THEORIES ON SHIP CONFIGURATION IN THE BRONZE AGE AEGEAN

It is only natural, I think, for one who is in the business of designing seacraft to be very curious about the origins of ship construction and the very closely associated shapes of the earliest of vessels. It is natural also to seek those origins here in the Aegean Archapelago believing as we do that here were sailed the earliest seagoing watercraft of Western cultures. Ships from the islands of Crete and the Cyclades pushed back their horizons to seek trade with neighbors and explore lands from which no ships yet sailed.

It is surely no revelation that existing evidence of ships that did these things is far from abundant. There is of course no written record, for the time was earlier than script. There is no record in poetry or song that we can reliably understand. There is only the graphic hand of the people in their art, and that is perhaps the best. For this we have the support of the well-known 19th century English philosopher, John Ruskin, who said: "Great nations write their autobiographies in three manuscripts, the book of their deeds, the book of their words, and the book of their art — but of the three, the only trustworthy one is the last".

It would be most interesting if time and space permitted to include a full study and analysis of the variety of iconographic sources for ancient Aegean ship reconstruction. However, because of the associated inconclusive and controversial nature and the fact that most consist of the work of artisans and not artists, we will go on to another and better source. It is time to put more confidence in the finest form of expressive Minoan art, their fresco painting. Consequently the major portion of this paper will deal with the development of the ship configuration of the Bronze Age ships illustrated in a remarkable fresco.

Until less than fifteen years ago none of all the beautiful Minoan period frescos from Crete or elsewhere brought forth any scene containing watercraft. During the 1972 season of archeological excavation on the island Santorini, ancient Thera, under the direction of Spiridon Marinatos, this condition of ignorance was suddenly ended. In one of the excavated structures called the West House, later the House of the Fisherman, which was already rich in frescos, there was a remarkable find, done in a miniature style for a continuous fresco freize containing a procession of ships. This procession was also attended by smaller watercraft and dolphins, among many other things, — a scene by now that is familiar to all of you who share this interest in ancient ships. It is, as you know, typical of other graphic art of this time, quite flat as it projects the subject, with all of the objects in profile. There is no need to describe this most valuable as well as beautiful fresco. One cannot help but notice that the artist was not only skillful in his craft but also familiar and knowledgeable about the sea. The painting is full of many details particularly of the ship as well as their surroundings. We are convinced of the artist's reliability by the objects we recognize, each painted correctly. Of the various leaping dolphins, there are two recognizable species, for example.

It is most important to compare the profile features of the seven large vessels in procession as well as the seven small craft for similarity in shape. They all have the same identifiable sheer line and distribution of body bulk. They are not simple symmetrical crescent-forms as might first appear. The larger vessels disguise their basic profile form perhaps more than the smaller, being as they are, in full parade dress. Strip off the decorations visually — the flower garlands, bow-extended antennae, paper-like butterflies, stern-draped animals and perceive the ship! The form is clear.

Now it is possible to concentrate on the clearest, most intact ship in this fragmented fresco. This painted ship needs little, if any, restoration having only insignificant missing fragments. The illustration here is from the archaeological report by Professor Marinatos and is the approved archaeological construction. The fragmentation of the other fresco ships is individually considerable but collectively their basic configuration matches the nearly intact ship, and they have each been so restored. The hull profile shows a distribution of body volume which is concentrated toward the stern. One whose center of volume is *aft* rather than forward of the midship division. As a part of such shape the stern rises more steeply or, in terms of the sheer line's after portion, it shows a shorter radius of curvature than the forward line. These significant characteristics are repeated in *all* of the vessels, large and small, in the fresco. Such a profile is a *significant* identity that relates these ships to other ships of this time and even others of more recent time. This feature of profile, as will be observed, is most important in establishing the cross-sectional body distribution of the Thera ship.

There is little doubt that the ships of Thera in this late Minoan period had some kinship with Egyptian vessels in hull configuration. I believe that this similarity however was simply the result of the "state-of-the-art" of shipbuilding for this time and general part of the world. There are discernible differences that will be seen that indicate purely Aegean development. The feature that shows most clearly however in this stripped down profile is the previously noted unsymmetrical crescent-form. As applied to variously known vessels, the shape may be extensively drawn out longitudinally or it may be concentrated toward the median axis, depending upon the vessel's required bulk. This configuration recognized by the sternward concentration of volume is a classical one. It is a concept that shipwrights understand and control for proper and practical reasons. It carries with it identifiable and measurable indications, the most apparent and perhaps simplest of which is the variation of ship's breadth, both at sheer level and at any chosen waterline. The whole hull tends to reach its maximum breadth aft of the middle section and this greater breadth diminishes at a lesser rate when going sternward than when going toward the bow. A sailor or shipwright or designer would describe this shape as "fine forward with a good broad run aft".

With such a hull and broad after deck as this and a sheerline that sweeps up in the stern, the helmsman occupies a traditional and necessary platform for steering control with good lateral visibility. On the larger boats this station is adequate for other important members of the crew for sail-handling and command. The whole vessel with sailing rig, over-hanging ends, with the weight and volume aft of center will ride more comfortably and steer more easily. One can become convinced that the ancient shipwrights were aware of these things and shaped their ships accordingly.

With the recent disclosure of the underwater discovery of the 14th century B.C. "Kas"* ship we now have some confirmation of Bronze Age hull structure. While this paper does not intend to explore the broad question of ship construction of this period, it cannot be ignored. The manner of joining the hull's parts is undeniably related to the hull configuration. At this time it is too early for conclusive statements on the "Kas" ship. However, the first evidence from the remaining wood of the hull's structure indicates that planks were joined edge-to-edge by an early form of mortice and tenon. This would indicate that the well-known method of shell construction has been used surely for at least an additional millennium. It further suggests that the Thera ship, which was closely contemporary with the "Kas" ship, may well have had an embryonic keel timber.

At any rate it should not be ruled out that while the Bronze Age hulls were most certainly of shell-first construction some may also at the same time have been edge-fastened by fiber lashings in a sewn seam structure. There may have been, quite possibly, the combination of lashings and tenon fastenings with the lashings to attach partial frames and internal truss in place of a heavier central keel. In either type of structural fastening it can surely be stated that the process was a tedious one and the form of hull was generated by a skillful shipwright by his hand and eye.

Knowing more closely the nature of the hull's structure as well as its distribution of volume, it is a shorter step to move from the dimensional profile to a three-dimensional presentation in the conventional architectural projection.

The first additional line to be added to the profile was the necessary waterline. This line was simply determined by locating the water surface level where the paddlers' blades seemed to be properly immersed. The true waterline must be close to this. The leading paddlers forward seem to have their blades immersed slightly deeper than the others in graduated order. This conforms to the style of multiple in-line paddling as opposed to rowing where the crew remove and dip their blades sequentially. The sequence of immersion begins forward and moves aft following an elongated wave of progression. The location of *this* ship's water line is thus one of direct approach.

The stem of the ship was terminated at a point where the color of the bow

* 1 JNA 13.4, pp. 271-279. INA Newsletter 1985, Vol. 12, No. 1.

projection in the fresco changes from red to light blue. It seems to indicate by this and other markings that the further extension is an apparent antennae-like attachment, most likely temporary and functionally detachable. This strapping technique indicates the same sort of functionability as the stern appendage fastenings.

With the profile of the ship well-established we have some basic dimensions assigned that are all derived from the proportionality as it exists in the original ship's painting and from the convincing degree of realism provided by the ancient artist. With twenty-one paddlers along the side requiring a reasonable working space for each we can logically establish a length between the hull's ends of 24 meters and a length on the waterline of 16.2 meters.

The missing dimension, breadth, can be derived empirically through the knowledge of conventional proportionality between waterline length and breadth. In this case the proportion from ships of antiquity, of which adequate examples exist, as well as sailing vessels of similar size generally. The sources include Egyptian tomb models, burial ships, and underwater archaeological finds all of which bracket the Thera time frame. The indication is clearly that the proportion (excluding war galleys) falls somewhere between 3.5 and 4.0 breadths to the length on the water. This is also consistent with the limits of modern sailing vessels under 25 meters. The Bronze Age sailors of the Aegean must have recognized and demanded a successful and ageless beam-to-length proportion for sailing capability. The beam at the waterline is thus 4.2 meters and the maximum beam is 5 meters.

The midsection of the Thera hull was also developed with an ancient inheritance, similar to Nile ships with a rather flat but flaring rise to the sides on a rounded bilge of good radius. Some dead-rise to the bottom was given amidships and increased toward the ends to favor the idea that an embryo keel form was possible and appropriate. This presumption is reinforced by the "Kas" ship discovery where planks in shell-tenon fastenings most functionally begin in a centerline timber even though it may be merely a heavier single center plank. The shape of the midbody sections develop toward both ends where the planks will naturally rise and at the same time meet in a "V" form ridge rather than the old spoon form of Egypt. This becomes then an exclusively "Aegean form". While it conforms to the progressive shipbuilding techniques of the era, it geometrically contributes to the structural strength in the hull for the sea requirements.

The hull form as shown in the three conventional projections is submitted with the lines drawing complete, as described. It is seen as a three-dimensional ship projection that provides a subject for dimensional criteria and limited analytic hypothesis.

As the ship is shown her dimensions are:

Overall length = 24.0 meters
Length on waterline = 16.2 meters
Draft of water = 1.0 meters

Beam extreme = 5.0 meters
Displacement = 24 tons
Sail area = 61.5 square meters

From these dimensions it is helpful to examine several coefficients:
The prismatic coefficient is 0.48
Displacement-length; $\Delta/(.01\times L)^3$ = 157.1
Sail area-displacement; SA/∇ 2/3 = 7.19

These values compared to those of other ships and boats of history, (actually so much later history that we are comparing ancient to modern), do make some notable statements. The first of worthy notice is the ***displacement-length*** ratio: it is a number without dimension that is telling us that among all vessels this ship of Thera is a light-displacement boat. Like a successful racing yacht where the contest is nearly assured in the boat of the least weight; modern values generally for highly efficient ocean racing vessels is between 150-190. And in the past this value for boats noted for speed, the fellucas, the war galleys, the clipper schooners, was always less than 200 where the average for merchant and cargo vessels is nearer 500.

It is all very well to have a low indicated displacement-length coefficient for great sailing potential but the vessel derives its sailing energy from the wind on the sail. The sail ***area-displacement*** coefficient of the Thera ship is comparatively very low. This is not surprising. There is but one sail and it is on a low mast and is also of a low aspect ration (sail's height÷mean width). Consequently the numerical coefficients computed and listed above quite probably confirm our visual presumptions. This vessel, essentially a sailing vessel for the Aegean and environs has potential for higher speed than can be realized with her low moderate single sail. The coefficients also tell us indirectly that with low prismatic coefficient (0.48) and with steering blades well aft that the vessel is highly maneuverable. Further, their relative lightness and the low moderate sail area indicate the practicability of operating cautiousty in the seasonal winds of this sea, at the same time being able to seek shelter easily while partially beaching sternward in shoaling water. These features perhaps have been assumed or presumed. But it is now possible, I believe, to depend upon the science of ship design for authoritative assurance.

The additional illustrations accompanying this paper are presented as further visual examples projected by a competent marine artist to depict the functional activity of some Minoan 1500 B.C. styled vessels.

Fig. 4 is of an undetailed but accurate scale model of the hull and rig which conforms to the lines and profile of Figures 2 and 3. It shows a very typical and satisfying hull shape, as described earlier, together with mast and yards and probable basic rigging. The rigging is workable using the halyard-eye lashings at the mast head of the fresco ships, allowing the yards to be braced freely around through 160° of arc. The lower yard forward braces lead through the deck-edge fair-leads, clearly evident in the fresco ship, which make possible the hardening down of an effective windward sail, shown in the artist's interpretive portrait in Figure 7.

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Figure:

1. Thera Fresco Ship - Archaeological Reconstruction, Prof. Spiridon Marinatos.
2. Dimensional profile of the Thera ship, T. Gillmer.
3. Thera Ship Hull Lines Draught. Reconstructed and developed T. Gillmer, 1982.
4. Scale Model of Thera Ship (from fig. 3) with basic rig. Model builder, Thomas Harsch, 1982.
5. Artist Rendering of Thera Ship with loading scene from stern platform, artist, William Gilkerson, 1982.
6. Construction of three-dimensional perspective of Thera ship under sail. T. Gillmer.
7. Artist's Rendering, Thera Ship at sea on hypothetical starboard tack, Artist, William Gilkerson, 1982.

8.-11. Artist's drawings of Thera-Minoan type boats in various operational activity, Artist, William Gilkerson.

Note: The artist, Mr. Gilkerson, together with the author developed the scenes of the renderings.

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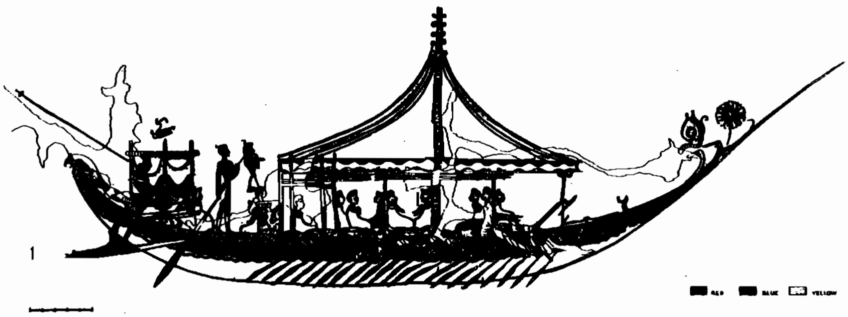

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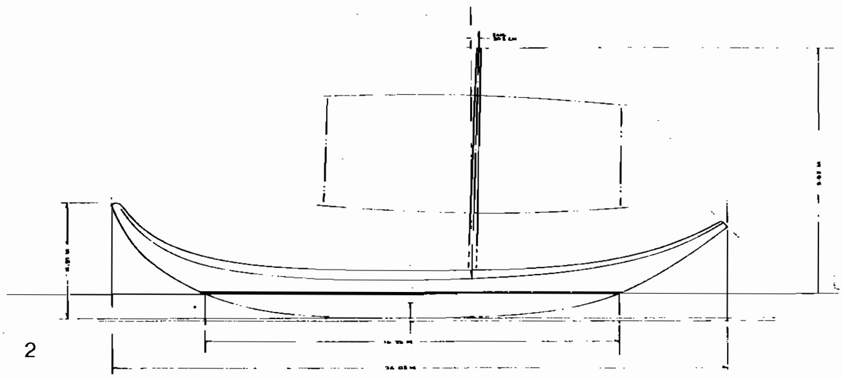

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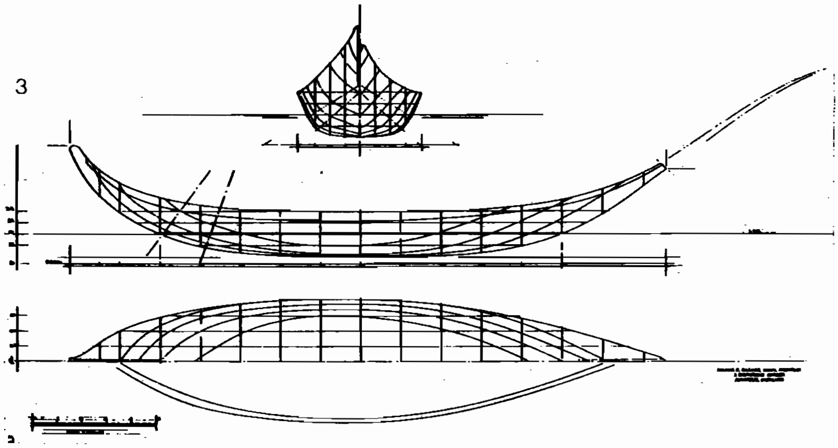

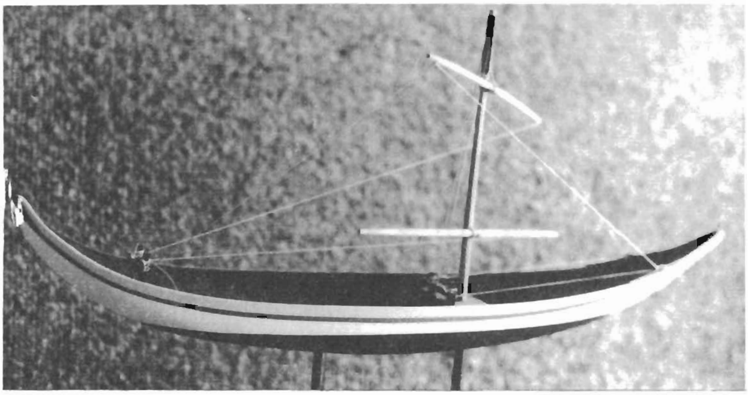

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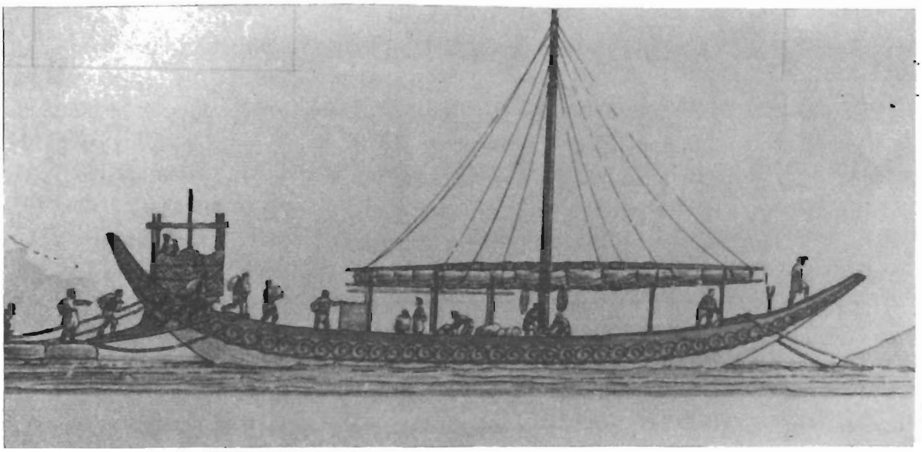

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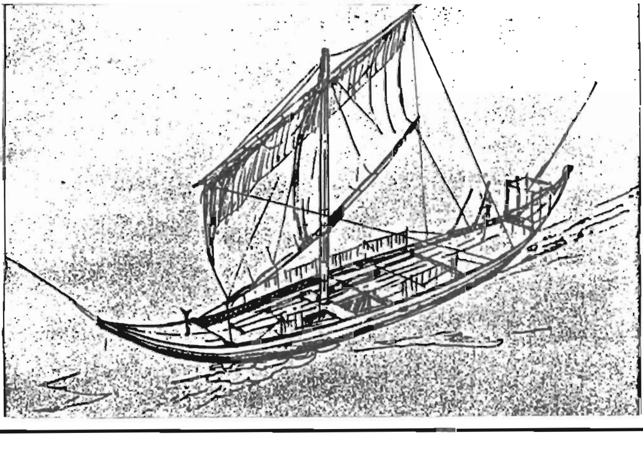

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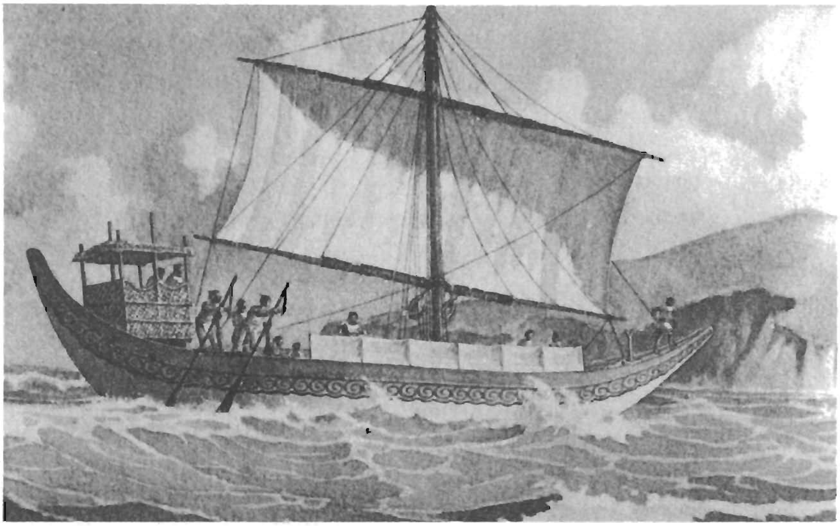
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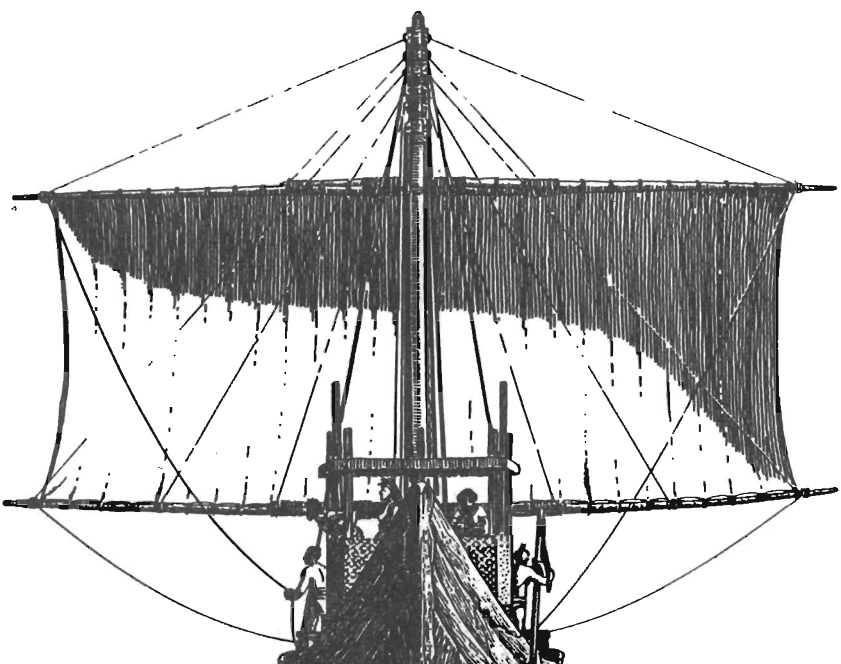
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