George Bevan – Alexander Jones – Daryn Lehoux

The Miletus Parapegma and the Keskintos Astronomical Inscription: New Evidence from Reflectance Transformation Imaging

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The Miletus Parapegma and the Keskintos Astronomical Inscription: New Evidence from Reflectance Transformation Imaging

In 2005, one of us (Lehoux) published a new edition of the 2nd century BC parapegma fragments from Miletus IMilet inv. 456A–D and N (= *SEG* 55.1264bis), and in 2006 another of us (Jones) published a new edition of the c. 100 BC astronomical inscription from Keskintos *IG* 12.1.913 (= *SEG* 56.953), both from autopsy of the inscriptions. Both inscriptions are currently held in Berlin's Antikensammlung.[1] In 2010, Bevan and Lehoux returned to Berlin to subject the most important and least well read of the parapegma fragments (IMilet inv. 456C) as well as the Keskintos Inscription to the computational-photographic technique known as reflectance transformation imaging (RTI), which has been shown to render difficult-to-read inscriptions more legible.[2] Images were taken of the whole parapegma fragment as well as of each text column individually, and these were processed into both RTI and polynomial texture mapping (PTM) formats. We photographed the Keskintos inscription in two halves, with separate close-ups of the crucial numerical sections, and processed the images into PTM format. Based on the results of this work, we are able to offer a much more complete reading of the Miletus fragment than was previously possible, as well as to make some improvements to Jones's edition of the Keskintos Inscription. Our article also includes discussion of some consequences arising from the new readings.

As illustrations of the clarity that the RTI imaging can offer, we provide screenshots of three regions where our editions significantly diverge from or augment previous readings. We would stress, however, that viewing RTI, like viewing an inscribed object directly with changing light, is a dynamic process, and not all key details may be visible with just one static simulated lighting direction and reflectance transformation. Figure 1 shows the ends of IMilet inv. 456C, i 1–2; in line 1 a rho and a beta, unambiguous in the RTI, were previously read respectively as eta and kappa, without dotting, and a phantom iota seems to have been suggested by a couple of small spots of surface damage between lambda and alpha, where the space is really too small even for a narrow letter. In Figure 2, a region containing parts of column ii 3–4 is shown firstly with simulated conventional lighting, secondly with diffuse gain (an enhancement of the directional variation in surface reflectivity). This part of ii 4 is severely damaged and had not been satisfactorily read before. Broadly speaking, the diffuse gain enhancement tends to improve legibility, but in this instance the letters TAT are clearer with default lighting. Figure 3 shows parts of lines 13–15 of *IG* 12.1.913, including the leftmost preserved part of the dedicatory line 15. Previously the first securely read letters were IΣ; with RTI we can be sure of not only the tentatively read alpha but also a hitherto unsuspected phi that secures the restoration of the nymphs as recipients of the votive offering.

[1] Lehoux 2005 (superseding Diels and Rehm 1904 and Rehm 1904); Jones 2006a and 2006b (superseding Tannery 1895 and *IG* 12.1.913, pp. 148–149 with addenda at 207). The fragments in the Berlin Antikensammlung also bear the museum inventory numbers SK 1472 (Keskintos), SK 1406 I (= IMilet inv. 456A), II (= inv. 456C), III (= inv. 456D), and IV (= inv. 456B). The present location of IMilet inv. 456N is not known, nor have we located a squeeze; for a photograph in the *Inscriptiones Graecae* archive see https://archive.nyu.edu/handle/2451/44434. Note also that "IMilet inv." numbers are distinct from the numbers ("IMilet" *simpliciter*) assigned in the publication series *Inschriften von Milet*, in which the parapegma fragments were never republished. The authors would like to thank the Antikensammlung and Dr. Sylvia Brehme for kindly allowing us to photograph the inscriptions for RTI. We have made the RTI and PTM files available online, at https://archive.nyu.edu/handle/2451/44192.

[2] A brief description of RTI can be found in Bevan, Lehoux and Talbert 2013.

Fig. 1. Detail of IMilet inv. 456C, i 1–3, screenshot from PTM with diffuse gain

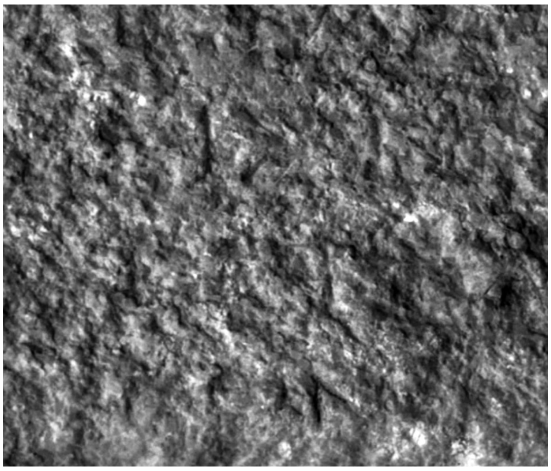

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2. Detail of IMilet inv. 456C, ii 2–5, screenshots from PTM
(a) with simulated conventional lighting, (b) with diffuse gain, (c) with tracings of visible letter strokes

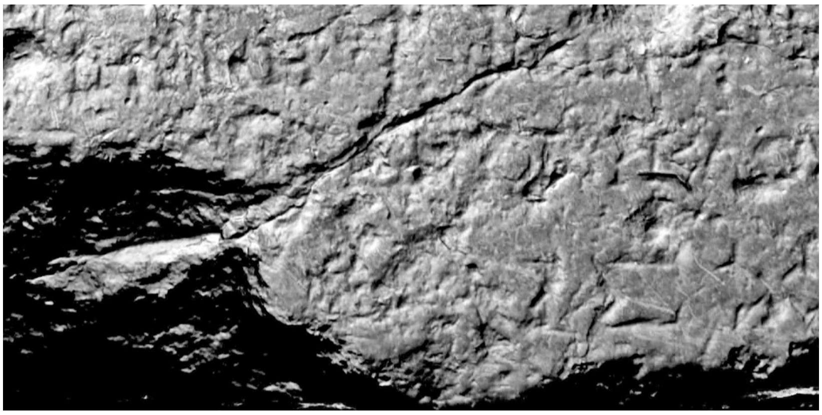

Fig. 3. Detail of *IG* 12.1.913, 13–15, screenshot from PTM with diffuse gain

IMilet inv. 456C

Unlike the other three fragments of this inscription (inv. 456A, D, and N), inv. 456C preserves only a little along its right edge from the parapegma proper, that is, the series of drilled holes and statements of annually recurring astronomical and meteorological events.[3] Along the top is part of a dedicatory line in large lettering. The main body of the fragment, comprising two columns of text that evidently functioned as an introduction to and explanation of the parapegma, is very badly weathered, and Lehoux's transcription was notably more cautious than the *ed. pr.* of Diels and Rehm. RTI has been particularly helpful with the leftmost sections of column i and the lower sections of column ii, offering considerably more text, and considerably more confidence, than was possible with autopsy, incidentally confirming some of Diels and Rehm's readings but significantly altering others. The text can now be read as follows:

1 [Ἐπ]ικράτης Πύλω[νος

i 1 [- 6 - κυ]κλίσκοις ὥ̣σπερ λαβὴν
i 2 [- 6 - ἑκάστ]η δὲ σελίς ἐστιν Α-
i 3 [- 5 - ἐκ]ά̣σ̣τ̣ο̣υ̣ ζωιδίου. οἱ δὲ κυκλίσ-
i 4 [κοι - 8 -]ΗΜ̣[̣ σε]λίς, *v* ἑκάστηι ἀψῖ-
i 5 [δι - 8 -]ΛΙ̣ΟΣ φερόμενος τὰς Α-
i 6 [- 3 - ἀνατο]λ̣ὰ̣ς καὶ̣ δύσεις τῶν ἀσ̣τέ-
i 7 [ρων - 16 -]ΣΙ̣ΝΣΗΜΑΙ̣Ν[

ii 1 γμένον *v* τὸν δ' ἐπιόντα παραπηγνύ-
ii 2 ναι. τὰς δ' ἡμέρας, ὅταν ὁ μεὶς διέλθηι, με-
ii 3 τατεθῆναι εἰς τὴν ἀν̣α̣γραφὴν τῶν
ii 4 ἡμερῶν ε̣ἰ̣ς τὰ τρυ̣π̣ήματα πρ̣ὸ̣ς *v* ΤΩ ̣
ii 5 ̣ΕΝ[ ]Ν[
ii 6 ΜΗΝ[

iii 1 Μ[
iii 2 ΙΝ[
iii 3 • Η[
iii 4 ΑΣ[
iii 5 [
iii 6 ΣΦ̣[
iii 7 • λύ̣[ρα
iii 8 [
iii 9 • [

3 For further details see Lehoux 2005, 133–135.

Translation

1 Ep]ikrates son of Pylo[n

i 1 [ ] little disks like a handle
i 2 [eac]h column is
i 3 [ ] of each zodiacal sign. The little disks
i 4 [ ]…[co]lumn, to each dowel (?)
i 5 [S]un (?) traveling, the
i 6 [ris]ings and settings of the stars
i 7 [ ]… sign [

ii 1 … to install markers for the following (month?).
ii 2 Whenever the month has passed, to transfer the days
ii 3 to the register of the
ii 4 days in the drilled holes …
ii 5 …
ii 6 …

iii 1 …
iii 2 …
iii 3 • …
iii 4 …
iii 5 …
iii 6 …
iii 7 • Ly[ra …
iii 8 …
iii 9 • …

Apparatus[4]

1 *DR*: ΕΠ?]ΙΚΡΑΤΗΣ ΠΥΛΩ[ΡΟΥ? *L*: ΕΠΙ]Κ̣ΡΑΤΗΣΠΥΛΩ[ΝΟΣ

i 1 *DR*: π̣οιεῖ [ὥ]σ̣τ̣ε̣ ἡ̣λι̣ακὴν *L*:]ἡ̣λι̣ακὴν | ω̣: serifed horizontal strokes along baseline, indistinct outline of loop. | 2 *DR*: ἡ̣ δὲ σελίς ἐστιν Α *L*:]Σ[. . . . .]ΣΤΙΝΑ | Along the left edge, serifed ends of descending diagonal stroke at base level and ascending diagonal stroke at top level, kappa or chi. | 3 *DR*: ζωιδίου ο̣ἱ̣ δὲ κυκλίσ- *L*: ζ]ωιδίου [. .]Δ̣Ε̣ κυκλισ- | α̣: indistinct apical letter | σ̣: left-side corners and indistinct continuations of all four strokes | τ̣: complete but blurred by surface damage | ο̣: faint and uncertain trace of complete loop. | 4 *DR*: [κοι . . . .] ἑκάστηι ἀψῖ- *L*: [μός ... ἑκ]ά̣σ̣τ̣η̣ι̣ ἀ̣ψ̣ῖ̣- | Μ̣: vertical stroke joined at top to rightward descending diagonal stroke, seemingly not steep enough for nu, possible trace of ascending diagonal at edge of large pit. | 5 *DR*: [δι . . . .]ος φερόμενος ΤΑΣ̣Ι *L*: [δι? . .]ο̣ς φερομ̣ε̣ν̣ο̣ς̣ ΤΑΣ[. . . .]Ν̣[. . .] | Ι̣: complete but indistinct. | 6 *DR*: . . . . ΤΟ̣ΥΣ . . . . ΤΩΝ . . . . *L*:]Υ̣[. . . . .]Ω̣Ν̣[| λ̣α̣: faint traces of two apical letters | Σ̣: serifed top and bottom strokes, rather indistinct. | 7 Ι̣ 1: indistinct vertical stroke in narrow space | Ι̣ 2: indistinct vertical stroke in narrow space.

ii 1 *DR*: . όμενον, τὸν δ’ ἐπιόντα παρα[π]α̣γῆ- *H*: παρα[π]η̣γ[ν]ύ- *L*: [. .]όμενον τὸν δ’ ἐπιόντ̣α̣ π̣αρα[π]α̣γῆ- | The gamma at the beginning of the line is somewhat blurred by surface damage but complete and recognizable in outline including serifs. | Because of surface damage, eta in (παραπ)η(γνύ-) has a conflicting appearance of alpha in some directions of illumination. | 2 *DR*: ναι, τὰς δ’ ἡμέρας, ὅταν ὁ μεὶς διέ[λθ]ηι, μ̣ε̣- *L*: ναι τὰς δ’ ἡμέ̣ρ̣α̣ς̣ [ὅτα]ν̣ ὁ μεὶς ΔΙ̣Ε̣[. . . με-] | 3 *DR*: τατεθῆνα[ι] εἰς τὴ̣ν̣ ἀ̣[να]γραφὴν τῶν *L*: τατεθῆνα[ι ε]ἰ̣ς [. . . . . . .]Ρ̣Α̣Φ[.]Ν̣ τ̣ῶ̣ν | (ἀ)ν̣α̣(γραφὴν): both letters very indistinct. | 4 *DR*: ἡμερῶν . . . . *H*: ΗΜΕΡΩΝΛ. ΤΛΤ.Σ̣ΗΜΑΣ . . . . *L*: ἡ̣[μ]ερῶ̣[ν | ε̣ἰ̣(ς) very indistinct but complete | (τρ)υ̣π̣(ήματα): upper left diagonal stroke of upsilon with serif, lower end of vertical stroke with serif; pi indistinct but all strokes visible | (π)ρ̣ό̣(ς): the vertical stroke of the presumed rho is clear but the loop is scarcely so if at all; presumed omicron is very indistinct. | In the narrow space between sigma and tau, a rough apparent stroke descending on a steep diagonal seems to be surface damage | (ΤΩ) ̣ : indistinct traces. | 5 *DR*: no readings *H*: . . Η̣Μ̣Ε[Ρ *L*: [. . .]Ν̣[. . . . .]Ν̣[| The left edge of the first letter obliterated, horizontal strokes with right-end serifs at top and baseline level and a small mark indented from left at half height, probably Σ or Ξ. After EN, any vestiges of writing cannot be reli-

[4] *DR* = Diels and Rehm 1904. *H* = Hiller von Gaertringen, reported in Rehm 1904. *L* = Lehoux 2005.

ably distinguished from surface damage except for one further, isolated nu. | 6 *DR*: MHN . . . . *H*: MHṆỌ[Σ *L*: ṂḤṆ[

iii 1 *L*: Ṃ[| 2 *DR*: I followed by the leftmost two strokes of mu or nu *L*: Ṇ[| 6 Φ̣: serifed top of vertical above normal letter height and serifed bottom of vertical below baseline.

Commentary

In general it is now more securely established that this part of the inscription comprised a description and instructions for operating or reading of the parapegma. In column i we find what seems to be an inventory of the components and layout (pegs, probably with circular heads; columnar organization of zodiacal signs; the specific mention of stellar phases). In column ii the focus seems to shift to operational instructions. If the name Ἐπικράτης in line 1 was the first word of this dedicatory line, its beginning would have been approximately aligned with the left margin of column i on the assumption that that column was the same width as column ii. It is not easy, however, to see how to restore i 1 as plausible initial words of the text, so that we suspect that one column (unlikely more) is missing from before column i.

Some of the vocabulary is straightforward to interpret: σελίς refers to a text column of the parapegma as laid out on the stone, τρύπημα is one of the drilled holes representing the individual days making up the solar year, and ζῴδιον is a sign of the zodiac or, by metonymy, the part of the solar year during which the Sun traverses a zodiacal sign. The ἡμέραι of ii 2–3 are apparently movable markers representing days, and we suspect that these markers were the κυκλίσκοι (small disks, not circular holes as Diels and Rehm believed) mentioned twice in column i.[5] The association with a μείς, "lunar month", suggests that the disks were inscribed or painted with some indication of a stage of a month, perhaps a visual representation of a lunar phase or a numeral or abbreviation for a calendar day.[6] The word ἁψίς was taken by Rehm to refer to the 'arc' of a zodiacal sign, but we believe that it is here being used in its architectural sense of 'peg' or 'dowel', referring to the peg as a whole, or perhaps to the shaft of the peg as distinct from its circular head.[7] Caution may be called for, however: the word ἁψίς is also attested in Plato, among others, to refer to the celestial vault, and so 'each orbit' may be possible for ἑκάστηι ἁψῖδι at i 4–5, although we prefer 'each peg', since orbits (in the plural) have little to do with parapegmata apart from lunisolar orbital periods, for which περίοδοι would seem more likely.

We note that the new text found in the parapegma seems to definitively reference pegs placed into holes, both in the plural. This is contrary to Lehoux's earlier argument that parapegmata must have universally used only one moveable peg to indicate the current date in the luni-solar cycle.[8] Clearly this parapegma seems to have used multiple pegs at once, perhaps indicating lunar months or phases across the entire year, as Rehm had originally claimed, though the statement that the completion of a month is the occasion for moving the day-markers leads us to prefer the hypothesis that just one complete lunar month at a time was marked with pegs.[9]

The peg holes in column iii probably mark the beginning of the parapegma as a whole, although there is insufficient information to allow us to state with confidence which zodiacal sign might have begun the parapegma. Lyra is listed as having a stellar phase in other parapegmata early in two zodiacal signs, Taurus (evening rising) and Aquarius (evening setting). The Milesian calendar year, at least at this period, began

[5] Diels and Rehm 1904, 102.

[6] Cf. for visual representations of the lunar phase the Trier ceramic parapegma mold, Rheinisches Landesmuseum Trier inv. ST12014 (Lehoux 2007, 176–177 and Lehoux 2016, 107 fig. IV–7 and 109) and the lunar phase displays of the Antikythera Mechanism (National Archaeological Museum, Athens, inv. X 15087) and the London geared portable sundial (London Science Museum inv. 1983–1393), for both of which see Wright 2006. Days of months in the calendar of Miletus were numbered continuously from the νουμηνία through the end of the second decad, and separately – it is not certain whether in increasing or decreasing order – in the third decad; see Samuel 1972, 115.

[7] For this use of ἁψίς, see Hellmann 1992, citing *IG* 12.2.161 A 70 and Hesychius *s.v.* ψαλίδες.

[8] Lehoux 2007.

[9] Rehm 1941.

around or following the vernal equinox with the month Taureon, so that Taurus might make sense as the first zodiacal sign of the parapegmatic year.[10]

Keskintos Inscription

The inscription comprises three distinct components.[11] Lines 1–13 are the surviving lower part of two side-by-side tables, each consisting of four columns and probably 20 or 28 rows exclusive of any headings. Each of the five planets Venus (Φωσφόρος), Mercury (Στίλβων), Mars (Πυρόεις), Jupiter (Φαέθων), and Saturn (Φαίνων), in that order and perhaps preceded by the Sun and Moon, was allotted four consecutive rows, with the planet's name appearing repeatedly in columns i and v. Each row pertained to one of four kinds of periods relating to the planet's motion, which were always listed (in cols. ii–iii and vi–vii) in the same sequence as κατὰ μῆκος ζῳδιακοί ("in longitude zodiacals"), κατὰ πλάτος τροπικοί ("in latitude tropicals"), κατὰ βάθος περιδρομαί ("in depth revolutions"), and κατὰ σχῆμα διέξοδοι ("in relative position passages"). Columns iv and viii respectively contained numerals representing the number of repetitions of the relevant kind of period for the planet in question that were supposed to be contained respectively in 29,140 solar years (equalling 29,160 Egyptian calendar years) and 291,400 solar years (equalling 291,600 Egyptian calendar years). Below the tables, line 14, so far as it is preserved, is a metrological statement defining the μοῖρα ("degree") and στιγμή ("point") as subdivisions of a circle into 360 and 9720 units respectively. Lastly, line 15 is a dedicatory sentence designating the inscription as a votive offering.

We offer a new edition only of lines 14–15 and of the numerical columns iv and viii of the tabular part (1–13) of the inscription, since the contents of the other columns follow a simple repeating pattern such that revised readings would yield no new information.[12] For typographical convenience, the numbers of myriads are represented by superscripts following the M instead of centered above the letter as they appear on the inscription, and the small raised semicircle signifying thousands is represented by ^.

Planet/period	*Edition* iv	viii	*Translation* iv	viii
Mercury				
κατὰ σχῆμα	M[$^{\text{Θ}}$ ^]ΑΩΝΔ̣ [–]	Μ̣[$^{\text{ϙΑ}}$] [^]ΗΦ̣Μ̣ [–]	91854	918540
Mars				
κατὰ μῆκος	M$^{\text{Α̣}}$ ^ΕΥϙ̣Β [–]	M$^{\text{ΙΕ}}$ ^ΔϡΚ [–]	15492	154920
κατὰ πλάτος	M$^{\text{Α}}$ ^ΕΥ̣Λς [–]	M$^{\text{ΙΕ}}$ ^ΔΤΞ [–]	15436	154360
κατὰ βάθος	M$^{\text{Δ}}$ ϡΞΔ̣ [–]	M$^{\text{Μ}}$ ^ΘΧΜ̣ [–]	40964	409640
κατὰ σχῆμα	M$^{\text{Α̣}}$ ^Γ̣[ΧΜ]Η̣ [–]	M$^{\text{ΙΓ}}$ ^ςΥΠ [–]	13648	136480
Jupiter				
κατὰ μῆκος	^ΒΥ̣Ν̣ –	M$^{\text{Β̣}}$ ^ΔΦ –	2450	24500
κατὰ πλάτος	^Β̣ΥΝς –	M$^{\text{Β}}$ ^ΔΦΞ –	2456	24560
κατὰ βάθος	M$^{\text{Β}}$ ^ΔΣΞ –	M$^{\text{ΚΔ}}$ ^ΒΧ –	24260	242600
κατὰ σχῆμα	M$^{\text{Β}}$ ^ςΧϙ –	Μ̣$^{\text{Κς}}$ [^ςϡ –]	26690	266900
Saturn				
κατὰ μῆκος	ϡϙΒ –	^Θ[ϡ]Κ̣ [–]	992	9920
κατὰ πλάτος	ϡΠΘ ΣΙς	^ΘΩϘς̣ –	989 216	9896
κατὰ βάθος	M$^{\text{Β}}$ ^ΖΡΟς –	M$^{\text{ΚΖ̣}}$ ^ΑΨΞ –	27176	271760
κατὰ σχῆμα	Μ̣$^{\text{Β̣}}$ ^ΗΡΜΗ –	M$^{\text{ΚΗ}}$ ^ΑΥΠ [–]	28148	281480

[10] Trümpy 1997, 92–93. Whether the month name Taureon had any connection with the zodiacal constellation Taurus seems doubtful; Taureon is attested already in the fifth century BC, whereas the zodiacal constellations other than Scorpius do not appear in Greek sources before Eudoxus in the fourth century, though the Babylonian astronomical compendium MUL.APIN (composed before the late eighth century) includes the Bull of Heaven among the seventeen constellations of the "path of the Moon".

[11] For further details and discussion see Jones 2006b.

[12] For the other tabular columns see the edition in Jones 2006a, 109 (with a typographical error at 11 iv noted in the apparatus below) and Jones 2006b, 12.

14 -ε]χε̣[ι] δὲ ὁ κύκλος μο(ιρῶν) $\overline{\overline{\text{ΤΞ}}}$, στιγμῶν [^]$\overline{\text{ΘΨΚ}}$. ἡ μοῖρα στιγμῶν $\overline{\text{Κ}}$[$\overline{\text{Ζ}}$.]
A circle contains 360 degrees, and 9720 *stigmai*. A degree contains 27 *stigmai*.

15 νύμ]φαις χαριστήριον.
Thank-offering to … the nymphs.

Apparatus[13]

1 iv *IG*: no reading *J*: . . . . | Δ̣: triangular indentation suggesting an apical letter. | viii *IG*: ϙ Η *J*: M$^{[ϙA]}$ [^]ΗΥ̣[ ] | Φ̣: serifed bottom of vertical stroke, extending below baseline, possible trace of lower right part of loop. Μ̣: serifed bottom of vertical stroke, slightly sloping, suggestive of mu but other letters cannot be excluded. | 2 iv *IG*: M$^{\Delta}$ ^ΖΥ . Β – *J*: Μ̣^{A} ^ΕΥΛϛ [–] | Α̣: faint trace of apical letter. | viii *IG*: M^{IZ} ^ΔↄΚ *J*: M^{IE} ^ΔↄΚ | 3 iv *IG*: M$^{\Delta}$ ^Θ̣ΥΛϛ – *J*: M^{A} ^ΕΥΛϛ [–] | Υ̣: left descending diagonal and lower vertical stroke, with small trace of serif of right end of right ascending diagonal. | viii *IG*: M$^{I\Gamma}$ ΔΤΞ *J*: M^{IE} ^ΔΤ̣ Ξ | 4 iv *IG*: M$^{\Delta}$ . . . . *J*: M$^{\Delta}$ ↄΞ . – | Δ̣: horizontal stroke at baseline met at its right end by a faint descending diagonal. | viii *IG*: M^{M} ^ΑΧΠ – *J*: M^{M} ^Α̣Χ̣Ν̣ | Μ̣: leftmost stroke serifed at bottom and sloping rightward; pitting obscures the middle of the letter, but there seems to be a vestige of an ascending diagonal meeting the top of the rightmost stroke, which is serifed at the bottom, vertical but somewhat bent towards the left at mid height. Nu cannot be excluded. | 5 iv *IG*: M$^{\Delta}$ . . . . . *J*: M^{A} ^Γ̣[ΧΜ]Η̣ – | Α̣: indeterminate apical letter. Γ̣: complete but faint. Η̣: very faint and indistinct. | viii *IG*: M$^{I\Gamma}$ ^ϛΥΠ – *J*: M$^{I\Gamma}$ ^ϛΥΠ̣ | 6 iv *IG*: M . . . . *J*: [^]Β̣Υ̣Ν̣ – | Υ̣: outline of left side of letter and serif of right ascending diagonal. Ν̣: pitted, no distinct strokes. | viii *IG*: M^{B} ^ΑΦΟ̣ *J*: M^{B} ^ΔΦ | 7 iv *IG*: M . . Ιϛ – *J*: [^]Β̣ΥΝ̣ϛ – | Β̣: outline of complete letter, pitted. | viii *IG*: M^{B} ^ΑΦΞ *J*: M^{B} ^ΔΦΞ | 8 iv *IG*: M^{B} ^ΔΣΞ *J*: M^{B} ^ΔΣΞ – | viii *IG*: M$^{K\Delta}$ ^ΒΧ – *J*: M$^{K\Delta}$ ^ΒΧ | 9 iv *IG*: M^{B} ^ϛΧϙ – *J*: M^{B} ^ϛΧϙ̣ – | viii *IG*: M^{Kϛ} . . . *J*: Μ̣^{Kϛ} [^ϛↄ] | 10 iv *IG*: ↄΜ *vacat* *J*: ↄϙ̣Β – | viii *IG*: no reading *J*: [^]ΘↄΚ̣ | Κ̣: serifed bottom of vertical stroke. | 11 iv *IG*: ↄΜ ^ΘΣΙϛ – *J*: ↄΠΘ ΣΙϛ (misprinted ↄΑΘ ΣΙϛ in Jones 2006a) | viii *IG*: ^ΘΩΙ̣ *J*: ^ΘΩϙϛ | ϛ: top horizontal ending in short downward stroke. | 12 iv *IG*: M^{P} ^ΖΡΟϛ – *J*: M^{B} ^ΖΡΟϛ – | viii *IG*: M ^ΑΨΞ *J*: M^{KZ} ^ΑΨΞ | Ζ̣: pitted, indistinct. | 13 iv *IG*: M^{P} ^ΗΡΜΗ – *J*: Μ̣^{B} ^ΗΡΜΗ – | Μ̣^{B}: serif of first stroke of mu (counting from left), all of fourth stroke, and top of third stroke; upper loop of beta. | viii *IG*: M^{KH} ^ΑΥΠ – *J*: M^{KH} ^ΑΥ̣Π | 14 *IG*:]Ν̣ ὁ κύκλος μο(ιρῶν) $\overline{\overline{\text{ΤΞ}}}$ στιγμῶν ΘΨΚʹ. ἡ μοῖρα στιγμῶν [κζ] *J*:] . [. . . .] . . . ὁ κύκλος μο(ιρῶν) $\overline{\overline{\text{ΤΞ}}}$, στιγμῶν [^]$\overline{\text{ΘΨΚ}}$. ἡ μοῖρα στιγμῶν $\overline{\text{Κ}}$̣[$\overline{\text{Ζ}}$.] | χ̣: serifed upper halves of both strokes. ε̣: outline, pitted; eta not excluded. | 15 *IG*: θεο]ῖς χ[α]ριστήριον *J*:] . . α̣ις χαριστήριον

Commentary

The tabular part of the inscription is of considerable interest for the history of Greek astronomy, in particular for the following three reasons:

1. It is the most explicit and detailed instance in the context of scientific astronomy of the principle of a Great Year, that is, the assumption that there exists an interval of time within which all the periodic motions of the heavenly bodies repeat an exact whole number of times so that their initial cosmic configuration is restored. In the inscription, the Great Year of the left table, 29,140 solar years, is an imperfect one since Saturn's period in latitude (line 11) – as well as possibly other periods in the lost upper rows of the table – is assigned a non-integer number of repetitions, 989 3/5 (expressed as 989 followed by 216, meaning 216/360). Multiplying the interval by ten in the right table resulted in integer numbers for all the surviving periods, and presumably all the periods in the table.
2. Although a tabulation of four kinds of period for each planet does not constitute anything approaching a complete description of the underlying theory of the planet's motion, the relations among the numbers indicate that the theories were significantly different from any that we know of from other Greco-Roman sources. The periods κατὰ μῆκος and κατὰ σχῆμα are, on the face of it, the most straightforward to interpret, both from the numbers themselves and from the broader use of the terminology in Greek astronomical texts, as respectively the (mean) period of the planet's making a complete circuit of the zodiac, and the (mean) synodic period, that is, the period of the planet's apparent motion through the zodiac relative to that of the Sun, which is also the period of its cyclic variations in apparent speed and direction of motion. For each of the three "superior" planets Mars, Jupiter, and Saturn, the numbers of periods of these two kinds sum to the number of solar years in the Great Year, whereas for the "inferior" planets Mercury and Venus the number of periods κατὰ μῆκος

[13] *IG* = Hiller von Gaertringen's text in *IG* 12.1. *J* = Jones 2006a/2006b. The readings from these editions have been normalized to the typographical conventions of the present article.

is identical to the number of solar years. The periods κατὰ πλάτος pertain to the planet's oscillatory motion north and south of the ecliptic circle that runs through the middle of the zodiacal belt, and the fact that these numbers are slightly different from those of the periods κατὰ μῆκος means that the nodal points of intersection of the ecliptic and the planes of the planets' motions were assumed to have a gradual motion. The periods κατὰ βάθος are the most problematic and interesting. From the use of this term in other astronomical texts, one would expect these to be the same as the periods κατὰ σχῆμα since in typical Greek planetary theories motion in "depth" was strictly correlated with position relative to the Sun. Instead, for Jupiter and Saturn the periods κατὰ βάθος are – with a small discrepancy that is itself an enigma – obtained by *subtracting* the periods κατὰ μῆκος from those κατὰ σχῆμα. In the case of Mars the number of periods κατὰ βάθος was previously subject to some uncertainty because of an apparent conflict between the readings from line 4, columns iv and viii, but according to the reading preferred in the previous edition, it was three times the number κατὰ σχῆμα, again with a small discrepancy. The implications of these very strange numbers go beyond the scope of the present article, but we wish to emphasize the importance of resolving the readings in line 4.

3. Separate from the peculiarities of the underlying planetary theories outlined above, the accuracy of the fundamental period relation for each planet relating solar years, circuits of the zodiac, and synodic periods provides an index according to which the inscription's astronomy can be situated in terms of sophistication and perhaps of chronological development relative to other documentations of Greek planetary theory.

Considering the poor state of preservation of the stone, we are fortunate that the tables' structure provides several controls on the reading of the numerals. First, we have the principle that, in any row, the numeral in column viii should be exactly ten times that in column iv. Secondly, for Mars, Jupiter, and Saturn, we know that the numbers in the first and fourth rows should sum to 29,140 and 291,400. Thirdly, the higher-order digits of the numbers for the periods κατὰ μῆκος and κατὰ σχῆμα (and to a lesser degree those κατὰ πλάτος) can be confirmed against estimates derived from the durations of these periods according to modern astronomical knowledge. In the 2006 edition, taking these factors into account, Jones was confident of all the numbers in lines 2–13 except for those in line 4, where the number in column iv was read as 4096x (less likely 4036x), such that the final digit x corresponds to an indeterminate Greek letter having a horizontal stroke at baseline, but the number in column viii was read as either 401,650 or 401,640 (less likely 404,650 or 404,640). Now the RTI imaging establishes the number of column iv as 40,964 (the traces of the lowest order digits are faint but, we believe, reasonably secure), and that of column viii as 409,640 or 409,650. A further consideration favoring reading 40,964 and 409,640 arises from the small discrepancies mentioned above as appearing in the κατὰ βάθος numbers. As we noted, the numbers for Jupiter and Saturn are obtained by subtracting the κατὰ μῆκος numbers from the κατὰ σχῆμα numbers, but to obtain complete agreement one has to add another 20 in column iv and 200 in column viii, thus:

Jupiter: 26,690 – 2450 + 20 = 24,260
Saturn: 28,148 – 992 + 20 = 27,176

Mars's κατὰ βάθος number, on the other hand, is obtained by tripling the κατὰ σχῆμα number; applying the same "correction" of 20, we have:

Mars: 13,648 × 3 + 20 = 40,964

which might mean that a consistent adjustment to the κατὰ βάθος numbers was applied to reflect some difference in frame of reference applying to these periods, which we do not pretend to understand.[14]

The highest-order digits of the numbers for Mercury's period κατὰ σχῆμα are lost in both columns, but can be restored on the basis of the planet's mean synodic period, which is approximately 115.88 days, so that 29,140 years of 365.25 days would comprise approximately 91,848 synodic periods. With the lower-

[14] See however Jones 2006b, 32 for an argument favoring a discrepancy of 21 for Mars, and thus reading 40,965 and 409,650.

order digits now secured, we can compare the period relation implied in the inscription to other period relations attested in Greek astronomy, scaled up to 29,140 solar years:

Keskintos
29,140 solar years = 29,140 zodiacal circuits = 91,854 synodic periods

Babylonian Goal-Year period[15]
46 solar years = 46 zodiacal circuits = 145 synodic periods, hence:
29,140 solar years = 29,140 zodiacal circuits = 91,854.35 synodic periods

Babylonian ACT period[16]
217 solar years = 217 zodiacal circuits = 684 synodic periods, hence:
29,140 solar years = 29,140 zodiacal circuits = 91,851.43 synodic periods

Ptolemy[17]
29,140 years of 365 1/4 days = 91,849.43 synodic periods
29,140 tropical years of 365 1/4 – 1/300 days = 91,848.59 synodic periods

The inscription's period relation for Mercury is thus on the same order of inaccuracy as the comparatively crude Babylonian Goal-Year period (which was known to Hipparchus in the second century BC according to Ptolemy, *Almagest* 9.3), and could have been derived from it. Similarly, the inscription's relation for Mars appears to have been obtained from the longer and more accurate of the two Babylonian Goal-Year periods for that planet (equating 79 solar years with 42 zodiacal circuits and 37 synodic periods).[18] Contrastingly, the inscription's relations for Jupiter and Saturn are significantly less accurate even than those planets' Goal-Year periods, apparently as a result of their having been subjected to certain numerologically motivated modifications.[19] There is nothing to suggest that the author of the inscription had access to more accurate period relations such as the Babylonian ACT ones or the comparable ones (for Venus and Saturn) attested in the Front Cover Inscription of the Antikythera Mechanism (date disputed but from an archaeological context close to 60 BC).[20]

Lastly, it is highly intriguing that the dedication of the inscription in line 15 turns out to have been, at least in part, to the Nymphs.[21] Two other inscriptions, rather disparate in date, from the environs of Lindos attest to some sort of cult of the Nymphs: ILindos 456, probably first century AD, may have belonged to an altar and cites the Νύμφαι ἀέναοι in connection with water and the others of the four elements; and *IG* 12.1.928, a third century AD inscription originally above a doorway, from near Massari, preserves parts of epigrams honoring the Nymphs and the Sun. Perhaps we are not dealing with a block transported to the Rhodian countryside from an original urban location, as was previously suggested,[22] but one that once adorned a rural shrine close to a spring or stream.[23]

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15 Neugebauer 1975, 1.554.

16 Neugebauer 1975, 1.399.

17 Ptolemy, *Almagest* 9.3.

18 Jones 2006b, 25 with Table 4 on p. 26.

19 Jones 2006b, 31–32.

20 Anastasiou *et al*. 2016, 291 and 294.

21 We are grateful to John Ma for drawing our attention to the possible significance of this new reading. See also Morelli 1959, 165 and Larson 2001, 206–207.

22 Jones 2006b, 6.

23 For the Keskintos site see Jones 2006c.

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George Bevan, Department of Geography, Queen's University
bevan@queensu.ca

Alexander Jones, Institute for the Study of the Ancient World, New York University
alexander.jones@nyu.edu

Daryn Lehoux, Department of Classics and Department of Philosophy, Queen's University
lehoux@queensu.ca