THE "KUPPELGRAB VON TIRYNS" AS A PARADIGM FOR THE USAGE OF MEASURING RODS AND ROPES IN PREHISTORIC GREECE.

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By reason of the similarities of Minoan and Mycenaean architecture in single forms, technical details, but especially in the typology of tombs, it is a question, whether there did exist a common planning procedure and an also common system of a linear measure in the eastern part of the Mediterranean during the Bronze Age.

J. W. Graham[1] postulated in 1960 a foot-measure ("Minoan foot") of about 0.91 m (0.303 m - 0.304 m, more exactly 0.3036 m) after trying vainly to fit his results of measurements to a cubit like the from Old Egypt wellknown length of about 0.523..m-0525 m (the so-called "royal cubit") or a cubit of about 0.45 m (the so-called "little cubit"). But this shorter cubit is only part (6/7) of the really cubit[2] that we now call "Egyptian cubit".

D.Preziosi[3] published his studies of the same theme in 1983. He presumes the presence of evaluated units which he also interprets as foot-measures, namely a "longer foot" (about 0.33 m - 0.34 m = about 1 m/3) and a "shorter foot" (about 0.27m - 0.28 m).

On the other hand the author did find references to the existance of the Egyptian cubit (more exactly 0.5236 m) in the relicts of Minoan palace-architecture. Already at the "Kolloquium zur Ägäischen Vorgeschichte" (Mannheim, 1986) he[4] could point out that there is a very strong consistence in the "measures" mentioned above as follows:

1.91 m (3 "longer feet" + 3 "Minoan feet')	:1.91 = 1 m (1.91 E)
1 m (1.91 E)	: 1.91 = 0.5236 m (1 E)
0.5236 m (1 E)	: 1.91 = 0.274 m (1 "shorter foot")

Therefore it seems likely that the cubit (E) is the really and only determinative measure in the Minoan palace-architecture.

Fundamental in the Minoan palace-architecture are, by the statement of the author, rectangles with the shorter side (1) and the longer side (2) double as big.

In early times of research Sir W.M.Flinders Petrie excavated some measuring rods in Egypt and published them in detailed form[5]. Unfortunately they are no longer traceable. Only one remained. It is now in the Science Museum, Exhibition Road, LONDON. The so-called El-Lahun measuring rod is wooden and yields incisions giving the lengths 38.2 cm, 20 cm, 10 cm and 9.1 cm besides others, as the author pointed out in his essay "Konstruktionsprinzipien der minoischen Palastarchitektur"[6]. Such rods and surely ropes - as we will see later - were used by Minoan and Mycenaean architects as well.

Preziosi interprets the length of, for example, about two metres as 6 "longer feet":

$$0.333 \text{ m} \times 6 = 2 \text{ m}.$$

In the interpretation of Graham this is 6.6 "Minoan feet':

$$0.303 \text{ m} \times 6.6 = 2 \text{ m}.$$

Preziosi's "shorter foot" (about 0.274 m) is connected with the cubit by the ratio 1.91, as was already shown.

These and similar measured lengths did seduce both scientists to the acceptance of foot-measures. But it will become obvious that in truth the usage of the cubit and the geometrical and constructive planning procedure, used in the investigated architecture, is the essential reason for the misleading interpretations mentioned above.

This will now be pointed out by the analysis of the "Kuppelgrab von Tiryns" as a paradigm (see Fig. 1 and Fig. 2):

Kuppelgrab von Tiryns in : Tiryns VIII (1975)

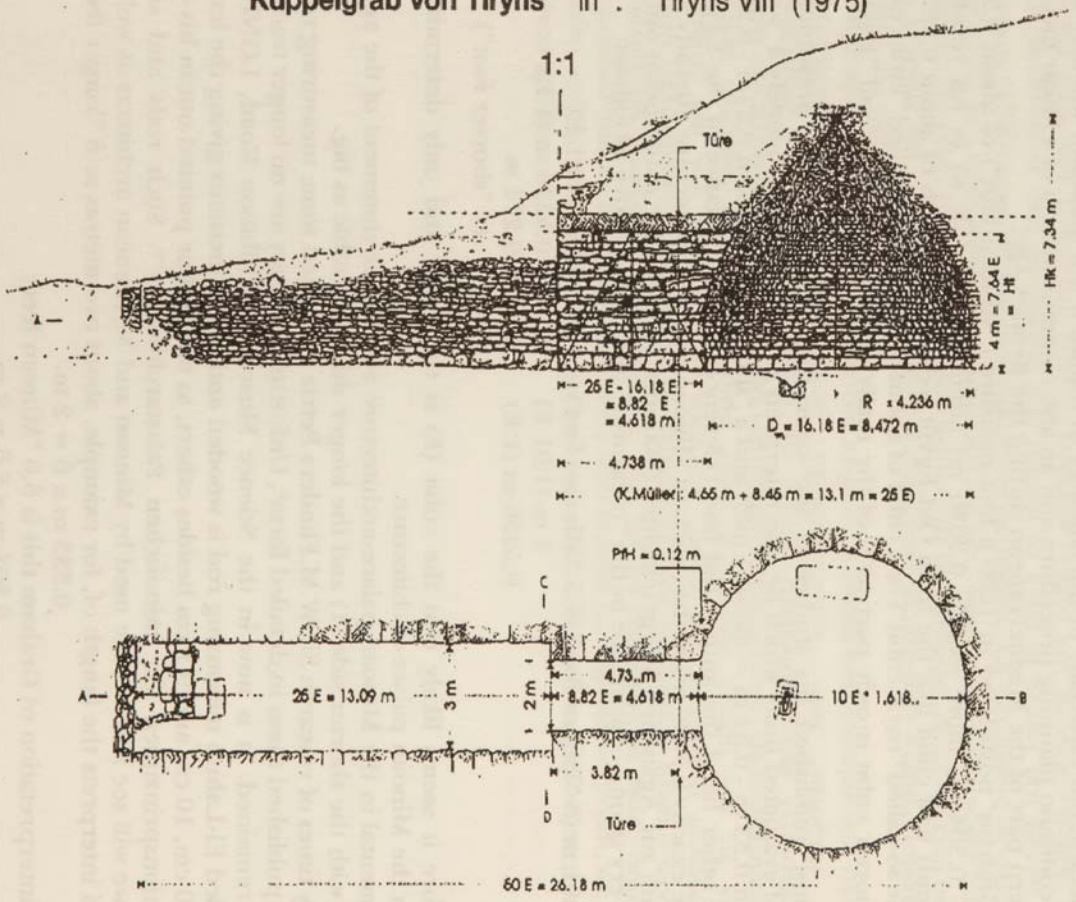

Fig. 1

In Accordance with K. Müller
(Plan by E. Samesreuther)

Das Kuppelgrab von Tiryns
The Planning Procedure of the Tholos Tomb of Tiryns
(Total Length of the Tomb : 2 x 25 cubits of 0.5236 m = 26. 18 m = 50 E)

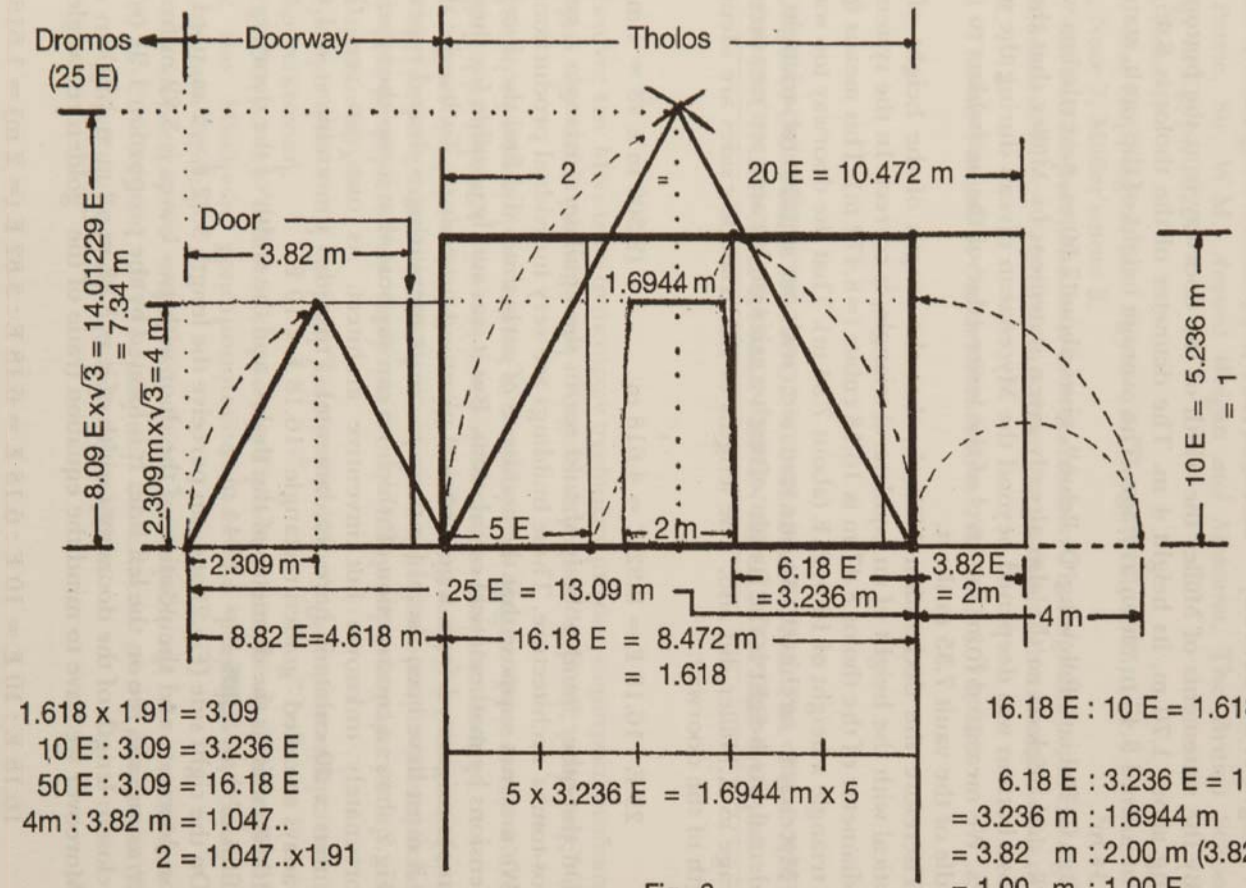

Fig. 2

This tomb was excavated in 1913. The excavation stood under the leadership of H. Dragendorff. One member of his team was Kurt Müller. Müller[7] gives a very good description of its architecture. An exact plan, made by E.Samesreuther in 1938, was added.

Fig.1 shows this plan with my interpretation in the system of the cubit (0.5236 m). The total length of the tomb is about 26.18 m = 50 cubits, divided in two equal parts:

length of the dromos = diameter of the tholos
+ length of the doorway = 25 cubits (13.09 m)

By the statements of Müller the width of the doorway is at the bottom 2 m, at the ceiling about 1.70 m, its height 4 m. The diameter of the tholos is 8.45 m - 8.50 m. We measured 8.47 m on an average. The average height of the vault, stated by Müller, is 7.34 m[8].

But C. Dobiat[9], following O. Pelon[10], gives about 7.50 m, nevertheless with question-mark, and neglects so the also already given statement by Müller that the level of the tholos's bottom was deepened beyond the Mycenaean niveau during the use in Roman times. We measured from the level of the lower edge of the basisshlars to the top at the middle of the vault 7.35 m short.

Therefore the declaration Müller's, that the length of the height of the vault is identical with the height of an equilateral triangle, is correct. In the system of the cubit the diameter of the tholos 8.47 m is 16.18 cubits (=8.472 m). This means for an equilateral triangle a height of 14.012..E (about 7.34 m). That the doorway too was planned by the Mycenaean architect, as one can see, with an equilateral triangle, can not be accidental. Its height is the height of such a triangle because we measured 4 m on an average as K.Müller did also. The lengths of this triangle's sides are identical with the length of the doorway:

$$25\ E - 16.18\ E = 8.82\ E = 4.618\ m \qquad (2.309\ m \times \sqrt{3} = 4\ m)$$

On the other hand nobody should see in the equilateral triangle a general rule of tholos-tombs' architecture. These buildings are very individual productions.

We may not suppose that the architects of early times did find the discribed accurate dimensions by mathematical calculations. But it was surely possible for them to measure distances originated from a geometrical planning procedure. To handle their architecture it must have been useful for them to create measuring rods and ropes.

Fig.2 shows a construction of which we can suppose that it was the special plan of the unfortunately unknown but inventive architect. As one can see, the rectangle 10 cubits x 20 cubits is here fundamental. From this the architect did construct the nowadays so-called "golden rectangle" 16.18 E x 10 E.

16.18 cubits is the diameter of the tholos, and the width of the doorway at the ceiling is a fifth of that: 3.236 E = 1.6944 m.

On the right side (Fig.2) one can perceive the length 3.82 E = 2 m, used for the width of the doorway, and the position of the door with two leaves is 3.82 m from the facade apart, as one can see on the left side. It is located by the proportion 1.91 (when the door was closed: length of the doorway / width of it = 3.82 m : 2 m = 1.91).

Moreover we have to mind the equation (ratio of the "golden rectangle"):

$$16.18\ E : 10\ E = 10\ E : 6.18\ E = 6.18\ E : 3.82\ E\ (= 2\ m) = 1.618$$

All mentioned lengths and measurements are to be found in this construction plan, and it seems quite sure that these accurate straight lines could only be handled with as needed new made wooden rods (and ropes). Finally we can conclude: the cubit measure (0.5236 m) and the constructive planning procedure, used by the Mycenaean architects, is the same that was used in the Minoan palace-architecture.

NOTES

1. Graham, J. W., «The Minoan Unit of Length and Minoan Palace Planning», *AJA*, 64, 1960, 335-341.
2. So already recognized by A. Schlott, *Die Ausmaße Ägyptens*, Diss. Tübingen, 1969, 62, note 1.
3. Preziosi, D., *Minoan Architectural Design*, 1983.
4. Kamm, W., «Konstruktionsprinzipien der minoischen Palastarchitektur», in *Schriften des Deutschen Archäologen-Verbandes*, IX, 1987, 28-40.
5. Flinders, Petrie, Sir, W.M., *Ancient Weights and Measures*, The British School of Archaeology in Egypt, 1926.
6. See above, Note 4.
7. Müller, K., «Das Kuppelgrab von Tiryns», in *Tiryns*, VIII, 1975, 1-4.
8. See above, Note 7, Müller's note 3.
9. Dobiat, C., «Zu den Maßverhältnissen in mykenischen Tholosgräbern», in *Beiträge Zur Ägäischen Bronzezeit*, Kleine Schriften aus dem Vorgeschichtlichen Seminar Marburg, H.11, 1982, 1-12.
10. Pelon, O., «Tholoi, Tumuli et Cercles Funéraires», *BEFAR*, 1976, 229.

ΠΕΡΙΛΗΨΗ

Ο ΘΟΛΩΤΟΣ ΤΑΦΟΣ ΤΗΣ ΤΙΡΥΝΘΟΣ ΩΣ ΠΑΡΑΔΕΙΓΜΑ ΓΙΑ ΤΗΝ ΧΡΗΣΗ ΜΕΤΡΗΤΙΚΩΝ ΣΧΟΙΝΙΩΝ ΚΑΙ ΡΑΒΔΩΝ ΣΤΗΝ ΠΡΟΪΣΤΟΡΙΚΗ ΕΛΛΑΔΑ

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Οι αρχιτέκτονες των Μινωϊκών ανακτόρων σχεδίαζαν με μία γεωμετρική διαδικασία, κάνοντας χρήση της -πολύ γνωστής στην Αρχαία Αίγυπτο- "κυβικής μέτρησης" (περ. 0.524m).

Η βάση για τη σχεδίαση ήταν κυρίως ένα ορθογώνιο σχήμα, διαστάσεων 100 x 50 "κύβων". Η χρήση μετρητικών σχοινιών και ράβδων πιθανολογείται επίσης.

Καθώς οι ομοιότητες μεταξύ Μινωϊκής και Μυκηναϊκής Αρχιτεκτονικής είναι προφανείς, ο συγγραφέας έκανε το 1998 μία συγκριτική μετρολογική ανάλυση θολωτών τάφων με ακριβείς μετρήσεις στην Κρήτη και στην Ελληνική ενδοχώρα με την ευγενή άδεια των Ελληνικών αρχών.

Το συμπέρασμα ήταν ότι η "κυβική"μέτρηση (0.524m) χρησιμοποιήθηκε και στην Μυκηναϊκή Αρχιτεκτονική.

Από το παράδειγμα του "θολωτού τάφου της Τίρυνθος" μπορεί να καταδειχθεί ότι οι αρχιτέκτονες των Μυκηνών χρησιμοποιούσαν τα ίδια βοηθήματα, όπως αυτά ανακαλύφθηκαν στην Κρήτη.

Γι' αυτό τον συγκεκριμένο τάφο, την βάση της σχεδίασης του απετέλεσε ένα ορθογώνιο 10 x 20 "κύβων". Η γεωμετρική διαδικασία που χρησιμοποιήθηκε καταδεικνύει την χρήση μετρητικών σχοινιών και ράβδων.