</td>
<td>Wooden model EM 4814</td>
<td>82</td>
</tr>
<tr>
<td>5-1</td>
<td>Khufu I</td>
<td>91</td>
</tr>
<tr>
<td>5-2</td>
<td>Khufu I midship construction view</td>
<td>92</td>
</tr>
<tr>
<td>5-3</td>
<td>Planking plan</td>
<td>93</td>
</tr>
<tr>
<td>5-4</td>
<td>Ligatures in Khufu I backing timbers</td>
<td>98</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>5-5</td>
<td>Fastening plan for Khufu I</td>
<td>100</td>
</tr>
<tr>
<td>5-6</td>
<td>Khufu I fastenings</td>
<td>101</td>
</tr>
<tr>
<td>6-1</td>
<td>Photo montage of the Khufu II pit</td>
<td>120</td>
</tr>
<tr>
<td>6-2</td>
<td>Tracing of hull components visible in pit montage</td>
<td>124</td>
</tr>
<tr>
<td>6-3</td>
<td>Khufu I deckhouse construction</td>
<td>126</td>
</tr>
<tr>
<td>7-1</td>
<td>Plan of Khafra’s rock-cut boats</td>
<td>134</td>
</tr>
<tr>
<td>7-2</td>
<td>Khafra Boat 1</td>
<td>135</td>
</tr>
<tr>
<td>7-3</td>
<td>Models from the tomb of Kaemenu</td>
<td>138</td>
</tr>
<tr>
<td>7-4</td>
<td>Khafra Boat 2</td>
<td>139</td>
</tr>
<tr>
<td>7-5</td>
<td>Khafra Boat 3</td>
<td>140</td>
</tr>
<tr>
<td>7-6</td>
<td>Khafra Boat 4</td>
<td>142</td>
</tr>
<tr>
<td>7-7</td>
<td>Limestone structures from the mastaba of Kagemni</td>
<td>148</td>
</tr>
<tr>
<td>7-8</td>
<td>Brick solar boat of Ne-user-re</td>
<td>149</td>
</tr>
<tr>
<td>7-9</td>
<td>Khufu Boat 3</td>
<td>151</td>
</tr>
<tr>
<td>7-10</td>
<td>Khufu Boat 4</td>
<td>152</td>
</tr>
<tr>
<td>7-11</td>
<td>Khufu Boat 5</td>
<td>153</td>
</tr>
<tr>
<td>8-1</td>
<td>Cargo ships from the causeway of Unas</td>
<td>159</td>
</tr>
<tr>
<td>8-2</td>
<td>A causeway at Labun</td>
<td>161</td>
</tr>
<tr>
<td>8-3</td>
<td>Lisht, Site A</td>
<td>162</td>
</tr>
<tr>
<td>8-4</td>
<td>Lisht, Site F</td>
<td>163</td>
</tr>
<tr>
<td>8-5</td>
<td>Lisht, Site D</td>
<td>164</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>8-6</td>
<td>Lisht, Site D plan</td>
<td>165</td>
</tr>
<tr>
<td>8-7</td>
<td>Lisht, Site I</td>
<td>166</td>
</tr>
<tr>
<td>8-8</td>
<td>Lisht, hull timbers at Site G</td>
<td>167</td>
</tr>
<tr>
<td>8-9</td>
<td>Lisht, Site G</td>
<td>167</td>
</tr>
<tr>
<td>8-10</td>
<td>Typology of plank shapes</td>
<td>171</td>
</tr>
<tr>
<td>8-11</td>
<td>Mortise-and-tenon joints from Lisht planks</td>
<td>173</td>
</tr>
<tr>
<td>8-12</td>
<td>a) Lashing fastenings b) lashing in a ligature</td>
<td>174</td>
</tr>
<tr>
<td>8-13</td>
<td>Lisht, repair to a mortise-and-tenon joint</td>
<td>175</td>
</tr>
<tr>
<td>8-14</td>
<td>Frame from Lisht, Site G</td>
<td>178</td>
</tr>
<tr>
<td>8-15</td>
<td>The Lisht frame</td>
<td>179</td>
</tr>
<tr>
<td>8-16</td>
<td>Lisht, Site G framing timbers</td>
<td>180</td>
</tr>
<tr>
<td>8-17</td>
<td>Upper timber from Site G</td>
<td>181</td>
</tr>
<tr>
<td>8-18</td>
<td>Reconstruction of a Lisht hull’s planking pattern</td>
<td>182</td>
</tr>
<tr>
<td>8-19</td>
<td>Cross-section of a Meir boat model</td>
<td>186</td>
</tr>
<tr>
<td>8-20</td>
<td>Cross-section of a Lisht hull reconstruction at a frame</td>
<td>188</td>
</tr>
<tr>
<td>9-1</td>
<td>Planked boat model from Lisht</td>
<td>197</td>
</tr>
<tr>
<td>9-2</td>
<td>Detail of Lisht boat model</td>
<td>198</td>
</tr>
<tr>
<td>10-1</td>
<td>Chicago Dashur boat, hull lines</td>
<td>205</td>
</tr>
<tr>
<td>10-2</td>
<td>Carnegie Dashur boat, inner surface of hull planking</td>
<td>206</td>
</tr>
<tr>
<td>10-3</td>
<td>Dashur boat, cross-section</td>
<td>209</td>
</tr>
<tr>
<td>10-4</td>
<td>Carnegie Dashur boat, open mortises</td>
<td>209</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>10-5</td>
<td>Carnegie Dashur boat beams 3 and 6</td>
<td>212</td>
</tr>
<tr>
<td>10-6</td>
<td>Carnegie Dashur boat, tenon</td>
<td>219</td>
</tr>
<tr>
<td>10-7</td>
<td>Carnegie Dashur boat, mortise marks</td>
<td>219</td>
</tr>
<tr>
<td>10-8</td>
<td>Carnegie Dashur boat, recut dovetail mortise</td>
<td>222</td>
</tr>
<tr>
<td>10-9</td>
<td>Carnegie Dashur boat, eroded original fastening</td>
<td>222</td>
</tr>
<tr>
<td>10-10</td>
<td>Carnegie Dashur boat, reconstruction of ligatures</td>
<td>223</td>
</tr>
<tr>
<td>10-11</td>
<td>Carnegie Dashur boat, adze marks</td>
<td>228</td>
</tr>
<tr>
<td>10-12</td>
<td>Model funerary boat</td>
<td>229</td>
</tr>
<tr>
<td>10-13</td>
<td>Carnegie Dashur boat, outer face S3-2</td>
<td>231</td>
</tr>
<tr>
<td>10-14</td>
<td>Carnegie Dashur boat, patches from S3-2</td>
<td>232</td>
</tr>
<tr>
<td>10-15</td>
<td>Ceremonial boat, Middle Kingdom</td>
<td>234</td>
</tr>
<tr>
<td>11-1</td>
<td>Sketch plan of the Mataria boat</td>
<td>241</td>
</tr>
<tr>
<td>11-2</td>
<td>Mataria hull model built by the Egyptian Antiquities Organization</td>
<td>242</td>
</tr>
<tr>
<td>11-3</td>
<td>Inner planking surface</td>
<td>243</td>
</tr>
<tr>
<td>11-4</td>
<td>Mataria hull tenons and peg</td>
<td>244</td>
</tr>
<tr>
<td>11-5</td>
<td>Graffito on a Mataria plank</td>
<td>245</td>
</tr>
<tr>
<td>11-6</td>
<td>Mataria planking fragment (I)</td>
<td>248</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>Adze blade types from Tomb 3471, Saqqara</td>
<td>52</td>
</tr>
<tr>
<td>3-2</td>
<td>Dimensions and fastenings of Tarkhan planks</td>
<td>63</td>
</tr>
<tr>
<td>3-3</td>
<td>Thickness of planks from Egyptian hulls</td>
<td>65</td>
</tr>
<tr>
<td>4-1</td>
<td>Dimensions of Early Dynastic mudbrick boat graves</td>
<td>79</td>
</tr>
<tr>
<td>5-1</td>
<td>Distribution of ligatures in Khufu I</td>
<td>97</td>
</tr>
<tr>
<td>6-1</td>
<td>Projected measurements of Khufu II hull components in meters</td>
<td>123</td>
</tr>
<tr>
<td>7-1</td>
<td>Selected boats and boat graves from the Early Dynastic period through the Old Kingdom</td>
<td>133</td>
</tr>
<tr>
<td>7-2</td>
<td>Characteristics of the rock-cut boats of Khafra and the wooden Khufu I hull.</td>
<td>136</td>
</tr>
<tr>
<td>8-1</td>
<td>Derived dimensions and shapes for Lisht planks</td>
<td>169</td>
</tr>
<tr>
<td>8-2</td>
<td>Dimensions for Meir boat models in cm.</td>
<td>185</td>
</tr>
<tr>
<td>9-1</td>
<td>Distribution and dimensions of strakes in the planked Lisht model</td>
<td>196</td>
</tr>
<tr>
<td>10-1</td>
<td>Dimensions of the Dashur boats</td>
<td>204</td>
</tr>
<tr>
<td>10-2</td>
<td>Central strake dimensions for the Dashur hulls in meters</td>
<td>208</td>
</tr>
<tr>
<td>10-3</td>
<td>Dashur boat strake lengths in meters</td>
<td>213</td>
</tr>
<tr>
<td>10-4</td>
<td>Carnegie Dashur boat planking dimensions in meters</td>
<td>214</td>
</tr>
<tr>
<td>10-5</td>
<td>Field Museum Dashur boat planking dimensions in meters</td>
<td>215</td>
</tr>
<tr>
<td>10-6</td>
<td>Planking dimensions for EM 4925 and EM 4926 in meters</td>
<td>216</td>
</tr>
</tbody>
</table>
GLOSSARY

*battens*: thin strips of wood; in Egyptian hull construction, used to cover seams

*beam*: a transverse timber to provide lateral strength

*bottom*: the lower hull encompassing the vessel's bottom up to the turn of the bilge

*bulwarks*: side planks above deck level

*butt joint*: the meeting of two hull components created by abutting their ends

*carling*: a fore and aft timber at, or near, deck level. In ancient Egyptian hulls, it was one of the principal hull components.

*central plank*: in ancient Egyptian hull construction, the central plank was thicker and stronger than others in the hull and served as the hull's foundation

*channels*: holes of regular shape and dimension that held lashing material (see ligature)

*coak*: a wooden fastening inserted into a hole in one timber to engage a corresponding hole in another timber to prevent slipping

*floor timber*: a framing member centered over the keel or central plank whose arms extend over both sides of the bottom of the hull

*frame*: an assembly of transverse timbers that supported hull planking. In Egyptian hulls, frames often are fastened directly to the inboard planking surface.

*garboard*: the strake laid adjacent to the keel

*joggle*: a joint between two planks formed by a notch and the fitting projection; the notch or projecting piece used in such a joint

*joggled*: joined or attached by means of a joggle

*keelson*: an internal keel, firmly fastened in place on top of floor timbers and above the keel or central plank, that provided additional longitudinal strength to the hull

*lashing*: the use of rope or woven strips to connect hull components

*length:beam ratio*: a ratio that provides a rough description of hull shape; the higher the ratio, the longer and narrower the hull
ligature: a fastening for binding two hull components together, usually through channels
midships: the broadest part of a vessel
molded: refers to the height of a transverse hull component; that dimension which
    corresponds to a mold
mortise-and-tenon joint: a connection between two components in which a tenon was
    inserted into aligned, corresponding mortises in the components
open mortise: a mortise cut into the edge of a plank at the butt end so that one side of the
    mortise is open. See fig. 10-4.
peg: a tapered wooden pin driven into a pre-drilled hole, usually to lock mortise-and-
    tenon joints
pegged mortise-and-tenon joint: a mortise-and-tenon joint fixed by pegs driven through
    hull planking and the joint perpendicularly to the tenon’s longitudinal orientation
planking: the outer skin, or shell, of a hull
scarf: a type of joint formed by notching or angling two timbers so that they interlocked
    to form a continuous piece. Timbers must be joined end-to-end with a significant
    amount of long grain tabling.
seam: the longitudinal line or joint between two planks
shell-first construction: a method of hull construction in which a planking shell was
    established before frames were erected
sided: refers to the width of a transverse hull component
slips: wooden pegs with a rectangular or square section, inserted into mortises beside
    tenons in order to lock them in place
skeleton-first construction: a method of hull construction in which frames erected on a
    keel before planking was attached to them created the primary hull structure
stanchion: an upright support for beams or fore-and-aft timbers
steering oar: an oar used to steer a vessel, used alone or in pairs
strake: a continuous line of planks extending from bow to stern
stringer: a fore-and-aft timber for longitudinal reinforcement
timbers: all wooden hull components, in general; specifically, those timbers that formed the frames of a vessel

through beam: transverse timber that extended through the planking

treenail: cylindrical wood pieces driven through timbers and planks to connect them

upper timber: transverse timbers fastened to floor timbers as part of a frame assembly
CHAPTER I

INTRODUCTION

Because watercraft played such a vital role in the lives of ancient Egyptians, archaeologists today have a wealth of resources available to use in examining the ways people built, used, and conceived of ships. Although scholars have studied Egyptian shipping through texts, representations, and religious rites that include riverine and seagoing craft, studies of the physical remains of hulls have been limited.

The long tradition of river traffic in Egypt includes simple rafts for crossing the river and grand barges capable of carrying hundreds of tons. Details of wooden vessels buried beside Egypt’s pyramids suggest the development of indigenous and conservative patterns in hull construction, some of which remained static for 4,500 years; others changed to accommodate different economic and environmental conditions. The study of nautical traditions in ancient Egypt furnishes an understanding of both the manifest technological abilities and the unrecorded principles that guided shipbuilders.

The nautical traditions and technological skills of ancient Egypt developed in concert with the rise of the dynastic state and state religion (see Appendices 1 and 2 for a map of Egypt and a chronological framework). Waterborne trade fed Egyptian economic growth and fostered contact among societies of the ancient Eastern Mediterranean. Because the Egyptians transformed shipping from a practical technology and commonplace activity into a primary ingredient of the ideological sphere, boats became symbols of divine power and pharaonic glory, and, as such, were buried beside the funerary monuments of some of Egypt’s most powerful kings.

SHIPS AS SYMBOLS

Thousands of models, representations, and references to watercraft testify to the importance water transport played in the lives of ancient Egyptians, an importance

This dissertation follows American Journal of Archaeology style.
underlined by the association of boats with regeneration and with the waters of the primitive and chaotic abyss. The earliest images of state and kingship are intricately tied to ships,\(^1\) and the lack of roads until the Roman period guaranteed the use of ships for taxation, redistribution of goods, and the transport of warriors. Even the dead depended on water transport: magical spells summoned a reluctant ferryman and his ship to take the dead person to the gods in the sky.\(^2\)

Gods had their own sacred boats, and the sacred boat could be a divine manifestation of the god.\(^3\) The sun god Re’s two watercraft for traversing the sky by day and by night became an important part of divine mythology and are known today as solar boats. Wooden, or papyriform, hulls that imitated the shape of papyrus rafts also played important roles in funerary practices, especially as boats to transport the dead person to Egypt’s most holy pilgrimage sites.

The divine bark Userhêt, described here by Ramesses III, is perhaps the most colorful example remaining to us:

I hewed for thee thy august ship \(Ws.rht\), of 130 cubits, upon the river, of great cedars of the royal domain of remarkable size, overlaid with fine gold to the waterline, like a bark of the Sun, when he comes from the east, and every one lives at the sight of him. A great shrine was in the midst of it, of fine gold, with inlay of every costly stone like a palace; rams’ heads of gold from front to rear, fitted with uraeus serpents wearing crowns.\(^4\)

The ancient processions of sacred watercraft have echoed through more than 35 centuries. In the early 1900s, a river boat suspended in a tree was brought down, filled with children, and taken around Luxor’s fields on a cart once a year.\(^5\) Egyptians still celebrate a yearly parade around the sacred precincts of Luxor with decorated boats carried on pickup trucks.

Despite the abundance of archaeological and textual evidence for the practice of including boats, boat models, and representations of watercraft in burials and funerary monuments, we have difficulty defining the motives of the ancient Egyptians. Recent scholarship concerning the purpose of boat models and representations thus converges, and suggests that they served to connect magically the deceased with the godly attributes
of the pharaoh or to make the gods aware of the deceased's virtues.

One scholar writes, "Nowhere in mortuary literature is it stated that the deceased is to provide any boat, solar or otherwise, for his journey. Indeed, he is always described as using the boats of divinities who already have access to the desired destination." The different boats present in Old Kingdom funerary texts and equipment may have acted as "passports" for the deceased by demonstrating his knowledge of the gods' secrets.

Another discussion of ship and shipbuilding scenes in New Kingdom tombs places them within the same interpretive tradition: "Like all other tomb scenes, they have the primary purpose of allowing the tomb's owner to participate in the magic-religious event of the festival of rejuvenation, the going-in and coming-out (on earth) within and in front of the tomb according to the royal ideal." The wp-šnpt festival was performed by the Horus King acting at the godly level. Taboos preventing the portrayal of royal events encouraged officials to participate in the festival by representing themselves in pictures of shipbuilding and in acts associated with ships. D. Kessler calls the often-expressed idea that pictures in a tomb were designed to supply the official's needs in the afterlife "Egyptological fiction." By having scenes and statues in a funerary monument, the owner could continue his responsibilities to society as a whole. Funerary representations have a formulaic, general, and repetitive character. Whatever the tomb owner did on the walls of his tomb, he did forever, and inanimate figures performed other work, including shipbuilding, for him.

Performing the proper actions over and over again may be related to the concept of maa as correct behavior, especially in the iconographic coherence of pharaonic imagery. B. Williams suggests that objects that illustrate standardized scenes reflect the wishes of the object's owner to participate vicariously in the ceremonies portrayed: "Figures found on early pottery in Egypt were intended to impart the positive power of the occasion depicted to the vessel, its contents, and ultimately, to the user, to help sustain the Egyptian universe." Williams traces the association of oared boats and pharaonic imagery back to
Naqada I or the beginning of Naqada II, and sees a royal monopoly on ceremonial attributes of ships in Predynastic and Early Dynastic ship representations (fig. 1-1). The sacred bark belonged exclusively to the gods, the pharaohs, and the dead, never serving ordinary purposes. Control over the ship as a cultural symbol, both as a concrete object and a representation, suggests that the state already allocated resources preferentially and had access to materials and labor not available to the general population.

![Fig. 1-1. Ritual procession from the Qustul incense burner. (Courtesy The Oriental Institute of the University of Chicago)](image)

ENVIRONMENT, CULTURE, AND ECONOMY IN ANCIENT EGYPT

The cultural and environmental setting of ancient Egypt affected the way nautical technology developed and influenced hull design. Technology represents a society's effort to control its environment within the constraints of resources and knowledge. The predictability of the Nile and the natural power supply provided by prevailing winds to boats moving upstream and by currents downstream made getting around fairly simple. Economic prosperity and governmental constrictions added design imperatives and expanded the materials available for shipbuilding through trade and control of resources.
Environment and Prehistory

None of the major ecological regions in Egypt is today as it was in the past. The Aswan Dam halted the regular cycle of floods carrying rejuvenating silt to the long and narrow floodplain, and human activities have profoundly reduced the abundance and variety of plants and animals and increased the rate of desiccation in the desert, the Mediterranean coastal regions, and the Sinai.

Nile floods occur at the most propitious time of year for growing crops. Summer rains in sub-Saharan Africa feed the Nile at its origins, and its swelling waters reach Egypt by late August and discharge into the Mediterranean in late November. Before the Aswan Dam was built, water typically stood 1.5 m. deep in natural or artificial basins for six to ten weeks during the flood, followed by about 12 weeks of moist conditions ideal for planting and growing crops, and a 20-week period of increasing heat and dryness before the next flood.14 As K. Butzer points out, Nile floods were generally reliable, but short-term variation in flood levels drastically affected the amount and condition of cultivable land in Egypt.15 That in turn affected the prosperity of the country and the stability of the government.

But the first inhabitants of the Nile Valley were not farmers. They relied on the river’s bountiful supplies of fish, naturally occurring plants, and wild animals.16 Vast marshy areas lined the Nile, particularly towards the Delta, and winter rains in the desert and along the coast created a region of minor wadis lined by trees and desert shrubs. About 10,000 years ago, an unusually wet period made the drier regions even more hospitable, and hunter-gatherers, perhaps from the Nile Valley17 or perhaps from Libya or Nubia, expanded into the playas and oases of southern Egypt. The stone tools of the desert peoples differed significantly from those used by the fishing-gathering-hunting people of the Nile Valley, suggesting different origins and/or subsistence patterns for the two groups.

Archaeologists who study the origins of agriculture have learned that people try to control food resources in marginal environments rather than in areas with abundant resources. This is true in Egypt, where the oldest cultivated grain was found at the desert
site of Nabta (7000 B.C.) in conjunction with pottery and the bones of domesticated cattle and sheep/goat.18 Cultivated plants first appear in Nile sites at levels dating to about 5000 B.C.

A shift to drier conditions about 5000-4000 B.C. coincided with the introduction of agriculture to the Nile Valley and the first Neolithic sites there. Interestingly, no domestic animals or plants have been recovered from some of the Neolithic sites in the Faiyum (c. 4500 B.C.). Most Faiyum Neolithic occupations seem to have silos, used to store gathered foods, and hundreds of hearths, probably used for drying fish.19 The abundance of resources in the Faiyum may have discouraged its Predynastic inhabitants from becoming fully sedentary and dependent on agricultural activities like their neighbors in the Delta and Middle Egypt.

At Badari, Omari, Khattara, and Maadi, people cultivated crops and lived in villages. The most commonly recovered remains of crops are flax, emmer wheat, barley, and bitter vetch, an edible legume used as human food and animal fodder for pigs, sheep, goats, and cattle. Hunting, fishing, and gathering continued to play a major role in the floodplain economy.

Agriculture may have arrived in the Nile Valley with small groups of Saharan pastoralists seeking relief from drought conditions in the desert. According to Hassan, the assimilation of many individual groups of Saharan peoples into existing Nilotic settlements over a millennium accounts for local differences in Early Neolithic tools and pottery in the Nile Valley.20

An expansion of Hassan’s thesis suggests that Saharan groups interacted with Nile Valley populations long before the Neolithic period, exchanging practices, products, plants, and animals, and influencing Nile dwellers’ artistic depictions, economics, language, and land management (grazing and water control).21 The shift in subsistence from collected foods to produced foods is illustrated by a change in artistic styles. During the Predynastic Period, although their bones are common on Nile Valley archaeological sites, domestic animals were rarely portrayed on artifacts, reflecting their lack of importance in ideology. In contrast, agricultural and animal management became a
dominant theme in Dynastic art. Cattle, particularly, symbolized power and majesty throughout Egyptian history.

Agriculture allows people to store food for times of shortage and for trade. Abundant food reserves enable populations to increase, allowing an expansion of settlement areas. A wetter environment between 4000 and 3000 B.C. allowed even greater expansion of the agricultural base. The effects of this wet phase are reflected in hunting and ritual scenes of Predynastic objects that feature large, and now exotic, animals such as elephants, leopards, and giraffes. Increased moisture permitted extended wooded areas, as shown by tree stumps found in the desert throughout the Nile Valley.

During this moist phase, major settlements spawned new villages. As people spread out, they maintained territorial allegiance as well as perhaps kinship and economic ties with central large towns. The expansion of settlement fostered the development of a hierarchical administrative system, however rudimentary, to control markets and perhaps arbitrate land allotments, irrigation rights, or ownership. In addition, the potential for alliance or conflict with neighboring groups was high when the fringes of linear outgrowth or land-use for hunting or pastoralism overlapped. That territorial groups existed is shown by the firmly established emblematic nome symbols on Predynastic artifacts, including standards on watercraft painted on Naqada II pots.

The Nile’s regularity contributed to the nearly simultaneous appearance of calendrical systems and mathematics with agriculture. Fertility cults and rituals became more elaborate, a religious elite evolved, and the agricultural surplus as well as almost all resources, including labor, became part of a redistributive system. In Old Kingdom times, the importance of governmental control of food is reflected by the huge granaries and food storage areas built into the temples and mortuary complexes.

The convergence of a central administration, ritual elite, and protective (or expansionist) military forces culminated in a state headed by a divine king who was responsible for duplicating the order of the heavens on earth. Performing tasks and rituals repetitively and in an orderly manner was crucial to ancient Egyptian identity and one of the king’s most important duties. B. Kemp writes, "[Ideology] is the distinctive filter
through which a society sees itself and the rest of the world, a body of thought and symbol which explains the nature of society, defines its ideal form, and justifies action to achieve that ideal.\[^{25}\] In ancient Egypt, symbolic watercraft, bulls, thrones, and kings on objects dating to the wet phase of c. 3500 B.C. demonstrate a firmly established ideology.

These same symbols appear even earlier in Nubia, suggesting that interaction with Nubia influenced the very conceptualization of Egyptian society. According to B. Williams, Nubian artifacts imitate Egyptian Amratian/Naqada I styles, but during Naqada II and III, local materials and styles displace Egyptian features at Qustul, near the modern border between Egypt and Sudan.\[^{26}\] At Qustul, symbols of kingship such as the serekh (palace facade), falcon, feline deity, royal ship, throne, and the crown were used before their adoption in Egypt. Williams notes that it was only after the Aha’s Dynasty I Nubian campaign that Nubia began to follow Egypt’s lead once more. Ward has pointed out that the Egyptian language demonstrates a mixture of Semitic-African influences with a Semitic "super-stratum" heavily overlaid with African traits.\[^{27}\]

Predynastic peoples also had contact with groups in Palestine, Syria, and, perhaps indirectly, Mesopotamia.\[^{28}\] Palestinian chipped stone tools, wavy-handled pottery, asphalt, and copper in Naqada II Maadi, near Cairo, link it with Wadi Ghazze in the northern Negev. Palestinian imports may have included resins, oils, and cosmetics as well as agricultural produce.\[^{29}\] Agricultural products and dried fish probably formed the core of traded goods from Egypt, supplemented by raw materials for tool making and for the manufacture of decorative objects.

At Wadi Ghazze, black-topped Egyptian wares like those found abundantly at Maadi, similar chipped stone tools, Nile mollusc shells and catfish spikes saved in pots led Rizkana and Secher to suggest that the inhabitants of Maadi and Palestine shared a common ancestry or had some form of cultural exchange from the Predynastic through Dynasty I, emphasized by the presence of five times more Egyptian than Canaanite artifacts in coastal Northern Sinai during Dynasty I.\[^{30}\] Ben-Tor suggests that Egyptians lived in stations along the Northern Sinai land route, especially in the Egyptian sites of Tel’Erani, Hurvat Ma’ahaz, and ‘En Besor in southern Palestine, and that Canaanite
merchants, illustrated on ivory labels from Dynasty I, lived in Maadi and Minshat Abu Omar.\textsuperscript{31} The Palestinian connection continued until the Old Kingdom, but then was virtually severed as Egyptian attention focused on Syria, probably as a result of seaborne trade.\textsuperscript{32}

**DYNASTIC EGYPT**

By 3100 B.C., a single king ruled Egypt, and the state bureaucracy affected the life of every Egyptian. Family relationships were important in Egypt, but, much as in the present era, the highest allegiance was to the state rather than to a tribal lineage or clan. The king controlled all resources, and what he granted to his officials and priests enabled them to climb higher within the hierarchical system and to better their chances for immortality by close association with the king, who would become Osiris in the afterlife.

At Abydos, Early Dynastic tombs demonstrate the large portion of resources devoted to the monuments and cults of the dead. Thousands of perfume-filled stone vases, elaborate jewelry, and other finely crafted objects were buried with each king. The funerary complex at Abydos also includes 12 boat graves, each more than 20 meters long, probably dating to Dynasty 1 (see Chapter IV below). The sacred nature of the hulls and the importance of watercraft in the panoply of kingship and ritual is demonstrated by the lack of any secondary burials or buildings in the area until the Middle Kingdom. Even though burial at Abydos enhanced one’s chances in the afterlife, a 1200-m\textsuperscript{2}-area that included the boat graves was left inviolate for more than 1,000 years.

After Dynasty 1, flood levels began their first major decline since the introduction of agriculture nearly 2,000 years earlier. The Palermo Stone records steadily decreasing flood levels during Dynasty 2,\textsuperscript{33} and Butzer notes that Khasekemwy, the last king of Dynasty 2, was crowned only with the crown of Upper Egypt, suggesting political disorder may have increased.\textsuperscript{34}

Butzer and others have suggested that environmental conditions, particularly declining flood levels, contributed to the collapse of the Old, Middle, and New Kingdoms. Several lines of evidence have been used to support this hypothesis. For
example, narrative texts testify to the effects of flood failures. Unfortunately, Egyptologists disagree about how to interpret texts that describe abnormal social strife and economic hardship. Many see the texts as purely literary devices with little historical value. But because certain texts also relate specific incidents that happened to individuals, they are more likely to be realistic.\textsuperscript{35}

Other scholars have taken a quantitative approach to studying archaeological remains. Statistical examination of trends in wealth (indicated by size, complexity, and lavishness of Old Kingdom tombs) suggests a general decline in the costliness of tombs from the beginning of Dynasty 4 through the end of Dynasty 6. The most serious drop occurs during Khufu's reign. By the end of Dynasty 5, "lower" officials could no longer afford their own tombs. Only higher officials and viziers built tombs in early Dynasty 6, but they had also stopped by its end.\textsuperscript{36}

Desert and countryside scenes painted in tombs reflect increasingly drier conditions and barren landscapes during the Old Kingdom. A reduced wood supply may have prompted changes in shipbuilding techniques to conserve timber, but the effects of environmental shifts did not prevent Old Kingdom officials from boasting about the enormous freighters they caused to be built in Upper Egypt.\textsuperscript{37}

The Old Kingdom ended with a series of catastrophic Nile failures that resulted in starvation and cannibalism c. 2200 B.C., coinciding with the First Intermediate Period. Another series of severely reduced floods marked the transition between Dynasties 11 and 12 of the early Middle Kingdom.\textsuperscript{38}

By the reign of Senwosret III, high, fluctuating flood levels created a "wild" Nile. At Semna South, army officials recorded flood waters 7-8 m. higher than modern levels. The higher, irregular floods have been linked to increased homage paid to the divinity of water and vegetation, a change in artistic styles, and "complaint" texts interpreted as long-term dissonance over unpredictable flood levels and a general decline in Dynasty 13.\textsuperscript{39} This decline led to the Second Intermediate Period (c. 1797 B.C.), marked by the death of Amenemhat III.

About 1200 B.C., another widespread decline throughout the Near East began.
The very low floods of about 1260 ± 50 B.C. resulted in a cessation of agriculture in Nubia and the onset of dune formation across the flood plains of the Nile.\textsuperscript{40} The change of location for the Ramessid Delta residence after the reign of Ramesses II may also point to a reduction in Nile flow. After 1200, and into the Third Intermediate Period, historical records suggest that grain prices increased dramatically, probably reflecting the loss of cultivable land. Increased economic and social strife is indicated by food riots, worker strikes, and tomb-robber trials.

Political power and continuity depended on the king's ability to care for the people at all times, and fluctuating flood levels diminished this authority by creating times of hardship. Although the Egyptian government seems always to have dominated the economy through bureaucracy, during the Middle Kingdom, a time of unpredictable flood levels, Egypt achieved the dubious distinction of becoming perhaps the most bureaucratized state ever to exist.

RESOURCES, LABOR, AND POWER

The Egyptian state depended on symbols to reinforce its divine right to control of the produce of the land, including human labor. Egyptian bureaucracy reinforced and supported the stability and prosperity of the kingdom, enabling the king to fulfill his responsibilities as a wise and pious leader through the creation of an elaborate tax system.\textsuperscript{41}

We cannot cite a date marking the dawn of bureaucracy in Egypt, but the introduction of writing was crucial to its formation. Writing often begins as a way to identify possessions, and one scholar sees the origins of hieroglyphs in pot-marks, pottery motifs, and on artifacts created more than a thousand years before Dynasty 1.\textsuperscript{42} Formalized record-keeping also may reflect the desire of chiefs or kings to commemorate political and military triumphs. Baines attributes the introduction of writing to a desire to define and display cultural features, but dates its origin to Dynasty 1.\textsuperscript{43} Regardless of when it began, writing became one of the most powerful tools of the Egyptian state.

Rigid control of literacy meant that no more than one percent of the Egyptian
population could read and write at any time. Official positions required literacy, and even in Dynasty 3, people with the very highest status were described as scribes or administrators of scribes. Kemp provides an outstanding synopsis of Egypt’s redistributive economy and the assiduous record-keeping required for its operation.

Scribes held supervisory positions in the administration of temples, estates, and the government, referred to as "king’s house" or "the residence," and in construction and craft works. Payments for services passed through the scribes of the "residence" as "praise" from the king in the form of gold, ornaments, estates, or other income-producing gifts. B. Kemp and C. Eyre both have suggested that the success of massive building projects depended upon the successful administration of resources and labor; Eyre also points out that Manetho credited Imhotep, honored for building the Step Pyramid of Djoser, with developments in writing.

Craft specialization during the Early Dynastic period had created a pool of talented workers whose engineering expertise is evident in the works of their Old Kingdom successors, who transformed mudbrick and wooden architecture into stone. All citizens below the rank of official worked on state projects, and they were organized into work crews that reflected the early focus of mass labor: water transport.

Boats transported goods and people so efficiently that Egypt had no roads until the Roman era. Naval officers, or at least persons with naval titles, held prominent positions in all areas of government. Work crews, whether working in the turquoise mines of the Sinai or transporting stone from Hatnub, split into s3, or "gangs." Listed from greatest to least seniority, there were the forward-starboard (jmj-wr), forward-port (t3-wr), aft-starboard (w3d), aft-port (nds), and steerage, or rudder, (jmj-nfr) gangs. Each of these gangs was divided into two to four subgroups. This ordering of labor may even have extended to the priesthood, although recent scholarship offers an alternative interpretation of evidence.

It is possible that, originally, Egypt’s navy existed primarily for the purpose of obtaining and transporting resources. Because access to the Nile could be tightly monitored from the Mediterranean, population centers did not need to prepare for naval
attacks. The Egyptian army seems to have skirmished often with the tribes of the south, however, and military expeditions that included warships are known. Egyptian ships also made overseas expeditions to Lebanon and Punt, but most early nautical activity focused on domestic transport.50

Of particular interest are inscriptions that provide details about ships and seafaring, such as hull size, voyage length, the amount of time required to build a particular vessel, and the sailing season. Although most stone-transport expeditions occurred during the inundation season, some officials bragged of bringing cargoes "when the water was not covering the sandbanks."51 One official provided a picture of the boat that transported his sarcophagus from Tura to Giza in five (or seven) days; freight boats of King Unas (Dynasty 5) reportedly brought granite columns 580 miles from Aswan in a week.52

Weni (Dynasty 6) had this record of service carved on his tomb:

His majesty sent me to Abhat to bring the sarcophagus called the Box of the Living Ones, with its cover, and an obelisk, and the costly furniture for my mistress (?) the pyramid Kha-nefer of Merenra. His majesty sent me to Abu to bring the granite doors and bases of the over-ground temple of my mistress (?) the pyramid Kha-nefer of Merenra with six broad boats, three transports, three eight-oars, and one warship: never was this done, Abhat and Abu (reached with?) one warship, in the time of any of the kings...

His majesty sent me to Het-nub to bring a great table of offerings of the alabaster of Het-nub. I brought him down this table of offerings in seventeen days, quarrying it in Het-nub, and causing it to float down in this broad boat. For I had cut for it a broad boat of acacia wood, 60 cubits long, 30 cubits broad, and built it--all this(?) in seventeen days, in the third month of harvest, when behold there was no water on the ...[i.e. sandbanks] of the channel (when the Nile was very low), and I moored at the pyramid Kha-nefer of Merenra in peace...

His majesty sent me to cut five channels in the South, and make three broad boats and four transports of the acacia of the Wawat. Behold, the princes of Areathet, Wawat, Aam, and Meza were felling (?) wood for them. I did all in one year, and floated (the boats) laden with very much granite for the pyramid Kha-nefer of Merenra...53

The territories of Upper Egypt (Areathet, Wawat, Aam, Abu, and Meza) were heavily
wooded in Dynasty 6 (see Chapter III below). Most inscriptions of this type date to the Old Kingdom, suggesting that what had been worthy of note then was no longer unusual in later times.

Middle Kingdom rulers looked to their predecessors of the Old Kingdom for guidance in the proper way to prepare for the afterlife. Pyramids, although smaller and more cheaply built, again consumed massive amounts of the nation's available labor. Scribes used their skills to calculate the exact amount of material to be moved, the number of workers required to perform a job, and the rations and fractions thereof needed to feed the workers. Kemp summarizes the effect neatly: "In this way the supply of the three essentials for major building projects—materials, labour, and rations -- could be constantly monitored. It was the scribe's pen as much as the overseer's lash or the engineer's ingenuity that built the pyramids."54

During Dynasty 12, the management of information and organization of labor had reached the point that a vizier in Memphis monitored every minor movement of planks, hides, and new and used tools in and out of a royal shipyard near Abydos, nearly 350 miles away.55 The scribe, already portrayed in shipbuilding scenes of the Old Kingdom, continued to play a major role in the daily operation of government shipyards.

Shipbuilding Scenes

Scribes kept track of logs, tools, and labor in Egyptian shipyards, and they appear in some, but not all, shipbuilding scenes from late Dynasty 4 until the New Kingdom. One of the simplest shipbuilding scenes is found in Ka-em-ankh's late Dynasty 4 tomb where three workshop areas include metal workers, linen stores, and woodworkers in a shipyard.56 The whr.t, or dockyard, scene is only sketched, but large sailing ships on the adjacent wall illustrate the end result of Ka-em-ankh's building activity. More elaborate Old Kingdom depictions are found in the tombs of Tep-em-ankh,57 Nefer and Ka-Hay,58 Niankhmun and Knunhotep,59 Aba,60 and Ti61 which illustrate much more of the process of shipbuilding but leave us with many questions.

In these reliefs, woodworkers wielding axes fell trees and trim branches to feed to
goats. Then, a row of workmen carries a trunk suspended from a pole that rests on their shoulders into the shipbuilding area. Such scenes may be interpreted in two ways: 1) ships were built near forests that supplied their wood or 2) shipbuilding scenes served as a visual shorthand that skipped the transport and curing of felled timber.

The tomb of Aba shows workers splitting a trunk, and it and several others show rough trimming of planks with axes. Other planks are sawn. Sliwa's suggestion that sawing played a greater part in ship construction than that portrayed in tombs is borne out by saw marks on all timber faces from the ancient Egyptian hulls I have recorded.  

Most tombs illustrate the final stages in construction. The tomb of Tep-em-ankh, however, includes a partially built hull with only its lower strakes and a companion vessel receiving the last plank in its upper strake; the Middle Kingdom construction scene at Beni Hassan shows a boat that seems about half-finished. Two reliefs show shipwrights checking hull measurements. Other scenes feature late stages in construction: final adze trimming, mortise placement for bulwarks or oarlocks, and the fitting of battens and lashing inside the hull.

Boats in the Niankhnum and Ti scenes feature workers who hold short pieces of wood upright for adzing. A worker in another of the Ti boats trims a bifurcated pole, perhaps a stanchion for a carling or stringer, and a second worker saws a small stave vertically. The pieces he works with are too large for tenons (although they could be tenon blanks), too small for crossbeams, and too narrow for deck planking. Cabin construction is not shown in any of the representations, so superstructure elements can be excluded from consideration. The only documented function for narrow, medium length pieces of wood on Egyptian hulls is as battens.

Two scenes illustrate the next stage of construction, that of tightening the lashing inside the hull. A painting at Zawiet el Meitin and a relief from the tomb of Nefer and Ka-Hay (fig. 1-2) show workers pulling cordage tight and other workers beating the cordage with a maul or rock. Some have suggested that these scenes show a hull being given its curvature because a truss is wrapped around the stem and stern, but as Sliwa points out, placing stress on a hull with this type of truss would cause its seams to split
Fig. 1-2. Simplified drawing of a shipbuilding scene from the tomb of Nefer and Ka-Hay. (After Moussa and Altenmüller [1971] fig. 19)
open. He suggests that we are seeing a composite view of all stages of ship construction. Instead, we may be seeing a hull whose planks are being forced tightly together so that lashing can be tightened over battens inside it.

The exciting depictions of shipwrights at work bring the study of Egyptian boatbuilding to life. Many stages of construction are omitted from the scenes, and others may represent a number of separate stages shown together, but the ship construction scenes offer evidence for boatbuilding and the importance of watercraft to Egyptian society.

*Textual Evidence*

The opportunity to browse through 3,800-year-old accounts of a dockyard, to peruse magical spells designed to awaken a cranky ferryman for a voyage to eternity, and to read captioned descriptions of ship construction and sailing provides a lens to see ancient Egyptian attitudes toward and uses of watercraft more clearly. For example, the dockyard records of Senwosret I mention the shipyard and the coppersmith nearby, demonstrating the links between shipbuilding, metalworking, and state control seen in tomb paintings and reliefs from the Old Kingdom.  

The titles of officials furnish substantial information about the organization of the administration and the navy. D. Jones's extensive glossary of ancient Egyptian nautical terms and titles presents all known references to nautical matters. Records of dockyard workshops, timber sales, and boat repairs also provide information about hull construction (see below). We even have the daily logs from New Kingdom rivercraft.  

In addition, the Old Kingdom *Pyramid Texts* and Middle Kingdom *Coffin Texts* each contribute to a comprehensive study of ancient Egyptian watercraft. The Old Kingdom spells allude to 32 different types of boats, including celestial vessels sailed by the gods and the stars, earthly boats for the king, boats of divine justice and taxation, transport boats to bring food to the king in the other world, and funerary boats. One study of the boats in the *Pyramid Texts* focuses on identifying the different names of the boats with determinatives and shows that they are not all to be classed as solar boats.
In the Middle Kingdom, specific enumeration of construction elements in watercraft provides complementary information to that given by models, paintings, and the physical remains of hulls. Faulkner's translation of the spells provides documentation of his interpretation of boat parts and illustrates the richness of textual evidence for shipbuilding. Unfortunately, Egyptologists disagree about the meaning of terms describing hull components and many are simply unidentified.

Spells command a boat to be brought, and the deceased must name the different parts of the hull and compare them to godly images, such as the "ribs of Nephthys," or what seems to be a rope: "Take a n'w snake which is with the Controller of the Two Lands and put it in her [the hull], with its head in your hand and its hinder-part in my hand, and we must pull it tight between us in its name of Pain."72

The advantages of applying knowledge gleaned from a study of ancient Egyptian hulls to texts that discuss them are many. Problems have arisen in the past from the application of knowledge of modern or ancient Mediterranean shipbuilding practices to ancient Egyptian terminology; hull components and construction techniques provide concrete evidence for testing the meaning of a word or phrase.

CONCLUSIONS

The interdependence of ancient Egyptians and the Nile produced a society with a highly developed nautical technology. By studying the qualities of the society itself, we can learn about some factors that affected how boats were built. Because watercraft held such potent power as symbols, traditional forms probably were retained simply because of precedent. Like the pyramid complexes of the Middle Kingdom, boat burials at Dashur and Lisht emulate those of the Old Kingdom, demonstrating the king's knowledge of the proper order and ritual.73

Environmental changes affected the prosperity of the country, and it is interesting to note that we have hulls only from Egypt's moister, and most prosperous, periods. The royal monopoly on fine timber, and probably also on local resources, including
shipwrights, meant that most vessels were built by and for the state and its officials. Small fishing craft, ferries, and papyrus boats, however, would always have been part of the lower level economy of villages and individuals.

Peering into the ancient Egyptian past with the aid of models, representations from tombs, and textual references provides a sense of the richness of the boat as metaphor. Boats were the only way to reach the gods, and the gods each had their own boats. In other words, watercraft were equated with power, knowledge, and freedom from daily cares when referred to in a funerary context.

The sense of watercraft as powerful cultural images needs to be remembered as their physical aspects are discussed. In the chapters that follow, the materials and tools used in hull construction and early woodworking techniques add to a more general understanding of where the hulls fit within a broader context. Then, specific details of ancient Egyptian watercraft from Abydos, Giza, Lisht, Dashur, and Mataria can contribute to understanding how the ancient shipwright viewed his craft and furnish a framework for understanding ancient Egyptian nautical technology.
ENDNOTES


6. Miosi (supra n. 3) 177.


8. Kessler (supra n. 7) 87-88.


11. Williams (supra n. 9) 319.

12. Williams 1988 (supra n. 1) 38.


15. Butzer (supra n. 14) 105-106.


27. W.A. Ward, "Relations between Egypt and Mesopotamia from Prehistoric Times to the end of the Middle Kingdom," *JESHO* 7 (1964) 1-45, 121-135.

28. The complexities of arguments for direct or indirect Mesopotamian contact require more attention than can be focused upon them in this brief overview. The presence of artifacts and similarities of architectural and artistic style point to some type of interchange. Ward (supra n. 28) suggests that contact was mediated by Syria. B. Williams (supra n. 25) has suggested that pastoralists might have had more wide-ranging contacts and that Mesopotamian influence was channeled by Nubia.


31. Ben-Tor (supra n. 29) 15.

32. Ben-Tor (supra n. 29) 20.


34. Butzer (supra n. 14) 108.

35. Butzer (supra n. 14) 108.


40. Butzer (supra n. 13) 107-108.
41. Kemp (supra n. 13) 20.


45. Kemp (supra n. 12).


47. Kemp (supra n. 13) 128; Eyre (supra n. 44) 8.

48. Eyre (supra n. 44) 12.

49. Roth (supra n. 46).

50. Eyre (supra n. 44) 13 summarizes several of the Old Kingdom biographical inscriptions that describe stone transport.

51. Eyre (supra n. 44) 16.

52. Eyre (supra n. 44) 11.

53. Griffith (supra n. 37) 17-18.

54. Kemp (supra n. 13) 128.


57. L. Borchardt, *Das Grabdenkmal des Königs Ne-user-rê* (Leipzig 1907) fig. 103.

59. A.M. Moussa and A. Altenmüller, *Das Grab des Nianchchnum und Chnumhotep* (Mainz 1977) e.g. fig. 8.

60. N. de G. Davies, *The Rock Tombs of Deir el-Gebrawi I* (London 1902) 20, pl. 15-16.

61. G. Steindorff, *Das Grab des Ti* (Leipzig 1913) pl. 119-120.


64. Davies (supra n. 60) and P. Duell, *The Mastaba of Mereruka III* (Chicago 1938) pl. 152.

65. A. Varille, "La tombe de Ni-ankh-pepi à Zaouyet el-Mayetin," *MIFAO* 70 (1938) 15, fig. 5.

66. For the dockyard at This, see Glanville (supra n. 55); for the tomb of Tep-em-ankh, S. Hodjash and O. Berlev, *The Egyptian Reliefs and Stelae in the Pushkin Museum of Fine Arts, Moscow* (Leningrad 1982); for Ka-em-ankh, see Junker (supra n. 56).

67. See also T. Säve-Söderbergh, *The Navy of the Eighteenth Egyptian Dynasty* (Uppsala 1946).


71. Miosi (supra n. 3).

72. Faulkner 1977 (supra n. 2) 22-23, Spells 396-397.

73. For Old Kingdom boat burials, see Chapter VII, especially Table 7-1. A brick-vaulted boat grave dating to the Middle Kingdom was excavated at Lisht by the Egyptian Expedition of the Metropolitan Museum of Art in 1924, but not identified.
as such until D. Arnold’s re-evaluation of excavation records and archives. The Lisht boat grave is probably associated with the owner of subsidiary pyramid 5, although it could also be associated with Senwosret I. Arnold also notes that the Middle Kingdom pyramid complexes of Amenemhat III, Senwosret II, and Senwosret III all included brick-vaulted boat graves on the south side of the pyramid. D. Arnold, *The Pyramid Complex of Senwosret I* (New York 1992) 52-53, n. 83, pls. 64-65.
CHAPTER II

NATURAL RESOURCES

The technology developed by a society reflects the materials, knowledge, and labor available to it. In Egypt, materials available to shipwrights ranged from local plants to prestige woods such as cedar from other lands. Intensive animal grazing and the damage it caused in the arid lands throughout the Near East make it difficult to evaluate the range of species and materials available to ancient woodworkers and builders, but archaeological recovery and identification of ancient woods has helped define local and foreign resources exploited by the Egyptians.

NATIVE GENERA

Egypt’s native woods are often dismissed as being of low quality and fairly scarce, but Old Kingdom and Middle Kingdom excursions to Middle and Upper Egypt record great quantities of timber.\(^1\) How late these forests survived is suggested by a late-12th-century A.D. report on state-owned forests at Oxyrhynchus. Thirteen thousand feddans (c. 13,250 ac.) were overrun by peasants without making an appreciable difference to the forests.\(^2\)

Cyclical flooding in ancient Egypt created a landscape unlike any other in the world. Trees grew along the banks of canals or branches of the Nile, at oases, and in the Delta, but the river’s annual floods prevented seedlings from establishing firm hold in the alluvial plain. Egypt encompasses Mediterranean coastal affinities (although it lacks the maquis and garigue typical of other Mediterranean vegetation zones), papyrus swamps, oases, agricultural, Saharan steppe, and tropical Sudanian zones. Descriptions of plants with known or suspected use in the construction or sailing of Ancient Egyptian watercraft follow.

*Acacia.* Acacia nilotica or *A. arabica.* Texts document Old Kingdom expeditions to Middle and Upper Egypt that built acacia boats 60 and 100 cubits (32-52
m.) long, and modern records of traditional watercraft from Upper Egypt and the Sudan suggest that it remained a primary wood source for the region. Theophrastus described the acacia as a tree with curving branches and brittle wood, but noted that it produced planks up to six m. long. Dockyard records of the early Middle Kingdom refer to the delivery of boatloads of "white" acacia timber.

Its hardness was valued for manufacturing tenons; the Khufu vessel, the Lisht timbers, and the shrines of Tutankhamen include acacia tenons. Coffins from the Old, Middle and New Kingdoms had both tenons and pegs of acacia; furniture of all eras, Predynastic logs and roots, Early Dynastic beams, and tree trunks of acacia are also known.

Acacia was also valued for tool-making. Large mallets made of wood taken from the root-trunk junction utilized the natural strength of the gnarly wood, and axe hafts from the Predynastic to the Coptic period are identified as acacia.

**Acacia tortilis**. This small tree (10 m. or more) or shrub (2-4 m.) used for making statues and possibly boats was distributed from East Africa to the Near East and common throughout the Sahara to the 30th parallel. *A. tortilis* prefers aeolian soils, but can be found on many soil types. In Egypt, *A. tortilis* is found in the Libyan, Arab, and Nubian deserts, in the Nile Valley, in dry and hot depressions, and in gravelly soil. Davis recorded a population east of Cairo near Gebel el Galala in 1953. An essential component of the steppe-like landscape of Egypt, the leaves and fruits of *A. tortilis* are eaten by wild and domestic animals. With *smd*, it was the sacred tree of Sile, on the northeastern frontier of Egypt.

**Carob. Ceratonia siliqua** L. *Ndw.* The carob is a small, evergreen tree with a thick and knotty trunk up to 10 m. high. Carpenters appreciate its reddish, dense wood today. Although there is no direct evidence of its use in boatbuilding, carobwood's utilization in New Kingdom furniture suggests that its qualities may also have been appreciated in the superstructure or furnishings of finer watercraft. Shipboard rations in the medieval Mediterranean included its fruit, 40-50% sugar and protein. The carob prefers nonirrigated, semi-arid to arid conditions; its roots can extend quite deep in order
to reach subterranean water.

Carob, a dominant eastern Mediterranean plant, is recorded from Gebel Haggege on the western desert coast of Egypt in association with Juniperus phoenicea and Olea europaea. Lucas noted that scattered carob trees grew along the northwest Egyptian coast. Although some authors describe this population as a relic of an ancient alliance, Baum believes that local conditions argue against the development of shrubby, Mediterranean maquis vegetation, and the uniqueness of the population may more reasonably point to introduced plants. True relic populations in Yemen, Eritrea, Uganda, Kenya, Tanzania, the central Negev, Jordan, Somalia, and Oman were recorded by 19th century botanists.

The word *ngm* appears in the First Intermediate Period at Dendera, in a list of orchard plants from Dynasty 18, and in recipes for perfumes and unguents from Late Period laboratories at Edfu and Dendera. New Kingdom pharaohs obtained carobwood furniture and logs from Syria. The same word, but with a different determinative, is used to describe a product of Punt, but Baum thinks this was an acacia.

*Date Palm. Phoenix dactylifera, burt.* The date palm's cylindrical trunk reaches 20 m. or more. Salt and heat tolerant, the date palm lives in the Delta and Nile valley, the Libyan oases, humid parts of the desert, and along the Red Sea coasts. A food source from at least the Palaeolithic period in Egypt, the date palm appears on Predynastic palettes and in Dynasty I lists of offerings. Its leaves, fibers, and poor quality wood were used to make mats, baskets, and roofs. Date palm wood has also been identified in two wood samples from coffins. It is included here as a potential source of the matting commonly shown in depictions of ancient Egyptian watercraft.

Archaeologists have commonly attributed ancient cordage samples to the date palm, but a recent analysis suggests that people of pharaonic times relied on it far less often than do modern Egyptians.

*Dom Palm. Hyphaene thebaica, m3m3.* Like the date palm, this was predominantly a fruit tree, but ancient woodworkers used its harder trunk for beams and boat or raft construction. The ancient Egyptians associated the dom palm with Nubia
and Punt, and it was sacred to the temple of Hathor at Dendera. The dom palm’s primary
distribution is in Upper Egypt from Abydos southwards and in the Western oases,
although a relict Sudanian vegetation complex on the border of the Delta shows that it
may once have grown there.

A Dynasty 2 or 3 tomb at Saqqara used dom palm wood for roofing, but the tree
is not mentioned in texts until after the Old Kingdom. The Dynasty 18 black granite
statue of the Butler and Foreman of Works, Minmosi from Medamud, proclaims: "I taxed
the chieftains of the land of Nubia...many ships of dom-palm wood as yearly taxes...."
Minmosi was superintendent of works under Amenophis II at the Turah quarries.\textsuperscript{22}

\textit{Halfa grass, Desmostachya bipinnata.} This is a type of perennial grass whose
name means binding material (\textit{desmos}) with a narrow inflorescence (\textit{stachys}). In Egypt,
halfa grass is recorded from the Nile and canal banks, drains, ditches, roadsides, and
waste ground. Halfa grass grows on waste ground and along waterways throughout North
Africa, Palestine, Sinai, Egypt, Arabia, and in lands further east.\textsuperscript{23}

Halfa grass was used as lashing for the early Middle Kingdom Lisht vessel\textsuperscript{24} and
provided the most diverse group of 18 ancient Egyptian cordage samples botanically
identified by Ryan and Hansen.\textsuperscript{25} Rural Egyptians use it today to make ropes, baskets
and mats, to bind sand, or as fodder if more palatable plants are unavailable.

\textit{Juniper, Juniperus phoenicea.} w’n. Common throughout the Mediterranean, this
tree is the only spontaneous Egyptian conifer. It grows to 10 m. in the mountains of
Northern Sinai today,\textsuperscript{26} and probably represents the remnants of a once abundant
woodland dating to the Neolithic period.\textsuperscript{27} A Dynasty 3 coffin from Saqqara included
this wood.\textsuperscript{28}

The amount of juniper berries strewn over many Predynastic and later burials
suggests local availability, but Loret argues that the word’s Semitic origin and inclusion
with Syrian woods in texts point to a Levantine origin for juniper.\textsuperscript{29} Phoenician junipers
produce abundant berries, and Egyptians probably exploited this local resource. But
because the Phoenician juniper attains only 10 m., discussions of juniper timber for
boatbuilding and construction in royal and governmental affairs probably do reflect
imports (see *J. excelsa* below).

*J. phoenicia* may have filled local needs for tool handles and small hull components.

**Papyrus.** *Cyperus papyrus.* Papyrus, a giant sedge which grows to 2-3 m. and has a triangular stem, probably was introduced spontaneously to Egypt in floating clumps from its native central Africa. Only a small population remains in a wild state in modern Egypt, but it once filled marshes and was common along the Nile. Each of six papyrus cordage samples identified by Ryan and Hansen utilized the culm to create ropes 1.5-7.6 cm. in diameter. Primarily used in paper manufacturing, papyrus also was used to make boats, cords, sandals, mats, furniture, and decorative garlands.

**Persea.** *Mimusops laurifolia* (Forsk.) Friis. *shw3b.* This evergreen tree grows to 15-20 m. tall in the valleys and plains of Ethiopia, Yemen, and northwestern Somalia. It is also indigenous to mountains bordering the Red Sea and the Gulf of Aden, but was introduced and cultivated in Egypt by Dynasty 3. New Kingdom carpenters used the wood to make statues, boxes, and furniture. A heavily used *persea* mason's mallet dates to the First Intermediate Period or the early Middle Kingdom.

**Sidder or jujube.** *Zizyphus spin-a-Christi, nbs.* Lucas describes it as a very hard wood used for fasteners and coffins. Sidder tenons have been identified in the Khufu I hull, and axe hafts in the British Museum are sidder. Lucas suggests that it once had wider local use because many 19th-century water wheels were made of this wood, an idea supported by Baum's documentation of sidder in landscape and orchards of Old Kingdom representations and in the sacred landscape of the Pyramid Texts. She also notes its strong influence on toponyms and geography in the Late Period. Sidder is found from northwestern India to east Africa and in Egypt's Nile Valley, Delta, oases, desert depressions, and Red Sea mountains.

Sidder is found in Predynastic to late sites throughout Egypt. The Arab name *nabq* for sidder is related to the Egyptian name attested in a series of Dynasty 1 vases from Abydos and Saqqara. Sidder is one of the most common components of offering lists in the form of *i-nbs* bread, pastries, and beer made from its fruit. Baum also records
New Kingdom statues, weapons and tablets of siddar.

_Sycamore_ fig. _Ficus sycomorus, nht_. This is one of the most ancient and holy trees in Egypt. Although sycamore is often unappreciated by western writers, its consistent use in funerary equipment and the role it played in religious ideology point to its importance to the ancient Egyptians.

Brought to Egypt before 5,000 B.C., the tree cannot reproduce without human assistance, because its pollinator in Egypt, the parasitic wasp _Cerastolen arabicans_, does not cause seeds to set.38 Further south, along Ethiopian and tropical floodplains, large sycamores reproduce without human intervention. The tree’s girth can reach 8 m. and its height 20 m. Permission from the palace was required before cutting sycamore trees.

Baum documents the many sacred associations of the sycamore fig with Hathor, Neith, Nut, and other goddesses, usually with the goddess in the tree or receiving fruit from it. Represented in tombs throughout Egyptian history with huge trunks and many small branches, the sycamore dominates the subterranean world and appears in the Pyramid and Coffin Texts.39

Sycamore wood was used for boatbuilding, coffins, statuettes, boxes, butterfly cramps, models, and vases. Of 28 wood specimens from Egyptian coffins in Czechoslovakia, 20 were sycamore.40 Early Middle Kingdom dockyard records include sycamore planks 1.5-3.5 m. long and 0.7-1.0 m. wide.41 When Hatshepsut (Dynasty 18) built the huge barges for transporting her obelisks, a call for sycamore trees was issued across the land. Late New Kingdom prices suggest that the standard value of a sycamore log, of unspecified size but probably quite small, was one-fifth that of an axe.42

_Tamarisk_. _Tamarix sp. isr_. Many species of _Tamarix_ are known from Egypt and the lands of the Mediterranean. Most artifacts made of tamarisk have not been identified to the species level. Baum notes that paintings cannot be identified to species level either.43 Most authors dismiss this tree as too stunted and knotty to be of much use,44 but many ship timbers at Lisht (2+ m. in length) were shaped from tamarisk. It flourishes in salty ground where roots up to 50 m. long seek fresh water. Today, it is often found at the ends of irrigation systems where the water becomes increasingly salty, and it is likely
that this was also true in the past.

Attested from the Pliocene at Wadi Qena and the Kourkour oasis, tamarisk remains reflect changes in Egypt's climate. In the Nile valley and at Wadi Kubbaniya, tamarisks were part of the semi-desert vegetation from the Epipaleolithic (18,000-12,000 B.P.). Stumps from the Fayum and el Omari date to the Neolithic, and the ubiquity of the wood throughout the pharaonic period to modern times show the tamarisk to be one of most common features of Egyptian landscape.

According to Baum, *T. aphylla* is unique among the Tamarix because it forms a true tree with vegetative propagation and rapid development. Its trunk, 2.5-3 m. high with a 2 m. diameter, has many large horizontal branches with suckers that reach 5-6 m. in height. The suckers were used to make staffs, and a green tamarisk staff was used to beat the Unfortunate Peasant. Rites of protection for the afterlife included possession of a tamarisk stick to beat one's adversaries.

Tamarisk trees were planted at Hatshepsut's funerary temples at Deir el Bahari and at the cemeteries of Abydos. They also were sacred to the Ptolemaic 17th Nome of Upper Egypt and other entities. The tamarisk was widely associated with the idea of regeneration, probably because of the rapid regrowth of cut suckers and branches.

The solid wood was widely used in furniture building and in "turned" products, and for fuel. Tamarisk species contain tannins; some (*T. mannifera, T. aphylla, T. macrocarpa*) host parasitic insects that excrete tiny drops of manna, collected by bedouins at dawn before evaporated by the sun's heat. Walking sticks, throw sticks, tenons, axe hafts, coffins, box lids, butterfly cramps, and other objects were made of tamarisk wood. Original tenons from the Dashur boat in the Carnegie Museum of Natural History were tamarisk, and Winlock showed that the Dynasty 11 temple of Mentuhotep was fronted by a tamarisk grove.Nibbi reports that of about 140 Coptic objects representing 12 genera in the Louvre, more than 80 are tamarisk.

Janssen records Late New Kingdom prices and lengths for tamarisk beams (x3y). No prices are related to size, but beam lengths are 9-16 cubits (c. 4.5-8 m.) and 5, 10, 18, and 60 deben. Wood for a coffin cost 4 deben, a little less than the cost of an axe.
Willow. *Salix subserata* Willd., same as *S. safsaf* Forsk. *yc.* This small tree or shrub grows to 10 m. and is distributed in Libya, Egypt, Sudan, and from Ethiopia to South Africa. A hydrophilic tree found on the banks of the Nile, beside ponds, and along irrigation canals where it can develop dense thickets.

Willow was used to make parts of houses, portions of ship cabins, doors, and staffs. Lucas identified a Dynasty XVIII chariot pole as willow,\(^5\) and its leaves often appear in garlands and bouquets.

**IMPORTED GENERA**

Other than a few identified samples from the Khufu boat and planking from the Dashur boats in Chicago and Pittsburgh, we have little information on the use of imported woods other than textual references to the use of ‘s wood in hull construction. This section includes woods identified in other types of artifacts from Egypt that may also have been used in hull construction.

Ash. The ash (*Fraxinus ornus*) was not native to Egypt, but grew in the Lebanon mountains of Syria and Asia Minor. Ash is very tough and is known from tool shafts, chariot felloes, and bows.\(^5\)

Boxwood. *Buxus longifolia*.\(^4\) Box, a short bushy plant, produces a hard, pale wood with close straight grain. Egyptian sources for box documented by the Tell el-Amarna tablets seem to be primarily in Syria and Phoenicia, but it also grows on Cyprus. Box was most commonly used for furniture and cabinetry, and the Late Bronze Age diptych from the Ulu Burun shipwreck was made of boxwood.\(^5\)

*Cedar*. *Cedrus libani*. ‘s? *mrw*?. Botanists define four species of cedar today, but it is not possible to differentiate between the wood each produces. Although the Egyptians may have exploited Libyan and more western resources, texts point to the Levantine coast as the source of cedar and other large conifers.\(^5\) *C. deodara* grows in the Himalayas, *C. brevifolia* in Cyprus, *C. atlantica* in the Atlas mountains of the Maghreb, and *C. libani* in forests at elevations to 1000 m. above sea level in Lebanon, on the coastal mountains of
Syria, and in southern Turkey.\textsuperscript{57} Trees reach 40 m., attaining a girth of 5-8 m. Cedar trees characteristically have thick trunks with horizontal, stout branches.\textsuperscript{58} Killen suggests that although cedar can be knotty and has a very pronounced grain pattern, it was preferred by the Egyptians because its softness allowed their copper tools to be more effective.\textsuperscript{59} Egyptians also appreciated the fragrance and rot resistance of cedar.

Some authors have stated that cedar was an inferior wood,\textsuperscript{60} but it seems possible that modern preconceptions may interfere with our understanding of the high value placed on cedar by the ancient inhabitants of the eastern Mediterranean. Timell's discussion of compression wood may point to the origin of our prejudice.\textsuperscript{61} When branches or leaders of gymnosperms are stressed even a few degrees by snow, wind, or even the weight of the branch itself, compression wood is laid down on the underside of the inclined stem (trunk) along the grain, creating pressure on the stem to return to vertical. Even after the stem returns to vertical, the compression wood continues to develop.\textsuperscript{62} Timell points out that this quality is essential to the life of the tree, but creates "a very serious defect in both sawn timber and plywood."\textsuperscript{63} Cedar, as a much branched conifer, has a great deal of compression wood, and thus does not meet modern timber standards.

But ancient Egyptians may have appreciated cedar for the very qualities that cause us to reject it. Green compression wood has twice the density, more compressive strength, and greater elasticity, hardness, and toughness than normal wood. Air-dried compression wood is inferior to normal wood in most strength qualities, but it is important to note that compression wood absorbs less water than normal wood, and traps the water it does absorb.\textsuperscript{64} Normal wood shrinks 0.1-0.3\% in length but 2-8\% or more radially and twice that tangentially. Compression wood has 5\% longitudinal shrinkage, a common complaint about cedar, but less than 2\% combined radial and tangential shrinkage. Air-dried compression wood from \textit{Picea abies} has 44\% greater maximum crushing strength than normal.\textsuperscript{65} The knee-like mast supports and crotches prominent on Egyptian models and in depictions of watercraft could have made excellent use of compression wood.
Grain patterns in planks from Egyptian hulls show that shipwrights did not cut straight planks. The planks curved and followed grain lines as did knees and curved pieces in furniture. Dendrochronologists sampling the Carnegie Dashur boat and funerary equipment note that the Egyptians usually trimmed away both bark and sapwood. Planks from the Carnegie Dashur boat cut from the same tree demonstrate the use and avoidance of compression wood in different parts of the boat. The presence of compression wood, viewed today as a weakness in cedar because we want straight planks, was expected, appropriately used, and probably even desired by ancient Egyptian boatbuilders.

The debate about the identification of cedar with the hieroglyphic word 'ṣ or mrw has overshadowed the fact that the Egyptians obtained large amounts of coniferous timber from Lebanon since at least Dynasty 2, and probably much earlier. Kings boasted of building huge 'ṣ ships and importing great quantities of timber from Syria throughout Egyptian history. One of the first state expeditions after the First Intermediate Period was to Hty.w nʿṣ, the forested highlands of Lebanon, to obtain wood. Cedar has been identified in the Khufu I hull, planks from the Dashur boats, large scale buildings, and in furniture, statues, butterfly cramps, tool handles, and coffins. Builders of Tutankhamen's large shrine used cedar planks 5.7 cm. thick.

Cedar was abundant in Lebanon, and significant amounts reached Egypt. Mikesell writes, "In view of the probable range of cedar and fir in antiquity and the proximity of cedar to the trading centers of Phoenicia, it is difficult to avoid the inference that the tree so highly esteemed in Egypt was Cedrus libani." P. Kuniholm's dendrochronological studies of the cedar Dashur boat in the Carnegie Museum of Natural History and coffins from a number of museums are expanding our knowledge of the extent of cedar usage by the Egyptians and establishing a dendrochronological sequence for dating.

Mikesell points out that when Egypt was a powerful, tribute-demanding state (as in the Old Kingdom and Dynasty 18), huge amounts of cedar were cut for the Egyptians and sent to Egypt, but that in Dynasty 21, Wenamun had a terrible time getting lumber for the ceremonial ship of Amun-Ra. Wenamun obtained seven logs, but then had to
provide jars of gold and silver, rolls of linen and papyrus, cowhides, ropes, lentils, and fish before the Syrian prince arranged for 300 men and oxen to cut and haul the remaining timber.

Contemporary Late New Kingdom economic documents from a necropolis village at Thebes also reflect the high cost of 'ś' wood used in shipbuilding. A mast 40 cubits long cost four silver deben, twice the cost of the most expensive bull. Long pieces, or trunks, of good quality were sold in 40-50 cubit lengths and cost between five and 10 silver deben. A keel (?) timber of good quality sold for five cubits per silver deben, and one of second quality for seven cubits per silver deben. Janssen notes that these are double the mast prices.

_Cypress. Cupressus sempervirens_. Another of the Levantine forest woods, cypress grows to 30 m. in coastal mountains from the Maghreb to Jordan. Cypress has been identified in the Dynasty III plywood coffin of Saqqara, Middle Kingdom dovetail tenons, and in Dynasty XVIII jewelry and toilet boxes, becoming more common in the Late Period. Meiggs reviews its use elsewhere in the eastern Mediterranean.

_Ebony. Dalbergia melanoxylon. ḫbn. _The Egyptian ḫbn_ is known to us as African blackwood, and is distinct from _Diospyros ebenum_, ebony obtained from India today. Although Beauvisage notes that _D. melanoxylon_ was grown in Alexandrian gardens in the early part of this century, ḫbn was always considered a product of the south by the ancient Egyptians. Lucas notes trade in small ebony logs just north of Khartum. By Dynasty I, ḫbn was used for tablets and other small objects. An early Middle Kingdom text includes a "post of ['š]-wood, a steering oar of [w'n] and a handle of ḫbn for the steering platform of the seagoing ship."

Craftsmen prized the dark brown to black decorative wood for furniture-making and small carvings like that of the Nubian on Tutankhamen's walking stick. Ebony was used for decoration rather than as a structural component until the New Kingdom when sufficient quantities were imported from the south to construct beds and other furniture. Tell el-Amarna tablets, Assyrian writings, Linear B tablets, and Ezekiel document ebony objects, and the Ulu Burun shipwreck (c. 1325 B.C.) carried several
Egyptian ebony logs.\textsuperscript{85}

\textit{Elm. Ulmus procera.} Common to Western Asia, the elm reaches 40 m. Although elm is suitable for heavy construction, documented use in Egypt is limited to New Kingdom chariots and wheels.\textsuperscript{86}

\textit{Fir. Abies cilicia or A. alba.} \textit{'\textit{s}? Fir grows with cedar in the upper zone of eastern Mediterranean coastal mountain ranges. A tall tree (to 30 m.), fir is light, relatively fast growing, and free of knots.\textsuperscript{87} The keel and second strake of the Ulu Burun shipwreck are fir.\textsuperscript{88} Homeric and Biblical descriptions of ancient ships refer to masts of fir, and Classical authors provide evidence of its importance in later shipbuilding.\textsuperscript{89}}

Although several authors support the interpretation of \textit{'\textit{s}?} as fir, I can find reference to only two small objects made of fir in Egypt before the 7th century B.C.,\textsuperscript{90} suggesting that in Egypt, fir did not receive the extensive use documented for \textit{'\textit{s}?} by texts.

\textit{Hornbeam. Carpinus betulus.} A European and western Asia native reaching 25 m., hornbeam is very hard, dense, and close-grained. The only published Egyptian object identified as hornbeam is an oar loom from the Khufu I hull.\textsuperscript{91}

\textit{Juniper. Juniperus excelsa, J. communis.} \textit{'\textit{s}? mrw?}. These species of juniper grow with cedar in the mountains of the eastern Mediterranean and reach 20-25 m. Ten percent juniper is mixed with cedar in a cedar forest growing between 1700 and 2000 m. in southern Turkey.\textsuperscript{92} Juniper's red, fragrant wood provides resin and oil used as incense, and was often confused with cedar although junipers were almost never of comparable height or girth.\textsuperscript{93}

A piece of wood from the Khufu I hull has been identified as juniper,\textsuperscript{94} as has wood from ancient Egyptian musical instruments in the Louvre.\textsuperscript{95} Dendrochronological testing by the Malcom and Carolyn Wiener Laboratory for Aegean and Near Eastern Dendrochronology identified juniper logs in the Dynasty 3/4 Meidum pyramid and the Dynasty 4 bent pyramid at Dashur.\textsuperscript{96} Nibbi argues that \textit{'\textit{s}?} is juniper, citing the scarcity of identified cedar samples before Dynasty 9 or 10, but juniper is less frequently reported than cedar for the same period.\textsuperscript{97}

\textit{Turkey and Kermes Oak. Quercus cerris and Q. coccifera. jrn}. Turkey oak is part
of the Mediterranean forest vegetation and can reach 40 m. Populations of Kermes oak in the northern Sinai and west of the Delta today indicate broader distribution in the past.\textsuperscript{98} The Kermes oak is a shrubby tree that can reach 7 m.

Oak, a hardwood, was much preferred in ancient times for both tenons and pegs in ship construction.\textsuperscript{99} The rare oak finds from Egypt include bark from Predynastic Gebelein, a single tenon in the shrine of Tutankhamen, the pole, axle and spokes of a Dynasty 18 chariot, and a New Kingdom scribe’s palette.\textsuperscript{100}

\textit{Pine.} Pinus halepensis, P. pinea, P. nigra. ‘\textit{s}\textsuperscript{2}. Coastal forests in the eastern Mediterranean are rich in pine, a wood valued for its length and straight grain and very common in Classical shipbuilding.\textsuperscript{101} Glanville suggests that pine was the Egyptian ‘\textit{s}, but the lack of pine artifacts in Egypt argues against it.\textsuperscript{102}

\textit{Yew.} Taxus baccata. Yew does not grow south of Syria. Although it was used mostly for sculpture, woodworkers between Dynasty 6 and 12 also used it in coffins.\textsuperscript{103}

CONCLUSIONS

Timber resources in Egypt were probably greater than has been suggested in the past, particularly if the use and abundance of acacia, sycamore and tamarisk are considered. Foreign timber was available but extremely expensive. Both local and foreign timber resources were under royal control, although trade on an individual level also occurred.\textsuperscript{104} The use of so many different imported woods and the quantities of wood imported imply that the Egyptians were economically powerful.

More thorough study of periods of wood importation might contribute to understanding cycles in the Egyptian economy. For example, descriptions of the earliest coffins of Naqada III/Dynasty 1 emphasize the use of local wood, often identified as sycamore, cut in irregular shapes that follow the wood’s grain. This style of coffin building continues, with a few exceptions, until the Middle Kingdom. Coffins from that period feature straight cedar boards cut in patterns that enhanced the appearance of the wood grain but did not use it frugally. Imported yew was also used in coffin construction.
The sudden change in coffin construction techniques between the Old and Middle Kingdoms is indicative of fewer restrictions, either economic or cultural, on the use of wood by officials. It may also reflect the expansion of royal privileges to a new group.

The prevailing Egyptological focus on imported woods obscures the importance of local Egyptian timber resources. Discussions of ancient Egyptian wooden objects often focus on the identification of words for imported woods, although only a small percentage of the objects themselves are of foreign origin.¹⁰⁵ This illustrates the lack of attention given to local woods; much as towns have been less preferred excavation sites than temples, so objects of local wood have generated little interest in scholars despite their importance in daily life. Yet local woods played a vital role in the waterborne commerce of the nation, and the abilities of ancient shipwrights to deal successfully with local materials and resources is reflected at every site where worked and unworked stone were brought by boats.
ENDNOTES

1. For example, J.H. Breasted Jr., Ancient Records of Egypt I (Chicago 1906) 145-50.

2. A.M. Fahmy, Muslim Naval Organization in the Eastern Mediterranean (Cairo 1966) 144.


5. Theophrastus, Ep IV.2.1.8.


13. Breasted (supra n. 1) 436 and 512.

15. Lucas (supra n. 7) 443.
16. Breasted (supra n. 1) 436 and 512.
17. From information collated by Baum (supra n. 12) 90-106.
20. Information collated by Baum (supra n. 12) 106-20 except as noted.
22. Cumming (supra n. 21) 139.
23. N.L. Bor, Graminae (Flora of Iraq 9, Baghdad 1968) 429.
25. Ryan and Hansen (supra n. 19) 24, Table 8, and 28, fig. 3.
28. Lucas (supra n. 7) 430.
29. V. Loret, La flore pharaonique (Paris 1892) 41-42.
31. Täckholm (supra n. 21) 790.
32. Ryan and Hansen (supra n. 19) 25, Table 9.
33. From Baum (supra n. 12) 87-90.
34. Baum (supra n. 12) 169-76.

35. Lucas (supra n. 7) 440, 446; Podzorski et al. (supra n. 8) 124.


37. Lucas (supra n. 7) 443.


39. Baum (supra n. 12) 18-87.

40. Brezinova and Hurda (supra n. 18) 141.

41. Simpson (supra n. 6) 34.

42. J.J. Janssen, Commodity Prices from the Ramessid Period (Leiden 1975) 371.

43. Baum (supra. n. 12) 205.

44. For example, G. Killen, Ancient Egyptian Furniture I (Warminster 1980) 6.

45. Most of this information is collated by Baum (supra n. 12) 200-206.


47. Identified by Donna Christensen, Forest Products Laboratory, Madison WI.

48. Lucas (supra n. 7) 448.


50. Janssen (supra n. 42) 373-75.

51. Information from Baum (supra n. 12) 196-99.

52. Lucas (supra n. 7) 436.

53. Killen (supra n. 44) 1; Lucas (supra n. 7) 431.
54. Meiggs (supra n. 46) 280-1.


59. Killen (supra n. 44) 2.

60. e.g., Nibbi (supra n. 49) 24.


62. Timell (supra n. 61) 1-2.

63. Timell (supra n. 61) vii.

64. Timell (supra n. 61) 4, 531, 559-61.

65. Timell (supra n. 61) 531.


67. Including, but not limited to, V. Loret, "Quelques notes sur l’arbre âch," ASAE 16 (1916) 33-51; S.R.K. Glanville, "Records of a Royal Dockyard of the Time of Thutmose III: Papyrus British Museum 10056," ZÄS 68 (1932) 8-10; Nibbi (supra n. 49) 14-27; Meiggs (supra n. 46) 405-16.

68. Breasted (supra n. 1) 146.


70. For example, Lucas (supra n. 7) 430; Gale (supra n. 8) 128; O. Kofoed-Petersen, Catalogue de sarcophages et cercueils égyptiens (Copenhagen 1951) 13; seven inscribed dovetail tenons are described from Lisht in Arnold (supra n. 46) 97-99.
71. Lucas (supra n. 7) 433.

72. Mikesell (supra n. 57) 14.

73. Kuniholm and his dedicated team work at the Malcom and Carolyn Wiener Laboratory for Aegean and Near Eastern Dendrochronology, in the Department of the History of Art & Archaeology at Cornell University.

74. Mikesell (supra n. 57) 13.


77. Lucas (supra n. 7) 434; Arnold (supra n. 46) 97-99.

78. Meiggs (supra n. 46) 416-20.


80. Lucas (supra n. 7) 434.


83. Killen (supra n. 44) 3-4 and Lucas (supra n. 7) 435-36.

84. G. Bass, "The Tell el Amarna Tablets and the Ulu Burun Shipwreck," presented in 1987 at the Oriental Institute, Chicago, in honor of the 100th Anniversary of the discovery of the Tell el Amarna Tablets (Proceedings forthcoming; Gordon Young ed.).


86. Lucas (supra n. 7) 436-7.

87. Meiggs (supra n. 46) 119.

89. For example, Theophrastus, *EP* 5.7.1-3; 5.1.5 and 7; T.D. Seymour, *Life in the Homeric Age* (repr. New York 1965); Meiggs (supra n. 46) 43.

90. Lucas (supra n. 7) 430.

91. Zaki Nour (supra n. 36) 45.


93. Meiggs (supra n. 46) 410-16.


95. Nibbi (supra n. 49) 23.


97. Nibbi (supra n. 49).

98. See Rowton (supra n. 76) for a review of the extensive coverage of forested areas of the eastern Mediterranean into this century, including a cypress-oak-juniper forest at Petra in Jordan.


101. Meiggs (supra n. 46) 43-44. The Kyrenia shipwreck was almost completely pine; Steffy (supra n. 99) 87.

102. Glanville (supra n. 67) 9; Lucas (supra n. 7) 438; Nibbi (supra n. 49) 23. A single inscribed butterfly tenon from the Middle Kingdom pyramid site of Lisht has been identified; Arnold (supra n. 46) 97-99.

103. G. Beauvisage, "Recherches sur quelques bois pharaoniques," *Recueil de travaux* 18 (1898) 78; Lucas (supra n. 7) 439.

104. Janssen (supra n. 42) 370-83.
105. Meiggs (supra n. 46) 404.
CHAPTER III

TOOLS AND WOODWORKING

The development of nautical technology depended upon the raw materials available for both hull construction and tool manufacture and upon knowledge of woodworking techniques. Egypt's arid environment has preserved a large quantity of worked wooden objects and tools, permitting us to follow the development of woodworking techniques, and reliefs in and models from tombs illustrate how tool use changed with time.

TOOLS

The earliest Egyptian tools were stone, and stone tool manufacture and use continued side-by-side with extensive metal production even until modern times. Although certain classes of stone tools required specialized craftsmanship, others were easily made. In addition to being less expensive than metal tools, stone tools could be resharpended easily and repeatedly. Their primary disadvantage is that blades thin enough to perform most woodworking tasks are easily broken.

Few studies of stone tools for woodworking have been published, and a thorough analysis of lithic technology is beyond the scope of this study. A few examples, not representative but perhaps indicative of local responses to technological demand, permit a glimpse into ways ordinary people coped with changing demands.

Stone Tools

The success of Egyptian groups in working planks despite limited access to metal is amply demonstrated in Naqada II cemeteries at Naga-ed-Der and elsewhere and by the many depictions of wooden boats on contemporary pots. A number of Naqada II graves included frames built of boards 3-9 cm. thick, up to 40 cm. wide and 2 m. long. The lack of metal tools in even the richest unplundered graves at Naga-ed-Der illustrates their scarcity and suggests that these planks were at least partially fashioned with stone tools.¹
Polished stone axes dating to the early Predynastic have been found at many Egyptian sites; earlier examples exist in Nubia. By the Late Predynastic Period, some stone axes imitated contemporary metal shapes. Some examples incorporate lashing holes that suggest they were used as amulets, but similar stone axes were used for woodworking. A series of flint axe blades from Giza and heavily used stone axes, adzes, and a saw from the Middle Kingdom settlement at Kahun attest to the continued use of stone tools.

Saw-edged blades like those from el Badari illustrate the precision possible in the fashioning of stone tools (fig. 3-1). These blades were too thick to cut more than a few centimeters of wood at a time, and their use probably required extensive kerf-wedging and patience. Badari graves also include examples of early stone adzes, including some that are necked with small rounded heads, a form that does not appear in metal tools until

Fig. 3-1. Examples of stone tools from Badari. (After Branton and Caton-Thompson pls. 20 and 29)
the Old Kingdom. As far as I know, no studies of edge-wear analysis of Predynastic tools have identified woodworking tools.

**Metal Tools**

Until the Late Period, metal tools in Egypt were made of copper or bronze. An adze dated to Naqada IIb is one of the earliest recovered copper woodworking tools. Other early copper tools include an axe blade, a 34-cm.-long tanged saw blade, and a 22-cm.-long adze blade that date to Naqada III (c. 3100-3000 B.C.) from Minshat Abu Omar. Dynasty 1 inscriptions in the Sinai prove that the Egyptians were exploiting copper sources there by about 3000 B.C., and a contemporary deposit of over 325 copper tools in tomb 3471 at Saqqara includes saws, adzes, axe blades, chisels, knives, and gravers.

Tool deposits constitute unique assemblages in Predynastic and Early Dynastic graves and may identify the graves of artisans. Copper, and later bronze, tools bearing royal names and the names of work crews indicate centralized control of metals.

**Axes.** Egyptian woodworkers used the axe, *minh*, for felling and trimming trees and roughly shaping planks. The earliest metal axes in Egypt have Nubian A-Group and Near Eastern parallels, and the first broad-bladed rectangular axes come from A-Group cemeteries. Thin, rounded blades appear at the end of the Late Predynastic Period. Leather lashing bound thin, rounded blades to slotted handles. With time, lugs and holes in the part of the blade nearest the handle simplified the task of binding metal blades securely.

Seventy-five axe blades from Saqqara tomb 3471, originally classified as blanks, have one sharpened edge and range from 0.15 to 0.7 cm. thick. A shipyard worker in the Dynasty 6 tomb of Aba cries: "The axe cuts home, I am about to see something good." Dockyard records from the time of Senwosret I show standardized axe weights of 50 and 40 deben (c. 700 and 560 g.), and Middle Kingdom carpenter's axes in the British Museum weigh between 524 and 1948 g. Axe blades described by Ramesside ostraka weighed c. 455 and 637 g.; Davies records New Kingdom axes with weights of
400, 468, 607, 672, 677, 803, 810, and 1272 g. One heavily used Dynasty 18 axe, possibly from Thebes, bears an incised boat.

Saws. Saws, ḫ3, were a vital part of the Egyptian tool kit. A description of a saw and six blades from Saqqara tomb 3471 reports saw blades 25.1 to 40 cm. long, 4.5-6.5 cm. wide, and 0.05-0.15 cm. thick with irregularly shaped teeth. Teeth in Egyptian saws faced the handle, cutting on a pull stroke, and did not always reach the tip of the blade. Most teeth on the Saqqara blades are roughly triangular with flat tops, but a few are smaller and pointed. All are about a millimeter long, but some teeth are up to three times wider than others.

Emery suggests that the irregularity in tooth width was accidental, but that the shortness of teeth was purposeful as it appears on an unused sawblade as well as the used blades. Saw marks in many directions covering the surface of a coffin plank from Tarkhan suggest the perseverance demanded of a woodworker. Like the Tarkhan coffin, planks from all the Dashur boats and the Lisht timbers have saw marks that consistently demonstrate a one-millimeter tooth length and illustrate continuity in tool traditions.

Many authors have commented on the pull saw and its accompanying vice, ḏbt, which held vertical boards tightly lashed to an upright. Representations often illustrate a weighted stick used to keep the lashing taut, and sawyers are shown adjusting the position of the lashing as they cut lower in the board. A wedge prevents the kerf from binding on the blade. Spier points out that because a pull saw's blade does not need to withstand compressive forces, it can be thinner and made with less or inferior metal, resulting in the removal of less wood with each cut as well.

When push saws were compared with a Japanese pull saw designed to be used with two hands like Egyptian saws, the pull saw demonstrated greater efficiency and ease of use, suggesting that they "may make more effective use of the forces available and transmitted from the body." Saws from Bronze Age Europe have teeth set towards the handle, but were replaced by push saws with the introduction of iron.
woodworkers continued to use pull saws in the Far East, Greece, and Turkey into modern times despite the easy availability of iron, other factors, perhaps related to the nature of labor and goals of craftsmanship, must also be at work.

Adzes. Egyptian woodworkers depended on the adze (‘nt or nwt) for rough shaping and finishing of timbers. Like the saw, the adze performs its work on a pull stroke, making a cut perpendicular to the handle. Petrie noted that blades with parallel sides widening slightly toward the cutting edge date to before Dynasty 3, but necked blades with narrow, rounded heads, much wider bodies, and flared edges rapidly replace them.26

Nearly 100 adzes and adze blades from tomb 347 at Saqqara include blades 13.4-28 cm. long, 1.8-5.6 cm. wide, and 0.02-0.6 cm. thick. Cord or leather thongs bound blades to wooden hafts 37.2-44.0 cm. long.27 Fig. 3-2 plots the distribution of blade sizes. Most are either 2.9-3.0 or 3.2-3.5 cm. wide and about 21 cm. long. Emery divided the blades into two types,28 but two other types emerge if blade shape and thickness are considered (Table 3-1).

![Fig. 3-2. Distribution of adze blades by length.](image-url)
Table 3-1. Adze blade types from Tomb 3471, Saqqara.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Thickness</th>
<th>No. of blades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Convex sides</td>
<td>0.5-7.0 mm</td>
<td>60</td>
</tr>
<tr>
<td>Type 1a</td>
<td>Convex sides</td>
<td>0.2-2.5 mm</td>
<td>20</td>
</tr>
<tr>
<td>Type 2</td>
<td>Expanding sides</td>
<td>0.2-2.3 mm</td>
<td>17</td>
</tr>
<tr>
<td>Type 2a</td>
<td>Expanding sides</td>
<td>3.0-7.0 mm</td>
<td>1</td>
</tr>
</tbody>
</table>

Emery suggested that the thinnest blades were for ceremonial purposes, but at least two had buckled in use. In modern carpentry, blades of finishing tools can be less than a millimeter thick. Neither Egyptian representations nor tool kits include finishing tools; it is possible that the extremely thin adze blades were designed to smooth nearly finished work. As the thinnest blades are also the broadest (18 blades between 3.8 and 5.6 cm. wide), it is also possible that they were lightweight imitations of larger tools or meant to be used in the ceremony for the opening of the mouth.

Adze blade marks on the Dynasty 18 Dashur boat in the Carnegie Museum of Natural History are 2.5, 3.3, 4.3 and 5.3 cm. wide; Dashur boats in the Cairo Museum retain adze marks 3.0, 3.3, and 4.0 cm. wide. Senwosret I’s dockyard used adze blades weighing 15 deben or 200 g., but New Kingdom carpenters used heavier blades of 364-455 g.²⁹

At all times, adze wielders were represented in tomb scenes and thus were an important and characteristic feature of shipbuilding that would be recognizable to anyone.

Chisels. Chisels are used for removing wood along or across the grain and for cutting holes. Chisel-type blades are among the most ancient in Egypt, dating to Naqada II. Until Dynasty 2, chisels had two sharp edges, but after that only one edge was sharpened. Two-edged chisels were unknown outside Egypt.³⁰

Chisels (mnkh) for mortising account for more than half of 51 chisels in Saqqara tomb 3471. Blades 14-21 cm. long, 0.8-1.2 cm. wide and 0.8-1.3 cm. thick were attached to handles with flattened ends suitable for heavy work that required a mallet or rounded
handles for hand use. The shortest chisels in this group (14 x 0.7 x 0.8/0.9 cm.) were well used, and their dimensions suggest they had undergone considerable sharpening as most others in this group are 19 to 21 cm. long. Other chisel blades with round-ended handles for hand work averaged 11.5 x 0.5 x 0.7 cm. or 9 x 1.0 x 0.2 cm.\textsuperscript{31}

Chisel marks in mortises on Dashur boat planks define a blade at least 16 cm. long and 1.4 cm. wide with a shank 0.8 cm. thick. Mortises on Lisht planks include marks from a chisel blade 2.0 cm. wide with a 0.6-cm.-thick shank and able to reach the base of a mortise 17 cm. deep. A worker on a ship under construction in the Dynasty 6 tomb of Aba shouts: ‘Lo, I’m chiselling,’\textsuperscript{32} and chiselling is one of the most common elements of ship construction scenes.\textsuperscript{33} The dockyard workshop of Senwosret I dealt with chisels of 14 or 20 deben (196 or 280 g.).\textsuperscript{34} Tool lists in funerary inscriptions sometimes include a thousand chisels for the tomb owner’s use in the afterlife; Ka-em-ankh (Dynasty 4) requested 1,000 each of four types.\textsuperscript{35}

Round-bar chisels with flat heads were typically used for working stone but could also be used in woodworking. In the tomb of Aba, men working on a large log or beam use mason’s mallets to strike what appear to be round-bar chisels without handles as another man wields a two-handled maul.\textsuperscript{36} This scene probably depicts splitting or rough shaping of the wood.

*Graving chisels.* Naqada I gravings chisels, *md3t* (?), Egypt’s earliest known copper tools, were double-ended with a square bar.\textsuperscript{37} By the First Dynasty, graver blades were equipped with rounded handles and measured 8-12.5 cm. long, 0.2-0.3 cm. wide, and 0.4-0.5 cm. thick.\textsuperscript{38} Their inclusion in Ka-em-ankh’s list of tools for the shipyard points to their use in shipbuilding.\textsuperscript{39}

*Drills.* The bow drill, known in Egypt since Early Dynastic times, was used to create stone vases. It probably developed from the bow and arrow, a common weapon in the Predynastic Period.

Woodworking scenes that portray the construction of furniture or the sculpting of statues sometimes illustrate bow drills, but the bow drill is never portrayed in a known
shipbuilding scene until the late New Kingdom. In the Tomb of Ti, carpenters use the bow drill, but it was not portrayed with the shipwrights. This possible demarcation of appropriate uses of technology is also reflected in the physical remains of ancient hulls: none I have examined has tool marks that suggest its builders used a bow drill during hull construction. Mortises, known to be partially drilled in later times, have many chisel marks but never any drill marks.

I have not examined either the pegged mortise-and-tenon joints in the Khufu I deckhouse or cylindrical holes in the bottom of the Lisht frame (see below), but both probably were made with a bow drill. Only the Mataja vessel of c. 500 B.C. provides physical evidence for drilled peg holes (see below). In some mortise-and-tenon joints in that hull, drilled holes held fasteners with a head size of c. 2 cm. diameter.

Other Tools

Woodworkers in shipbuilding scenes use two types of mallets, hrpwy, to strike chisels. A number of the larger-headed mallets with straight handles have been recovered, and other types are illustrated by finds from Deshasheh and Kahun. Kahun also provides a small whetstone, found with a cache of broken copper tools, chisels, flint flakes, and bronze pieces.

Stone rubbers for polishing woodwork are common in many carpentry scenes, and the lack of toolmarks on Khufu I hull planks testifies to their use on ships. This stage of hull construction may be illustrated in the tomb of Tet-em-ankh, where a worker is apparently rubbing a small tool on planks at the end of a hull.

Other tools can be seen in ship construction scenes. Shipwrights in the tomb of Ti use large two-handled wooden pounders to drive planks onto tenons set in the edges of lower planks; the pounders are pictured in the tomb of Mereruka, but their function is unclear. A worker pounds lashing with a large stone or maul in the hull of a nearly completed ship in the tomb of Nefer and Ka-Hay (see fig. 1-2).

Wachsmann suggests that the Nefer scene and similar depictions in the Dynasty 4 tombs of Rahotep and Atet at Medum show the tightening of rope battens along plank
seams, but I think they illustrate the tightening of transverse hull lashing of the type found in the Lisht timbers. Wachsmann has also pointed out that the tightening of lashing with forked sticks was portrayed in an Old Kingdom ship scene and a New Kingdom chariot scene.

The same shipbuilding scenes also illustrate the use of ropes for moving wood. Ropes looped beneath logs and over poles are used to carry logs; workers using short ropes position a plank in the upper strake, in one instance assisted by a worker using a lever outside the hull.

Measuring and marking devices. Measuring and marking devices form the last major category of shipbuilding tools. The royal 52.5-cm.-long cubit was used in the building of the Dynasty 1 mastaba tomb 1060 at Tarkhan; Robins showed that its architects used the small cubit of 45 cm. (the length of the arm from the elbow bone to the extended middle finger tip). Standardized subdivisions of the cubit are the living palm ($\times p$) of 7.5-8 cm. or one-sixth of a small cubit, and metrological fingers of about 2 cm.

Shipwrights marked plank joins and mortises on the Lisht and Dashur hulls with score marks and black, painted lines (see Chapters VIII and X below). The most extensive series of marks has been found on the Khufu I ship, but most of the hull signs probably were associated with its anticipated reassembly rather than with its original construction. The clearly marked centerline on the Khufu I vessel is the exception; it probably was used to check hull symmetry.

Metrological examination of hulls may demonstrate principles of construction. For example, V-shaped mortises on the Khufu I hull are typically separated by half a cubit (three palms) and mortise-and-tenon fastenings by two cubits. Lashing mortises in Lisht planks are usually one palm long, as are mortise-and-tenon fastenings in the Dashur hulls.

The Old Kingdom mastaba of Mereruka included an unusual illustration of a shipwright using a line, plumb bob, and marking implement either for establishing a centerline or for checking the dimensions of a funerary boat under construction. In the
tomb of Niankh-khnum and Khnumhotep, a shipwright working in the uncompleted center of a hull holds an upright staff in one hand and what appears to be a small stick, possibly for marking, in the other.\textsuperscript{55} Supervisors in the tombs of Ti and Niankh-khnum and Khnumhotep each hold a coiled line and plumb bob.\textsuperscript{56} Sliwa catalogues a variety of squares from excavations and representations,\textsuperscript{57} but no squares have been portrayed in ship construction scenes.

Although only the Mereruka and possibly Niankh-khnum tombs illustrate the marking of planks, ancient shipwrights probably used a system similar to that used by more recent Egyptian boatbuilders to outline plank curvature. Descriptions of the construction of early 20th-century Nile boats by Clarke and Homell document the use of red ochre and blue paint on a string for marking plank curvatures and fastening locations.\textsuperscript{58} Based on lexicographical arguments, the use of ochre in marking tombs, and the Clarke description, Darnell argues that the Dynasty 4 word $\delta d-(m)d\delta r$ present in the ship construction scenes means "remove the red [ochre]," that is, trim away ochre lines marking plank curvature.\textsuperscript{59}

CORDAGE

Twisted fibers bound the earliest papyrus rafts together, and the use of cordage played a dominant role in ancient Egyptian ship construction. The most common word for boatbuilding, $spt$, means "to sew." The basic technique for making rope involved the twisting of bundles of individual fibers in the same direction to create yarns or cords which were then twisted around each other in the opposite direction. By reversing the direction of the twist, tension created in the fibers of the individual yarns acts to maintain the final rope shape.\textsuperscript{60}

Emily Teeter has examined ancient Egyptian representations of the rope-making process as shown in tomb reliefs.\textsuperscript{61} As is the case in several other groups of paintings depicting a technological process, the scenes complement each other and provide slightly different perspectives on the illustrated activity. Teeter points out that cordage production
is often depicted next to boatbuilding scenes or in conjunction with swamps. Although some of hieroglyphic captions particularly refer to making rope for boatbuilding, adjacent scenes illustrate the building of papyrus boats rather than wooden hulls. Most rope-making scenes date to the Old Kingdom, with only two known examples from the New Kingdom.

In an analysis of hieroglyphic captions accompanying six of the scenes, Teeter defines several terms: "sorting the fibers," "twisting the fibers," and a phrase she interprets as "drawing the fiber" (without twisting it). The action in the tomb scenes bears out the defined terms. In addition to workers gathering what seems to be papyrus near swamps, there are agricultural scenes which suggest flax or some other plant product was collected.

Janssen's study of Late New Kingdom ostraka provides information on the price and length of rope for ships. Cables cost a silver deben for each 100 cubits, so a rope of 400 cubits cost about the same as a 's mast or two excellent bulls. Prices are provided for ropes 200, 300, 500, 1000, 1200 and 1400 cubits long. Lipke reports that the reconstruction of the Khufu I hull required 5,000 m. (about 10,000 cubits) of rope. This amount would have cost nearly 100 silver deben in 1200 B.C., the equivalent of a herd of about 200 fine cattle.

In one of the few scientific studies of ancient Egyptian cordage, D. Ryan and D. Hansen examined 16 specimens from sites throughout Egypt, although they stress that their study should not be seen as statistically representative. The examples date from the Middle Kingdom through Greco-Roman times and are part of the British Museum's collection of Egyptian artifacts.

The study of these material remains considered the structural form of the cord: its size, diameter, material of manufacture, and range of functional use. Ryan and Hansen point out that the identification of artifacts made of plant material has often relied on the general appearance of the material rather than on microscopic examination of internal anatomy. As a result, excavators and curators have tended to assign much of the ancient Egyptian cordage to Phoenix dactylifera or date palm, a choice likely to be influenced by
its dominant role in cordage manufacture in Egypt today.

The investigators found that the 16 samples were constructed of plant materials from three species: *Cyperus papyrus* (papyrus), *Desmostachya bipinnata* (halfa grass), and *Hyphaene thebaica* (dom palm). The largest number of samples, nine, were made of halfa grass. A sample of the plaited lashing material from Lisht has also been identified as halfa grass.

**EARLY WOODWORKING**

Depictions of woodworking found in Egyptian tombs and the extensive finds of wooden objects illustrate the range of materials and processes used by craftsmen. This brief overview of technological achievements used or potentially used in wooden hull construction provides a glimpse of other crafts that may have influenced nautical technology and evaluates planks that may have come from Dynasty 1 boats.

The oldest representations of ships in Egypt are contemporary with Naqada II wood-enclosed graves at several cemeteries, of which Naga-ed-Der is one of the best documented. Boards of uniform thickness were set against each other to make a bottomless enclosure; bodies lay on matting or wooden trays inside. Branches and planks above the frames showed that some graves were roofed and level with the ancient ground surface. Individual boards measured between 2 and 9 cm. thick.

One of the most elaborate graves had a roofing plank 2.1 x 0.30 x 0.055 m. No fastenings between boards were recorded. Although plank ends were shaped and butted or mitered together, corners were not fastened. Instead, vertical posts inside or outside the enclosure supported it and were lashed to it by cords passing through holes in the boards. The absence of fastenings between boards may reflect inadequate knowledge of joinery, the inordinate amount of time required to create mortises with available tools, difficulty in working with thin boards, or cultural demands that leave no archaeological record.

Furniture and coffins from Early Dynastic Tarkhan exhibit a concern for
economical use of wood and new woodworking techniques. The oldest archaeological examples of pegged mortise-and-tenon joints, lashing mortises, pegs, and wood patches come from Tarkhan. Beds dating to Naqada IIIa include pegged mortise-and-tenon joints, lashing mortises, and knees. Low trays, tables, and coffins were supported by crosspieces pegged to their lower surfaces.

The size and number of coffins in Tarkhan graves decreases with time, but the largest coffins were only 1.35 x 0.6 x 0.6 m. Unpegged mortise-and-tenon fastenings connected planks sawn from stock 10-30 cm. in diameter. Planks used in coffin construction are typically 1.5 to 3.5 cm. thick, and Petrie describes them as sycamore (probably Ficus sycomorus). Plank shape followed the natural growth curvature of the tree, establishing construction patterns that continued throughout the Old Kingdom, among lower classes, and in times of economic disturbance (fig. 3-3).

Seams were carefully fit and plastered, and patches sometimes replaced flawed wood. MacKay notes that it was difficult to separate many of the seams. The smooth seams in planks from coffins at Tarkhan and all later periods differ significantly from juggled edges that create an interlocking wall of planking in ancient Egyptian hulls.

Tarkhan coffins provide the first examples of sides fastened to ends and fitted lids. An attached floor replaces the traditional matting or tray for the body seen in Naqada II framework burials. Comers of the earliest coffins rely on halving joints; later coffin comers were mitered, but both relied on pegs that passed diagonally through the planks for strength. Peg holes were cleanly drilled, probably with a bow drill. Pegs were also inserted to lock lashing in place, as the remains of cordage and leather thongs were reported from many peg holes. Corner lashings, however, were not pegged.

At Tarkhan, holes through planks for sewing were connected by shallow grooves for the binding material, usually leather or linen. In addition to mortise-and-tenon fastenings, lashing through L-shaped and V-shaped channels joined plank edges in three places along side seams and two places along end seams. Lids, built of mortise-and-tenon joined planks in all but one instance, were generally lashed to the sides and ends of the coffins.
Fig. 3-3. Old Kingdom coffin EM 28038. (After Lacau [1904] pl. 8)
A Dynasty 1 coffin from Tarkhan in the British Museum has walls made of vertical boards edge-fastened by mortise-and-tenon joints and inserted into a framework. Mortise-and-tenon joints in the comers were pegged. The vertical construction of the sides foreshadows the elaborate panelled facades of some Dynasty 2 and 3 coffins from Tarkhan and elsewhere.

Petrie's earlier excavation of a panelled coffin that imitated a building probably influenced his interpretation of some unusual planks in Tarkhan coffins and lids. He reconstructed the planks shown in fig. 3-4 as part of a portable wooden house. Frankfort and Fairservis later suggested that the planks may instead have belonged to watercraft. S. Vinson's examination of Tarkhan planks curated at University College supports Frankfort and Fairservis. Vinson believes that at least three were parts of ships, but cautions that there is no proof that they were used that way. Table 3-2 presents information extracted from Petrie's and Vinson's reports; I have not examined the Tarkhan planks.

Vinson tentatively identified UC 17162 as a complete frame or futtock, UC 17156 as a broken frame or futtock, and UC 17166 as a plank. As he notes, UC 17166 includes the major fastening types used on the Khufu I hull, and whether or not these planks are from ships, they provide a vehicle to discuss ways Early Dynastic ships might have been built.

Like planks from the Khufu, Lisht, and possibly Dashur hulls, Tarkhan planks include V-shaped and L-shaped channels, probably for lashing (fig. 3-5). They measure about 3.2-4.2 x 1.1-1.4 x 2.0-2.8 cm. V-shaped channels occur in pairs on opposing sides of the planks, and L-shaped channels are found along plank edges. Tarkhan planks also have shallow edge-mortises, T-shaped channels that open onto three of the timber's surfaces, open mortises in timber ends, and mortises that pass through the timbers (through-mortises). With the exception of through-mortises, all of these fastening mechanisms are known from Egyptian hull remains.

Although some of the illustrated Tarkhan planks have lines of fastenings along their edges (both L-shaped channels and through-mortises), the holes are offset from each
Table 3-2. Dimensions and fastenings of Tarkhan planks.

<table>
<thead>
<tr>
<th>Timber</th>
<th>Dimensions in cm.</th>
<th>Description of fastenings</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC 17156</td>
<td>65.6 x 11.2 x 6.4</td>
<td>Open mortises at both ends; 2 T-shaped lashing channels c. 2.3 cm. thick</td>
</tr>
<tr>
<td>UC 17157</td>
<td>65 x 19.7 x 5.3</td>
<td>V-shaped channel, not penetrating</td>
</tr>
<tr>
<td>UC 17158</td>
<td>50.3 x 15.8 x 3.5</td>
<td>5 through-mortises 2.8-4.2 x 1.2-1.75, some with lashing</td>
</tr>
<tr>
<td>UC 17159</td>
<td>101 x 12.5 x 2.9</td>
<td>13 through-mortises 2-4.5 x .8-1.1</td>
</tr>
<tr>
<td>UC 17160</td>
<td>102 x 15.5 x 2.7</td>
<td>21 through-mortises 2.1-3.45 x .8-1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallel</td>
</tr>
<tr>
<td>UC 17161</td>
<td>49.2 x 13 x 3.5</td>
<td>Broken. 10 through-mortises as UC 17160</td>
</tr>
<tr>
<td>UC 17162</td>
<td>145 x 11 x 4.3</td>
<td>8 T-shaped channels; open mortise</td>
</tr>
<tr>
<td>UC 17166</td>
<td>200 x 46.5 x 3.1</td>
<td>3 pairs V-shaped channels 3.2-4.2 x 1.1-1.4; L-shaped channels 2-2.8 cm. deep. Edge mortises 4.5 x 0.7 x 3.1 and 3.3 x 1.2 x 3.2. Possible 2nd pair of edge mortises. Through-mortises 4.1-5.2 x .3-1.1</td>
</tr>
</tbody>
</table>

2 unlocated planks like 17157 have L-shaped mortises along edges.
Fig. 3-5. Fastenings used in the Tarkhan planks. a) through-mortise b) edge mortise c) V-shaped channel d) L-shaped channel e) T-shaped channel
other, like fastenings on bottom planks of the Khufu I hull. Side planks with offset channels would prohibit effective transverse hull lashing; parallel fastenings in planks only a few centimeters thick would weaken them prohibitively. An offset fastening arrangement would be more appropriate for a hull sewn along planking seams or for a flat plank assembly not associated with a ship's hull.

Unlike planking from later Egyptian hulls, most Tarkhan planks (excluding UC 17162 and UC 17156) incorporate mortises that pass through the thickness of the wood. Other differences include the relatively straight edges and thickness of Tarkhan planks. Even UC 17157, the thickest of those remaining, is less than half as thick as planks from either Boat 10 at Abydos or the Khufu I hull.79

As Vinson has pointed out, Classical ships built with planks 3-4 cm. thick show that watercraft can be built with thin planks.80 These pegged mortise-and-tenon hulls have even thicker planks than the 6th-century B.C. Bon-Porté shipwreck, which more closely resembles Vinson's reconstruction of Tarkhan plank use. In the Bon-Porté hull, pegged lashing along plank seams and dowels connect planks only 2 cm. thick.81 M. Fitzgerald's work has shown that plank thickness is a function of hull length in Mediterranean hulls.82 If Egyptian shipbuilders employed similar principles, the dimensions of Tarkhan planks suggest that if they were once part of a vessel, it probably was quite small (Table 3-3).

Table 3-3. Thickness of planks from Egyptian hulls.

<table>
<thead>
<tr>
<th>Hull</th>
<th>Date</th>
<th>Plank thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abydos 10</td>
<td>3000 B.C.</td>
<td>10-12 cm.</td>
</tr>
<tr>
<td>Khufu I</td>
<td>2600 B.C.</td>
<td>12-15 cm.</td>
</tr>
<tr>
<td>Lisht</td>
<td>1950 B.C.</td>
<td>8.5-18 cm.</td>
</tr>
<tr>
<td>Lisht frame</td>
<td>1950 B.C.</td>
<td>c. 12 cm.</td>
</tr>
<tr>
<td>Dashur</td>
<td>1850 B.C.</td>
<td>7-13.5 cm.</td>
</tr>
<tr>
<td>Mataria</td>
<td>500 B.C.</td>
<td>7-9 cm.</td>
</tr>
</tbody>
</table>
Documented Egyptian reliance on hull planks 7-18 cm. thick in hulls 10-43 m. long suggests that if the Tarkhan planks are from watercraft, they illustrate an undocumented tradition in hull construction. All of the Tarkhan planks under discussion have straight rather than joggled edges and only a few show slight curvature. Although some of the planks have been broken or trimmed, most have edge fastenings showing them to be little changed from their original condition. If the Tarkhan planks were used for shipbuilding, their straight edges are paralleled only by planks from the central section of the bottom in later hulls.

No ancient Egyptian hull examined by me incorporates mortises through plank thickness like those in Tarkhan planks. The best evidence for mortises penetrating planks below the waterline in early watercraft is provided by Landström's publication of Early Dynastic models in the Egyptian Museum. Cross-hatching interpreted as sewing along the rail and on the outside of the models provides details of hull construction.83

Papyriform in shape, ivory model EM 86169 has bindings around one end and sewing along the rail. A vertical sewn band at each end of the hull and horizontal sewn bands at what would be the central-first strake seam on each side of the bottom suggest that the bottom and sides of the hull were sewn together on the outside (fig. 3-6).

In my opinion, EM 86169 provides the best parallels for shipbuilding practices that would demand planks with some of the features of the Tarkhan group, but Vinson argues that because the lines of cross-hatching do not extend to bow and stern, they are unlikely to represent sewn seams.84 The characteristics of planks UC 17156 and UC 17162 in fig. 3-7 are those expected of a hull bottom sewn along longitudinal plank seams to the first strake.

As demonstrated by the Khufu I hull and many models, decorative finials could be attached to hull ends. If EM 86169 attempts to represent this practice, then the vertical lines mark the point of attachment between the "sleeve" and the hull. The lines encircling one end of the model probably represent binding, another common feature of later models (e.g., the models of Kaimesenu, Chapter VII below).
Fig. 3-6. Ivory model EM 86169, 17 cm. long. (After Landström [1970] figs. 70, 72)

In theory, the straight-sided Tarkhan planks could have functioned in another way. Archaeological reports of wooden floors and ceilings in Early Dynastic tombs have not included descriptions of fastenings between planks, but if these planks were securely bound to each other, L-shaped and V-shaped lashing channels like those in the Tarkhan planks could have allowed one nearly uninterrupted surface, a feature known to be desired in contemporary coffin-building.

It should also be pointed out that coffins from the end of the Early Dynastic Period provide evidence of panelled wood facades consistent with Petrie's reconstruction. Vinson's discussion of Predynastic and Early Dynastic dwellings documents houses with low mudbrick walls and reed superstructures and structures with niched mudbrick facades. He concludes that there are no parallels for panelled wooden facades in architecture, but the existence of wooden coffins with niched facades like those of mudbrick seems to contradict his position.

Vinson suggests that UC 17156 and 17162 (not included in the discussion above) may be complete and broken frames or futtocks on the basis of their curvature, fastenings,
and surface abrasion (fig. 3-7). Floor timbers in the Khufu I hull cross its flat bottom and extend about two-thirds of the way up the side planking. Lashing holes pass through each end of the floor timbers (7 cm. sided and 20 cm. molded).

A frame at Lisht provides the only other example of internal support for Egyptian hulls. Its floor timber is lashed to two upper timbers that include T-shaped lashing channels and an open mortise in the end of Timber C (fig. 3-8). The upper timbers are 15 cm. thick, 2.5 to 3.5 times thicker than UC 17156 and 17162. Upper timbers from the Lisht frame provide a stronger parallel for UC 17156 than any other source, and UC 17156 displays the characteristics of an upper timber from a frame assembly despite its small dimensions.

In his identification of UC 17162 as a possible ship’s frame, Vinson does not consider its very gradual rise. If it were a floor timber, the hull would have been wide and flat, lacking the hard chine visible in contemporary models and in the Abydos and Khufu I Hulls. UC 17162 is only 4 cm. thick, and despite the eight T-shaped lashing channels for fastening it to something, I see no similarities between it and the Khufu floor timbers or Lisht frame. I do not believe it could function as a futtock in Egyptian hulls as we know them from their remains. A timber shaped like UC 17162 could conceivably have provided transverse support to an arched roof like those seen on Early Dynastic buildings, however. It might also have been used as a stringer, rising at the end of the hull, tied into the lashing network through its T-shaped channels.

CONCLUSIONS

Boards of regular thickness in Predynastic coffins provide us with the first physical evidence of woodworking skills, but their thinness suggests considerable experience had already been accumulated. Because the graves with the most wood also contained the greatest number of artifacts, we can view the inclusion of worked wood as another indication of status and rank, foreshadowing the domination of material resources by the state in later times. By the beginning of the Early Dynastic period, woodworkers
Fig. 3-8. Upper timbers of a frame from Lisht. (Courtesy Dieter Arnold)
had developed a number of fastening techniques, probably facilitated by the use of metal tools, that became standard in the repertoire of both carpentry and shipbuilding. S. Vinson's research and analysis of Tarkhan plank features documents these traditions and furnishes a valuable tool for thinking about ways early Egyptian hulls could have utilized existing woodworking technology.
ENDNOTES


13. Davies (supra n. 4) 28.


15. Emery (supra n. 10) 51-57; W.B. Emery, "A Preliminary Report on the First Dynasty Copper Treasure from North Saqqara," *ASAE* 39 (1939) 427-37. Two blades are sharpened on each end, and both long edges of a third are sharpened. None of the blades were hafted.


19. Davies (supra n. 4) 45 and pl. 32.

20. Emery (supra n. 10) 30-31.


26. Petrie (supra n. 13) 16, 28, pl. 16 and 17.

27. Emery (supra n. 10) 31-37.

28. Emery (supra n. 10) 31-2.

29. Simpson (supra n. 17) 25; Janssen (supra n. 18) 321.
31. Emery (supra n. 10) 42-46.
32. Davies (supra n. 12) pl. 15-16.
33. For example, G. Steindorff, *Das Grab des Ti* (Leipzig 1913) pl. 119; Davies (supra n. 12) pl. 15-16.
34. Simpson (supra n. 17) 25.
36. Davies (supra n. 12) pl. 15-16.
37. Petrie (1913) 19. The graver is a sharp-pointed tool for cutting.
41. Steindorff (supra n. 32) pl. 133.
42. See Sliwa (supra n. 22) 34 for further references; also P.V. Podzorski, N.C. Rem, and J.A. Knudsen, "Identification of Some Egyptian Wood Artifacts in the Lowie Museum of Anthropology," *MASCA Journal* 3 (1985) 122-24; Petrie (supra n. 5) pl. 34; at Deshasheh, Petrie (supra n. 21) pl. 34.
43. At Illahun, Petrie (supra n. 5) 13.
44. Catalogued by Sliwa (supra n. 22) 37.
46. L. Borchardt, *Das Re heiligtum des Königs Ne-woser-rê* I (Leipzig 1907) 123, fig. 103.
47. Steindorff (supra n. 33) pl. 119; P. Duell, *The Mastaba of Mereruka* III (Chicago 1938) pl. 152.


50. Wachsmann (supra n. 49) 200-201.

51. The illustrations in the tomb of Aba and Nianchchnum show log transport; plank positioning is illustrated by Steindorff (supra n. 33) 119 and 132; Newberry (supra n. 11) pl. 29. See Wachsmann (supra n. 49) 199 for a discussion of previous misinterpretations of this activity.


53. Lipke (supra n. 44) 82.

54. Duell (supra n. 47) pl. 152.


56. Steindorff (supra n. 33) pl. 119; Moussa and Altenmüller 1977 (supra n. 11) pl. 19 and 20, fig. 8.

57. Sliwa (supra n. 12) 38-40.


61. Teeter (supra n. 60).

62. Teeter (supra n. 60) 75-76.

63. For flax cordage, see Lucas (supra n. 22) 135/

64. Janssen (supra n. 18) 439-40. Unfortunately, the diameter of the cables was unspecified.

65. Based on a price of 150 copper deben per animal. This price is a little higher than the highest recorded by Janssen (supra n. 18) 175.

67. Lythgoe and Dunham (supra n. 1) xiv-xv, 202-205.


69. Petrie also reported coffins made of plane tree, but no botanical identification of woods has verified this report.

70. See for example A.J. Spencer, *Death in Ancient Egypt* (New York 1982) 168-169; P. Lacau, *Sarcophages antérieurs au Nouvel Empire I-II* (Cairo 1904); and a Dynasty 9 coffin from Sedment illustrated by O. Koefoed-Petersen, *Catalogues des sarcophages et cercueils égyptiens* (Copenhagen 1951) 8-12 and pl. 2.

71. It is possible that this practice reflects earlier woodworking traditions that permitted no fastenings at corners.


73. See for example a Dynasty 2 coffin in Koefoed-Petersen (supra n. 70) 7-8 and pl. 1; and Dynasty 2-3 coffins in Petrie (supra n. 57) pl. 28; MacKay (supra n. 57) 29-30.

74. Koefoed-Petersen (supra n. 70) pl. 1.

75. Petrie (supra n. 57) 9 and pl. 9.


78. Vinson (supra n. 77) 81.

C. Haldane, "'A Pharaoh's Fleet:' Early Dynastic Hulls from Abydos," *INA Quarterly* 19.2 (1992) 12-13 and Chapter IV below; Lipke (supra n. 44) 103-104.

80. Vinson (supra n. 77) 78.


82. M. Fitzgerald (Diss. Texas A&M University forthcoming).


84. Vinson (supra n. 77) 172.

85. Koefoed-Petersen (supra n. 70) pl. 1.

86. Vinson (supra n. 77) 70-77.

87. Vinson (supra n. 77) 79.

88. Lipke (supra n. 44) fig. 48 and 52; Vinson (supra n. 77) 79 incorrectly states that there are no lashing holes in Khufu I floor timbers.

CHAPTER IV

EARLY DYNASTIC HULLS AT ABYDOS

More than 4,700 years ago, at least twelve boats were moored for eternity in the desert sands at Abydos, more than 11 kilometers from the Nile river. Entombed in mudbrick, boat-shaped graves, the hulls lay forgotten outside the funerary monuments of Egypt’s earliest historic kings until late 1991, when a University of Pennsylvania-Yale Expedition to Abydos excavation team under the direction of Dr. David O’Connor uncovered this Early Dynastic fleet -- the most ancient planked hulls in the world.¹

The fleet at Abydos more than doubles the number of known Egyptian hulls, bringing the total of extant hulls to 20. Although more than 20 funerary sites in Egypt included boat burials, there are twice as many boat graves at Abydos than at any other site. Before the Abydos find, Early Dynastic boat graves and hulls had been excavated at Saqqara, but little is known about the remains of hulls from mudbrick graves there.²

Sixteen model boats buried in a row east of the small Dynasty 6 pyramid of Queen Neit at Saqqara provide the only parallel for such a large number of buried watercraft.³ Like the Abydos hulls, the Neit models are aligned on an east-west axis.

S. Vinson’s comprehensive review of Early Dynastic boat burials excavated earlier this century provides background data that emphasize the distinctive aspects of the Abydos fleet.⁴ The Abydos graves are significantly longer than any at Saqqara (Table 4-1), and their uniquely shaped long, narrow graves with rounded, "capped" ends also set them apart (fig. 4-1). Early Dynastic boat graves at Saqqara had truncated ends, and contemporary boat graves at Helwan were characterized by one truncated and one pointed end.⁵

Archaeologists excavated an ancient pit in Abydos Grave 10 to assess the condition of the wooden hull remains and to examine the grave’s internal features. Their work revealed a flat-bottomed hull 1.47 m. wide at the top, 41 cm. wide at the bottom, and 41 cm. deep (fig. 4-2).⁶ Its profile resembles the profile of the larger Dynasty 4 Khufu I vessel (see Chapter V below). Wood condition in the excavated area varies from
Fig. 4-1. Working plan of the Abydos hulls. (Courtesy D. O'Connor)
poor to excellent. Planks are about 10 cm. thick. A layer of fibrous material, possibly reed matting, lies between the mudbrick filling and the planking. No details of fastenings or construction techniques were recorded for the hull.

Table 4-1. Dimensions of Early Dynastic mudbrick boat graves.

<table>
<thead>
<tr>
<th>Location</th>
<th>Dimensions in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abydos</td>
<td>19-29 x 3.5 x 0.5</td>
</tr>
<tr>
<td>Saqqara 3503</td>
<td>17.75 x 4.25 x 0.8⁷</td>
</tr>
<tr>
<td>Saqqara tomb of Aha</td>
<td>19.3 x 3.2 x 1.0⁸</td>
</tr>
<tr>
<td>Saqqara tomb of 'Ankh-ha</td>
<td>14.3 x 2.15 x 0.75⁹</td>
</tr>
<tr>
<td>Saqqara 3506</td>
<td>22.15 x 3.4 x 1.1¹⁰</td>
</tr>
</tbody>
</table>

Fig. 4-2. Profile of Abydos Boat 10. (Courtesy D. O'Connor)
It was possible to reconstruct the method used to build the boat graves, however. Trenches 10-25 cm. deep were cut into bedrock and coated with mud plaster. After setting the boats into the plaster, workers built gently curving mudbrick walls about 30 cm. thick and 50 cm. high around each hull, coated the walls with mud plaster, and then whitewashed the entire structure. Weathering on the windward side of the graves suggests that the graves had been exposed for a long time.

Today, the hulls are filled with mudbrick, yellow sand, or yellow sand with a "skin" of mudbrick across the top. Slight mounds over the hull area of the two northernmost boats recall low brick vaults over boat graves at other sites. Two small representations of watercraft found at Abydos portray central features. The small plaque may illustrate a vaulted hull (fig. 4-3a); a seal inscribed with, "The Ships of the King," includes three small ships with large thrones (fig 4-3b).

![Fig. 4-3 a) Small plaque of a hull b) "The ships of the king", on a seal from Abydos. (After Petrie [1903] pls. 7 and 22)
None of the boat graves exactly duplicates another, and the less-than-perfect alignment of the hulls is unusual in an area filled with geometrically precise funerary enclosures. One of the southernmost boats was set crookedly into its trench, and its surrounding wall is considerably thicker on one side as a result. The three boat graves at the south end of the row are linked by a mud-plaster pavement; at the north end, three graves have separate, well-made plaster footings.

Early Dynastic pottery deposited around the boat graves suggests that the boats were cultic recipients like the later rock-cut boats of Khafra (see Chapter VII). Deposits of pottery in the eastern ends of some graves, and single, large, unevenly shaped, desert stones incorporated in the brickwork at the eastern ends of three hulls are the only artifacts known to be associated with the unexcavated vessels.¹³

Planking visible in the uppermost surface of the boat graves can be seen throughout the narrower portion of the graves; plank edges meet just before the rounded ends.¹⁴ The hulls at Abydos are about 20 meters long and have a maximum width of 2.5 m. The extent of the lower hull cannot be determined yet; a wooden Naqada III model EM 4814 in the Egyptian Museum illustrates a hull substantially longer on the bottom than the sheer (fig. 4-4).¹⁵

Fig. 4-4. Wooden model EM 4814. (After Reisner [1913] fig. 88)

OTHER EVIDENCE FOR EARLY WATERCRAFT

A clay model dating to about 4000 B.C. from Merimde Beni Salaam provides the most ancient evidence for watercraft in Egypt, and by Naqada II, the custom of burying
boat models in graves dates had been established.\textsuperscript{16} After Dynasty 1, boat models, but not watercraft themselves, disappear from burials until late Dynasty 5 when a few models are reported and Dynasty 6, when large groups of wooden models portraying different vessel types were buried with the dead.\textsuperscript{17} Dynasty 6 and later Middle and New Kingdom models are useful for studying rigging, decoration, and construction features at deck level, but only rarely offer information about internal construction.\textsuperscript{18}

Predynastic and Early Dynastic boat models and representations collected by Landström, Petrie, and Vinson provide information on hull design features of the period.\textsuperscript{19} Details concerning hull construction from these early representations may help to interpret data from the Abydos excavations.

For example, Berlin Museum model 13801 (61 x 23 x 5 cm.; Naqada II, 3500 B.C.) includes crossbeams, a transverse ridge near one end, and a central longitudinal ridge, probably a stringer.\textsuperscript{20} Vinson illustrates models from the Egyptian Museum at Karl Marx University in Leipzig and Early Dynastic excavations at Helwan that also include central stringers.\textsuperscript{21} Compared to the side views of Naqada IIb and III watercraft painted on pots and carved on rock cliffs, the models seem quite broad. The consistency of the proportions in models from a number of sites suggests that at least some early hulls were built this way, however.

B. Landström has pointed out that EM 4814's long and narrow profile is similar to boats on Naqada II pots. He predicted that a Naqada II boat with 24 oars would be 25 m. long with a beam of 2.5 m. He also surmised that it would possess longitudinally sewn plank seams, a central shelf, beams, and a few frames.\textsuperscript{22}

L. Basch has compared a Predynastic boat model from Hierakonpolis (Naqada III) to the construction of the \textit{shilluk} of the White Nile, noting that both possess longitudinal and transverse members. The longitudinal feature is called a carling; the transverse pieces are referred to as "pseudo half-frames."\textsuperscript{23} As Basch observes, the "pseudo half-frames" in the \textit{shilluk} are essentially battens sewn in place over butt joins.

Basch points to the Khufu I hull (c. 2500 B.C.) as a development of the tradition represented by the Hierakonpolis model, and suggests that the Hierakonpolis model may
also illustrate sewn battens over plank seams. Because the flat bottom, angled sides, and thick planks of Boat 10 at Abydos are reflected by Khufu I several hundred years later, I expect to find that the builders of the Abydos hulls also made use of battens over plank seams.

The Abydos hulls provide the first opportunity to test both Landström’s and Basch’s proposals. Unfortunately, photographs of the section in Boat 10 reveal no plank seams, fastenings, holes or mortises, so we must await the 1994 excavation of one of the boat graves to answer specific questions about Early Dynastic hull construction.

CONCLUSIONS

The unprecedented number and size of boat graves at Abydos also provide evidence of the site’s importance. Although the royal funerary enclosures at Abydos have been known since the beginning of the century, some Egyptologists had suggested that Egypt’s earliest dynastic rulers were buried at Saqqara. The lack of boat graves at Abydos, and their presence at Saqqara, was a primary focus of the argument. Today, however, most scholars believe that the tombs at Saqqara are those of high-ranking nobles rather than kings and that Abydos was the resting place of kings.

The Abydos hulls may also affect discussions about early links between Egypt and the Near East. Tombs at Abydos with North Syrian pottery and beams and planks Petrie identified as conifers suggest Egyptian contact with the Levantine coast. University of Pennsylvania excavators at Abydos believe the reddish wood of Boat 10 is also from a conifer and report that it was aromatic when brushed.

To gain perspective on the amount of wood represented by the 12 hulls, we can look at some statistics concerning the cedar Dashur boat in the Carnegie Museum of Natural History (see Chapter X below). Its center strake measures 9.55 x [avg.] 0.25 x 0.11 m. and today, in a fairly dessicated state, weighs 110 kg. Projecting dimensions for the simplest possible hull to fit the evidence provided by the cleared area in Boat 10 produces a hull at least 20 m. long with three strakes 10 cm. thick and 40 cm. wide, weighing at least 1200 kg. (2640 lbs.).
Thus, the fleet required at least 14,400 kg. of finished timber to build. Even if the wood used was a locally available acacia or tamarisk, the amount of work involved in the manufacture and joining of planks is comparable to building an elaborate tomb or even one of the massive funerary enclosures looming over the boat graves today. If the boats were built of imported wood such as cedar and juniper, they provide the earliest and strongest testimony for direct, seabone Egyptian contact with the Levant to date.
ENDNOTES

1. The Abydos hulls have not been fully excavated. D. O'Connor, "Boat Graves and Pyramid Origins," Expedition 33.3 (1992) 5-17. I am grateful to Dr. O'Connor, University Museum of Anthropology and Archaeology at the University of Pennsylvania, and to his excavation team for inviting me to review the evidence gained in the 1991 survey season and for sharing their knowledge with me. Much of the information about the Abydos fleet was provided by Abydos expedition archaeologists D. O'Connor, M. Adams, S. Harvey, S. Olsen, and J. Waggener.


3. J. Poujade, Trois flotilles de la Vièense Dynastie des Pharaons (Paris 1948). Most boat models have been found inside tombs.


5. For example, Emery, GT II, 138 for Saqqara and A.Y. Saad, Royal Excavations at Helwan (Cairo 1951) plans 16-18. Helwan graves were not bricked, so the shape of the boat is perhaps clearer.

6. O'Connor (supra n. 1) 12.

7. Emery (supra n. 2) 138.


9. Emery (supra n. 2) 75.


11. For example, boat graves at Saqqara and an example from the Middle Kingdom funerary complex at the pyramid of Senwosret I at Lisht were vaulted. Tomb 3506 at Saqqara: W.B. Emery, Great Tombs of the First Dynasty III (London 1958) pl. 44. For an empty Middle Kingdom boat grave at Lisht, see D. Arnold, The South Cemeteries of Lisht III. The Pyramid Complex of Senwosret I (New York 1992) 52-53, pl. 64-65.


13. O'Connor (supra n. 1).
14. See O’Connor (supra n. 1) 12-13, fig. 11.


17. Mariette apparently discovered a group of model boats he considered too decayed to excavate from a Dynasty 5 tomb at Saqqara (personal communication Z. Hawass); A.M. Moussa and A. Altenmüller, *The Tomb of Nefer and Ka-Hay* (Mainz 1971) 45 and pl. 41a, describe a papyriform model boat with bound ends found in the debris of a Dynasty 5 tomb chapel with other material that also dated to Dynasty 5. The model was 58 cm. long, had a bipod mast 36 cm. high with a yard 30 cm. long, 10 oars between 16 and 19 cm. long, a central cabin 16 x 6.5 x 8 cm., and two 31-cm.-long planks that probably were deck-level stringers.


19. Sir F. Petrie, "Egyptian Shipping," *Ancient Egypt and the East* March (1933) 1-14; Landström (supra n. 18) 9-16; Vinson (supra n. 4) 82-177.


21. Vinson (supra n. 4) figs. 82 and 83, 167-72; Z.Y. Saad, *The Excavation at Helwan* (Norman OK 1969) pl. 104. Vinson calls these keelsons, but a keelson is an internal keel mounted over floor-timbers and above the main keel, providing additional structural strength. The narrow ridge in the Berlin and Leipzig models is at the bottom of the hull and occupies only the central third of the vessel. The structure does not extend over the full inner length of the model hull, suggesting that it was designed to strengthen only the central region. No floor timbers are indicated in the models under discussion; the only transverse timber indicated on the Berlin model is at the end of the hull. In addition, I disagree with Vinson’s suggestion that the Helwan model shows a timber in the bottom of the hull. The Helwan model seems to show a timber at deck level with deckbeams (referred to as floors by Vinson) and a bow bumper otherwise first seen in the Dynasty 11 Meket-Re boat models. This fragmentary model has much more in common with the Dynasty 11 Meket-re models than with earlier boat representations, and its dating may be suspect, particularly since many Middle Kingdom burials have been found at Early Dynastic sites throughout Egypt.
22. Landström (supra n. 18) 21.


24. W.M.F. Petrie, *Royal Tombs of the First Dynasty* I (London 1900) 9; also see S. Vinson (supra n. 4) 211-26 for a discussion of foreign contact in the Early Dynastic period.
CHAPTER V

KHUFU I

In 1954, the discovery of two sealed boat pits beside Khufu’s pyramid at Giza revolutionized our knowledge of ancient Egyptian shipbuilding. Despite hundreds of representations of boats and ships, finds of rock-cut boats, and the discovery of at least five boats at Dashur in the late 1890s, no one comprehended the elegance and magnificence of Egyptian hull construction until archaeologists opened one of the pits and found it filled with the dismantled pieces of a vessel more than 43 m. long -- about half the length of a football field. Just as stone architecture of the Old Kingdom translated wood and brick buildings into huge symbols that reflected the king’s power, so the Khufu I hull transformed a simple means of transportation into a massive ship of state.

DISCOVERY

Beyond the eastern enclosure wall of Khufu’s pyramid, archaeologists clearing accumulated sand and debris discovered a previously unrecorded boundary wall south of the pyramid. Excavations beneath the wall’s foundations revealed a layer of earth mixed with cedar and acacia wood chips, charcoal, and powdered limestone above a row of limestone blocks interpreted as the covering blocks of two boat pits. Forty blocks covered the western pit (see Chapter VI below), and 41 covered the eastern pit. Kamal el Mallakh, the archaeologist who discovered the pits, made a hole in the 22nd eastern block and saw a steering oar, boards, columns, beams, and remains of matting and ropes, all extremely well preserved. The forward papyriform finial showed that the bow of the dismantled ship pointed west.¹

The Egyptian Antiquities Service began removing the eastern pit’s covering blocks in November, 1954. Blocks weighing 15-20 tons each and measuring about 4.5 x 1.8 x 0.85 m. sealed the 32.5-m.-long pit. Block ends rested on a one-meter-wide ledge around the pit’s perimeter; adjacent blocks fit closely and any irregularities in the stones were
filled with gypsum plaster. Fine, white plaster had been poured over the covering blocks to help seal the pit; over the millennia, large lumps of it fell onto the entombed wooden ship. Unlike the rock-cut boats in the Giza funerary complex (see Chapter VII), the rectangular pit was intended to contain a disassembled vessel, not to be a permanent ship.

Excavation of the pit required nearly 20 months, and the reconstruction of its contents more than 20 years. Ultimately, a magnificently engineered royal ship emerged from the painstaking work of Hag Ahmed Mustafa, conservator for the Egyptian Antiquities Organization (figs. 5-1, 5-2). Shell-built with planks carved from logs at least 7 m. long, the Khufu I ship represents a tremendous investment of labor and capital. Its builders threaded ropes in and out of several thousand V-shaped channels aligned in rows across the inside of the hull. A collapsible deckhouse and canopy constructed from prefabricated panels provided shelter from the elements.

The Egyptian Antiquities Organization and, later, P. Lipke recorded procedures used during the excavation and the composition of the layers. Six hundred fifty-one major pieces and an additional 467 tenons in the hull and 200 tenons in the cabin were removed from the pit. The 651 major pieces included 30 planks, 16 floor timbers, 62 deck beams, 36 stanchions, a carling and two stringers, 22 sections of decking, 23 pre-assembled panels of the deckhouse, 58 papyrus-bud pillars, 5 doors, and 300 battens. Baskets of unused rope, lashings, and other cordage were also retrieved. When reconstructed, the hull measured 42.3 x 5.66 x 1.8 m.

RECONSTRUCTION OF THE HULL

The careful excavation of hull timbers enabled Hag Ahmed to begin planning the reconstruction almost immediately. Lipke suggests that the ancient Egyptians who stored the ship knew how it was built because the timbers were placed in a way that reflected their position on the ship and with the proper side "up." For example, backing timbers for papyrusiform ends were loosely knotted to the ends of the bottom planking in their proper position. Lipke has also observed that the two deck-level stringers were discovered with their notches down on either side of the carling which was placed with its notches up.
This is the proper orientation for fitting on the finished hull.\textsuperscript{6}

Fig. 5-2. Khufu I midship construction view. \(a\) = hemispherical socketed stringer, \(b\) = carling, \(c\) = stringers, \(d\) and \(e\) = V-shaped lashing channels, \(f\) = stringer hold downs, \(g\) = rabbeted deck beam, \(h\) = lashings through stringers for deckhouse pillars. (Drawing: P. Schmid and P. Lipke)

Lipke has proposed a construction sequence based on his analysis of information gathered from interviews with Hag Ahmed, photographs, drawings, and other records. In this sequence, the bottom planks were roughed out, laid side by side, then marked for lashing mortise placement before final fitting and cutting of V-shaped lashing channels. Ligatures at plank ends and in places of stress (fig. 5-3), called strategic lashings by Lipke, and shoring controlled the degree of bottom curvature (rocker) while the first side strakes were marked, rabbeted, and fit.
Additional side planks and sheer strakes, whose upper edges were already notched for deckbeam ends, were added similarly. A few carefully placed deckbeams at midships were placed to help maintain hull shape. In the same area, battens were fitted, labelled, and lashed in place, then a few floor timbers were inserted. As the shipwrights moved aft, more planking, battens, deckbeams, and floor timbers were lashed to the hull at intervals, possibly just in the area of floor timbers.

In other words, the main shell of the hull was built up plank by plank with minimum fastening, braced transversely by a few deckbeams, and lashed in the areas where floor timbers were placed.

In a second phase of construction, the partially notched carling was lowered into the hull by sliding it (in its two sections) between existing deckbeams. Stanchions raised the carling to deckbeam level where it was lashed to them and to the deckbeams that had already been placed. Then, the rest of the deckbeams were laid across the hull, and their positions were marked and cut in the carling, before they were notched into the sheer strake. Stringers were then roughed out and fitted over the deckbeams. Transverse lashing of all hull components was completed. With the addition of decking panels and the deckhouse and canopies, the hull was completed.7

Rather than retrace Lipke’s documentation of Hag Ahmed’s reconstruction of the ship, my discussion of the hull focuses on alternatives to the suggested construction sequence and on hull features that have received little attention in print. By examining plank shapes and positioning, fastenings, and floor timbers, it may be possible to discern principles that guided the ancient shipwrights.

Planks

Ancient Egyptian shipwrights built their ships and finished their plank edges like no other shipwrights in the world. Plank edges in watercraft from other places and times are straight; Khufu hull plank edges feature joggles that locked the edges of adjacent planks together. The projecting joggles incline in alternate directions (see fig. 5-3), adding to the stability of the seam’s longitudinal movement. This particularly Egyptian feature is crucial to understanding how Egyptian ships withstood the tremendous forces imparted by
the transport of massive stone objects and waves at sea.

Egyptian shipwrights also fastened their planks uniquely. Hulls that were sewn or lashed together along plank seams are known from almost all boatbuilding traditions, but, as far we know, only Egyptian ships relied on transverse lashing. J. Coates examined the strength and behavior of sewn seams, using Boat 1 from Ferriby with planks 8 cm. thick and a keel 12 cm. thick as his example. (Khufu I hull planks are 12-15 cm. thick.) He noted that hulls with massive planks depend on stitching to resist tensile forces that tend to open butt joints. As the hull increases in length and weight, both seam integrity and hull strength are adversely affected.

To maintain watertight seams, relative movement between planks must be confined. Coates found that longitudinal sewn seams can be as structurally strong as pegged mortise-and-tenon joint seams. The main difference between pegged mortise-and-tenon joint seams and longitudinally sewn seams is in the greater slide between planks connected by sewing. Coates did not evaluate transverse hull lashing.⁸

Interlocking joggled plank edges, especially when combined with extensive use of mortise-and-tenon joints and transverse lashing, prevented longitudinal sliding motion of planks in Egyptian hulls. Long planks tend to bend and hog; joggled edges resisted both hogging and bending by reducing the relative movement between planks. In addition, transverse lashing inside the hull spread any deformation across the entire vessel, reducing the stress on any particular joint.

The joggled edges of Khufu I planks are ancestral to joggled edges, that incorporated quite large projections, on the early Middle Kingdom Lisht planks (see Chapter VII below). Regular changes in plank width and shape in the Dashur hulls also reduce longitudinal movement, and the nibbed ends of their strakes are direct descendants of the Khufu I tradition (see below). The use of joggled edges to prevent sliding motion in planks, combined with the use of transverse lashing and beams, helps to explain why the Egyptians rejected the use of pegged mortise-and-tenon joints in hull construction although Egyptian carpenters had used pegged joints since at least 3100 B.C.
Fastenings

Mortise-and-tenon joints, transverse lashing, and ligatures are the primary fastening types in the Khufu I hull, but a number of other types also were used. Transverse lashings and ligatures, individually autonomous fastenings located at points of high stress, receive most attention in Lipke's description of Hag Ahmed's reconstruction. Only the dimensions and number of mortise-and-tenon joints are provided, but analysis of the hull suggests shipwrights depended on mortise-and-tenon joints to a greater degree than has been recognized.

Ligatures. Lashing through paired mortises that inclined at a 45° angle from the plank's inner surface to the center of its edge created strong ligatures (see fig. 5-3). Different numbers of these fastenings have been reported; Lipke reports, "277 holes in sets of two or three: 55 in the bottom planking, 104 to starboard and 118 to port."

Abubakr and Mustafa record 291 ligatures. Table 5-1 presents the disposition of these fastenings as shown in fig. 5-3. Ligatures pass beneath battens and cross plank seams. Also, in contrast to V-shaped channels for transverse lashing, ligatures overlapped mortise-and-tenon joints. For this reason, I believe it is possible that the ligatures were placed after the mortise-and-tenon joints, rather than before, as Lipke has suggested. This sequence could also account for the lack of tool marks on planks around the ligatures.

The most intensive use of ligatures occurs at the junction of the backing timbers and bottom planking at the ends of the hull. Four channels on either side of the central bottom plank were placed within a distance of 60 cm. along the plank's length (fig. 5-4). The backing timbers supported the most vertical and most visible symbolic elements of the hull, the papyriform endpieces, and the concentration of fastenings emphasizes the importance and difficulty of this join.

Ligatures between end planks in the bottom section accentuate the avoidance of this type of fastening in the rest of the bottom. The lack of ligatures, and in fact almost any fastenings at all between the three main bottom sections, is surprising to ship archaeologists, but the fastenings clearly were not needed. In other words, hull stresses between and along bottom planks were minimal compared to those at the ends of the
Table 5-1. Distribution of ligatures in Khufu I. Number of holes indicated by parentheses.

Bottom planking:
Fwd. end to backing timbers: 8 pairs (16)
Aft end to backing timbers: 8 pairs (16)
C1b to C1a: 4 L-shaped pairs and 4 V-shaped (12) ?
C3a to C3c: 2 L-shaped pairs and 2 V-shaped (6) ?
C2a to S2b: 2 L-shaped pairs (4)
C2c to P2b: 2 L-shaped pairs (4)

Total 58 or ?64 or ?61

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<td>1a to 4a 4 L pairs (8)</td>
</tr>
<tr>
<td>1b to 2a</td>
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<tr>
<td>1c to 2a</td>
<td>1c to 2a none</td>
</tr>
<tr>
<td>1c to 2b</td>
<td>1c to 2b 4 L pairs (8)</td>
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<tr>
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</tr>
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<td>2b to 4b 2 L pairs (4)</td>
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</tr>
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</tr>
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</tr>
<tr>
<td>5c to 5b</td>
<td>5c to 5b 1 L pair (2)</td>
</tr>
</tbody>
</table>

TOTAL: 104                  TOTAL: 114
Fig. 5-4. Ligatures in Khufu I backing timbers. (Courtesy P. Lipke)

bottom. The real purpose of ligatures is demonstrated in the forward part of the bottom where a combination of ligatures and V-shaped channels for lashing occurs in an area of particular stress.

If the ligatures were intended to hold the planking together during construction in the sense that Lipke describes, it is curious that there are no such lashings between the first side strakes and the bottom section. Ligatures seem to have been consciously avoided along this critical juncture of the hull and between the first strake’s central plank and the plank above it. Only two pairs of ligatures connect the bottom planking to each side of the hull, and these fastenings are between the bottom planking and the central plank of the second strake. A shallow channel for the rope used in these fastenings runs across the tips of the central planks in the first strake, but otherwise, the shipwrights relied on compression, mortise-and-tenon joints, and transverse lashing to link the bottom planking with the sides of the hull.
On either side of the hull, two pairs of L-shaped lashing channels for ligatures that joined the ends of the first strake's central plank to its end planks emphasize another point of great stress. The first strakes were among the primary determinants of the hull's shape, and it is not surprising that their curvature should be emphasized and reinforced. The first strake's central planks are the smallest timbers used in the sides of the hull, and their junction with the bottom is one of the most intricate examples of woodworking technique in the vessel.

Other ligatures occur at hooked S-scarfs at plank ends, along joggled plank edges, and across the tips of planks. Because the spacing and distribution of these lashings on the sides of the hull are uneven, it is likely that their location depended partly on the degree of resistance a particular piece of wood offered to the curvature it was sculpted to fit.

*Mortise-and-tenon joints.* Mortise-and-tenon joints played a more significant role in the construction of the Khufu hull than has been previously recognized. Although they are little discussed by any publication dealing with the boat, it is possible to derive some information from illustrations of the reconstructed hull (fig. 5-5).

The ancient shipwrights used three kinds of mortise-and-tenon fastenings in the hull. The most numerous type used free tenons, identified as sidder and sycamore, that measured 10 x 7 x 1.5 cm. (fig. 5-6a). The tenons are about half the length of tenons known from the Dashur and Lishat hulls but about the same width and thickness. Mortise-and-tenon joints placed at about 1.0-1.2 m. intervals are usually in the center of plank edges. Some seem to be slightly offset, perhaps to avoid flaws in the wood as builders of later hulls seem to have done. None of the hundreds of mortise-and-tenon hull fastenings is pegged, and no information about the fit of tenons within mortises is available.

The other two types of mortise-and-tenon fastenings are unique to Egyptian hull construction in the ancient world. The first type, more properly described as a coak, was placed perpendicularly to the plank edge across the grain (fig. 5-6b). Tenons in these
Fig. 5-6. Khufu I fastenings. Mortise-and-tenon joint (a), coak (b), open mortises (c).
fastenings measured 10 x 3.5 x 1.5 cm., i.e. half the width of other fastenings.\textsuperscript{13} Cutting mortises perpendicular to plank edges is opposed to shipbuilding practices elsewhere, but a mortise 3.5 cm. long in a plank 12-15 cm. thick would not weaken it significantly. Separation between strakes on the Khufu I hull today allows a few of these mortises to be seen; they are spaced about two meters apart. It is possible that these cross-grain mortise-and-tenon joints may have been an attempt to combat the sliding motion of long, sewn planks or that they were the original fastenings used to align planks for shaping.

The third type of mortise-and-tenon fastening occurs between sections of bottom planking (fig. 5-6c). The forward section is butt-joined to the center section with three mortise-and-tenon joints that are only 10 x 3.5 x 1.5 cm. Each of the two planks in the aft section is butt-joined to a plank in the center section with a fastening of similar dimensions.\textsuperscript{14} Fastenings of this type require open mortises in plank ends. An open mortise is a mortise open on one edge. In Egyptian hull construction, open mortises at two butted timber ends created a single fastening probably used for alignment. Open mortises are recorded in the Tarkhan planks, Khufu I hull, Lisht planks, Dashur boats, and the Mataria vessel.

The seeming insubstantiality of these joints offers us the opportunity to speculate on the ancient Egyptian shipbuilder’s philosophy. To the western mind, and to nautical archaeologists accustomed to strongly scarfed and joined keels, this seems a weak fastening for such a crucial part of the ship. If the coaks and open mortises functioned only to align planks, compressive forces pushing inward from the bow and stern and mortise-and-tenon joints between the first strake and the bottom were all that kept planks in the bottom in place.

One thing is clear: had stronger fastenings been required here, they would surely have been employed. The liberal use of fastenings elsewhere on the vessel and the care given to replacing knots in the cabin panels, for instance, attests to the amount of attention lavished on the construction of this vessel. I believe that what we see here is integral to understanding the ancient shipwright’s point of view and appreciating differences between that orientation and our own.
The overwhelming impression gained from studying the Khufu I hull is that shipwrights left the wood in the hull bottom alone as much as possible. Their experience may have taught them that increasing the number of fastenings there increased potential sources for leaks or that seating the first strake on top of the bottom planking and then rabetting the midships area made use of the hull’s weight and geometry and was sufficient to keep it together. The mortise-and-tenon fastenings in transverse lines and the transverse lashings of the hull created a watercraft that successfully balanced tension in the hull as the high ends and great weight balanced compression in its design.

Two other points also deserve mention. Only the butt joins in the central strake are fastened together by mortise-and-tenon joints. As mentioned above, there are lashings across butt joins of the first side strakes, but there are no wood-to-wood joins between them. Hook scarfs include vertical mortise-and-tenon fastenings, however. A mortise-and-tenon fastening passing through the end of a stealer at the tip of port strake 3 is the same size as mortise-and-tenon fastenings that join planking. The Dashur boats all exhibit a similar pattern of fastenings where the end planks of strake 2 join the central strake (see Chapter X below).

V-Shaped Lashings. The most numerous hull fastenings are the V-shaped lashings. These consist of pairs of channels cut at 45 degrees so that the bases meet at the "point" of a "V" (see fig. 5-2). Lipke notes that of the more than 4,000 of these fastenings cut into the interior surface of the planking, 901 are in the bottom planking, 1,656 in the starboard side, and 1,602 to port. Abubakr and Mustafa reported 895 in the bottom, 1,476 in the starboard side, and 1,529 in the port side. The discrepancy between the figures is unexplained. Holes measure 7 x 2 cm. and permit four or five passes of cordage through each V-shaped channel. They are spaced about 25 cm. apart longitudinally and 10 cm. apart transversely.\(^5\)

Again, evidence of the principles guiding the ancient Egyptian shipwrights is provided by the location of these fastenings. For example, no V-shaped channels were cut over mortise-and-tenon fastenings and the plank surface above and below those joints is
also left intact. Shipwrights created nearly vertical bands of mortise-and-tenon fastenings, perhaps designed to interfere as little as possible with V-shaped lashing placement, in the sides of the hull. Such precision implies shipwrights who employed specific planning and measurement rather than those who followed their intuition about how to shape a plank or place a mortise.

Shipbuilders also avoided both ligatures and V-shaped lashing channels in planks less than 40 cm. wide. The fastening diagram in fig. 5-5 demonstrates the lack of V-shaped channels at narrow, pointed plank ends such as those of planks C1b, C3b, P3a, and S2a; mortise-and-tenon fastenings were the primary means of joining plank edges in such areas.

*Other Fastenings.* Seven holes 1.5 cm. in diameter pierced each sheer strake in the aft quarter of the hull. Lipke reports that Hag Ahmed laced line through opposing holes to create "rope deck beams that help hold the stern together against the strain of the steering oars."\(^{16}\)

Lashing through pairs of mortises attached the backing timbers and their covers to the ends of the hull. Like the holes through the sheer strake, these fastenings were above the waterline; additionally, fenders, which Lipke suggests were meant to protect them from abrasion, covered them.\(^ {17}\) Fenders were held in place with small V-shaped lashings.

The sheer strakes also include S-scarfs fastened by pairs of holes that pass completely through the thickness of the planking. The forward port scarf has a single pair securing the tip of the plank P5a to P5c; two pairs fasten the tip of P5c to P5b.\(^ {18}\) One pair of mortises fastens both the forward and aft scarf tips on the starboard side, again emphasizing the importance of securing the tips of the end planks to the central plank.

I believe that these unusual through-hull fastenings were necessary to prevent the tips from springing outwards under pressure. Because the sheer strake has no planking above it, its fastenings and scarfs stand on their own more than those in the hull proper. Tying down the scarf tips, which today show a tendency to protrude from the hull where they are not tied down with such additional fastenings, seems a logical response to an
observed problem. Two pairs of similar mortises are to be found at each end of the central sheer plank (5b) on each side of the hull. I cannot find any documentation of their use or purpose. All through-hull fastenings, and the sheer strake itself, were above the waterline. Ancient Egyptian shipwrights clearly avoided through-hull fastenings below the waterline.

The final type of fastening secured the aft ends of planks S2a and P2a. Lipke notes that "rail to rail lashings run outside the hull to hold the end of the plank inboard by passing through a wide notch."\textsuperscript{19} The fastening is best seen in a National Geographic composite photograph where the notch in the outside of the plank is visible.\textsuperscript{20} This is the only place, on any Egyptian boat before the Ptolemaic period, that a fastening appears outside the hull below the waterline. Although a shallow channel on the outside of the planks reduced plank thickness, no mortises pass through the hull’s exterior surface and the basic avoidance of through-hull fastening was not transgressed.

Planks S2a and P2a are also unusual because they, and P3, are the only planks to have their forward ends extended by short planks. The extensions are not fastened to the planks directly; instead, they are joined to the strakes above and below them with mortise-and-tenon joints, but without V-shaped channels for transverse lashing. The strake 2 extensions are both c. 1.6 m. long; that of strake 3 is 1.3 m. long.

\textit{Cordage and knots}

Several baskets of unused cordage and 13 lashings were recovered in the excavation, but Hag Ahmed did not attempt to duplicate them in the reconstruction. The lashings have not been closely inspected, but Lipke reports six different types.\textsuperscript{21} The reconstruction is lashed with linen cordage, passed five or six times through each slot.\textsuperscript{22} To my knowledge, no identification of original cordage has been made.

\textit{Floor timbers, Stringers, Beams and Associated Timbers}

Sixteen floor timbers, eight full-length and eight three-quarter length, were notched on their lower surface and lashed to the hull through a mortise at each end of the
floor. Full-length floor timbers span the hull from just above the seam between strakes 3 and 4; three-quarter length floor timbers reach just past the seam between strakes 1 and 2. No dimensions are given for them in any of the publications available, but drawings show that they are sided 9 cm. and molded 25 cm. Floor timbers, spaced 2-3 m. apart, seem designed to maintain hull shape rather than to serve as structural support.

Rectangular notches on the lower surface of some floor timbers probably served as limber holes; hemispherical notches fit over battens that covered plank seams.

Stanchions socketed into the center of each floor timber supported the carling. The beam, 26 x 0.26 x 0.11 m., was made in two parts connected with a hook scarf. Notches in its upper surface held transverse deck beams whose ends fit into mortises in the sheer strakes. Sectional measurements of deck beams varied with their position in the hull from 10 x 10 cm. to 12 x 12 cm. in section. The largest deck beam measured 30 x 10 cm. Landström has suggested that this beam carried or supported a bipod mast; Lipke believes that it was part of a hatch assembly.

A carling, notched to fit beneath deck beams, and two stringers notched to fit over deck beams provided longitudinal stiffness to the hull. Each of these components was made of two pieces scarfed together and measured about 11 x 26 cm. in section. Stringers, curved to reflect the hull’s shape, included a 1.5-m.-long scarf with three long, horizontal steps. Lashing secures the stringers to deck beams and to round-sectioned poles that run beneath the stringers under the beams.

Deck, Superstructure, Oars and Decoration

The Khufu I hull is almost fully decked end-to-end within the area bounded by the stringers. Deck panels, made of planks fastened with mortise-and-tenon joints, were supported by crossbraces pegged to the lower panel surface. Planking under the cabin has the straightest runs. All sections of deck planking have sockets and slots for receiving and tying down elements of the superstructure.

A roofed deckhouse 9 m. long and 2.5-2.17 m. high includes a chamber 2.2 m. long. Constructed of 22 individually framed panels, the deckhouse could have been...
easily dismantled. Palmette columns supported the central carrying beam of the roof and
were lashed to it by rope that passed through copper staples.\textsuperscript{30} Papyriform columns
outside the deckhouse created a framework, possibly for a mat or linen canopy, that
extended 13 m. forward of the the deckhouse. A deckhouse on a First Intermediate Period
boat model (EM 4918) has a similar chamber and doors; model figures are shown only in
the chamber. Unlike Khufu I's deckhouse, the model's includes knees and pegged scarfs
between joints in the roof beams.\textsuperscript{31} A separate, wooden-roofed canopy 2.2 m. long at the
front of the ship is portrayed in many Old Kingdom ship representations.\textsuperscript{32}

The huge oars of the Khufu I hull can also be seen in Old Kingdom ship
representations. The 12 oars found with the Khufu hull are arranged in pairs 6.58-8.35 m.
long. Lipke has suggested that the weight of the oars (57 kg.) is prohibitive and that they
may all have been intended for steering or guiding the Khufu I hull as it was towed.\textsuperscript{33}
Each oar is carved from a single piece of wood. Two oars with arrow-shaped incisions on
their blades are lashed in place as the steering oars for the hull. The use of two steering
oars on papyriform funerary craft shaped like the Khufu I hull continues into the New
Kingdom, although other kinds of boats used only a single steering oar by Dynasty 11.

Some authors have argued that the Khufu hull was unused because it lacked paint,
and many papyriform craft were painted white, green, or yellow. White paint on a few
"of the side pieces of the boat" and a red-painted board have been used by others to argue
that the boat was never used because it was painted.\textsuperscript{34} Neither argument is conclusive.
Carved column and pillar capitals and finials with rope bindings rendered in wood are the
only other decorative elements on the hull.

HULL CONSTRUCTION

This general discussion of the oldest excavated and recorded Egyptian hull applies
evidence of Egyptian shipbuilding practices used on other extant hulls toward a better
understanding of this vessel's construction. Evidence provided by hulls, texts, tools, and
representations contributes to a reconstruction of standard methods used to build wooden
hulls in ancient Egypt.
Funerary inscriptions occasionally boast of the construction of boats, and the hull's type and length are included as primary descriptive elements. The wood used and hull width appear in some, but not all, documents and are of secondary importance. Traditional boatbuilders have used the same criteria throughout the ages,\textsuperscript{35} and it is likely that Khufu ordered his shipwrights to build a particular type of hull 80 cubits long.\textsuperscript{36}

Once hull length had been decided, shipwrights had to acquire suitable timber. Acacia forests and other native trees provided wood for boatbuilding, but additional, more exotic timber had been imported from the Levantine coast since the Predynastic Period.\textsuperscript{37} Most imported timber, fine stone, and metal remained under state control for much of the dynastic period.\textsuperscript{38} In the Old Kingdom, the king alone commanded the resources necessary to build large watercraft. Although only a few of the Khufu hull components have been identified by botanists, it was primarily built of up to 23 m. lengths of imported conifer timber, which Hag Ahmed believes to be cedar.

As illustrated in several Old Kingdom tombs, woodworkers probably trimmed tree trunks with axes. Builders of the Khufu ship had visualized the shape and dimensions of its planks before laying out the central section of the bottom, and planks in the midships area were crucial in defining hull curvature. The great concentration and close spacing of V-shaped lashing channels amidships emphasizes the importance of the midships section and perhaps provides an indication of stresses within the hull.

The shipwright, who began with the 12-m.-long midships section of the hull bottom, marked prepared trunks. First axed and sawn to rough shape, then trimmed by workers with adzes, the center plank of the midships section anchored the plank assembly (see fig. 5-1). One of the most important steps in this early stage was the establishment of a center line, marked by hieroglyphs, and probably used throughout the construction of the hull to check its curvature and symmetry.\textsuperscript{39}

After finishing the center plank's edges, the shipwrights shaped and fitted the planks beside it with the assistance of coaks. Mortise-and-tenon joints fastened plank edges together. Workers chiseled mortises on the edges of the center plank first, inserted
corresponding tenons, then accurately marked mortise locations on the inside edges of the outer planks with a twig or brush dipped in charcoal. The angle and placement of the mortise within the edge probably depended on grain patterns, desired curvature, and the shipwright’s experience.

The forward and aft bottom sections were built up in a similar manner with the addition of shoring beneath the curving hull to support the 36-m.-long bottom. A few ligatures on the inner surface helped hold planks together near the ends. Open mortises, small mortise-and-tenon joints, used to align the forward and aft sections with the central section are half the depth and less than half the width of other mortises in the hull. Tenons, also half-size, were level with the inner planking surface (see fig. 5-6c).

The next plank to be fitted was one of the smallest (7.2 m.), most regularly shaped, and most important planks used in the sides of the hull: the central plank of the first side strake. According to drawings by Hag Ahmed, the port and starboard planks are the same size. The mitered rabbet in the midships section varied significantly along its length and required great care in its manufacture because the angle of this plank was crucial in determining final hull shape. Mortise-and-tenon fastenings joining the first strake to the hull bottom are the only direct fastenings between the bottom and the sides of the ship (see fig. 5-5).

The end planks of the first side strake rest on top of the forward and aft bottom sections. Only where their ends approach midships did the shipwrights cut a rabbet and use mortise-and-tenon joints to fasten them to the edges of the central section. Ligatures secured curved scarfs between plank ends; mortise-and-tenon joints were not used here. Hag Ahmed believed the first side strake’s ends were fitted first because of the direction of scarfs and bevels at their midship ends. The complexity of the rabbet and the continual emphasis on the midships section of Egyptian hulls even into the middle of this century for adjusting the fit of frames, beams, and other hull parts supports an alternative sequence, however. There is nothing inherent in those joins as published that would prevent the center plank being fitted first.

The midships plank of strake 2 was fitted next, fastened with mortise-and-tenon
joints, tied in two places to the midships section of the bottom, and in one place to the aft section of the first strake.\textsuperscript{42} Mortise-and-tenon fastenings and ligatures joined the aft plank of strake 2 to the aft plank of the first side strake. In creating a planking plan like this, the shipwright was probably following a tradition also represented in the Dynasty V tomb of Ti, where a boat with a similar planking plan is under construction.\textsuperscript{43}

Next, the only plank in strake 3 was roughed out and a complicated series of joggles was cut along its lower edge. Mortise-and-tenon fastenings continued to be positioned above those in the planks below, creating vertical lines of tenons across the hull. Ligatures fasten strake 3 to the forward plank of the first strake and to both planks of the second strake. The ends of strake 3 are not secured to surrounding planks.

The two planks of strake 4 were roughed out, fastened, and tied at stress points, probably with the forward plank fitted first. The last strake had its central plank fitted first. Its central plank is the longest in the hull. Strake 4's central plank on the port side may have had a fault because the typically symmetrical placement of lashing mortises is not present on its after end. Scarfs joining plank ends in strakes 4 and 5 angle upwards towards midships rather than downwards as in strakes 1 and 2. Scarfs in strakes 4 and 5 also include mortise-and-tenon joints, a feature not seen in lower strakes.

After the hull planking was completed, V-shaped lashing channels were cut. The avoidance of mortise-and-tenon joints throughout the hull suggests that the lashing channels were cut after the tenons were placed. Lashing through V-shaped channels placed a tremendous strain on the planks and was not used in planks less than 40 cm. wide. The lines of lashing channels also are directly related to mortise-and-tenon joint position. Where mortise-and-tenon joint spacing is slightly irregular, the spacing between lines of lashing channels is also irregular (see fig. 5-5). If the channels had been cut first, their spacing would have been more regular.

Workers then laid battens along seam lines, across scarfs, and over most plank ends before threading preliminary lashing through V-shaped channels. Battens were marked both with hieroglyphs that matched signs carved into the inner surface of adjacent planks and with a glyph designating to which quarter of the ship it belonged.\textsuperscript{44} These
signs would serve no purpose if the hull's builders did not plan for its reassembly.

After the hull was completed, a few deck beams maintained its rigidity while 16 floor timbers were cut and fit to its inner surface. Stanchions, one on each floor timber, supported the carling which ran the length of the deck. Beginning with the pair of deck beams fore and aft of midships, shipwrights fitted deck beams into notches cut into the inner surface of the sheer strakes and the carling. Deckbeams were lashed in place. At this point, the backing timbers could be accurately fitted, joined, and loosely tied on with lashing through V-shaped channels.

Had the backing timbers been lashed to the ends of the hull before the planking was erected as Lipke and Hag Ahmed suggest, elaborate shoring systems would have been required to support these heavy, unwieldy timbers. Their weight would also distort the curvature of the bottom section. Support for putting on the backing timbers last is offered indirectly by Hag Ahmed himself. A photograph of the model building process he used to learn how the ship was constructed shows him holding unattached backing timbers next to one end of the hull which already was planked to strake 4. The other end has no backing timbers, showing that the backing timbers were not necessary to provide proper lines.

After all the major elements of the hull were in place, shipwrights completed the transverse lashing. A scene from the tomb of Nefer and Ka-Hay (c. 2400 B.C.) illustrates this process (see fig. 1-3). Rope encircles the hull four times, and is laid over a forked stanchion amidships before being wrapped around the ends. A worker tightens the ropes around the hull by twisting a stick, and I believe that the standing figure is shown pulling transverse lashings tight. If not tightening the lashings themselves, he is tightening the rope truss in preparation to do so. The man to his right is striking the rope with what seems to be a stone. This final tightening of cordage would have been crucial to the hull's integrity.

At this stage, stringers and their supports that ran beneath deck beams, backing covers, decking, superstructure, finials, oars, and fenders completed the hull.
THE PURPOSE OF KHUFU I

Because Khufu I's high ends and upright finials resemble those of papyrus boats, it is called a papyriform vessel, a ceremonial type that reflects the origins of Egyptian hull construction. Representations of papyriform hulls are usually ritualistic in nature. Papyriform boats are used for pilgrimages to sacred sites, for symbolically charged hippopotamus hunts, and by the gods, particularly the sun god Re for his travels across the sky in the miṣnēt (day) and night (mskt) boats. When Khufu I and the neighboring sealed boat pit were discovered, scholars began a debate about its purpose that continues nearly 40 years later.

As discussed below (Chapter VI), Z. Hawass believes that the southern pits hold solar boats for Khufu to use in his persona as the sun god Re for his daily voyages across the sky. Scraps of wood found in the eastern graves on either side of Khufu’s mortuary temple suggest that these pits also held wooden hulls, probably interred without being disassembled. Hawass believes that these boats were for Khufu as the sky god Horus. He suggests that they run north and south because Horus’ power extended north and south of the land of Egypt; the fifth boat grave, beside the causeway leading to Khufu’s mortuary temple, carried the body of the king or was used by the goddess Hathor.

An alternate point of view is offered by Černý, who suggests that the Khufu I hull was a funerary boat for carrying the body of the king to Giza and the four other boats were intended to ceremonially transport him to the four cardinal directions. Thomas agreed with Černý that the Khufu I was not solar in nature because of its 10 propulsion oars and the rectangular, rather than boat-shaped, pit it was buried in. Abubakr and Mustafa described the three boats on the eastern side of the pyramid as watercraft used during Khufu’s lifetime for pilgrimages to Buto, Sais, and Heliopolis, important cult centers of Egypt. The disassembled boats on the southern side of the pyramid were intended for the rites of coronation and for the sons of Horus to use during the coronation. They state that Khufu I was not a solar boat.
Among other arguments, they point out that the *Pyramid Texts* do not mandate a solar boat for the king, that the Khufu hull has a different form than most solar boats, and that none of the symbolic elements of solar boats were found with the Khufu I hull.\textsuperscript{53} The Khufu hull, in their opinion, exhibits none of the attributes of solar watercraft as enumerated by S. Hassan.\textsuperscript{54} Hawass rebuts this last argument by pointing out that reed mats and flint tools can be considered solar symbols, and the matting and single flint knife from the Khufu I pit disproves the idea that the Khufu hull lacks a connection with solar boats.\textsuperscript{55} Whether or not the flint knife and matting are solar symbols, none of the other typical features of solar boats such as thrones, feathers, hawks and vaulted cabins were present.

Arguments about the purpose of the Khufu hulls and boat graves also feature opinions as to whether or not the Khufu I hull was used. Abubakr and Mustafa countered with evidence of rope impressions on battens that could only have been made when the battens were wet and soft; Lipke points out that we should expect more battens to be so marked if they can be considered a sign of use.\textsuperscript{56} The argument of the battens is compelling, but no analysis of the number and positions of rope-impressed battens has been offered.

As noted above, white paint on some of the boards at the time of excavation suggested to some authors, including Hawass and Nour, that the boat was never used. The Dashur and Abydos hulls as well as the Lisht model (Chapters X, IV, and IX) were also covered with a white, calcium-carbonate substance, probably plaster, when excavated, and it should also be pointed out that coatings can be applied to a hull at any time, not just before it is put in the water.

Landström and Iskander both suggest the boat was built in a hurry, on-site according to Iskander.\textsuperscript{57} The suggestion that the ship was built in a hurry is countered by hundreds of points of fine finishing and polishing of the hull and its superstructure. Hag Ahmed swears that no tool marks are present anywhere on the ship. If the 43-meter-long hull was built "in a hurry," it must have been built by a squadron of shipwrights. Goddard pointed out that four men using stone tools required a month to produce 14
planks 4 x 0.2 x 0.025 m., an amount of finished wood less than that found in two strakes from the Khufu hull.

In my opinion, actual use of the Khufu hull can be neither proved nor disproved, so we must turn to the hull itself to consider whether it could have been used. The shape, design, and construction of the hull reflect what we know of Egyptian ship construction from the Abydos hulls, Old Kingdom depictions, and features that can be traced all the way to modern boatbuilders on the Nile.

The only lingering question about the hull’s construction concerns the coherence of the bottom, whose three sections seem scarcely fastened together at all. But the parallel construction of central strakes composed of three sections in the Dashur hulls and Lisht model indicates the longevity of this fastening pattern. I believe the interplay of mortise-and-tenon fastenings in plank edges, the weight of the planks, transverse lashing, and bouyancy harnessed the forces necessary to compress the central strake. Every aspect of the Khufu I hull was planned, built, and finely finished. Perhaps built expressly for burial, Khufu I nonetheless provides us with an authentic example of the shipwright’s craft.
ENDNOTES


3. Zaki Nour *et al.* (supra n. 1); Lipke (supra n. 1) 7-26.

4. Abubakr and Mustafa (supra n. 2) 2. Lipke (supra n. 1) 97, provides dimensions of 43.6 x 5.6 x 1.8 m., but notes that these dimensions are extrapolated from a model built by Hag Ahmed and that they may not be correct.

5. Lipke’s work synthesizes the major sources of information on the Khufu I ship. His long series of interviews with Hag Ahmed Youssef Mustafa provided him with insights into the hull’s construction and reconstruction that are unmatched in any other source. The factual information presented in this section is based upon Zaki Nour *et al.* (supra n. 1) and Lipke (supra n. 1). In this discussion, I use the terms *carling*, *stringer*, and *floor timbers* for Lipke’s central longitudinal beam, side girders, and frames.


7. Lipke (supra n. 1) 117-21; (supra n. 6) 30.


9. Lipke (supra n. 1) 64, 79.

10. Abubakr and Mustafa (supra n. 2) 6.

11. Lipke (supra n. 1) 64.


13. Lipke (supra n. 1) 64.

14. Lipke (supra n. 1) 64, fig. 44.
15. Lipke (supra n. 1) 78-79; Abubakr and Mustafa (supra n. 2) 6.

16. Lipke (supra n. 6) 79.

17. Lipke (supra n. 6) 25.

18. Jenkins (supra n. 12) 108-109, fig. 93.

19. Lipke (supra n. 1) 79.


21. Lipke (supra n. 1) 115-17.

22. Lipke (supra n. 1) 78-79.

23. Lipke (supra n. 1) fig. 53.

24. B. Landström, Ships of the Pharaohs (Garden City 1970) 31; Lipke (supra n. 6) 29.

25. Lipke (supra n. 1) 103.

26. Lipke (supra n. 1) fig. 52.

27. Lipke (supra n. 1) 107.

28. Jenkins (supra n. 12) fig. 90.

29. Lipke (supra n. 1) 107-12 provides an extensive description of the superstructure.

30. Zaki Nour et al. (supra n. 1) 49.


32. See, for example, H. Junker, Giza IV. Grabungen auf dem Friedhof des Alten Reiches. Die Mastaba des K3jm’nh (Wien and Leipzig 1940) pl. 9.

33. Lipke (supra n. 1) 103, 126.

34. Zaki Nour et al. (supra n. 1) 8, 9 and 47.
35. The practice of finding an Egyptian boatbuilder for the desired hull shape and providing that builder with the desired end length is described by S. Clarke, "Nile boats and other matters," *Ancient Egypt* 5 (1920) 2-9, 40-51.

36. The documents provide measurements of ships in terms of cubits, but we do not know where the Egyptians measured the hulls. The deck, waterline, and forward-to-aft-most points have all been suggested. If the Egyptians were interested in measuring useful space, the deck or waterline length was probably used. If they were more concerned with overall size, the decorative, and usually nonfunctional, ends would have marked the hull's boundaries.


39. See, for example, P. Duell, *The Mastaba of Mereruka* III (Chicago 1938) pl. 152.

40. Lipke (supra n. 1) 106, fig. 65. Note that "d" incorrectly illustrates a V-shaped lashing over a mortise-and-tenon fastening.

41. Lipke (supra n. 1) 63-64.

42. Although strakes 2 and 3 do not run end-to-end on the hull, their size and importance in the hull is such that I have labelled them strakes.

43. G. Steindorff, *Das Grab des I* (Leipzig 1913) pl. 119.

44. Lipke (supra n. 1) 84.

45. Lipke (supra n. 1) 107 provides a thorough discussion of this process.

46. Lipke (supra n. 1) 117.

47. Jenkins (supra n. 12) fig. 56.

48. A. Moussa and H. Altenmüller, *The Tomb of Nefer and Ka-Hay* (Mainz 1971) pl. 19 and 20. This scene has sometimes been interpreted as showing the process of giving curvature to the hull planking, 'rq, but if that were the case, fastenings between seams would be destroyed.


52. Abubakr and Mustafa (supra n. 2) 12-16.

53. Abubakr and Mustafa (supra n. 2) 16.


55. Z. Hawass, The Funerary Establishments of Khufu, Khafra, and Menkaura during the Old Kingdom (Diss. Univ. of Pennsylvania 1988) 75.

56. Abubakr and Mustafa (supra n. 2) 16; Lipke (supra n. 1) 125.

57. Landström (supra n. 24) 33; Zaki Nour et al. (supra n. 1) 29-57.

CHAPTER VI

KHUFU II

In 1954, while clearing sand away from the south side of the Dynasty 4 pyramid of Khufu at Giza, workers discovered two pits, each more than 20 m. long and sealed with massive limestone blocks. Archaeologists recovered the planks and other pieces of the now-reconstructed Khufu I hull (43 m. long) from one pit. The contents of the other pit were the subject of much speculation until October, 1987, when the National Geographic Society and the Egyptian Antiquities Organization conducted a non-destructive investigation of the second pit to record its contents and to attempt to recover ancient air, uncontaminated by modern pollutants.¹

Using a specially designed drill and camera system, project members produced both video footage and still photographs which revealed the dismantled timbers of a sister ship to Khufu I (fig. 6-1). Through extensive evaluation of the video footage and photographs, it was possible to evaluate the hull’s condition, to generate dimensions for it, to analyze its construction, and to identify deck structures and other features of the vessel.²

Because the planks from the first excavated boat pit were in such excellent condition, many people were surprised at Khufu II’s rather decayed appearance. Photographs document the sharp edges of many planks as they were lifted from the Khufu I pit,³ raising hopes that the second pit would be sealed as efficiently; however, Khufu II seems to have undergone a normal amount of degradation.

A report by atmospheric scientists responsible for evaluating the air samples records their surprise that any wood remains at all: "The temperature and the humidity seem favorable to biological decay, and there is absolutely no lack of oxygen."⁴ The authors of the report suggest that if the wood is cedar, the natural high concentration of fungicidal chemicals in the wood would have slowed the decay rate, now estimated at 200-1000 g. per year.⁵ They also dismiss the suggestion that the presence of a cement mixing machine above the second pit was responsible for the greater amount of decay.
Photographs of Khufu I show a similar amount of gypsum mortar on the surface of the wood in the pit, as well as a similar depth of wood within the pit. This suggests to me that we were extraordinarily lucky to have recovered one vessel in such excellent condition and that the condition of Khufu II may be influenced by other factors such as the type of wood used in its construction.

When the Khufu I pit was opened in 1954, its excavators discovered timbers from a dismantled ship stacked in layers. During the hull's reconstruction, it was realized that these layers corresponded to the sequence of construction, with the last stage, the superstructure, on the top of the pit, and the first planks to be assembled, the central section of the center strake, on the bottom. In addition, the backing timbers and papyriform finials were placed where they would be found on the ship -- at the ends of the pit -- a clue Hag Ahmed Yusef Mustafa, the ship's reconstructor, says was vital in determining their position on the reconstruction (see Chapter V).

DESCRIPTION

The surface layer visible in the Khufu II pit also contains beams, oars, and prefabricated decking, deckhouse, and roofing panels. Few hull timbers can be seen, but the examination of both still photographs and video footage confirms the presence of thick planks with V-shaped mortises cut into their inner faces.

Several differences between the placement of timbers within the two boat pits can be seen. The most striking is the lack in the Khufu II pit of reed matting and fabric visible over some surfaces of Khufu I's uppermost layer. Although no direct evidence for matting in the Khufu II pit exists, a patch of material in the central part of the pit, directly beneath the camera, may be all that remains of a similar deposit. Because the surface layer timbers are more degraded than those in the first pit, we may simply be confronted with a lack of preservation. It seems reasonable to suggest, however, that if there was reed matting and or cloth, there was probably less of it deposited originally.
CATALOGUE

The catalogue presents hull components visible in the Khufu II pit identified through the use of the joint National Geographic Society-Egyptian Antiquities Organization imagery. Paul Lipke participated in discussions and initially offered many of the identifications presented here. Catalogue dimensions presented are approximate, derived from known measurements of ceiling blocks and the width of the pit with the assistance of a PASCAL program written by Steven Ward. The modern cement disk dropped into the pit as part of the air testing process also provides a reference measurement. Catalogue numbers in Table 6-1 refer to labeled pieces in fig. 6-2.

Planks. Fastening type and placement and the thickness of planks 28-31 link the contents of the two pits and offer proof that the unexcavated pit contains a ship fastened by transverse hull lashing and mortise-and-tenon joints like Khufu I. Paired mortises, suggest the V-shaped lashing mortises of Khufu I; other mortises, presumably for tenons, can be identified on plank edges. The planks, located at the pit's east end, include a fragment propped up on limestone blocks in the center of the pit like the central strake in the Khufu I pit. Lipke believes that the curved edge of plank 29 is reminiscent of the backing timbers of Khufu I, but I do not concur.

Backing Timber Covers. On the basis of their similarity in cross-section to backing timber covers on Khufu I, catalogue items 3, 23, and 24 have been identified as possible backing timber covers. In the reconstructed hull, these components ride over the knife-shaped backing timbers uniting the central strake and hull planking and provide a level foundation for the decorative papyriform finial. The cross-section and length of component 3 are closest to backing timber covers on Khufu I.

Components 23 and 24 have the same overall shape, a notch cut into their narrow ends, and seem to face each other; 24 has mortises in its upper edge. Their appearance is quite similar to Khufu I backing timbers, but they are only about a third as long. If 23 and 24 are backing timber covers, the backing timbers they covered were considerably smaller than those in Khufu I. The position of 3, 23, and 24 on the upper layer argues
Table 6-1. Projected measurements of Khufu II hull components in meters.

<table>
<thead>
<tr>
<th>No.</th>
<th>Identification</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prefabricated panel</td>
<td>4.67 x 2.27</td>
</tr>
<tr>
<td>2</td>
<td>Prefabricated panel</td>
<td>4.20 x 2.70 (W)/2.59 (E)</td>
</tr>
<tr>
<td>3</td>
<td>Backing timber cover?</td>
<td>4.36 m. long; 0.25 wide at east end</td>
</tr>
<tr>
<td>4</td>
<td>Beam</td>
<td>7.20 x 0.18 x 0.06</td>
</tr>
<tr>
<td>5</td>
<td>Crosspieces</td>
<td>0.50-0.70 long</td>
</tr>
<tr>
<td>6</td>
<td>Deckhouse end panel</td>
<td>2.88 x 2.50 (NW-SW)/2.77 (SE-NE)</td>
</tr>
<tr>
<td>7</td>
<td>Pole ?</td>
<td>1.63 (min.) x 0.04</td>
</tr>
<tr>
<td>8</td>
<td>Patches</td>
<td>0.21 x 0.055; 0.17 x 0.068</td>
</tr>
<tr>
<td>9</td>
<td>Carrying beam</td>
<td>11.14 x 0.20; ledge 0.055 deep</td>
</tr>
<tr>
<td>10</td>
<td>Pole</td>
<td>3.16 x 0.068</td>
</tr>
<tr>
<td>11</td>
<td>Beam</td>
<td>2.32 x 0.20 x 0.04</td>
</tr>
<tr>
<td>12</td>
<td>Beam</td>
<td>4.50 x 0.14</td>
</tr>
<tr>
<td>13</td>
<td>Decking panel</td>
<td>0.71 (min.) x 2.68</td>
</tr>
<tr>
<td>14</td>
<td>Decking panel</td>
<td>1.17 (min.) x 2.60</td>
</tr>
<tr>
<td>15</td>
<td>Pole</td>
<td>3.77 x 0.05</td>
</tr>
<tr>
<td>16</td>
<td>Pole</td>
<td>2.16 x 0.075</td>
</tr>
<tr>
<td>17</td>
<td>Pole</td>
<td>3.17 x 0.05</td>
</tr>
<tr>
<td>18</td>
<td>Door ?</td>
<td>1.54 (min. length)</td>
</tr>
<tr>
<td>19</td>
<td>Oar blade</td>
<td>1.15 x 0.34</td>
</tr>
<tr>
<td>20</td>
<td>Oar blade</td>
<td>1.25 x 0.11</td>
</tr>
<tr>
<td>21</td>
<td>Pole</td>
<td>1.00 x 0.10</td>
</tr>
<tr>
<td>22</td>
<td>Pole</td>
<td>1.00 x 0.10</td>
</tr>
<tr>
<td>23</td>
<td>Backing timber cover?</td>
<td>1.33 x 0.50 (broad end)/0.13 (tip)</td>
</tr>
<tr>
<td>24</td>
<td>Backing timber cover?</td>
<td>1.26 x 0.56 (broad end)/0.11 (tip)</td>
</tr>
<tr>
<td>25</td>
<td>Tenons</td>
<td>c. 0.06 wide</td>
</tr>
<tr>
<td>26</td>
<td>Decking panel</td>
<td>1.37 x 1.81/2.57 (including broken plank)</td>
</tr>
<tr>
<td>27</td>
<td>Pole</td>
<td>1.29 long</td>
</tr>
<tr>
<td>28</td>
<td>Plank end</td>
<td>1.00 long</td>
</tr>
<tr>
<td>29</td>
<td>Plank</td>
<td>3.22 x 1.00</td>
</tr>
<tr>
<td>30</td>
<td>Plank</td>
<td>2.34 x 0.30</td>
</tr>
<tr>
<td>31</td>
<td>Plank</td>
<td>1.65 x 0.14</td>
</tr>
<tr>
<td>32</td>
<td>Copper fastening</td>
<td>0.13 x 0.055 x 0.014</td>
</tr>
</tbody>
</table>
Fig. 6-2. Tracing of hull components visible in pit montage.
against their identification as backing timbers if Khufu II is stacked in layers reflecting hull construction order, especially because 23 and 24 lie transversely across the top layer. In the Khufu I pit, backing timber covers were found in the lowest layer.

_Decking and deckhouse panels._ Egyptian woodworkers used prefabricated wooden panels to build the Khufu I deck and deckhouse. Edge-joined planks, reinforced by crosspieces, formed panels either tapered to reflect changing deck dimensions or straight-edged and framed for use as deckhouse walls or roof sections (fig. 6-3).

Lipke and I identify components 13, 14, and 26 as decking panels because they lack framing. Deck panel 26, one of the few components whose upper surface is visible, illustrates how plank shapes reflect changes in hull width. One of four planks used to build panel 26 has fallen away from it, and the tapered plank shape is clearly visible. Mortise-and-tenon joints fastened plank edges within the three decking panels; crosspieces pegged to panel backs about every 75 cm. provided transverse strength. Each decking panel is about 2.6 m. wide; panels 13 and 14 lie beneath other components, but panel 26 is only 1.37 m. long. Deck panels in Khufu I ranged from 2-6 m. in length.

Khufu I's deckhouse had 10 side, 10 roofing, and two end panels forward and aft. Components 1, 2, and 6, identified as deckhouse panels, are fully framed. Double lateral braces on panel 2 mirror those of deckhouse side panels in Khufu I; framing details of panel 1 are not as clear. Panel 6, framed on all sides and possessing a central, lateral brace, is most similar to deckhouse end panels on Khufu I.

The principle observed difference between Khufu I and II panels is in the length
Fig. 6-3. Khufu I deckhouse construction. (Courtesy P. Lipke)
long, nearly half the overall length of the entire Khufu I deckhouse and twice as long as its side panels.

Beams. The longest visible hull component, beam 9, was the main carrying beam for the deckhouse and supported both crossbeams and roofing panels. Its length, crescent-shaped notches for receiving crossbeams, and double ledges for holding roofing panels are mirrored on the Khufu I ship. Copper loops attached to the beam below each notch and on its upper surface at its western end probably secured lashing for the roofing panels. Although physical features of this component are similar on both hulls, the main carrying beam for Khufu I’s deckhouse was found in the third, rather than the uppermost, layer of the pit.

At 7.2 m. long, beam 4, at the western end of the pit, is the second longest visible component. Its width is comparable to that of beams 9 and 11; like beam 9, its narrow surface is studded with copper loops.

Beam 12 lacks copper loops but includes a 5-cm.-diameter lashing mortise. It is of even width (14 cm.) throughout its 4.5 m. length. The beam end closest to the center of the pit, splintered by a large chunk of plaster, perplexed us at first because of its resemblance to a shaped wedge or mallet, but it can be reconstructed with certainty as belonging to beam 12.

Beam 11 is as wide as beam 9, but only 2.32 m. long. Although we originally suggested that component 11 was a bulkhead cap, projected measurements show that it is of even width across its length (2.32 x 0.20 m.), not narrower on the ends like the bulkhead cap in the Khufu I deckhouse. Beam 11 has two copper loops, about 5 cm. in diameter, in each end.

I could find no parallels on Khufu I for beams 4, 11, or 12.

Door. Lipke has pointed out that component 18 is about the same width and is braced like doors on the Khufu I hull; I would add only that its edge seems thicker than the edge visible in photographs of Khufu I’s doors.¹⁰

Tenons, patches, and copper loops. The prefabricated panels on the pit’s upper
layer of wood relied on mortise-and-tenon joints to fasten plank edges. Six-cm.-wide
tenons between plank edges can be seen in several places including panels 2, 13, and 26.

Several planks in Khufu I had replacement patches, attached with small pegs, for
areas of flawed wood. Panel 6 includes a similar patch, or possibly two (component 8).
Patching was practiced at least since Naqada IIIb when patches were lashed to coffin
planks at Tarkhan.\textsuperscript{11}

Hull components in the upper layer of the unopened pit have nearly double the
number of copper fastenings present in all of Khufu I. Thick, copper, D-shaped loops on
panel framing elements and along beams are much larger than the wire-like copper
fastenings in Khufu I. For example, component 32 is a bent copper strap or rod 30 cm.
long, 5 cm. wide, and 1.4 cm. thick with a 5-cm.-diameter hole in one end. Copper’s
density is 8.96 g. per cubic cm.; component 32 probably weighs about 2 kg. (4.4 lbs.).
Both its function and its relationship to the D-shaped loops are unclear.

\textit{Poles and crosspieces}. Components 5, 7, 10, 15-17, 21, 22, and 28 have varying
diameters and finishes, but they all seem to have a round cross-section. Components 5
and 27 probably represent panel crosspieces. Photographs of poles 15-17 in the
northeastern pit area show them surrounded by many other poles of indeterminate length.
On the opposite side of the pit, poles 21 and 22 disappear beneath other hull components.
Many of these poles may be oar looms, but because the Khufu II poles are incompletely
defined, it is difficult to assign them a particular function. Similar poles on Khufu I
served as oar looms, canopy supports, mooring posts, and papyriform columns.

\textit{Oar blades}. Oar blades 19 and 20, both warped, lie alone at the eastern end of the
pit. Neither is attached to a loom, but both are shaped like oars on the Khufu I ship. Four
oars were found on the surface of the excavated pit in 1954.

\textbf{ANALYSIS AND CONCLUSIONS}

The nondestructive investigation of the second boat pit south of Khufu’s pyramid
revealed its contents and answered questions about the condition of the wood stacked
within. This knowledge will allow more precise evaluation of the feasibility of excavation and conservation of the second ship by the Egyptian Antiquities Organization and it provides ship scholars with information about the hull.

Paul Lipke and I looked to the Khufu I ship for all identification equivalents because of obvious similarities in overall appearance of pit contents and the presence of prefabricated panels for decking and, probably, a deckhouse. The similarities provided a good starting point, but Lipke and I interpreted some images differently. We also had to evaluate hull components with similar shapes but much smaller or larger dimensions than known elements of Khufu I.

Most of the components on the surface layer of Khufu II belong to decking or superstructure components. Only a few timbers at the eastern end of the pit provide information about how the ship was built, but those few glimpses of planks confirm that Khufu’s second ship relied on thick planks with mortises for transverse bands of cordage and edge-joined by mortise-and-tenon fastenings.

No decorative endpieces can be seen, and we cannot predict hull shape from the available evidence. It is possible to reconstruct the deckhouse somewhat, however. The carrying beams for the two ships are almost exactly the same length, suggesting that total deckhouse dimensions might have been equal. The similarity in construction and shape of decking and deckhouse panels points to a similar deck plan.

If Khufu II panels 1 and 2 did belong to a deckhouse, it was built differently than that of Khufu I. At 4.2 and 4.67 m. long, these panels would have been unwieldy if portability was an issue. Because panels 1 and 2 are framed, we did not identify them as decking panels, although their size would be comparable to decking panels in Khufu I.

The incredible preservation of timbers from Khufu I was not extended to hull components in its sister ship. It is possible that the use of different woods in Khufu II’s construction offered less protection from time, but we will probably never know what caused its higher levels of degradation. We are fortunate, however, to have the opportunity to compare two such large and stately vessels, built more than 4,500 years ago. The Egyptian Antiquities Organization is considering an excavation of the now-
closed pit; while such an excavation offers much to scientists, the problems of conservation and curation are immense.
ENDNOTES


2. I am grateful to the National Geographic Society for providing me the opportunity to evaluate the documentation of the pit contents with Paul Lipke. Paul Lipke's knowledge of the Khufu I hull, particularly its superstructure, enabled him to suggest many of the preliminary identifications presented here, and it has been a pleasure to work with him cooperatively on this project.

3. M. Zaki Nour, Z.Y. Iskander, M.S. Osman, and A.Y. Moustafa, The Cheops Boats pt.1 (Cairo 1960) pl. 48, for example; see also Miller (supra n. 1) 524-33.


5. Tans, et al. (supra n. 4) 13.

6. Zaki Nour, et al. (supra n. 3) pls. 31 and 43.

7. Compare Zaki Nour, et al. (supra n. 3) pls. 31 and 45 with Miller (supra n. 1) 525-8.


9. Lipke (supra n. 8) 30, fig. 9, illustrates backing timbers from Khufu I.

10. Lipke (supra n. 8) fig. 6.

CHAPTER VII

ROCK AND BRICK BOATS OF THE OLD KINGDOM

During the reign of Khufu, funerary monuments increased exponentially in size and complexity. Throughout Dynasty 4, vast resources poured into the coffers of the state and were passed out again as rewards to those who labored for kings. Work crews, divided into groups that reflected the nautical origins of organized labor, built the largest pyramid in Egypt. Stoneworkers and sculptors created both delicate and massive statues commemorating kings and gods, and objects previously made only of perishable materials were copied in stone or brick.

The Step Pyramid of Djoser at Saqqara provides the first example of the large-scale application of this practice, probably designed to provide the dead king with the benefits of "immortal" structures. At Giza, workers cut huge rectangular pits for burying disassembled boats, boat-shaped pits for interring whole vessels, and sculpted subterranean negative images, or reverse molds, of papyriform boats like those that travelled on the Nile and played prominent roles in Egyptian cosmology. Because rock watercraft would not decay, ancient Egyptians concerned with immortality may have viewed such hulls as more valuable than wooden boats.

In Egyptian religious practices of the Old Kingdom documented by the Pyramid Texts, names for 32 different boats used by Re, the king, and the gods in proper religious funerals and the afterlife indicate the importance of watercraft in mortuary ritual. The dead king boards the "great boat" and sails to the horizon with Re or travels with Re in another boat where, in Re's stead, he commands the crew and gives orders to the gods. Although the names for the various boats are known and some representations include labels that tell us what type of craft is represented, linking watercraft buried in mortuary complexes with religious literature has proved difficult.

No single, satisfactory explanation for the presence of watercraft in mortuary establishments has been offered, but the numbers of hulls and boat pits testify to their
symbolic importance (Table 7-1). Wooden, rock, and brick vessels represented distinct types with individual characteristics. Information gained from studying the actual hulls represented may enable other scholars to link the separate types with mortuary literature and representations of hulls to answer questions about their purpose.

Table 7-1. Selected boats and boat graves from the Early Dynastic period through the Old Kingdom. All measurements in meters.

<table>
<thead>
<tr>
<th>King</th>
<th>Material</th>
<th>Size</th>
<th>Orientation/Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Djer?</td>
<td>12 wood hulls</td>
<td>22 x 3.5 x 1</td>
<td>NE-SW at Abydos</td>
</tr>
<tr>
<td>Hor-Aha</td>
<td>Boat grave</td>
<td>19.3 x 3.2 x 1</td>
<td>E-W; Saqqara tomb</td>
</tr>
<tr>
<td>Den</td>
<td>Wood hull</td>
<td>14.5 m. long</td>
<td>E-W; Saqqara tomb</td>
</tr>
<tr>
<td>Khufu I</td>
<td>Wood hull</td>
<td>42.3 x 5.7 x 1.8</td>
<td>E-W; S. of pyramid</td>
</tr>
<tr>
<td>Khufu II</td>
<td>Wood hull in pit</td>
<td></td>
<td>E-W; S. of pyramid</td>
</tr>
<tr>
<td>Khufu 3</td>
<td>Rock-cut hull</td>
<td>51.5 x 7 x 7</td>
<td>N-S; E. of pyramid</td>
</tr>
<tr>
<td>Khufu 4</td>
<td>Rock-cut hull</td>
<td>51.5 x 7 x 7</td>
<td>N-S; E. of pyramid</td>
</tr>
<tr>
<td>Khufu 5</td>
<td>Rock-cut hull</td>
<td>43 x 4 x 7</td>
<td>E-W; beside causeway</td>
</tr>
<tr>
<td>Queen’s pyramids</td>
<td>Rock-cut hull</td>
<td>30.25 x 4.25 deep</td>
<td>E-W; between 2 pyramids</td>
</tr>
<tr>
<td></td>
<td>Rock-cut hull</td>
<td>unpublished</td>
<td>E-W; between 2 pyramids</td>
</tr>
<tr>
<td>Djedefre</td>
<td>Boat pit</td>
<td>35 x 3.75 x 9.2</td>
<td>N-S; S. of pyramid</td>
</tr>
<tr>
<td>Khafra 1</td>
<td>Rock-cut hull</td>
<td>25 x 3.7 x 1.6</td>
<td>E-W; at causeway</td>
</tr>
<tr>
<td>Khafra 2</td>
<td>Rock-cut hull</td>
<td>21 x 3.7 x 1.6</td>
<td>E-W; at causeway</td>
</tr>
<tr>
<td>Khafra 3</td>
<td>Rock-cut hull</td>
<td>24 x 3.6 x 1.6</td>
<td>E-W; at causeway</td>
</tr>
<tr>
<td>Khafra 4</td>
<td>Rock-cut hull</td>
<td>23.5 x 5.1 x 1.6</td>
<td>E-W; at causeway</td>
</tr>
<tr>
<td>Khafra 5</td>
<td>Pit</td>
<td>37.5 x 7 deep</td>
<td>N-S; at causeway</td>
</tr>
<tr>
<td>Khafra 6</td>
<td>Unfinished</td>
<td>32 x 11 deep</td>
<td>N-S; at causeway</td>
</tr>
<tr>
<td>Ne-user-re</td>
<td>Brick boat</td>
<td>30+ x c. 8.8</td>
<td>E-W; S. of sun temple</td>
</tr>
<tr>
<td>Unas 1</td>
<td>Stone-lined hull</td>
<td>36.5 x 6.1 x 7</td>
<td>E-W; S. of causeway</td>
</tr>
<tr>
<td>Unas 2</td>
<td>Stone-lined boat</td>
<td>unpublished</td>
<td></td>
</tr>
<tr>
<td>Kagemnii</td>
<td>2 roofed pits</td>
<td>11 x 2</td>
<td>? Saqqara</td>
</tr>
<tr>
<td>Raneferef</td>
<td>2 wood boats</td>
<td>3+ m. long</td>
<td>? Abusir</td>
</tr>
<tr>
<td>Dyn. 6</td>
<td>&quot;2 solar-barques, the timbers of which were fastened together with ropes&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THE ROCK-CUT BOATS OF KHAFFRA

The most unusual ancient Egyptian hulls may be the rock-cut boats of Khafra (c. 2500 B.C.). The pyramid complex of Khafra lies west of Khufu's, and it includes at least four subterranean rock boats, excavated by Selim Hassan in 1934 (fig. 7-1).² Straight-sided trenches 1.0 or 1.1 m. wide descend into the limestone plateau where the hulls and other features are carved out of the rock. If a substance such as epoxy resin were poured into the rock-cut boats and the surrounding rock chipped away, a solid model of a ship more than 20 meters long would remain. A pair of boats is aligned on an east-west axis on each side of the causeway leading to the mortuary temple; a possibly rectangular pit and another unfinished pit run along a north-south axis nearby.

Fig. 7-1. Plan of Khafra's rock-cut boats. (After Hassan [1946] fig. 19)
The four causeway boats are 21-25 m. long, 3.6-5.1 m. wide, and 1.6 m. deep. The flat-bottomed hulls include massive stone floor timbers, and two have cabins. Table 7-2 provides extrapolated dimensions. None of Khafra’s boats held any wood, wood fragments, peg holes, or mortar for attaching wood to the rock walls, suggesting to Hassan that the ancient Egyptians believed them to fulfill their purpose as they were. These four boats are best documented of the six cuttings, but the amount of information available varies. The physical characteristics of each vessel are described, then I discuss those features from the perspective of nautical technology. Following the catalogue, theories regarding the putative purpose of the hulls are reviewed in the same terms.

Catalogue with Analysis

Boat 1. (Fig. 7-2) This boat, located south of the causeway, is the largest. One upright and one sloping end were carved in the rock. The western portion of the vessel’s bottom is longer and narrower than the eastern end. Floor timbers carved in the bottom of the hull are two to three times broader than high; wooden floor timbers from Egyptian vessels are two to three times higher than broad. Floor timber spacing seems appropriate to hull length when compared to floor timber placement in Khufu I, the only comparable wooden hull, where floor timbers are two to three meters apart.

Fig. 7-2. Khafra Boat 1. (Based on Hassan [1946] fig. 21)
Table 7-2. Characteristics of the rock-cut boats of Khafra and the wooden Khufu I hull.$^5$

<table>
<thead>
<tr>
<th>Boat</th>
<th>Alignment</th>
<th>Hull Size in m. (L:B ratio)</th>
<th>Other Features (measurements in m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E-W</td>
<td>$25 \times 3.7 \times 1.6$</td>
<td>Cabin: $7.4 \times 3 \times 2.5$; 12 floor timbers sided c. 15-30 cm., molded 10 cm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($6.7:1$)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>E-W</td>
<td>$21 \times 3.7 \times 1.6$</td>
<td>10 floor timbers c. sided 30-75 cm., molded 10 cm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($5.7:1$)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>E-W</td>
<td>$24 \times 3.6 \times 1.6$</td>
<td>Cabin: $3 \times 2.5 \times 2.5$; 13 floor timbers sided c. 40-50 cm., molded 16 cm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($6.7:1$)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>E-W</td>
<td>$23.5 \times 5.1 \times 1.6$</td>
<td>Raised structure 50 cm. inboard of sheer for most of its length.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($4.5:1$)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N-S</td>
<td>$37.5 \text{ L;}$</td>
<td>No sections provided.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$7.0 \text{ total depth}$</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>N-S</td>
<td>$32.2 \text{ L;}$</td>
<td>Unfinished. No sections. May not be a boat pit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$11.5 \text{ total depth}$</td>
<td></td>
</tr>
<tr>
<td>Khufu I</td>
<td>E-W; upright bow to W</td>
<td>$42.3 \times 5.66 \times 1.8$ ($7.5:1$)</td>
<td>Cabin: $9 \times 4.1 \times 2.5$; 8 full and 8 three-quarter floor timbers sided c. 10 cm., molded 30-50 cm.; side stringer raised 26 cm. above sheer.</td>
</tr>
</tbody>
</table>

In Boat 1 and other boats with floor timbers, the transverse center line provided by Hassan bisects the floor timber at amidships, and a longitudinal waterline drawn through the maximum depth at midships intersects the hull at or very near the endmost floor timbers. Two rectangular holes at the beginning of the rise of the vessel’s east end are not illustrated. Hassan suggests that perhaps the holes held a transverse timber or served a practical purpose in the construction of the chamber.$^6$ The holes are not found at the boat’s west end. The rectangular cabin is 7.4 m. long, 3 m. wide at its greatest breadth, and 2.5 m. tall.
Artifacts excavated from the sand filling Boat 1 include the legs of a limestone sphinx (identified with the sun god in later times), a green basalt roller, and two redware plates.

*Analysis.* My reconstruction drawing of Boat 1 differs from Hassan's most significantly in the designation of the bow and stern. Hassan believed this vessel points east; I believe its bow is to the west. The reconstruction of the Khufu I hull more than 40 years after the Khafra boat excavations provided a full-sized craft with a stem higher than the bow, and a shape longer and more slender before amidships than after. Moreover, like the cabin on Boat 1, the rectangular Khufu cabin dominates the aft section of the deck. The Khafra Boat 1 cabin shares the same height (2.5 m.) and roughly the same L:B ratio (2.5:1) with the Khufu I cabin (2.2:1 at maximum width).

The similarities between hull shape and cabin location of the Khufu I hull and Khafra Boat 1 suggest that the vessel points west rather than east. I have reconstructed ends like that of the Khufu I hull, primarily as a demonstration of possible form.

Eleven model boats from the mastaba complex of Kaemenu, a Dynasty 6 priest of the Abusir (solar) pyramid complex, offer further support for designating Boat 1's west end as the bow. Three of four models with bipod masts forward of amidships are beamier aft than forward (fig. 7-3a, b). One of the masted hulls (fig. 7-3c) is almost double-ended and may be beamier forward than aft, which might support Hassan's designation of Boat 1's prow if we assume Boat 1 had a mast. The other models are fuller in the stern, which is higher than the bow.

Ten of the Kaemenu models also have a transverse timber at one end of the hull. Hassan suggests that the holes described at the rise of the eastern end of Boat 1 could have held a transverse timber; the models offer evidence for such a timber and place it firmly in the stern (fig. 7-3a, b, c, and e). The single model without a transverse timber (fig. 7-3d) is a papyriform boat.
The floor timbers of Boat 1 are molded only c. 10 cm. They cross the bottom of the hull and rise only slightly above the implied location of the central section/garboard seam. The distribution of the floor timbers offers an interesting parallel to the disposition of deck beams on Khufu I by Hag Ahmed. He describes his difficulty placing the beams until he visited a boatyard where the builder showed him the *betelgoz* -- paired deck beams. Deck beams were placed in pairs, fore and aft, of amidships. Boat 1 floor timbers also seem to be paired, with the widest single floor amidships, slightly aft of center as in Khufu I. The other floor timbers can be separated by width into pairs that alternate fore and aft.

I can offer no suggestions about the upper details of the ends of the vessels. Hassan thought the bead curtain present at the forward end of solar boats was represented but provides no supporting evidence. The small, stepped cuts are not discussed by Hassan, but, if the boat orientation is reversed, they could represent a bead curtain over a tall bow finial.
Boat 2. (fig. 7-4) This vessel is aligned with Boat 1 and lies about 9 meters west of it. According to Hassan, its unroofed trench included a 50-cm.-deep rebate that held wall foundations. Hassan reconstructed the hull with a vertical end and a steep, upward-sloping, stepped cut at the other end. The hull section shows asymmetry between the two sides relative to the trench opening; its sheer view suggests one end was higher and fuller than the other.

The floor timbers are the broadest drawn, but many are incompletely defined. No artifacts were specifically related to the boat, but fragments of diorite and alabaster statues were common in the pit and on the surface.

Fig. 7-4. Khafra Boat 2. (Based on Hassan [1946] fig. 21)

Analysis. Some contradictions within Hassan’s drawing make analysis of Boat 2 difficult. The sheer view is probably the most accurate representation of the vessel’s shape, but the plan is difficult to reconcile with the published sheer drawing. Rotating the plan 180° creates more agreement with the sheer view, but the published presentation
should have priority, as I have not seen the hull. For the sake of this discussion, I will disregard the plan, except to point out the smoothly curving lines it suggests.

The eastern end of the sheer view is higher and more steeply sloped than the western end. If Boat 2 was designed to resemble Boat 1 and other Old Kingdom hulls and representations, the eastern end is the stern. If the published plan were reversed, the hull shape would reflect that of Khufu I and Khafra Boat 1.

*Boat 3.* (Fig. 7-5)\(^1\) Located north of the causeway, this rock-cut hull was roofed with limestone slabs like Boat 1. The hull shape is the most symmetrical of the boats, and its \(L:B\) ratio is the same as Boat 1's. The vessel's transverse center line bisects the broadest floor. Like Boat 1, floor timbers seem to be paired fore and aft by width. The section provided by Hassan includes the only indication of their height; floor timbers reach just above the turn of the bilge. The illustrated amidships floor timber is about 16 cm. molded, and it is the vessel's broadest at c. 50 cm.

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![Diagram of Khafra Boat 3](image)

*Fig. 7-5. Khafra Boat 3. (Based on Hassan [1946] fig. 22)*
A naos-shaped cabin, rectangular but with convex sides, is described as being a little aft of dead center. Neither its length nor exact position is ascertainable from information provided, but its maximum width and height are exactly those of the cabin on Boat 1.

Artifacts found in this hull include a blue faience bead from a ceremonial flail, an incense burner, a redware flask, a model vase, a shell, an unstated number of 15 x 9 cm. blocks of dressed limestone, an alabaster plate fragment, a redware pot 30 cm. in diameter, and the bones of an ox at the eastern end of boat.

*Analysis.* Boat 3 closely resembles Boat 1 in its proportions, number and disposition of floor timbers, and superstructure, but differences in hull, floor, and cabin shape exist. Although Hassan describes the cabin as "aft of dead center", he does not say which end of the boat is which. His fig. 22 does not include a compass orientation; perhaps the ambiguity is appropriate because the hull is so symmetrical. My drawing shows the boat pointed west, but, based on the data provided, it could as well have pointed east.

*Boat 4.* (Fig. 7-6) Only small sheer and section views on the site plan supplement the written description of this unroofed boat, the least well preserved causeway vessel. Its 4.6:1 length-to-beam ratio is exactly that of the Dashur boat EM 4925, now in the Egyptian Museum in Cairo, and close to that of the other three recorded Dashur hulls. Boat 4's ends are horizontal.
Fig. 7-6. Khafra Boat 4. (Based on Hassan [1946] fig. 19)

According to Hassan, "A long, rectangular cutting occupies nearly all the centre of the hull." This cutting, of unspecified length, is about 50 centimeters high. Hassan suggests that it may be a low cabin, awning, or perhaps a sail.\textsuperscript{13}

The sand fill in Boat 4 contained ox bones, a redware incense burner with charcoal, the upper part of a head of an alabaster statue with a royal uraeus (possibly Khafra), a small, dark-green, glazed pottery dish, and alabaster with turquoise paint on hieroglyphs.

\textit{Analysis}. Boat 4 is the beamiest of Khafra's boats. No floor timbers are indicated. The drawings lack detail in any case: no plan is provided. The ends of the boat are ill-defined, and I have not attempted to reconstruct them. Hassan does not provide a heading for this boat.

If the boats are meant to be full-size stone replicas of wooden boats as other features indicate (particularly the cabin heights of Boats 1, 3, and Khufu I), Hassan's interpretations of the long "cutting" are unsatisfactory. I think it more likely that this
cutting represents either the stringers as seen on the Khufu I hull, or a raised bulwark as seen in the Dashur boats and many models, including those of Kaemenu (see fig. 7-3).

**Boat 5.** Hassan implies, but never specifically states that this cutting is boat-shaped. It lies perpendicular to the west end of Boat 1 on a north-south axis. No section drawings are provided, but Hassan says the vessel’s prow pointed south. He describes the pit as being cut into poor quality rock, having eroded sides, and possibly being unfinished. No traces of interior fittings, cabins, or other features were reported.14

**Analysis.** The pit’s lack of definition and Hassan’s statement that it may have been unfinished suggests that the pit may actually have had a rectangular section like the pits holding Khufu I and II. But because Hassan describes five, possibly six, "rock-cut boats" at the Khafra complex, and as I have not seen the boats, the question cannot be resolved by the evidence provided.

**Boat 6.** This cutting may or may not be boat-shaped. It was clearly unfinished, and unlike the other five, its surface trench is wavy-edged and uneven. This 11.5-m.-deep trench is four meters deeper than that of Boat 1, the next deepest. Hassan used this pit to reconstruct the sculpting process used to create the other boats.

Stone masons excavated a long trench about one meter wide at the surface, 1-4 m. deep to the highest point of the cabins or vessels, and 5-11.5 m. to the floor of the hulls or pits. Once the bottom was long and deep enough, it was widened, shaped like a hull, and given auxiliary details. Masons left marks of the pointed picks used to work the stone on the wall faces. Some of the trenches then had roofing slabs positioned and bedded down in a rebate at the surface.15

**Interpretation**

The rock-cut boats of Khafra represent hulls that, had they been made of wood, could have travelled on the Nile. The hull shapes and such fittings as are represented are in accord with a long tradition of shipbuilding that stretches as far back as the Early Dynastic boats from Abydos.

Khafra Boats 1-4 exhibit lines similar to those of ancient Egyptian wooden hulls
and boat models. They are 40-47 cubits long, 7 or 10 cubits wide, and 3 cubits deep. Floor timber proportions and placement are remarkably similar to the system used to place deckbeams in the Khufu I hull. If we knew more about the floor timbers of that hull, we might find the Khafra pattern reflected even more closely.

With the exception of the uneven and poorly defined floor timbers of Boat 2, the Khafra hulls reflect Old Kingdom hull construction as we know it from the Khufu hulls. Identical cabin heights in Boats 1 and 3 and Khufu I suggest standardization of size. The conformity of the Khafra boats to principles evident in the Khufu vessels suggests that a master shipwright supervised the masons who cut the boats.

As Hassan noted, Boats 1 and 3 seem to be a pair. The drawings show that each has a cabin, the same L:B ratio, and was roofed with limestone slabs. It is important to note, however, that Boat 1 has a rectangular and Boat 3 a naos-shaped cabin, perhaps indicative of different functions within Egyptian cosmology. The bottom of each boat is identical below the maximum depth waterline. The smooth, tapering lines indicate hulls fairly symmetrical fore and aft. In addition, the spacing, placement, and width of most floor timbers are similar.

Unroofed, and without cabins, Boats 2 and 4 also seem to be a pair. Despite the greater width of Boat 4, the shape of these boats below the maximum depth line is virtually the same. As has been made clear, not enough data is available to recreate hull lines, but this pair of boats is shorter and fuller on one end than the other. This is the major difference between the two sets of boats as well.

Hassan believed Boats 1 and 3 faced east and Boats 2 and 4 faced west, placing them in a prow-to-prow arrangement. My evaluation of the data Hassan provides suggests that Boats 1 and 3 faced west. The orientation of Boats 2 and 4 is not presently determinable.

Boats 3 and 4 on the northern side of the causeway contained ox bones and incense burners that seem to have been found in situ. Nothing similar was found in Boats 1 and 2 on the southern side of the causeway. Hassan states that the incense burners and remains of a sacrifice show that the boats were served by their own cult priests.\textsuperscript{16}
The lack of information on Boats (or Trenches) 5 and 6 prevents expanded
discussion, but their length suggests that they, too, were meant to be paired.

Were These Solar Boats?

The sun god Re, in all his aspects, dominated Old Kingdom religious beliefs.
After death, the king sought to reach Re in the sky and travel with Re in his celestial, or
solar, boats. Solar boats were usually paired, but not always. The earliest references to
solar boats refer to a papyrus float constructed of two bundles of reeds. Egyptologists
have traced a preoccupation with duality, the quality of doubling, and with orientation
along the sun’s path to religious practices associated with Re. Old Kingdom watercraft in
mortuary complexes are often described as solar boats, but such designations seem to be
intuitively rather than empirically based.

Khafra Boats 1-4, oriented east-west beside the mortuary temple causeway, are
called solar boats by Hassan. While implying that the north-south boats (or pits) are not
solar boats, he does not discuss them. Hassan’s study of solar boats, including early
dynastic and Old Kingdom representations and Middle Kingdom boat models, produced
the following list of symbolic equipment common to such vessels:

1. A mat or curtain hanging from the bow
2. Pegs and/or a crowned hawk surmounting the bow post
3. A hawk perched on an upright
4. One or more large uprights
5. A small swallow (?)
6. A lotus flower (?) emblem
7. Another unidentified emblem
8. A bent staff with various attachments
9. One or two rectangular or naos-shaped vaulted cabins
10. A seat or throne.

Models and pictures of watercraft that include most of these symbols are those labelled
by the ancient Egyptians as solar boats, but the origins of solar watercraft were simpler.

Hassan believes that reed floats, made of bundles of papyrus tied together, were
the most ancient form of watercraft in Egypt, predating the hulls seen on Naqada IIb pots. An illustration of a large reed raft, resembling a ladder on its side with two cabins and three standards, may represent the float shn.wr, "Great Reed Float," used for Re's celestial journeys. Through time, the float became an entity, and the appellation "Great Protector," which stemmed from its name, was applied to Re. Even in the New Kingdom, shn.wr was a solar divinity, although he had been demoted to doorkeeper for the gods.

Modern use of reed floats may provide explanations for the emphasis on duality in references to reed watercraft. Nubians at the second cataract used a "huge wedge-shaped bundle of reeds" about four meters long, made of two conical bundles of reeds lashed together to cross the Nile. Breasted links modern reed floats to the ancient shn.wj, from the word for "to embrace" or "armful," represented by pairs of elongated ovals and among the oldest symbols in the Pyramid Texts. He cites Utterance 337a, "the two shn of the sky are laid for Re, that he may ferry across to the horizon therewith." The dead king also traveled on the two shn of the sky. Breasted believes that the practical basis of the actual double reed float explained the constant duality of its determinative.

Reed floats, used in Middle Egypt by fisherman of Bahr Yusef in the first half of this century, were made anew for each individual and use, carried only one person, and were intended for short journeys. According to Hassan, the king’s need for his own reed float and the perceived brevity of the king’s journey to heaven were related to the characteristics of actual floats.

In the Pyramid Texts, reed floats are used for short journeys, such as from earth to heaven or across flooded celestial fields. Their construction was unsuited to the much longer journeys later Egyptians believed were made by solar boats. Once in Heaven, the king met four spirits from the east, sometimes identified as divine shipwrights or sons of Horus, a god associated with the east. In Utterance 519, four young people tie reed floats together to make a solar boat, presumably for that day’s use.

The oldest Pyramid Texts are those of the Dynasty 5 ruler Unas. Solar identifications of Unas with Re are strong, but links with earlier rulers are not as clear. Although the solar cult declined rapidly after Unas, and Re is not mentioned in the
Pyramid Texts of later rulers, solar boats, and the transport of reed floats in solar boats, continued to play a major role in the conception of the afterlife. Hassan suggests that because the duality of the reed float was theologically important, wooden solar boats, which did not need to be double, came to be seen as Day and Night boats, "thus retaining their duality and at the same time assigning a logical reason for it."²¹

An emphasis on duality can be seen in the disposition of both Old and Middle Kingdom watercraft in mortuary settings. The wooden Khufu hulls seem to be a pair, and models of funerary boats often occur in pairs yet five (or more) boats also are reported. At Saqqara, the discovery of a pair of boats prompted this notice: "In the filling on the north side of a mastaba of the Sixth Dynasty were found two solar-barques, the timbers of which were fastened together with ropes."²² No other details, including the basis for identifying the pair as solar, are provided, and the boats are unpublished. A pair of long and narrow limestone structures with tapered ends above the mastaba of Kagemni at Saqqara was identified as a pair of solar boats (fig. 7-7),²³ and excavations beside the Dynasty 6 pyramid of Raneferef recently revealed two 3-m.-long wooden boats.²⁴ These examples from the late Old Kingdom point to ritualized belief in the symbolic importance of paired vessels, but without sufficient information on hull types and disposition, determining their original purpose is difficult.

If only some features of the Khafra boats are considered, their duality seems clear. Boats 1 and 3 resemble each other more than they resemble eastern Boats 2 and 4. Hassan suggests that the western roofed boats were the Night Boats of the king and that the cabin and larger overall size showed the greater importance accorded to the Night Boat by the Egyptians. He believes that the eastern boats, left open to the sun and weather, were the Day Boats.²⁵

In identifying the Khafra boats as solar, Hassan seems to have placed greatest importance on their duality. Cabins on two Khafra boats are the only link with his list
of solar symbols from watercraft. The slightly later brick boat of Ne-user-re at Abusir and the sculpted and rock-built boats of Unas at Saqqara include more of these features and thus are more convincingly identified as solar boats.

Borchardt first described the Ne-user-re boat as facing west. More than 30 m. long with sides 3.5 m. high at the time of excavation, the boat was built on an east-west axis about 100 m. from the western wall of Ne-user-re’s sun temple (fig. 7-8). Maximum width seems to be 8.5 m. (inside 2.3-m.-thick brick walls), reflecting a 3.5:1 length-to-beam ratio. The brick walls of the boat imitate the sweep of planking in a pattern similar to planking in the Khufu I hull and some Old Kingdom ship reliefs.

Hassan believes the Ne-user-re boat faced east and represented the Night Boat. Pedestals and platforms in the hull conform to the placement of symbolic equipment seen in representations and on later models. In my opinion, a transverse pedestal in the east end of the boat may support Borchardt’s original westward orientation of the boat and can be compared with the transverse pieces in the Kaemsenu models (see fig. 7-3). Hassan argues elsewhere that Night Boats were covered to keep them in the dark; the brick boat of Ne-user-re was above ground and unroofed and thus does not meet his criteria.

Hassan identified a boat he discovered south of the causeway leading to the pyramid of Unas as a solar boat. Carved out of bedrock and faced with white limestone, this symmetrical vessel had the same flat bottom and rising ends of the Khafra
Fig. 7-8. Brick solar boat of Ne-user-re. (After Borchardt [1907] fig. 46)

boats. It measured 36.5 x 6.1 x 7.15 m., a 6:1 L:B ratio. The bottom of the vessel was paved with masonry, but had unpaved sections that Hassan interprets as foundations for platforms or cabins. A large, almost cubical "throne" is described but not pictured. A second boat is not as well reported and was unknown to Hassan at the time he wrote.\(^{29}\)

The boat grave north of Hor Aha’s Dynasty 1 tomb at Saqqara is included in Hassan’s list of solar boats. This mudbrick grave for a wooden boat (no longer present) was coated with white plaster and probably resembled the Abydos boat graves (Chapter IV). Its L:B ratio of 6:1 is in accordance with many of the boats discussed here.\(^{30}\) The boat was oriented on an east-west axis, but the direction it faces is open to interpretation.

The Dynasty 1 boat grave of Den (Udimu) might also have been considered a solar boat by Hassan on the basis of its similarity to that of Hor Aha had he known of it. In 1954, north of the tomb wall, W. Emery found a wooden boat with a central cabin filled with pottery vessels. Like Hor Aha’s boat, this 14.3 x 2.15 x 0.75 m. vessel was
above ground in a plaster-coated, mudbrick grave. Emery provides no description of the hull. 31

Hassan makes a forceful argument for the Egyptian perception of solar boats as dual entities and discusses the Khafra boats in those terms. Two of the Khafra boats, roofed and with cabins, are designated as Night Boats. He then refers to the Ne-user-re, Unas, and Hor Aha boats as solar boats and Night Boats, yet except for the Unas pair, of which only one was known at the time Hassan wrote, the Dynasty 1 and Dynasty 5 boats are unpaired, above ground, and unroofed. Their singular rather than dual nature prevents them from being identified as the same kind of boat as that represented by Khafra. We may call one or the other type solar but not both. The Dynasty 6 boats are paired and could fit Hassan’s criteria for solar boats, but they are so poorly published that their duality is the only feature we can reliably cite.

I would also argue that differences in cabin shape and the profiles of Boats 1 and 3 are significant enough to demand that Boats 1 and 3 be considered individually rather than as a pair. The same argument can be made for the broad-beamed Boat 2 and the narrower Boat 4 with deck-level stringers. Papyriform boats with coffins or statues of the dead person, thus funerary boats, almost always exhibit a deck-level stringer or bulwark of the same proportions and locations.

One could argue that Boat 2 is meant to be the broad papyrus ferry boat, or mhnt. The profile of Boats 1 and 3 generally corresponds to the profiles of solar boats, or boats for the god Horus (shms-Hor). Boat 4 may be a funerary boat because that is the only later hull type to retain the deck-level stringers that I believe became bulwarks. The problem comes in identifying characteristic features of real vessels and vessels that existed only in the spiritual realm. My experience lies in evaluating the physical characteristics of hulls; their religious characteristics can be better studied by others. Hassan’s argument that the presence or absence of roofing blocks defines Night and Day boats seems plausible, but the different boat types represented by Khafra Boats 1-4 prevent simplistic interpretations.
THE ROCK-CUT BOATS OF KHUFU

Beside Khafra's pyramid is that of Khufu, his predecessor by just over 30 years. Two rectangular pits outside the pyramid's south enclosure wall held disassembled wooden hulls. Three rock-cut boats are known from the Khufu pyramid complex and two from between two subsidiary pyramids nearby. 32 Like the pits on the south side of the pyramid, the stone boats are hewn out of the limestone of the plateau. The presence and shape of wood fragments in the bottom of the rock-cut boats suggest that they once held complete wooden vessels (figs. 7-9 to 7-11). Steps leading into one of the hulls and the breadth of Khufu's rock-cut boats indicate that they were open to the sky but below ground level.

Fig. 7-9. Khufu Boat 3.
Fig. 7-10. Khufu Boat 4.

Details of the boat-shaped pits are difficult to interpret on Hassan’s drawings, but illustrations by Maragioglio and Rinaldi and site visits provide additional information incorporated into figs. 7-9 to 7-11. In conformance with what we know of the rock-cut vessels of Khafra and the wooden Khufu I hull, I have designated the fuller, northern end of Khufu Boat 3 as the bow. Khufu Boat 3 includes blocks of stone along the forward sides of the pit, perhaps for supporting a wooden hull. A rounded depression, visible only in the pit itself, encircling the hull above the sheer strake may indicate stringers.

Boat 4 faces Boat 3, and its prow is to the south. This pit’s truncated ends share the same width and shape. A solitary, small block of stone is indicated amidships. Hull profiles of Boats 3 and 4 are virtually identical, and they are the same length and width.

Boat 5’s shape is irregular, yet the narrowing and greater depth of the eastern end suggests that it is the bow. Lack of clarity in excavation report details precludes specific conclusions about the presence of raised, transverse stone features, but they might
represent floor timbers, in which case it should be considered as a rock-cut hull rather than a boat-shaped pit.

Fig. 7-11. Khufu Boat 5.

Z. Hawass has studied the boats in the Khufu complex. He believes that Khufu Boats 3 and 4, on a north-south axis parallel to the east side of the pyramid on each side of the funerary temple, were the mj.t boat and the d3t bark of Horus, the sky god, for taking the king to the horizon of Re. Khufu I and II from south of the pyramid are seen as msktt (night) and mjndt (day) solar boats. The east-west boat north of the causeway is viewed as the funerary boat for transporting the mummy to Giza, or as possibly connected with the cult of Hathor, wife of the sun god Re and mother to the king.

CONCLUSIONS

If Hawass is correct, the Khufu boats offer a very different perspective on the creation of rock-cut boats and the burial of hulls than that provided for the Khafr, Unas, Kagemni, Dynasty 6, and Ne-user-re boats. It is difficult, however, to link the single or
paired examples of demonstrably solar boats and the large groups of Khufu and Khafra. Khufu I is most similar to Khafra’s Boat 1; Khufu II and Khafra Boat 3 may also be closely related. Khufu Boat 3 and Khafra Boat 4 may also represent the same boat type, if the rounded cut-outs in Khufu 3 were for stringers above the sheer strake.

The four rock-cut boats of Khafra are examples of different types of boats within a specific conceptual framework. Integral to the mortuary establishment of the Old Kingdom, stone and brick hulls designed to be permanent magical or practical watercraft are present at many Dynasty 4–6 pyramid complexes. Dynasty 5 and 6 vessels, either single or paired examples, can be convincingly identified as solar boats. None of the Khufu or Khafra boats can be identified as such at this time.
ENDNOTES


2. All factual information about the Khephren boats is drawn from S. Hassan, *Excavations at Giza 1934-1935* VI, pt. 1 (Cairo 1946) 59-66; my interpretations are identified as such. Dimensions in Hassan’s text differ from those presented in drawings; my presentation is primarily of data from the drawings. I have not visited these hulls, now filled with sand.

3. Hassan (supra n. 2) 59-60.

4. In Hassan (supra n. 2) fig. 21, the basis for fig. 7-2, the cross-section of the hull is smaller than the plan drawing of the central portion of the boat. I have chosen to reduce plan dimensions amidships by 15% to bring them into harmony with the midships section drawing because I feel that the cross-section more accurately reflects the true dimensions of the rock-cut hull.


6. Hassan (supra n. 2) 59.

7. C. Firth and B. Gunn, *Excavations at Saqqara: Teti Pyramid Cemeteries* II (Cairo 1926) pl. 49. The excavators called the models solar boats, partly because, like known solar boat representations, they had no oars, crew or superstructure. This also means, however, that they had none of the attributes of solar boats. Hassan cites the models, saying only one (fig. 7-3d) is a true solar boat, but he does not compare hull forms.

8. Lipke (supra n. 3) 70.

9. Hassan (supra n. 2) fig. 21 is the basis for fig. 7-4, but the views it offers of the hull are inconsistent. The plan does not seem to agree with the sheer view, and in fact, it seems to fit better if the plan is rotated 180°.

10. Hassan (supra n. 2) 61.

11. Boat 3’s ends are upright in Hassan’s sheer view (Hassan [supra n. 2] fig. 22) which is shown as 24 m. long, but as horizontal in his fig. 19 where the pit is 27 m. long. I have used the length shown in the sheer view to calculate the L:B ratio; fig. 7-5 retains the upright ends of the published sheer view. The testimony of the
Kaemenu models suggests that horizontal ends could be as just as valid, however.

12. Fig. 7-6 is based on Hassan (supra n. 2) fig. 19.
13. Hassan (supra n. 2) 64.
14. Hassan (supra n. 2) 64.
15. Hassan (supra n. 2) 65.
16. Hassan (supra n. 2) 62-63.
17. Hassan uses the word "club" in his list. He is referring to an upright pole or timber, sometimes slightly widened and flattened at the top.
18. Many later depictions of wooden boats include a low, rectangular base, sometimes with vertical bars, that may be an adaptation of the raft motif or, perhaps more appropriately, may represent a wooden sledge such as that found with the Dashur boat and featured in many boat depictions.
20. A. Blackman, "The Earliest Boats on the Nile. A Supplementary Note by the Editor," JEA 4 (1917) 255, pl. 54.
21. Hassan (supra n. 2) 21.
23. Firth and Gunn (supra n. 6) 88.
25. Hassan (supra n. 2) 46.
27. Hassan (supra n. 2) 80-81.
28. Hassan (supra n. 2) 81-82.
29. *Forschungsergebnisse in Ägypten in den Nachkriegsjahren* (Marburg 1951) 9, fig. 5; *Orientalia* 19 (1951) 120, pl. 1.

30. Hassan (supra n.2) 38.


34. Thomas (supra n. 30) 66.


36. Hawass (supra n. 31) 27.
CHAPTER VIII

THE LISHT TIMBERS

Forty timbers found during recent Metropolitan Museum of Art excavations at Lisht, and more than 50 timbers from much earlier excavations, can be identified as parts of watercraft, broken apart and used as foundations for roadways and ramps around the early Dynasty 12 pyramid of Senwosret I (c. 1950 B.C.).¹ Planks, a frame, and other transverse timbers sculpted from locally available woods demonstrate a previously unknown manner of hull construction using plaited lashing, intricate scarfing of timbers, and deep mortise-and-tenon joints.

Although the Lisht timbers differ from other ancient Egyptian hulls in some aspects, their characteristics also establish a direct relationship with the shipbuilding technology used in those hulls. Khufu and Dashur hull planking is, in general, longer, more regularly shaped, and thinner than Lisht planks. Khufu I and at least two of the Dashur hulls were made of imported cedar; the Lisht timbers have been identified as tamarisk and acacia. The hull shape and decoration, as well as the circumstances of their burial next to pyramid complexes, identify the Khufu and Dashur vessels as papyriform funerary craft. The broken-apart planks at Lisht received no ceremonial burial, however; their thrifty re-use as components of ramps and causeways shows that the Egyptians saw them as utilitarian, not ritual, in nature.²

This attitude reflects the original function of the Lisht timbers as planks in freight boats. Intricately joggled edges, planks more than half as thick as broad, and fastening types and patterns suggest that the timbers belonged to a sturdy freight vessel. Freighters carried stone from the granite quarries at Aswan to Helwan in Early Dynastic times, and shipbuilders learned early to cope with the problems of stress from heavy loads. As D. Arnold has pointed out, a single stone block 1 x 1 x 2 m. weighs about five tons;³ the elaborate building programs of the ancient Egyptians required efficient freighters. Boats with thick, intricately shaped and interlocking planks, deep mortise-and-tenon fastenings, and lashing fulfilled those requirements.
The Lisht timbers document construction practices for non-ceremonial watercraft. Thus, they are particularly valuable in providing balance to the past Egyptological focus on ceremonial procedures and records associated with burial which acted as a filter through which we glimpse daily life. Life in Egypt centered on the Nile, and boats played a crucial, practical role in the transport of food, raw materials, administrators, and royal persons. Yet we know little about working boats in ancient Egypt. Even reliefs such as those from the causeway of Unas depicting the transport of granite columns from Aswan to Saqqara by freight vessels are rare (fig. 8-1), because most vessels shown in reliefs are pleasure or ceremonial types.⁴

Fig. 8-1. Cargo ships from the causeway of Unas.

However, autobiographies and boat construction scenes carved in tombs provide clues to the construction and use of ancient working craft; for example, during Dynasty 6, Weni described his voyages to bring architectural elements for the royal pyramid complex and mentioned the type and number of boats he took.⁵ Hatshepsut's great temple at Deir
el Bahari illustrates the transport of her two great obelisks; the construction of these vessels has been a center of controversy for many years. The recent analysis of problems in transporting the Colossi of Memnon points out the advantages of looking at construction techniques in solving such problems.

ARCHAEOLOGICAL BACKGROUND

The Egyptian Expedition of the Metropolitan Museum of Art (MMA) uncovered about 50 timbers buried in the sands surrounding the pyramid of Senwosret I between 1906 and 1934. Recent re-excavation of the site by Dieter Arnold for the MMA brought the known total of timbers in the pyramid complex to at least 90. Arnold’s excavations south of the causeway on the eastern side of the pyramid revealed more than 20 timbers in varying states of preservation. Fifteen of these timbers recorded in 1985, 1986, and 1988, now reburied on site, and archival records of timbers found previously form the basis for discussion of timber and vessel features in this chapter. Photographs and site plans from earlier excavations complement recent full-scale drawings and timber catalogues.

Buried beneath a layer of plaster and limestone, the timbers had been used as foundations for a system of roadways and ramps in the pyramid complex. In addition to the causeway area on the eastern side of the pyramid, timbers were recorded from the ramp of a nearby mastaba, between subsidiary pyramids, along the inner enclosure wall, and in and beyond the outer court on the western side of the pyramid. Timbers of similar shape and size were imbedded in quarry roads or construction ramps at other pyramids, including Senwosret II’s at Lahun (fig. 8-2). At Lisht, planks were laid with their outer surface uppermost in every case. Although general shapes of adjacent timbers seem to fit together, fastening patterns prove that proximity in the ground is not an indication of the original position of planks within a hull. A few timbers from the outer court (Site G) are the exception, however (see below).

D. Arnold and the Metropolitan Museum of Art have kindly provided archival information for 67 of 90 timbers reported from Lisht (figs. 8-3 to 8-9). Some timbers
Fig. 8.2. A causeway at Lahun. (Drawing: D. Arnold)
Fig. 8-3. Lisht, Site A. (Drawing: D. Arnold)
Fig. 8-4. Lisht, Site F. Scale c. 1:50. (After MMA Egyptian Expedition plan)
Fig. 8-5. Lisht, Site D. (Courtesy D. Arnold)
Fig. 8-6. Lisht, Site D plan. Scale c. 1:100. (After MMA Egyptian Expedition plan)
Fig. 8-7. Lisht, Site I. (Courtesy D. Arnold)
Fig. 8-8. Lisht, hull timbers at Site G. (Courtesy D. Arnold)

Fig. 8-9. Lisht, Site G. (Courtesy D. Arnold)
were little more than traces in the sand, and few details could be recorded. Table 8-1 presents minimum dimensions and approximate shapes derived from photographs and scaled site plans; fig. 8-10 illustrates plank typology.

TIMBER CHARACTERISTICS

The condition of the timbers varies from extremely poor to very good. Generally, plank surfaces were soft and slightly eroded, and some checking was present. Other planks were heavily eroded, however, and had little structural integrity remaining. Recorded planks range in length from 1.01-2.6 m. Width ranges from 12-40 cm., but in most cases, planks are 16-20 cm. wide. Planks are 9-15 cm. thick, and have a sturdy, squat appearance in cross-section. Samples of wooden fastenings and timbers suggest that the same wood was sometimes used for both.

When the ancient shipwrights carved these planks from lengths of tamarisk (Tamarix sp.) or acacia (Acacia sp.), they avoided major knots, a potential source of structural weakness, but a common characteristic of both woods. Several planks bear traces of large knots and reveal techniques used to remove the knot while retaining as much of the timber as possible. In all cases, an economy of wood use is evident. For example, grain patterns indicative of large knots, but not including the knots, are common at plank ends.

All of the recorded timbers from the causeway called Site A, except timber C, have joggled edges that help to maintain the integrity of the planking shell. Some of the joggles are small and regular, others are curved and large. The positioning of each projection and notch was determined by the design of adjacent planks. Joggle cuts on a single plank edge angle towards each other, and if an edge has only one cut, it angles away from the closest end. Both inboard and outboard plank edges were joggled.

The shipwrights took great care with the joggles; most exhibit angles of 120° and are 2.2-2.5 cm. deep. Others cuts vary only a few degrees in angle, except those found on timbers 5 and 7, where the cut angles vary from 100-115°. The joggles were sawn, as
Table 8-1. Derived dimensions and shapes for Lisht planks (in centimeters).

<table>
<thead>
<tr>
<th>No.</th>
<th>L x W x Th</th>
<th>Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1</td>
<td>160 x 35</td>
<td></td>
<td>Blocky, straight plank</td>
</tr>
<tr>
<td>F-2</td>
<td>105 x 25</td>
<td>F?</td>
<td>Length remaining</td>
</tr>
<tr>
<td>F-3</td>
<td>185 x 25</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>F-4</td>
<td>200 x 25</td>
<td>H</td>
<td>Length remaining</td>
</tr>
<tr>
<td>F-5</td>
<td>230 x 25</td>
<td>F or H</td>
<td></td>
</tr>
<tr>
<td>F-6</td>
<td>225 x 35</td>
<td>C or I</td>
<td>Length remaining</td>
</tr>
<tr>
<td>F-7</td>
<td>190 x 15</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>F-8</td>
<td>235 x 25</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>F-9</td>
<td>225 x 25</td>
<td>F</td>
<td>Length remaining</td>
</tr>
<tr>
<td>F-10</td>
<td>170 x 20</td>
<td>H?</td>
<td>Curved with a joggle</td>
</tr>
<tr>
<td>F-11</td>
<td>254 x 27</td>
<td>D</td>
<td>Two notches; one joggle</td>
</tr>
<tr>
<td>F-12</td>
<td>205 x 17</td>
<td>H</td>
<td>Very curved</td>
</tr>
<tr>
<td>F-13</td>
<td>249 x 7</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>F-14</td>
<td>305 x 25</td>
<td>D</td>
<td>Central notch</td>
</tr>
<tr>
<td>F-15</td>
<td>215 x 20</td>
<td>F</td>
<td>Small peak</td>
</tr>
<tr>
<td>F-16</td>
<td>240 x 35</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>F-17</td>
<td>151 x 20</td>
<td>A?</td>
<td>Definition imprecise</td>
</tr>
<tr>
<td>G-2</td>
<td>290 x 20</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>G-3</td>
<td>320 x 15 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>G-4</td>
<td>410 x 22 x 12</td>
<td>C or I</td>
<td></td>
</tr>
<tr>
<td>G-5</td>
<td>270 x 22 x 12</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>G-6</td>
<td>190 x 22 x 12</td>
<td>A?</td>
<td></td>
</tr>
<tr>
<td>G-7</td>
<td>270 x 28 x 12</td>
<td>F</td>
<td>Length remaining</td>
</tr>
<tr>
<td>G-8</td>
<td>270 x 30 x 12</td>
<td>B?</td>
<td>Length remaining</td>
</tr>
<tr>
<td>D-1</td>
<td>260 x 22 x 15&lt;sup&gt;2&lt;/sup&gt;</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>D-2</td>
<td>275 x 30 x 15</td>
<td></td>
<td>No discernible features</td>
</tr>
<tr>
<td>D-3</td>
<td>210 x 25 x 15</td>
<td></td>
<td>No discernible features</td>
</tr>
<tr>
<td>D-4</td>
<td>165 x 22 x 15</td>
<td></td>
<td>No discernible features</td>
</tr>
<tr>
<td>D-5</td>
<td>190 x 25 x 15</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>D-6</td>
<td>200 x 21 x 15</td>
<td></td>
<td>No discernible features</td>
</tr>
</tbody>
</table>

<sup>1</sup>All Site G plank thicknesses are estimated from known dimensions of the complete frame.

<sup>2</sup>All Site D thicknesses are estimated; 15 cm. is a minimum measurement.
Table 8-1. Continued.

<table>
<thead>
<tr>
<th>No.</th>
<th>L x W x Th</th>
<th>Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-7</td>
<td>250 x 30 x 15</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>D-8</td>
<td>200 x 22 x 15</td>
<td>B?</td>
<td></td>
</tr>
<tr>
<td>D-9</td>
<td>300 x 30 x 15</td>
<td>C or I</td>
<td></td>
</tr>
<tr>
<td>D-10</td>
<td>210 x 28 x 15</td>
<td>A</td>
<td>Curved, not straight</td>
</tr>
<tr>
<td>D-11</td>
<td>170 x 28 x 15</td>
<td>A?</td>
<td>Only one joggled edge visible</td>
</tr>
<tr>
<td>D-12</td>
<td>200 x 12 x 15</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>I-1</td>
<td>165 x 28 x 8</td>
<td>A</td>
<td>Fits I-2</td>
</tr>
<tr>
<td>I-2</td>
<td>160 x 28 x 8</td>
<td>A</td>
<td>May have a notch</td>
</tr>
<tr>
<td>I-3</td>
<td>203 x 15 x 12.5</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>I-4</td>
<td>160 x 18 x 12</td>
<td>D</td>
<td>Two notches with pegs</td>
</tr>
<tr>
<td>I-5</td>
<td>168 x 15 x 12</td>
<td>H</td>
<td>One joggled edge</td>
</tr>
<tr>
<td>I-6</td>
<td>88 x 12.5 x 8</td>
<td></td>
<td>Extremely eroded</td>
</tr>
</tbody>
</table>

causeway planks

| A-A | 232 x 23.5 x 13.5 | A    | Curved                           |
| A-B | 215 x 26 x 13    | F    | Soft peak                         |
| A-C | 245 x 24 x 18    | B    | No features                       |
| A-1 | 200 x 39.5 x 15  | I    | Curved end                        |
| A-2 | 182 x 29.5 x 17  | F    |                                   |
| A-3 | 268 x 35 x 18    | I    |                                   |
| A-4 | 237 x 26.5 x 14  | A    | Eroded                           |
| A-5 | 186 x 21.5 x 9   | F    | Flattened peak                    |
| A-6 | 166 x 21.5 x 14  | A    | One edge has only one joggle      |
| A-7 | 158 x 25 x 14.5  | G?   |                                   |
| A-8 | 179 x 21.6 x 15  | A    | Curved                            |
| A-9 | 191 x 24 x 11    | A    | Curved                            |
| A-10| 176 x 20 x 9.8   | A    |                                   |
| A-20| 180 x 28.8 x 13  | F    | Off-center peak                   |
Fig. 8-10. Typology of plank shapes.
shown by saw marks both on the face and at the base of cuts. Saw marks across vertical
tables are very faint and 1 mm. apart; those at joggle bases are vertical and 2-4 mm.
deep. Shipwrights avoided knots when placing the joggles, but mortise-and-tenon joints
and ligatures could be superimposed on joggle cuts.

Fastenings

Like other ancient Egyptian hull planks, the Lisht planks had holes for fastenings
only on their inner surfaces and on plank edges. Mortise-and-tenon joints are found in
regular, but not identical, patterns in the edges of timbers. Mortises commonly measure 7-
9.5 x 1-1.5 x 12 cm. In addition, 5 x 5 x 1.5 cm. open mortises are present at some plank
ends. All other ancient Egyptian hulls also used open mortises in plank ends, probably to
align planks during construction. Only one open mortise in the Lisht planks retains a
tenon, but tenons are common in standard mortises.

How tenons fit in the mortises is an intriguing feature of the Lisht planks that
cannot be studied in any other Egyptian hull remains. In many cases, spaces about 1 cm.²
can be seen on one or both sides of the tenon. Other mortises preserve not only the tenon,
but wooden slips in the spaces beside the tenon (fig. 8-11). Mortises with empty
spaces of similar dimensions probably once held slips as well. When slips are on one side
only, they are on the same side of all mortises on the plank edge.

Tenon thickness corresponds so closely with mortise thickness that removing the
tenons was difficult. Tenons tapered from a width of about 6.5 cm. at the midpoint in
their length to a width of about 4.5 cm. at their tips. The tips were bevelled at either end;
the bevels, about 6.5 mm. long on each side of a tenon, were well preserved. Preserved
tenon length ranges from 10.5-14 cm., because tenons were broken in half when the
planks were taken off the hull. Original tenon length was probably 20-25 cm. Like
mortise-and-tenon joints in other ancient Egyptian hulls, the Lisht joints were unpegged.

In addition to mortise-and-tenon joints, the builders of the Lisht hull relied on
ligatures for lashing planks. L-shaped lashing holes 6.5-9.5 x 5 x 1 cm. are present on
one face and both edges of most of the recorded timbers (fig. 8-12a). Lashing mortises
tend to be slightly wider on the timber face than on its edge, possibly because the tension
Fig. 8-11. Mortise-and-tenon joints from Lisht planks.
Fig. 8-12. a) Lashing fastenings b) lashing within a ligature
and sliding movement caused wear on mortise edges. Ligature placement is very similar to the pattern of ligatures on the excavated Khufu hull and to the pattern of former ligatures on the Dashur vessels (see Chapter X).

A flat, plaied strip woven from about 15 strands fills more than half of the ligatures (fig. 8-12b). Dr. Willeke Wendrich has tentatively identified the material as a grass, probably halfa (Desmostachya bipinnata).¹¹ Lashing strips were cut apart at timber edges.

**Construction Errors and Repairs**

By studying the placement and dimensions of fastenings, one can identify a few examples of both ligatures and mortise-and-tenon joints that were placed incorrectly during construction. In one case, a mortise was begun, but aborted when the chiseler ran into a knot. Other examples suggesting a miscalculation of mortise placement are pairs of mortises virtually atop one another but with only one mortise used as a fastening.

The only evidence of repair occurs on plank A-9, where a trapezoidal peg was used to lock a tenon in place (fig. 8-13). The peg (2.8 x 2 x 1.8 cm.) fits snugly in a mortise cut only 3 cm. (to its center) from the plank edge. The peg passes through the inner face of the plank and into the tenon, but it does not pass through the tenon into the outer planking face. This repair may have occurred at any time in the vessel’s history, from its construction to just prior to its disassembly, but loosening of the tenon within the joint, possibly as a result of wear, probably prompted the repair.

![Fig. 8-13. Lisht, repair to a mortise-and-tenon joint.](image)
Tool Marks

Reconstructing the tool kit used to build a hull is possible by studying the tool marks remaining on the timbers. Despite damage caused by erosion and insects, the Lisht timbers provide good evidence for several types of tools. Chisel, axe or adze, and saw marks predominate.

Mortise cutters used chisels with blades about 2 cm. wide and shafts 0.06 cm. thick. In several cases, the mortise cutter leaned back on the chisel handle as one side of the mortise was cut, probably when the chisel was used to pry out the wood from within the mortise, producing an area of crushed wood. The crushed areas occur on many of the planks, appearing as small depressions 6 mm. wide at one end of the mortise. When several mortises on the same plank had this feature, each member of the group had the crushed area on the same end of the mortise, supporting the idea that a mortise cutter worked along the plank edge in a single direction.

Some mortises on plank edges in the Dashur boat in the Carnegie Museum of Natural History also have crushed areas about 6 mm. wide. D. Haldane has suggested that such marks may indicate an increasingly dull chisel, and that it may be possible to determine when a new or freshly sharpened chisel was used by the sudden absence of crushed marks in a line of mortises that have them.\textsuperscript{12}

Deep hatch marks on the edges of planks A-8 and A-9, up to 6 mm. deep, resemble chopping marks made by axe or adze blades. Minimum blade width is provided by a single mark 5 cm. long. Similar deep blade marks are present on the edges of some of the Carnegie Dashur boat planks. Such marks may reflect rough trimming that bit too close to final plank edges to allow further smoothing.

Saw marks make up the largest set of recorded marks on Lisht timbers, which is interesting since most ship scholars consider the adze to be the principal shaping tool of ancient Egyptian shipwrights. Saw cuts are present on joggle tables and bases, on plank ends and surfaces, and on planks A-9 and A-B at large knots where they demonstrate some of the shaping methods used by the ancient shipwrights and reinforce the impression of frugal wood use. A blade held perpendicular to the plank edge was used to
make several deep saw cuts on either side of the knot’s center. Because the entire exposed surface of the knot is also covered with saw marks made by a blade held parallel to the plank face, I believe shipwrights cut vertically into a branch stub to remove small sections of it before the plank face was evened out with a saw blade held parallel to it.

The ends of three tenons on plank A-5 bear saw marks. One tenon is cleanly sawn off 2.5 cm. from the plank edge, but the other two are only partially sawn through, then broken on the edge towards the outer face. These tool marks and break indications provide clues to the ancient means of breaking timbers apart. In this case, someone partially sawed through tenons from the inside of the hull; then, the timber was pulled away from the outside of the hull, snapping any tenons not already sawn through.

The other recorded tool mark was a score line which probably marked a butt join in timbers above plank A-5.

FRAMES AND TRANSVERSE TIMBERS

One frame and several frame components were found with a group of timbers at Site G beyond the outer court on the west side of the pyramid complex during 1914 (see fig. 8-9). The following description of the frame is derived from photographs and drawings provided me by Dr. Dieter Arnold from the Metropolitan Museum of Art Archives (fig. 8-14). The frame was accessioned by the Cairo Museum, Jd’E 60271, but I have not seen it.

The frame was built of three timbers: two upper timbers (B and C), each about 1 meter long, fastened to a 2.4-meter-long curved floor timber (A) by mortise-and-tenon joints and lashing (fig. 8-15). Mortise dimensions are similar to those from Lisht planks.

Floor timber A (2.89 m. long, molded 22 cm., sided 12 cm.) has 12 slightly triangular notches on its outer face. Notches in the center of the frame average, 10 cm. deep and 5 cm. wide at the base; elsewhere, average depth is only 6 cm. The outer face
also is perforated by three holes 8 cm. deep and 6 cm. in diameter. One is located in the center of the floor timber; the other two are about 80 cm. to either side of the central hole. No other information is available for these features.

Timbers B and C are about 1.25 m. long, molded 20 cm., and sided 15 cm. near the inboard ends. Outboard ends are notched like the lower face of the floor timber and continue its curvature for 40 cm. on one side and about 25 cm. (remaining) on the other. A gap of 50 cm. separates the inboard ends of the timbers; this opening corresponds to a 1-cm.-deep notch on the inner face of floor timber A.

Timbers A, B, and C are fastened together with a complex system of mortise-and-tenon joints, lashing, and mortises which pass through the thickness of the timbers. Each of the upper timbers has a single T-shaped lashing channel as illustrated by B-B of fig. 8-15. Lashing channels and mortise-and-tenon joints are present in the upper edge of timbers B and C; the lower faces of timbers B and C are joined to floor timber A by both lashing and mortise-and-tenon joints, providing a complex and secure frame assembly. Through-mortises were empty when the frame was photographed after excavation.

Archival photographs and drawings of the ramp west of the pyramid at Site G document four other upper timbers. I identify them as upper timbers because their notched ends, lack of curvature, and fastening patterns are so similar to the proven upper
timbers from the complete frame. Site G upper timbers are 1.67-2.58 m. long, sided about 10 cm., and molded 20-32 cm. (figs. 8-16 and 8-17). The largest has one notch; the smallest has three.

Fig. 8-16. Site G framing timbers. (After MMA drawing, courtesy D. Arnold)
Fig. 8-17. Upper timber from Site G. (After MMA drawing, courtesy Egyptian Expedition)

ANALYSIS

Planks and Fastenings

Despite the temptation to assume that all of the Lisht timbers originated from a single vessel, none of the recorded Site A planks seem to fit together. Planking shapes can be matched to suggest the appearance of the planked shell (fig. 8-18), but it is not possible to directly reconstruct a hull. Consistency in mortise size, patterning, and joggle details and dimensions appear to strengthen the contention that all of the timbers are from a single hull. The similarity to planks from other Middle Kingdom construction ramps and to the same features in the Old Kingdom Khufu hulls and the Dashur boats of the later Middle Kingdom suggests, however, that shipbuilding principles may be the source of consistency.
Fig. 8-18. Reconstruction of a Light hull's planking pattern.
The timbers from Lisht represent planks from one or more vessels. The timbers are identified as hull members primarily on the basis of their shape and curvature and secondarily on the basis of the fastening techniques and patterns used. Framing elements could have come only from watercraft.

Comparison of the Lisht timbers with planking from the Dashur and Khufu vessels shows similarities in plank shape, fastening patterns, tool usage, and plank-edge-shaping techniques. None of these hulls has mortises or holes that pass completely through the thickness of planks, a trait shared by Lisht hull components other than frames. This common trait enables uncut plank faces to be designated as outer faces.

It is also possible to provisionally designate inboard and outboard edges of some Lisht planks. In the Dashur hulls, open mortises occur only on outboard edges and on the edges of the central planks. Because open mortises only occur on one edge of Lisht planks, I regard them as comparable. Like the Dashur planks, not all Lisht planks include open mortises. At Site G, frame timber AM 2704 has an open mortise on its squared end on the edge opposite the notch and offers indirect support for designating an edge that contains an open mortise as the outboard edge (see fig. 8-17).

As seen in the Khufu and, probably, the Dashur vessels, ligatures tie planks together in areas of stress; as in the Dashur hulls, deep mortise-and-tenon joints are the main method of fastening the Lisht planks. Mortise-and-tenon joints in Lisht planks are twice as deep as those in Khufu I but have the same depth as those in the Dashur boats. The Lisht planks include mortise-and-tenon joints that are paired. Ligatures and deep mortise-and-tenon joints, sometimes placed in pairs within the plank edges in planks as thick or thicker than those from the Khufu and Dashur hulls, suggest a more sturdily constructed vessel than any other available for study.

Because the Khufu vessels were disassembled and the Dashur hulls had been taken apart and reassembled with modern tenons, it was not possible to study complete mortise-and-tenon joints in place. Pegged mortise-and-tenon joints in Mediterranean shipbuilding techniques fought lateral and longitudinal slippage; the Egyptian shipwrights knew the benefits of pegs, but chose not to use them. No pegs perpendicular to tenons
have been recorded from ancient Egyptian hulls, with the exception of the repair to Lisht plank A-9, but Egyptian carpenters used this type of fastening frequently. Sarcophagi, furniture, and a sledge found with the Dashur boats all have perpendicularly pegged mortise-and-tenon joints. Even the cabin on the Khufu vessel used such pegs. The Lisht timbers have shown us how slips could be wedged against one or both sides of tenons; I believe these slips, like the intricately joggled plank edges, may have been intended to fight longitudinal slippage along plank seams. J.R. Steffy has suggested that slips may have combatted mortise edge wear. Longitudinal and lateral slippage may have been combated by the use of mortise-and-tenon joints in pairs; by spreading the forces along two fastenings, one behind the other, the shipwrights may have lessened the impact of lateral movement.

In any case, when mortise-and-tenon joints were below the waterline of a hull, Egyptian shipwrights avoided pegging mortise-and-tenon joints \textit{perpendicularly} in the well-known manner evidenced by the hulls of many Mediterranean ships. However, a ship construction scene in the late Dynasty 19 tomb of Qaha at Deir el Medineh depicts the round fastenings passing through planks.\textsuperscript{13} The spacing and size of the round heads suggest that these were treenails, probably for fastening frames to the planking shell. I do not believe they are tenon pegs.

Lashing material in the Lisht timbers differs noticeably from that used in the Khufu ship. Rope was used to lash planks together on the Khufu ship; it measured 1, 1.5, and 2 cm. thick at the time of excavation. The plaited strip of twisted grass fibers used to fasten Lisht timbers together would have caused less wear to mortise edges by spreading forces across its width.

\textit{Frames and Transverse Timbers}

The frame found in the 1914 Metropolitan Museum of Art excavations at Lisht is one of the site's most extraordinary finds from a ship scholar's point of view. The earliest recorded frames elsewhere in the world post-date the dynastic period, so the Lisht frame is important not only for what it reveals about Egyptian boatbuilding technology, but for what it can suggest about the level of technology available to Bronze Age shipwrights.
throughout the eastern Mediterranean.

The excavated Khufu vessel had 16 floor timbers for its 43-m. length. The 2-3 m. between floor timbers does not seem to have been designed to lend much support to the hull and probably reflects provision of support for the carling. Floor timbers carved of stone in the rock-cut boats of Khafra are low and widely spaced. The 10-m.-long Dashur hulls had no framing. In contrast, the Lisht frame is massive, complex, and built to carry heavy loads.

The Lisht frame was a composite structure, not a single floor timber, and it probably was treenailed to the hull (see fig. 8-15). The broad, recessed notch in the floor timber’s upper surface probably was designed to receive a longitudinal strengthening timber or carling. The notch and corresponding gap between the upper timbers provide minimum sided dimensions of 50 cm. and a molded height of at least 35 cm. A longitudinal timber with these dimensions located at the bottom of the hull would function as a keelson and provide a lower center of gravity for the vessel.

A unique group of Dynasty 11 boat models from Meir provides documentation for keelsons (Table 8-2).14 Each of the four models includes a keelson notched to hold removable deckbeams. The cross-section provided by Belger (fig. 8-19) seems to indicate that the rectangular keelson rested on a floor timber. In the model, the keelson is wider than the carling painted on its upper surface. Many models include red-painted carlings at deck level, but I know of no others that portray structural features of the lower hull.

Table 8-2. Dimensions for Meir boat models in cm. (L = Length, B = Beam, D = Depth)

<table>
<thead>
<tr>
<th>Model</th>
<th>Dimensions</th>
<th>L:B</th>
<th>D:L</th>
<th>B:D</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM 4798</td>
<td>95 x 16.5 x 9</td>
<td>6:1</td>
<td>10:1</td>
<td>1.8:1</td>
</tr>
<tr>
<td>EM 4799</td>
<td>176 x 21 x 9.5</td>
<td>8:1</td>
<td>18:1</td>
<td>2:1</td>
</tr>
<tr>
<td>EM 4800</td>
<td>86.5 x 16 x 8.5</td>
<td>5.4:1</td>
<td>10:1</td>
<td>2:1</td>
</tr>
<tr>
<td>EM 4801</td>
<td>187 x 21 x 10</td>
<td>9:1</td>
<td>18:1</td>
<td>2:1</td>
</tr>
</tbody>
</table>
Lisht planks bear no marks testifying to the use of battens or any type of caulking, and 5 cm. seems a small space for a batten and whatever attached it to the planking. If the triangular notches were intended solely for the free passage of water inside the hull, then we must imagine that the frame was seated over very small battens or that plank seams were not covered by battens, meaning that notches at the ends of the upper timbers serve no purpose unless the hull's builders envisioned a need for the circulation of water to at least 50 cm. depth. It seems more reasonable to suggest that the deeper notches in the center of the frame facilitated water circulation and that the notches, in general, allowed the frame to be seated over ligatures that crossed or battens that covered plank seams.

Within the frame itself, mortise-and-tenon joints, lashing through three types of holes, and open mortises fastened the upper timbers to the floor timber. T-shaped lashing channels near the squared ends of timbers B and C are similar to T-shaped mortises in a Dynasty 1 timber from Tarkhan. The Tarkhan timber, curved at one end and square at the other, resembles the upper timbers of the Lisht frame although no notches remain. Two T-shaped lashing channels and two L-shaped mortises in its curved end are the only recorded fastenings. Timbers from Tarkhan are evaluated in a recent work by S. Vinson (also see Chapter III).

The upper timbers and the floor timber were not a complete frame, however. The distribution of fastenings along the top of the upper timbers and slots that pass completely through the thickness of each part of the frame provide the means to fasten the frame to other components. Because archaeologists discovered the upper timbers connected to the
floor timber, we learned how the frame was joined. By studying the existing frame and nearby hull components, I have learned that a complete frame was a mammoth structure.

At Site G, four timbers with notches at one end can be identified as upper timbers for a frame (see figs. 8-16 and 8-17). Upper timbers from Site G are 0.5-2.4 m. longer than those on the assembled frame and exhibit different fastening patterns. AM 2701, fig. 8-16, has six mortise-and-tenon joints, two lashing channels, a mortise that passes vertically through the timber’s squared end, the most curvature of any upper timbers, but no through-mortises. AM 2702, fig. 8-16, includes at least six mortise-and-tenon joints and one through-mortise but no lashing channels. AM 2703, fig. 8-17, is most similar to upper timbers from the frame as it includes T-shaped and L-shaped lashing channels, through-mortises, and mortise-and-tenon joints. It also includes mortises passing at a 45° angle from the edges to its wide face. Lashing and mortise-and-tenon joints on AM 2704’s lower surface resemble the pattern of fastenings on the assembled frame’s upper timbers B and C (see. fig. 8-16), but AM 2704’s upper surface has only two small mortise-and-tenon joints and an open mortise at its squared end.

Despite general similarity in appearance, inconsistent fastening patterns suggest that the four timbers did not have analogous functions. Although the widely differing lengths might be due to the use of these timbers in different frames, it is also possible that they were all part of the same assembly. Fig. 8-20 illustrates one way that timbers with dimensions, shapes, and fastening patterns like the framing elements from Site G could have been incorporated as a single unit.

Mortise-and-tenon joints and lashing mortises on the upper surface of frame component C match those on AM 2701’s lower surface, and extend the span of the frame by a meter. AM 2704 is positioned above AM 2701 because their fastening patterns are so similar. The open mortise at the squared end of AM 2704 shows that another timber butted against it. I see AM 2704 as the uppermost timber because the through-mortises and lashing channels near its lower surface would allow the entire frame to be lashed via channels in the floor timber and AM 2704. Also, the half-size fastenings in its upper surface seem more like coaks, perhaps to keep a deck beam from slipping, than full
Fig. 8-20. Cross-section of a Lisht hull reconstruction at a frame.
mortise-and-tenon joints.

Like the upper surface of AM 2701, AM 2702 has only mortise-and-tenon joints; thus, AM 2702 probably fit over a timber like AM 2701. AM 2702 is not included in the reconstruction, but a timber with its characteristics could have been placed between AM 2701 and AM 2704.

AM 2703 was also excluded from the reconstruction because I believe it belonged to a different, and much larger frame assembly. AM 2703, which has a fastening pattern closest to timber B in the excavated frame, is 2.58 m. long, which, doubled, provides a minimum beam of 5.68 m. True beam at this point was probably close to 8 m. if AM 2703 was an upper timber in a frame analogous to that found at Site G.

CONCLUSIONS

The planks and framing elements from Lisht offer new perspectives on ancient Egyptian shipbuilding techniques. The hull planking demonstrates a previously unrecorded manner of hull construction using plaited lashing, intricate fitting of timbers, and deep mortise-and-tenon joints wedged in place by slips. Each of these features is present in some form on either the Khufu or Dashur vessels, but the combination of them is unique, and offers insight to a controversial passage in Herodotus (2.96.1-2) describing ancient Egyptian shipbuilding in the 5th century B.C.

The Herodotus passage, often applied to any Egyptian ship from any period, has been interpreted as saying that the Egyptians caulk the seams of their vessels from within with papyrus. No trace of caulking has been found in any ancient Egyptian hull, however, and we have no evidence for the practice. When the passage is evaluated from both lexicographical and ship construction viewpoints, it is clear that Herodotus could have been describing plank seams bound or fastened from within by papyrus, a practice which corresponds to the use of lashing in the Lisht timbers.\textsuperscript{17}

In addition to providing ship scholars with a new form of construction, the Lisht timbers are the first remains of what was probably a working boat to be studied. Both the Khufu and the Dashur hulls are from ceremonial contexts, and may reflect different
construction practices. The technology used to combat strain and stress caused by the transport of great weights may be similar to that used in the construction of seagoing vessels, another point of contention among ship scholars. At the very least, studying the Lisht timbers informs us about what was possible for ancient Egyptian shipwrights.

The Lisht frame is another unique find. Floor timbers on the Khufu I hull are notched to pass over battens covering planking seams, but have neither top timbers nor internal fastenings. The heavy construction and rigid fastening of the Lisht frame provides mute evidence in support of the hypothesis that these timbers belonged to a working freight vessel.

The Lisht frame contains mortises which pass through its sides, possibly for joining it to adjacent frames, but the lack of tenons in any through-mortises argues against this. I think it probable that these mortises held lashing which was wrapped around the frame and its several upper timbers, but there is no other evidence for the practice in ancient Egyptian hull construction.

The broad recessed area on the upper face of the floor timber suggests that it once held a longitudinal timber at least 50 cm. wide and 30 cm. high. This timber could have served as a keelson, supported deck beams, or perhaps served as the internal support for a steering post or mast. Evidence from the Meir models does not support the latter hypothesis, however.

Holes in the bottom of the floor timber suggest that it probably was treenailed to the bottom of the hull. Such a departure from other known practices may be due to the function of the Lisht hull as a freight ship rather than a ceremonial vessel. The lack of evidence for other through-hull fastenings below the waterline on ancient Egyptian hulls, however, makes me feel uncomfortable about proposing this deviation from observed practices.

The timbers buried at Lisht reflect broader hull construction traditions. Ramps and slideways at Middle Kingdom pyramids of Amenemhat I and Senwosret II also include planks shaped like those from the pyramid of Senwosret I at Lisht. Reuse of ship’s timbers is implied by documents and spells from the Middle Kingdom and later, but there
is no evidence of secondary use on the Lisht planks. If standardization of plank form was as common as plank shapes spanning 60 years suggest, reused planks could have utilized original mortises, but probably would require alternating rows of new and "old" wood. Consistency of joggle projection angles offers indirect support for the idea of interchangeable planks, but such frugality seems impractical.

The reconstruction of the Lisht vessel presented in figs. 8-18 and 8-20 is based on recorded plank and frame shapes, fastenings, and indirect evidence concerning cargo vessels which suggest they were three times longer than wide. The length of AM 2703, whose fastening pattern most closely resembles that of upper timbers B and C, is 2.58 m., suggesting that beam at this station could have been 8 m. Hull dimensions as reconstructed are 24 x 8 x 1.5 m.; these are minimum measurements based on the assumption that the frame assembly belonged amidships. In reality, we have no evidence to suggest its location in the ship.

The cross-section in fig. 8-20 is based on the Site G frame (including a floor timber and two levels of upper timbers) and the Meir models illustrating keelsons (fig. 8-19). The keelson may have been made of more than one piece of wood, but I have illustrated a single timber about 50 cm. square. Evidence for the third level of upper timbers meeting above the keelson is provided by the lower edge fastening patterns in AM 2704, which approximate those in the upper edge of AM 2701. Sided dimensions increase with hull depth.

The open mortise at the inboard end of AM 2704 testifies to the presence of a butt joint; two small mortise-and-tenon joints in its upper surface probably connected it to a beam. Treenails anchor beam ends to the hull as in the Dashur hulls, and deep mortise-and-tenon joints, joggled edges, and ligatures secured plank edges. Plank orientation in the longitudinal section is based on the determination of outboard edges by comparing open mortise locations with those on the Dashur hulls; plank size reflects the size of Lisht planks.

Except for Unas' cargo ships (see fig. 8-1), short planks like the Lisht corpus seem to be characteristic of riverine cargo vessels in the small handful of tomb reliefs that
include indications of hull planking. Most of these reliefs date to the New Kingdom, and illustrate single-masted cargo ships with rows of short planking.¹⁸ Plank edges in the reliefs are straight rather than joggled. The lack of joggled edges may indicate smaller ships, different construction techniques, or artistic license; the ca. 500-year distance between the Lisht timbers and the later New Kingdom might have included significant changes in nautical technology.

Techniques used to build the Lisht vessel(s) also would have served the builders of Hatshepsut’s barge for carrying two obelisks. A recent evaluation of the different reconstructions of the barge focuses on whether it is possible to build a barge like Hatshepsut’s to transport the Colossi of Memnon (ca. 720 tons each) according to what is known about ancient Egyptian hull construction.¹⁹ Through computer programs, the authors tested the characteristics of two barges, 58 x 5.6 x 20 m. and 70 x 24 x 6 m., built like Khufu I of cedar planks only 13 cm. thick. They point out that acacia planks would have provided an even stronger hull, and conclude that the Colossi of Memnon could easily have been transported on such a barge.²⁰

In other words, a hull built more lightly than an ancient Egyptian shipwright would build it theoretically could carry 1440 tons. Hatshepsut’s obelisks probably weighed about 320 tons each and were 30 m. tall.²¹ A 70 m. long and 24 m. broad hull, built like cargo carriers as exemplified by the Lisht material with planks 15-20 cm. thick, supported internally by massive carlings and frames (as fig. 8-18) fastened to the protruding beams, could have had an even shallower draft and maximum depth than the tested hull designs.²² Such a hull could easily carry the weight of the obelisks and would require no complicated engineering that had not already been tested by at least 500 years of shipbuilders before Hatshepsut’s time, including the shipwrights who fashioned the Lisht planks.
ENDNOTES


3. Arnold (supra n. 2) 277.


8. Arnold (supra n. 2) 85-90, especially.

9. Arnold (supra n. 2) 92, fig. 3.44; F. Petrie, G. Brunton, and M. Murray, Lahun II (London 1923) pl. 8, 13, 15, and 25.

10. I have called these "side pegs" in the past, but J.R. Steffy informs me that slips is a more appropriate name for them.

11. Personal communication, Dr. W. Wendrich.

12. Personal communication, D. Haldane.

13. S. Wachsmann, Seagoing Ships and Seamanship in the Late Bronze Age Levant (Diss. Hebrew Univ. 1989) 199.

14. C. Belger, "Deck, Ruderbanke und Mastbefestigung an ägyptischen Schiffsmodellen," ZÄS 33 (1895) 24-32; G. Reisner, Models of Ships and Boats (Catalogue général des antiquités égyptiennes du Musée du Caire, nos. 4798-4976


18. See, for example, N.de G. Davies and A. Gardiner, *The Tomb of Huy* (London 1926) pl. 31; N. de G. Davies, *The Tomb of Neferhotep at Thebes* (New York 1933) pl. 42 and 43; and N. de G. Davies, *Two Ramesside Tombs at Thebes* (New York 1927) pl. 30.


20. Wehausen, *et al.* (supra n. 19) 300, 305.

21. Arnold (supra n. 2) 278.

CHAPTER IX

A PLANKED MODEL BOAT FROM LISHT

In 1914, excavators for the Metropolitan Museum of Art (MMA) discovered a pair of boat models outside the southern enclosure wall of the Dynasty 12 mastaba of Imhotep, buried more than a meter below ground level. Imhotep's titles include Hereditary Prince and Count, Treasurer, High Priest of Heliopolis, Prince of Horus, Prince of Min, Chief Scribe of Divine Records, Superintendent of Land, Superintendent of All Works, and King's Favorite. Imhotep probably was the architect of Senwosret I's pyramid. Because the model boats, here called the Lisht models, were buried outside his tomb's southern enclosure wall, some question about their origins have been raised.

A pair of wooden statues and a shrine also buried outside the southern enclosure wall near the funerary boats were originally linked with Senwosret I.\(^1\) Reanalysis of their position and associated ceramics by Dorothea Arnold favors a deposition date during the reign of Amenemhet II, who ruled for six years between Senwosret II and III.\(^2\) Although nothing links the model boats with the Amenemhet II material, the boats could have been buried at the same time. Djedefre's built boat pits for his father Khufu after his death; those pits lie beneath a wall outside the southern enclosure wall of Khufu's pyramid and may offer a parallel for later deposition of the funerary boat models at Lisht.

The larger Lisht model, 2.75 m. long, had been protected by a mudbrick vault and was in excellent condition. Carved from a solid piece of wood with separate papyriferae finials, its bow pointed west. Traces of red paint remained on the bulwark.\(^3\) This model is curated by the Metropolitan Museum of Art, but I have not recorded it.

Archaeologists left the second model unexcavated because of its poor condition. In 1986, it was re-excavated, briefly recorded, and subsequently reburied during MMA excavations at Lisht under the direction of Dr. Dieter Arnold. The second model's extremely poor condition can probably be attributed to the way it was built. Rather than carving it from a block of wood, the builders of this model shaped planks only a centimeter thick into a shell-built hull edge-fastened by mortise-and-tenon joints. The thin
planks suffered the effects of burial more than the block model because of the greater amount of surface area exposed and their increased susceptibility to drying action.

The wood remaining is severely fragmented. The amount of shrinkage can be defined at seams, butt joins, and nibbed plank ends preserved only in natural molds made of mud, plaster, and paint (figs. 9-1 and 9-2). In many cases, planks are separated by a centimeter along seams and 2-3 centimeters at butt joins. The model lists slightly to the south in its burial site, and all traces of the bulwark on that side have disappeared. The eastern end of the boat is better preserved than the western end; the lower end of its upright papyriform finial is in good condition.

The 1.95-m.-long model is 41 cm. wide and at least 11 cm. deep (L:B c. 4.8:1). Table 9-1 provides a distribution of strakes, planking and maximum plank dimensions where it was possible to define them. Visible tenons measured about 4 x 6 x 0.5 cm. (see fig. 9-2). No mortises were recorded.

Table 9-1. Distribution and dimensions of strakes in the planked Lisht model.

<table>
<thead>
<tr>
<th>Strake</th>
<th>No. of Planks</th>
<th>Maximum Width</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>3</td>
<td>12 cm.</td>
<td>1.95 m.</td>
</tr>
<tr>
<td>First side</td>
<td>2</td>
<td>10 cm.</td>
<td>1.4 m.</td>
</tr>
<tr>
<td>Second</td>
<td>3</td>
<td>8 cm.</td>
<td>1.6 m.</td>
</tr>
<tr>
<td>Third</td>
<td>4</td>
<td>7 cm.</td>
<td>1.8 m.</td>
</tr>
<tr>
<td>Bulwark</td>
<td>4</td>
<td>7 cm.</td>
<td>1.4 m.</td>
</tr>
</tbody>
</table>

Green paint fragments are visible on the lower hull; the bulwark was decorated with red and blue stripes. Plaster and wood obscure other details.
Fig. 9-1. Planked boat model from Lisht. Length 1.95 m.
Fig. 9-2. Detail of Lisht boat model. Tenons are circled.
ANALYSIS AND CONCLUSIONS

The planked boat model from Lisht is the first known example of a shell-built ancient Egyptian boat model joined by mortise-and-tenon fastenings. The model exhibits many characteristics of the slightly later Dashur boats discovered outside the pyramid enclosure of Senwasret III (see Chapter X below).

Planking plans for the model and for Dashur boats in the Carnegie Museum of Natural History (Pittsburgh) and the Field Museum of Natural History (Chicago) are strikingly similar. The number of strakes on either side of a thicker central strake is the same for both the Lisht model and the Dashur boats; the number of planks within strakes also coincides. In addition, plank and hull shapes of the model boat from Lisht are virtually identical to those shown by the Dashur hulls, suggesting standard design and construction practices that were reflected in both the Lisht model and full-sized hulls.

The discovery of two model boats with papyriform ends like those of the Khufu I hull buried end-to-end on the south side of a funerary enclosure—and the location of the Dashur hulls on the south side of the pyramid of Senwasret III—suggests that all of these vessels might have served similar ceremonial functions. Although the Khufu ship has a more elaborate planking plan, its basic construction pattern is similar to that of the Dashur boats and the Lisht model.

Two other boat models buried about 10 m. north of the same enclosure wall had been destroyed long ago by tomb robbers, but excavators discovered two pairs of finials and two complete sets of the symbolic/magical objects associated with solar boats on other models and paintings. The posts and equipment retained bright paint, but the tenons used to attach them to the models were broken.5

The burial of two solar boat models with very different equipment within the same funerary complex suggests that the funerary boat and solar boat existed as separate conceptual entities in Egyptian funerary practice. If the solar and funerary models were seen this way, and Middle Kingdom burial practices reflect Old Kingdom traditions, Khufu I cannot be a solar boat and must instead be a funerary craft.

The planked model boat from Lisht is valuable to ship scholars not only for its
unusual method of construction, but because it shows that there was an accepted norm for the construction of ceremonial vessels in the Middle Kingdom. The size of the 1.95-meter-long Lisht model, buried near the mastaba of a high priest, supports the interpretation of six, 10-m.-long, cedar hulls as a kingly display of wealth and power at Dashur.
ENDNOTES


4. Lythgoe (supra n. 3) notes blue, green, and red stripes at the bow.

5. Lythgoe (supra n. 3) 12; see also W. Hayes, *The Scepter of Egypt* (New York 1953) 271-72.
CHAPTER X

THE DASHUR BOATS

The largest collection of excavated Egyptian wooden hulls comes from the Middle Kingdom pyramid of Senwosret III at Dashur. Five or six wooden hulls were uncovered there during a search for an underground entrance to the pyramid by J. de Morgan in 1894. De Morgan reported finding three boats, each about 10 meters long, beside a large brick chamber, probably a boat grave, and three other boats about 100 meters south of the first group.¹ Subsequent maps of the pyramid complex illustrate only three or five boats, however, and only three boats can definitely be traced to de Morgan's excavations.

Those three boats are displayed in the Egyptian Museum in Cairo (EM 4925 and EM 4926) and in the Field Museum of Natural History in Chicago (Acc. No. 1842).² A fourth hull in the Carnegie Museum of Natural History, Pittsburgh, acquired by the same person who secured the Chicago boat and purchased through a member of de Morgan's excavation team, is virtually a duplicate of the Chicago example. It is certain to have come from Dashur despite no official records of its excavation.³ Radiocarbon dating on deck planks from the Field Museum vessel produced an average date of 1949 ± 47 B.C. and the Carnegie hull was dated to 1830 ± 170 B.C.⁴

The boats are associated with Senwosret III on the basis of their proximity to the pyramid. No inscriptions or other artifacts from the excavation prove or disprove the relationship. Popular accounts of the Carnegie boat associate it with a "master of royal watercraft," but no documentation of the claim exists.⁵ A basket filled with crude miniature ceramic containers is displayed with the Chicago hull, but there is no evidence linking the basket with the excavation of the boats other than tradition.

Senwosret III (c. 1878-59 B.C.) was one of the most powerful kings of Dynasty 12. He campaigned in Nubia, Kush, and possibly in Syria and Anatolia after gaining the throne. He restricted the power of the Egyptian governors and provincial officials, indirectly contributing to an increase in the bureaucratic middle class of Egypt. Governmental scribes monitored the movement of food, labor, and materials throughout
the country; the royal dockyard papyri detailing movements of individual planks, tools, and hides under the Memphite vizier's supervision is indicative of societal control through the management of supplies.º

Such bureaucratic scrutiny would surely have been applied to the construction of the Dashur boats. At least four hulls were built of imported cedar under the supervision of experienced craftsmen about 1850 B.C. and buried beside the pyramid of Senwosret III. The somewhat perjorative adjectives applied to the Dashur hulls in modern times reflect the eroded and worn condition of their uppermost timbers, but the craftsmanship and engineering visible in their construction document principles of Egyptian hull construction from almost 4,000 years ago.

I began to study the Dashur boats in 1983, when Douglas Haldane and I spent 11 hours recording the boat curated by the Chicago Field Museum of Natural History. In 1984, we spent a day recording the Carnegie Museum of Natural History Dashur boat, then disassembled, with its planks stacked on shelves as carefully as the ancient Egyptians had stacked Khufu I hull components.¹ A 10-day study of the planks in 1988 included the production of 1:1 tracings now curated by the Carnegie. In 1986, I was allowed to record the hulls in the Egyptian Museum for an afternoon. The discussion of the boats and their construction focuses on the Carnegie hull as it is the most thoroughly recorded, but information from all the boats provides comparative data.

DIMENSIONS AND SHAPE

Hull measurements made in the past decade differ from those reported earlier in the century.¹ Eroded ends and separated planking probably contribute to differences, but the essential proportions of about 4:1 are unaffected. Table 10-1 presents overall measurements and plank distribution taken during hull recording.
Table 10-1. Dimensions of the Dashur boats.

<table>
<thead>
<tr>
<th>Boat</th>
<th>Length</th>
<th>Max. Width</th>
<th>Max. Depth</th>
<th>No. of Planks</th>
<th>L:B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnegie</td>
<td>9.25 m</td>
<td>2.43 m</td>
<td>0.78 m</td>
<td>27</td>
<td>3.8:1</td>
</tr>
<tr>
<td>Field Mus.</td>
<td>9.80 m</td>
<td>2.37 m</td>
<td>0.72 m</td>
<td>27</td>
<td>4.1:1</td>
</tr>
<tr>
<td>EM 4925</td>
<td>9.40 m</td>
<td>2.15 m</td>
<td>0.79 m</td>
<td>34</td>
<td>4.4:1</td>
</tr>
<tr>
<td>EM 4926</td>
<td>9.92 m</td>
<td>2.15 m</td>
<td>0.77 m</td>
<td>27</td>
<td>4.6:1</td>
</tr>
</tbody>
</table>

The Carnegie hull planks weighed 1889 pounds in 1988, but they had probably lost at least a third of their original weight. Hausen calculated the weight of EM 4926 and its equipment as 1.8 tons. Although he used figures reflecting a denser and heavier wood than cedar, he also underestimated planking thickness by 2.5-7 cm., so the theoretical weight is about right and coincides with the Carnegie measurements.

Each hull exhibits about the same rounded shape and curvature with a slightly flattened midsection. In each example, the stem is slightly higher than the bow, and the boats are somewhat fuller aft of amidships (fig. 10-1). Planks were built up around a thicker central strake, creating a planking shell. Deep mortise-and-tenon fastenings join thick planks worked into symmetrical strakes, and a second type of internal fastening across plank seams is also present (fig. 10-2). Modern reconstruction of the hulls has obscured most of the evidence showing that the mortises filled by dovetail tenons were once lashing mortises (see Fastenings, below).

STRUCTURAL COMPONENTS

The Carnegie hull was built completely of cedar (Cedrus cf. libani), still fragrant, with at least some tamarisk (Tamarix sp.) tenons. Planking from the Field Museum boat has also been identified as cedar. To my knowledge, no scientific identification of EM 4925 or EM 4926 has been made, but most of the wood used in those hulls shares the
Fig. 10-1. Chicago Dashur boat, hull lines.
Fig. 10-2. Carnegie Dashur boat, inner surface of hull planking. The bulwarks are not illustrated. The bow is to the left. (Drawing: C. Haldane)
same gross characteristics of the boats now in the United States. Gottlicher and Werner suggested that EM 4925 was built of mulberry, probably *Ficus sycomorus*, the mulberry-leaved sycamore fig, but I do not believe that to be the case.\textsuperscript{11} Other materials used in the construction of the boats have not been identified. Tenons, pegs to fasten beam ends and deck planking, cordage for lashing bulwarks, beams, and planks, and possibly rawhide or metal bands helped fasten the hulls together.

Our labelling system for the hulls sequentially numbers planks within strakes from bow to stern, and strakes from bottom to top. The central strake is designated by the letter C; port and starboard by P and S (see fig. 10-2).

*Central Strake*

The central strake is composed of three butt-joined planks in each Dashur boat. The planks, 2.25-4.55 m. long and 0.09-.123 m. thick, are the largest and thickest in the hull. The end planks mirror each other, but the center plank is slightly wider after midships than before.

Table 10-2 provides central strake dimensions for the four hulls. Measurements for the boats in Cairo were taken from the outside of the hull, while those in the United States were taken from the inside of the hull. Edges cut at angles of 75-80 degrees from the inner face produced planks 2-4 cm. wider outside the Carnegie hull than inside, so the dimensions are not directly comparable.

Each end of the central strake is rectangular in section and includes three mortises passing through the thickness of the plank probably intended to seat decorative finials like those illustrated in models and representations. The most forward mortise in C1 passes through the plank’s edges and fastens the forward ends of the third strake to it. All of the planks include shallow rectangular sockets near their centers. The sockets, aligned with beam notches and also present on planks in the first strakes, probably anchored stanchions intended to support deck beams or a now-vanished carling or stringer (fig. 10-3) (see below).
Table 10-2. Central strake dimensions for the Dashur hulls in meters.

<table>
<thead>
<tr>
<th>Boat/Plank</th>
<th>Length</th>
<th>Width Fwd.</th>
<th>Width Aft</th>
<th>Max. Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnegie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>2.74</td>
<td>0.16</td>
<td>0.28</td>
<td>0.28</td>
<td>0.10-.12</td>
</tr>
<tr>
<td>C2</td>
<td>4.18</td>
<td>0.275</td>
<td>0.29</td>
<td>0.355</td>
<td>0.108-.12</td>
</tr>
<tr>
<td>C3</td>
<td>2.63*</td>
<td>0.275</td>
<td>0.14*</td>
<td>0.275</td>
<td>0.094-.123</td>
</tr>
<tr>
<td>Field Mus.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>2.87</td>
<td>0.15</td>
<td>0.31</td>
<td>0.31</td>
<td>0.12</td>
</tr>
<tr>
<td>C2</td>
<td>4.55</td>
<td>0.32</td>
<td>0.27</td>
<td>0.39</td>
<td>0.09-.12</td>
</tr>
<tr>
<td>C3</td>
<td>2.79*</td>
<td>0.26</td>
<td>0.14</td>
<td>0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>EM 4925</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>2.25</td>
<td>0.11</td>
<td>0.26</td>
<td>0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>C2</td>
<td>3.87</td>
<td>0.27</td>
<td>0.27</td>
<td>0.30</td>
<td>--</td>
</tr>
<tr>
<td>C3</td>
<td>3.31</td>
<td>0.29</td>
<td>0.10</td>
<td>0.29</td>
<td>0.09</td>
</tr>
</tbody>
</table>

* Remaining

Open mortises 4-6 cm. wide, 4 cm. deep, and 1.8-2.1 cm. thick connect butted plank ends. The open mortises connect only the central strake planks and have no mates in the first strakes. In other words, the shipwrights designed the central strake to make use of compression along it to force plank ends together. Plank ends are alternately somewhat convex and concave, perhaps to assist in preliminary fitting.

Mortises 4-6 cm. wide, 2-3 cm. deep, and 2 cm. thick cross butt joins on the inner face (fig. 10-4). Replacement dovetail tenons have been fit into these mortises in all the Dashur boats, but the mortises that cross central strake butt joins in the Carnegie hull have straight sides. The mortises resemble mortises across butt joins between central strake sections in the Khufu I hull. The Khufu I tenons in these mortises protruded above
Fig. 10-3. Dashur boat, cross-section. Grain reflects actual patterns of Carnegie planks.

Fig. 10-4. Carnegie Dashur boat, open mortises.
the planking surface, according to Abubakr and Mustafa (see fig. 5-6c). F. Hocker has plausibly suggested that these inner face fastenings would have prevented transverse shifting of planks during construction and also pointed out that boatbuilders often make use of temporary fastenings in this manner.

Both C1 and C3 have single examples of mortises only 5 cm. deep on the port edge of the strake that may have been used for aligning planks. The C1 mortise is in the expected location for a mortise-and-tenon fastening; the mortise in C3 is cut above a full-sized mortise where the second strake is fastened to C3. Both mortises could as easily represent errors in judgement by the mortise cutter.

The pattern of mortise-and-tenon fastenings in the central strake typically includes pairs 10-15 cm. apart from fastening center to fastening center. The measurements of about 25 or 42 cm. between the outer edges of pairs are consistent across the hull (see fig. 10-2). The symmetrical fastening pattern visible on both edges of the planks may be roughly based on the cubit of 42.5 cm.

While mortises in the center of the hull are parallel with the inner surface, those in the forward and after two meters of the hull are slanted from the edge towards the outer face. The ends of some of the most steeply slanted mortises are visible from the eroded outer planking surface, as are their mates in the ends of strakes 2 and 3.

Each end plank (C1 and C3) includes six former lashing mortises now filled by modern dovetail tenons; the central plank has only four. The strake’s forwardmost and aftermost lashing mortises are shallower, more eroded, and more curved than almost all others in the hull. A single lashed fastening connected each end of the side strakes to the central strake. These lashing mortises are comparable in position to strategic lashings on Khufu I.

The central plank, C2, contains the fewest knots and the finest grain of all the planks in the Carnegie boat. Each of the end planks has two large knots (10-20 cm. diameter), but their overall appearance suggests considerable care in their selection. Central strake edges are pinkish-red and show the same degree of weathering.
**Bow and Stern**

The stern rises about 50 cm. above the bow and is slightly fuller. Planking ends were fastened directly to the central plank, and no additional structural components were used. De Morgan illustrates what seem to be small backing timbers at the bow of an excavated hull;\(^{15}\) presumably, these helped to support a decorative finial. A groove around the stern of EM 4925 is thought to have held a metal or hide lashing for attaching a finial.\(^{16}\)

**Beams**

Eleven or 12 beams crossed the hulls and fitted into notches in the sheer strake. Their ends were visible outside the hull, but they did not protrude beyond it. Spaced 60-85 centimeters apart, the few original remaining beams were slightly cambered, 13-18 cm. wide, and 6-8.5 cm. thick (fig. 10-5). Upper surfaces were smoothly finished; the undersides of beams bear many adze and saw marks.

Beam notches cut into the sheer strake about every 73-85 cm. (10-11 palms) tended to be narrower on the outer surface of the strake. Shipwrights drove pegs 3.0 x 2.5 cm. at an angle from the top of the beam to the sheer strake’s outer face about 8 cm. below the beam notch to secure the beams to the sheer strake (see fig. 10-3). Beam 5 in the Carnegie hull was the only beam not fastened to the hull. Smaller pegs fastened the ends of deck planking to ledges 3-5 cm. wide on forward and aft beam edges.

A fragment of rope crushed between beam 3 and the sheer strake provides another clue to techniques used to fasten beams to the hull (fig. 10-5). The Dashur boat cross-section includes a rope girder that passes around each beam and along the sides of the hull (see fig. 10-3).

Sockets in the central and first strakes of the Carnegie hull provide evidence for stanchions to supported beams. The sockets, about 2.2 x 2.0 x 0.5-1.2 cm., occur in transverse rows aligned with beams 2-10. These sockets conform to no known arrangement of canopies, cabins, or other superstructure, and their alignment with the beam notches indicates a relationship between them. Fig. 10-3 includes stanchions in recorded socket positions.
Fig. 10-5. Carnegie Dashur boat beams 3 and 6.
It is impossible to evaluate the possibility that beams on the Dashur hulls were paired fore and aft of midships like those on Khufu I and modern Egyptian hulls as most surviving beams are broken, eroded, and not in their correct position.

Planking and Bulwarks

Table 10-3 provides strake lengths for each of the hulls; planking dimensions in Tables 10-4, 10-5, and 10-6 indicate measured widths and thickness. Planks were smoothly finished inside, but only the upper part of the exterior was worked smooth. Planks follow the wood's grain and most include heartwood. Both the inner and outer faces are slightly concave. Planks in the first strake are wider and thicker than other hull planks in the Carnegie and Field Museum hulls; planks in the Cairo boats are widest in the second strake. Bevelled edges created inner planking surfaces up to seven cm. narrower than outer faces.\(^\text{17}\) Plank edges are shaped so that planks are widest above and below butt joins in other strakes and narrowest at butt joins.

Table 10-3. Dashur boat strake lengths in meters.

<table>
<thead>
<tr>
<th>Strake</th>
<th>Carnegie</th>
<th>Field Mus.</th>
<th>EM 4926</th>
<th>EM 4925</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>9.75</td>
<td>10.21</td>
<td>-</td>
<td>9.43*</td>
</tr>
<tr>
<td>Port 1</td>
<td>5.81</td>
<td>6.16</td>
<td>6.58</td>
<td>6.08</td>
</tr>
<tr>
<td>Stbd 1</td>
<td>5.91</td>
<td>6.40</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Port 2</td>
<td>7.92</td>
<td>8.55</td>
<td>8.79</td>
<td>8.57</td>
</tr>
<tr>
<td>Stbd 2</td>
<td>7.97</td>
<td>8.60</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Port 3</td>
<td>9.25</td>
<td>9.82</td>
<td>9.84</td>
<td>10.44</td>
</tr>
<tr>
<td>Stbd 3</td>
<td>9.32</td>
<td>10.09</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bulwarks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port</td>
<td>7.01</td>
<td>7.11</td>
<td>8.05</td>
<td>7.61</td>
</tr>
<tr>
<td>Stbd</td>
<td>7.00</td>
<td>7.02</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

\* Remaining
Table 10-4. Carnegie Dashur boat inner surface planking dimensions in meters.

<table>
<thead>
<tr>
<th>Plank</th>
<th>Length</th>
<th>Width Fwd.</th>
<th>Width Aft</th>
<th>Max. Width</th>
<th>Max. Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1-1</td>
<td>2.95</td>
<td>0.07</td>
<td>0.38</td>
<td>0.40</td>
<td>0.098 - 0.118</td>
</tr>
<tr>
<td>P1-2</td>
<td>2.86</td>
<td>0.37</td>
<td>0.03</td>
<td>0.425</td>
<td>0.09 - 0.138</td>
</tr>
<tr>
<td>S1-1</td>
<td>3.06</td>
<td>0.09</td>
<td>0.38</td>
<td>0.39</td>
<td>0.085 - 0.11</td>
</tr>
<tr>
<td>S1-2</td>
<td>2.86</td>
<td>0.28</td>
<td>0.10</td>
<td>0.37</td>
<td>0.09 - 0.115</td>
</tr>
<tr>
<td>P2-1</td>
<td>2.51</td>
<td>0.04</td>
<td>0.28</td>
<td>0.38</td>
<td>0.08 - 0.117</td>
</tr>
<tr>
<td>P2-2</td>
<td>2.74</td>
<td>0.27</td>
<td>0.26</td>
<td>0.39</td>
<td>0.08 - 0.118</td>
</tr>
<tr>
<td>P2-3</td>
<td>2.67</td>
<td>0.25</td>
<td>0.05</td>
<td>0.42</td>
<td>0.102 - 0.128</td>
</tr>
<tr>
<td>S2-1</td>
<td>2.50</td>
<td>0.03</td>
<td>0.26</td>
<td>0.32</td>
<td>0.088 - 0.115</td>
</tr>
<tr>
<td>S2-2</td>
<td>2.87</td>
<td>0.28</td>
<td>0.30</td>
<td>0.41</td>
<td>0.087 - 0.116</td>
</tr>
<tr>
<td>S2-3</td>
<td>2.60</td>
<td>0.31</td>
<td>0.04</td>
<td>0.40</td>
<td>0.083 - 0.117</td>
</tr>
<tr>
<td>P3-1</td>
<td>1.66</td>
<td>0.09</td>
<td>0.23</td>
<td>0.30</td>
<td>0.08 - 0.11</td>
</tr>
<tr>
<td>P3-2</td>
<td>2.66</td>
<td>0.23</td>
<td>0.26</td>
<td>0.29</td>
<td>0.082 - 0.10</td>
</tr>
<tr>
<td>P3-3</td>
<td>3.06</td>
<td>0.25</td>
<td>0.28</td>
<td>0.31</td>
<td>0.084 - 0.118</td>
</tr>
<tr>
<td>P3-4</td>
<td>1.87</td>
<td>0.25</td>
<td>---</td>
<td>0.31</td>
<td>0.10 - 0.12</td>
</tr>
<tr>
<td>S3-1</td>
<td>2.01</td>
<td>0.28</td>
<td>0.30</td>
<td>0.40</td>
<td>0.09 - 0.118</td>
</tr>
<tr>
<td>S3-2</td>
<td>2.66</td>
<td>0.26</td>
<td>0.26</td>
<td>0.30</td>
<td>0.085 - 0.098</td>
</tr>
<tr>
<td>S3-3</td>
<td>2.87</td>
<td>0.25</td>
<td>0.28</td>
<td>0.30</td>
<td>0.09 - 0.117</td>
</tr>
<tr>
<td>S3-4</td>
<td>1.78</td>
<td>0.26</td>
<td>0.17</td>
<td>0.32</td>
<td>0.09 - 0.11</td>
</tr>
</tbody>
</table>

**Bulwarks**

| P/S-1 | 1.99 | 0.12 | 0.22 | 0.22 | 0.08 - 0.095 |
| P/S-2 | 2.75 | 0.22 | 0.24 | 0.24 | 0.07 - 0.105 |
| P/S-3 | 2.26 | 0.22 | 0.18 | 0.22 | 0.08 - 0.11  |
Table 10-5. Field Museum Dashur boat planking dimensions in meters. Inner surfaces.

<table>
<thead>
<tr>
<th>Plank</th>
<th>Length</th>
<th>Fwd. Width</th>
<th>Aft Width</th>
<th>Max. Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1-1</td>
<td>2.82</td>
<td>0.08</td>
<td>0.32</td>
<td>0.30</td>
<td>0.10 - 0.135</td>
</tr>
<tr>
<td>P1-2</td>
<td>3.34</td>
<td>0.33</td>
<td>0.07</td>
<td>0.335</td>
<td>0.08 - 0.105</td>
</tr>
<tr>
<td>S1-1</td>
<td>3.14</td>
<td>0.07</td>
<td>0.32</td>
<td>0.34</td>
<td>0.06 - 0.11</td>
</tr>
<tr>
<td>S1-2</td>
<td>3.26</td>
<td>0.33</td>
<td>0.11</td>
<td>0.325</td>
<td>0.075 - 0.11</td>
</tr>
<tr>
<td>P2-1</td>
<td>2.56</td>
<td>0.08</td>
<td>0.32</td>
<td>0.42</td>
<td>0.08 - 0.095</td>
</tr>
<tr>
<td>P2-2</td>
<td>3.10</td>
<td>0.31</td>
<td>0.28</td>
<td>0.36</td>
<td>0.09 - 0.115</td>
</tr>
<tr>
<td>P2-3</td>
<td>2.89</td>
<td>0.27</td>
<td>0.07</td>
<td>0.26</td>
<td>0.085 - 0.105</td>
</tr>
<tr>
<td>S2-1</td>
<td>2.57</td>
<td>0.05</td>
<td>0.22</td>
<td>0.23</td>
<td>0.10 - 0.11</td>
</tr>
<tr>
<td>S2-2</td>
<td>3.08</td>
<td>0.23</td>
<td>0.33</td>
<td>0.33</td>
<td>0.085 - 0.10</td>
</tr>
<tr>
<td>S2-3</td>
<td>2.95</td>
<td>0.32</td>
<td>0.06</td>
<td>0.39</td>
<td>0.083 - 0.105</td>
</tr>
<tr>
<td>P3-1</td>
<td>2.26</td>
<td>0.08</td>
<td>0.32</td>
<td>0.34</td>
<td>0.07 - 0.075</td>
</tr>
<tr>
<td>P3-2</td>
<td>2.44</td>
<td>0.33</td>
<td>0.36</td>
<td>0.40</td>
<td>0.095 - 0.105</td>
</tr>
<tr>
<td>P3-3</td>
<td>3.13</td>
<td>0.36</td>
<td>0.38</td>
<td>0.40</td>
<td>0.075 - 0.10</td>
</tr>
<tr>
<td>P3-4</td>
<td>1.99</td>
<td>0.30</td>
<td>0.32</td>
<td>0.30</td>
<td>0.08 - 0.085</td>
</tr>
<tr>
<td>S3-1</td>
<td>2.07</td>
<td>0.08</td>
<td>0.30</td>
<td>0.315</td>
<td>0.08 - 0.09</td>
</tr>
<tr>
<td>S3-2</td>
<td>2.82</td>
<td>0.31</td>
<td>0.37</td>
<td>0.37</td>
<td>0.08 - 0.09</td>
</tr>
<tr>
<td>S3-3</td>
<td>2.80</td>
<td>0.39</td>
<td>0.32</td>
<td>0.32</td>
<td>0.10 - 0.105</td>
</tr>
<tr>
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<td>2.40</td>
<td>0.28</td>
<td>0.05</td>
<td>0.34</td>
<td>0.082 - 0.098</td>
</tr>
</tbody>
</table>

**Bulwarks**

<table>
<thead>
<tr>
<th>Plank</th>
<th>Fwd.</th>
<th>Aft</th>
<th>Max. Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.26</td>
</tr>
<tr>
<td>P-2</td>
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<td>0.26</td>
<td>0.24</td>
<td>0.28</td>
</tr>
<tr>
<td>P-3</td>
<td>2.34</td>
<td>0.23</td>
<td>0.18</td>
<td>0.23</td>
</tr>
<tr>
<td>S-1</td>
<td>2.07</td>
<td>0.16</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>S-2</td>
<td>2.44</td>
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<td>0.29</td>
<td>0.30</td>
</tr>
<tr>
<td>S-3</td>
<td>2.51</td>
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<td>0.22</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Table 10-6. Planking dimensions for EM 4925 and EM 4926 in meters. Inner surfaces.

<table>
<thead>
<tr>
<th></th>
<th>Width</th>
<th>Length</th>
<th>Width Fwd.</th>
<th>Max. Aft</th>
<th>Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EM 4925</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P-1</td>
<td>1.17</td>
<td>0.07</td>
<td>0.30</td>
<td>0.30</td>
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* Remaining
Strakes 2 and 3 included notches, cut at 110° angles, that fit snugly over the nib ends of the strake beneath them (see fig. 10-2). The only ancient scarf was a simple stepped scarf between the second and third bulwark planks on the Field Museum hull. Mortise-and-tenon joints and lashing mortises connect planks within and between strakes. The first strake was simply laid against the central plank; there is no rabbet.

The bulwarks enclose most of the deck area. Three planks in the Carnegie and Field Museum boats and four planks in the Cairo boats make up the bulwark. They are butted and lashed at plank ends. Mortise-and-tenon joints and two types of lashing mortises fastened the bulwarks to strake 3.

Fastenings

Mortise-and-tenon joints, the primary hull fastenings, were the most important contributors to its strength. The builders of the Dashur boats also used three types of lashing mortises. Bulwark lashings and rectangular and round pegs for fastening beam and deck planking ends have already been discussed.

Mortise-and-tenon joints. Most hull mortises measure 7.5 cm. wide (one palm), 1.8-2.0 cm. thick (one digit or finger), and 12 cm. deep although depth ranges from 10-13 cm. Mortise-cutters used chisels with 0.6 cm. thick shafts and 1.2 cm. long blades. One edge of the mortise was cut vertically into the wood; the opposite edge was cut at a slight angle. Mortises are slightly wedge-shaped in cross-section.

Chisel shafts crushed wood at mortise edges as wood inside the mortise was pried out; the damage usually occurs at the corner of the mortise closest to the inner face on inboard edges and closest to the outer face on the outboard edges. Crushed areas usually are found on the after edge of mortises, but some mortises, especially those cut into knots, have two crushed edges. It is possible that plotting the distribution of crushed edges may also provide a key to determining where the mortise cutters began using a fresh or sharpened chisel.

A relief in the Old Kingdom tomb of Ti includes an apprentice perched on the end of a hull shaping tenons with an adze. Tool marks from Carnegie hull fragments
suggest tenons may have been cut from smooth blanks and provided with slightly tapering ends. Two fragments of original tenons were removed during the recording of the Carnegie boat and identified as Tamarix sp. by Donna Christensen of Forest Products Laboratories. The wide surfaces and edges were smoothly finished, but the ends bear marks of tools used to shape the roughly bevelled tips (fig. 10-6). The fragment from P2-3 was only 4 x 4.8 x 0.09-.12 cm.; that removed from S2-3 was 6.4 x 5.45 x 1.3 cm. Both tenon fragments had ends 4 cm. wide.

The original tenons in the Dashur hulls probably measured 22-25 centimeters in length, 7.5 cm. wide and 1.8 cm thick at plank seams, and reduced their thickness and width by nearly 50% at the ends. A mortise in the second strake of the c. 1325 B.C. Late Bronze Age shipwreck at Ulu Burun, Turkey, was 7 cm. wide and 17 cm. deep in a plank 6 cm. thick; tenons from the 4th-century B.C. Kyrenia shipwreck were about 15 x 4.5 x 0.55 cm.¹⁸

A 6 x 3 x i.9 cm. fastening aligned outboard plank edges across the first strake butt joins in the Carnegie boat. Small fastenings also crossed butt joins along the outboard edge of P2-2 and P2-3; P3-1 and P3-2; and S2-2 and S2-3. The butt join at P2-1 and P2-2 has no fastening. Partial mortises in the forward ends of S1-2, S2-2, S3-2, and S3-3 have no mates. The lack of mates for those mortises and of the fastening at other joins in the hull might indicate that larger mortises cut for aligning unshaped outboard plank edges were almost entirely trimmed away. The use of these mortises for aligning rather than fastening ends is emphasized by the partial mortise at the forward end of S3-3. The after end of S3-2 is notched for a beam where it meets S3-3 and thus could not have relied on the outboard edge fastening for structural strength.

Hollows along some inboard plank edges preserve black lines marking mortise positions (fig. 10-7). Where planks rubbed against each other or fit closely, no marks remain. The black marks are perpendicular to plank edges and are slightly inside mortise edges, suggesting that they outlined tenons projecting from the outboard edge of the plank they were to be fitted against.
Fig. 10-6. Carnegie Dashur boat, tenon.

Fig. 10-7. Carnegie Dashur boat, mortise marks.
Six starboard and three port planks retain the marks, most of which correspond well with mortise placement. S2-2 has a mortise mark on the inboard edge of a plank with no corresponding mortise; a mortise on the outboard edge is exactly opposite, however. A second set of marks show adjustments made after marking the forward mortise in S1-1, and S3-2 includes a mortise cut about 3 mm. forward of its lines as part of changes required by a repair (see below).

Ligatures. I have suggested elsewhere that what appear to be butterfly or dovetail fastenings on the Dashur boats may be the remains of shallow lashing mortises, significantly eroded at the time of discovery and subjected to substantial alterations along with the rest of the hull.¹⁹ Fastenings across plank seams that now hold modern dovetail tenons usually occur in the same positions as those on Lisht planks: near plank ends on one edge and slightly closer to the center of the plank on the opposite edge (see fig. 10-2). Butt joints with substantial separation in the upper stake of the Dashur boat in the Field Museum of Natural History in Chicago, and some plank edges of one of the two boats in the Egyptian Museum, Cairo, include butt joints that do not follow the pattern.

Dovetail mortises in all of the Dashur hulls are roughly sawn or recut, of varying depth, and of much poorer workmanship than the rest of the hull. All dovetail tenons in all hulls are modern. De Morgan, excavator of the Dashur boats, did not refer to dovetail mortises or, more tellingly, include them in his drawing of one of the boats.²⁰ Reisner noted, "So far as I was able to learn, the greater part, if not all of the dove-tail joints are modern. At any rate I so understood M. Barsanti [conservator at the Egyptian Museum]."²¹ I believe that Reisner was referring to the entire joint, not the tenons as some have suggested. He also states, "the hull is constructed of mortised and tied planking," with no mention of dovetail fastenings,²² but this statement is inconclusive on its own.

The technique of joining wood with dovetail fastenings existed from at least 2500 B.C., when Fourth Dynasty carpenters used dovetail fastenings in the construction of furniture for Hetepheres.²³ Makers of a sledge found with the Dashur boat in the
Carnegie Museum of Natural History dovetailed one end of a crosspiece into a runner. Other crosspieces, and the opposite end of the dovetailed piece, had tenons which fit into mortise in the runners. These tenons and the dovetailed end are pegged. Dovetail fastenings were also used in constructing stone bases of pyramids. With the exception of the Dashur boats, however, no other evidence for the use of dovetail fastenings in ship or boat construction has been discovered: hulls, tomb reliefs, models, an original drawing of the Dashur hull by its excavator, and other depictions give no indication of their use.

The evidence presented so far is mainly negative, but the recording of the Carnegie hull included scrutiny of all dovetail fastenings on its planks. Seven mortises retain finely cut, somewhat eroded features that provide the most compelling evidence for identifying the present-day dovetail mortises as former lashing mortises.

The clearest and most complete example of an ancient fastening is located on the forward inboard edge of Carnegie plank P3-1. A two-cm.-deep channel between an oval mortise 4.8 x 1.3 x 0.6 cm. and the plank edge has sweeping, eroded sides. Its appearance is strikingly different from all other cross-seam fastenings in the hull, but I think the other fastenings originally resembled this survivor. The aftmost dovetail in C-3, the forwardmost dovetail in C-1, and a dovetail on P3-4’s outboard edge exhibit the same gracefully curved, eroded edges.

Oval mortises present in three other recut fastenings are also 4.8 cm. long and 1.3 cm. wide, but their depth is only 0.3-.4 cm. due to hull renovations. Bulwarks P-1 and S-3, C-1, P1-1, and sheer plank S3-4 also retain ovals in the bottom of recut dovetail mortises. A dovetail mortise on bulwark P-1 (fig. 10-8) illustrates the ancient oval, now 3 mm. deep, that was not entirely included in the fastening created by hull renovations, but corresponds well to the mortise illustrated by fig. 10-9.

I believe the ovals mark the base of a V-shaped channel, eroded at excavation and cut away by reconstructors of the boat. Fig. 10-10 details my reconstruction of the fastening’s original appearance, including a recessed groove for the lashing.

Repairs made to the Dashur boats included the provision of new fastenings. Cairo boat EM 4925, port strake 1, includes a crudely cut dovetail mortise, shallower and even
Fig. 10-8. Carnegie Dashur boat, recut dovetail mortise.

Fig. 10-9. Carnegie Dashur boat, eroded original fastening.
Fig. 10-10. Carnegie Dashur boat, reconstruction of ligatures.
rougher than other re-cut mortises, that has no mate in the central strake. The crudity of execution suggests it was cut during the reconstruction of the hull at the turn of the century. There is no indication that it was part of the authentic hull design.

My study of dovetail fastenings on four Dashur hulls convinces me that these fastenings are substantially modified lashing channels. The extensive repairs to the hulls included drastic reshaping of these fastenings, reshaping designed to make them fit existing knowledge of Egyptian carpentry but unrelated to the original intent of the shipwrights who built the boats.

Deck

Deck planking, once painted white, extends from the forwardmost to aftermost beams on the Dashur boats. The planks, now broken and eroded, are 60-68 x 13-35 x 2-4 cm. Decking next to the hull conformed to its shape. Most deck planks have peg holes 8 mm. in diameter for fastening their ends to beam ledges. Only the decking at EM 4926’s bow and stern was pegged.26 Reisner noted that EM 4925 included panels of deck planking joined by mortise-and-tenon joints;27 the Khufu I hull is the only other known vessel to share that characteristic, but it probably was fairly common.

Deck planks were probably manufactured from wood trimmed away during plank shaping or perhaps from old timbers. The ends are chamfered and thinner than the centers; plentiful adze blade marks 1.7, 2.2, 3.1, 3.4, 3.8, and 4.2 cm. wide testify to the lack of concern with finishing the lower surface. The upper surface was smooth and level with beam tops.

P. Kuniholm informs me that the deck planking provides an extensive sequence of rings for dendrochronological dating, but the deck plank sequence cannot be cross-matched with that obtained from the planks.

Steering Oars and Stanchions

The Dashur boats seem to have had the typical steering arrangement of Egyptian funerary vessels, one oar on either side of the stern. Two stanchions, connected by a crosspiece, supported the upper ends of the oars. A transverse beam protruded about 25
centimeters beyond the sides of the hull and supported the lower end of the oar looms. A blue-wigged hawk head caps one end of the transverse beam on EM 4925, the only one still attached to a hull. Hawk heads also crowned stanchions on EM 4925.

Stanchions about two meters long pass through holes in the beam beneath them and rested on the sides of the hull. Their round section gradually thickens and tapers to a nearly square section 55-60 cm. from the stanchion’s beveled lower end. Stanchions are mortised to receive crosspieces.

The steering oars and stanchions seem to have been arbitrarily divided between the four boats. EM 4926 had two yellow stanchions with green and red stripes, but Reisner noted that EM 4925’s stanchions were mismatched: one was yellow and the other red.28 One stanchion on the Field Museum hull had seven stripes; the other had two. The Carnegie hull’s single stanchion has a tenon at the upper end, probably for an ornamental head, but no indications of paint. Each of the Cairo hulls has two steering oars; the boats in this country have only one oar each.29

The steering oars are 3.3-4 m. long; their round blades are about a meter long with a maximum width of 65 cm. Square holes (3 x 2.5 cm.) in the blades, also present in boat models, provided a channel for rope used to secure the oars to the hull. Two or three tenons through the flattened loom connected the blades.

Impressions made by a Z-twist rope on the Carnegie stanchion and tiller suggest that they were bound together for burial. The curved Carnegie tiller reaches a maximum diameter of 5 cm.; it is 95.6 cm. long.

Decoration

White plaster and traces of red, blue, and black stripes remain on the outer hull of each of the Dashur boats. The once-lovely painted wedjat eyes, rosettes, and stylized lotus leaves on the steering oars of EM 4925 and EM 4925 have faded, leaving a negative impression on the wood’s surface, and only a little red paint remains on stanchions described as having green and red stripes.30

A small patch of red paint on the outside of Carnegie plank S2-3 suggests that its
lower hull may have been painted red; green paint over plaster imbedded in adze marks on the outer surface of the after plank in EM 4925's central strake is difficult to reconcile with Reisner's description of a yellow hull.³

No traces of cabins or other superstructure were noted by Reisner or de Morgan, but the Carnegie hull includes two small poles with tapered ends that may have supported a small altar table or other deck structure. They are shaped like miniature stanchions, with a maximum diameter of 3 cm. that tapers to 1.5 cm. over the 1.06 or 1.11 m. length. One of the poles retains flecks of red paint in grooves on its tapered end.

No decorative finials were recovered with the hulls, but models and representations of funerary boats include upright and bent posts. Mortises through the ends of central strakes may have seated posts. A groove around the after end of EM 4925 could have held lashing for a stem finial; alternatively, a post-bearing sleeve could have been slid onto the hull like Khufu I finials.

CONSTRUCTION

Construction of the Carnegie Dashur hull began with the selection of timber balks from at least 18 cedar trees.⁴ The timber probably came from a royal storehouse; even the movement of planks of local Egyptian woods was supervised by regional viziers.⁵ Tomb paintings show us that woodmen used axes for the primary trimming of logs. The next steps are not shown, but it is likely that planks were roughly marked and sawn out. End grain patterns prove that the planks were carved, not bent, to shape.

Knot and end grain patterns in P3-2 and S3-2, P3-3 and S3-3, and P3-4 and S3-4 coincide and suggest that each pair might have been cut from a single log. Dendrochronological analysis has shown that the bulwark planks on opposite sides of the hull were cut from the same trees. It also proved that three other pairs matched in a similar manner were not sawn from the same tree, however, so the "pairs" in strake 3 may also be an artifact of timber selection for transverse symmetry. The hypothesis can be neither proved nor disproved as at least one member of each pair was not sampled for dendrochronological analysis. Ethnographic reports provide some support for this idea,
however.

In Clarke's description of an early 20th-century Nile boat, the shipwright bought living trees for timber, had them cut down and roughly squared, then marked plank curvatures with red ochre. After the timber's end was set up on a vertical brace, a large saw was used to obtain three or four 10-cm.-thick planks from each timber. Planks were then adzed to the proper curvature, and a small brush (made of a chewed stick) dipped in red ochre marked fastening locations. Construction of the Dashur hulls was probably not much different although charcoal paint rather than ochre was used.

The central plank of the center strake in each hull (C-2) has the fewest knots and the closest grain of any plank. C-2 in the Carnegie boat is flat from 0.5-3.28 m. aft of its forward end. The ends curve upward 1 cm. for each 10 cm. in length. The shipwright probably established a centerline, then cut C-1 and C-3, planks with mirror images and dimensions. Tenons in mortises about 3 cm. deep and wide in each plank end and across butt joins aligned the strake; these tenons may or may not have been maintained after adjoining strakes were fitted. Both ends would need to be supported by shoring, a process illustrated in Old and Middle Kingdom shipbuilding scenes.

Edge mortises were marked and cut next. The mortise pattern on the starboard edge mirrors that on the port edge for both mortise-and-tenon joints and lashing. Mortise-and-tenon joints line up in transverse rows as seen on Khufu I; I believe the rows were explicitly designed to function as internal frames.

After shaping the planks in strake 1 and checking the fit, mortise locations were marked along the inboard edge and the plank flipped over for cutting. Then, the plank could be pounded onto tenons slipped into central strake mortises and its outboard edges aligned by small tenons. By having the first strake reach from C1 to C3, the shipwright created a stable bottom that utilized compression and tension structural forces.

The center plank in the second strake was centered over the butt join in strake 1, then the knife-shaped end planks were shaped and fit. The many adze marks and beveled edges on outer faces of the knife-shaped planks suggest that they gave the shipwright the most difficulty, and they probably were trimmed as the sides were built up. The center
planks of the sheer strake were also joined to the hull before the ends. This pattern allowed more adjustments to be made to hull curvature as needed.

Notches cut in the sheer strake about every 70-85 cm. held beam ends. Rope was lashed around each beam, possibly as part of a rope girder running along the edge of the hull before beams were pegged. Holes for rectangular pegs 3 x 2.5 cm. angle from the center of the beam end to the outer face where they were cut off flush with it. Mortises for attaching the bulwarks flank each notch; some recut notches removed the closest edges.

Bulwark planks have few knots and were carefully finished. They enclose 75% of the deck area, the same percentage enclosed by stringers on Khufu I. After the bulwarks were fitted and lashed together and to the hull, outer surfaces were carefully finished to slightly below the beam pegs but left rough on the lower hull. Adzes with blades up to 4.3 cm wide left huge gouges on the outer surface of a few planks (fig. 10-11).

![Image](image_url)

Fig. 10-11. Carnegie Dashur boat, adze marks.

Ligatures may have been placed after the hull interior was smoothed and polished free of tool marks, but they could have been added at any stage in the construction.
Ligatures are symmetrical across the center line and exhibit the pattern shown on Lisht timbers: mortises on one edge are nearer the ends and on the opposite edge nearer the center of the planks. The shallowness of the Dashur mortises might indicate their relative unimportance in the hull's construction, but it is difficult to speculate about a fastening type that no longer exists in its original form.

Decking, steering gear, finials, superstructure, and decoration were the last elements of the hull to be completed. When finished, the hull had the same proportions, shape, and decoration of Middle Kingdom funerary models like that in fig. 10-12.

Fig. 10-12. Model funerary boat. (After Glanville [1957] fig. 13)

REPAIRS

All of the boats excavated at Dashur underwent drastic repairs during their reconstruction and some timbers show evidence of previous use, but only one hull was repaired in antiquity. As the Carnegie hull was being recorded, we checked each plank's outer surface carefully because time limits prohibited recording them at full-scale. The inner surface and edges of starboard strake 3-2 had been catalogued and drawn, and its unusual curly grain noted when we turned the plank and realized that it also included two patches on the outer face (fig. 10-13).

Today, a major crack runs through most of the lower outer face of plank S3-2,
and it clearly caused trouble as the hull was being built because two 50-cm.-long patch pieces were carefully fitted into an extensively dubbed area of very tight and curly grain (fig. 10-14). The shipwright’s need to match the curvature of the hull forced him to position inboard edge mortises closer to the outer face than anywhere else in the hull. Tenon placement in the strake below exacerbated the problem of working with the grain; the planking skin may have broken as the outer surface received its final dubbing or perhaps earlier as the bulwark was pounded home.

The patches fit closely in smooth-edged cavities with triangular sections. The upper patch, patch 1, is locked in place by a beam peg in a rabbet at its straight end. Two small pegs driven at an angle into a slanted mortise cut into the patch and the plank edges secured the pointed end. Patch 2 required four small pegs and mortises to fasten it; its after end was sawn off at an angle during reconstruction.

Modern repairs to the hull include iron nails driven in with round-headed iron hammers to hold the patches in place. About four centimeters from the end of one Carnegie boat plank were sawn off, and almost all beam notches were recut. Some mortises in the upper planks were enlarged by crude chiselling; and blue pencil was used to mark locations of replacement tenons. Heavy iron hammers with a distinctively patterned head were used to pound the outboard edges of strakes onto replacement tenons, and encircling iron bands were screwed to all of the hulls. Dovetail tenons, all of which are easily identifiable as being made after excavation, have been discussed above.

The boats in Cairo seem to have undergone even more extensive reworking. Stealers in the sheer strakes obscure planking plans that originally resembled the U.S. hulls much more closely. Modern scarfs connect the stealers to the sheer strake. Clarke noted that 20 years after the excavation, he hardly recognized the Cairo boats because they had been so highly repaired. The eroded surfaces of all the wood in those boats today make it difficult to assess relative age and quality of wood; wood sampling might identify replacement pieces.
Fig. 10-14. Carnegie Dashur boat, patches from S3-2.
Reisner does not discuss repairs to the boats, but describes them as being made of timbers "used once before." He cites nine plugged peg holes in one bulwark plank; the third starboard strake also includes plugged holes. One ancient hole passes through a mortise-and-tenon joint in S3-3 of EM 4926, but it was not possible for me to tell which came first, the mortise or the peg.

ANALYSIS AND CONCLUSIONS

The Dashur boats exhibit symmetry, planned design, and structural competence as well as fine woodworking skills and a high level of craftsmanship. They incorporate principles of shipbuilding and techniques that date to at least a millennium before their launching, and they would have been sturdy, serviceable craft. Whether their last, and possibly only, voyage was across the river or to Abydos and back, these hulls could take their place with any other watercraft on the Nile.

Their shape and decoration suggest that they were funerary boats. Garstang noted that each of 11 Middle Kingdom burials of minor officials at Beni Hasan included a model of a rowing and a sailing boat, and a granary. The idea of two boats interred with a burial can be linked to Khufu I and II and to the Lisht models outside the mastaba tomb of Imhotep. Their importance to the dead person was on a par with the provision of grain -- the staple food of ancient Egypt. Other excavations of Dynasty 12 tombs also included two or three model boats: two funerary craft and one boat with solar symbols.

Middle Kingdom models of funerary boats are often painted green or yellow, have striped bulwarks and two steering oars like the Dashur hulls, and have the same 4:1 proportions. Models have often been dismissed as inaccurately reflecting the vessels they mimic, but if proportions are checked, cargo and travelling boats are about 3:1, war or racing hulls are much longer and narrower, and funerary boats are 4:1.

Mortises for seating finials also suggest that the Dashur hulls originally included papyriform finials like towed watercraft in illustrations of funeral ceremonies. A sledge found with the boats is of the same type as one carrying a funerary boat on a Dynasty 12 coffin (fig. 10-15). Similarities between planking plans of the Dashur boats and the Lisht
planked model point to standardized hull types associated with burials in funerary complexes.

Fig. 10-15. Ceremonial boat, Middle Kingdom. (After Lacau [1904] pl. 22)

The four Dashur boats all represent the same type of hull. The appearance of the four vessels was accomplished by the shaping of hull planks, possibly in a ritually ordained pattern. Planks mirror each other within strakes and across the hull. The hull was constructed symmetrically, according to a definite plan. Planks S3-4 and P3-4 suggest how the symmetry may have been maintained (see fig. 10-3). I believe these timbers demonstrate how planks were shaped to the same curvature, placed opposite each other, and marked almost identically for beam notches and mortises.

Similarities between Dashur hull bulwarks and the Khufu I stringers 500 years earlier suggest that the bulwark replaced the above-deck stringer. The Khufu hull has no bulwark, and because I cannot find any representations or models of hulls with stringers other than Khufu I and one of the Khafre rock-cut boats, I believe the stringers may have been an archaic feature even in the Old Kingdom. Models and representations of the later Old Kingdom feature bulwarks on hulls that show any structure above the sheer; a cursory review of the literature suggests that travelling and funerary craft are the main
vessel types to include it.

Like Khufu I stringers, Dashur bulwarks were tied to deck beams and enclosed 75% of the deck area, stopping short of the last beams. Bulwark ends are lashed to the hull, and the bulwark is proportionally the same height as Khufu I stringers. I think the bulwark is simply the stringer moved atop the sheer strake, continuing to longitudinally stiffen the hull.

Like Khufu I, the central strake in each of the Dashur boats was built of three sections and depended completely on the strength of the hull’s design to keep the bottom from falling out.

Interestingly, most models include a carling like that in the Khufu I hull; none of the Dashur hulls provide any evidence for such a structure unless the line of stanchions down the center strake of the Carnegie hull also supported longitudinal timbers. Parallel rows of sockets on the first strakes probably held stanchions that supported deck beams, but there is no corroborating evidence for this hypothesis in models, representations, or other hulls.

Plank ends reflect another change in shipbuilding techniques between the time of Khufu I’s design and construction of the Dashur boats. On the Khufu I hull, large knife-shaped backing timbers were secured to the ends of the central strake and covered strake ends (see fig. 5-3). I believe that the planking expansion of the Carnegie Dashur hull reflects the transposition of Khufu I backing timbers to strake ends. The essential shape and function remains the same: connecting side strakes to the central strake, but the Dashur boats accomplish the task more easily.

Only the swelling and narrowing of planks at joins and the nibbed plank ends recall the intricately joggled edges of the Khufu and Lisht hulls. The changes in planking width shape achieved practically the same result as the joggled edges of the Khufu and Lisht planks, although the jogging contributed more directly to hull stability in the larger vessels. The sleek planking edges of "travelling boats" indicated in watercraft featured in the tomb of Ti and other representations dating soon after the Khufu vessel was buried may suggest hulls considerably smaller than the Khufu ship.
Ligature placement in the Khufu, Lisht, and Dashur watercraft reflects utilitarian concerns for securing plank seams. It may be that ligatures actually served to hold down battens more than anything else. I do not believe they were responsible for holding the hull together during its construction; shoring and the alignment tenons would do the job more efficiently.

The Dashur boats demonstrate thousands of years of expertise in ship construction. Even in the powerful Middle Kingdom, the use of at least six, and probably 10 or more, tons of wood to build six cedar boats required tremendous expenditures of labor and capital. Burying these hulls south of the pyramid of Senwosret III enhanced the prestige and standing of their owner or owners in the afterworld and in the ritualized world of the mortuary cult. Their construction reflects their importance, and attests to technological continuity and change from the earliest hulls.
ENDNOTES


7. The 1983 and 1984 studies formed the basis for my M.A. thesis at Texas A&M University, *The Dashur Boats* (M.A. Thesis Texas A&M Univ. 1984). I am grateful to Glen Cole of the Chicago Museum of Natural History, and to James B. Richardson III and David Watters of the Carnegie Museum of Natural History for permission to record the hulls curated by their institutions and for the kind assistance of their staff. Dr. M. Saleh of the Egyptian Museum in Cairo also provided welcome support for the recording of the two hulls (EM 4925 and EM 4926) in his care.

8. Reisner (supra n. 2) 83 and 86 reports 10.2 x 2.24 x 0.85 m. for EM 4925 and 9.9 x 2.28 x 0.74 m. for EM 4926; EM 4926 has also been reported as 9.8 x 2.18 x 0.75 m. by Hyslop (Anonymous, "Ein viertausend jähriges Boot," *Wassersport* 24 [1906] 6-7).


10. Donna Christensen of Forest Products Laboratory, Madison WI, kindly identified samples of planks from both hulls and tenons from the Carnegie boat; Peter Kuniholm and the Malcolm S. and Carolyn Weiner Aegean Dendrochronology Laboratory identified all sampled planks, beams, and decking from the Carnegie
hull as cedar; side and deck planks from the Chicago hull have been identified as cedar by Donna Christensen and W.F. Libby.


12. Haldane 1984a (supra n. 2) fig. 24 illustrating fastenings at butt joins is not paralleled in the Carnegie hull. I was unable to examine this feature on the hulls in Cairo.


14. Also see Reisner (supra n. 2) 85, fig. 317.

15. de Morgan (supra n. 1) fig. 203.

16. Reisner (supra n. 2) 85.

17. In Haldane 1984a (supra n. 2) 22, I wrongly described the Field Museum boat as having alternately wider inner and outer planking surfaces; it also has inner faces consistently narrower than outer faces and edge angles are consistent, not opposite on adjacent planks.


20. de Morgan (supra n. 1) 81-83.

21. Reisner (supra n. 2) xxiii, n. 1.

22. Reisner (supra n. 2) xxiii.


24. Reisner (supra n. 2) 88.
25. At least two dovetail mortises between the bulwark and sheer strake of EM 4925 include similar features, but they are not as well recorded.

26. Reisner (supra n. 2) 87.

27. Reisner (supra n. 2) 85.

28. Reisner (supra n. 2) 84.

29. A 1.98-meter-long, round-sectioned pole with a projecting tenon may be all that remains of a second steering oar on the Carnegie hull. See Haldane 1984a (supra n. 2) 60.

30. de Morgan (supra n. 1) pl. 31; Reisner (supra n. 2) 84 and 87.

31. Reisner (supra n. 2) 84.

32. Letter from M. Newton at the Aegean Dendrochronology Laboratory.


35. Clarke (supra n. 34) 9.

36. Reisner (supra n. 2) 86.


38. G. Daressy, "Fouilles de Deir el Bircheh," ASAE 1 (1900) 17-43.
CHAPTER XI

THE LATE PERIOD BOAT AT MATARIA, CAIRO

Excavations for utility construction in 1987 in the Cairo suburb of Mataria, ancient Heliopolis or On, revealed a boat 10 m. below the surface. About one-third of the hull was destroyed by heavy machinery, but the conservation department of the Egyptian Museum attempted to record and preserve the rest of the vessel. In November of 1988, Dr. Shawki Nakhla of the Egyptian Museum, Cairo, invited me to look at its remains.

According to Dr. Nakhla, the hull rested on barren sand, suggesting that it was last beached near an old river channel. Roman artifacts were found in the layers above the boat, but archaeologists discovered no artifacts directly related to the boat. Dr. Nakhla reports that the Radiocarbon Laboratory of Gif-sur-Yvette, France, dated wood samples from the hull to 2450 ± 50 B.P. and identified them as sycamore fig (*Ficus sycomorus*), a local Egyptian wood. Several additional samples have been taken of planks, pegs and tenons for further identification; at least three other wood types are present.

Because the utility construction had to continue, the hull was excavated under salvage conditions. Archaeologists made a sketch plan of the hull (fig. 11-1), but no sections were drawn. The plan reflects a great deal of parallax; the most accurate portion seems to be in the upper left corner. A cardboard model of the hull as found displays a hull curvature similar to that of the Dashur boats (fig. 11-2). Egyptian Museum staff described the model as being proportional to the hull; it measures 55 x 15 x 8 cm. (c. 7:2:1). Reported hull measurements of 8 (rem.) x 4 x 1.2 m. (c. 7:3.5:1) are considerably broader, proportionally, than the model. I believe problems with parallax and perhaps inconsistent measurements explain the difference. Site photographs support the measurements provided by Dr. Nakhla.

Several sections of the hull were selected for salvage and conservation.
Fig. 11.1 Sketch plan of the Mataria boat. (Courtesy Egyptian Antiquities Organization)
Unfortunately, many of the planks broke apart and lost their labels during treatment. Most fragments today are 35-50 cm. long. The Department of Conservation made its first attempt at the use of sugar as a bulking agent in the treatment of waterlogged wood from this vessel.\(^1\) After an abbreviated course of treatment, the wood was removed from the tanks and air-dried on tables in a shed. Small tanks and a lack of equipment to heat the solution prevented the treatment from adequately replacing lost cellulose.

In late 1988, the treated wood seemed in stable condition, although many of the pieces were twisted along the knotty wood grain and the surface of many fragments was highly friable or fragile. A small tub of untreated wood, mostly small plank fragments, tenons, and pegs, holds hull components that are essentially sound, although slightly spongy, with good surface preservation remaining. A catalogue of randomly selected planking fragments is located at the end of this chapter.

**HULL CONSTRUCTION**

Only the planked shell of the hull remained: neither frames, deckbeams nor
maststep were recovered. The sketch plan and model illustrate the remains of a shell-built vessel. A central strake, about 20 centimeters wide, serves as the foundation of the hull. Archaeologists described the central strake as protruding one or two centimeters below the vessel's outer surface. Two large mortises through the strake may be related to mast placement.

Dr. Nakhla reported an original hull length of about 11 meters based on reports from construction workers. The lack of any curvature at the wide end of the hull suggests that the boat abruptly curved upward in the missing portion of the hull or that the hull was considerably longer than 11 meters.

At the point of maximum preservation, the vessel has 15 planks on either side of the central strake; only seven strakes run into the preserved end. All planks in the hull were described as about 20 cm. wide; a photograph of the area in the upper left part of the plan suggests that planks were about 8 cm. thick (fig. 11-3). Plank length seems to range between 0.8 and 6 m. with most planks 2-4 m. long.

Fig. 11-3. Inner planking surface. (Courtesy Egyptian Antiquities Organization)
The sketch plan suggests that strakes were added to the hull with shorter, irregular shapes common near the end where the only curvature in the hull can be seen. Within the main body of the hull, most joins appear to be butt joins. A planking fragment in wet storage may support an alternative interpretation, however; half its thickness has been sawn away, leaving a configuration that could be part of a half-lap. Some planks are slightly swollen near their centers in a manner reminiscent of Egyptian boat construction of the Old and Middle Kingdoms. Planks below the turn of the bilge are straighter and more regularly shaped than those above.

Despite the Mataria vessel’s similarity in hull design and planking plan to boats of Dynastic Egypt, its fastening system is radically different than techniques used in other ancient Egyptian watercraft available for study. For the first time, an example of an Egyptian hull includes pegged mortise-and-tenon joints. Tenons in fig. 11-3 are at least 17 x 10 x 2 cm.; pegs locking them in place have 2-cm.-diameter heads. A loose tenon identified as sidder, *Zizyphus* sp.,² was only 9.7 x 4.2 x 1.2 cm. and had no peg. The catalogue presents additional fastening measurements.

A mortise in the largest single planking fragment remaining (57 x 18.5 x 7 cm.) was 14 cm. long and 3.1 cm. wide at the plank’s finished edge. No peg hole could be seen, but the mortise was incompletely preserved. This particular example gives an idea of the enormous tenons used to join plank edges. Fig. 11-4 illustrates a peg and several tenon fragments.

![Fig. 11-4. Mataria hull tenons and peg.](image)

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² *Zizyphus* sp. refers to the name of the sidder species used in the mortise-and-tenon joints.
**Graffito**

One planking fragment had a graffito scratched on one surface (fig. 11-5). Lines 0.02-0.025 cm. deep form symbols, perhaps Greek or Demotic Egyptian letters. The graffito is being evaluated by linguists.

![Fig. 11-5. Graffito on a Mataria plank.](image)

**CONCLUSIONS**

The Mataria vessel travelled on the Nile about the time Herodotus described Egyptian boat construction: "From this acacia tree they cut planks three feet long, which they put together like courses of brick, building up the hull as follows: they join these three-foot lengths together with long, close-set tenons; when they have built up a hull in this fashion (out of planks), they stretch crossbeams over them. They use no ribs, and they bind in the seams from within, using papyrus fibers." The Mataria planks were much longer than those described by Herodotus, but the basic method of construction was the same.

The boat from Mataria is the latest known Egyptian hull, built 1,400 years after the Dashur boats. Its builders lived in a prosperous, yet unstable, time and probably were ruled by the Persian Empire (525-404 B.C.). A Greek colony at Naukratis in the Delta
dates to the 6th century B.C., and the Late Period saw increasing numbers of foreign residents in Egypt, providing the opportunity for Egyptians to observe different technological practices. The Mataria hull reflects Egyptian nautical traditions that incorporated a feature of Mediterranean shipbuilding found in ships dating from the Late Bronze Age to the Byzantine period.

As already noted, pegs driven perpendicularly through tenons lock some mortise-and-tenon joints in the Mataria planks in place. Not all mortise-and-tenon joints in the hull were pegged, however, and the present condition of the planking fragments prevents an analysis of how the use of pegs relates to the construction of the vessel. The lack of records for peg placement in the Mataria hull prevents the definition of any pattern in their use. It does seem, however, that peg length was greater than plank thickness and thus might reflect their use as treenails for holding structural elements onto the hull. Fastenings through plank thickness are suggested by 8-cm.-diameter holes in the lower surface of the Lisht frame (see Chapter VIII), and a New Kingdom shipbuilding scene shows a few scattered treenails in hull planking, probably for attaching frames.

Modern watercraft, built in the Wadi Halfa-Shellal tradition of Upper Egypt, illustrate the continuity in nautical traditions illustrated by the locally built and used Mataria vessel. One Wadi-Halfa-Shellal boat described by Hornell measured $9.2 \times 4 \times 1.28$ m. with planks 25-30 cm. wide and about 5 cm. thick. The Wadi Halfa-Shellal boats were shell-built, beginning with the central strake. Planks were nailed together across seams, and the short lengths used probably produced a hull that looked and behaved much like the Mataria vessel. A few inserted frames were 6 cm. sided and 10 cm. molded and had uneven fore-and-aft holes for drainage.⁴

The Mataria hull provides the only evidence for the use of pegged mortise-and-tenon fastenings in Egyptian hull construction, although the fastening was known and used in the manufacture of furniture, coffins, and statues from the time of the First Dynasty. The large tenons continue an ancient tradition; the pegs might reflect shipbuilding techniques adopted by the Egyptians in the late New Kingdom (c. 1250 BC). We must distinguish, however, between the Mediterranean practice of locking every joint
in place with pegs on either side of a plank seam and the Egyptian practice of using pegs, or treenails, occasionally.

Fragment Catalogue

A. Plank fragment 36 x 14.5 x 8.5 cm. Fair condition, but original surface obscured or missing. No fastening traces remain.

B. Plank fragment 30.5 x 16 x 7 cm. Poor condition. Peg fragment remaining; head shows impressions of pounding. The thin and twisted peg currently measures 1.4 x 1.1 cm.

C. Plank fragment 20.5 x 6 x 3.2 cm. Fair condition. Only feature is a smooth, oval peg hole 1.4 x 1 cm. An associated warped peg was 5.3 cm. long with a squared tip 0.8 x 0.6 cm.

D. Plank fragment 23 x 4.5 x 3 cm. Fair condition. Its only feature is a graffito on one surface of the plank; the other surface is split away. Scribed lines 2-2.5 mm deep across the grain of the piece may be Greek or Demotic Egyptian (see fig. 11-5).

E. Plank fragment 14.4 x 5 x 7 cm. Cracked surface, but not warped. Mortise fragment 2.3 cm. thick in a plank edge that is split away. May be broken at or just before a peg hole.

F. Plank fragment 25.2 x 11.5 x 7.5 cm. Mostly taken up by a large knot. Possibly a plank tip as it has an angled end with mortise fragments 2.3 cm. thick at the opposite side.

G. Tenon fragment 15.6 x 8.5 x 2 cm. Distorted fragment, perhaps half of the original tenon, which contains a peg hole 1.5 cm. in diameter, drilled at a 45 degree angle. The peg hole is at the very tip of the tenon.

H. Plank fragment 23 x 10 x 4.3 cm. Bears 2.3-cm.-thick mortise and was broken through a peg hole 1 cm. in diameter. More than half the plank's thickness is missing.
I. Plank fragment 34 x 12 x 8.7 cm. Good condition. Bears a mortise 2.8 cm. thick with a well preserved chisel mark in the mortise edge (fig. 11-6). The blade measured 1.8 cm. across its slightly convex end and 1.5 cm. a centimeter further up the blade.

Fig. 11-6. Materia planking fragment (I).

J. Plank fragment 57 x 18.5 x 7 cm., but seems shrunken. Largest single fragment seen. A mortise in the edge is 14 wide x 3.1 cm. thick. It passes through to the other side but is only 12 cm. wide there. No peg.

Miscellaneous Pieces

Mortises from several other fragments measured (width x thickness) 10 x 2.3 cm.; 12.5 x 2.6 cm.; 11.2 x 2.4 cm.; 6+ x 3.2 cm.; 2+ x 12.6 cm. None of the fragments included peg holes. Fastening fragments in wet storage, not subjected to conservation, also provided information. A tenon 10.5 x 8.5 x 2.7 cm. was bevelled at its narrower end to a roughly trapezoidal shape; sampled for wood identification. A peg with shaved sides was 7.7 cm. long, and had an oval head 1.6 x 1.9 cm.; its tip was 1.5 x 1.3 cm. An 11.5 x 5 x 7 cm. plank fragment included a well preserved peg hole 1.8 x 1.4 cm. on one surface, and 1.5 cm x 1.3 cm. on the other.
ENDNOTES


2. Identification courtesy of Dr. Shawky Nakhla.


CHAPTER XII

CONCLUSIONS

Nautical archaeological resources from ancient Egypt provide the most complete picture of boatbuilding traditions in the ancient world before the Classical period. Models, representations, economic and religious texts, and more than 20 wooden hulls allow us to trace the development of nautical technology in Egypt between 5,000 and 2,500 years ago. The picture that evolves is one of dedication to certain principles and of flexibility in the face of need. The ancient Egyptians sought innovative and practical solutions to problems while maintaining traditional hull construction techniques to build thick-planked, broad, shallow hulls. Even in this century, shipwrights worked with the same tool types used more than 4,000 years ago to craft wide hulls not much different in form than those built by their ancestors. Despite the many changes in political entities through time, Nile shipwrights still use principles first articulated more than five millennia ago.

Five thousand years ago, woodworkers had the skills to produce thin, flat boards, but fastening techniques were simple, and not suited for hull construction. Boards butted against each other or were tied at corners by lashing through simple perforations. By the beginning of the Early Dynastic period (c. 3,100 B.C.), however, grave sites included timbers displaying all of the major fastening techniques used in ancient Egyptian hull construction. The introduction of metal tools sped the construction process, and the demand for warships, freighters, and ritual craft hastened the evolution of nautical technology. Still, Egyptian builders relied on methods originally developed by woodworkers using stone tools.

Building watercraft, whether with stone or metal tools, required a tremendous investment of labor. The adaptive advantages of royal control of shipwrights and other woodworkers becomes clearer if we appreciate the realities of production. For example, traditional boatbuilders using stone adzes and axes in the southwest Pacific Ocean cooperated to construct large vessels.
Four men, working an eight-hour day, will be adzing for a month to produce 15 planks, each plank being four m. long, 20 cm. across, and 2.5 cm. thick. The preparation of the wood and the shaping of the members of the boat is again so enormously time consuming that it is not an uncommon practice here, as in many parts of the world, to re-use members extracted from old boats. This has always been the practice. When a community broke up, the community Baurua [large proa] was also demolished, the various parts being shared out among the individuals of the erstwhile community.¹

The Polynesian workers were not subsidized by the state, but it is easy to see why state control and support of woodworkers developed in Egypt. By the later Old Kingdom, an autobiographical inscription brags of building a 30-m.-long freighter in only 17 days, a feat that demonstrates not only the speed with which large hulls could be built, but the king's power to command the resources and laborers necessary to do it.

As the state's power increased during the Early Dynastic Period, it also increased its visible manifestations through building monumental structures. Narrow, fast hulls like those buried at Abydos were not intended to transport heavy loads, but ebony tablets from Early Dynastic tombs at Abydos feature large, rounded cargo carriers that could have moved grain, laborers, or even building materials.² The slender hulls are yet another expression of state wealth and power, while the carriers met practical demands for transporting the huge stones needed to erect monumental structures, and were themselves revolutionary feats of engineering. One technical demand drove another, and the craftsmen of Egypt quickly developed sophisticated solutions to problems of water transport.

Water transport allowed the builders of the Early Dynastic temple at Hierakonpolis to incorporate granite from Aswan and facilitated the construction of an entire temple of stone by Khasekemwy (Dynasty 2).³ At the same time, the kings and the wealthiest officials continued to build mudbrick tombs faced with wooden planks. ⁴ Wood suggests that those who could not afford wood or the skilled workers required to join plank edges -- and I would add those who did not have access via the king to skilled woodworkers -- began to use stone facings in imitation of wood.⁵ In an interesting
transformation of cultural practice, Egypt's kings began building stone mortuary complexes in Dynasty 3 that include stone imitations of organic forms, especially wood.

The growing demand for stone architectural elements fostered the development of efficient, sturdy hulls. For example, the Dynasty 3 Step Pyramid of Djoser includes a three-ton granite plug from Aswan and other massive stone elements that had to be brought by boat. The effect on hull construction practices can only be imagined, but it probably compared in magnitude to the tremendous changes in architectural practices of the time.

PRINCIPLE FEATURES OF EGYPTIAN HULL CONSTRUCTION

Models, texts, and representations testify to many different kinds of Egyptian watercraft, but excavated Egyptian watercraft provide evidence for only two branches of hull construction: sturdy, durable cargo carriers and elegant ceremonial hulls. Cargo carriers, exemplified by the Lish timbers and the Mataria boat, were broad and shallow hulls designed to transport heavy goods. In contrast, the ceremonial Abydos, Khufu, and Dashur vessels were intended to carry people (or gods) and perhaps funeral equipment, so they were more lightly built and proportionally narrower. Despite these differences, the two hull types shared many design features. Thick planks with joggled edges, fastened by a combination of mortise-and-tenon joints and ligatures or lashing, created shallow hulls, built up plank by plank around a central section.

Planks in other kinds of structures have been edge-joined in Egypt since at least Dynasty 1, when mortise-and-tenon joints connected boards in coffins and furniture and some planks that may be from a vessel. Mortise-and-tenon joints, called menkh in the Old Kingdom, carried the abstract meaning of durable, constant, faithful, and loyal, suggesting their demonstrated utility in hull construction. Although carpenters began using pegs to prevent tenons from working loose from mortise-and-tenon joints in furniture about 3100 B.C., pegged mortise-and-tenon joints are undocumented in Egyptian hull construction until 500 B.C. when they were used in some joints of the Mataria boat. Pegged mortise-
and-tenon joints would have made the documented disassembly and reassembly of Egyptian hulls impossible (see below).

Both ceremonial and cargo vessels could incorporate framing, inserted after the planked shell was assembled. Carlings and stringers also contributed to hull integrity. External planking surfaces below the waterline were smooth, marked by butt joints and S-scarfs but almost never by fastenings that pierced the planking. Both types also relied on compression, transverse beams, and the weight of the planks themselves to force planks together.

But because the Lisht planks, and similar planks reported from other Middle Kingdom sites, came from working freight boats, they exhibit markedly different characteristics than planks from ceremonial vessels. The Lisht planks vividly demonstrate the way shipwrights, and the state, made maximum use of scarce resources, demonstrating thrift in their construction, as opposed to the more wasteful methods used to build ceremonial vessels. Short lengths of acacia and tamarisk were cut into virtually flat planks with curved and notched edges.

Saw marks on most plank faces suggest that ancient shipwrights sawed thick slices from trimmed logs just as Upper Egyptian boatbuilders did at the turn of this century. Short planks fashioned from such slices generated little waste. By incorporating only a very slight curvature along the longitudinal plane, shipwrights could create planks for building or repairing hulls and that could be easily reused as foundations for slideways and construction ramps.

In contrast, cedar planks from the Khufu and Dashur hulls are longer and more curved. Saw marks on some of the Dashur planks suggest that they might also have been sawn from a timber balk, but grain patterns show that the hypothetical balk was probably twice as wide and three times thicker than the resulting plank. Open mortises at butt joins offer a separate thread of evidence suggesting planks originally were much wider than finished pieces. Some open mortises have no partners in the planks they butt against; some butts have no open mortises.

One explanation for these observations is that shipwrights fit incomplete planks to
the hull. I imagine that broad planks, roughly shaped to fit the curvature of the planks below them, had open mortises 10-15 cm. deep at butted ends. As the shipwrights adzed the plank to its final curvature, they also trimmed its upper edge, sometimes completely eradicating the open mortise used to align butts. Trimming planks after fitting can also explain areas in the hull, for example Carnegie Dashur plank S3-2, where mortises are located only a centimeter or two from the outer planking surface.

Framing, like planking, shows significant differences in conceptualization between the construction of ceremonial and cargo types. The one-piece Khufu floor timbers supported stanchions that held the carling at deck level and spread its weight across the hull; Dashur boats have no frames but preserved stanchions that supported deck-level hull components. Deck beams provided sufficient lateral stability to those vessels. The Lisht frame, however, was a complex assembly of timbers that created a massive bulkhead and locked a heavy carling into the lower hull, lowering its center of gravity to counter a deckborne cargo.

The construction of the Lisht frame, like the Lisht planks, also shows frugal timber use; by making the curved floor timber very shallow and tying it to short, straight upper timbers, the shipwrights could use the same flat, thick timber "blanks" used to fashion hull planks. The height of the Lisht floor timber was only 35 cm.; obtaining the wood for it from naturally curved trees would have been fairly simple whereas finding naturally curved wood for the Khufu floor timbers, up to 1.3 m. high, would have been extremely difficult. Its manufacture required a more extravagant approach to wood use.

REUSE AND DISASSEMBLY

The expense of worked wood, particularly that of large planks used in building watercraft, was a driving force in the development of Egyptian nautical technology. For ceremonial vessels, raw materials were an even greater expense, because imported conifer timber from Syria was so highly prized. References to wood from older, broken up hulls in dockyards make it clear that wood was stored for reuse in other watercraft. Some planks in the Cairo Dashur boats were used once before, and a beam from the Carnegie
Dashur boat is so much older than the other timbers that it probably also was reused.

Another aspect of recycling hull timbers must also be considered. Middle
Kingdom pyramid complexes include construction ramps and slideways that incorporated
hundreds of planks with remarkably similar shapes, dimensions, fastening patterns, and
even joggle angles. Similarities between planks at a single complex could be explained by
the reuse of timbers from a single, massive, freighter, but the repetiveness of shapes
across four sites and 150 years illuminates part of the great web of Egyptian bureaucracy.
Scribes in the shipyard monitored every scrap of wood and sharpened metal tool; a
society so obsessed with bookkeeping and balancing accounts logically would plan ahead
for the day when a vessel's planks were no longer fit for service in a hull but could meet
other needs of the state.

Curved, sculpted planks cut from the center of trees and fashioned into ceremonial
watercraft could not have been reused in construction projects for practical reasons, in
addition to probable religious proscriptions. But short, thick, flat planks like those from
Lisht seem almost designed for secondary use that included causeway and ramp
foundations. Planks with the standardized features of the Middle Kingdom slideway and
ramp timbers also would be much more easily incorporated in repairs to existing hulls or
even in building a new hull than planks cut to express a particular curvature and to fit
only in one place.

Middle Kingdom Dashur planks also hint at standardized shapes, particularly if
the identical planking plans of the Lisht model and the Carnegie or Chicago boats are
considered. The Lisht model is one-fifth the size of the Dashur boats, but its planks are
arranged in the same manner, suggesting fairly rigid conceptions of how to build this hull
type. Formulaic expressions of ritual beliefs are common in Egyptian religion, so it is not
surprising that ceremonial watercraft, whose characteristic decorative features have long
been recognized, also had specific methods used in their construction.

Reuse of timbers and standardized shapes were not the only issue that influenced
construction methods. Egyptian hulls seem specifically designed to allow disassembly.
Khufu I provides the finest, and least controversial, example of this practice. Hieroglyphs
on battens covering plank seams in the Khufu hull match those on planks where the battens fit, suggesting step-by-step instructions for later workers.

Unlike sewn hulls elsewhere in the world, the Khufu I hull relied on transverse lashing across plank surfaces rather than lashing along plank seams. Ropes used for the transverse lashing passed freely in and out of V-shaped channels; ropes threaded through drilled holes along plank seams required pegging at each drilled hole to prevent longitudinal slippage. Hulls with transverse lashing could be quickly reassembled with about one-fifth the cordage required for similar sized hulls with lashing along longitudinal seams.

Evidence for the transportation of ships, which would surely have been simpler if they were disassembled, is offered by boat petroglyphs on the walls of the Wadi Hammamat, which stretches to the Red Sea from Koptos, the ancient and historic port of Upper Egypt, as well as by autobiographical inscriptions and brief references to the practice from the New Kingdom up until the 19th century.

Tuthmosis III recorded ships built and carried by wagons on his campaigns in Syria, and Middle Kingdom plank fragments and ropes from Wadi Gawasis, at the Red Sea terminus of the Wadi Hammamat, provide physical evidence for the process. The Classical author Diodorus and an early 19th-century A.D. traveler in Egypt record the Egyptian practice of building ships, taking them apart, transporting them across land, and reassembling them where they were needed.

If the practice of building ships on the Nile, disassembling them, and transporting them across the desert to the Red Sea dates to Naqada II or earlier, as J. Zarins suggests, then it is to be expected that the division of workmen at all times during the Dynastic Period followed naval administrative divisions. The logistical needs and the coordination of resources required to complete projects successfully on this scale left an indelible mark on the organization of labor in Egypt, which ever after divided workers into squads identified by the labels port, starboard, fore, aft, and rudder.
EGYPTIAN HULLS AND SEAFARING

At least one author has suggested that seagoing Egyptian hulls were built as early as the Nagada I period so that the Egyptians could travel north to the Sinai and south to Punt, or God’s Land. Obsidian has proved to be a good indicator of trade with Arabia and the African coast; Egypt became part of a network that linked East Africa, Arabia, the Indian subcontinent, and Mesopotamia during the Predynastic period. Naqada, Hierakonpolis, and Abydos controlled access to the routes across the Eastern Desert, and probably held near monopolies on the ships that traversed the Red Sea. The power associated with the redistribution of imported goods that may have included obsidian, incense, silver, sea shells, and lapis lazuli contributed to the dominance of those cities in the Early Dynastic period. The prestige of these sea journeys became part of the potent symbolism of watercraft.

Descriptions of overseas voyages occur throughout the Dynastic period as well. A few royal monuments also provide illustrations of the laden hulls returning successfully from dangerous journeys. References to seaborne trade with other nations are many, including the lament of a shipwrecked sailor from the Middle Kingdom.

Although contact with Nubia, Palestine, and Syria is attested from the beginnings of the Early Dynastic Period, the idiosyncrasies of Egyptian hull construction, when viewed in light of later Mediterranean traditions, imply independent development and persistent use of native techniques to fasten planks and create stable, sturdy hulls. Unfortunately, we are unable to directly compare Egyptian and Mediterranean hull construction, because no seagoing Egyptian nor riverine Mediterranean watercraft have been excavated. Comparing Egyptian river boats and Mediterranean ship construction, especially across 500 years, would be like comparing apples and oranges. Additionally, the earliest excavated Mediterranean hull dates to Egypt’s Dynasty 18 (ca. 1325 B.C.), a time for which we have no remains of Egyptian craft of any kind. Comparisons between the two traditions can highlight contrasts in shipbuilding philosophies, but it is impossible to tell whether the distinctions we see relate to time, vessel type, or cultural and economic factors.
The Late Bronze Age Ulu Burun shipwreck near Kaş, Turkey, is the oldest excavated Mediterranean seagoing hull. A keel and several edge-joined planks briefly recorded, but not yet fully studied, demonstrate methods of hull construction vastly divergent from the nautical technology of Egyptian shipwrights who built river craft. One of the most marked contrasts is the use of thick central strakes, not keels, in excavated Egyptian hulls. Some New Kingdom models and representations, however, illustrate a projecting central timber on seagoing and so-called "travelling" vessels, as well as on the obelisk barges of Hatshepsut. C. Monroe has suggested provided longitudinal stability and rigidity.\textsuperscript{15} Ulu Burun planks were only 6 cm. thick, two-thirds the thickness of Dashur planks and half, or less than half, the thickness of Khufu and Lisht planks. In Egypt, thick planks added strength to the hull, and their weight contributed to the forces of compression that helped hold the hull together. In the Mediterranean, only the immense Roman cargo-carriers had planks as thick as those of Egyptian hulls.

Another visible difference between the two building styles is in the method of fastening planks together. Both styles used deep mortise-and-tenon joints of about the same width, but the Ulu Burun joints are 4 cm. deeper. In addition, Ulu Burun shipwrights drove pegs 2.2 cm. in diameter through each joint.\textsuperscript{16} Egyptian shipwrights avoided piercing the hull planking below the waterline; mortise-and-tenon joints in river craft were wedged side-to-side to forestall longitudinal slippage but offered less resistance to lateral forces.

Archaeologists at Ulu Burun also have uncovered what seems to be a deck-level enclosure and have taken precise measurements of cargo distribution that will allow the hull’s curvature to be reconstructed. No framing, rigging, or internal hull components have been found, however, so basic questions about Late Bronze Age seagoing ship construction remain. The extant Egyptian vessels provide more information about Bronze Age hull construction, over the greatest length of time, than any other source. But again, the evidence is for a specific culture, whose practices might not have been shared throughout the ancient Mediterranean world.
ANCIENT EGYPTIAN HULL CONSTRUCTION

One of the most technologically advanced and economically powerful cultures from the ancient world evolved along the banks of the Nile River and drew its strength from the vessels that plied its waters. The earliest attempts at crossing its waters may have been made on bundles of reeds gathered at the river’s edge. Buoyant reed bundles tied together served many purposes in Egypt, from fishing and hunting hippopotamus to providing platforms for ritualized mock battles between boat crews or ferrying the dead to immortality. But our first representations of watercraft seem to be connected to warfare and domination. It is possible that the 12 unexcavated Early Dynastic hulls at Abydos may commemorate the role of swift, long, and narrow vessels in the formation of the state; their burial attests to the immense wealth of its early rulers.

When they built Khufu I more than 4,500 years ago, Egyptian shipwrights translated the simple papyrus raft into an extraordinary work of art and complex engineering that reverberates with the majesty of a state so powerful that it could afford to build a 43-m.-long hull of imported wood and bury it beside a pyramid for eternity.

The dedication of resources becomes even more awe-inspiring when we realize that another disassembled and three complete, but now vanished, vessels surrounded Khufu’s pyramid. While the wood type and dimensions of the unexcavated Khufu II hull are unknown, its deckhouse was about the same size as Khufu I’s and at least some component dimensions are similar suggesting a ship of similar size, requiring a similar investment of labor and capital.

The rock-cut, brick, and small wooden hulls and boat graves located in pyramid complexes of the later Old Kingdom testify to decreased wealth, possibly as a result of a drier climate and slowly deteriorating economic conditions. After Khufu, the next known wooden hulls date to Dynasty 12, one of the most powerful groups of rulers in Egypt’s history. At Dashur, five, or perhaps six, cedar papyriform boats paid tribute to the recently dead king and honored, through emulation, the legendary rulers of the Old Kingdom. A planked model only a fifth the size of the Dashur hulls buried outside the tomb of a highly respected official at Lisht suggests that the Dashur hulls represent a
comparatively large investment.

Also at Lisch, and other Middle Kingdom pyramid complexes, are the remains of working vessels built of sturdy, straight, short planks, fastened together with deep mortise-and-tenon joints and ligatures, and reinforced with walls of wood intricately connected in a framing assembly. The massive construction of such hulls allows us to comprehend more easily the incredible transportation and engineering feats involving stone monuments weighing hundreds of tons.

The traditions of thick planks, joggled edges, and fastening by deep mortise-and-tenon joints survive in Egyptian hull construction through the end of the sixth century B.C. and, with the substitution of nails for mortise-and-tenon joints, into the present. An abandoned freighter, stripped of its internal timbers and left on a small branch of the Nile near Matara provides evidence for a departure from past principles of hull construction. For the first time, pegged mortise-and-tenon joints are documented from an Egyptian hull. Not all joints were pegged, and the pegs, or treenails, may also have fastened frames to the hull, but one of the identifying characteristics of Dynastic Egyptian hull construction had been irrevocably changed.

The remains of 20 different ancient Egyptian vessels probably represent only five, of more than 100, documented types of watercraft that carried people, cattle, gods, obelisks, and foreign traders on the Nile between 5,000 and 2,500 years ago. By studying how these hulls were built, and where they fit into the fabric of society, we can gain some sense of the complex solutions to practical problems developed by Egyptian shipwrights. Whether swift warships, giant cargo carriers, wooden imitations of flimsy papyrus rafts or heavily laden seagoing vessels, Egyptian watercraft incorporated design and technological features as complex, and durable, as those of the more visible stone monuments of ancient Egypt.
ENDNOTES


2. Petrie, RT II, 21 and pl. 10.


4. Wood (supra n. 3) 65-66.


6. Drilling holes through planks was an anathema to Dynastic Egyptian shipwrights in any case.


10. Zarins (supra n. 9) 368.

11. Zarins (supra n. 9) 368.

12. Zarins (supra n. 9) especially 368.

13. Landström (1970) remains one of the most accessible sources for representations of watercraft. His interpretations, however, reflect a bias toward the construction features of Khufu I, whose construction includes a number of archaic details. For Old Kingdom depictions of the voyages of Sahure to Syria, see figs. 187-91; for Hatshepsut's voyage to Punt, fig. 372. For seagoing ships at the Unas causeway, see S. Hassan, "The Causeway of Wnis at Sakkara," ZÄS 80 (1955) 136-39. For further information on Sahure, consult L. Borchardt and E. Assmann, Das Grabdenkmal des Königs Sahu-ré II (Leipzig 1913) 2-28, 133-46. For Punt, and

14. S. Wachsmann, Seagoing Ships and Seamanship in the Late Bronze Age Levant (unpub. Ph.D. dissertation, Hebrew University, December 1989) 8-27, provides the most complete collection of references to seagoing Egyptian ventures and hulls currently available. For the account of the shipwrecked sailor, see A.M. Blackman, Middle Egyptian Stories (Brussels 1932) 41-48.

15. For example, eight Tut'ankhamūn model boats include this feature. D. Jones, Model Boats From the Tomb of Tut'ankhamūn (Oxford 1990). C.M. Monroe, The Boatbuilding Industry of New Kingdom Egypt (M.A. Thesis Texas A&M Univ. 1990) 74.

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APPENDIX 1

MAP OF EGYPT
APPENDIX 2

CHRONOLOGY AND SELECTED KINGS

*Predynastic Period* (3550-3000 B.C.)
Naqada I (Amratian)
Naqada II (IIb = Gerzean)
Naqada III (IIIb = Dynasty 0)

*Early Dynastic Period* (3000-2600 B.C.)
Dynasty 1 (3000-2820 B.C.)
Dynasty 2 (2820-2670 B.C.)
    Khasekhemwy
Dynasty 3 (2670-2600 B.C.)
    Zjoser

*Old Kingdom* (2600-2195 B.C.)
Dynasty 4 (2600-2475 B.C.)
    Khufu (Cheops)
    Djedefre
    Khafra (Khephren)
Dynasty 5 (2475-2435 B.C.)
    Sahure
    Neuser-re
    Unas
Dynasty 6 (2345-2195 B.C.)

*First Intermediate Period* (2195-2040 B.C.)
Dynasties 8-11

*Middle Kingdom* (2040-1781 B.C.)
Dynasty 11
Dynasty 12
    Amenemhet I (1994-1964 B.C.)
    Senwosret I (1974-1929 B.C.)
    Amenemhet II (1932-1898 B.C.)
    Senwosret III (1881-1842 B.C.)
Dynasty 13
Second Intermediate or Hyksos Period  (1650-1550 B.C.)
Dynasties 14-17

New Kingdom  (1550-1075 B.C.)
Dynasty 18
  Hatshepsut  (1479-1458 B.C.)
Dynasty 19
Dynasty 20

Third Intermediate Period  (1075-664)
Dynasties 21-24

Late Period  (710-332 B.C.)
Dynasty 25
Dynasty 26
Dynasty 27 (Persian)  (525-404/401 B.C.)
Dynasty 28
Dynasty 29
Dynasty 30

Second Persian Period  (343-332 B.C.)

End of the Dynastic Period  (332 B.C.)
APPENDIX 3

LETTERS OF PERMISSION

National Geographic Magazine
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December 11, 1992

Ms. Cheryl Haldane
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VITA

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Fellowships and grants awarded include the Texas A&M College of Liberal Arts Technology and Society Dissertation Award, the Harriet Pomerance Aegean Bronze Age Fellowship from the Archaeological Institute of American, a Gordon Childe and Margary Bequest from the Institute of Archaeology (London), an Honorary Fellowship from the American Research Institute in Turkey, and PAL and Abell grants from Texas A&M University.

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