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Babylonian observational astronomy

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[Plates 3–10]

The cuneiform texts from ancient Assyria and Babylonia that are preserved offer direct evidence for systematic astronomical observation in two widely separated periods. From the first half of the second millennium B.C., later tradition has transmitted the dates of successive Venus appearances and disappearances in the reign of a king of the First Dynasty of Babylon. From the middle of the eighth century B.C. to the middle of the first century B.C. are preserved a large number of fragments of astronomical diaries attesting extensive daily observations of naked-eye astronomical phenomena.

Some 125 years separate us from the pioneering stage of the decipherment of the cuneiform script used in ancient Mesopotamia (modern Iraq) for about 3000 years until the first century of our era. Many thousands of clay tablets with this sort of cuneiform writing have been published, and several hundreds of thousands are known to be stored in museums all over the world. It is a fair indication of the expansion of knowledge in this field that a current dictionary of Akkadian, one of the two major languages of ancient Mesopotamia, contains more than 3500 pages in 12 volumes, and is only about two-thirds complete.

And yet, despite this immense accumulation of texts, one is always painfully conscious of the haphazard character of the archeological activities that have unearthed these clay tablets. Relatively few sites have been dug, and none of any size has been completely excavated. For some periods there are no (or virtually no) documents; for others, there are many more than the field of cuneiform studies can digest. A similar unevenness is evident when one considers the regional distribution of the preserved texts or the subject matter of their contents. One must learn constantly to keep in mind the temporal, geographical, and topical lacunae of the primary sources.

When we limit our view to the cuneiform clay tablets containing records of serious astronomical observation (i.e. we exclude schematic calendaric astronomy or lists of names of constellations, and the like), we are left with only two groups of extant documents, separated by a gap of about a thousand years.

The first group is essentially only one document which in the Babylonian calendar (using lunar months, the first day of which begins on the evening of the first visible crescent after conjunction) lists the dates for the consecutive first and last appearances of Venus as an evening star and as a morning star during the 21-year reign of a certain King Ammiṣaduqa of the First Dynasty of Babylon. The most famous member of this dynasty from the first half of the second millennium B.C. is King Hammurapi of the famous law stele. The list of Venus dates, to which omen predictions were secondarily appended, was copied and recopied for many centuries, and, in fact, we have it only in the form of much later copies made in the eighth and later centuries B.C. (and with partly corrupt details) embedded in one of the tablets of a standard collection of astronomical and meteorological omens. How, when, and why omen predictions – for example, 'the harvest will be normal' or 'a king will send messages of peace to another king' – were attached to the Venus dates are questions that we cannot begin to answer in the present state of our knowledge. Indeed, it is quite clear that the scribes who made the much later copies that we happen to have preserved did not have the faintest idea that the reign of King Ammiṣaduqa was involved, and in fact the ascription of the dates to this king was the result of the brilliant reading of a critical line in the text by F. X. Kugler. Scholars are still arguing about the absolute chronology of the reign of King Ammiṣaduqa and, with him, the whole First Dynasty of Babylon as well as preceding dynasties of several centuries' duration; the so-called Middle Chronology places Ammiṣaduqa's reign between –1645 and –1625. It is astonishing to find that somebody or other, for the whole of King Ammiṣaduqa's 21-year reign at so early a period, observed and recorded the Venus dates. Who was this observer? Did he have some reason to observe only Venus, or is it by chance that we do not have preserved his record of the dates of the other planets visible to the naked eye? Why just the reign of King Ammiṣaduqa? We have, alas, no answers to any of these questions either.

The second group of documents that record serious astronomical observations comes from the ancient capital city Babylon in southern Iraq. I have applied the term 'astronomical diaries' to these texts, on an edition of which I have been working for some years. There are more than 1200 fragments of astronomical diaries of various sizes and in diverse states of preservation. With very few exceptions, these texts are now in the British Museum, where, for the most part, they arrived in the 1870s and 1880s. A few dozen were excavated by H. Rassam for the Trustees of the British Museum, but all the rest were bought from antiquities dealers in Baghdad. It is fairly clear that the purchased tablets were quite accidentally excavated by gangs of workmen who, in fact, were primarily intent on removing the excellent baked bricks for re-use in modern construction in a nearby town. It is most fortunate that the British Museum was interested in acquiring these documents at a time when no other institution was purchasing antiquities in Iraq. Needless to say, there is no record of archeological context for any of our tablets.

As we shall soon see, the earliest datable fragment of an astronomical diary comes from –651, the latest six centuries later, from around –50. We have several different reasons to believe that the astronomical diaries began about –750 with the reign of the Babylonian king Nabonassar, a century before the earliest datable piece. From the second century A.D., Ptolemy's *Almagest* (book III, chapter 7) reports that records of observations (at Babylon) beginning with the reign of Nabonassar were still available. Furthermore, we actually have some fragments of cuneiform tablets from Babylon containing records of lunar eclipses going back roughly to this period. It is all but certain that these eclipse records could have been extracted only from the astronomical diaries. Finally, it is highly significant that the so-called Babylonian Chronicle, a record of historical events, begins with the reign of King Nabonassar since, as we shall see, the astronomical diaries contain historical reports.

When we begin to have datable astronomical diaries preserved in significant numbers, from about –400 on, we find that the basic patterns are fairly well fixed. The normal astronomical diary covers the 6 or 7 months comprising the first or second half of a particular Babylonian year.

Certain categories of astronomical events are always recorded within each month. Some of these astronomical phenomena are precisely those that are predicted by the mathematical astronomical cuneiform texts of the Hellenistic period. For the Moon, these characteristic significant phenomena are:

(1) At the beginning of each monthly paragraph, a statement about the length of the

previous month (i.e. 29 or 30 days), followed by an observation made the evening of the first visible lunar crescent measuring the time between sunset and moonset. When clouds or mist prevent the observation, an estimate of the time interval is recorded – how such estimates were made is unclear – followed by such remarks as 'because of clouds I did not observe'.

(2) Around full moon, two pairs of time intervals are recorded (or estimated whenever weather conditions prevented observation): one pair for moonset to sunrise and sunrise to moonset, the other pair for moonrise to sunset and sunset to moonrise. For details, see figure 1.

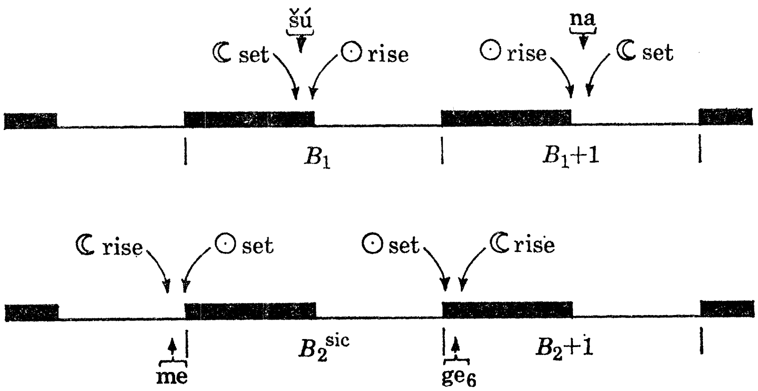

FIGURE 1. The Babylonian day (B) begins at sunset. Night is indicated by a heavy black line. The four significant time intervals around full moon are called šú, na, me, ge_6 in the texts.

(3) Toward the end of the month, the morning of the last visible crescent, with the time interval from moonrise to sunrise (or a prediction when the weather prevented observation).

(4) Lunar and solar eclipses, not only those which took place at Babylon but also those which, as the texts put it, 'passed by'. Various details are reported for lunar eclipses: when the eclipse began, its magnitude, the time from beginning to greatest magnitude, the planets that were visible during the eclipse, sometimes the name of a culminating star, the prevailing wind during the eclipse, etc.

For the outer planets Mars, Jupiter, and Saturn, the diaries always report the dates of first visibility, first stationary point, acronychal rising, second stationary point, and last visibility; and, for first and last visibility, also the zodiacal sign. For Mercury and Venus one always finds recorded the dates and zodiacal signs for first and last visibility as a morning star and as an evening star. All of these characteristic planetary phenomena, again, are also the goals of Babylonian mathematical astronomy.

Furthermore, the dates of the equinoxes and solstices as well as the dates of the significant appearances of the star Sirius are all given as computed by a known scheme.

In addition to all these significant lunar, planetary, and seasonal phenomena, the 'conjunctions' of the Moon and each of the planets with some thirty so-called 'normal stars' (i.e. reference stars) scattered about the zodiacal belt are recorded as they occur, and the distance 'above' or 'below' is given in cubits of 2° and fingerbreadths of 5′. Table 1 lists these reference stars by the transliteration of their Babylonian names and by their modern identifications, together with their longitudes and latitudes for part of the period that concerns us. The reference stars are fairly well distributed in longitude until approximately 230°, after which there is a gap of more than 40°; after about 290° there is an even bigger gap of more than 60°.

All sorts of meteorological events are reported as they take place in the rainy winter season.

TABLE 1. THE STANDARD BABYLONIAN REFERENCE STARS AS THEY APPEAR IN TEXTS AFTER APPROXIMATELY −300

Babylonian name	star	−600 λ	−600 β	−300 λ	−300 β	0 λ	0 β
múl kur *šá* dur *nu-nu*	η Pisc	350.7°	+5.2°	354.9°	+5.2°	359.0°	+5.3°
múl igi *šá* sag ḫun	β Arie	357.9	+8.4	2.0	+8.4	6.2	+8.4
múl *ár šá* sag ḫun	α Arie	1.5	+9.9	5.7	+9.9	9.8	+9.9
múl-múl	η Taur	23.9	+3.8	28.0	+3.8	32.2	+3.8
is da	α Taur	33.7	−5.7	37.8	−5.6	42.0	−5.6
ŠUR gigir *šá* si	β Taur	46.5	+5.2	50.6	+5.2	54.8	+5.2
ŠUR gigir *šá* u$_x$	ζ Taur	48.7	−2.5	52.8	−2.5	57.0	−2.5
múl igi *šá še-pít* maš-maš	η Gemi	57.4	−1.2	61.5	−1.2	65.7	−1.1
múl *ár šá še-pít* maš-maš	μ Gemi	59.2	−1.1	63.3	−1.1	67.5	−1.0
maš-maš *šá* sipa	γ Gemi	63.0	−7.1	67.1	−7.0	71.3	−7.0
maš-maš igi	α Gemi	74.2	+9.9	78.4	+9.9	82.5	+9.9
maš-maš *ár*	β Gemi	77.5	+6.5	81.6	+6.5	85.7	+6.5
múl igi *šá* alla$_x$ *šá* u$_x$	θ Canc	89.7	−1.0	93.8	−1.0	98.0	−0.9
múl igi *šá* alla$_x$ *šá* si	γ Canc	91.5	+3.0	95.6	+3.0	99.8	+3.0
múl *ár šá* alla$_x$ *šá* u$_x$	δ Canc	92.6	0.0	96.7	0.0	100.9	0.0
sag A	ε Leon	104.6	+9.5	108.7	+9.5	112.9	+9.6
lugal	α Leon	113.9	+0.4	118.0	+0.4	122.2	+0.4
múl tur *šá* 4 kùš *ár* lugal	ρ Leon	120.3	0.0	124.4	0.0	128.6	0.1
GIŠ-KUN A	θ Leon	127.3	+9.7	131.4	+9.7	135.6	+9.7
gìr *ár šá* A	β Virg	140.5	+0.6	144.7	+0.7	148.9	+0.7
dele *šá* igi absin	γ Virg	154.4	+3.0	158.5	+3.0	162.6	+3.0
sa$_4$ *šá* absin	α Virg	167.8	−1.9	171.9	−1.9	176.1	−1.9
rín *šá* u$_x$	α Libr	189.0	+0.7	193.2	+0.6	197.3	+0.6
rín *šá* si	β Libr	193.3	+8.8	197.4	+8.8	201.6	+8.7
múl múrub *šá* sag gír-tab	δ Scor	206.5	−1.7	210.6	−1.7	214.8	−1.7
múl *e šá* sag gír-tab	β Scor	207.1	+1.3	211.2	+1.3	215.4	+1.3
si$_4$	α Scor	213.7	−4.2	217.8	−4.3	222.0	−4.3
múl kur *šá* kir$_4$ *šil* pa	θ Ophi	225.3	−1.5	229.4	−1.5	233.6	−1.6
si máš	β Capr	267.9	+4.9	272.1	+4.9	276.2	+4.8
múl igi *šá* suḫur-máš	γ Capr	285.6	−2.3	289.7	−2.3	293.9	−2.4
múl *ár šá* suḫur-máš	δ Capr	287.3	−2.1	291.5	−2.2	295.6	−2.2

Good weather is never mentioned. Various kinds of cloud and storm conditions are couched in abbreviated or laconic technical terms, many of which, I must confess, I do not really understand. Occasionally the terminology borders on the quaint: some texts distinguish between rain followed by the 'removal of sandals' and obviously milder rain after which sandals were not removed. Elsewhere in cuneiform literature, this expression about the sandals and rain occurs, to my knowledge, only in an Old-Babylonian proverb. Archeologists who have excavated in southern Iraq tell me that the workmen today hang their shoes around their necks when the ground becomes too muddy after a rain. Rainbows, thunder, lightning, rain, cold, haloes, wind directions and velocities (the last in a terminology that escapes me), etc., are commonly reported in the diaries.

Between the astronomical phenomena – especially the Moon, which passes by a reference star or some planet on many days of the month – and the meteorological events of the rainy season, one often finds one or more events reported for every day of the month.

After the last astronomical or meteorological happening of the month is duly recorded, each monthly paragraph always continues with a statement about the respective amounts of barley, dates, pepper(?), cress(?), sesame, and wool – i.e. the necessities of life in ancient

Mesopotamia – that could be bought for one shekel of silver. These commodities are invariably listed in the same order. If the amounts changed during the month, this is indicated. In one extreme case, the varying amounts for the morning, the middle of the day, and the afternoon in the course of a single day are recorded.

Following the commodity prices, each monthly paragraph proceeds to list the zodiacal signs in which the various planets were to be found during the month.

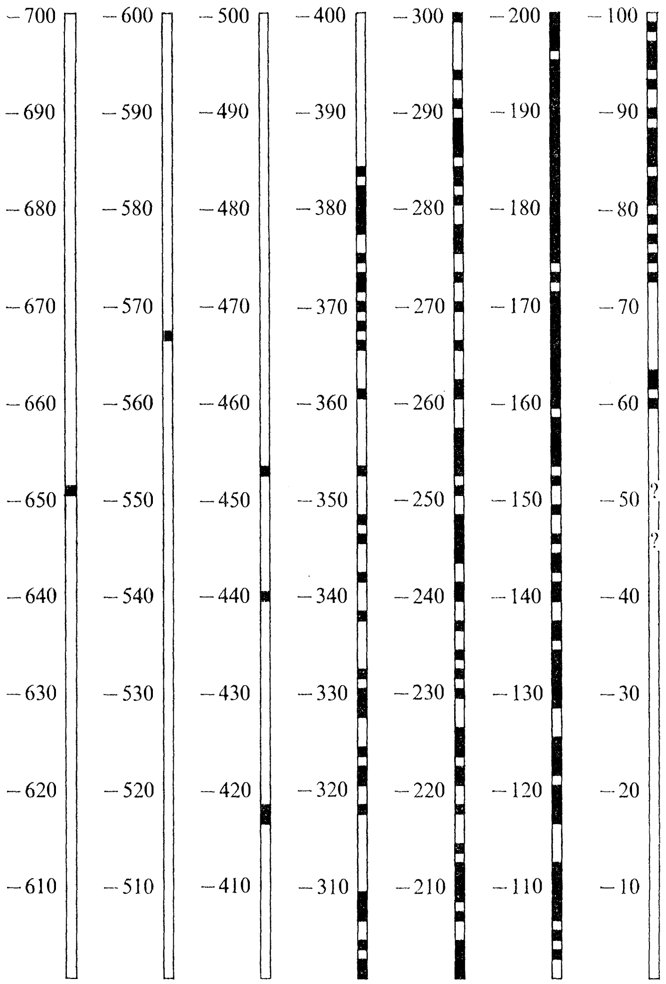

FIGURE 2. The extant datable astronomical diaries, from –700 to 0.

This information, in turn, is followed by a report on the change of river level at Babylon in the course of the month. The rise and fall are measured in cubits and fingerbreadths. The reading of a river gauge of some sort is also given, with one unit on the gauge scale equal to four fingerbreadths – probably to be interpreted as the thickness of a layer of bricks.

The river-level data are often followed by a report of secular events or rumours of such events. These can be of very local interest, such as an outbreak of fire in some quarter of Babylon, or the discovery of a theft in a temple in Babylon. Or the events can be of great historical importance, such as a report about the joy with which the cities of Babylonia greeted the soldiers of Alexander the Great as liberators after the battle of Arbela. A few years later, the death of Alexander the Great is recorded, allowing us to date it with precision. Battles, military expeditions, the change of reigns, the overthrow of the Seleucid Empire by the Arsacids, raids on Babylon by Arabs in the Arsacid period are all recorded in astronomical diaries.

The distribution of the diaries over the seven centuries before the beginning of our era is uneven. In figure 2, the seven vertical columns, from left to right, represent the time scale from −700 to 0. Each blackened square signifies the existence of at least one datable fragment of an astronomical diary for that year. After the earliest piece at −651, almost a century elapses before the next in −567, and then more than a century intervenes before the next fragment in −453. From about −385 to the end of the fourth century, the diaries become fairly dense, more so in the third century, and are very well represented for more than a century after −200. The last datable piece is from about −50. All in all, we have at least one fragment from more than 180 different years.

Unlike most other writing materials, clay tablets fortunately do not decay in the ground after thousands of years. But they do break into pieces, and virtually no astronomical diary of any decent size arrived at the British Museum undamaged. Rejoining the broken pieces is an important, if often time-consuming, task. In order to use the astronomical data in a fragment for dating purposes, I computed, some years ago, the significant phenomena (first and last appearances, first and second stationary points, and acronychal risings) for Saturn, Jupiter, Mars, Venus, and Mercury (only first and last appearances for the latter two planets) from −600 to 0, transforming the dates into the Babylonian calendar. More recently, B. Tuckerman has published I.B.M. tables of longitudes and latitudes for the Moon and the planets at 5- and 10-day intervals, and the Smithsonian Astrophysical group have very kindly computed various lunar data for me. All these tables have proven to be of immense help not only in dating fragments but also in supplying the possibility of independent, detailed control in following the astronomical contents of the astronomical diaries.

The earliest datable diary, shown in figure 3, plate 3, is from −651. When I first tried to date this text, I found the astronomical contents to be just barely adequate to make this date virtually certain. It was a great relief when I was able to confirm the date by matching up a historical remark in the diary with the corresponding statement for −651 in a well-dated historical chronicle.

Some diaries have had to be pieced together to form larger fragments. The diary illustrated at the top of figure 4, plate 3, dated −375, shows that the texts were already broken up in antiquity. Two of the pieces were blackened in a smoky fire, the other was not. Presumably, the original clay tablet fell (or was knocked off) a shelf, and the broken pieces were scattered over the floor of a burning room.

The three pieces of a diary dated −253 are shown at the top of figure 5, plate 4, as separate fragments which were later joined to make the much bigger fragment shown at the bottom.

Beautiful, and very good, copies made by T. G. Pinches at the British Museum in the 1890s, many hundreds of which I was privileged to publish in 1955, are shown in figure 6, plate 5, for the obverse of an astronomical diary for −324. The broken lines indicate the relationship between the five fragments which Pinches copied separately. The photograph shows the text as now pieced together.

Very large pieces are rather rare. A beautifully written diary dated −77 (or year 234 of the Seleucid Era, more than 60 years after the beginning of the Parthian period) is illustrated in figure 7, plate 4. The obverse of a diary for −346/−345 (year 12 of Artaxerxes III, Babylonian months IX to XII) is photographed in figure 8, plate 6. The obverse of the large

FIGURE 3. B.M. 32312. $\frac{2}{3}$ actual size.

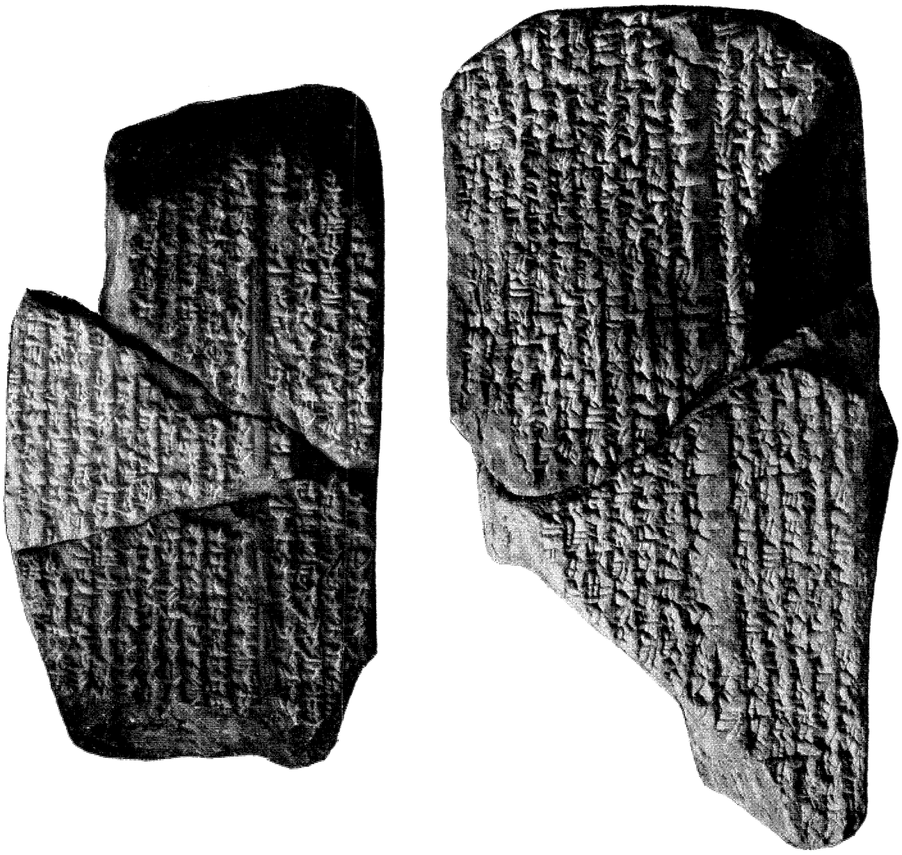

FIGURE 4. Top: B.M. 34642+35417+78829. Bottom: B.M. 132279 joined to tablet in the Wellcome Historical Medical Museum and Library. $\frac{2}{3}$ actual size.

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Figure 7. B.M. 45689. $\frac{2}{3}$ actual size.

Figure 5. B.M. 34105 + 41901 + 42041. $\frac{2}{3}$ actual size.

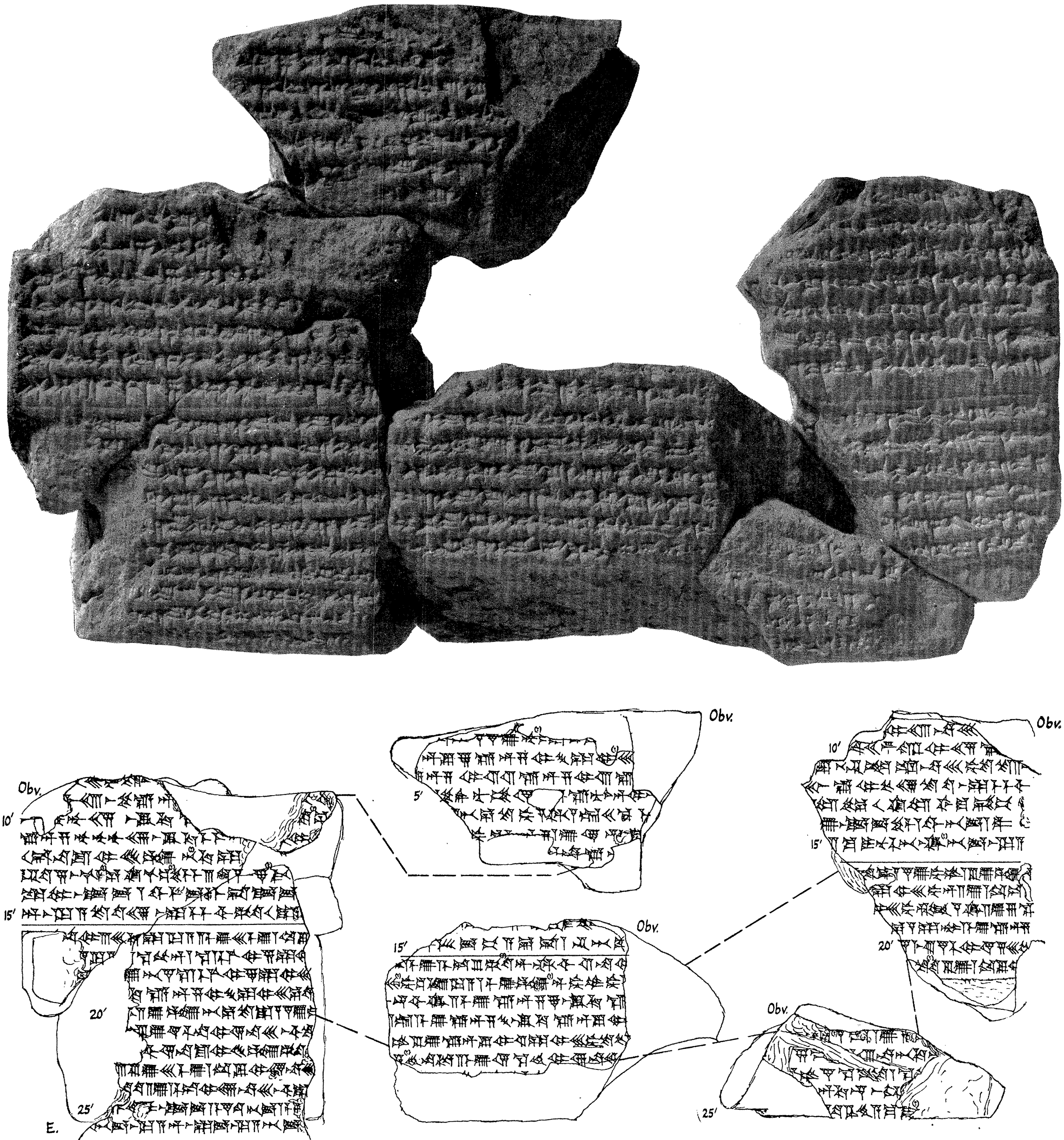

FIGURE 6. B.M. 34794+34919+34990+35071+35329. Actual size.

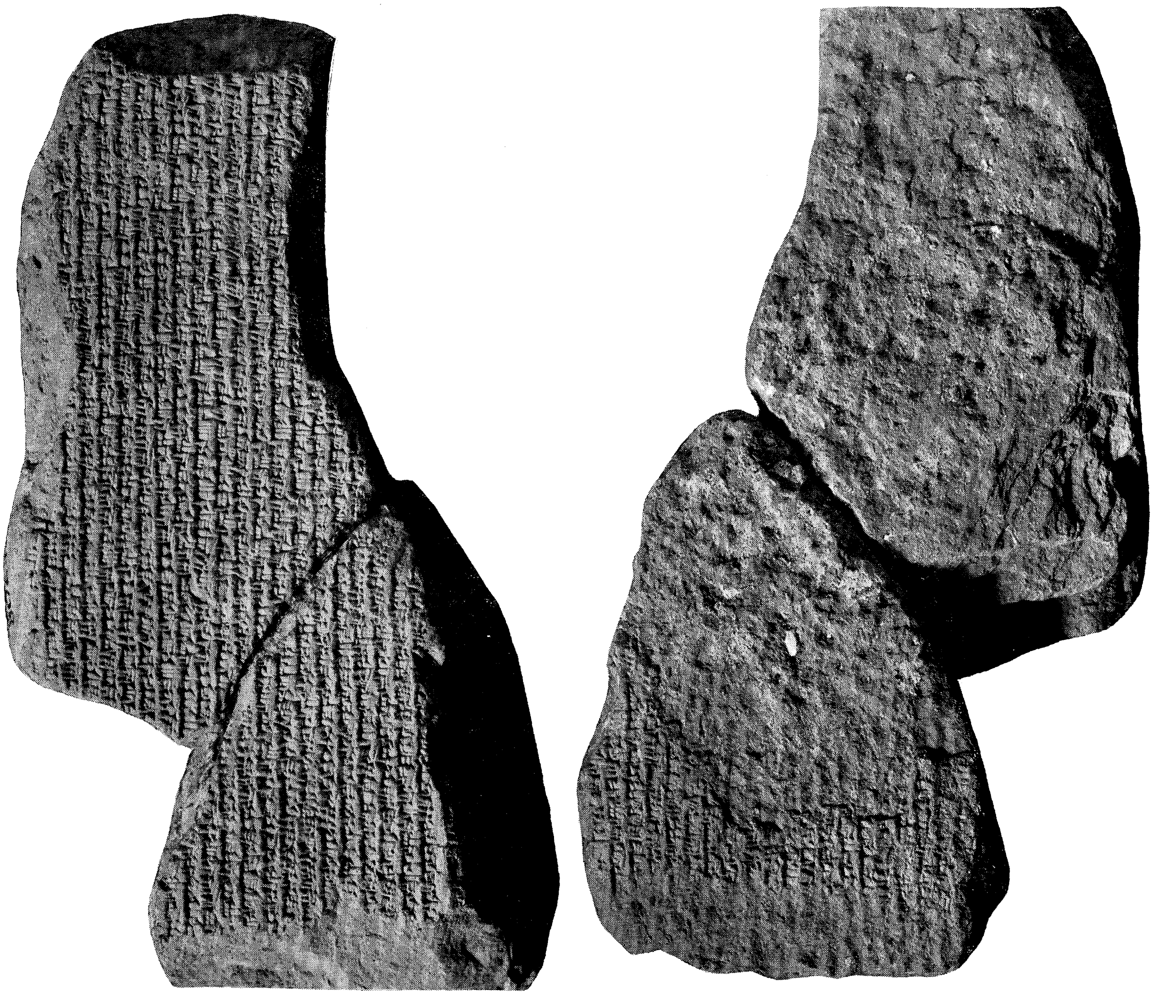

FIGURE 9. B.M. 45708. ⅔ actual size.

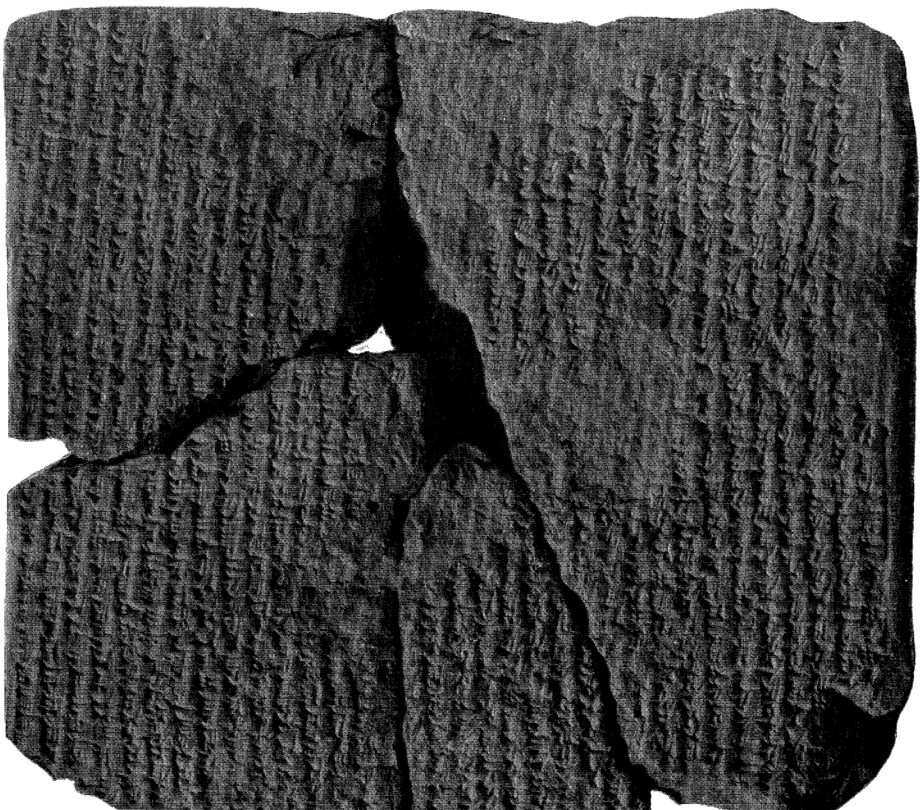

FIGURE 8. B.M. 46229, pieced together by T. G. Pinches from SH. 81–7–6, 691 + 82–7–4, 83 + 98 + 113. ⅔ actual size.

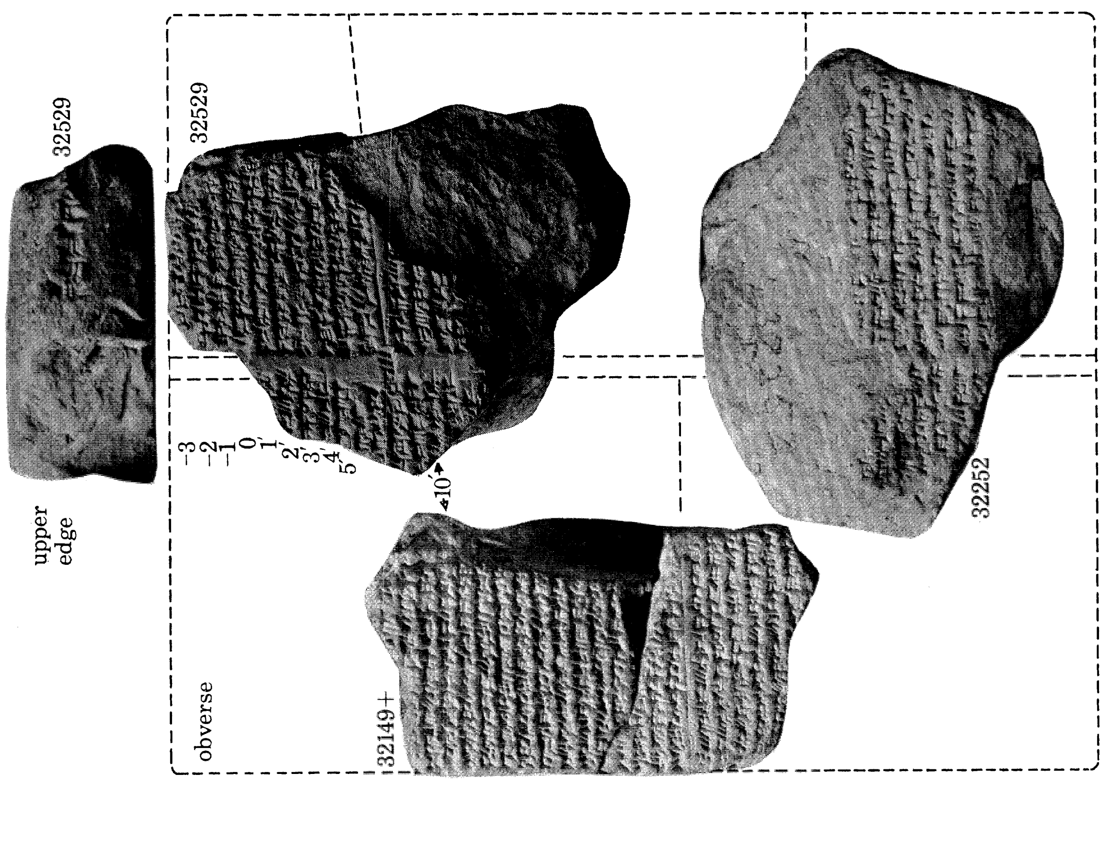

FIGURE 10. B.M. 32149+...; B.M. 32252; B.M. 32529. ⅔ actual size.

FIGURE 11. B.M. 31476; B.M. 34000; B.M. 34562. ⅔ actual size.

FIGURE 12. B.M. 31474; B.M. 40095 + 55572; B.M. 45722. $\frac{3}{4}$ actual size.

Figure 13. B.M. 41529 + 41546 + 132278 joined to a fragment in the Böhl Collection (Leyden). $\frac{9}{10}$ actual size.

Figure 14. Top row: B.M. 34694, 34504, 34521. Second row: B.M. 34520, 34700, 34697. Third row: B.M. 46154, 46080, 34670. Bottom row: B.M. 46110, 34699, 34492. $\frac{2}{3}$ actual size.

FIGURE 16. CBS 17. $\frac{2}{3}$ actual size.

FIGURE 15. B.M. 36600. $\frac{2}{3}$ actual size.

chunk shown in figure 9, plate 6, dated −125, is well preserved; the deplorable condition of the reverse is unfortunately all too common.

The arrangement of a diary into two columns is unusual, and is never attested after the beginning of the Hellenistic period. Figure 10, plate 7, illustrates the reconstruction of a two-column diary for −366, using non-joining pieces that can be placed exactly, thanks to a duplicate tablet.

The normal astronomical diary, as has already been mentioned, covers the 6 or 7 months of the first half or the second half of a Babylonian year. From the Hellenistic period we also have a large number of shorter diaries which refer to a period of anywhere from several days to 2 or 3 months. These short diaries presumably formed the basis for the preparation of the larger astronomical diaries of standard half-year size. Three typical short diaries are to be seen in figure 11, plate 7. Dating from 3 years in the neighborhood of −170, one covers 6 days, another 5 days, the third 16 days. The three short diaries illustrated in figure 12, plate 8, are for somewhat longer intervals: 1 month and 3 days in −186, 1 month in −181, and 2 months and 5 days in −182. The hand-writing shows that these three short diaries were written by the same scribe.

Although the vast majority of the extant diaries are in the British Museum, a few isolated pieces are stored in various museums all over the world. Occasionally, it can be shown that some of these odd fragments must be part of the same original tablets from which other pieces are now in the British Museum. Thanks to the cooperation of museum officials, it has been possible to bring together, momentarily, fragments of this sort which belong together. The lower part of figure 4 illustrates two pieces rejoined for a few hours, one from the British Museum, the other from the Wellcome Historical Medical Museum and Library, 5 minutes' walk from the British Museum. The date is −277. Figure 13, plate 9, is a photograph of three pieces in the British Museum joined temporarily to a fragment that crossed the Channel from the Böhl Collection in Leyden; date, −90.

The mention of so many dated diaries may have led the reader to the false impression that everything is placed chronologically and that nothing remains to be done. Actually, the datable pieces come from 183 years and comprise only about one-third of the available 1200 fragments. Many of the undated pieces are small and fairly insignificant, like the 12 pieces illustrated in figure 14, plate 9, but there still remain many as yet undated pieces that are rather large. Generally, this means that the astronomical data are simply not of the right kinds to warrant a large-scale hunt for the date.

We also have other texts, which extract special kinds of information from the astronomical diaries. For example, the tablet shown in figure 15, plate 10, contains nothing but Mercury data, year after year, from at least −389 to −374. Similar texts for Jupiter, Mars, Venus, and lunar eclipses are preserved.

From about −250 on and continuing for two centuries, we have a fairly large number of so-called 'goal-year texts'. Each contains materials for the making of predictions of lunar and planetary phenomena for some specific year which we call the goal year. The data for each planet and the Moon are extracted from an astronomical diary that precedes the goal year by a period appropriate for the particular planet. There are two Jupiter paragraphs 71 and 83 years before the goal year, 8 years for Venus, 46 years for Mercury, 59 years for Saturn, 79 and 47 years for Mars, and 18 years for the Moon. All these periods are reasonably good, but we do not know how the necessary adjustments were made for the predictions. Figure 16, plate 10, shows a goal-year text for −86, in the University Museum of the University of Pennsylvania.

Finally, mention should be made of a group of letters written to the royal court of Assyria in the seventh century B.C. by various astrologers/astronomers who report astronomical events and their possible astrological importance for the empire. To what extent these people are the same as the observers of the astronomical diaries is unclear.

Photographs of texts in the British Museum are published by courtesy of the Trustees of the British Museum.

Bibliographical note

S. Langdon, J. K. Fotheringham, and Carl Schoch, *The Venus tablets of Ammizaduga* (Oxford University Press 1928) contains an edition of the texts and a full analysis of the problem as viewed before 1930. The later history of the controversy is sketched in the two most recent discussions: B. L. van der Waerden, *Die Anfänge der Astronomie* (Basel 1968), pp. 34–49; John D. Weir, *The Venus tablets of Ammizaduga* (Istanbul and Leiden, 1972). E. Reiner is preparing an edition of all the Venus omens in the standard astrological composition.

For the astronomical diaries and related texts, a large number of copies are published and catalogued in *Late Babylonian astronomical and related texts copied by T. G. Pinches & J. N. Strassmaier prepared for publication by A. J. Sachs with the co-operation of J. Schaumberger* (Brown University Press, Providence, R.I. 1955). P. Huber's treatment of this material in B. L. van der Waerden, *Die Anfänge der Astronomie* (Basel 1968) is very competent.

FIGURE 3. B.M. 32312. $\frac{2}{3}$ actual size.

FIGURE 4. Top: B.M. 34642 + 35417 + 78829. Bottom: B.M. 132279 joined to tablet in the Wellcome Historical Medical Museum and Library. ⅔ actual size.

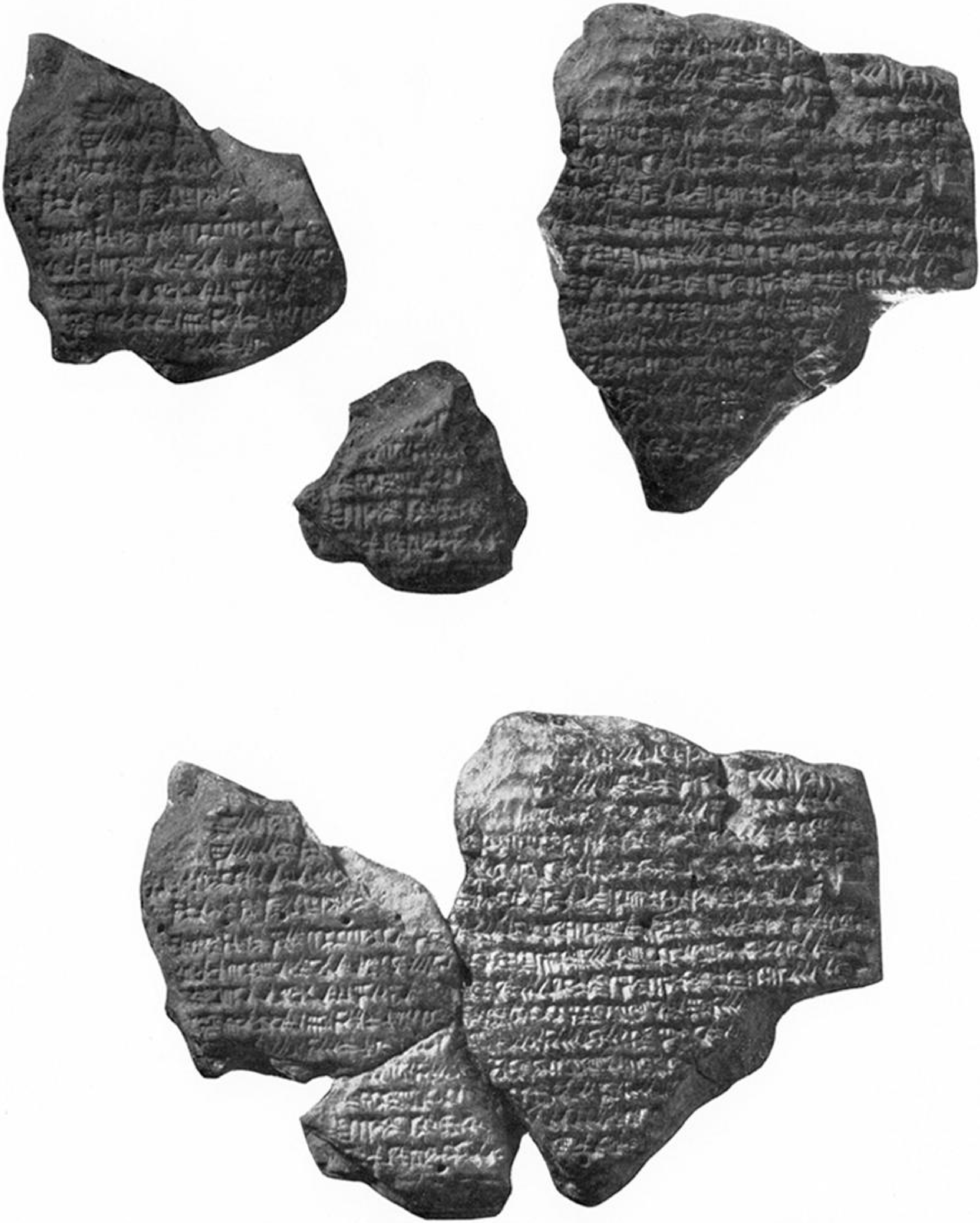

FIGURE 5. B.M. 34105 + 41901 + 42041. $\frac{2}{3}$ actual size.

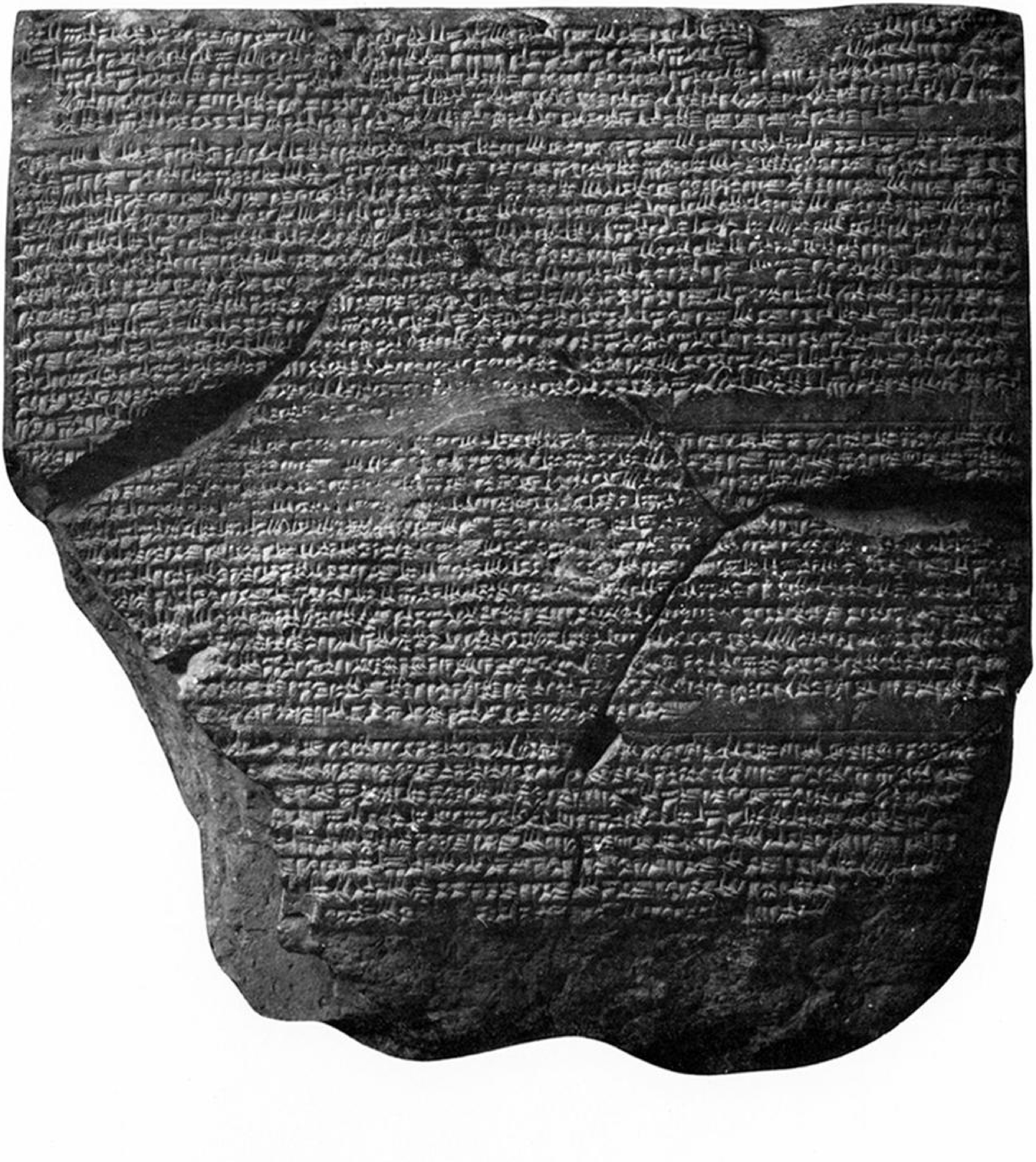

FIGURE 7. B.M. 45689. ⅔ actual size.

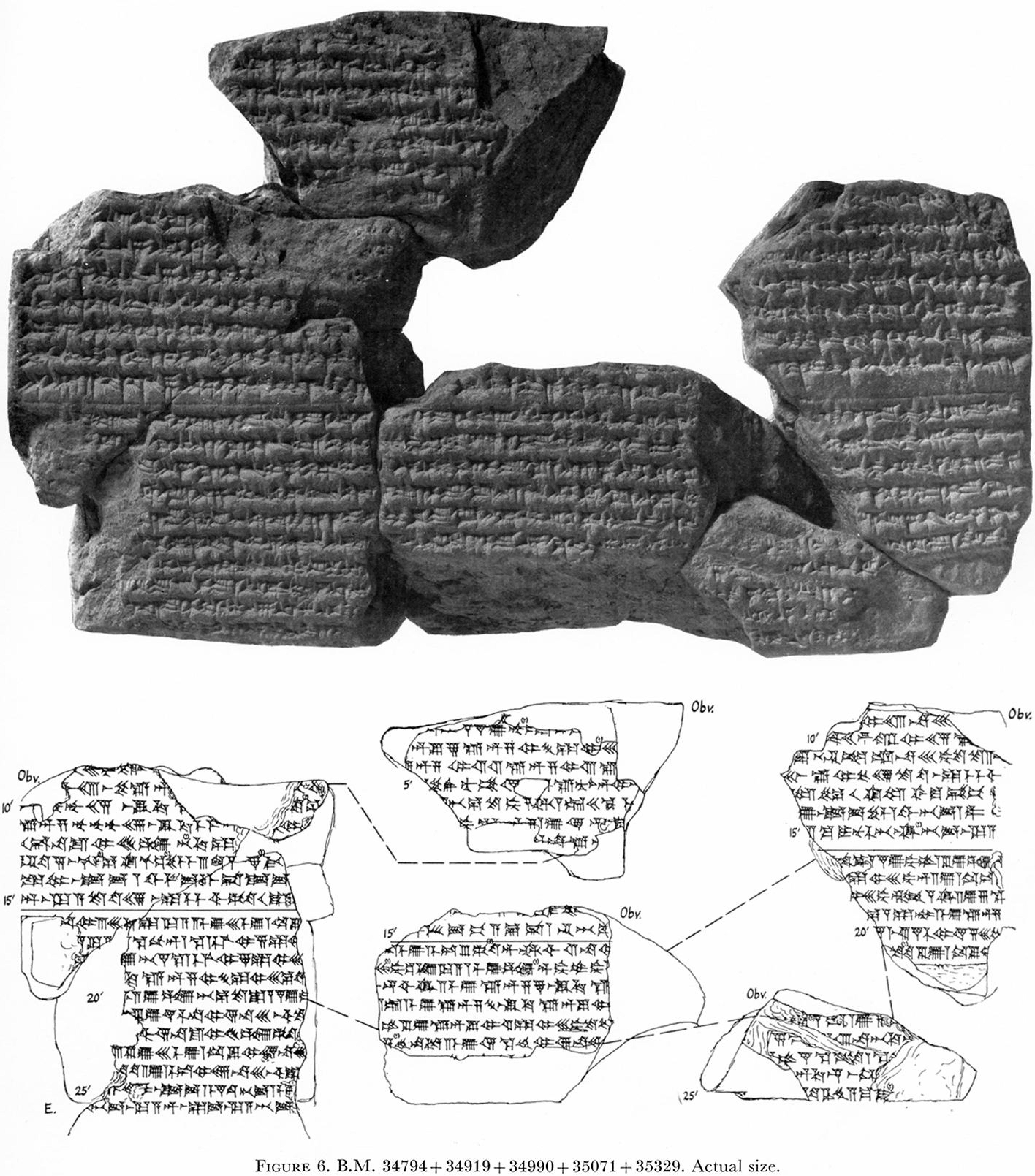

FIGURE 6. B.M. 34794 + 34919 + 34990 + 35071 + 35329. Actual size.

FIGURE 8. B.M. 46229, pieced together by T. G. Pinches from SH. 81–7–6, 691 + 82–7–4, 83 + 98 + 113. $\frac{2}{3}$ actual size.

FIGURE 9. B.M. 45708. $\frac{2}{3}$ actual size.

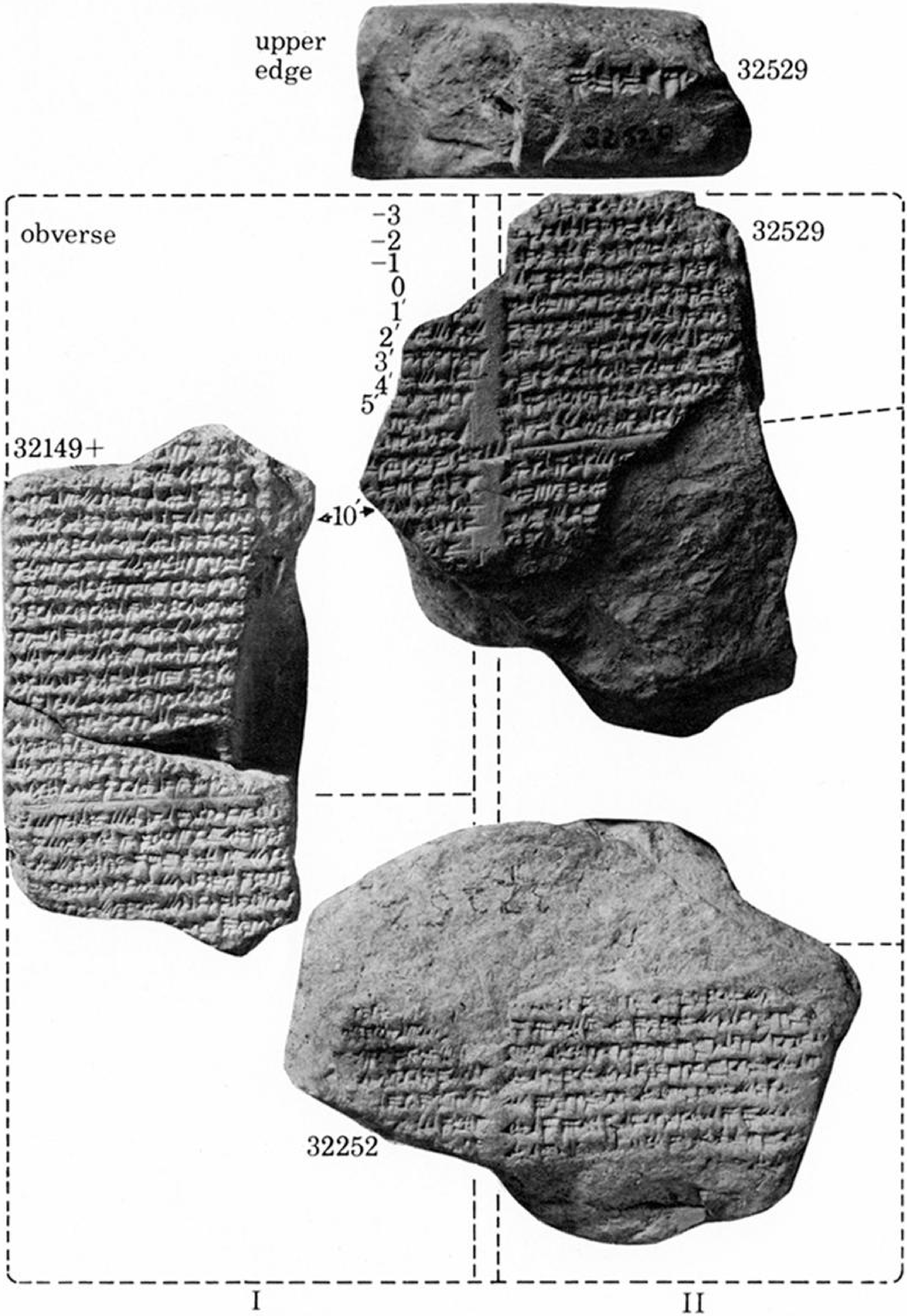

FIGURE 10. B.M. 32149+ . . .; B.M. 32252; B.M. 32529. ⅔ actual size.

FIGURE 11. B.M. 31476; B.M. 34000; B.M. 34562. ⅔ actual size.

Figure 12. B.M. 31474; B.M. 40095 + 55572; B.M. 45722. $\frac{3}{4}$ actual size.

FIGURE 13. B.M. 41529 + 41546 + 132278 joined to a fragment in the Böhl Collection (Leyden). $\frac{9}{10}$ actual size.

FIGURE 14. Top row: B.M. 34694, 34504, 34521. Second row: B.M. 34520, 34700, 34697. Third row: B.M. 46154, 46080, 34670. Bottom row: B.M. 46110, 34699, 34492. $\frac{2}{3}$ actual size.

FIGURE 15. B.M. 36600. ⅔ actual size.

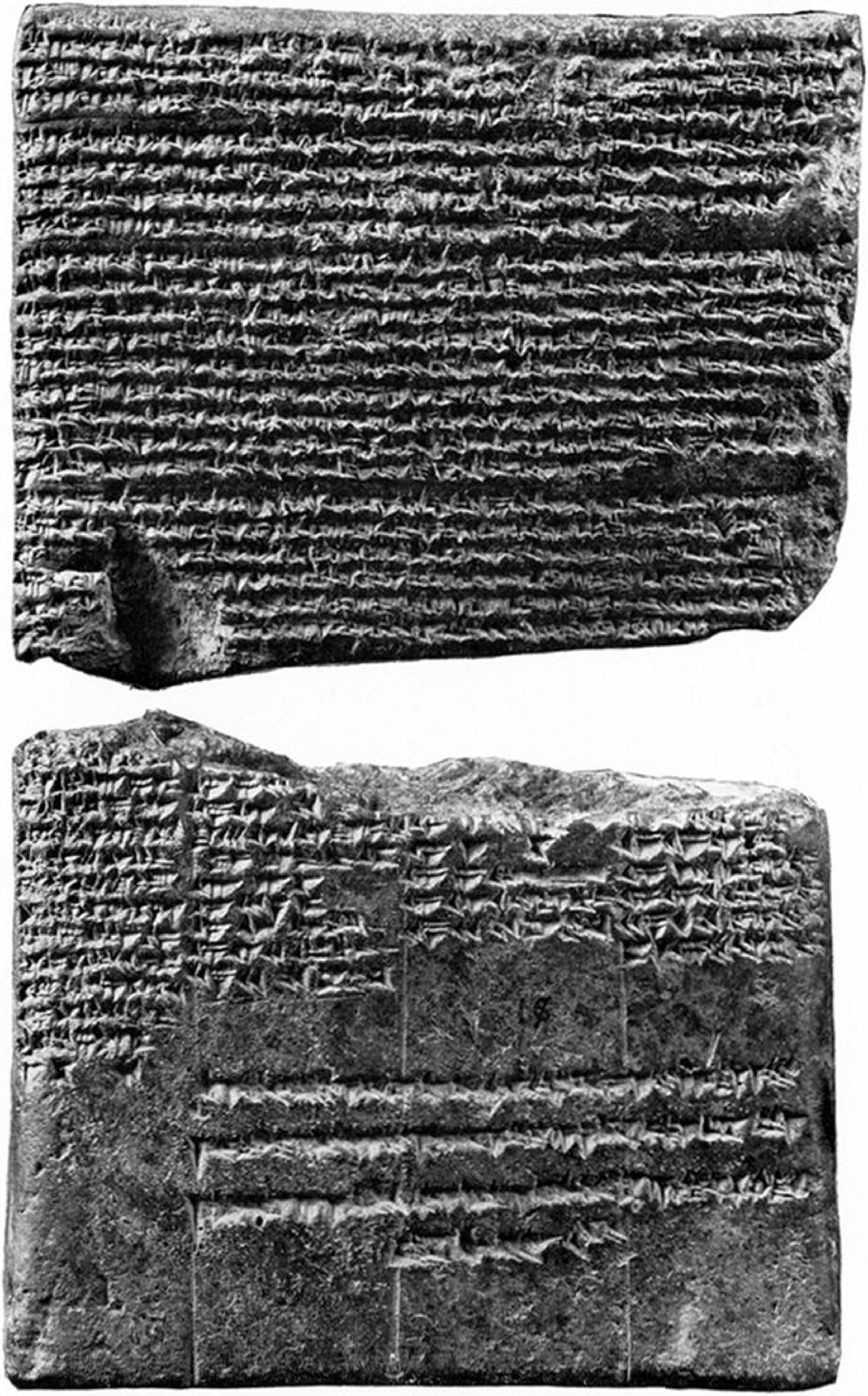

Figure 16. CBS 17. ⅔ actual size.