CHANHU-DARO EXCAVATIONS

1935-36

BY

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Chapter XV

OBJECTS OF SCIENTIFIC INTEREST

Weights at Chanhu-daro. (By A. S. Hemmy)

Some 132 stone objects have been found which are noted as probably or possibly weights. These have been tabulated and the results (Col. III) tabulated in descending order in Table I of this Chapter.

The nearest ratio to the Harappā standard of 13.625 gms. has been assigned (Col. IV) and in Col. V the corresponding value of the unit has been given.

Many of the specimens are chipped or broken, others appear to be unfinished, some appear to have been damaged by fire. Their condition is noted in Col. II. A number are noted as doubtfully weights. In the cases where the calculated values of the unit diverge markedly from the Harappā standard, it is unlikely that they were used for weighing. Such are marked in Col. II with a question mark. The remainder, of which the field numbers are underlined in Table I, have been used in the calculation of the distribution curve. The great majority have units which lie between 12.6 gm. and 14.6 gm. The few divergent cases form no grouping and can be left out of account.

The calculation is performed as follows. Dividing the whole range into steps of a tenth of a gramme range, the numbers of specimens differing from the mid-point value of a step by not more than a twentieth of a gramme are counted and the result is tabulated in Col. II, Table II. These numbers are now smoothed (Col. III) by substituting the value of $(a + 2b + c)/4$ for b, where a, b, and c are the numbers of specimens for three successive steps.

In Fig. 1 a distribution curve is plotted in which the abscissa x is the weight of the mid-point of the step and + coordinate y is the smoothed value of the number of specimens with weights within the range of the step.

There is a single maximum, so only one standard is involved.

The Mode, or value of maximum frequency, has a value of 13.64 gm. This is the most probable value of the unit from the data. From the much larger number of specimens collected at Mohenjo-daro and Harappā the value of the standard has been calculated as 13.625 gm.[1]

The standard at Chanhu-daro is evidently the same. The difference can readily be accounted for from the paucity of numbers at Chanhu-daro as well as from the fact that it was a place of manufacture of weights so that many of the accepted weights have not been finally adjusted to their correct values, thus making the Mode a little high.

The weights have much the same characteristics as shown by those found at Mohenjo-daro. The majority are of chert and more or less cubical in shape (Pl. XCI, 29-32). There seem to be a larger proportion of misshapen weights, a condition to be expected at the place of manufacture. They may be rejects.

[1] Hemmy, "Statistical Treatment of Ancient Weights," *Ancient Egypt*, Dec., 1935, p. 88.

In the list in Table I, in order to obtain a unit approximating to the Harappā standard, such ratios as 30, 15, 3, 1/24, etc. have been used. As ratios involving the factor 3 are foreign to the system, the specimens are probably aberrant; even with the ratios assigned, only rarely is the unit found a good approximation.

The ratio 5/2 shown by one cube weight and one doubtful specimen, is a possibility, as it would be ten times the quarter standard, but as only three weights of about that standard have been found elsewhere, the possibility is dubious.

The data herein discussed were now combined with those of the previous finds at

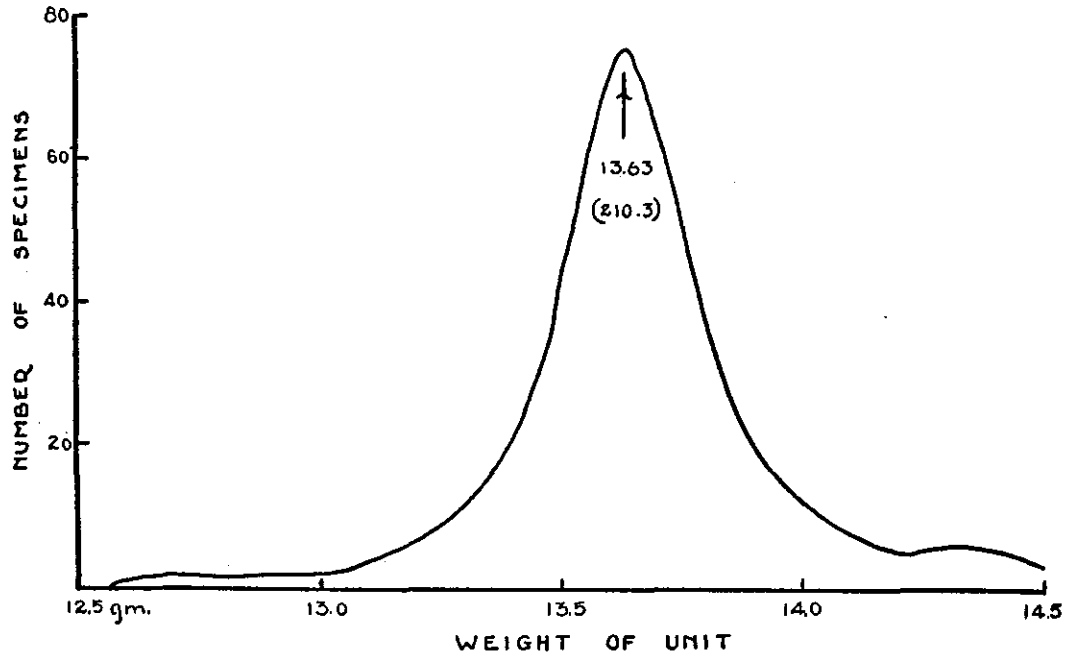

Fig. 1. DISTRIBUTION CURVE: Harappā, Mohenjo-Daro, and Chanhu-Daro combined, omitting all doubtful ratios and weights below six grammes.

Harappā and Mohenjo-daro. All doubtful specimens were rejected, including those with unlikely ratios, as well as all with weights below 6 gms. The smaller weights were definitely less accurate than those weighing between 6 gms. and 150 gms. After this revision the number of specimens within the range of each step is given in Col. IV, Table II, and the smoothed values in Col. V. The results are plotted in Fig. 1.

The value of the Mode is 13.63 gm. (210.3 gm.). This must be a close approximation to the true value and must express the Harappā standard to the nearest centigramme. This result was checked and confirmed by repeating the process with the difference that, instead of taking the mid-points of the steps as 12.6, 12.7, etc., the mid-points were placed at 12.65 gms., 12.75 gms., etc. This change should show if any bias in favour of round numbers existed.

TABLE I

List of Weights

I Field No.	II Condition	III Weight	IV Ratio	V Unit	I Field No.	II Condition	III Weight	IV Ratio	V Unit
5056	bc.	1330.68 +	100	13.31 gm.	2303	g.	27.41 —		13.70 +
2075	g.	544.77 +	40	13.62	3822	sc.	27.36 —		13.68
3482	unf.	392.76 +	30	13.09	3164	sc.	27.34 —		13.67
2016	unf.	273.59	20	13.68	2904	sc.	27.30 +		13.65 +
1287	?	260.52		13.03	2264	g.	27.26 +		13.63
5234	?	185.04	15	12.34	881	?	27.19 +		13.60 —
2529, *ff*	sc.	136.65	10	13.66	2867	g.	27.14 —		13.57
3025	p.	136.39 +		13.64	1814	g.	27.10 +		13.55 +
2650	g.	136.04		13.60 +	1737	g.	26.98 —		13.49 +
4669	bc.	133.92		13.39	4598	sc.	26.68 +		13.34
2474	bc.	131.47 +		13.15 —	2415	unf.	23.70 +		11.85 +
3593	?	129.69 +		12.97	1096	?	23.12		11.56
1590	bc.	126.58 +		12.65	1095	?	21.39	3/2	14.26
2029	g.	120.88 —		12.09	1750		20.89 +		13.93
1488	?	69.61	5	13.92	1482		20.24 —		13.49
1412	unf.	60.93		12.19	1265	?	19.33		12.89
157	?	57.17 +	4	14.29	3837	?	18.10 +		12.07
2423	sc.	54.73 —		13.68	1888	?	14.90 +	1	14.90 +
4756	sc.	54.61		13.65 +	2475	?	14.61 +		14.61
5074	?	54.50 —		13.62	2659, a	bt.	14.03 +		14.03
2326, *g*	p.	54.36 —		13.59	" , b	bt.	13.97 +		13.97
1951	sc.	54.13 +		13.53	4058	sc.	13.93 +		13.93
1298	?	53.58		13.39	3692	sc.	13.85 +		13.85 +
3881	bc.	52.08		13.02	2592	g.	13.80 +		13.80 +
4716	sc.	51.10		12.77	3116	g.	13.75 +		13.75 +
4774	sc.	50.72 —		12.68	3121	p.	13.71 +		13.71
2388, *b*	bc.	49.69 —		12.42	2569	sc.	13.68 +		13.68
1927	?	45.55 +		11.39	3078	sc.	13.64 +	1	13.64
765	?	42.88 —	3	14.29	2320	p.	13.51 —		13.51
2413	sc.	33.10 +	5/2	13.24	1404	sc.	13.45 +		13.45
1389	?	32.38 +		12.95	3236	?	13.42 +		13.42
2545	?	30.39 —	2	15.19	3504	sc.	13.41 —		13.41
1072	?	30.28 —		15.14	884	?	12.40 +		12.40
1055	?	29.15		14.67	3523	?	10.65		10.65
3629	sc.	28.87 +		14.44	1260	?	9.13 +	2/3	13.69
1461	?	28.36 —	2	14.18	2472	?	8.906		13.36
1631	?	28.27 +		14.14	2451	sc.	8.520		12.88
2388	bt.	28.14 +		14.07	921	p.	7.457	½	14.91
1787	sc.	28.05 +		14.03	2326, *b*	p.	7.345		14.69
4897	sc.	27.95+		13.98	2374	g.	7.147		14.29
2760	p.	27.66 +		13.83	3626	sc.	6.985		13.97
3189	sc.	27.53 —		13.76	557	g.	6.9435		13.89

Abbreviations: Column II. p. = perfect; g. = good; sc. = slightly chipped; bc. = badly chipped or fractured; unf. = unfinished; bt. = damaged by fire. The question mark denotes doubtfully a weight.

I Field No.	II Condition	III Weight	IV Ratio	V Unit	I Field No.	II Condition	III Weight	IV Ratio	V Unit
4843, *a*	g.	6.8595		13.72	2326	g.	3.800		15.20 —
2461	p.	6.845		13.69	3203	sc.	3.644		14.58
2326, *h*	g.	6.836		13.67	2214	sc.	3.543		14.17
" , *d*	unf.	6.8255		13.63	4426	g.	3.517		14.07
4760	?	6.808		13.62	2543	p.	3.4685	¼	13.87
2306	g.	6.783		13.57	1925	sc.	3.4055		13.62
2040	g.	6.649		13.30 —	3883	sc.	3.405 —		13.62
2933	sc.	6.641		13.28	3548	sc.	3.3285		13.31
3416	?	6.634		13.27	4702	?	2.961		11.84
3699	?	6.149		12.30 —	4843	g.	2.365	1/6	14.19
1137	?	5.956		11.91	3913	p.	2.063 —	1/8	16.50
4900	?	5.471 —		10.94	2326, *n*	p.	1.9395	1/8	15.52
1475	?	4.844	1/3	13.43	2317	sc.	1.891		15.13
1252	?	4.520	1/3	13.56	1581	?	1.630		13.04
4833	p.	4.227		12.68	178	bc.	0.886	1/16	14.18
2494	g.	4.040		12.12	2317	g.	0.5985	1/24	13.36
2418	g.	3.865	¼	15.46	2326	g.	0.5695	1/24	13.67

TABLE II

Distribution of Unit

	Chanhu-daro		Combined			Chanhu-daro		Combined	
I Mid.-pt. of Step.	II No. of Spec.	III Smoothed	IV No. of Spec.	V Smoothed	I Mid. pt. of Step.	II No. of Spec.	III Smoothed	IV Oo. of Spec.	V Smoothed
12.6 gm.	0	0.2	2	1.7	.7	15	12.5	68	62.7
.7	1	0.7	2	1.7	.8	4	7.0	28	35.2
.8	1	1.0	1	1.5	.9	5	4.2	17	19.5
.9	1	1.0	2	1.5	14.0	3	3.0	16	12.7
13.0	1	0.7	1	1.5	.1	1	1.7	2	6.7
.1	0	0.5	3	3.5	.2	2	1.5	7	5.7
.2	1	1.7	7	6.5	.3	1	1.2	7	6.2
.3	5	4.0	9	10.2	.4	1	0.7	4	4.7
.4	5	5.0	16	19.7	.5	0	0.2	4	4.0
.5	5	7.7	38	44.7	.6	0	0.0	4	3.0
.6	16	13.0	87	70.0					

The Cube Weights in Boston. (By Ardelia Ripley Hall, Department of Asiatic Arts, Museum of Fine Arts, Boston).

Of 118 weights found at Chanhu-daro, 58 were sent to the Museum of Fine Arts[1] in the division of the finds. Of these 58, there were 36 cube weights, 5 spherical weights with flat base and top, and 17 pebble weights. Only a few of the important weights were weighed by the Expedition. Those which remained in India were weighed by Dr. Sd.

[1] A preliminary discussion of the weights in the Museum of Fine Arts was presented at the meetings of the Archaeological Institute of America, in December, 1937.

M. A. Hamid, Curator of the Central Asian Antiquities Museum in New Delhi. While the weights which came to the Museum of Fine Arts were first weighed there, later, through the kind cooperation of Professor F. G. Keyes and Professor L. F. Hamilton of the Massachusetts Institute of Technology, arrangements were made for them to be weighed by John E. Tyler, of their staff, to four points beyond the decimal on precise and delicate scales. This verification by the Massachusetts Institute of Technology has proven most valuable, especially in consideration of the smaller cube weights. The results obtained are given in Mr. Hemmy's Table I.

In Mr. Hemmy's report and accompanying list of all weights found, he has made a special and valued study of the frequency of distribution, showing that the "mode or value of maximum frequency" has a value of 13.64 grams. In connection with Mr. Hemmy's determination of the standard unit of weight for the Indus civilization as the Ratio 16 (13.63 grams), which he has so graphically illustrated in his "Distribution curve for Chanhu-daro" and for the three sites of "Mohenjo-daro, Harappā, and Chanhu-daro combined," there is a vast amount of material on the dominance of 16 in Indian culture.

John Allan,[2] with reference to Mr. Hemmy's report[3] that the ratio 16 was most frequently found at Mohenjo-daro, has stated with regard to coinage that, "Very little is known concerning the denominations and standards of ancient India," and added, ". . . We shall be content to point out that the ratio of 16 annas = 1 rupee goes back at least 2,000 years to the 16 *māṣakas* = 1 *kārṣāpaṇa* of the law-books."

Among the numerous literary references which Dr. A. K. Coomaraswamy has been so kind as to bring to my attention are those included in an "Appendix on So *Soḷasī*"[4] (*soḷasī* meaning sixteen). The author, in discussing the phrase "not a sixteenth part of" (which is comparable to our own use of "not an ounce of") has asked, "Why was this particular fraction used to express a minute value? It is common in Skt. works . . ., early and late, . . . and it became a conventional number, perhaps owing to the Sānkhyan system of subdividing. I have found a number of passages which I give here (a) to show a similar use and (b) the ideas from which this use arose." In the passages which he quotes the old formula is given in which the "metaphysical whole" is thought of as having sixteen parts.

Again, regarding the chapter of the Praśna Upanishad,[5] "Concerning the Person with sixteen parts," Professor Hume states, "These old conceptions, namely that the 'Lord of Creation' is sixteenfold and that a human person also is sixteenfold, are here philosophically interpreted . . ."

One other quotation, from the Jātakas,[6] is especially interesting because it reveals the

[2] John Allan, *Catalogue of the Coins of Ancient India. (A catalogue of the Indian coins in the British Museum*, vol. 7, 1936), Introd. p. clix.

[3] John Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 596.

[4] F. L. Woodward, *The Book of Gradual Sayings (Anguttara-Nikaya)*, vol. V, p. 240.

[5] Robert Ernest Hume, *The Thirteen Principal Upanishads*, p. 389.

[6] E. B. Cowell, *The Jātaka or stories of the Buddha's former births*, vol. I, p. 246 ("Mittavinda-Jātaka," 414).

persistence of the progression found in the Indus weights. "Now at that time one of the damned who had put on the circlet and was suffering the tortures of hell, asked the Bodhisattva—'Lord, what sin have I committed?' The Bodhisattva detailed the man's evil deeds to him and uttered this stanza:

'From four to eight, to sixteen thence, and so
To thirty-two, insatiate greed doth go
—Still pressing on till insatiety
Doth win the circlet's grinding misery.'"

It is, of course, well-known today that the conventional use of these numbers was dependent upon an ancient usage hitherto unsuspected; namely, that the traditional importance of 16 and the sequence of 4, 8, 16, 32 may be traced to the prehistoric civilization of the Indus Valley. This is a striking example of the imprint which these prehistoric people have left on the culture of India.

Mr. Hemmy has listed the Chanhu-daro weights under ratios from the fraction 1/24th to 100. He has taken the "value of maximum frequency" 13.64 grams as the standard unit of 1, and the value .856 grams as 1/16th. In the first report on Indus weights,[7] made by Mr. Hemmy,[8] this same unit of 13.6 grams was used as the standard unit "A" with the sequence represented as 1/4 A, A, 2A, 4A, etc. Later, in his report on the weights found at Mohenjo-daro,[9] the smallest weight then known of .856 grams was only "arbitrarily" taken as the unit. And it is now clear that it should be accepted as a 16th part of the standard unit. However, the fractional weights have multiplied, Chanhu-daro has notably contributed to the greater differentiation of small weights than has previously been recognized, and there are 39 weights in Table I below ratio 1. In this discussion of the cube weights in the Museum of Fine Arts, as a matter of convenience, we have followed the old ratios of 1 to 1600. By avoiding fractions, we believe the relation of one weight to another in the series is more readily discernable. And there is no mathematical difference between the two ratios, whether one rises from 1/16 to 100, or from 1 to 1600.

By transposing the ratios in Table I from 1/16th to 1, it may be found that most of the weights from Chanhu-daro fall in the simple ratios 1, 2, 4, 8, 16, 32, 64, 160, 320, 640, and 1600, with the possible intrusion of doubtful weights in the ratios 24, 48, 240, and 480, as well as ratios 40 and 80. The notable exceptions are fractional ratios of the usual series. The discovery of two weights (listed as ratio 1/24th) in the ratio of 2/3 of 1, or 2/3 of the smallest degree thus far recognized lend to Chanhu-daro the distinction of further extending the system by one degree. The excavations of Mohenjo-daro by Dr. Mackay have recently added to the upward extension by weights of the ratios 3200 and 12800.

All of the 35 cube weights in Boston, which are listed in Table IV, like the block weights found at other sites, were made of chert. Through the good offices of Mr. William

[7] *A. S. I., A. R.*, 1925-1926, p. 92.
[8] See footnote 1, Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 589.
[9] *Ibid.*, p. 589.

J. Young of the Museum of Fine Arts, a group of ten have been further identified by Dr. Harry Berman of the Department of Mineralogy at Harvard University as agate, chalcedony, jasper, and calcite. The majority are beautifully veined and banded stones, opaque or semi-transparent. All were carefully squared and polished and occasionally the edges were bevelled. There is much of interest regarding these excellent examples. Of the 36 in the list 21 are undamaged and in good or perfect condition.

The five spherical weights with flat base and top now in Boston, were made of limestone, granite, and agate. As might be expected from previous reports, they fall into the simple ratios as the cube weights, with one exception which is unfinished (3482, see Table I) in the ratio 480.

Most of the pebble weights are granite, others are of limestone. This limited data bears out the observation already made by Mr. Hemmy[10] that "It is interesting to note that all weights which are not cubical are *not* made of chert . . . (and) on the whole not so accurate." All the pebble weights are only doubtfully regarded as weights. They are followed by a question mark in Table I. It is to these alone that Mr. Hemmy refers as "probably or possibly weights." It may be well to add a word as to why they have been included at all. Of the 17 in Boston, all are worn smooth like pebbles from the shore or a river bed, 9 are more or less worked stones with a flattened base. With but rare exceptions they weigh to the usual ratios and in the usual frequency, 11 are in the common ratios 8, 16, and 32. There is little doubt that pebbles were cheap and practical substitutes for the finer cube and spherical weights, just as the clay bangles were made to answer for the bracelets of faience and metal.

The cube weights, on the other hand, are without the slightest question weights. In fact Dr. Mackay regards them as master-weights. And for this reason we regard them as worthy of separate consideration. In omitting the other types and all substitute weights which are open to question we believe a fairer appraisal of the accuracy of weights from Chanhu-daro may be reached.

Following the method described by Mr. Hemmy[11] the calculated unit value of .865 grams was obtained for the 27 weights in Boston unmarred or only slightly chipped. This is slightly higher than the calculated unit weight from Harappā of .860 grams based on 34 examples, and that from Mohenjo-daro[12] of .865 grams based on 113 examples. If

[10] Mackay, *Further Excavations at Mohenjo-daro*, p. 605.

[11] Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 589: "The method of arriving at the most probable value of the unit was as follows: a casual inspection of the weights showed that, with a few exceptions which were omitted, the weights fell into a series of groups which were in simple numerical ratios with one another. Giving the smallest the arbitrary value of unity, the others were in simple ratios, 2, 4, 8, etc. The mean weight of each group is divided by this ratio and multiplied by the number of specimens. The products for all the groups are added together and divided by the total number of specimens. This gives a mean value for the group of smallest weight in which every specimen weighed is allowed equal importance. The mean values of all groups are then obtained by multiplying this mean value by the ratio already found. In this way we arrive at the calculated values . . . ."

[12] *Ibid.*, p. 590: "Table I. Weights from Mohenjo-daro." The number of specimens listed in this table is 113. A typographical error appears under group C, where 9 instead of 2 is given for the

weights were manufactured at Chanhu-daro, it is possible that they were less worn by use. Certainly, the limited number on which the calculation is based is a factor. The calculated unit value based on the 174 examples from Harappā, Mohenjo-daro, and Chanhu-daro is .857. This unit value[13] has been used in Table IV to obtain the calculated value of the ratios.

The usual weights are much the same as those found at Harappā and Mohenjo-daro. In the list of cube weights in Boston, the locus and level where each weight was found has been given. The find spots of the weights and their association with one another appear very suggestive of their use. Most of the cube weights came from the Harappā II level of Mound II at Chanhu-daro, and 22 came from one house and its immediate neighborhood. (These 22 do not all appear in Table IV, as 6 remained in India). This house is the bead-maker's shop that has a room with flues running under the brick floor. It is already distinguished for that unusual feature, and also for the abundance of interesting objects found in its rooms and court. Beside bronze beads and stone beads of etched carnelian, lapis lazuli, and steatite, there were quantities of unfinished beads of carnelian and steatite found there, as well as the raw materials for the stone cutter (nodules of carnelian and a rock of crystal), and also stone polishers and copper and bronze bead-maker's tools. This was the establishment of a maker of fine jewelry of stone and metal.

In the small outer room of this house (Sq. 9/D, loc. 215) 14 weights and scale-pans of copper were discovered and an additional weight was found in the furnace-room (Sq. 9/D, loc. 287). Of the 15 weights 2 were in the ratio of 2/3 of 1, 2 in the ratio 2, 2 in the ratio 4, 5 in the ratio 8, 2 in the ratio 32, 2 in the ratio 64.

Just across the street (Sq. 8/D, loc. 290) was 1 weight of the ratio 16, and at the next corner (Sq. 9/D, loc. 192)[14] 2 more weights of the ratio 16 were found. In the building on the north side of the bead-maker's shop (Sq. 8/D, loc. 178) was a weight in the ratio 4. In the adjoining house on the other side (Sq. 9/D, loc. 179) were 2 weights of the ratios 64 and 160, and in the next building (Sq. 9/C, loc. 208) was the fine weight in the ratio 2/3 of 8. It seems probable that these weights may have been scattered at the time the city in this occupation was deserted. And we have, then, substantial evidence that these smaller weights (only those up to ratio 160 were found) were used to weigh the precious metals and stones used in the jeweler's craft and trade. This theory was first proposed by Ridgeway.[15] It is not astonishing that the smallest weights known should have been found in the workshop of a lapidary. It is possible that the weights were made there also, but no unfinished weights were found. One unfinished seal was found in the corridor leading from the outer room.

number of specimens. It is plain that this figure should be 2, from Table III in which the weights found at both Mohenjo-daro and Harappā are listed, from the list with expedition numbers given in the Appendix I, p. 596, and from Mr. Hemmy's statement, just below Table I, that "Out of a total of 120 weights selected for their good condition, only seven do not fall into the above table . . . ."

[13] Mr. Hemmy obtained .857 in his combined tables for Mohenjo-daro and Harappā.

[14] The level of Sq. 9/D, loc. 192 was + 8.75 feet, somewhat lower than the level at which all the other weights were found. This was probably due to subsidence, as the drains under the street dropped from + 8.2 feet at 211 to + 6.7 feet at 218.

[15] Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 589.

The appearance of 2 weights in the ratio of 2/3 of 1 and another in the ratio of 2/3 of 8 with all the others in the usual sequence shows that, in actual use, these fractional weights were supplementary to the simple ratios and did not form a separate light system.

The weight in Boston, in the ratio of 2/3 of 1 (Exp. No. 2326 D) is almost a perfect cube of brownish jasper, weighing .5695 grams, it varies from the calculated value .5712 by only one thousandth of a gram (.0017). This is an extraordinary degree of accuracy, but no less remarkable than the minute beads running 37 to an inch, found in the same room. The second weight, weighing .5985 grams, is in India. One other weight which might be included in this ratio is from Mohenjo-daro, weighing .550 grams. Recently published,[16] it was listed as of an undetermined ratio.

Of the other exceptional weights found at Chanhu-daro, two were in the ratio of 1/3 of 8; again one is in Boston and the other remained in India. This ratio has long been known and is designated by Mr. Hemmy [17] in his table of Mohenjo-daro weights as " ." The mean weight of the two Mohenjo-daro examples is precisely the calculated value of the ratio. Only the weight which remained in India approaches them in accuracy.

The ratio of 2/3 of 8 is another new ratio of which the two perfect cube weights from Chanhu-daro are so far the only examples known.

A rectangular block of grey stone is in the ratio 2/3 of 32 and varies from the calculated value by only 18 grams. However, it has been described as a doubtful weight and it was found at another level. In addition to these weights, there are others from Chanhu-daro that have been included, but they are not as accurate. Comparable weights from Mohenjo-daro and Harappā have also been listed, notably the sole weight in the ratio 2/3 of 2, which Mr. Hemmy had especially noted, "B (g) 23 (from Harappā) weighing 1.255 made of chert, is in excellent condition. It cannot be placed with any group."

We have now assembled a new series of 15 weights from the three sites, forming a secondary sequence of fractional ratios. The ratios 2/3 of 1, 2/3 of 2, 2/3 of 4, etc. to 2/3 of 32, may also be read as 1/3 of 2, 1/3 of 4, 1/3 of 8, etc. to 1/3 of 64. (It is possible that the missing smallest weight of 1/3 of 1 may yet be discovered). Again the whole series, with the smallest weight as 1 may be resolved into the usual sequence of 2, 4, 8, 16, etc. The limited number of fractional weights leads one to suppose that they had only a special use, and that like our Troy Weight, they were used in weighing gold, silver, and precious stones.

The use of thirds in a binary system is also an interesting extension of the mathematical knowledge of the Indus people. And in contrast to the cube form of the weights, there have been found tetrahedrons or small triangular pyramids of perfect form. One was found at Chanhu-daro in the bead-maker's shop along with the 14 weights. Others have been found at Mohenjo-daro. All are most carefully made of faience, limestone, and cast bronze. In each case all the sides are equal, so that each face is the plane surface of an equilateral

[16] Mackay, *Further Excavations at Mohenjo-daro*, pp. 604 and 607.
[17] Marshall, *Mohenjo-daro and the Indus Civilization*, p. 590, Table I.

TABLE III

Fractional Weights in a Series of Thirds

Ratio	Number of Specimens	Expedition Number	Source	Present Location	Weight	Calculated Value	Difference between Weight and Calculated Value
2/3 of 1		DK 12774 [1]	Mohenjo-daro	India	0.550		.021
or							
1/3 of 2	3	2326 d	Chanhu-daro	Boston	0.5695	0.5712	.0017
		2317	"	India	0.5985		.0273
2/3 of 2							
or	1	B(g) 23 [2]	Harappā	India	1.255	1.1424	.113
1/3 of 4							
2/3 of 4		HR 4331 [3]	Mohenjo-daro	India	2.33		.05
or							
1/3 of 8		HR 3079 [3]	"	"	2.24		.04
	5	DK 2106 [3]	"	"	2.07	2.2848	.21
		3913	Chanhu-daro	Boston	2.0626		.22
		4843	"	India	2.365		.083
2/3 of 8		2494	"	Boston	4.0403		.53
or	2					4.570	
1/3 of 16		4833	"	India	4.227		.25
2/3 of 16		DK 6346 [4]	Mohenjo-daro	"	8.850		.29
or	2					9.140	
1/3 of 32		2451 (?)	Chanhu-daro	"	8.520		.62
2/3 of 32		3837	"	Boston	18.1028		.18
or	2					18.280	
1/3 of 64		DK 5679 (?) [5]	Mohenjo-daro	India	17.970		.31

[1] E. Mackay, *Further Excavations at Mohenjo-daro*, vol. I, pp. 604, 607.
[2] J. Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 592.
[3] *Ibid.*
[4] E. Mackay, *loc. cit.*
[5] *Ibid.* A cylindrical weight with plane ends.

triangle. The weight of the faience tetrahedron from Chanhu-daro (now in Boston) offers no obvious connection with the weights, nor would it seem plausible that weight would be of any consequence in a faience object of such a special form, because it could not be controlled. Rather the choice of faience offers an excellent material for a clean-out measurement of length and sharp angles. The length of the sides of the tetrahedrons seems to bear some relation to the length of the cube weights in the ratios 8, 16, and 32. These speculations are very inconclusive, yet the possibility that these faience tetrahedrons were a solid geometric form by which some standard of measurement was established may be worthy of further consideration.

TETRAHEDRONS

Expedition Number	Source	Material	Length of All Sides in Inches	References
2326 i	Chanhu-daro	Faience	1.0	(4.7724 grams weight)
SD 2880	Mohenjo-daro	"	0.94	Marshall, *Mohenjo-daro and the Indus Civilization*, vol. II, p. 559, vol. III, pl. CLIII, 40.
C 46	"	White limestone	0.75	Marshall, *loc. cit.*, vol. II, p. 559, vol. III, pl. CLII, 41.
8027	"	Faience	0.61	Mackay, *Further Excavations at Mohenjo-daro*, vol. I, p. 572 and pp. 577, 8; vol. II, pl. CXXXVII, 7
8110	"	"	0.70	E. J. H. Mackay, vol. I, *ibid.*, vol. II pls. CXXXIX, 12 drawing), CXLII, 64 (photo).
6386	"	"	0.85	Mackay, vol. I, *ibid.*; vol. II, pl. CXLII, 73.
6642	"	Cast Bronze	0.9	Mackay, *ibid.*, vol. I; vol. II, pls. CXXXIX, 11 (drawing), CXLII, 63 (photo).

Animal Bones

The expedition is grateful to Dr. Glover M. Allen, of Harvard University, for his identifications of certain animal bones from our site, some in a bad state of preservation.

No. 1480. Sambar deer (*Rusa unicolor*). Tip of tine of antler. From Sq. 8/E, locus 103, level: + 14.4 feet. Nos. 1628, 1819, 4039, and 4471 were also tines and pieces of antler of the Sambar deer.[2]

No. 1654. Tines of the Hog deer (*Cervus porcinus*). From Sq. 9/D, locus 130, level: + 16.8 feet.

"No. 3031. *Bos. sp.* Bone implement from an anterior rib (see Pl. XC, 23). It quite matches that of a large domestic bull, but it is not possible to tell whether it is from a wild or domestic animal, or what breed of cattle. This tool was taken from the inside of the

[2] No. 1628, from Sq. 8/C, loc. 109, lev. + 12.2 ft. No. 1819, from Sq. 8/C, loc. 152, lev. + 11.7 ft. No. 4039, from Sq. 8/E, loc. 104, lev. + 9.3 ft. No. 4471, from Sq. 8/F, loc. 418, lev. + 8.7 ft.

TABLE IV

Cube Weights in the Museum of Fine Arts, Boston

Ratio	Calculated Value	Number of Specimens	Expedition Number	Locus	Level	Material	Condition	Size in inches	Weight in grams	Mean Weight	Difference between mean weight and calculated value
1600	1371.2	1	5056	Mound 1, Sq. 12/K, loc. 15	Plus 15.0 ft.	Chert	Badly chipped	3.4 lg.	1330.6845		40.5155
			1590	Sq. 8/C, loc. 109	" 16.25 "	Chert	" "	1.6 "	126.5835		
160	137.12	3	2474	Sq. 9/D, loc. 179	9.8 "	"	" "	1.61 "	131.4735	131.4830	5.637
			3025	Sq. 8/F, loc. 418	8.3 "	"	Undamaged	1.52 "	136.3930		
			2388b	Sq. 9/D, loc. 215	9.38 "	"	Badly chipped	1.1 "	49.6895		
64	54.848	4	1951	Sq. 9/E, loc. 125	" 14.40 "	"	Slightly chipped	1.2 "	54.1315	53.2266	1.6214
			2326g	Sq. 9/D, loc. 215	10.45 "	"	Undamaged	1.3 "	54.3558		
			2473	Sq. 9/D, loc. 179	9.8 "	"	"	1.22 "	54.7299		
			4598	Mound 1, Sq. 13/K, loc. 36	" 14.12 "	"	Slightly chipped	0.9 "	26.6846		
			2867	Sq. 9/E, loc. 124	9.9 "	"	Edges rounded	1.11 "	27.1391		
32	27.424	6	2904	Sq. 9/F, loc. 401	8.28 "	"	Worn	1.01 "	27.3039	27.4769	.0529
			3164	Sq. 6/E, loc. 431	" 10.17 "	Agate	Undamaged	0.9 "	27.3394		
			3189	Sq. 8/E, loc. 280	" 7.0 "	Chert	"	1.0 "	27.5255		
			3629				"	0.93 "	28.8724		
2/3 of 32	18.280	1	3837	Cut. Sq. 10/F, loc. 465	2.4 "	"	Worn rectangular	1.0 "	18.1028		.1772
			3504	Sq. 8/B, loc. 453	7.55 "	"	Slightly chipped	0.7 "	13.4074		
			2320	Sq. 8/E, loc. 114	10.07 "	"	Undamaged	0.71 "	13.5098		
			2569	Sq. 8/D, loc. 290	9.85 "	"	Slightly chipped	0.78 "	13.6830		
16	13.712	7	3121	Sq. 9/F, loc. 407	6.55 "	"	Undamaged	0.8 "	13.7130	13.7388	.0268
			3692	Sq. 8/B, loc. 233	7.6 "	"	Slightly chipped	0.81 "	13.8548		
			2659b	Sq. 9/D, loc. 192	8.75 "	"	" "	0.87 "	13.9731		
			2659a	Sq. 9/D, loc. 192	8.75 "	"	Undamaged	0.70 "	14.0306		
			2933	Sq. 10/E, loc. 218	6.9 "	White chalcedony	"	0.6 "	6.6412		
			2326h	Sq. 9/D, loc. 215	10.35 "	Chalcedony	"	0.68 "	6.8361		
8	6.856	5	2374	Sq. 9/D, loc. 215	10.40 "	Chert	"	0.62 "	7.1470	7.0830	.227
			2326b	Sq. 9/D, loc. 215	10.40 "	"	"	0.61 "	7.3345		
			921	Trench B(3)	− 5.6 "	"	"	0.63 "	7.4566		
2/3 of 8	4.570	1	2494	Sq. 9/C, loc. 208	9.9 "	Calcite	"	0.5 "	4.0403		.5297
			3883	Mound I, Sq. 13/J, loc. 3	15.6 "	White chalcedony	"	0.5 "	3.4046		
			4426	Mound I, Sq. 12/K, loc. 26	14.08 "	Calcite	"	0.49 "	3.5168		
4	3.428	5	3203	Sq. 8/D, loc. 178	7.6 "	Chalcedony	"	0.53 "	3.6437	3.6460	.218
			2418	Sq. 9/D, loc. 287	9.9 "	Colored jasper	"	0.5 "	3.8654		
			2326o	Sq. 9/D, loc. 215	10.45 "	Chert	Worn	0.49 "	3.7996		
2/3 of 4	2.285	1	3913	Cut. Sq. 10/F, loc. 423	2.88 "	Calcite	Undamaged	0.39 "	2.0626		.222
1	.857	1	178	Trench D(1)	− 1.65 "	Chert	Slightly chipped	0.3 "	.8856		.286
2/3 of 1	.5712	1	2326d	Sq. 9/D, loc. 215	10.40 "	Colored jasper	Undamaged	0.25 "	.5695		.0017