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Typological and Quantitative Approach to the Ancient Weight Systems. Susa, Persian Gulf and Indus Valley from the End of the III Mill. to the Beginning of the II Mill. BC*

§ 1. Introduction

Among archaeological classes of artifacts, weights constitute a distinguished realm of research. They anticipated some methodological problems, that only in the second half of the XXth century other archaeological categories have considered. However, a long period of standstill followed those first uncertain though dynamic steps towards an interpretative perspective of valuable analyses. In that static phase scholars continued to apply methodological patterns established in the past, that resulted to be no longer able to answer the new historiographical, ethno-anthropological and archaeological questions.

The most used kind of analysis on ancient metrology was conceived in 1838 by August Böckh. In his work "Metrologische Untersuchungen über Gewichte, Münzfüsse und Masse des Altertums in ihrem Zusammenhang", he established the so-called "vergleichende Metrologie", which mainly consists in the study of the relationships among different weight systems. In spite of the criticism raised by F. H. Weissbach (Weissbach 1907) and O. Viedebantt (Viedebantt 1917) the vergleichende Metrologie still represents one of the bases of many metrological studies.

This comparative approach to the ancient Near Eastern weight systems must be supported by rigorous methodological criteria which define comparisons between weight classes and, at the same time, permit the identification of multiples and sub-multiples of a single system.

* This paper presents the preliminary results of a quantitative evaluation of the Susa and Indian corpus of weights. This subject had been presented in a poster exhibited in the 43rd Rencontre Assyriologique Internationale at Prague (July 1–5, 1996). Both the authors collected in a Data Base Management System 944 weights with all the information found in the original publications. § 1 and § 2.2 is by E. Ascalone; § 2.1 and § 3 is by L. Peyronel; the conclusion is by E. Ascalone and L. Peyronel.
We wish to express our gratitude to Paolo Matthiae and Frances Pinnock for their suggestions and encouragement. We are particularly grateful to Nicola Parise, which has discussed this article with us.

This paper is aimed to identify unit values of weights taken into consideration by studying shapes and materials used in two different areas, Susiana and Indus Valley, that had closed economical contacts. Furthermore, since this goal can be grasped only by a larger comparison, a distributive analysis of the Persian Gulf weights is included, trying to underscore connections between geographical areas cited above. Four representative centers have been sampled: Susa for the Susian Plain, Harappa, Mohenjo-daro and Chanhu-daro for the Indus Valley.[1]

Mere numerical data visualized in tables and charts are used to understand the possible relations existing among weight systems, shapes and materials, in order to contribute to the historical evaluation of the commercial role of the two regions.

The total number of weights taken into consideration is 944. They were examined according to 27 different categories of intrinsic (i.e. shape, material, weight of the object) or extrinsic (i.e. site, archaeological context) information. Here, only their provenance, chronological period, shape, material, absolute weight, unit value and the weight system are examined during the time span from the end of the IIIrd millennium to the beginning of the IInd millennium BC (ca. 2300–1700 BC).[2]

Precise chronological determinations is hampered by stratigraphical records available from the excavation reports, mostly published in the Thirties. Hence, only the materials from precisely established chronological context are include in the sample.

As regards shapes and materials we adopted the description published in the excavation reports. Instead, weight systems are re-analyzed in concordance with the metrological classes present in the IIIrd and IInd mill. BC, as result from the new metrological studies.

For the Mesopotamian and Indian systems there are no problems of chronological diffusion and of identification of their unit value (respectively gr 8,40 and gr 13,65); on the contrary difficulties might rise as regards the so-called "Egyptian system" and "Syrian system" (gr 9,40, gr 7,80). But it has been recently demonstrated that both systems were already used in Syria during the Early Bronze Age.[3]

The so-called "Anatolian system" (unit value: gr 11,70), was used outside the Khatti region also before Shuppiluliuma first campaign in Syria and it was

[1] The authors are preparing a study which takes into consideration the whole Iranian and Indian corpus in relation to the commercial network of the IIIrd and IInd Millennium BC.

[2] There are several reasons to investigate only this time span: first of all, this is a period of important commercial relations between Susiana and the Indus Valley, rising from the Akkadian economical policy and developing also because of the receptivity of the Indian market; moreover the weights are scarcely represented before and after the period taken into analysis.

[3] The specimens found at Byblos (Dunand 1958, p. 246, n. 6566, p. 188, n. 2955), Gözlü Küle (Goldman 1956, p. 275, n. 129), Tell Sweyhat (Holland 1975), Ebla (Archi 1987a) and the upper Tigris area with Tepe Gawra (Speiser 1935, p. 92, n. 22), testified the knowledge of these weight systems before the Late Bronze Age. Finally they were attested at the same period at Ebla (Archi 1987a) from Early Bronze Age IVA to the end of the Middle Bronze Age (ca 2400–1600 BC), in spite of A. De Maigret objections (De Maigret 1980, pp. 161–169).

known in Tarsus and Byblos during the Early Bronze Age, as N. Parise have satisfactorily demonstrated.[4]

It is possible to identify five weight systems, which are typical of five different geographical and cultural regions but not necessarily used only in the area they were originated. Therefore, for our work the terminologies used are only conventional and they do not always reveal the geographical area where the weight was used.[5]

We gave to the Mesopotamian and Indian system a limit value, beyond which the weights were not classified as belonging to that system. Then we pointed out the mean values of each weight system as described in the following scheme (see also Tab. 5).[6]

	Limits (gr)	Unit Value (gr)
Indian	13,00–14,20	13,65
Mesopotamian	8,10–8,60	8,40
Syrian	/	7,80
Egyptian	/	9,40
Anatolian	/	11,70

§ 2. Quantitative analysis: materials, shapes and systems

2. 1. The Indus Valley corpus

The publications of the Mohenjo-daro, Chanhu-daro and Harappa excavations before the Second World War supplied the basic archaeological data about the

4 D. Arnaud proposed to identify the Anatolian system in Syria only after Shuppiluliuma's conquest when the Aleppo-Karkemish region was under the Hittite control (Arnaud 1967, pp. 151–169). His study deals with the weights found in the stratigraphical sequence of Alalakh. However, N. Parise identifies some weights of this system, in Byblos and Tarsus, in the Middle Bronze Age layers (Parise 1970–71, pp. 27–29; see also Parise 1984).

5 W. M. F. Petrie considered the unit value of gr 9,40 as an Egyptian system: it appeared, for the first time, in the Nile Valley during the XII Dyn. and it became the most used weight system in the XVIII Dyn. (Petrie 1926). Subsequently archaeological activities in Syria demonstrated that the so-called "Egyptian system" was used during the Early Bronze Age. We will use Petrie's terminology only for convenience and not to indicate the Egyptian origin of this unit weight. The so-called "Egyptian" shekel of gr 9,40 was probably originated in the Syrian coastal area, while the "Syrian" shekel of gr 7,80 was the standard unit of the Inner Syria from the Early Bronze Age.

6 W. M. F. Petrie identified the following system weights and their limits: *Peyem* gr 7,38–8,10, *Daric* gr 8,10–8,60, *Stater* gr 8,60–8,91, *Qedet* gr 8,91–9,87, *Necef* gr 9,60–11,00, *Khoirine* gr 11,00–12,20, *Beqà* gr 12,20–14,00 (Petrie 1926).

Indus Valley civilization: they constitute still today the starting point for every analysis of the Harappan material culture.[7]

The quantitative analysis is based on a data-base of 702 specimens: 364 from Mohenjo-daro, 215 from Harappa and 117 from Chanhu-daro. All the information was taken from the original excavation reports (see above, § 1). In the following pages we provide the results of the main cross-tabulations regarding shapes, materials and systems.[8]

Materials (Chart 1). Indications about the materials are available for 481 weights: 240 from Mohenjo-daro, 206 from Harappa and only 34 from Chanhu-daro. There are a variety of materials but the lack of mineralogical analysis makes sometimes the evidence doubtful. In some cases only the colors of the stones are indicated, following a rather subjective criterion.[9]

The simple bar-graph shows the percentages of the different stones used in the three sites. It appears evident that in the Indus Valley there was an absolute predominance of chert or banded chert (from 69 to 73%).[10] The other stones are rather occasional but the percentages of agate (from 1,9 to 4,6%) and limestone (from 7,5 to 9,2%) reveal an intentional choice of the Indian craftsmen. Limestone was a very common stone, generally adopted for heavy weights: in fact the manufacture of this stone is rather easy, especially for simple spherical or cubical objects like weights. Chert and limestone are the most used materials and their percentage is very similar in the three sites, revealing a strong homogeneity probably connected with common administrative structures of management. However, chalcedony seems to be the second material used at Chanhu-daro (12%), while it is virtually absent at Mohenjo-daro and Harappa.[11]

Shapes (Chart 2). Indications about shapes are available for 516 weights: 245 from Mohenjo-daro, 203 from Harappa and 58 from Chanhu-daro. Mohenjo-daro is the site with the greatest variety of shapes: H. S. Hemmy identified 8

[7] For a useful short outline of the Harappan civilization see now Franke-Vogt 1995 with previous bibliography. For more detailed works see Allchin – Allchin 1982; Possehl 1979; 1982; 1993.

[8] The information is taken from Hemmy 1931; 1938b; 1943; Vats 1940, pp. 360–366. For a preliminary quantitative evaluation of the Harappan system of the three sites (502 weights; without those listed in Hemmy 1931) see Hendrickx-Baudot 1972.

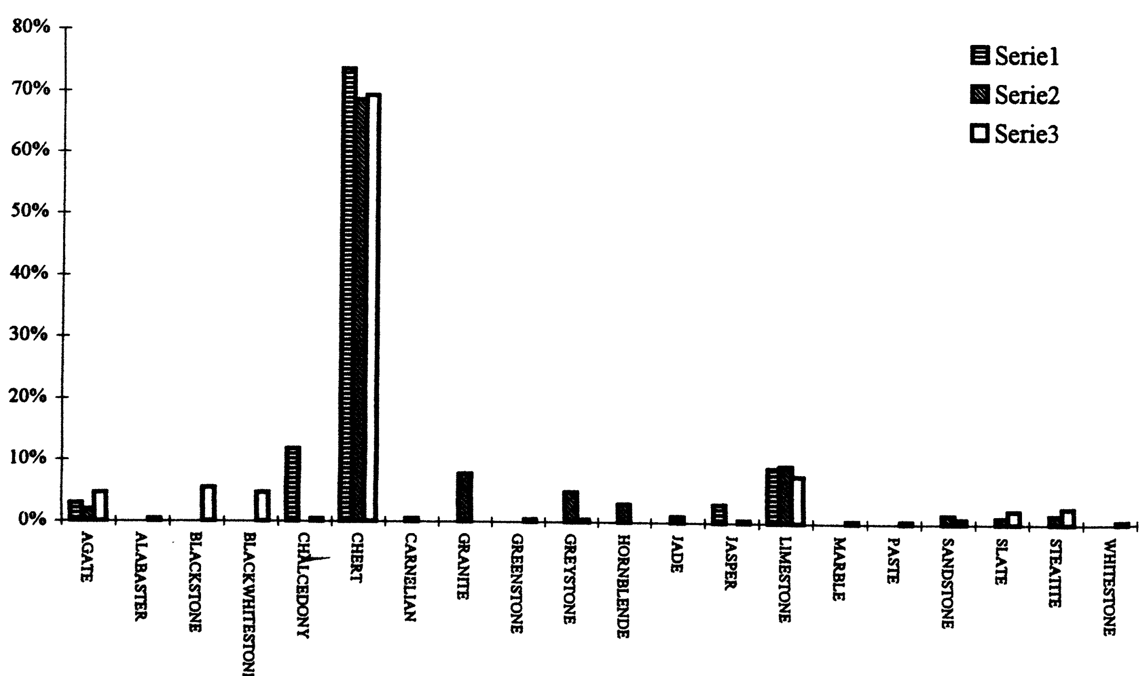
[9] I.e., this particular problem involves the Mohenjo-daro weights, which include 13 specimens of "black stone" and 11 of "black-white stone". Could these stones be hematite? Of course it is not possible to answer this question, but it is interesting to observe that some black stone weights are possibly related to the Mesopotamian system as $^{1}/_{2}$, 3, 4, 5 shekels. Moreover, two of these are barrel-shaped, stressing another significative link with the Mesopotamian alluvium.

[10] For a brief mineralogical description see Hendrickx-Baudot 1972, note 2.

[11] Out of 34 weights with indicated material, 25 are made of chert, 4 of chalcedony, 1 of agate, 3 of limestone and 1 of jasper. The corpus is scanty, but the evidence seems statistically significative: for example, out of 240 specimens from Mohenjo-daro only 1 is made of chalcedony. Nevertheless, this semi-precious stone is similar to agate (agate is a variety of chalcedony) and could be confused with it.

CHART 1: Indian weights (materials)

	Serie 1 Chanhu-daro	Serie 2 Harappa	Serie 3 Mohenjo-daro
AGATE	2,94%	1,94%	4,58%
ALABASTER			0,41%
BLACKSTONE			5,41%
BLACK-WHITE ST.			4,58%
CHALCEDONY	11,76%		0,41%
CHERT	73,52%	68,44%	69,16%
CARNELIAN		0,48%	
GRANITE		7,76%	
GREENSTONE			0,41%
GREYSTONE		4,85%	0,41%
HORNBLENDE		2,91%	
JADE		0,97%	
JASPER	2,94%		0,41%
LIMESTONE	8,82%	9,22%	7,50%
MARBLE			0,41%
PASTE			0,41%
SANDSTONE		1,45%	0,83%
SLATE		0,97%	2,08%
STEATITE		1,45%	2,50%
WHITE STONE			0,41%
N°.TOT.	34	206	240



shapes that were taken as a basic typology also for the weights found after his publications (Hemmy 1931, pp. 461–462; 1938, pp. 401–404).[12]

We have retained the following Hemmy's typology:

a) barrel
b) cone
c) cone with hole
d) cube
e) cylinder (with flattened base and top)
f) hemisphere
g) pebble
h) sphere (with flattened base and top)

The bar-graph shows that in the Indus Valley the cube-shape mostly occurs (from 60,3 to 91,1%). The comparison among the three sites emphasizes some interesting differences: firstly, we found only at Mohenjo-daro all the representative shapes, while at Harappa there are no cones with hole, hemisphere and pebble weights; secondly, the barrel-shaped weights are rather numerous at Harappa, whereas the spherical ones are virtually absent; at Mohenjo-daro we observe a different trend with a very high percentage of spherical weights (ca. 7%).

Barrel-shaped weights require particular considerations, since they resemble the most important shape of Mesopotamian weights in the morphological aspect (see above the description of the Susian shapes). It is very probable that this particular Indian group of weights was used for a special kind of economic transactions related to the international long-distance commerce.[13]

The importance of the connection material/shape in ancient weight systems is indubitable: this fact is particularly evident in the Indus Valley corpus where we observe a close relationship between cubical shape and chert: the latter is usually associated with cube-shape with only two exceptions: one spherical weight (gr 6,7) and one pebble weight (gr 6,37), both from Mohenjo-daro, whereas the cubical shape is used with almost all the materials.[14]

Another significative association is given by limestone and spherical shape (6 specimens or 2,18%)[15]. Finally, we can observe that 6 weights of hornblen-

[12] The pebble-shape was added in the second publication: Hemmy 1938, p. 404. However, M. S. Vats excluded the hemispherical and conical shapes: Vats 1940, p. 361; see also Hendrickx-Baudot 1972, p. 7 and note 5.

[13] Already A. S. Hemmy noticed the barrel-shaped weights peculiarity. In 1938 he wrote: "It is just possible that these barrel-shaped weights may have been importations from other parts of India, perhaps from places nearer the coast where communication with Elam and Sumer, where the barrel-shaped weight was most popular, was perhaps easier": Hemmy 1938, pp. 400–401.

[14] See the cross-tabulations in Hendrickx-Baudot 1972, pp. 10–11.

[15] The weights come from Mohenjo-daro and are all very heavy: gr 1431,670; gr 1445,850; gr 2576,310; gr 2735,780; gr 2792,000; gr 5556,000. They are corresponding, in the above order, to 100, 100, 200, 200, 200, 400 Harappan units.

CHART 2: Indian weights (shapes)

	Serie 1 Chanhu-daro	Serie 2 Harappa	Serie 3 Mohenjo-daro
BARREL		5,91%	3,67%
CONE		1,97%	0,40%
CONE WITH HOLE			1,63%
CUBE	60,34%	91,13%	81,63%
CYLINDER	1,72%	0,49%	1,24%
HEMISPHERE			0,40%
PEBBLE	29,31%		2,45%
SPHERE	8,62%	0,49%	6,93%
N°.TOT.	58	203	245

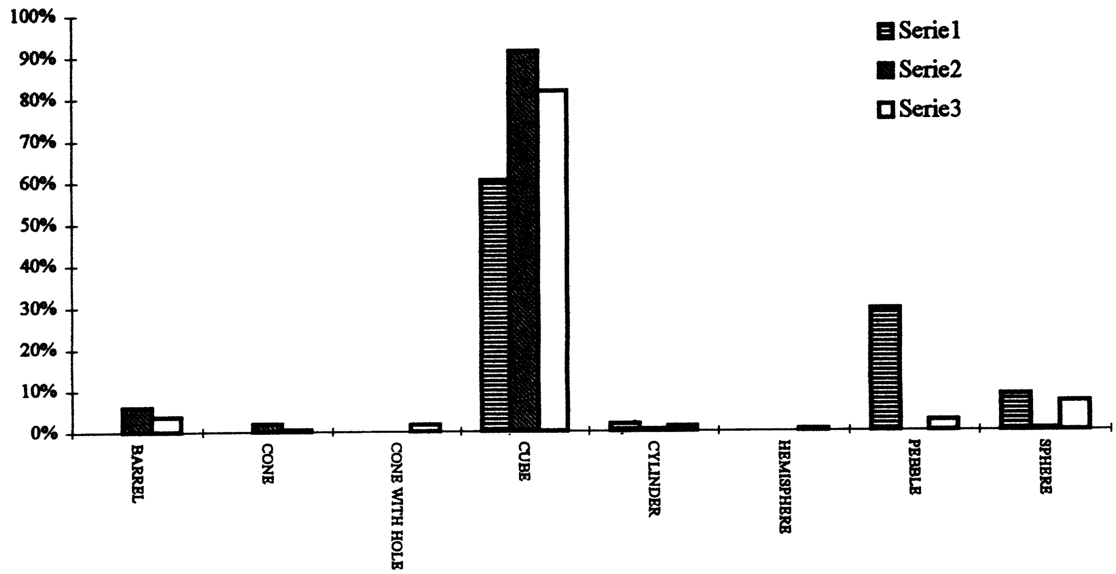
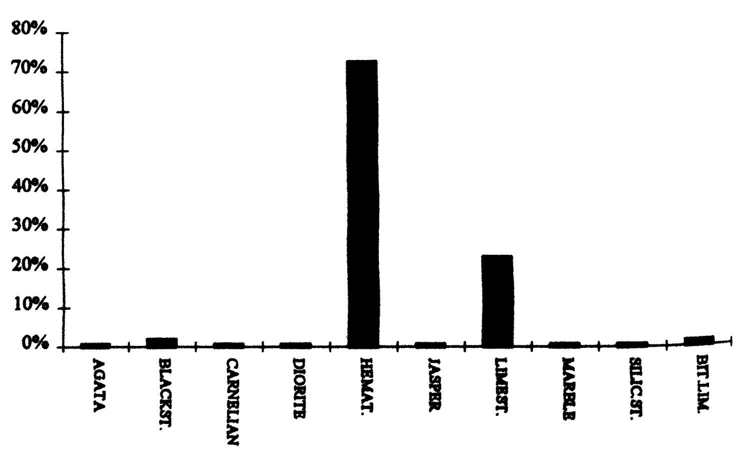


CHART 3: Susian weights (materials)

AGATA	0,40%
BLACK ST.	1,61%
CARNELIAN	0,40%
DIORITE	0,40%
HEMATITE	72,17%
JASPER	0,40%
LIMESTONE.	22,58%
MARBLE	0,40%
SILICEOUS ST.	0,40%
BITUMINOUS LIM.	1,20%
N°.TOT.	248



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de were found at Harappa: they are all barrel-shaped and 4 of these are possibly related to "foreign" systems.[16]

Systems (Tab. 1–4). The Harappan culture had a peculiar weight system, completely different from those existing in Mesopotamia and Syria at the same time (2200–1800 BC): it was binary for the submultiples and decimal for the multiples of the "standard" unit (Hendrickx-Baudot 1972, p. 14).[17] The standard absolute value of the unit could be fixed around gr 13,65, as is evident in Tab. 1 Col. III-V (see also Hendrickx-Baudot 1972, pp. 12–15, 28).[18] The weights found

Tabelle 1: Mohenjo-Daro – Chanhu-Daro – Harappa indus weights: radio and mean values

Col. I ratio	Col. II speci-mens (n°)	Col. III limits (gr)	Col. IV mean weight (gr)	Col. V expected mean weight (gr)	Col. VI difference Col. V–IV (gr)
1/16	5	0,81–0,88	0,86	0,85	–0,01 (1,2%)
1/8	15	1,60–1,75	1,69	1,71	0,02 (1,2%)
1/4	50	3,20–3,55	3,41	3,41	0,00 (0,0%)
1/2	79	6,55–7,00	6,81	6,82	0,01 (0,1%)
1	120	13,00–14,20	13,66	13,65	–0,01 (0,0%)
2	153	25,85–28,40	27,23	27,30	0,07 (0,3%)
4	49	52,00–56,00	54,13	54,60	0,47 (0,9%)
5	2	67,50–69,70	68,55	68,25	–0,30 (0,4%)
10	31	129,30–138,00	134,07	136,50	2,43 (1,8%)
14?	2	185,00–185,50	185,27	191,10	5,83 (3,1%)
20	9	260,50–275,00	267,41	273,00	5,59 (2,0%)
30	1	/	392,76	409,50	16,74 (4,1%)
100	3	1370–1381	1375	1365	–10 (0,7%)
120?	1	/	1595	1638	43 (2,6%)
200	4	2735–2792	2764	2730	–34 (1,2%)
400	2	5444–5556	5500	5460	–40 (0,7%)
500	1	/	6903	6825	–78 (1,1%)
800	1	/	10262	10920	658 (6,0%)
900	1	/	11467	12285	818 (6,7%)
TOT:	529				

16 Two weights are related to the Indian system (gr 128,15 and gr 130,20); two are possibly related to the Syrian system as 8 and 12 units of the "shekel" of gr 7,8 (respectively gr 61,3 = 8 × 7,66 and gr 89,7 = 12 × 7,47); one could be corresponding to 10 Mesopotamian shekel (gr 80,7 = 10 × 8,07), although the unit of 8,07 seems too light.

17 For the number of specimens related to ratios see Tab. 1, col. 1–2: most of the weights correspond to 1/2 (79 weights), 1 (120) and 2 (153) units of gr 13,65.

18 A. S. Hemmy asserted in his first metrological analysis that our standard unit was a 16 multiple of a minimum unit of gr 0,8; he adopted the latter as starting point for the comprehensive reconstruction of the Indian system: Hemmy 1931, pp. 589–591; see also Hemmy 1938, pp. 601–603; for the correct interpretation see however Hemmy 1943, pp. 236–237.

in the Persian Gulf, combined with epigraphic evidence, are of an extraordinary importance because they witness to the existence of a Dilmun/Harappan mina of ~ gr 1350 (see § 3), or 100 units of ~ gr 13,5. This evidence suits our quantitative analysis of the Indian weights.[19]

The great number of specimens allows us to establish the limits of the main ratios and the mean values of each ratio (see Tab. 1 col. IV). The expected mean values (starting with a unit of gr 13,65) are very similar to those obtained (see Tab. 1 col. V-VI).

Beside this Harappan metrological system we think that also other systems were probably used in the Indus Valley at the end of the IIIrd millennium BC. Observing the absolute weights of the specimens we isolated three main groups of weights possibly related to the Mesopotamian, Syrian and Egyptian systems.

Tabelle 2: Mohenjo-Daro Quantitative distribution of weights by systems and ratio

Ratio	I (n°)	M (n°)	E (n°)	S (n°)	A (n°)
1/16	4	1			
1/8	10			2	
1/4	30	1	1	3	
1/3			1		
1/2	49	2		3	
2/3		1			
1	84	1	1	1	
1+1/2	1				
2	90	1	1	3	
3		2			
4	26	1	1	3	
5		1			
6				1	
10	13		1		
14	1				
20	6	1		1	
100	3				
200	3				
400	1				
500	1				
800	1				
900	1				
TOT:	324	12	6	17	0

19 In the Indus Valley we find 3 specimens surely related to the Dilmun/Harappan mina (a weight of gr 1330 from Chanhu-daro, a weight of gr 1375 from Mohenjo-daro and again a weight of gr 1375 from Harappa). We would like to point out that each of the three settlements has this unit documented only once.

The Mesopotamian and Syrian groups are rather well represented with respectively 31 and 45 specimens (see Tab. 2–4).[20] Only 21 weights could be related to the so-called Egyptian system (unit of gr 9,4).[21] If we consider also the

Tabelle 3: Chanhu-Daro Quantitative distribution of weights by systems and ratio

Ratio	I (n°)	M (n°)	E (n°)	S (n°)	A (n°)
1/16	1		1		
1/8	1				
1/4	7	1	1	2	1
1/2	14	2	2	2	
2/3		1	1		
1	15	1	2	1	
1+1/2	3				
1+1/3				1	
2	19		2	1	
3		1		1	
4	11	2		2	
5	1	1			
6				1	
8				1	
10	7				
14	1				
16				1	
20	2				
30	1				
100	1				
400	1				
TOT:	85	9	9	13	1

[20] We found the hypothetical Mesopotamian weights so distributed: 12 from Mohenjo-daro, 10 from Harappa and 9 from Chanhu-daro. The most significative occurrences are the weights of gr 4,19 – 4,19 – 4,22 – 4,60 – 8,52 – 17,18 – 25,20 – 25,35 – 25,35 – 33,55 and 86,20: they are strictly connected to the Mesopotamian system with ratios 1/2, 1/2, 1/2, 1/2, 1, 2, 3, 3, 3, 4 and 10 (unit of gr 8,35/8,60).
The Syrian weights are so distributed: 17 from Mohenjo-daro, 13 from Harappa, 13 from Chanhu-daro. We note especially the weights of gr 0,98 – 1,30 – 3,90 – 3,90 – 7,90 – 7,90 – 39,40 corresponding to 1/8, 1/6, 1/2, 1/2, 1, 1, 5 Syrian shekels (gr 7,8/7,9). For the occurrences of weights related to the Syrian system see also Zaccagnini 1986, p. 21 note 10 (the author quoted 29 specimens).
G. L. Possehl (1996, p. 177) quoted 17 specimens defined as Mesopotamian type 'barrel weights', considering as "Mesopotamian type" all the barrel-shaped specimens, independently from the systems they belong to (for example nn. 9, 16 are related to the 'Egyptian' shekel and nn. 4, 13 are related to the 'Syrian' shekel). Moreover, in our opinion his nn. 1, 5, 8 and 11 could be related to the Indian system.

[21] It is more difficult to explain in historical perspective the presence of an "Egyptian" system in this region; for this reason we would state that some weights are only theoretically related to this western metrological system. Further archaeological discover-

materials and the shapes we can see that there are significative percentages of "anomalous" shapes and "unusual" materials: we would like to underline that these differences are probably not casual but concern the necessity to relate some specific weights to particular specific economic functions.[22]

Summing up, this short quantitative analysis shows on one hand the great degree of homogeneity of the Indian weights and on the other hand the very probable knowledge of the main contemporary systems of the Ancient Near East.[23]

Tabelle 4: Harappa Quantitative distribution of weights by systems and ratio

Ratio	I (n°)	M (n°)	E (n°)	S (n°)	A (n°)
1/8	8		1	1	
1/6				1	
1/4	20			2	
1/3		2		2	
1/2	27	1		1	
1	29		1	2	1
2	59		1	2	
3		4			
4	17		3		
5	1			1	
8				1	
10	17	2			
20	1				
60		1			
100	1				
120	1				
200	2				
TOT:	183	10	6	13	1

ies are necessary to corroborate the hypothesis. We found 6 specimens from Mohenjo-daro, 6 from Harappa and 9 from Chanhu-daro. The weights of gr 0,59 – 2,30 – 2,36 – 19,00 – 37,18 – 37,50 could be related to a shekel of gr 9,3/9,4 with ratios 1/16, 1/4, 1/4, 2, 4, 4.

22 Regarding the shapes, we can relate 5 barrel and 3 pebble weights to the Mesopotamian system; 5 barrel and 1 pebble weights to the Syrian; 3 barrel, 2 cone, 1 cylinder weights to the "Egyptian" system. Regarding the materials, we can distinguish 4 specimens of limestone, 8 of dark stones (gray or black stone), 1 of slate, 1 of hornblende and 1 of white stone, related to the Mesopotamian system; 4 specimens of dark stones, 2 of hornblende, 1 of jasper, 1 of steatite and 1 of limestone, related to the Syrian system; 2 specimens of agate, 2 of sandstone, 1 of steatite, 1 of hornblende, 2 of dark stones related to the Egyptian system.

23 For the presence of different kinds of objects and materials related to the Indus civilization in Mesopotamia, Iran and Arabian Gulf, which reflects the existence of a complex pattern of socio-economic relationships, see in particular Chakrabarti 1990 and Possehl 1996 with previous bibliography.

2.2. The Susa corpus

The archaeological work carried out in Susa left many stratigraphical problems open, rendering the documentation fragmentary and susceptible of new chronological interpretation.[24]

The first reliable chronological arrangement of the most ancient periods is due to L. Le Breton (Le Breton 1957, pp. 79–124), mainly interested in the Susian cultural evolution that has always been considered as influenced by Mesopotamia at the beginning and by Iran later.

He divided the most ancient phases of Susa in four main periods, each of them with relative subphases, analyzing the formal and stylistic evidences in the archaeological material.[25] But it was only in the Seventies that the Délégation Archéologique en Iran tried to reorder the stratigraphies of Ville Royale I,[26] Ville Royale II,[27] Acropole I,[28] Tell de l'Apadana[29] and Acropole II.[30]

The weights found at Susa from 1921 to 1933, during the archaeological excavations under the direction of R. de Mecquenem, were studied by N. T. Belaiew (Belaiew 1934, pp. 134–141, pls I–XIX). Among the 424 weights, only 248

[24] In 1897 an important French archeological mission, under the direction of J. de Morgan, started working on the site, focusing their attention on the earlier periods. Only from 1908 the work was conducted by R. de Mecquenem who resumed the excavation of the Achaemenid Palace. In 1946, R. Ghirshman became Mecquenem's successor in Susa and developed also the sounding of Tchoga Zanbil. Finally, in 1968 a new French-Iranian team, led by J. Perrot, re-studied deeply the chronological periods at Susa with a stratigraphical analysis.

[25] L. Le Breton divided the earlier periods in Susa A, Susa Ba-b-c-d, Susa Ca-b-c and Da-b-c-d-e and he compared the most important sites of the Mesopotamian area (Warka-Eanna, Jemdet Nasr, Tello, Ninive, Tepe Gawra) with the stratigraphical sequences of Susa, mostly, but not exclusively, on the bases of the ceramic typologies.

[26] E. Carter (Carter 1978, pp. 197–212; 1979, pp. 451–454; 1980, pp. 7–134) analyzed the stratigraphy (levels 18–4) of Ville Royale I looking for comparisons with Acropole I.

[27] P. de Miroschedji (Miroschedji 1981, pp. 9–136) analyzed the western part of Ville Royale reconstructing the stratigraphies of the I mill. BC (from the last centuries of the II Mill. BC to VI century BC) that he used to study the Neo-Elamite history.

[28] The first tentative to re-order the chronology of the acropolis is by M. J. Steve and H. Gasche (Steve – Gasche 1971). They studied, in the campaign of the 1964–65, the results of the so-called "Deep Sounding" (1965) and those of the 1966 excavations. The early periods at Susa were excavated by A. Le Brun (Le Brun 1971, pp. 163–216; 1978a, pp. 57–154; 1978b, pp. 177–192) in Acropole I. He identified 27 stratigraphical levels, dividing them in three periods: Per. I: lev. 27–23 (Susa A in Le Breton's terminology); Per. II: lev. 22–17 (Susa B); Per. III: lev. 16–9 (Susa C-D).

[29] M. J. Steve and H. Gasche (Steve – Gasche 1990, pp. 15–60) re-studied the excavations of J. de Morgan and R. Ghirshman in two different trenches (24 and 25) and they came to the conclusion that there were, in both areas, settlement occupation during the Susa A and Uruk Periods.

[30] D. Canal (Canal 1978a, pp. 11–55; 1978b, pp. 169–176) divided the archaeological sequence of Haute Terrasse, in the area so-called Acropole II, in eleven levels and two periods. He compared them with the stratigraphical results of Acropole I.

are chronologically reliable and thus analyzable according to the methodological criteria explained in our introduction.

We have considered nor the weights collection published by M. Soutzo (Soutzo 1911), neither the following volume by N. T. Belaiew who conceived as weights 36 objects "en forme de cloche" (Belaiew 1943, pp. 195–207). Also in this case the exclusion is motivated by the impossibility to insert these data in a precise chronological context. Moreover, as far as the "bell-shaped" objects are concerned, we think that their function as weights still has to be convincingly demonstrated in details.

N. T. Belaiew divided the 424 weights into six weight units, using the terminologies and the numerical limits proposed by W. M. F. Petrie in 1926, based mostly on the measure known from Egypt.[31]

Charts 3–4 show the percentages of the different materials and shapes used at Susa in the Paleo-Elamite period (ca. 2300–1600 BC).

Material (Chart 3). Indications about the material are available for 248 weights: the most used material is hematite (70,17%) followed by limestone (22,58%).[32] As it appears from these percentages, the other materials represent an evident minority.

Probably the choice of hematite is due to its chemical composition: it is composed by 70% of iron and so it has a high specific weight that allows the production of small shaped weights.

On the contrary the composition of limestone is totally different but this material was frequently used because easily found in the alluvial areas.[33]

The low quantity of precious and semi-precious stones is understandable because of the high cost of the materials. For this reason we hypothesize that this kind of weights could have different functions besides the commercial one. The material (jasper, agate, carnelian etc.), often associated with complex shapes, could give an intrinsic value pecuniary and maybe symbolic at the same time.[34]

[31] N. T. Belaiew divided the weights found in six different systems: *Daric* gr 8,10–8,60, *Qedet* gr 8,91–9,87, *Pejem* gr 7,38–8,10, *Necef* gr 9,90–10,90, *Khoirine* gr 11,10–12,20, *Beqà* gr 12,20–13,90 (Belaiew 1934, p. 134): concerning the Mesopotamian system (gr 8,10–8,60) he used three mina values: gr 491,20 (D. I), gr 502,20 (D. II), and gr 511,83 (D. III) (Belaiew 1929, p. 13; 1934, p. 137). Finally, it is important to point out that he concluded his study identifying an indigenous Elamite system of gr 3,04 as unit value, which is exactly 1/3 of *Qedet*. However, this hypothetical Elamite system is attested only for the 12,9%, while the Mesopotamian and Egyptian systems are more recurrent, respectively 45% and 18%. This percentage (12,9%) seems too low to support the presence of an indigenous system.

[32] We distinguished the bituminous limestone from the limestone and the hematite from the "black-stone" but it is probably that were the same material.

[33] The mineral composition of limestone is clay, calcite and dolomite, which are typical elements of the alluvial plains such as Susiana and Mesopotamia.

[34] This hypothesis is also suggests by the fact that a significative number of the weights was found in funerary contexts.

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CHART4: Susian weights (shapes)

BARREL	30,25%
CONE	0,40%
CUBE	0,40%
CYLINDER	0,80%
DISCOID	27,41%
DUCK	10,88%
HEMISPHERE	3,22%
FROG	0,80%
INSECT	1,16%
PEBBLE	22,98%
SHELL	0,80%
LION	0,40%
N°.TOT.	248

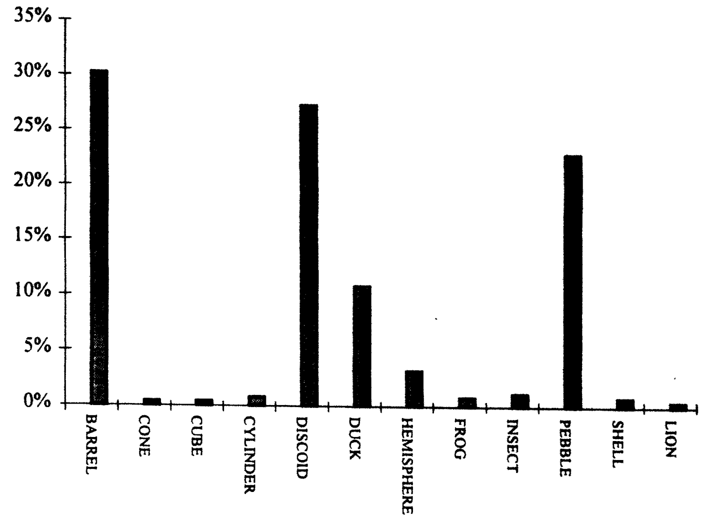
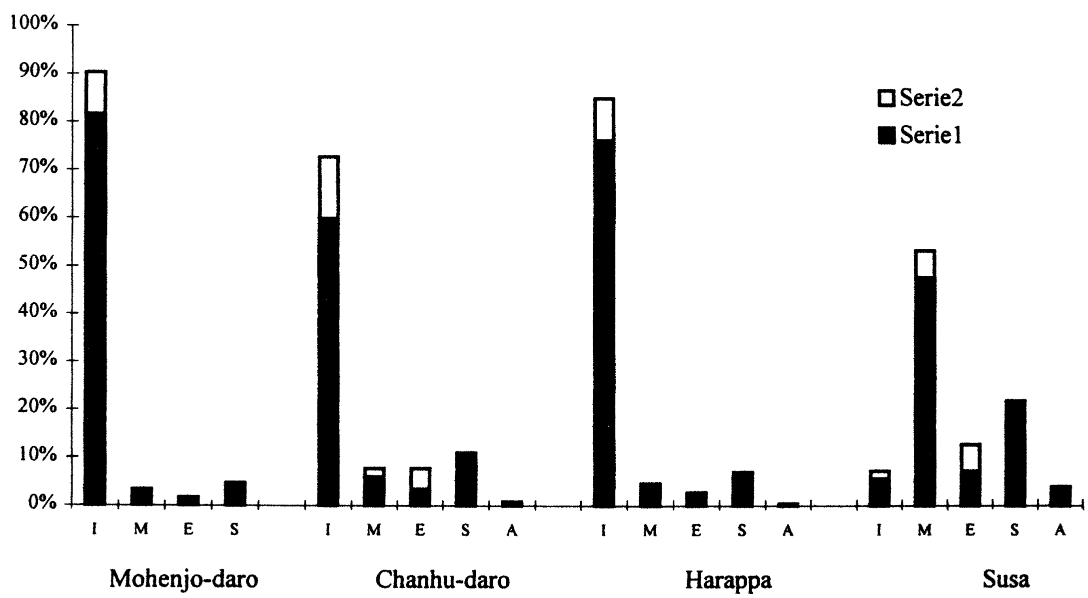


CHART 5: Indus Valley and Susa: the weight systems



Serie2 = Uncertain weights
Serie1 = Certain weights

I = Indian system
M = Mesopotamian system
E = Egyptian system
S = Syrian system
A = Anatolian system

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Shapes (Chart 4). Indications about the material are available for 248 weights: barrel-shape is the most common, representing the 30,25% of the total corpus. The other two important shapes are the discoid (27,41%), and the pebble (22,98%). The cube, which is the most common shape in the Indus Valley (see § 2.2), is attested only for one specimens (0,40%): this weight, made of chert is without doubt an artifact directly imported from the Indus Valley (Amiet 1986, p. 143, fig. 93). The specimens included in the Indian system that are not cube-shaped were probably made at Susa and used to convert the Indian unit value into the local system.

The complex shapes, such as frogs, shells and lions (all of them between 0,40% and 0,80%), are significantly rare (one or two specimens). They required a specific craftsmanship, and because of the material used and of the time spend to make them, the production cost must have been high and there must be a difference in the use of these objects.

On these bases it could be possible to identify three different functions – one not excluding the others – in the corpus analyzed:

1) unit measure for economic transactions
2) economical value, as indicated by particular shapes and materials
3) symbolic value, as indicated by funerary contexts.

It is probable that the second and the third function were more often coincident in a same weight.

Tabelle 5: Susa Mesopotamian weights: Ratio and mean values

Col. I ratio	Col. II specimens (n°)	Col. III limits (gr)	Col. IV mean weight (gr)	Col. V expected mean weight (gr)	Col. VI difference Col. V–IV (gr)
1/8	1	/	1,07	1,05	–0,02 (1,9 %)
1/6	4	1,35–1,45	1,41	1,40	–0,01 (0,7 %)
1/4?	4	2,00–2,20	2,16	2,10	–0,06 (2,9 %)
1/3	11	2,70–2,90	2,81	2,80	–0,01 (0,4 %)
1/2	12	4,05–4,40	4,23	4,20	–0,03 (0,7 %)
2/3	17	5,40–5,70	5,54	5,60	0,06 (1,1 %)
1	22	8,10–8,60	8,40	8,40	0,00 (0,0 %)
1+1/2	1	/	12,75	12,60	–0,15 (1,2 %)
2	16	16,20–17,20	16,61	16,80	0,19 (1,1 %)
3	10	24,50–25,50	24,93	25,20	0,27 (0,1 %)
5	8	40,80–42,90	41,30	42,00	0,70 (1,7 %)
6	1	/	49,25	50,40	1,15 (2,3 %)
10	7	81,10–86,20	82,61	84,00	1,39 (2,2 %)
30	3	246,80–253,00	249,60	252,00	2,40 (1,0 %)
180	2	1471–1491	1481	1512	31 (2,1 %)
300	2	2434–2476	2454	2520	65 (2,6 %)
TOT:	123				

Systems (Tab. 5–6). We divided the 248 specimens studied in five weight systems (Anatolian, Egyptian, Indian, Mesopotamian and Syrian), following the unit value presented in the introduction.

Table 6 shows the quantitative distribution of weights by system and ratio.

The Mesopotamian system is most used with 133 specimens (about 50%) while the Syrian system is the second unit weight more common (55 weights). Finally, the Anatolian system is less known with only 10 specimens.

The weights of Susa reveal a balanced presence between four different systems: on this base we excluded an Elamite-indigenous weight system. We think that the basic local system is the Mesopotamian one but also the others had an important role in the economic and commercial activities of the city.[35]

Table 6 shows the Mesopotamian weights corpus with the number of specimens studied, their limits, mean weight and the expected mean weight.

Tabelle 6: Susa Quantitative distribution of weights by systems and ratio

Ratio	I (n°)	M (n°)	E (n°)	S (n°)	A (n°)
1/16	1			2	
1/12			1		
1/8	3	3		3	
1/6		4	4	6	
1/4	7	4	8	2	3
1/3		11	4	5	
1/2	2	14	6	7	4
2/3		20	2	7	
1	1	23	3	7	3
1+1/2		1			
1+1/3				1	
2	1	18	1	8	
3		10		3	
4		1	2	1	
5		8			
6		1			
10		7		1	
12			1		
20		1		1	
30		3			
40	1				
80	1				
100	1				
180		2			
300		2		1	
TOT:	18	133	32	55	10

35 The presence of some weights (10) related to the Anatolian system is possible but quite doubtful.

§ 3. Distribution of weights in the Persian Gulf

The corpus of weights from the Persian Gulf is very scanty until now, even if the weights distribution is significative to throw light upon the commercial network and exchange systems during the IIIrd and IInd millennium BC. For this reason we are forced to analyze only the typology and the kinds of systems, as the quantitative test necessary for a complete metrological valuation is not yet possible.

The Mesopotamian cuneiform sources of the Isin-Larsa period (ca. 2000–1800 BC) talk about a Dilmun shekel, whose value is different from the Mesopotamian one: in fact the merchants of Ur needed some mechanisms of equivalence to convert the weight of the goods for and from the lands of the Persian Gulf.[36] In these cases the phrase ended with the words "... according to the standard of Dilmun": so we are able to know that one mina of Dilmun corresponds to 2 and 2/3 minas of Ur, with a ratio 8:3 for the Ur to Dilmun minas (Leemans 1960, pp. 38–39, 48–50; Roaf 1982). Since is normally accepted that a Mesopotamian mina had an average weight of ~ gr 500 (Belaiew 1929; Roaf 1982, pp. 139–140), the weight of a Dilmun mina must be corresponding to ~ gr 1350.

The history of the Dilmun weight system, as revealed from the archaeological material, is a very young one: the first group of weights was found during the Danish excavation at Qala'at al-Bahrain, in the so-called Excavation 520 or North Wall Sounding, at the northern end of the site (Bibby 1970; Lombard – Kervran 1989, nn. 57–61; see now Andersen – Højlund 1994, pp. 395–397, figs 1985–1989). The archaeological context is a peripheral area of the Dilmunite settlement very close to defensive city wall, which is provided with a monumental gate: in the inner sector some architectural units were discovered, with good samples of material *in situ* (pottery, stamp-seals, bitumen artifacts, metal slags and objects, weights).[37] Nine weights are published: seven related to the

[36] On the cuneiform sources related to the commercial activity in the Persian Gulf during the beginning of the II mill. BC see Oppenheim 1954; Leemans 1960; 1968; Potts 1990a, pp. 219–231.
The presence of the term gín.dilmun – "Dilmun shekel" – in the Eblaite texts, as a proof of the use of the Dilmunite system in the Syrian area during the Early Bronze Age (Pettinato 1983, pp. 78–80; Stieglitz 1987) is not satisfactory: for an alternative explanation and correct translation see now Archi 1987b.

[37] The final report of the excavations is now published (Andersen – Højlund 1994). The Danish archaeologists have re-examined the original documentation of the Sixties: the archaeological evidence seems to indicate a substantially private and domestic character of the area, while T. G. Bibby explains it as a sort of public "custom" complex related to commercial functions (also for the occurrence of seals and weights) at the main entrance of the city: see Bibby 1969, p. 355; contra Andersen – Højlund 1994, p. 471.

Indian system and two to the Mesopotamian one. The former group is decisive for the reconstruction of the ancient weight system used in the Persian Gulf, in relation to the epigraphic evidence from Ur (Bibby 1970; Powell 1983; Roaf 1982; Zaccagnini 1986). Three weights are cubes of dark steatite (520.AOI and 520.AMT) or of banded chert (520.TH), while the others are spherical weights with flattened base in limestone or marble (only 520.ANA is in black diabase). Assuming the Harappan unit of 13,65 gr, we can observe that all these specimens are its multiples or submultiples.[38] The division factor points to a decimal system: the Dilmun mina is a 100-multiple of a 13,5/13,6 gr unit (Harappan system), but is a 80-multiple of a 17 gr unit too. The latter unit is the link with the Mesopotamian system because it is exactly the double of the Mesopotamian shekel (8,4/8,5 gr).[39]

Recently another weight from Qala'at al-Bahrain (Andersen – Højlund 1997, p. 38 fig. 108) has been published: it is a gr 83,3 ovoidal quartz pebble corresponding to 10 Mesopotamian shekels.

Finally several weights were found as funerary assemblage inside the burial mound n. 352 at Saar and in unspecified graves at al-Hajjar site 2:

a) Saar burial mound n. 352: 8 hematite weights (7 barrel-shaped) together with two scales of copper/bronze.[40] Their weights correspond to 1/8, 1/2, 2/3, 1, 2, 3, 5, 10 Mesopotamian shekels. It seems very probable that these weights

[38] We report the weights starting from the lighter: gr 13,5 (520.AMT); gr 13,9 (520.ANA); gr 27 (520.TH); gr 171 (520.ALV); gr 670 (520.ANG); gr 1370 (520.ALM). They correspond, in the above order, to 1, 1, 2, 12, 50 and 100 Harappan standard units. Following C. Zaccagnini we think that the weight of 1,8 (520.AOI) is too heavy to fit well into the Indian/Dilmunite system (with ratio 1/8 it would correspond to a unit of 14,4 gr), and we prefer to consider it as 1/4 × gr 7,2. Thus, it could be related to the Syrian system, best represented in Syria since the end of the IIIrd until the Ist millennium BC; it seems to be represented also in the Indian weight corpus (see above, main text, § 2): see Zaccagnini 1986, p. 19 and note 10. For the "Phoenician" (Syrian) system as revealed by the Eblaite weights see Archi 1987a; De Maigret 1980.

[39] Zaccagnini 1986, p. 20. The suggestion that the Harappan unit is also a double of a "shekel" of gr 6,5, related to the "Aegean" system, needs further elements and could be accepted only in a theoretical way: Zaccagnini 1986, p. 21.

[40] For a photograph of the Saar barrel-shaped weights see Vine 1993, p. 47 (upper right). On the occurrences of scales in the Ancient Near East see Joannès 1989, pp. 125–127. It is very interesting that scales were founded in two graves of Isin-Larsa period at Ur (LG/23 and LG/45) together with set of hematite weights: the Saar evidence suggest that this burial custom was attested at Bahrain: we think that it could be connected to particular groups of people involved in commercial and mercantile activity. Moreover were found several Dilmun stamp-seals in burial mounds and graves at Bahrain which could be considered and investigated as important tools to understand the activity of the people buried. For example the Burial Complex at Saar shows a significative percentage of graves with stamp-seals (39 graves or 17% of the excavated tombs): for these seals see Ibrahim 1982, pp. 80–82, figs. 48–50; Mughal 1983, pp. 95–99, pl. 45–49.

represent a set buried because the dead was involved in commercial/handicraft activities;

b) al-Hajjar site 2: a set of four barrel-shaped hematite weights: they weight gr 2,1 – 5,6 – 8,5 and 16,4 and they are related to the Mesopotamian shekel with ratios 1/4, 2/3, 1 e 2 (Lombard – Kervran 1989, p. 35 n. 56).

Moreover we have news about a weight from Ali and one from the Saar settlement (Crawford 1993, pp. 12–14). The latter is a cube of milky white stone weighing gr 7,3. It was found in a rubbish level over House 53. The anomalous weight could be explained either as $^1/_2$ of a Harappan unit (gr 13,5), or as a Mesopotamian shekel, being the object partially damaged (Crawford 1993, p. 14). Both the hypotheses are questionable: in the first case we have a ratio unusual for the Harappan metrological system, in the second, we have a Mesopotamian weight with cubical shape.[41] The Saar example witnesses how the study of the Dilmun metrology is still a work in progress.

Actually, only three specimens are known from the Omanite peninsula: two weights come from Tell Abraq and the third from Shimal.

The specimens from Abraq, are dated around 2200–2000 BC, in the late Umm an-Nar period; they are found in domestic and working place contexts (Potts 1990b, pp. 42–44, figs. 42–45).

The first (TA 125) is a cube of jasper of 14,20 gr and the second (TA 146) is a cube of banded chert of 53,95 gr. Both are clearly related to the Harappan weight system with ratios 1 and 4.

The weight from Shimal, found in Tomb 6, dated ca. 1900–1800 BC, is a cube of chert of gr 26,30, corresponding to two Harappan units of gr 13,15 (de Cardi 1988; 1989).

To sum up, the evidence from Oman testifies to the interrelations between the Indus valley civilization and the Umm an-Nar culture, as many scholars have pointed out, but stresses the Indian system preservation during the first phase of the Wadi Suq period. On the contrary, the weights from the land of Dilmun, either in the morphological characteristics or in the metrological aspects, belong to a "mixed" system, with some weights related to the Mesopotamian system and others to the Harappan one. Moreover, the Dilmun system itself is a metrological hybrid (mina of 80 or 100 units) with many advantages for a people that based their wealth on the commercial overseas activities between the cities of the Mesopotamian alluvium and those of the Indus valley (Zaccagnini 1986). Chronologically, the Dilmun specimens from Qala'at al-Bahrain point to a prevalence of cubical and spherical weights of Indian type during period Ib–IIa (ca. 2200–2000 BC), while the weight dated to the period IIb together with the

[41] A third suggestion could be that this weight was one Syrian shekel of gr 7,8/7,9 as observed for some specimens of Harappa, Chanhu-daro and Mohenjo-daro (see Tab. 1–3).

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findings from Saar and al-Hajjar point to a prevalence of hematite barrel-shaped weights related to the Mesopotamian system at the beginning of the II mill. BC (ca. 2000–1800 BC).

§ 4 Conclusion

The evidence of different metrological systems used in the last two centuries of the IIIrd mill. BC and the first half of the IInd mill. BC, testifies to the existence of international economic relationships between the areas of Southern Mesopotamia, Iran, Indus Valley and Persian Gulf during the chronological span considered (see i.e. Amiet 1986; Curtis 1993; Lamberg-Karlovsky 1986; Potts 1977). Moreover, may be stated that the Syrian milieu of the Early and Middle Bronze Age was involved in this complex development of cultural links reflected also by the exchange network of goods and various products.[42] The weights are surely connected with the economic sphere and allow to underline some interesting aspects about direct or indirect contacts among these regions. Materials, shapes and especially unit values, show the "cultural" belongings of the system itself. Hence, weights represent an important archaeological hallmark of local cultures and, at the same time, might indicate modifications and innovations of internal social, political and economic organization like other significant artifacts, such as pottery, metal objects, seals etc.

The policy of the Akkadian kings forced the balance of the previous period, developing and changing the main routes across the Iranian plateau and partially shifting the trade enterprises along the coast of the Persian Gulf (Potts 1994, pp. 282–290). The emergence of Harappan cities was another decisive factor for the development of this articulated exchange system: the outposts of the Makran coast and the direct contacts with the Omanite Peninsula show well the impact of the Indian culture on the Indo-Iranian borderlands and on the Persian Gulf area. Moreover, the presence of Harappan or Harappan-related artifacts, as stamp seals, found in Southern Mesopotamia from the Akkadian period onward, is another important proof of the scope of Harappan trade.[43]

A comparison between the weight systems of Susa and those present in the Indus Valley (Chart 5) suggests the following observations:

a) Susian weights point to an integrated multiple system of equally employed metrological classes;

[42] A meaningful piece of evidence about contacts between Inner Syria at the end of the Early Bronze Age (BA IVA: ca. 2400–2300 BC) with the East is represented by the numerous fragments of lapis lazuli unworked, stored in the Royal Palace G at Tell Mardikh-Ebla: Pinnock 1986; 1991; 1995.

[43] For the objects (mainly seals) with Harappan inscriptions found outside the Indian regions see now Parpola 1994.

b) Harappan weights largely depend on a homogeneous local system;

c) the Indus Valley corpus shows a scanty percentage of "foreign" weights related to the Mesopotamian, Syrian and Egyptian systems: the amount of the few specimens ascribable to the three systems are almost the same;

d) weights referable to the Syrian system are the most used class after local metrological groups (Mesopotamian for Susa and Indian/Harappan for the Indus Valley cities).

Summing up, Susian weights reflect the particular role of a city lying in a inter-cultural zone, which exploited its geographical position, being situated on one side near the Iranian highlands, which are strictly related to the Harappan world, and on the other near the Persian Gulf and the Mesopotamian Alluvium.

On the contrary, the Indian corpus reflects both the existence of an independent system with specific typology of weights and the strong links which the Harappan culture established with the West. For a closer study of the metrology and the trade system of the Indus Valley will be necessary to investigate in particular the regions of Eastern Iran (Sistan, Baluchistan) and also the regions of Margiana and Bactria. These Indus Valley neighboring areas are surely an indispensable chain-ring in the articulated network of international exchanges of the Early and Middle Bronze Age.

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