TEXTILE TOOLS FROM PHAISTOS, CRETE

A total number of 429 objects is recorded in the database (figures 1a and 1b). Both the object date and the context date were recorded for the objects. Depending on which of these dating systems we base our analysis on, we get slightly different results. This affects our interpretation of the textile production, especially the interpretation of the spindle whorls. We have therefore chosen to present both sets of results in order to achieve a differentiated but also more secure and representative interpretation of the textile production in Phaistos.

Object date	Loom weight	Spindle whorl	KS whorl	Conulus	Spool	Tablet	Stone Ring	Needle	In all
3800-1700	1								1
3500-3000		54							54
3000-2000?		1							1
3000-2000	1	26							27
3000-1600	1								1
2800-1700	1								1
2200-1900	2								2
2100-1600	1								1
1950-1700	108								108
1900-1850	1								1
1900-1750	1								1
1900-1450	4								4
1800-1700	2								2
1800-1600	5								5
1700-1600	1								1
1600-1450	5								5
1500-1450	30								30
1450-1400	4								4
1400-1250		1	1						2
1300-1200	3								3
1300-1150? Hell?		1							1
1300-1150		5	55	1	1				62
300-150	1								1
Neolithic		9					1		10
Neolithic?		1							1
Neolithic?EM?		2							2
Neolithic?Geometric?					1				1
FN		6							6
FN-minoan		1							1
Minoan	1	7		2			1	1	12
Minoan?		1							1
Minoan? Geometric?		1			2		1		4
EM		1					5		6
EM?	2	5							7
EM LM?		6							6
EM?II-III		2							2
Protopalatial		2							2
MM					1				1
MM IB?						1			1
MM II?		1							1
MM-LMI						1			1
MM? Myc?		1							1
LM	8								8
LM?	1								1
LM III			3						3
LM III?		1							1
LM IIIB?					1				1
LM IIIB-C					3				3
LM IIIB-C?					1				1
LM III?Geometric?		2			1				3
LM III? Hell?		1							1
LM III?Geom?Hell?		4							4
LH III/Hellenistic		1							1
Geometric		1			1				2
Hellenistic	3	2							5
Unknown	2	4		3			2		11
In all	189	150	59	6	12	2	10	1	429

Figure 1a. The total number of objects recorded in the CTR database based on object date.

Context date	LW	SpW	Ks whorl	Conulus	Spool	Tablet	Stone ring	Needle	In all
Neolithic		7					1		8
Final Neolithic		35							35
Final Neolithic?		1							1
Neolithic-Minoan?		1							1
Minoan	1	14			1		1	1	18
Minoan?					1				1
Minoan? Geometric							1		1
EM		1							1
EM?		1							1
EM II		2							2
EM II-III		4							4
EM III/MM IA	1								1
EM/MM	1								1
EM?MM?	1								1
Protopalatial	104								104
Protopalatial?	1								1
MM	2	8			2		3		15
MM I	1								1
MM IA	1								1
MM IB						1			1
MM II	5	9					2		16
MM II-III	5								5
MM III	1								1
MM-LM		1							1
MM-LM I						1			1
MM I-LM I	1								1
Post MM		3							2
Palatial	3								3
Neopalatial	1								1
LM I	4	4			1				9
LM IB	34								34
LM I-LM III			1						1
LM III		1	3						4
LM III?		1							1
LM IIIB	3		2						5
LM IIIB-C		3	15		6				24
LM IIIB-C?		1							1
LM III/Geometric	5								5
LM-Geometric		1							1
Geometric		11	5		1				17
Hellenistic	2	6	1						9
Mixed		1							1
Modern			1	1					2
Unknown	12	34	31	5			2		84
In all	189	150	59	6	12	2	10	1	429

Figure 1b. The total number of objects recorded in the CTR database based on context date.

Object date	LW	SpW	Ks whorl	Conulus	Spool	Tablet	Stone Ring	Needle	In all
3500-3000		54							54
3000-2000	1	26							27
2200-1900	2								2
2100-1600	1								1
1950-1700	108								108
1900-1850	1								1
1900-1750	1								1
1900-1450	4								4
1800-1700	2								2
1800-1600	5								5
1700-1600	1								1
1600-1450	5								5
1500-1450	30								30
1450-1400	4								4
1400-1250		1	1						2
1300-1200	3								3
1300-1150		5	55	1	1				62
300-150	1								1
Neolithic		9					1		10
FN		6							6
Minoan	1	7		2			1	1	12
EM		1					5		6
Protopalatial		2							2
MM					1				1
LM	8								8
LM III			3						3
LM IIIB-C					3				3
Geometric		1			1				2
Hellenistic	3	2							5
In all	181	114	59	3	6	0	7	1	371

Figure 2a Chronological distribution of the recorded objects based on object date.

As can be seen in figure 2a, 371 of 429 objects can be divided into different periods based on their object date. 58 objects have an uncertain object date such as "LM III? geom?" and are therefore excluded in the contextual analyses in this report. The object date as recorded in the database is sometimes relative, sometimes absolute. To make the tool analysis more transparent we have chosen to use only the relative dating system when presenting the results (figure 2b). We are aware of that this might not be the most optimal solution but the presentation would otherwise have become quite confusing.

FN	FN, Neolithic, 3500-3000
EM	EM, 3000-2000
MM	MM, Protopalatial, 1950-1700, 1900-1850, 1900-1750, 1900-1450, 1800-1700, 1800-1600, 1700-1600
LM	LM, 1450-1400, 1400-1250, 1300-1200, 1300-1150

Figure 2b. The dating system used in the analyses based on the recordings in the database.

Context date	LW	SpW	Ks whorl	Conulus	Spool	Tablet	Stone ring	Needle	In all
Neolithic		7					1		8
Final Neolithic		35							35
Minoan	1	14			1		1	1	18
EM		1							1
EM II		2							2
EM II-III		4							4
Protopalatial	104								104
MM	2	8			2		3		15
MM I	1								1
MM IA	1								1
MM IB						1			1
MM II	5	9					2		16
MM II-III	5								5
MM III	1								1
Palatial	3								3
Neopalatial	1								1
LM I	4	4			1				9
LM IB	34								34
LM III		1	3						4
LM IIIB	3		2						5
LM IIIB-C		3	15		6				24
Geometric		11	5		1				17
Hellenistic	2	6	1						9
Modern			1	1					2
In all	167	105	27	1	11	2	7	1	321

Figure 2c. Contextual chronological distribution of the recorded objects.

As can be seen in figure 2c, 321 of 429 objects are divided into different periods based on their find contexts. 108 objects are excluded in the contextual analyses in this report because, according to recordings in the database, they are from contexts that have an overlapping "date", for example MM I-LM I.

Date	Context		Spw	Ks whorl	Lw	Spool	Stone ring	Number
Final neolithic (3500-3000)	settlement	household	32				1	33
		workshop	1					1
		other	1					1
	palace	other	1					1
2200-1900	settlement	household			2			2
Protopalatial (1950-1700)	settlement	household			7			7
		other			1			1
	palace	household	1					1
		other	2		91			93
	other	other			1	1		2
1900-1450	settlement	household			1			1
	palace	other			2			2
1800-1600	palace	other			4			4
1700-1600	other	other			1			1
1600-1450	settlement	household			1			1
	palace	other			3			3
	other	other			1			1
LM Ib (1500-1450)	settlement	household			25			25
		workshop			1			1
	other	household			1			1
		other			4			4
LM IIIB-C	settlement	household	2	12	3	1		18
		other		2				2
	palace	other				1		1
	other	other		5		2		7
geometric	settlement	household	1					1
	palace	other				1		1
300-150	other	other			1			1
In all			**41**	**19**	**150**	**6**	**1**	**217**

Figure 2d. Chronological and contextual distribution of the recorded objects. Note that only objects with concurring object and context date are included.

Finally, 217 objects have the same object and context date (see figure 2d).

SPINNING AND SPINDLE WHORLS

150 spindle whorls, 59 Ks whorls and 6 conuli, in all 215 objects, are recorded in the dB as spinning tools. Four objects have been excluded by us as spinning tools (PHAE-b, PHAE-1214, PHAE-1216, PHAE-1051 see also comments in dB). Furthermore, 4 objects recorded in the dB as loom weights have been reclassified as spindle whorls (PHAE-0065, PHAE-0105, PHAE-0106, PHAE-0107 see also comments in dB). To conclude, 215 objects from Phaistos are considered to have had a function as spindle whorls.

Material and type

As can be seen in figure 3, material and type are available on 212 whorls. The majority of the spindle whorls are made of clay (198 whorls) and they are generally biconical or cylindrical in shape. 15 spindle whorls are made of stone and they are generally discoid in shape (figure 3). Just one whorl is made of bone.

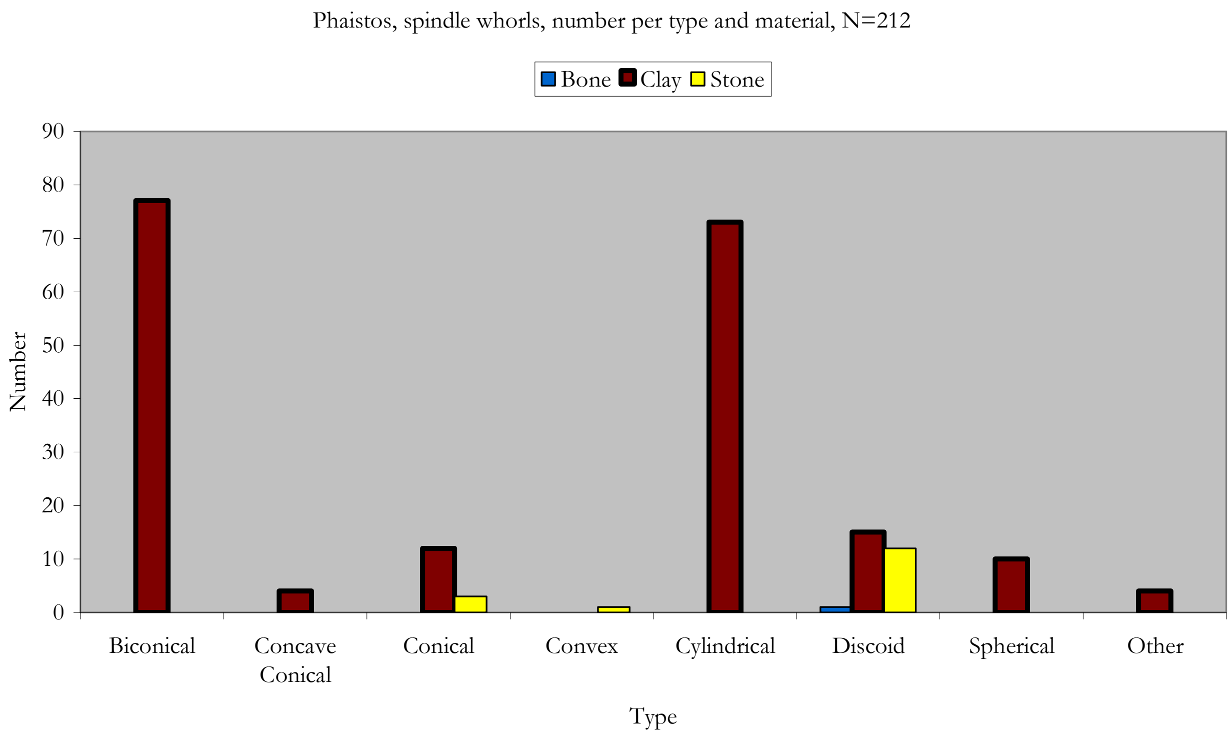

Figure 3. The relationship between type and material.

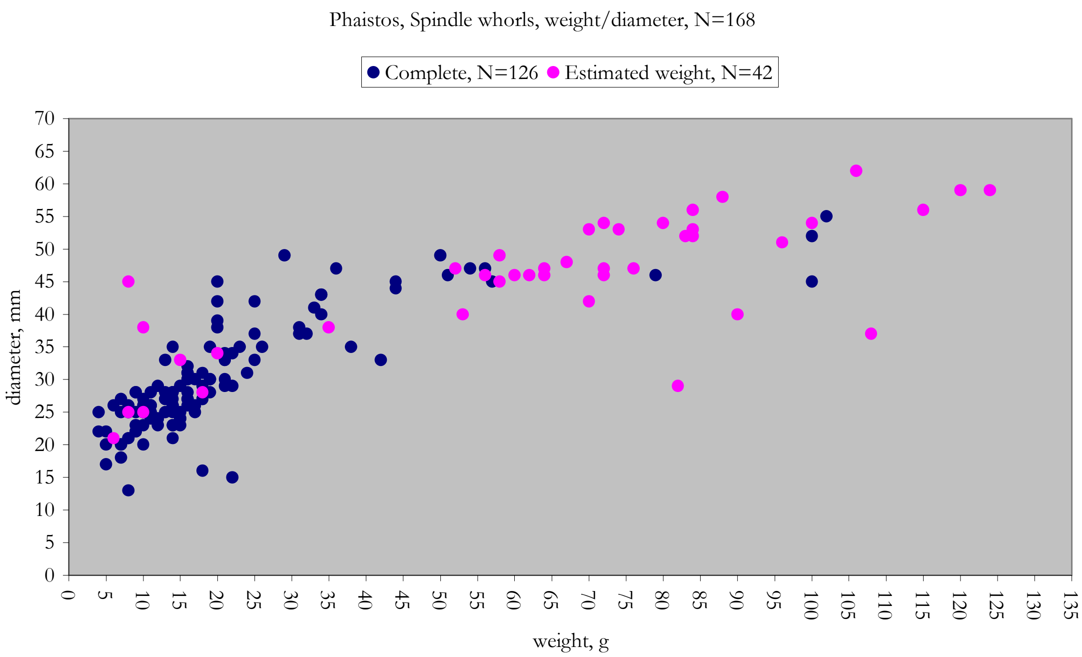

Figure 4. Complete and slightly fragmentary spindle whorls.

134 spindle whorls are completely preserved. For 76 other whorls their weight has been estimated: 38 are half preserved, 14 have small fragments missing, 4 are partially fragmentary, and, finally, 20 are just fragmentarily preserved. A comparison between the complete whorls (134 objects) and whorls with an estimated weight and a preserved diameter (56 objects, the fragmentary whorls have been excluded) demonstrates that they do not always fall within the same weight range (figure 4). However, we do not

estimate the margin of error in the calculation of weight to be more than 10% (1g for a whorl weighing ≤10g, 2g for a spindle whorl weighing ≤20g and so on). A variation of 10% would not have affected the finished product of the whorl and we have therefore decided to include the whorls with an estimated weight in this study.

The weight, diameter and material are recorded on 189 spindle whorls. There is no clear relation between the material of the whorls and the spindle whorls' weight/diameter, although the clay whorls display a larger variation in both weight and diameter (figure 5).

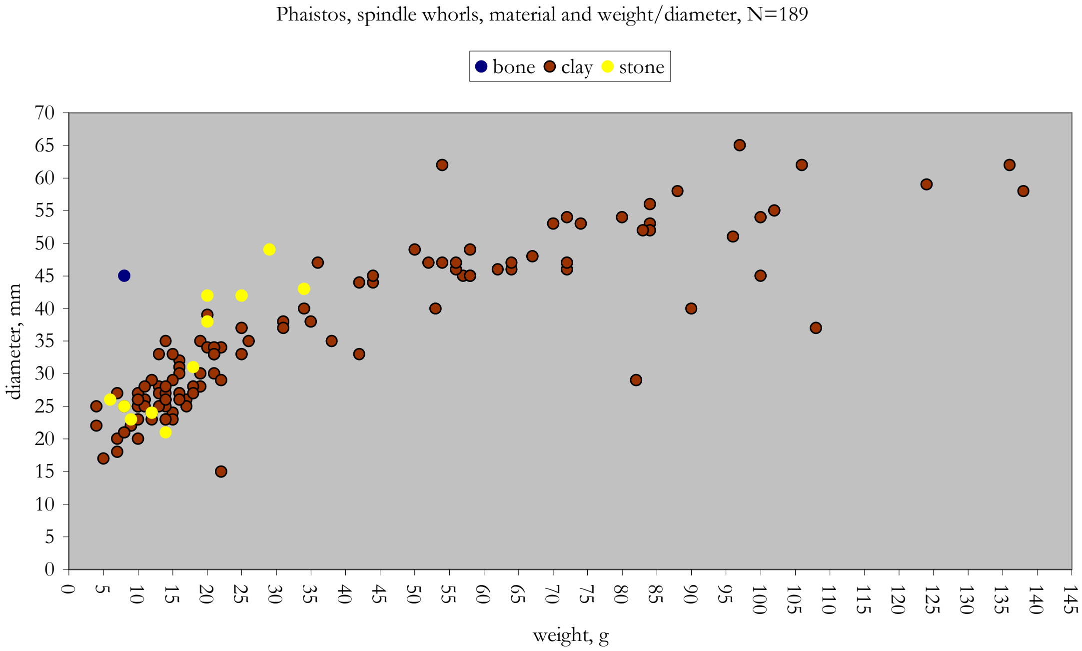

Figure 5 The relationship between material and weight/diameter.

The weight, diameter and the type are recorded on 184 spindle whorls. As can be seen in figure 6, the biconcial spindle whorls are in general both heavier and bigger than the other types.

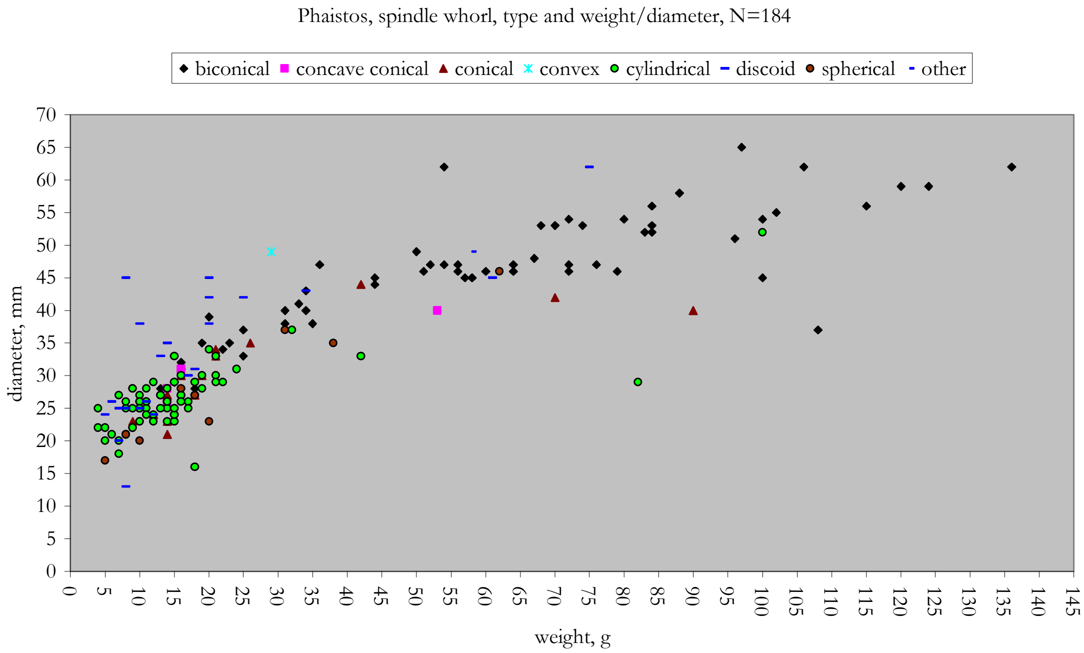

Figure 6. The relationship between type and weight/diameter.

SPINNING IN PHAISTOS - CONTEXT AND OBJECT DATE: SIMILARITES AND DIFFRENCES

Depending on which dating system (object or context date) we use we get slightly different results. It is important to demonstrate this and to discuss these results and how they affect our interpretation of textile production in Phaistos. Note that we have chosen to use relative chronology and not absolute chronology (figure 2b).

When comparing object and context date with type and material, the analysis clearly demonstrates three differences (figure 7a and 7b)

1. 52 biconical spindle whorls are, according to object date, from FN, while only 31 biconical spindle whorls have actually been found in FN layers, according to the context date.
2. 54 cylindrical spindle whorls have an LM object date, while only 17 have an LM context date.
3. No spindle whorls are from MM according to the object date, while 17 were found in an MM context, according to the context date.

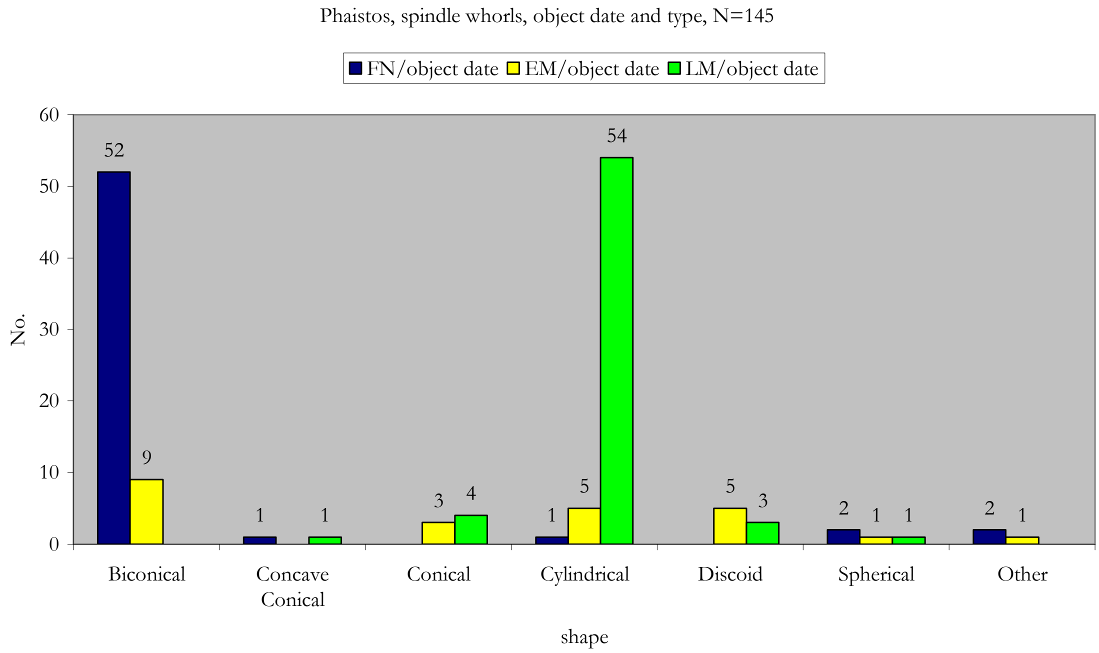

Figure 7a. Spindle whorls, object date and type/no.

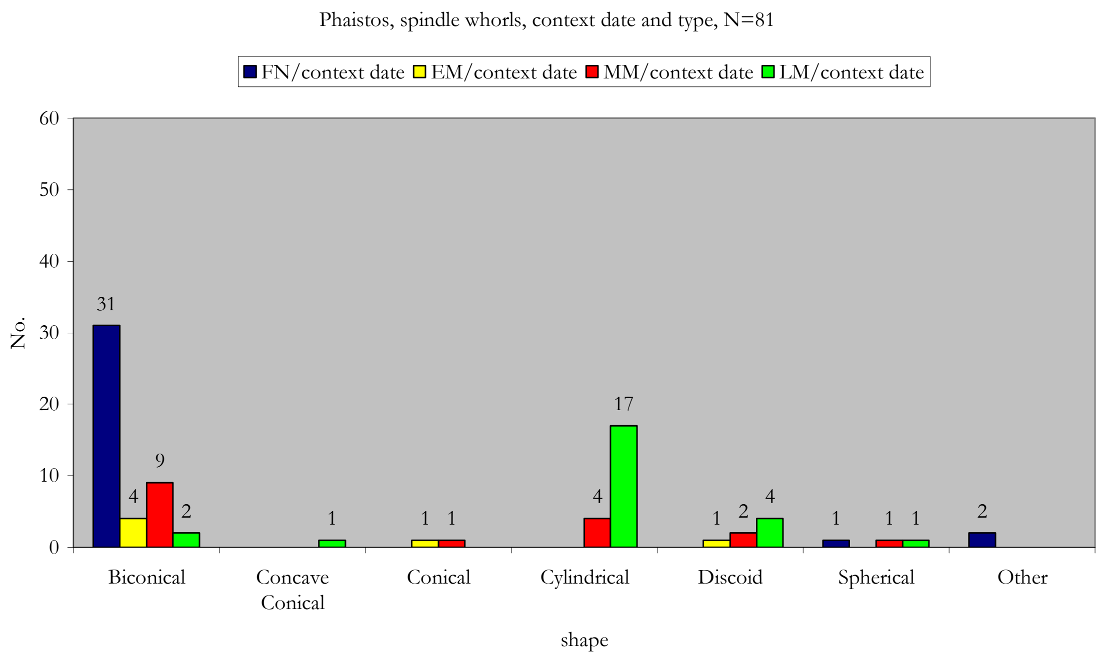

Figure 7b. Spindle whorls, context date and type/no.

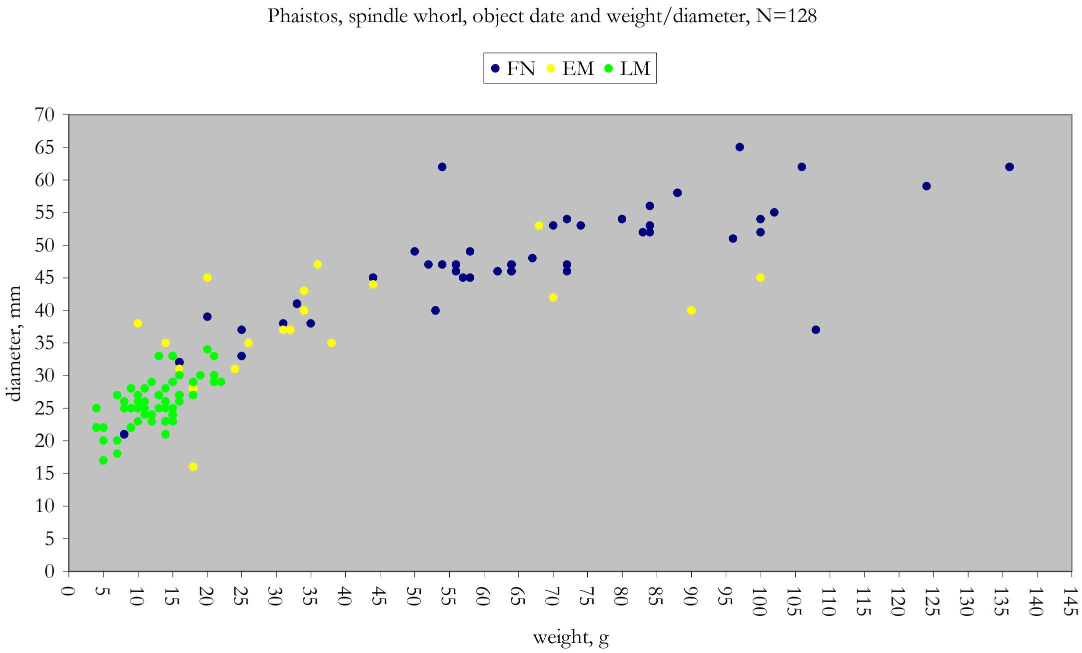

Figure 8a. Spindle whorls, object date and weight/diameter.

Object date (figure 8a)

The analysis of the spindle whorls' object date and weight/diameter demonstrates that the thread qualities during FN vary from thin to very thick. The weight of the FN whorls varies from 8g to 138g and their diameter varies from 21 mm to 65 mm. The majority of these spindle whorls is, however, weighing more than 50g, indicating a production with primarily thick spun yarn. 9 whorls are weighing less than 50g, indicating a production of thinner spun yarn as well. The FN spindle whorls are thus characterised by a great variation in production.

The weight of the spindle whorls from EM varies from 8g to 105g and their diameter varies from 16 mm to 48 mm. The variations in weight within the group of spindle whorls from this period decrease compared to the previous FN period, but still the spinners from Phaistos spun many different types of thread, from thin to very thick. There is a slight increase in the variation of diameter in EM suggesting that the spinners produced both hard and loosely spun thread. The majority of the EM spindle whorls weigh less than 50g indicating an emphasis of the production of thinner threads compared to FN.

No spindle whorls have an MM object date.

The spindle whorls from LM vary in weight from 4g to 22g and the diameter varies from 17 mm to 34 mm. The analysis indicates a relatively varied production from thin to very thin yarn, although compared to the FN and EM the production is quite narrow. The thread spun with the lightest whorls (below 8g) would be thinner than the yarn spun with the heaviest spindle whorl. The very thin type of yarn would demand well prepared raw materials and the spinners had to be experienced. The fabrics produced with these thin threads would have taken a considerable time to make.

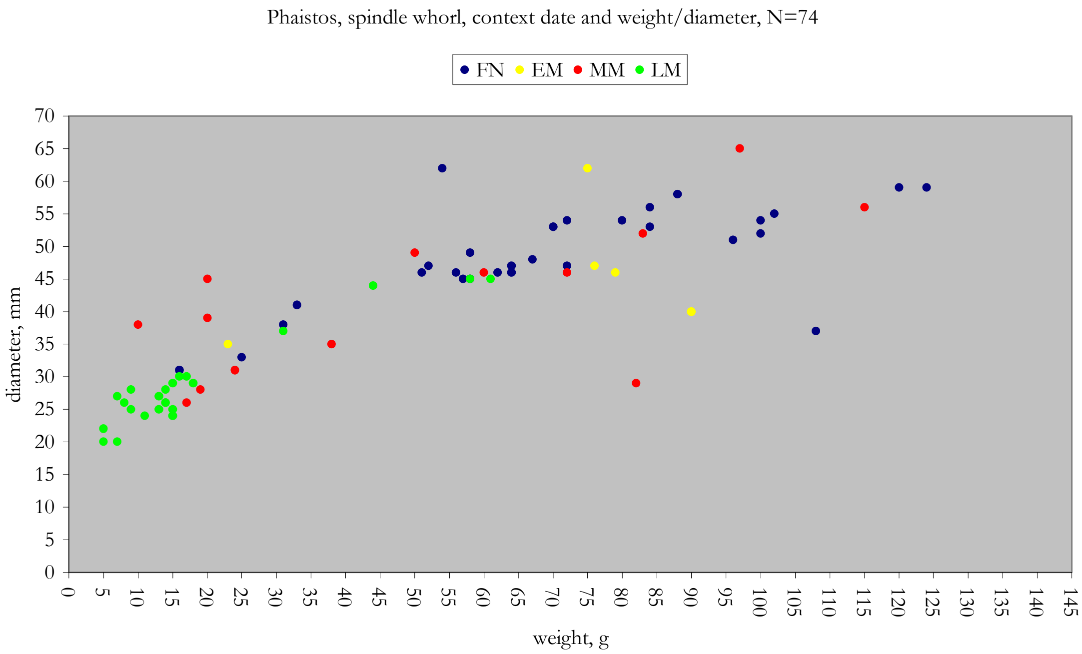

Figure 8b. Spindle whorls, context date and weight/diameter.

Context date (figure 8b)

The analysis of the spindle whorls made on the basis of the context date demonstrates that the thread spun during FN varied from thin to very thick. The weight of the FN spindle whorls varies from 16g to 124g and the diameter varies from 31 mm to 62 mm. The majority of the spindle whorls are weighing more than 50g (only four whorls are weighing less), indicating a varied production with emphasis of thicker yarn.

Only 5 EM spindle whorls have a preserved weight and diameter. The spindle whorls' weight varies from 23g to 90g and the diameter varies from 35 mm to 62 mm. The variations in the weight and diameter of the EM spindle whorls decrease compared to the previous FN period, but still EM the spinners from Phaistos spun different types of thread, from relatively thin to very thick. However, four out of the five EM spindle whorls are weighing more than 50g, indicating a production of primarily thicker yarns.

According to the context date, 17 spindle whorls, out of which 14 spindle whorls have a preserved weight and diameter, are dated to MM. The weight varies from 10g to 115g and the diameter varies from 26 mm to 65 mm indicating a very varied production with several qualities of yarn from thin to very thick. However, no distinctive clustering in weight classes is visible, although there is a vague tendency for a group of the MM spindle whorls to cluster around 20 g. The variation in the weight and diameter of the MM spindle whorls is greater than the EM whorls, and not unlike the FN whorls.

The spindle whorls from LM vary in weight from 5g to 61g and the diameter varies from 20 mm to 45 mm. The analysis indicates a varied production with an emphasis on yarn from very thin to thin yarn but also some thicker yarn. The thread spun with the lightest whorls (below 8g) would be much thinner than the yarn spun with the heaviest spindle whorl. The thin type of yarn would demand well prepared raw materials and the spinners had to be experienced. The fabrics produced with these threads would have taken a considerable time to make. The slight emphasis on the thinner qualities observed in MM is more outspoken in LM, but there is still a variation in the production from thicker threads to finer.

Conclusion

The analyses demonstrate that there is a change in the production of spun yarn from FN to LM, but the exact distribution patterns vary significantly depending on whether we use the spindle whorls' object date or context date.

	Object date	Context date
FN	Thin to very thick spun yarn Primarily thick	Thin to very thick spun yarn Primarily thick
EM	Thin to very thick spun yarn Primarily thin	Thin to very thick spun yarn Primarily very thick
MM	-	Thin to very thick spun yarn No concentration
LM	Very thin to thin spun yarn Primarily very thin and thin	Very thin to thick spun yarn Primarily very thin to thin

Figure 9. Summary of the different results derived from using either the object dates or the context dates.

The analysis of both of object date and context date demonstrates that there is a change in production from FN to LM. The yarn produced during FN was in general thicker while the yarn during LM in general was thinner The general trend is that the emphasis moved over time from thicker threads to thinner threads and towards a more specialised production, with less variation. The analysis based on the context date, however, demonstrates a degree of variation in production during the LM, which is completely lacking in the analysis based on the object date. The greatest differences between the two dating systems, however, are visible in the periods EM and MM. The object date results suggest a production of primarily thin thread in EM and no production at all in MM, whereas the context date results demonstrate primarily very thick yarn in EM and a varied production in MM.

WEAVING AND LOOM WEIGHTS

189 loom weights are recorded in the dB. 4 objects recorded in the dB as loom weights have been reclassified as spindle whorls (PHAE-0065, PHAE-0105, PHAE-0106, PHAE-0107 see also comments in dB). Furthermore, 12 spools and 10 stone rings are recorded in the dB as 'Other Textile Tools' and they can also be considered as loom weights. To conclude, 207 objects from Phaistos are considered to have had a function as loom weights.

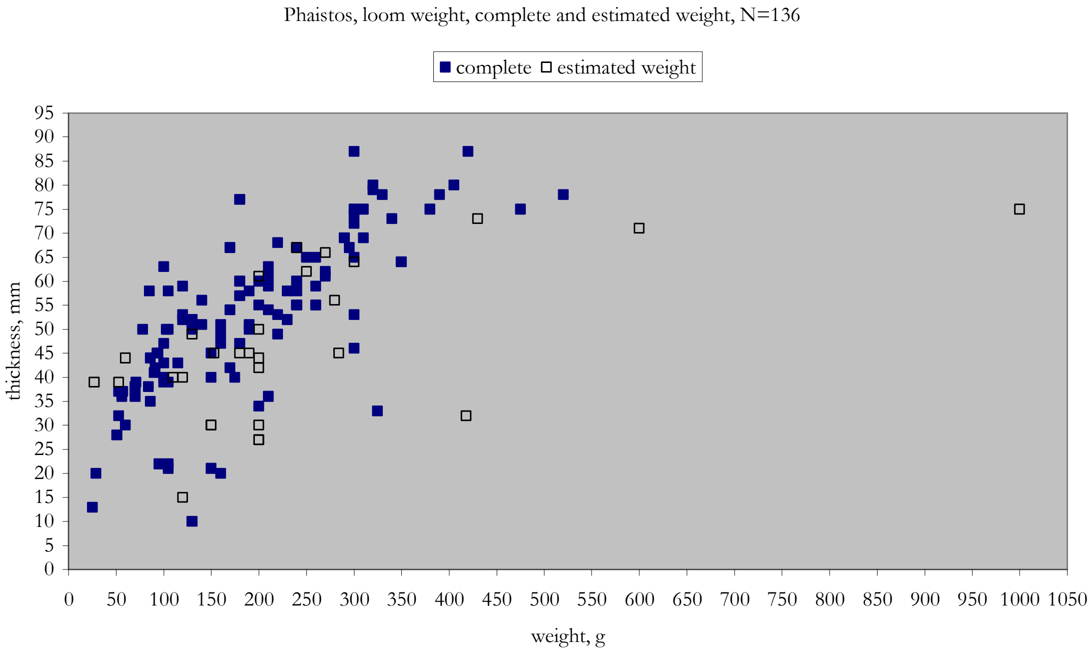

Figure 10. Complete loom weights and loom weights with an estimated weight. With 'thickness' we refer to the measurement that affects the loom setup (see p. 5 in the introduction). In dB this measurement has been recorded in different ways depending on which type of loom weight is recorded, and we have therefore chosen to include data that is not recorded as 'thickness' but rather what is actually the part of the loom weight that affects the loom setup and the fabric.

Complete and estimated weight

107 loom weights are completely preserved. For 34 other weights the weight has been estimated: 15 are half preserved, 5 have small fragments missing, 9 are partially fragmentary, and finally 10 are just fragmentarily preserved. A comparison between the complete loom weights (99 objects) and weights with an estimated weight but preserved diameter (29 objects, the fragmentary loom weights have been excluded) demonstrates that they, with one exception (PHAE 0123), fall within the same weight range (figure 10). We do not estimate that the margin of error in the calculation of weight would have affected the finished product and we have therefore decided to include the loom weights with an estimated weight in this study.

The weight, thickness and type are recorded on 137 loom weights. The majority of the loom weights have a cylindrical or a spherical shape (figure 11), and are made of fired clay. There is no clear relation between the shape of the weights and the loom weights' weight/thickness (figure 11).

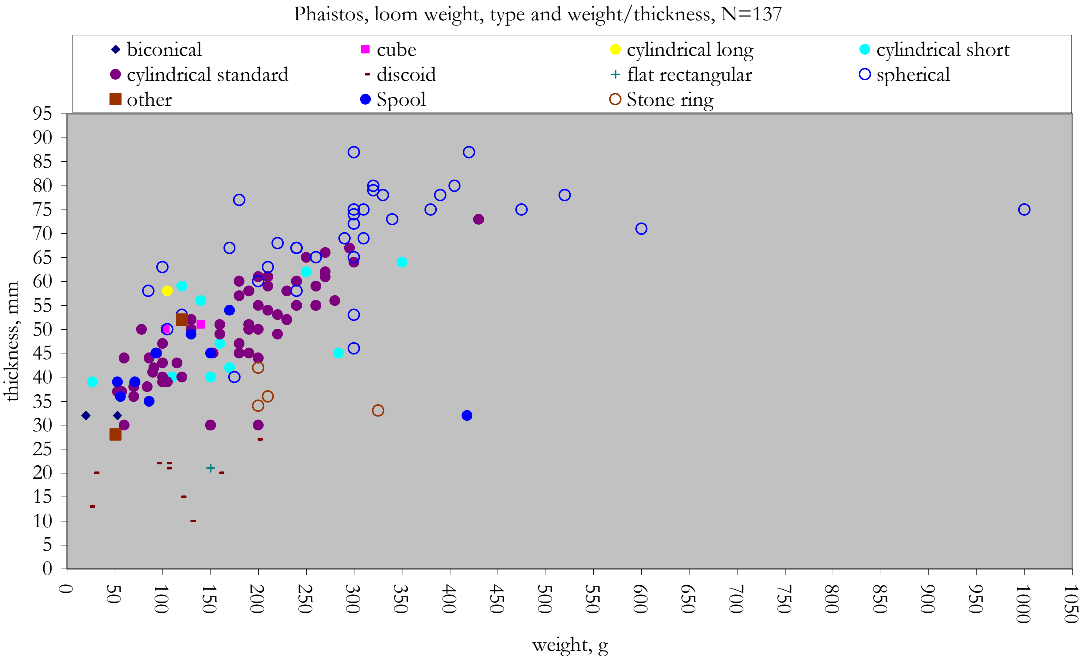

Figure 11. The type and weight/thickness of the loom weights.

WEAVING IN PHAISTOS DURING THE PROTO-PALATIAL AND LM IB PERIODS

In the following analysis we have chosen to focus only on loom weights with identical object date and context date, and on periods containing more than 5 weights. Only two contexts/periods fulfil these criteria: the Proto-palatial period 1950-1700 B.C. and the LM Ib period 1500-1450 B.C. with findings from the settlement area.

		fired clay	unfired clay	stone
1950-1700	biconical			1
	cube	1		1
	cylindrical long	1		
	cylindrical short	9		
	cylindrical standard	70	2	1
	spherical ovoid	2		1
	spherical rounded	2		1
	other		1	2
1500-1450	cylindrical standard	2		
	spherical ovoid	4		
	spherical rounded	23		
In all		**114**	**3**	**7**

Figure 12. The date and type/material of the loom weights.

As can be seen in figure 12, the majority of the loom weights from the Proto-palatial period is cylindrical and made of fired clay, while the loom weights from LM Ib are mostly spherical but also made of fired clay.

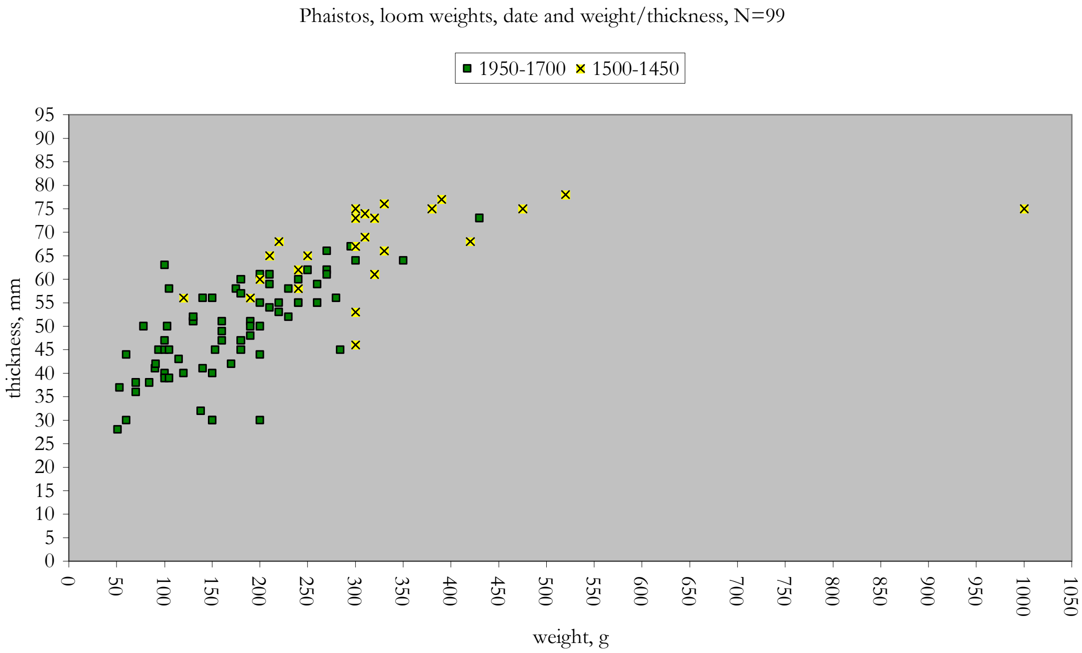

Figure 13. Loom weights, date and weight/thickness

It is not only the type that differs between these two periods but also weight and thickness. The LM Ib loom weights are in general larger and thicker than the loom weights from the Proto-palatial period.

PROTO-PALATIAL - 1950-1700 B.C.

To elucidate our interpretation of the loom weights we have calculated four possible loom setups on the basis of four Proto-palatial loom weights and suggested which fabrics we consider the most likely result. We have chosen 4 cylindrical loom weights from the palace area weighing 53g, 180g, 295g and 430g, respectively. Please note that these suggestions are based on our experience and experiments but are on the other hand conjectural as to what is optimal.

Loom weight PHAE 0091: weight 53g, thickness 28 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	5	2-3		
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	10	4-6		
Warp threads per cm	2-3	1-2		
TTTC's evaluation of suitability of the tool	Unlikely	Unlikely	Unlikely	Unlikely

Figure 14. Calculation of possible loom setups with loom weight PHAE 0091

The calculation demonstrates that no warp thread tension would function well with loom weight PHAE 0091 (figure 14). This loom weight is too light to function as a loom weight in a warp weighted loom (see discussion below).

Loom Weight PHAE 0033: weight 160g, thickness 51 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Number of threads per loom weight	16	8		
Number of threads per two weights (one in front layer, one in back layer)	32	16		
Warp threads per cm	5	2-3		
TTTC's evaluation of suitability of the tool	TTTC choice	Unlikely	Unlikely	Unlikely

Figure 15. Calculation of possible loom setups with loom weight PHAE 0033

The calculation demonstrates that loom weight PHAE 0033 would function best with a warp thread requiring 10g tension (A) (figure 15). The fabric produced with this loom setup would have had 5 threads per cm in warp and weft (if weft faced up to 10 threads per cm in weft). This fabric would be very open (figure 16).

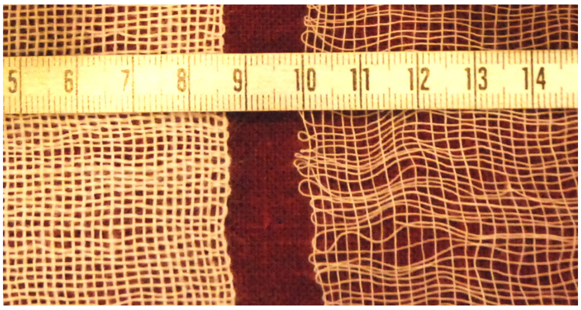

Figure 16. Two fabrics with threads requiring (left) 20g warp tension with approximately 6 warp threads per cm and 7 weft threads per cm, and (right) 10g warp tension with approximately 5 warp threads and 8 weft threads per cm

When focusing on TTTC choice A (figure 15), we suggest the following loom setup:

Loom setup (PHAE-0033) calculated on 10g warp tension
Starting border (width of the fabric): 100 cm
Number of loom weights needed: 32
Numbers of warp threads: 500 threads, 2 m each=1000 m
Weft 1: if a balanced tabby = 1000 m
Weft 2: if a weft faced tabby = 2000 m
Total amount of yarn with weft 1 (+ 2%) = 2040 m
Total amount of yarn with weft 2 (+ 2%) = 3060 m

The calculations also demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 58-87 hours to spin the thread needed to produce the fabric in this setup. Time for sorting and preparing the fibres is not included, neither is time for preparing the setup, weaving and finishing.

The type of fabric that could have been produced with this loom weight would have been quite open and veil like (if it was not woven as a weft faced fabric).

Loom weight PHAE 0062: weight 295g, thickness 67 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	29-30	15	9-10	
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	58-60	30	18-20	
Warp threads per cm	8-9	4-5	3	
TTTC's evaluation of suitability of the tool	TTTC choice	Possible	Unlikely	Unlikely

Figure 17. Calculation of possible loom setups with loom weight PHAE 0062.

The calculation demonstrates that loom weight PHAE 0062 would function best with a warp thread requiring 10g tension (A) (figure 17). The fabric produced with this loom setup would have had 8-9 thread per cm in warp and weft (if weft faced 16-18 threads per cm in weft). Also a warp thread of 20g tension (B) is a possibility for PHAE 0062. The fabric produced with this loom setup would have had 4-5 thread per cm in warp and weft (if weft faced 8-10 threads per cm in weft).

The types of fabrics that could have been produced with this loom weight (A and B) would be of very fine quality. However, the fabrics would visually be completely different. The first fabric, woven with a warp thread requiring 10g tension (A) would be denser while the second fabric (B) would be more open. If the fabrics were weft faced they would differ even more (figure 18).

When focusing on TTTC choice A (figure 17), we suggest the following loom setup:

Loom setup (PHAE-0062) calculated on 10g warp tension
Starting border (width of the fabric): 100 cm
Number of loom weights needed: 30
Numbers of warp threads: 900 threads, 2 m each=1800 m
Weft 1: if a balanced tabby = 1800 m
Weft 2: if a weft faced tabby = 3600 m
Total amount of yarn with weft 1 (+ 2%) = 3672 m
Total amount of yarn with weft 2 (+ 2%) = 5508 m

The calculations demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 104-157 hours to spin the thread needed to produce the fabric in this setup. Time for sorting and preparing the fibres is not included, neither is time for preparing the setup, weaving and finishing.

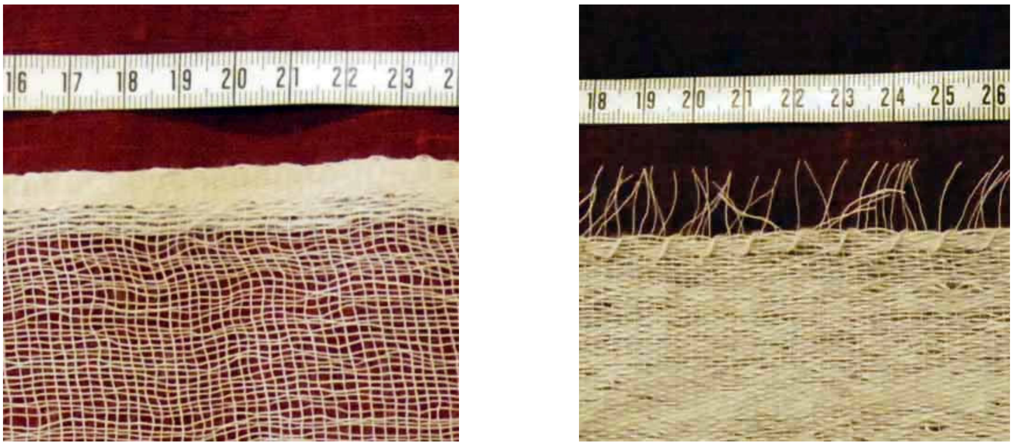

Figure 18. Two fabrics, both woven with threads requiring 10g warp tension. Left: a tabby with app. 5 warp threads per cm and 8 weft threads per cm. Right: a weft faced tabby with app. 6 warp threads per cm and 15 weft threads per cm. The spools that were used in this experiment weigh in average 100g and have a thickness of 40 mm (Mårtensson *et al.* 2006).

Loom weight PHAE 0015: weight 430g, thickness 73 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	43	21-22	14	10-11
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	86	42-44	28	20-22
Warp threads per cm	11-12	5-6	4	3
TTTC's evaluation of suitability of the tool	Unlikely	TTTC choice	Possible	Unlikely

Figure 19. Calculation of possible loom setups with loom weight PHAE 0062.

The calculation demonstrates that loom weight PHAE 0015 would function best with a warp thread of 20g tension (B) (figure 17). The fabric produced with this loom setup would have had 5-6 thread per cm in warp and weft (if weft faced 10-12 threads per cm in weft). Also a warp thread of 30g tension (C) could function. The fabric produced with this loom setup would have had 4 threads per cm in warp and weft (if weft faced 8 threads per cm in weft).

When focusing on TTTC choice B (figure 19), we suggest the following loom setup:

Loom setup (PHAE 0015) calculated on 20g warp tension
Starting border (width of the fabric): 100 cm
Number of loom weights needed: 28
Numbers of warp threads: 600 threads, 2 m each= 1200 m
Weft 1: if a balanced tabby = 1200 m
Weft 2: if a weft faced tabby = 2400 m
Total amount of yarn with weft 1 (+ 2%) =2448 m
Total amount of yarn with weft 2 (+ 2%) =3672 m

The calculations also demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 61-91 hours to spin the thread needed to produce the fabric in this setup. Time for sorting and preparing the fibres is not included, neither nor time for preparing the setup, weaving and finishing.

Conclusion on Proto-palatial loom weights

Cylindrically shaped loom weights are the most common type of loom weight recorded in the database from this period, but the weight and the thickness varies within this group (figure 13). The cylindrical loom weights are functionally comparable to spools. In the TTTC research program two weaving tests have demonstrated that it is possible to use spools as loom weights (Mårtensson *et al.* 2007). The spools tested in these experiments weighed 100g and 285g, and so the experiments still leave the important question whether spools weighing below 100g could function as weights in a warp weighted loom. In Phaistos 12 cylindrical loom weight have a weight below 100g.

As can be seen in figure 14, this low weight can not be considered optimal for loom weights in a warp weighted loom as such. Attaching less than 4 warp threads to one single loom weight is impractical, sometimes even counterproductive. The thickness of the cylindrical loom weights also becomes essential because consequently, if using a light but thick weight the fabric will become very open, which is usually not desirable in a fabric; therefore we consider this setup (figure 14) unlikely on a warp weighted loom. On the other hand, these types of cylindrical weights can be very useful as weights for tablet weaving, where one adds two to four threads per tablet or for other types of band weaving and braiding (see Gleba forthcoming). Also the fabric woven with a loom setup with cylindrical weights with a weight of 160g and a thickness of 51 mm (figure 15) would become quite open and veil like (if it was not woven as a weft faced fabric) while the fabric woven with weights like in the last example (figure 19) could be woven more densely or with thicker threads.

To conclude: cylindrical loom weights (and other loom weight types) with a weight under 100g and with a wide thickness would not function optimally as loom weights on the warp weighted loom.

Furthermore, the analysis demonstrates that the cylindrical loom weights from the palace in Phaistos are suitable for a production of fabrics woven with very thin to thin threads. Only the heaviest weight would have been functional when producing coarser fabrics.

LM IB - 1500-1450 B.C.

The 24 loom weights from this period differ from the loom weights from the Propto-palatial period in shape, weight and thickness (figures 12 and 13). They are also from household contexts, whereas the previous Proto-palatial loom weights were from a palace context.

To elucidate our interpretation of the loom weights we have calculated possible loom setups on the basis of three weights and suggested which fabrics we consider the most likely result. We have chosen three spherical loom weights from the household contexts weighing 120g 300g, and 520g respectively. Please note, that these suggestions are based on our experience and experiments but are on the other hand conjectural as to what is optimal.

Loom weight PHAE 0131: weight 120g, thickness 56 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	12	6		
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	24	12		
Warp threads per cm	4	2		
TTTC's evaluation of suitability of the tool	Possible	Unlikely		

Figure 20. Calculation of possible loom setups with loom weight PHAE 0131

The calculation demonstrates that loom weight PHAE 0131 could possibly function with a warp thread requiring 10g tension (A) (figure 20). The fabric produced with this loom setup would have had 4 threads per cm in warp and weft (if weft faced 8 threads per cm in weft). But for the reasons discussed above, we would not consider this weight an optimal loom weight.

Loom weight PHAE 0121: weight 300g, thickness 73 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	30	15	10	
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	60	30	20	
Warp threads per cm	8	4	3	
TTTC's evaluation of suitability of the tool	TTTC choice	Possible	Unlikely	

Figure 21. Calculation of possible loom setups with loom weight PHAE 0121

The calculation demonstrates that loom weight PHAE 0121 would function with a warp thread requiring 10g tension (A) (figure 21). The fabric produced with this loom setup would have had 8 threads per cm in warp and weft (if weft faced 16 threads per cm in weft).

Also a warp thread of 20g tension (B) could function. The fabric produced with this loom setup would have had 4 threads per cm in warp and weft (if weft faced 8 threads per cm in weft). The two types of fabrics (A and B) that could have been produced with this loom weight would be of very fine quality, quite open and veil like. However, the fabrics would visually be different, and if the fabrics were weft faced they would differ even more.

When focusing on TTTC choice A, (figure 21) we suggest the following loom setup:

Loom setup (PHAE-0121) calculated on 10g warp tension

Starting border (width of the fabric): 100 cm
Number of loom weights needed: 26
Numbers of warp threads: 800 threads, 2 m each=1600 m

Weft 1: if a balanced tabby = 1600 m
Weft 2: if a weft faced tabby = 3200 m
Total amount of yarn with weft 1 (+ 2%) = 3264 m
Total amount of yarn with weft 2 (+ 2%) =4896 m

The calculations demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 93-139 hours to spin the thread needed to produce the fabric in this setup. Time for sorting and preparing the fibres is not included, neither is time for preparing the setup, weaving and finishing.

Loom weight PHAE 0122: weight 520g, thickness 78 mm				
	A	B	C	D
Warp threads requiring	10g warp tension	20g warp tension	30g warp tension	40g warp tension
Numbers of warp threads per loom weight	52	26	17	13
Numbers of warp threads per two loom weight (one in front layer, one in back layer)	104	52	34	26
Warp threads per cm	13	6-7	4	3
TTTC's evaluation of suitability of the tool	Unlikely	TTTC choice	Possible	Unlikely

Figure 22. Calculation of possible loom setups with loom weight PHAE 0122

The calculation demonstrates that loom weight PHAE 0122 would function with a warp thread requiring 20g tension (B) (figure 22). The fabric produced with this loom setup would have had 6-7 threads per cm in warp and weft (if weft faced 12-14 threads per cm in weft).

Also a warp thread of 30g tension (C) could function. The fabric produced with this loom setup would have had 4 threads per cm in warp and weft (if weft faced 8 threads per cm in weft). Two types of fabrics (B and C) could have been produced with this loom weight. However, the fabrics would visually be different and if the fabrics were weft faced they would differ even more (figure 18). If the 30g tension (C) thread was used, the fabric would be quite coarse.

When focusing on TTTC choice B (figure 22), we suggest the following loom setup:

Loom setup (PHAE-0122) calculated on 20g warp tension
Starting border (width of the fabric): 100 cm
Number of loom weights needed: 26
Numbers of warp threads: 700 threads, 2 m each=1400 m
Weft 1: if a balanced tabby = 1400 m
Weft 2: if a weft faced tabby =2800 m
Total amount of yarn with weft 1 (+ 2%) = 2856 m
Total amount of yarn with weft 2 (+ 2%) =4284 m

The calculations also demonstrate that the amount of yarn needed is substantial. According to the TTTC experiments it would take approximately 71-107 hours to spin the thread needed to produce the fabric in this setup. Time for sorting and preparing the fibres is not included, neither is time for preparing the setup, weaving and finishing.

Conclusion on LM 1B loom weights

The analysis demonstrates a production of fabrics primarily produced with very fine to fine threads and in many different qualities depending on 1) the type of yarn, 2) if it was a balanced tabby or a weft faced tabby, and finally 3) the weights' weight and thickness. The calculations of the heaviest spherical loom weight PHAE 0122 also demonstrate that it was possible to produce coarser textiles. Furthermore, some of the lightest and thickest loom weights, e.g. PHAE 0131, would not function optimally as a weight in a warp weighted loom.

WEAVING IN PHAISTOS, A SUMMARY

The calculations and the analysis demonstrate that during both the Proto-palatial period and LM Ib fabrics with primarily very thin or thin threads were produced. Several of the suggested fabrics are quite open and veil like.

It is interesting that there are only few findings of loom weights before 1950 B.C. It is likely that another type of loom had been in use in the previous periods, and it is possible that the weavers in Phaistos continued to use this/these type(s) of loom(s) for e.g. coarser textiles since the analysis of the looms weights excavated so far demonstrates a production of primarily finer fabrics. The visible production during the Proto-palatial period demonstrates high quality textiles that 1) demanded well prepared raw material, 2) were time consuming to produce (compared to coarser textiles) and 3) demanded skilled crafts people. The context is of course very interesting since the Proto-palatial loom weights are from the palace. But even more interesting is that the production reflected in the loom weights during LM Ib is basically the same type of production but now in a household context.

TEXTILE PRODUCTION IN PHAISTOS

The number of objects is relatively small when comparing different contexts and periods and therefore the analysis cannot be considered statistically representative. However, the analysis clearly demonstrates certain tendencies that most be discussed.

During FN there are finds of spindle whorls but no loom weights. The analysis of the spindle whorls demonstrates a production of primarily quite thick threads that could have been used for the production of coarser textiles.

The number of spindle whorls from EM is small but here one must note the differences that arise by using the two dating systems. The object date demonstrates a production of mostly thin spun yarn while the context date shows a continuous pattern of production of thicker yarns from the previous period (FN). There are no findings of loom weights from EM so it is impossible to interpret which types of fabrics the weavers in Phaistos produced.

During MM there are, according to object date, no findings of spindle whorls at all, while the context date demonstrates a production of many different types of thread from thin to very thick. If the MM context date is the most reliable the lightest whorls (of which some are from the palace context) could have been used to spin the thread needed to weave the different qualities of fabrics that were produced according the analysis of the loom weights. It is also clear that if these whorls were used as spindle whorls during MM, the spinners could also have spun very thick threads for coarser textiles.

The production suggested required a substantial amount of yarn in different qualities. The time it took to produce the thread differs much depending on the type and size of the textile. In the examples discussed above the time consumption for spinning the yarn, 58 hours at least and 157 hours at most, presumably also indicate the value of these textiles. The production of the finest fabrics would have taken a considerable period of time to make and demand well prepared raw materials, even-spun threads and a developed knowledge on weaving techniques. From our experience, we can also add that the setup and weaving with many thin threads is much more time consuming than the setup and weaving of a coarser fabric.

From LM there are finds of both spindle whorls and loom weights. The spindle whorls, however, are foremost dated to LM II-III and the loom weights to LM Ib. The analysis indicates a varied production with several qualities of yarn from very thin to thin yarn, but also thicker yarn could have been spun. This result supports the analysis of the loom weights, despite the slight difference in time.

It is also very interesting that the production during MM and LM is very similar. There are nevertheless two major differences. During MM the majority of the loom weights has a cylindrical shape while during LM most the loom weights are of a spherical shape. This difference, however, is not of a functional character, i.e. the change in shape is not connected to a change in the production pattern. During both periods the majority of the weights is considered to have been made in a good or medium production quality. The other difference is that during MM the loom weights are from the palace area and during LM they are from the household area. This suggests a change in the organisation of production.