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Grégory Chambon & Adelheid Otto (eds.)

Weights and Measures as a Window on Ancient Near Eastern Societies

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Preface

Grégory Chambon – Adelheid Otto

The study of metrology can open up new pathways into the study of Near Eastern societies. This, however, requires systematic interdisciplinary research, since the material and the written sources contain complementary information. Therefore, the editors of this volume—a French epigraphist and a German archaeologist, both interested above all in the historical and socio-cultural relevance of ancient sources—initiated the interdisciplinary project METROLOGIA. The idea was to go beyond the quantitative approach and to develop methods by crossing archaeological and epigraphic data, in order to understand the far-reaching implications of metrology for society and economy in the Ancient Near East.

The project was based on the cooperation between the University of Brest (Université de Bretagne Occidentale and Centre François Viète) on the one side, and the universities of Mainz (Johannes Gutenberg-Universität), then Munich (Ludwig-Maximilians-Universität) on the other side. Members of the METROLOGIA project were (in alphabetic order): Abdulmuin Almohemid, Stefanie Boskugel, Grégory Chambon, Sarah Clegg, Berthold Einwag, Christoph Fink, Michaël Guichard, Ioannis Kanellos, Janoscha Kreppner, Denis Lacambre, Anna Lorente-Gall, Lionel Marti, Martine Melein, Adelheid Otto, Tanja Pommerening, Lorenz Rahmstorf, Fabian Sarga.

Several scholars of other universities and countries were cooperating with this core group. The meetings during the first two years (2012-2013) were funded by the DAAD (German Academic Exchange Service) and Campus France (Partenariat Hubert Curien)[1]; the cooperation has been continued ever since.

Some of the results of the METROLOGIA project were presented in the workshop "Weights and Measures as a Window on Ancient Near Eastern Societies", which took place in Munich on December 14, 2013.[2] Other results were published elsewhere, some of them in the important volume on "Weights and Marketplaces", edited by Lorenz Rahmstorf and Edward Stratford in 2019. Rahmstorf's approach towards metrology is a cross-cultural one, since the principles of controlled economic exchange were similar in the ancient world and because most of the metrological systems stood either in direct contact or were developed on the model of previous ones.

The contributions by the members of the METROLOGIA Project form the core of this publication. Additionally, it includes papers that were handed in by invited speakers during the 2013 workshop in Munich (Etienne Bordreuil, Nicholas Postgate). Two more papers by William B. Hafford and Luca Peyronel perfectly complement the purpose of this publication and have been included during the last stage of the editorial work.

Many contributions by members of the METROLOGIA project resulted from work carried out jointly and were presented collectively. This form of presentation is based on the observation that a complementary approach between philologists and archaeologists and the pooling of research results can enrich considerably the studies on metrology.

1 Unfortunately, supranational research funding initiatives are far too rare still today. The more so are our sincere thanks due to the DAAD and to Campus France for bringing scholars from different countries, but working on similar topics, together.

2 We thank the Fritz Thyssen Foundation, which supported the workshop. It focused on the following questions: How was royal ideology concretised in practical life and "material culture"? To what extent did the royal authority control the use and development of standards in the field of weights and measures? Which other social groups were able to use and develop their own standards of measurement? How can we understand the process of 'standardisation' in the field of weights and measures? What was their social function in the Ancient Near East?

We would like to thank all the members of the METROLOGIA project for their long lasting cooperation, and the contributors to this volume for their in-depth studies of socially relevant aspects of metrology. Our apologies and sincere thanks are due to Etienne Bordreuil, Sarah Clegg, Lorenz Rahmstorf, and Nicholas Postgate, who submitted their papers many years ago. It took much longer than scheduled to assemble the papers and edit this volume. Our thanks are also due to Martin Gruber for the layout of this volume, to Ilona Spalinger for correcting the English of all papers, to Peter Werner of the PeWe editing house for his continuous assistance, and to the Institute of Near Eastern Archaeology at LMU Munich for supporting this publication.

The cover image of this book expresses well the aim of the collected contributions. It was taken in 2009 at a rest stop in Iran, where A. Otto observed oranges being weighed as a matter of course with simple stones that were no more officially calibrated than most in the Ancient Near East. Metrology is determined by sellers and buyers, by the acceptance and the regulations of society, and is therefore an ideal window into past ideas and concepts.

New perspectives in the study of weights and measures of the Ancient Near East

Grégory Chambon – Adelheid Otto

§ 1. Why weights and measures can serve as a window on Ancient Near Eastern societies

Trade and exchange connect people who share different habits and cultural values and who have possibly never met before. Thus, the *conditio sine qua non* of every functioning economy is the control of trade or, at least, of the practice of giving and counter-giving. Different means of control had developed over times in the Ancient Near East, the most important being the oversight of the payment and the "trade tools", especially the weight stones and balances, capacity measures, and seals. The control took place either centrally by the state, a temple, other institutions, or simply by counter-weighing. While these mechanisms seem to have been fairly similar in many cultures of the Near East, Egypt, the Aegean and the Indus region from at least the third millennium onwards, the metrological systems varied; different weight standards were in use in the mentioned extended areas and were disseminated through economic and cultural contacts (Powell 1987–1990).[1]

The study of weights and measures has developed into a separate field of study, metrology, which had often been considered as a minor research area of natural or economic sciences. But it is much more. The large variety of measuring systems and the diversity of ancient measuring methods represent important cultural markers of individual ancient societies. Metrology is not only relevant at a technical and mathematical level, but holds enormous historical and socio-cultural potential, because it involves human activities, gestures and social relationships that manage and control measurement practices within the framework of cultural traditions and innovations. The material weights and capacity containers constitute—despite their little spectacular appearance—an essential tool for defining cultural zones and borders and for understanding internal administrative procedures and external relations at a trading and political level. However, the relevance of metrology goes much further, well into the private sphere of individuals. Legal certainty has been the base of most functioning societies, and not only texts but also depictions in various pictorial media emphasize the role metrology played with respect to the ancient concepts of law, justice and righteousness, as will be shown in the following.

Archaeology and philology used to pursue their own methodological approaches towards studying the measures and weights of the Ancient Near East, based on the artefacts found in excavations or on the information gained from cuneiform texts. However, only the combined analysis of philological and archaeological sources allows the determination of the individual measuring and weight systems on site, and conclusions on the organisation of the local economic systems and the interre-

1 Rahmstorf (2012: 315): "The study of 3rd millennium weights [...] in the region from the Aegean to the Indus Valley has shown that most probably only a handful of units of weights were in contemporaneous use around the middle of the millennium: one weight system with three interrelated weight units (7.83 g; 9.4 g; 11.75 g) in the East Mediterranean (Syria, Anatolia and the Aegean), one in the Indus region with a unit of 13.71 g, a Mesopotamian system of weight with a unit of c. 8.33 g, and finally an Egyptian unit (13–14.5 g?), which as yet escapes any precise fixation for the 3rd millennium BC [...]"

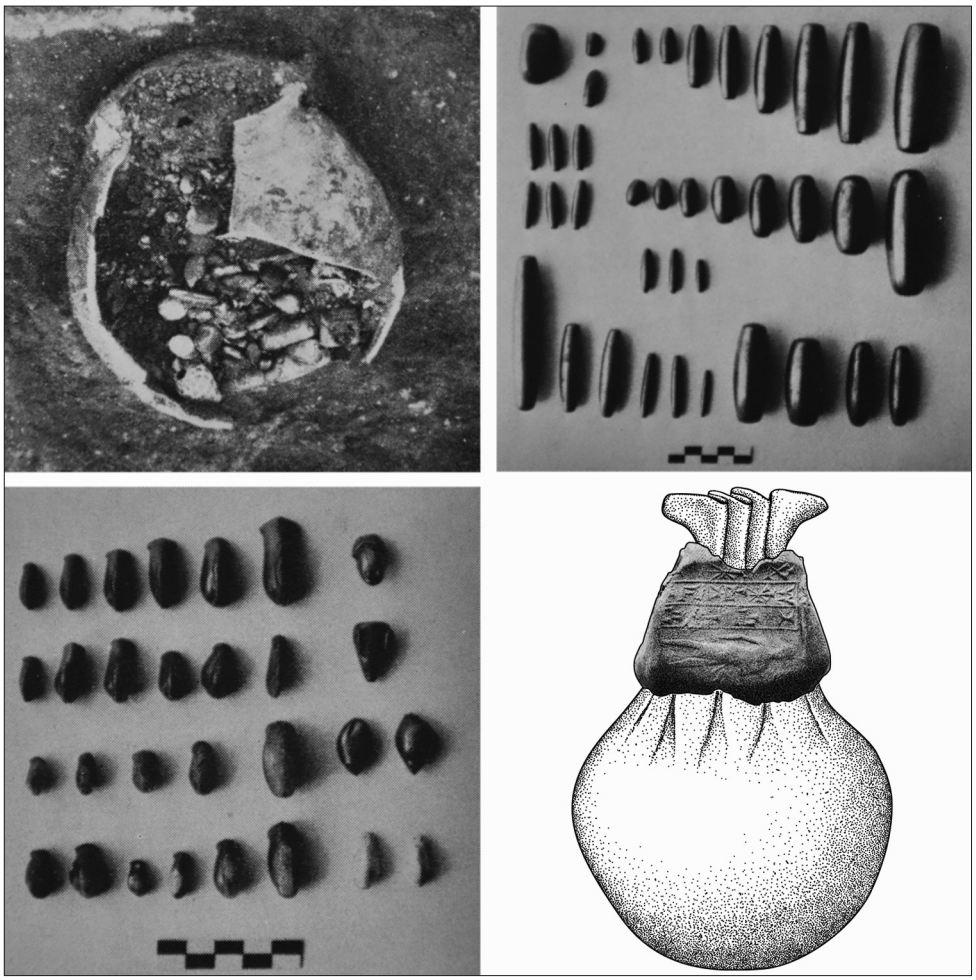

Fig. 1. The Larsa Hoard with sets of sphendonoid and duck-weights (Arnaud et al. 1979: Figs. 5, 15, 18) and the reconstruction of a sealed silver sack (A. Otto/M. Lerchl/photo of sealing: Arnaud et al. 1979: Pl. I,2).

gional political, cultural and economic contacts.[2] These range from the reconstruction of economic activities at local level (the administration of the palaces and temples, the management of resources etc.) to the relations at international level (trade, the exchange of presents between royal courts, military tributes etc.). Already in the third and second millennium, a successful economy was the basis for many flourishing societies, and sometimes those depending mainly on trade were strong enough to do without any royal authority.[3]

Yet, the study of weights and measures should not only serve an economic perspective through a quantitative approach, but should also take into account the political and social objectives as well as anthropological aspects of weighing and measuring. Nowadays, the interest in metrology is closely linked with the current debate concerning such concepts as "money", "market exchange" or "private business", which is largely based on the study of the circulation of precious metal—mostly silver—in Near Eastern societies (Powell 1996; Paoletti 2008; Van der Spek et al. 2018; Rahmstorf et al. 2021). In particular silver was used as a reference value and a medium of "commercial" exchange.[4] Since silver used to be recycled

2 This combined method has been successfully applied with the determination of Egyptian measures of capacity (Pommerening 2005).

3 It has to be pointed out that Near Eastern societies were organised differently; hierarchical power exercised in palatial systems were one model of organised power, but not the only one. Heterarchical models of power were frequent especially in societies which depended heavily on commerce, e. g. in the Old Assyrian–Old Anatolian trading communities or in Northern Mesopotamia during the Late Bronze Age—to name just a few.

4 The debate between the Substantivist and Formalist Schools, concerning whether the "money" function of silver existed or not (see

again and again and is found only in rare instances during excavations, e. g. when a hidden hoard had escaped the attention of ancient potential users, the early "money" must be studied through the balance weights that served for weighing the currency.[5] Only after stamped metal coins had come up in 6th century West Asia (Von Kaenel 2012), the weighing of the silver currency (or more rarely other metal) was no longer necessary. But already 2000 years earlier, weighed and sealed silver (*kaspum kankum*) was the obvious early currency, although not the silver itself, but the attached labels or clay closures of sacks containing the silver were impressed with seals (Stol 1999: 574),[6] which was described as *kīsum qadum kunukkiša*.[7]

This kind of "sealed silver" has been evidenced e. g. in the "Hoard from Larsa" (Arnaud et al. 1979). It comprises the equipment of the weighing office in the temple of the sun god or his daughter (more precisely in the *bît kittim*, the office for weights and measures; see Charpin 2017), where several balance weight sets of geometric and zoomorphic shapes were associated with large amounts of hacksilver, jewellery, seals and sealings. Although the respective involvement of the power organisations (palace, temple) in the control of the measuring process is still unclear, this case study exemplifies the procedures of controlled payment: precious metal was weighed, packed in small sacks, then the sack closure was sealed and the mass inscribed in the sealing by the officer for weights and measures (**Fig. 1**).[8] Therefore weight stones, silver, and seals had been closely interconnected from at least the third millennium onwards, since they were but different instruments within the same control system.[9]

Furthermore, some expressions in cuneiform texts refer to the certification of the quality and the value of silver, which was given to persons or used for trade (Chambon/Marti 2019). This value was determined by a certification office not mentioned in the texts (maybe an office for weights and measures, as seen above) and seemed to depend on the individual cities, because the texts mention amounts of silver weighed "according to the weights of this or that city", which certainly refers to both the market rate and the local economy. How these values were established therefore not only depended on economic conditions, but also on political decisions. In parallel with trade, the ceremonial exchange of silver between the elites occurred mainly through standardised objects, i. e. vessels and rings, which have both symbolic and economic value (Peyronel 2014: 310). Some evidence in the administrative documentation suggests that one should differentiate between the physical amount (the mass) of a precious object (Akkadian *kīnum*) and its "nominal value" (Akkadian *nībum*), i. e. a conventional value, which is based on a consensus among the parties in the diplomatic gift exchange of inter-state relations (Chambon/Marti 2019: 53–54). Thus, weighing and setting values took place within an economic as well as an ideological framework. The process of silver certification also involved social relationships between the political authorities and the weighmasters, who could be officials, merchants or craftsmen (Bartash 2019: 152–168).

§ 2. Philological and archaeological data on metrology

The Ancient Near East provides a wealth of material and epigraphic evidence with respect to weights and measures. However, it must be stressed that the studies of Mesopotamian metrology have so far not tapped their full potential since—on the one hand—many of them have been serving primarily the purpose of economic history, by giving quantitative data (amounts of commodities, weighing metals, field measurements …), and—on the other hand—because the archaeological and epigraphic information has been studied independently without being correlated or cross-referenced.

a summary of this debate in Stol 2004: 904–911), has been recently challenged: see Peyronel 2014 for the discussion on the role of silver in economic exchange.

5 The ongoing Italian SCANE project has been investigating silver hoards, hacksilver and weights more closely, Peyronel 2019 and in this volume. Reade 2018: 177 describes the situation for the 1st millennium: "The use of weighed silver money became essential to the Neo-Assyrian economy, but nearly all of the money has been buried or recycled and is no longer directly accessible. Its use can be studied in indirect ways, notably through the written documentation and through the evidence of artefacts such as inscribed weights and their archaeological associations."

6 Moneybags are also attested for other periods (see e. g. Vargyas 2005).

7 AEM I/2 387 no. 463 rev. 8; Stol 2004: 884–885.

8 Arnaud et al. 1979; Charpin 2017: 86–99: Half a mina silver, 66 weight stones, beads, cylinder seals and sealings were found together in a clay pot which had been hidden under a bench of Room 13 of the É.babbar shortly before the destruction by Samsu-iluna in 1738 BC. Some of the sack closures had been sealed with the seal of a certain Sîn-usili, weighing official of the *bît kittim* of Ur (KÙ.LÁ É.GI.NA *ša* URÍ), servant of Samsu-iluna. See also Otto/Chambon in this volume.

9 For the development of record-keeping procedures such as bullae, tags, seals and sealings, weights, containers from the 3rd millennium onwards, see Peyronel 2021.

The cuneiform documentation gives abundant information on metrology. From the archaic texts of Uruk at the end of the 4th millennium BC onwards, repertories of signs for numbers and measures used in the administrative documentation had evolved for several centuries. A dozen of numerical and metrological systems, which depended on the quantified or measured products, have been identified in these archaic documents (Nissen et al. 1993). Both quantitative and qualitative information is most often embodied in the same sign, whose numerical or metrological value depended on the system used. The first clear distinction between the signs for numbers or measures and the signs for products or objects, which became the rule during the 3rd millennium BC, has been interpreted as the emergence of a concept of "abstract numbers", not depending on the quantified objects or measured products.[10] But we have to keep in mind that this distinction was realised on clay according to scribal practices, which followed specific cultural traditions. We do not know to which extend it reflects the conception of numbers and measures of the ancient Mesopotamians. According to the epigraphic evidence, it actually seems that the notions of "container" (material), "content" (commodity) and "volume" (capacity measure) were highly intertwined.[11]

For example, vessels of standard volumes were used as a gauge unit for transporting liquids (wine or oil), and names of certain containers, given in particular on lexical lists, were confused with the capacity unit corresponding to their capacity. The main systems of notations for measures used in administrative texts until the 1st millennium BC concern capacities, weights, surfaces and lengths, and served as a means for managing and controlling the movements of goods and services by facilitating accounting practices.[12]

The earliest standardised material weights emerged with the formation of complex urban societies and city-states at the end of the 4th and beginning of the 3rd millennium (see Ascalone/Peyronel 2006a: 475–488 for an overview). Commodities were rare in the Mesopotamian lowlands and subsistence strategies had to be complemented by exchange and trade from the Chalcolithic period onwards. But also settlements in Northern Mesopotamia and Syria were heavily dependent on exchange and trade.[13] A few stone objects from Tepe Gawra Levels IX–VI, dated to the early Middle Uruk period (early 4th millennium), are among the earliest scale weights known so far (Hafford 2019). More weight stones from the Late Uruk period have been published recently: they originate from the Late Uruk trading station of Habuba Kabira South:[14] At least three of the eight recorded haematite pieces may be considered as balance weights, the remaining ones could be nodules of the precious raw material iron oxide, which occurs in the limestone heights bordering the nearby Euphrates valley (Melein 2018).

The first period for which the use of material weight stones is confirmed by textual evidence, namely a writing system including weight units, is the so-called Early Dynastic III period (c. 2600 BCE). The demand for standardised metrological values was clearly caused by the extension of trade and the increasing need for copper and other metals by the continually enhanced handicraft from the 5th millennium onwards. This growing need led to the conceptual and practical development of weighing and measuring on the one hand, and of the notation of metrological units on the other hand.

The material evidence of Near Eastern metrology seems to be quite abundant at first sight, but is relatively scarce, not only for objects connected with measuring, but even for those involved in weighing purposes. Millions of balance weights must have existed, if we assume that every man and woman who was involved in trading and selling activities during 3000 years of Near Eastern history must have possessed weights, more precisely sets of them. However, only several thousands of balance weights have been published or exhibited in museum collections so far. Only a fraction of them had come to light during regular excavations at archaeological sites in the vast area in and around Mesopotamia from the Mediterranean region to the Iranian plateau, and from Anatolia to the Persian Gulf.[15]

10 Damerow 2017. Concerning the issue of "abstract" numbers versus "concrete" numbers, see Overmann 2018.

11 See the remarks in Chambon 2011a: 50 and 68 and Chambon/Marti 2020: 89–90. In the lexical lists in particular, terms for units of measurement are included in (and often confused with) the names of containers and vessels (for example ^{dug}sila$_3$, "ceramic vessel of 1 (measure-)sila$_3$" or "^{dug}1 bán", "ceramic vessel of 1 (measure-) bán").

12 For an overview of these measuring systems, see Chambon 2021.

13 For example, Mari was situated in a very unfavourable place, outside the rainfed zone, in a fairly narrow fertile plain of the Euphrates valley. From its very beginning in the early 3rd millennium, this major Syro-Mesopotamian city could never have existed without an economic surplus through massive trade activities.

14 Strommenger et al. 2014: 271, Oberfl.: 44, AA X:71, DD XII:1, Oberfl.: 54; Pl. 165,9. More objects that are tentatively named gaming pieces might be balance weights, e. g. Pl. 164,2–10.

15 Good overviews of balance weights and studies on weights are offered by Alberti et al. 2006; Hafford 2012; Rahmstorf 2014; Kulakoğlu 2017. Unfortunately, even excavated and stratified weight stones have not been fully published, therefore every pub-

The disturbing scarcity of existing balance weights has several reasons, e. g. metal weights can have melted down, and the extremely stable stone weights can have been in constant use for centuries. We are, however, convinced that the main reason lies in our wrong conception of weights, which has urgently to be revised—hopefully also with the help of this volume. It is widely assumed that weight stones were of regular shape and corresponded to a few well-defined shapes (see **Fig. 1**), such as the sphendonoid, dome- or duck-shape, or—less frequently—the cylindrical, conical, spherical, cubical, ovoid, loaf or stele form.[16]

Yet, irregular forms of weights are by far more common than assumed. They fall into two categories: 'irregular weights', which are of various amorphous forms, but show clear traces of intentional working, and 'pebble weights', which are unworked stones used as weights—also called "make-weights". The latter can be detected only by their archaeological context or if they bear marks or inscriptions (Hafford 2005: 353–354). For example, an irregular goethite weight and a beautifully shaped haematite duck-weight were found together with two fayence Mittani Common Style cylinder seals and a bead in a house of 14th century Tall Bazi (**Fig. 2**).[17]

Certainly not every pebble was a weight stone, and it is often difficult to distinguish them from gaming pieces, tokens used for accounting, polishers, pounders or sling bullets (Hafford 2019: 17). But only when every single small, medium-sized and large stone is collected during excavations—a demanding task for archaeologists even today and clearly impossible in the former large-scale excavations with hundreds of workmen—it will become obvious how numerous the irregular and pebble weights were. Especially in regions close to the sources of the raw material, mostly iron oxide stones, the irregular and pebble weights outnumber the regularly shaped weights

Fig. 2. An irregular goethite weight, a haematite duck-weight, two fayence cylinder seals and a bead found together in a house of 14th century Tall Bazi.

by far, e. g. at Ebla (Ascalone/Peyronel 2006a; 2006b) or Tall Bazi (Fink 2012 and in this volume).

Weighing scales have been found even more rarely than weighing stones, because parts of them were from organic material and perishable (strings and wooden parts such as the beams), and the balance pans—if they consisted from copper or bronze—were frequently melted down. Not many metal balance pans have survived in archaeological contexts, of which only a few recently discovered ones are mentioned here. Several pairs of small balance-pans—the equipment *par excellence* of the Assyrian and Anatolian merchants—were found in graves at Kültepe-Kaneš levels II and Ib (Kulakoğlu 2017). In Late Bronze Age Ugarit, several bronze balance pans, stone and metal weights were found (Bordreuil in this volume). One of the best examples of scales, which were found together with sets of weight stones, was found buried in the Late Bronze Age Uluburun shipwreck. According to C. Pulak, this was the professional equipment of a handful of Syro-Canaanite merchants travelling on this ship from the Levantine coast to the Mycenean centres; the 149 objects from the shipwreck which were catalogued as balance weights fall into four sets of sphendonoid precision weights for weighing silver or gold bullion, three sets of domed weights for weighing heavier goods, and several zoomorphic weights (Pulak 2000; 2008). Seven pairs of scale pans associated with balance weights have also been found in the Late Bronze Age houses in Akrotiri/Thera (Michailidou 2008). Even the remains of a large balance for weighing heavy commodities have been reported: A large carbonized balance beam found together with an ovoid pendant weight of 2 mina and unworked pieces of lapis lazuli served for weighing the precious commodity under royal supervision in Palace G at Ebla (Peyronel 2019: 69–70).

lication in this respect is extremely valuable; see the contribution by Rahmstorf in this volume.

16 Hafford 2005; 2012; Peyronel 2019. Hafford's study of 476 weights excavated by Woolley at Ur resulted in 307 (64.5 %) sphendonoid and 92 (19.3 %) duck weights (Hafford 2012: 30, Table 2). The total number of only 33 weights from the large Old Babylonian house quarter AH is much too low, if compared with the number of weights found in recent excavations at Ur (see Hafford/Einwag/Otto in this volume), and is just one of many examples for the little attention that weights and pebbles have received in most excavations.

17 Weststadt of Tell Bazi, House 41 South, secondary room e. Otto 2006: 120–125, Fig. 62.3 ; 64.1–2. The mass of the irregular weight (Bz 29/31:5) is 13.1 g, the mass of the duck-weight (Bz 29/31:3) is 16.0 g (see Fink in this volume).

Fig. 3. Syro-Hittite commemorative stele of a merchant holding two balances (Bonatz 2000: Pl. IX, C10).

Ancient images are our second archaeological source of metrology. A scene on the Rassam Obelisk found at Kalhu, dated to the reign of Aššurnasirpal II (883–859 BCE), shows two Neo-Assyrian officials weighing what may be round metal bars on a huge balance scale and provides an idea of what the weighing practices of heavy metal pieces might have been (Reade 1980). Another scene, on the famous wall relief depicting the looting of the Haldi temple in Muṣaṣir by the troops of Sargon II (Albenda 1986: pl. 133), relates the dismemberment of metal statues to the weighing procedures on large standing balances and also illustrates how quickly even objects bearing ritual significance could be reduced to their purely material value.

In general, scenes of everyday life were never depicted in Near Eastern pictorial media unless they fulfilled a specific function for the status or ideology of the image's sender or receiver. Consequently, the weighing or measuring procedures were only illustrated when the divine or royal role in the protection and warranting of the procedures should be emphasised. Therefore, it may

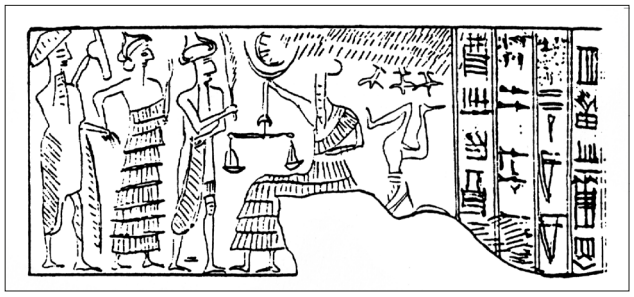

Fig. 4. Impression of a merchant's seal from Karum Kanesh II (Teissier 1994: no. 532).

be argued that the few depictions of the act of weighing were essential for the owner or sponsor of the image. The private Syro-Hittite memorial stele, depicting a merchant holding a small hand-held scale in both hands, emphasises that the balance was the tool par excellence and identifying feature of a merchant (**Fig. 3**).[18] In the case of cylinder seals with depictions of weighing and measuring practices, we can assume that they belonged to merchants, market overseers, official weighmasters or alike. For example, two Syro-Cappadocian seal impressions on tablets from Karum Kaneš II each show an audience scene in front of a deified king or god who is manipulating a hand-held balance, thus illustrating the royal or divine control over trade. One seal owner is qualified as a merchant (Sumerian dam.gar) by the inscription (**Fig. 4**).[19] The other seal is even more explicit and refers not only to the weighing but also to the measuring process (see below, **Fig. 12**, with further comments).

There is abundant textual evidence that not only balance weights, but also standardised vessels of different capacities were produced in order to facilitate the practical and economic activities of daily life (see e. g. Gruber 2015). Their size and range were configured according to the needs of storage, transport and trade exchange and could vary from place to place. Capacity measures most often appear as measures of dry commodities such as grain, predominantly barley (as ^{giš}ba.ri$_2$.ga/*parsiktu*, ^{giš}ban$_2$/*sūtu*, anše/*imēru*, ^{giš}PA/*parīsu* etc.), but standardised jars[20] were also used to transport

18 Stele from sandstone, H. 0.55 cm. Paris, Louvre AO 19221; probably from Maraş (Bonatz 2000: 17).

19 Seal impression from Karum Kaneš II (Teissier 1994: 178, no. 532).

20 For example, according to the Old Babylonian text ARM 9 n°6 from Mari, a "standardised" jar (dug/*karpatum*) for oil transport contains 10 (measure)-sila$_3$ (= 10 or 5 liters, depending on the modern value given to sila$_3$ in the region of Mari: see for this issue Chambon 2011a: 178–179 and Reculeau 2018: 109). We thank Laurent Colonna d'Istria for informing us that, during the period of

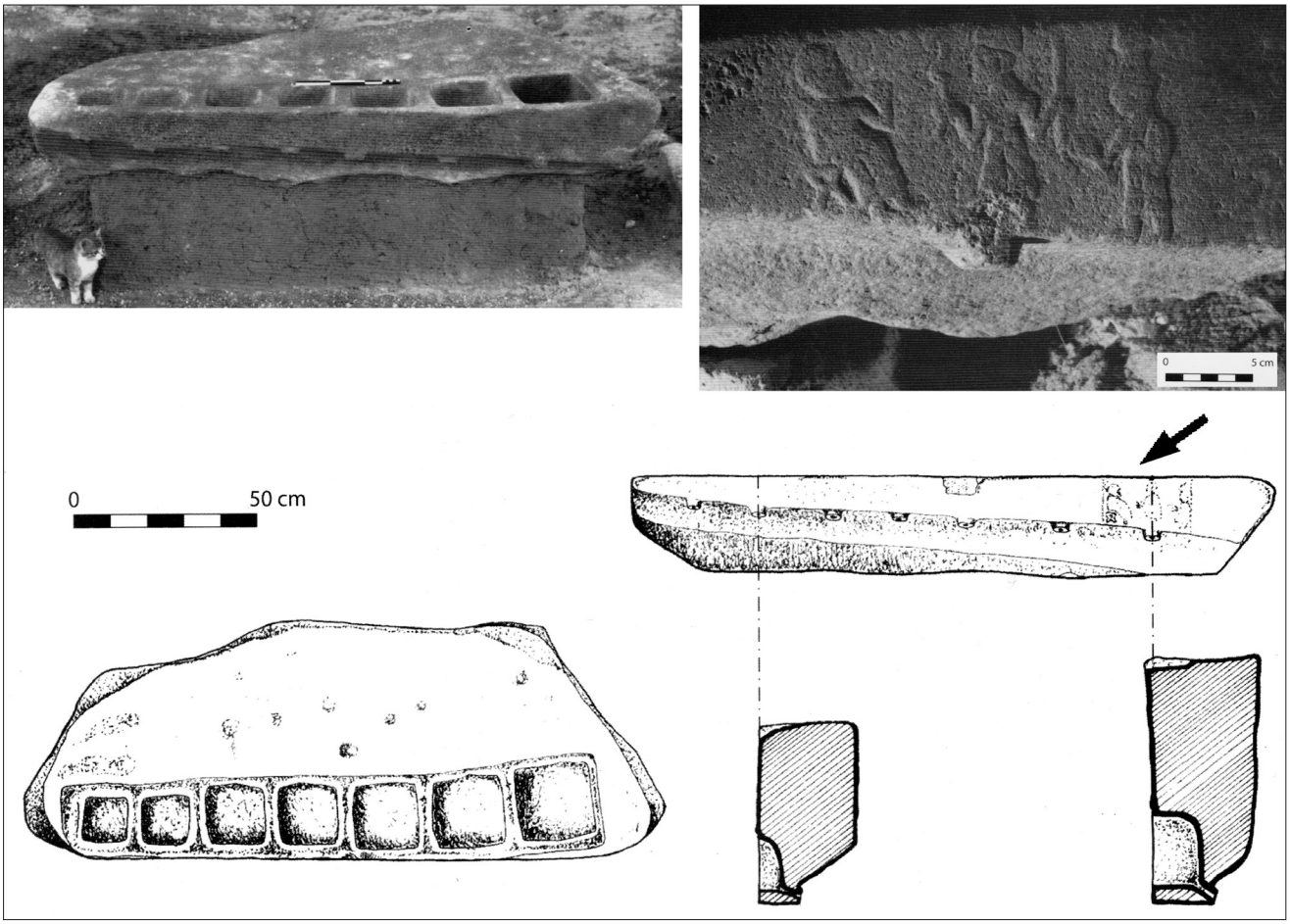

Fig. 5. Capacity measuring table TT.81.F.100 from Tall Tuqan, decorated with a man holding balance and strickle (Baffi 2006: 292 Figs. 1–2).

or distribute oil and wine (*karpatum*, *našpakum*, *diqārum* etc.). The determinatives of these vessels mentioned in thousands of cuneiform texts inform us that these vessels of standardised volume consisted mainly of wood (GIŠ) or reed (GI). The archaeological remains of capacity measures, by contrast, are disappointingly meagre: not a single measuring standard vessel—i. e. a container which could easily be manipulated for measuring dry products like barley, flour or fish, or liquid products like beer, oil, dairy products and others—has been materially identified so far. In this respect, it is useful to throw a glance at Egypt, where metal and wooden standard vessels used for measuring grain—often of cylindrical form—have been preserved; additionally, there are numerous depictions of the measuring of grain and other agricultural products in cylindrical vessels, especially from the Old Kingdom (see e. g. Pommerening 2013). In analogy, it can be assumed that most Mesopotamian capacity measuring vessels also consisted of wood, reed or bark, which explains why no archaeological evidence has remained in the wetter environment of Mesopotamia. However, there are probably at least two depictions of a cylindrical measuring container for grain on Late Akkadian seals (see below; **Fig. 6** and **Fig. 11**).

Several factors make it improbable that pottery vessels were used for precise measuring procedures. One is the production process including potting and shrinkage of the clay during the process of drying and firing. Another is the heaviness of clay containers. A large or medium-sized jar from clay can be lifted only with difficulties already while empty; but it would be extremely hard to manipulate a filled one. Instead, scholars have concentrated on studying a very small number of clay jars and vessels bearing inscriptions that may indicate their capacity, in order to obtain equivalences between the ancient standard units and that of our present system (see below).

the second Lagaš dynasty (22nd century BCE), the oil jars also had standardised capacities of 15, 30 and 60 $sila_3$ (Colonna d'Istria 2022).

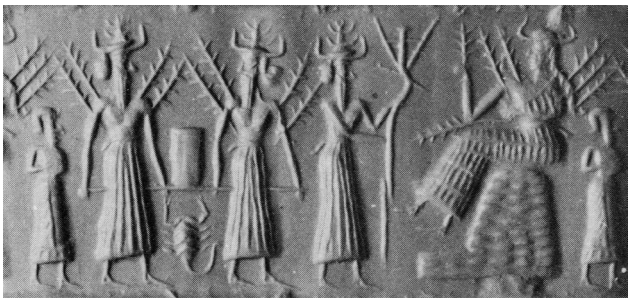

Fig. 6. Akkadian cylinder seal BM 129478 depicting two male vegetation gods carrying the measuring vessel to the goddess Nisaba, who is seated on a grain heap (Collon 1987: no. 106).

A single basalt table with seven square cavities for capacity measurements has been excavated to date (**Fig. 5**).[21] The large object came to light in the city gate of Tell Tuqan in Syria (Middle Bronze I), in deliberate proximity to the market area which was often situated near the city gate.[22] The aligned square cavities held capacities in ascending order between 500 cl and 4500 cl and had small openings on the lower side in order to allow the grain flow into a receiving container (Fiorentino 2006).[23] There is a scene of three figures depicted on the side of this referential measuring table: Two men approach a seated person; the central man holding a different object in each hand, which could be a balance in his right hand and a strickle for levelling the grain smooth in his left hand. It seems that these two instruments were the symbols for weighing and measuring (see § 8).

§ 3. Earlier studies on metrology

The so-called "comparative metrology" (*vergleichende Metrologie*), initiated in 1838 by A. Böckh, was based on the preconceived notion that several, or even all, measuring systems in the Ancient Near East and the Mediterranean area were related to each other by simple arithmetic relationships (Böckh 1838). According to C. F. Lehmann-Haupt (1912), the Roman pound of 327.45 g would correspond to 2/3 of the "normal" Babylonian mina of 491.2 g, while the Egyptian pound of 90.96 g would represent 1/6 of the "light" Babylonian silver mina of 545.8 g (Chambon 2011a: 30–31). According to this point of view, all ancient capacity and weight systems were interconnected and could be studied separately, regardless of the societies that produced and used them. The network of numerical relationships obtained between all the measure standards masked possible geographical and chronological peculiarities, and therefore led to a fictitious global vision.

At the beginning of the 20th century, F. H. Weissbach (1907) and O. Viedebantt (1923) criticized this approach, which was not based on homogeneous material corpora, but on data from different geographical areas and periods, and preferred an "inductive metrology". This empirical method consisted of studying material objects (especially weights) from the same culture very precisely, in order to reconstruct local measure standards, like the standard mina of Sargon II established at 501 g by F. H. Weissbach (1916). Unlike comparative metrology, which envisaged a multiplicity of arithmetically related measure standards, this new approach makes it possible to assume the existence of several measure standards with no rational relationship, and to draw chronological and geographical boundaries between them. At the beginning of the 20th century, the philologist F. Thureau-Dangin (1909; 1937) used a combination of comparative and inductive metrology at a micro-geographical level. He assumed that the capacity standard (Sumerian $\mathrm{sila_3}$, Akkadian *qa*), the weight standard (Sumerian ma-na, Akkadian *manûm*), and the length standard (Sumerian $\mathrm{kuš_3}$, Akkadian *ammatum*) from Southern Mesopotamia were related to each other, thus opening up the field of metrology to philological studies. This type of study had a certain impact on the research on metrology, and the results concerning "Mesopotamian standards" obtained by F. Thureau-Dangin constituted for decades the *opinio communis* in Assyriology: the capacity standard $\mathrm{sila_3}$ was set as approx. 0.8 to 1 liter, a standard mina as approx. 500 g, and a cubit as approx. 50 cm, for all periods and places.

Studies on Mesopotamian metrology according to epigraphic data were revived from the 1980s onwards. This was partly due to new trends in the study of mathematical texts and metrological lists/tables,[24] which paid more attention to the vocabulary and the aim of this scholarly literature, and partly due to a better understanding of the earliest measurement systems in archaic texts or even in the accounting token systems used before the advent of writing.[25] On the archaeological

21 Basalt table TT.81.F.100 (Baffi 2006: 292, Fig. 1).

22 See Otto 2019 for more examples of market places in second millennium Syro-Mesopotamia.

23 The volume of each cavity was studied by A. Archi.

24 See for example the works of Jens Høyrup (1990) and Jöran Friberg (1987–1990).

25 See for example the works on tokens initiated by D. Schmandt-Besserat (1996) and the works on archaic measurement systems by H. Nissen, P. Damerow and R. K. Englund (1993).

side, the issue of accuracy has become central to data processing, by establishing the exact mass of the weight standards and the volume of capacity standards, or by estimating the precision of ancient scales (see § 4). The methodologies focused above all on arithmetical and absolute values of measure and weight units (see § 6). This led to M. A. Powell's important synthesis of weights and measures in the *Reallexikon der Assyriologie und Vorderasiatischen Archäologie* (Powell 1987–1990). It postulated—as many works based on it afterwards—a diversity of the material standards in everyday practice, reflected by various designations in the administrative documentation—an assumption that is difficult to verify by archaeology. For instance, the terms used for capacity measures refer in particular to material, religious or administrative aspects, such as the "big *sūtu* (capacity measure)", "the *bariga* of (the sun god) Šamaš", "the weight of the royal office", "the mina (weight measure) of the (city) Karkemiš", etc.[26] Powell's approach was primarily arithmetic in reconstructing the structure of measurement systems and the numerical relationship between measurement standards, and did not pay much attention to the context of use or the actual function of these different standards.

These earlier treatments of weights and measures provide important epigraphic and archaeological data and give a good understanding of the structure of the main measurement systems used in Ancient Near East, with the relationship between the measure units. This is particularly useful for philological work, when trying to interpret the quantities of foodstuffs recorded in documents from different regions and therefore sometimes referring to different measurement systems. However, they did not provide evidence for the actual form and function of the measuring vessels or of the material weights, and also the various contexts and practices of measuring remained largely unexamined for a long time.

§ 4. The issue of accuracy in studying metrology

Current research still focuses on the notions of accuracy, precision and norm when studying material measure standards. The values given for ancient weights and measures are often expressed with several figures after the decimal point, and are supposed to vary around ideal but fictitious standards, like—for example—the "Mesopotamian" shekel of 8.416 g. But does this notion of accuracy and metrological norm not merely reflect modern scientific thought, which is influenced by our accurate and uniform metric system, and is far away from the practical concerns of ancient societies? By analysing a sample of balance weights from Ur of Middle Bronze Age date, which is structured around the Mesopotamian shekel of c. 8.4 g (Hafford 2012), N. Ialongo and L. Rahmstorf noted that the standard deviation around this value is strikingly higher than the normal expectations for ancient weights. They concluded that these results "strongly argue against the common practice of setting pre-determined thresholds for the accuracy of ancient measures, since the real structure of weight systems is much more approximate than it is usually believed to be" (Ialongo/Rahmstorf 2019: 117). The study of recently excavated weight stones from Ur also corroborates this observation (see Hafford/Einwag/Otto in this volume).

The current use of precise quantitative methods is in fact based on the implicit model of the natural sciences, itself derived from the metrology of 18th century astronomers and physicists, who postulate a reality independent of the observer, which they attempt to measure precisely with increasingly precise instruments and fewer technical errors. However, before the emergence of this model in Europe, ancient measure standards were set more on the basis of practical and social requirements rather than scientific and technical motives. It would certainly not have been possible in antiquity to manufacture vessels and weights with a high degree of precision or consistency. Regarding the empirical evidence, K. M. Petruso points out that: "Given that most sets of balance weights were likely manufactured by duplicating existing sets, errors were necessarily introduced in the manufacture of each set, and would likely be compounded in the manufacture of subsequent copies of copies. It follows that basing calculations on a single chosen mass standard—to two decimal places, no less—is highly arbitrary, and ensures that all calculations that arise from any such choice are suspect." (Petruso 2019: 6 note 1).

Furthermore, precision and accuracy were not necessarily the purpose of ancient accountants, who had another notion of "standard" than we do. The term "standardisation" literally refers nowadays to the process of unifying dimensions, types, procedures or similar, the aim of which is to create common "standards". In contrast, the term "standard" has different nuances of meaning: It can describe the product of a standardisation process: a uniform or unified, widely accepted way of producing or carrying out something that has prevailed

26 See for these designations the remarkable studies by Veenhof 1985 for the Old Babylonian period and by Postgate 2016 for the Middle Assyrian period.

over others. "Standard" then characterises a rule or normal case, e. g. a standard version in the areas of "production technology" (industry standards, graphic standards, e. g. PDF format, etc.).

If argued from a bottom-up perspective, the accuracy of weight stones or capacity measures was certainly much less important for the ancient people than we assume today, since trade relied on mutuality. Weighing was not performed by one party only, but counter-weighing was a usual practice, which must have been so effective that deviations from the standard—which can be observed for nearly all the ancient everyday weight stones—were negligible.

Although capacity measures and weights served as an ideal means of measuring and weighing consistently, the main concern of ancient bureaucrats was not technical accuracy but efficiency and righteousness in administrative transactions. T.C. Wilkinson assumes that "Weighing systems imply a need for establishing trust between strangers" (Wilkinson 2018: 41). The quantitative data in a text, the results of a measurement or weighing, are not necessarily a very accurate reflection of reality, but correspond above all to a consensus between the different protagonists of the transaction (merchants, officials, craftsmen…), who have agreed on these data. As a result, any technical precision in the process of measuring or weighing must be sought in the archaeological data rather than in the epigraphic ones on the one hand, and a (modern) degree of tolerance must be applied when studying (ancient) measuring and weighing materials on the other hand.

The evaluation of large archaeological data sets of balance weights have resulted in giving an average ratio of deviation which seems to have been accepted in the daily practice of weighing (Hafford 2012: 38; Fink 2012). This ratio clusters around 5 %, which seems a reasonably low rate; but it means that a weight stone of one Mesopotamian shekel of ideally 8.3–8.4 g could have had a tolerated mass of 7.88–8.82 g.

§ 5. Deities, kings and other guarantors of accuracy and righteousness

In Mesopotamia, the above-described notion of standard and accuracy was above all linked with the ideological concepts of righteousness and truth, rather than with that of rational thinking and technical precision. We find a concrete counterpart in metrology. In Sumerian literature, for example, the goddesses Nisaba and Ninlil are given the means (the 1-rod reed and lapis lazuli measuring rope) to measure land justly and accurately for an equitable distribution of the harvest.[27] Nisaba is attested as the goddess of grain from the Early Dynastic period onwards, and developed to become the patroness of accounting and writing—an evolution which is clearly related to her authority as the guarantor for the righteousness of the measured grain. She is also the chief scribe of the goddess Nanše and shares with her a controlling function.

Nisaba's superior position in the process of grain measuring was possibly depicted on an Akkadian cylinder seal (**Fig. 6**)[28]: A female goddess with long hair, stalks of grain sprouting out of her shoulders and holding grain in both hands, is seated high up on a large heap of grain. Three male gods are approaching her, the first one carrying a plough, the second and third one—characterized as grain gods by grain stalks sprouting out of their shoulders—carrying along a heavy object on two poles. This object might very well be a large cylindrical capacity measurement container for grain.

At last, a hymn to the goddess Nanše, who also was responsible for the correct weighing procedures, concerns the potential fraudulent use of weights (Heimpel 1981: 67; see Otto/Chambon, in this volume). This role, attributed to the superior local female goddesses in the third millennium, was in large parts taken over by Utu/*Šamaš*, sun god and god of justice, from the second millennium onwards. The sun god was also considered as a supervisor of the correctness in commercial transactions, as becomes explicit in the hymn to Ḫendursanga,[29] and was occasionally explicitly associated with weighing (Rainey 1965; Stol 1999). Material evidence comes from large (duck-)weights with inscriptions in the name of Šamaš.[30]

The ideal of metrological justice is also reflected in royal rhetoric (Robson 2008: 119), particularly in the law

27 Lipit-Eštar Hymn B (ETCSL 2.5.5.2, l. 18–24) and the literary text "Enki and the World Order" (ETCSL 1.1.3, l. 412–417): see comments by Robson 2008: 117–118.

28 BM 129478 (Southesk Coll.). Boehmer 1965: no. 1266, Fig. 541; Collon 1982: No. 209. The goddess has been identified as a vegetation goddess (without attributing a name), and there has been no explanation for the carried object so far. We think that the depiction of the cylindrical measuring container is not unique, see remarks on Fig. 11 below.

29 See the hymn to Ḫendursanga A in ETCSL 4.06.1, segment C., l. 32.

30 E. g. a large sphendonoid weight of ½ true mina from Nippur (Hafford 2005) ; a large duck-weight "3 mina of the god Šamaš" (Marzahn et al. 2008: no. 194, Fig. 184). A complete inscribed duck-weight (26.7 kg) of "1 true (Sumerian g i-n a) talent" was found in the ziqqurat precinct at Babylon; the inscription ends "may Shamash take away whoever removes (this weight)"; Aruz et al. 2008: 371, no. 236.

collections promulgated by various kings of the third millennium and the Old Babylonian period. In this respect, the "metrological reforms" attributed to Ur-Namma (Ur III period) should certainly not be understood as political efforts to unify and standardise all weights and measures according to a single accurate standard in his empire, but rather as the will to use metrological rhetoric in order to make explicit the king's function as the supreme guarantor for justice and economic control (Chambon 2011a: 55). In practice, the measure units described in the reforms probably served as reliable standards of reference for the royal administration, in order to manage and record economic flows, and as one of the means of uniting legal obligations within the newly established state. However, some Ur III documents indicate the use of various capacity standards, which refer in particular to the specific density of grain at certain stages of processing and to the use of grain. To which extent (and how) the local measure standards were in competition with the royal standards is to be investigated further (see for this issue Clegg in this volume).

The control of trade—already described in § 1 as essential for every functioning economy—was exercised through legalised divine or human authorities: Gods and goddesses, the temple, the king, the palace, the city house, the market overseer, experts in measuring practices and many more. The tools of these different authorities needed obvious marks so that they could be immediately identified as referential objects. In the textual documentation they were labelled with the specific expression for "measure standards" (see Pommerening/Chambon/Marti in this volume in this volume). It is commonly accepted that these reference weights or standards were visibly marked as such. This could be done in material culture in various ways: either the balance weights and containers of 'normal shape and appearance' were marked by inscriptions that mentioned the kind of measuring standard used. In the case of containers, these were for example *ina* gišban$_2$ dutu "according to the standard (measure-)*sūtu* of (the god) Šamaš"; on material weights this was the Sumerian term gi-na "certified/established" (most often by the king) associated with weight units, or they were marked by geometrical symbols, or both. In some cases, the objects differed already considerably from ordinary measuring objects: either in material and colour[31], the elaborateness of the finish and the precision

Fig. 7. Three bronze lion-weights with inscription from Kalhu, North-West Palace, Room B (Curtis/Reade 1995: 193)

of the mass[32], or the shape. Typical examples of the latter are zoomorphic balance weights, among which the lion-shape, the 'duck'-shape[33] and the bull-shape are the most common ones. It may be assumed that the choice of these animals—at least of some of them—was deliberate and in some cases possibly related to deities or other powers, although the meaning of a frog, a fly, a shell or a boar's head is difficult to grasp.

The form of the lion-weights has long been accepted as being related to the royal Assyrian ideology. The best examples are the 16 Neo-Assyrian bronze lion weights that were found by A. H. Layard in Throne Room B of the North-West Palace in Nimrud/Kalhu, more precisely in Doorway b under the collapsed colossi (**Fig. 7**).[34] Reade (2018: 147–148) convincingly argues that "the bronze lion-weights from Room B with their royal inscriptions were special […] the Nimrud lion-weights had the formal status of approved government standards […]". Some of

31 Approx. 200 weight stones were found in houses, temples, defensive structures and palaces of Middle Bronze I–II Ebla; most of them were made from iron oxide stones and of sphendonoid, domed or spherical shape. However, one outstanding weight in form of a lion of 913 g, i. e. approx. 2 Syrian mina of 470 g, was found in the Western Palace and has convincingly been interpreted as a royal weight (Mazzoni 1980 ; Peyronel 2019). This shining black lion figure had bright red eyes and cheeks, inlaid with red stones, which made this referential royal weight immediately outstanding by its appearance.

32 Good examples are bronze lying bulls from Ugarit, which are not only unique, extremely finely modelled, objects (cast in the lost-wax-method), but had also been adjusted to the exact mass by coils of bronze wire strung around the neck.

33 For the so-called duck-shaped weights, their identification as goose-weights and their relation with specific deities see Otto/Chambon in this volume.

34 Peyronel 2015. Reade (2018: 180) describes them in detail: "B 6. Bronze lion-weight with handle (Fig. 1). BM 91221 = 1848,1104.67. Peyronel 2, Fig. 2; Fales 2; Curtis 534, Pl. XLII + analysis; RINAP 1, 171f.; SAA 6, Fig. 3a, c; Mitchell 2 style A; Curtis & Reade 1995, 193 (colour). Cuneiform on top: Palace of Shalmaneser; 5 minas "of the king". Left side: 5 strokes. Aramaic on right side: 5 minas "of the land", and 5 "of the king" on base. Provenance: see B 1. L 19.7, H 10.2 cm. Mass: 5,042.805g (Chisholm I, 2). 5,043 ÷ 5 = 1009g."

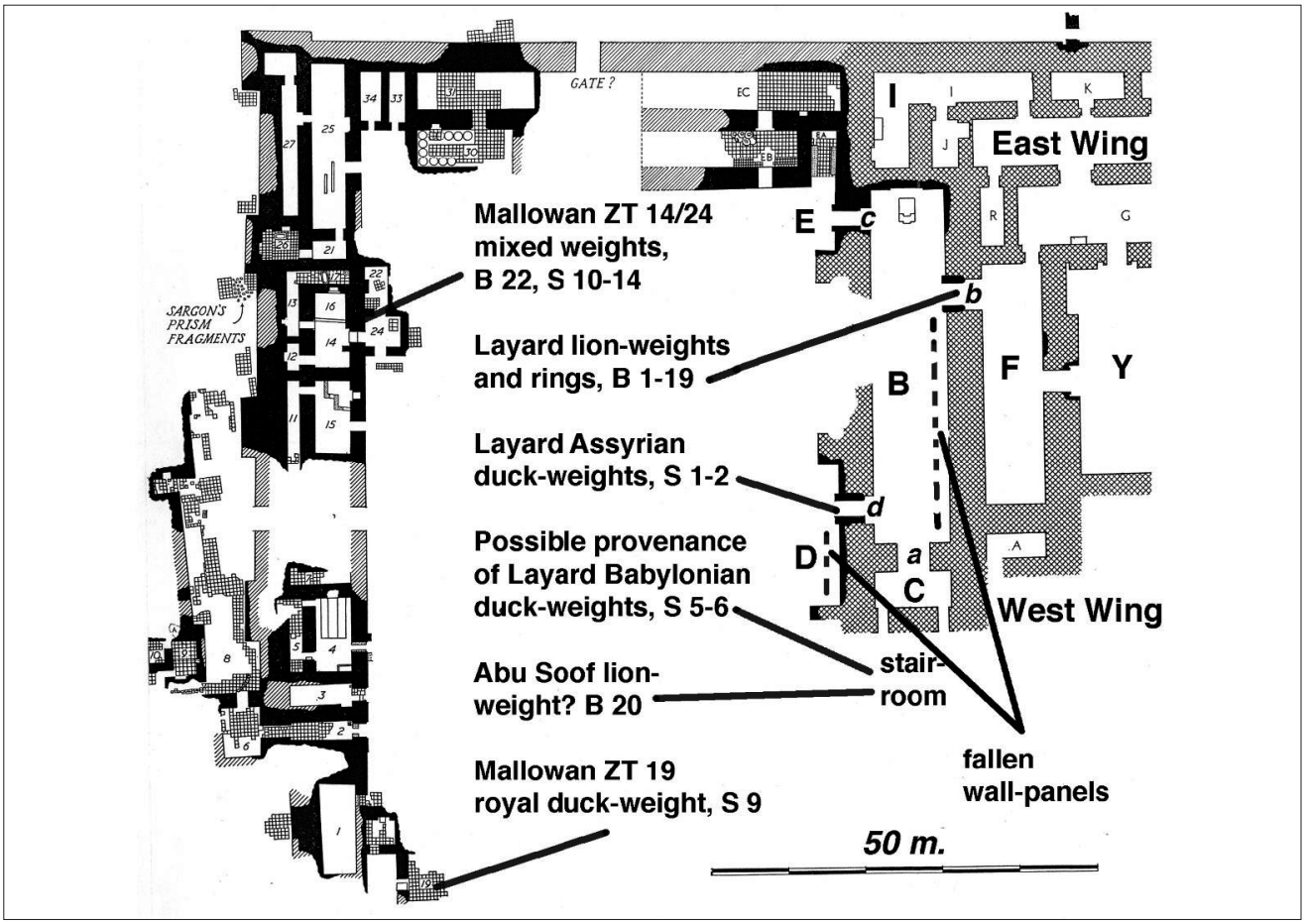

Fig. 8. Map of the approved government weights in the North-West Palace at Kalhu (Reade 2018: 129, Fig. 2).

them bore one inscription in cuneiform: "weight of the king", an additional inscription in Aramaic "weight of the land" and/or "weight of the king", and a number of vertical incisions indicating the number of units. Apparently, these government standards should be understandable by Assyrian, Aramaic and illiterate users of these referential weights within the huge Assyrian empire.

Reade illustrates the find spots of the weights in the very heart of this palace (**Fig. 8**) and also mentions a ceramic tub which was found near these 16 lion-weights (Reade 2018: 131–133). This tub (BM 91941) is a capacious straight-sided open ceramic tub—an unusual form of Neo-Assyrian vessels (**Fig. 9**). Two figures are applied in low relief to the side of the vessel, representing the scorpion-man or *girtablilu*. Reade argues that the scorpion-man's task in Mesopotamia was to guard the residence of the sun god, and that one of the duties of the god Šamaš was to ensure justice and equity. Therefore, he relates the cylindrical tub to the "worlds of commerce and taxation", and suggests that the lion-weights originally had been stored inside the tub (Reade 2018: 132–133). However, he seems to doubt his own explanation because he wonders why no green stain from verdigris was visible inside. One might add that no reasonable person would store heavy bronze tools in a fragile terracotta container, since the slightest blow would break it. Another explanation seems to impose itself: This container was the "approved government standard for capacity measures", which was kept side by side with the approved weight standards. Its capacity can be approximately calculated, since both height and rim-diameter are indicated as ca. 51cm. This would make a capacity of approx. 40 litres and equals the supposed capacity of the "5 *sūtu* measure" (if 1 *qa* = 0.8 litres) from Middle Assyrian texts (see Postgate in this volume). If the idea put forward here holds true, this would be the first royal capacity standard having survived so far—discovered by Layard at the dawn of the archaeological exploration of the Near East. There are more arguments in favour of this idea. It has been generally accepted that the Assyrian king had a close relationship to the sun god. Aššurnaṣirpal II chose the sun god in the winged disc to dominate the sacred tree in the two central relief slabs behind the

Fig. 9. Ceramic tub from NW-Palace, decorated with scorpion-men (*girtablilu*), probably the approved government standard for capacity measures (Reade 2018: 133, Fig. 3)

Fig. 10. Duck-weight marked as an Assyrian standard with the incised figure of a lion (Curtis/Reade 1995: 194, no. 206).

two throne pedestals in Room B.[35] Both the lion-weights and the capacity standard were found close to these two pictorial ideological statements that highlight the role of Aššurnaṣirpal. He is referred to as the "Sun (god) of all people", which means the executor of the supreme god of justice. The proximity of the main metrological reference tools to the royal throne is a distinct proof of how both the king and the sun god served as guarantors for the righteousness of metrological reference tools—still in the first millennium BC.[36]

Even more referential weights were excavated by Layard in 1846 in Throne Room B, this time in Doorway d under the collapsed lion-centaurs. The two "duck-weights" both show an incision of their mass and are marked as an Assyrian standard by the incised figure of a lion striding left (**Fig. 10**) (Reade 2018: 136–139, Fig. 8). More duck-weights are reported for Throne Room B and the area nearby, both of a mass given as 30 minas and weighing approx. 15 kg. They bear inscriptions of the Babylonian kings Nabû-šumu-lībūr (c. 1033–1026 BC) and Erība-Marduk (c. 775–765 BC). These Babylonian standard royal weights must have been kept in Babylon until the city was captured by the Assyrians, and then brought to Nimrud as a tribute. Apparently, the duck-weights represented so much the Babylonian standard that the need was felt to incise on them the striding lion, the Assyrian royal symbol. The mentioned examples hint at the possibility that also carved imagery was used to mark specific reference tools, containers or other objects as official referential documents—but this has to remain a field of further studies.[37]

§ 6. Capacity measures and the conversion of old measurement units into modern ones

Nowadays, the study of Mesopotamian metrology aims mainly at reconstructing the relative values in each measuring system, i. e. the values by which one unit of the system was converted into another—either as a multiple or a submultiple. Another objective is to identify absolute values of these units, expressed in our modern systems (in l, kg, m, m^2 …). This renders a lot of quantita-

35 Unfortunately, the old idea that the god in the sun disc represents the supreme god Ashur can still be found in literature, even in quite recent one. Ursula Seidl (2020) has convincingly demonstrated that this god in the sun disc is no other than the sun god.

36 It is right that none of the visible inscriptions on the inscribed weights refers to Aššurnasirpal, but most mention Šalmaneser, a few Tiglathpileser, Sargon and Sennacherib. This does not contradict our argument, but indicates that old reference weights had continuously been replaced by new ones, and that Throne Room B remained in use as the royal Assyrian metrological headquarter until the end of the Assyrian empire.

37 Especially interesting is the case of small duck-shaped objects with carved images on the lower side from the Neo-Babylonian period (e. g. YPM BC 038126; https://collections.peabody.yale.edu/search/Record/YPM-BC-038126). It will be interesting to investigate if these were used as weights or as stamp seals, or both.

tive data, based on the information recorded in texts or provided by material culture (volume of standard vessels or mass of material weights). All these data are primarily used for studies on economic history, e. g. for calculating the extent of the flow of goods in agricultural production, the volume of food rations delivered to the palace servants, or the quantities of traded precious metals.

For example, there are two main methods for establishing the value of Mesopotamian capacity units in litres. The first and most common one is to calculate the volume of a 'standard' vessel, found during archaeological excavations, and to compare it—if possible—with any metric data written on its neck or belly (Nicolle 2020). The capacity of the $sila_3$ has been established in this way, when the capacity (180 l) of a large Ur III vessel found at Nippur was related to the indicated 175 5/6 $sila_3$, which makes 1 $sila_3$ corresponding to approx. 1 litre (Gelb 1982). Another example is the inscribed Old Babylonian jar from Tall Rimah which gives a $sila_3$ of approx. 0.8 l (Postgate 1978). However, this method poses several problems. Firstly, it is difficult to generalise the values for the capacity standard reconstructed from only a few rare examples of jars inscribed with metric data for the whole of Mesopotamia. The multiplicity of measurement standards used in the ancient Mediterranean area, or even in the European cities of the Middle Ages, call for caution before postulating the uniform use of the same standard of capacity over a vast geographical area and an extended chronological scale. Secondly, the question arises as to the choice of the modern technique for establishing the volume of these jars and comparing it with the metric data of the inscriptions: should the total volume of the jar be calculated up to the rim—which is what is usually done—or only up to the neck, or even lower? And thirdly, why did the scribes record these metric inscriptions only on some (rare) jars and not on others? Finally, one may wonder if measuring the volume of the jars is not the wrong target. As Ch. Nicolle reminds us: "It is not the container (receiver) that allows us to evaluate a possible volume standard, it is the measuring vessel (dispenser), not a single example of which has been identified to date on Mesopotamian excavations".[38] It must be stressed, however, that the measuring vessels mentioned in the texts were made of reed or wood, and have therefore disappeared (see above § 2). The crucial question is therefore what was meant by the "standardisation" of ceramics? (see Kreppner/Sarga in this volume).

A second method of reconstructing the value of ancient capacity units is to combine socio-economic data from texts with practical realities. For instance by using rates of sowing and/or yield of fields in the Ancient Near East, or by estimating the load a donkey could carry, which was the most common means of transporting goods (Lewy 1965; Powell 1987–1990: 500; Freydank 2012: 210; Reculeau 2018: 103–105).

The first case can give interesting results on the capacity units that were used to express the volumes of sowing or harvesting as a function of field areas, but does not avoid the risk of circular reasoning. The very value of units of the length system, itself in line with the system for measuring areas, is in fact not certain at a given period and seems to vary with time and perhaps place. Recently, the study of a text from Umma dated to the Ur III period has made it possible to establish relevant hypotheses on the value of capacity units, by comparing the volume and weight of the dates recorded in the texts (thanks to the density of the latter) (Brunke 2011: 7–8). The method of comparing text data with practical reality is therefore promising but needs to be more contextualised. One cannot apply the value assumed for a measure unit, which was found in a specific place according to its documentation, over a large geographical area or a whole period of time. For example, the capacity unit $sila_3$, which is usually estimated to have been about one metric litre, had more precise absolute values that seem to have varied historically and regionally (see above), as Powell had already pointed out (Powell 1987–1990: 503–504).

More broadly, the reconstruction of the value of a unit, or of the arithmetical relationships between this unit and the lower and upper ones of the same system, is useful but does not explain its actual function and use in society. It is convenient from a modern point of view to quantify the flows of commodities of the ancient organisations, in order to gain insight into economic situations and behaviour, but it does not tell us much about the "metrological thinking" of ancient Mesopotamians, i. e. how they chose, used and represented units of measurement for practical as well as ideological purposes.

§ 7. Cross-reference of textual information and archaeological data

It is therefore not surprising that philologists are usually dedicating a paragraph or so to metrology in the introduction of their editions of administrative or legal documents. The aim is—above all—to give the keys for reading

38 Nicolle 2020: "Ce n'est pas le contenant (récepteur) qui permet d'évaluer une éventuelle norme de volume, c'est l'élément verseur (distributeur) dont aucun exemple n'a été identifié à ce jour dans les chantiers archéologiques de Mésopotamie".

the quantitative data in the texts (amounts of commodities, weighing of metals, field measurements …) and to justify the editorial choices of transcription that have not been standardised yet for weights and measures.[39] Most editions refer to Powell's work (Powell 1987–1990) and merely describe the order of units of measurement and the arithmetic relations between these units.

But it must be stressed that the aim of cuneiform texts was not limited to recording quantitative and qualitative information for the management of goods. They were written within the framework of accounting practices taking place in the main organisations (palace, temple, large household…), in order to participate in a memorisation of networks, useful for setting up and controlling the fiscal regime and for clearing up the responsibilities of each person in this system (Chambon 2020: 252). These organisations based the management of resources on an asymmetric relationship (between kings, vassals, high or low ranking officials, craftsmen, merchants, farmers…), which created "multiple subjectivities", to use Seth Richardson's terms (Richardson 2020). Therefore, quantitative data, as well as designations for measure and weight standards as seen above, were mainly based on a consensus between the persons involved in the transaction, rather than on an accurate and objective description of the transaction. As K. Veenhof (1985) pointed out, followed by N. Postgate (in this volume), it is actually hard to know whether these designations referred to physical containers or measurement standards with different volumes according to the offices using them at a material level, or to abstract volumes, fixed in relation to other norms, for accounting at a functional level.[40] The main concern was to agree on the value attributed to the commodities involved in a transaction and the quantities recorded in texts rather than on the equivalencies between local standards; this could explain the fact that no "conversion table" has been found so far in the administrative documentation of three millennia. Indeed, the amount of barley or metal recorded in the texts is above all the product of conventional values, which are based on a consensus among the parties in the exchange system (see above). In this respect, some expressions, which were considered to refer to the conversion of one weight or measure standard into another, should be reinterpreted in the light of administrative and fiscal concerns (Chambon/Marti 2017 and Pommerening/Chambon/Marti in this volume).

Therefore, studying metrological expressions involves first of all understanding the real function and purpose of administrative texts, which go beyond a description of accounting and bookkeeping practices.[41] Against this background, archaeology plays an important role in balancing approaches to ancient metrology. As already pointed out, textual sources often come from the highest levels of the social order and intended to facilitate the accounting practices and to set up exchange values within the framework of resource management—thereby conveing a distorted picture. Archaeological data, by contrast, offer the possibility to examine the remains of all levels of society and to study the daily use of weights and measures in material culture. In this respect, the archaeological approaches to the corpus of material weights of the recent years have become more contextual, by taking better into account the material found with these artefacts and their possible function in the place where they were found. Moreover, the numerous material balance weights and ceramic vessels that have been found in several Near Eastern sites allow archaeologists to make statistical and comparative studies of their volume and mass, and to draw up a "metrological topology", in synchrony and diachrony.

§ 8. The depiction of law and justice through symbols of measuring and weighing

A unique Akkadian cylinder seal depicts in a remarkably elaborate way the sun god's role as the protector of weighing and measuring (**Fig. 11**).[42] Three men are approaching the enthroned sun god. Only the man in the middle, carrying a kid in one hand and raising the other in adoration, behaves as usual in ritual scenes. The first and the third man are acting exceptionally: the first

39 See Proust 2009: 8–9, and Chambon 2013: 379. Concerning the problems of transcription of the capacity measure BÁN (*sûtu*) see Postgate 2013: 56.

40 The designations for measures in the texts are often ambiguous. In his study on the meaning of the term *sûtu* in state/private business in the Larsa kingdom, Z. Földi quite rightly stresses that this administrative term, which he translates as "concession" (for the right of collecting the commodities purchased by individual entrepreneurs from the state), has a "logographic writing ^{gis}bán—[which] suggests that it has a strong connection with *sûtu* as a capacity measure (and measuring vessel)" (Földi 2014: 108).

41 G. Chambon, Pourquoi écrire et tenir des comptes? Etude de la comptabilité dans le Palais de Mari au 18e siècle av. J.-C., in E. Bordreuil – V. Matoïan – J. Tavernier (eds.), *Administration et pratiques comptables au Proche-Orient* (PIOL), Leuven (in print).

42 Cylinder seal from the Moore Collection: Boehmer 1965, no. 1105, Fig. 458.

Fig. 11. Akkadian cylinder seal showing the act of weighing with a hand-held scale and the filling and levelling of a measuring container with a strickle (Boehmer 1965: Fig. 458)

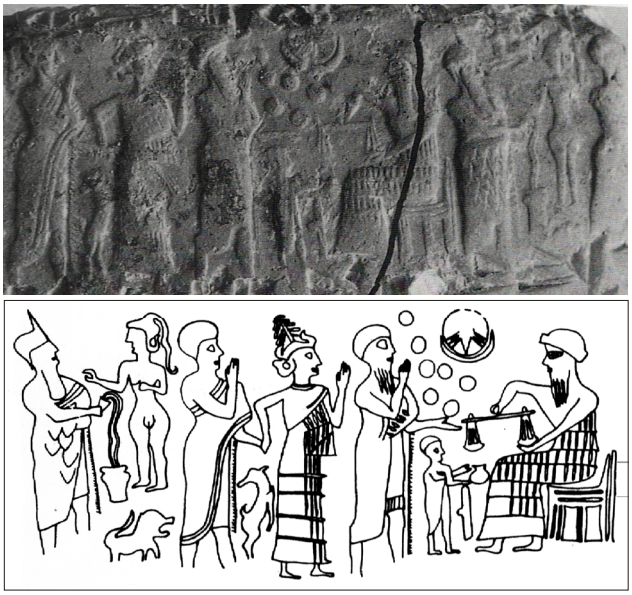

Fig. 12. Old Syrian seal impression from Karum Kanesh II (Özgüç 2006: Pl. 263; Teissier 1994: no. 533).

man is holding a balance above the altar in front of the god. The third one—depicted smaller and dressed in a short skirt, thus probably an assistant—is actively working (expressed by his bent body) in manipulating a linear object above a rectangular or cylindrical object. He is depicted—like the man holding the balance—with a high elbow, which expresses activity in Akkadian art. His action has not been understood so far, but since this is the only seal known to date where the seal owner explicitly stresses the act of weighing under divine control, we interpret this as a metrological action, too. As J. N. Postgate shows in this volume, measuring grain needed a container and a strickle (*mešēqum*), with which the grain was smoothed flat, level with the rim.[43]

43 Postgate refers to the translation of *mešēqum* in Old Babylonian texts by C. Wilcke (1983: 55–56) as "Glattstreich-Holz ».

Fig. 13. Strickle from 18th century AD France in use (https://fdmf.fr/les-mesures-a-grains-du-xviiieme-siecle/)

In the texts, the strickle can be of three types, thick (*kabrum*), medium (*birûyum*) or thin (*raqqum*). According to Postgate (2016), following Veenhof (1985), these types refer probably to the size of the wooden tool, which could be more or less thick. There were actually different ways of filling a grain container: filling it until the grain is horizontally flush with the rim, or heaping it up into the highest possible conical mound, and therefore different measuring procedures were possible.

In any case, this depiction on the Akkadian seal is to our knowledge unique in showing the act of weighing with a small hand-held scale and the filling and levelling of a measuring container. Because scenes on cylinder seals from the 3rd millennium have sometimes clear allusions to the profession of the seal owner, we may assume that this seal (unfortunately without provenance) belonged to a merchant or to a weighing office which stood perhaps under control of the sun god.

However, in the course of this study we have come to the conclusion that the depiction of the strickle (*mešēqum*), with which the grain was smoothed flat, was not a motif which disappeared from the imagery after the Akkadian period. We think on the contrary that the strickle became the symbol of the righteousness of economic transactions in general and therefore gained extreme popularity on cylinder seals, which were essential tools in trade control and any legal matters.[44]

An Old Syrian seal on a tablet from a merchant's house in Karum Kaneš II shows an audience and introduction scene in front of a deified king who himself is manipulating a hand-held balance, thus addressing the royal or

44 This is in line with a similarly used object, 'the measuring rod', which was depicted in the hand of major deities. This device became the symbol of fairness and justice in the management of the cadastre of arable land, since it is the essential tool in demarcating boundaries; Wiggermann 2007.

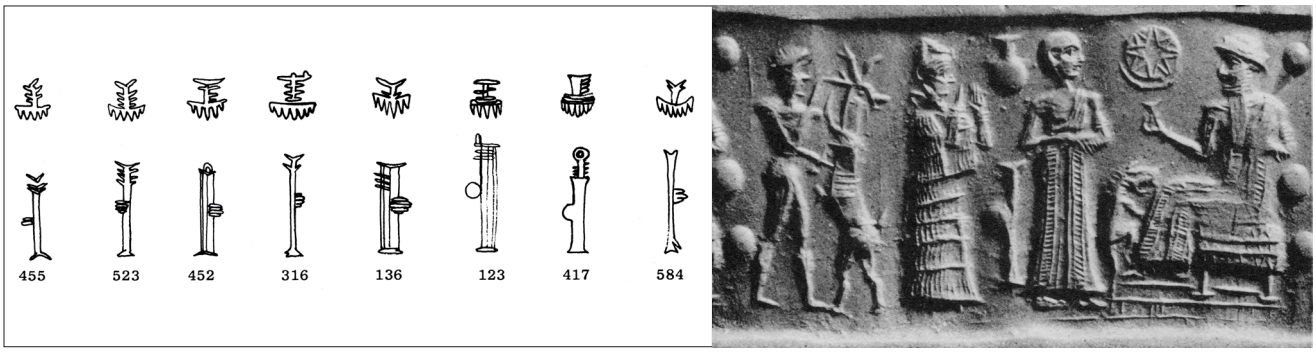

Fig. 14. Left: The "ball-and-staff" and "pot" on Old Babylonian cylinder seals (Collon 1986: 49); right: Old Babylonian cylinder seal depicting "ball-and-staff" and "pot" (Porada 1948: no. 320).

Fig. 15. Old Syrian cylinder seal showing a large man holding the strickle (*mešēqum*) and a small man holding a pot (Collon 1987: no. 139).

divine control of commerce (**Fig. 12**).[45] This object is very similar to the so-far enigmatic symbol "ball-and-staff", consisting of a vertical line with a short stroke across each end, and a circular or semi-circular excrescence on one side. It is frequently associated with an equally enigmatic object called "pot".[46] Dominique Collon (1986) has collected all the suggested interpretations, and more are being added constantly.[47] Grain was measured in Europe until the 19th century AD in a wooden cylindrical measuring container, and was either heaped or smoothed flat with a strickle consisting of an elongated tool of hard wood with a handle in the middle. A cord was added on one side, which served as an easy suspension when the tool was out of use (**Fig. 13**).[48] This corresponds exactly to how "ball-and-staff" motifs on seals are depicted (**Fig. 14**): in most instances they appeared isolated in the field (although often near the "pot"), but exceptionally also as an attribute: An Old Syrian seal (**Fig. 15**) shows a worshipper in front of a seated deity holding a ball-and-staff in his extended left hand (Collon 1987: no. 139).

Since it has been known since long that the "ball-and-staff" was one of the most frequently depicted motifs on cylinder seals of the second millennium, it was evident that its symbolic value was considerable, but no hitherto proposed identifications have been convincing. On the basis of the above-mentioned considerations we propose that the ball-and-staff motif goes back to the depiction of the strickle, in the course of time became the symbol for measuring and weighing under divine control, and developed further into the general symbol of law and justice. This idea is not unique for Mesopotamia. Until today, and at least since Roman times, the balance has been the attribute of Iustitia and the symbol of law and justice worldwide.

Few things are more challenging in art than the depiction of abstract concepts. It requires easily understandable symbols of theoretical notions and complex processes. Cylinder seals of the second millennium contain the maximally condensed information about the conception of the seal owner and his plea for protection, depicted in various meaningful scenes, but above all in numerous symbols. The protection against injustice was certainly

45 Seal impression CS 767, Kt. n/k 1926 C from Karum Kanesh (Özgüç 2006 : Pl. 263; Teissier 1994 : no. 533).

46 The object has often been called comb since the body looks striated; however, this is due to stylistic abstractions. Elaborate depictions show that indeed a vessel was intended to be depicted. It seems that the pot also related to the same or similar measuring procedures as the strickle, but its exact function or designation must wait for further study.

47 Collon (1986: 49–51) mentions interpretations of the "ball-and-staff" as a balance, a gate-post (and aryballos = the"pot") of water deities, a vertical loom, an elixir vase, a dropping tube for removing wine from a container, a water-pipe for smoking. B. N. Porter (2001: 31) suggested a case for holding drinking tubes, and E. Rossberger (2018: 121) a spouted jar for libations.

48 Drevet 2010. https://fdmf.fr/les-mesures-a-grains-du-xviiieme-siecle/ (download 25.05.2021).

not least important, which explains the enormously frequent depiction of the "ball-and-staff".[49]

§ 9. Conclusion

We may conclude that the study of practices associated with weights and measures has become essential for better delineating economic and cultural boundaries, for describing administrative processes and for understanding commercial and political relations. It requires a systematic comparison of archaeological and epigraphic sources that respond to and complement each other, because they do not concern the same aspect of metrology, and thus offer the possibility of better understanding the use and function of the different standards of measurement—both at local and interregional level.

The epigraphic sources facilitate an approach towards metrological practices mainly through the point of view of the accountants and administrators of economic and political organisations, while archaeological sources grant insight into the daily activities of craftsmen, measurement experts and palace or temple staff. The former sources give very little information about the weighing and measuring procedures (because only the results were relevant for accounting purposes) while the latter sources enable us to reconstruct the daily use of weights and capacity measures. It is in this respect that these two types of sources must be cross-referenced, in order to get a relevant picture of the use of weights and measures in Ancient Near Eastern societies, both against their economic and social background.

Metrology has been long understood as a valuable tool for better understanding commerce and interactions—the subject of thousands of ancient texts. However, the value of metrology for archaeological studies has not yet been fully recognised. It goes far beyond the better understanding of strangely shaped stones found in excavations, and well into the interpretation of images. The ancient desires and conceptions have found their way also into imagery, especially on cylinder seals, which encapsulate maximally condensed information. As far as we understand it now, depictions on seals often contained the explicit plea for law and justice, symbolised by metrological tools.

We hope that this book can demonstrate in how far the study of weights and measures can open the window on Ancient Near Eastern societies.

49 The contribution of archaeology to abstract concepts has not yet been evaluated. For example, the entry on law "Recht" in the *Reallexikon für Assyriologie und Vorderasiatische Archäologie* 11 (2006–2008) has no section "B. Archäologie", although socially fundamental concepts were certainly depicted—it is just not easy to understand the symbolic representations of abstract concepts.

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Weights and Measures as a Window on Ancient Near Eastern Societies

The study of weights and measures (metrology) of the Ancient Near East has long been understood as a valuable method for understanding ancient economic interactions and ways of quantification. However, the social value of metrology and the ubiquity of metrological actions and tools has not yet been fully recognized. Weighing and measuring are human processes that involve different people (experts and accountants, dealers and customers) and are based on culturally constructed representations such as the notions of justice, standardization and accuracy.

In this respect, epigraphic and archaeological sources complement each other. The epigraphic sources facilitate an approach towards weighing and measuring practices mainly through the point of view of the administrators of economic and political organisations, while archaeological material remains and depictions in images grant insight into the daily activities of private people involved in trade and exchange, measurement experts and palace or temple staff. The cross-referencing and interlacing of these sources, presented in this book by international experts and young scholars, aims to demonstrate how interdisciplinary studies of weights and measures provide a window on Ancient Near Eastern societies.

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