Eclipse Prediction on the Ancient Greek Astronomical Calculating Machine Known as the Antikythera Mechanism

Freeth T (2014) in PLoS ONE 9(7): e103275.
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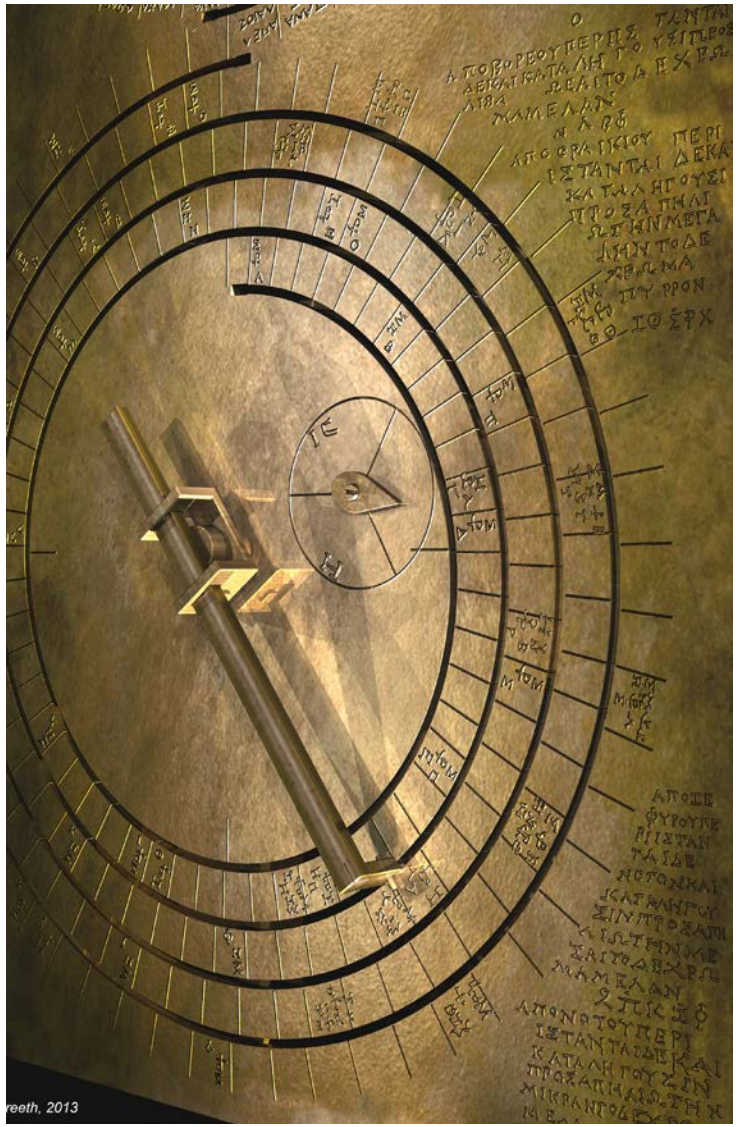
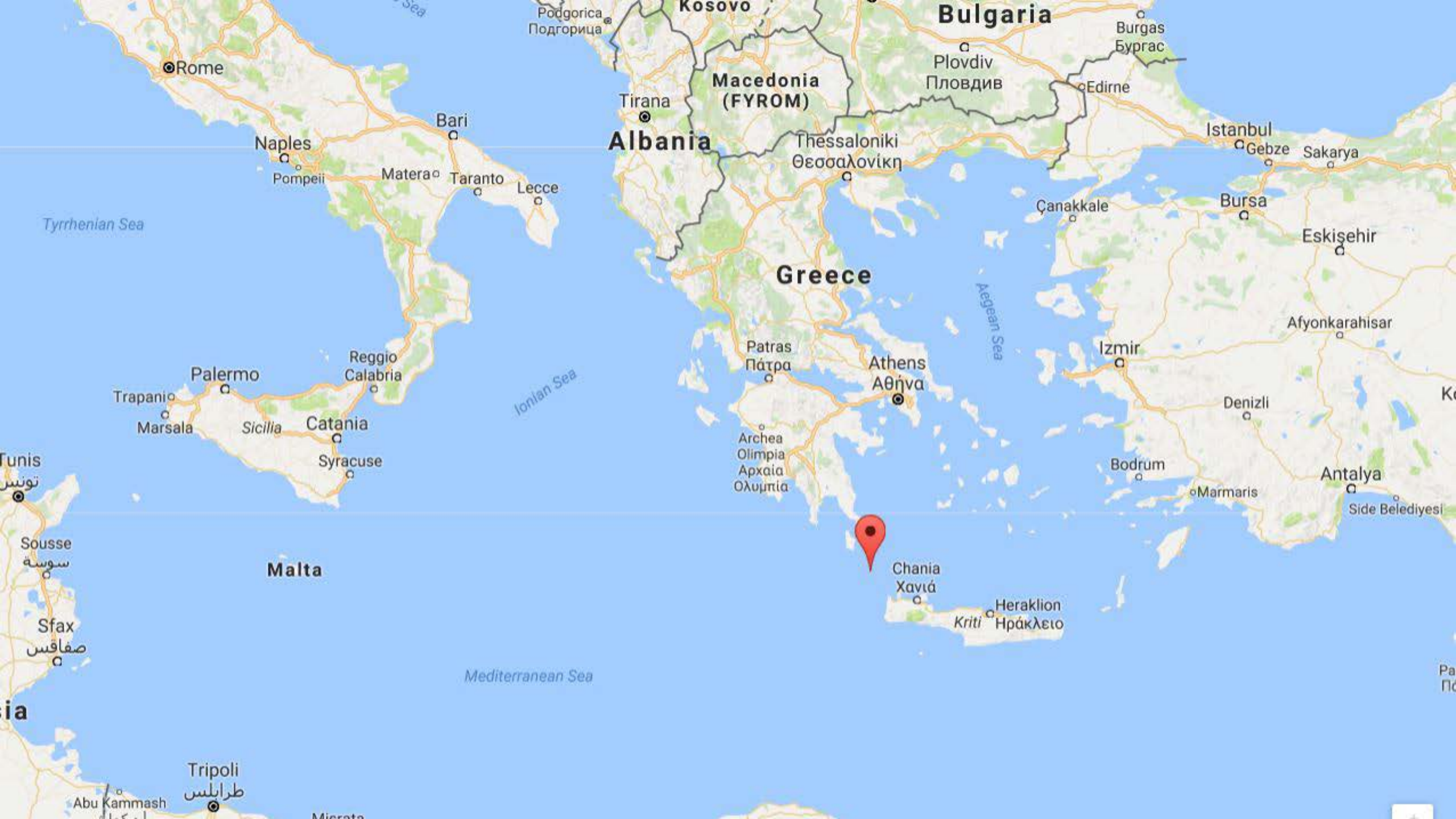


Freeth, 2014: Figure 11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Olimpia
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Antalya
Marmaris
Side Belediyesi
Tunis
تونس
Sousse
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Χανιά
Heraklion
Ηράκλειο
Kriti
Sfax
صفاقس
Mediterranean Sea
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طرابلس
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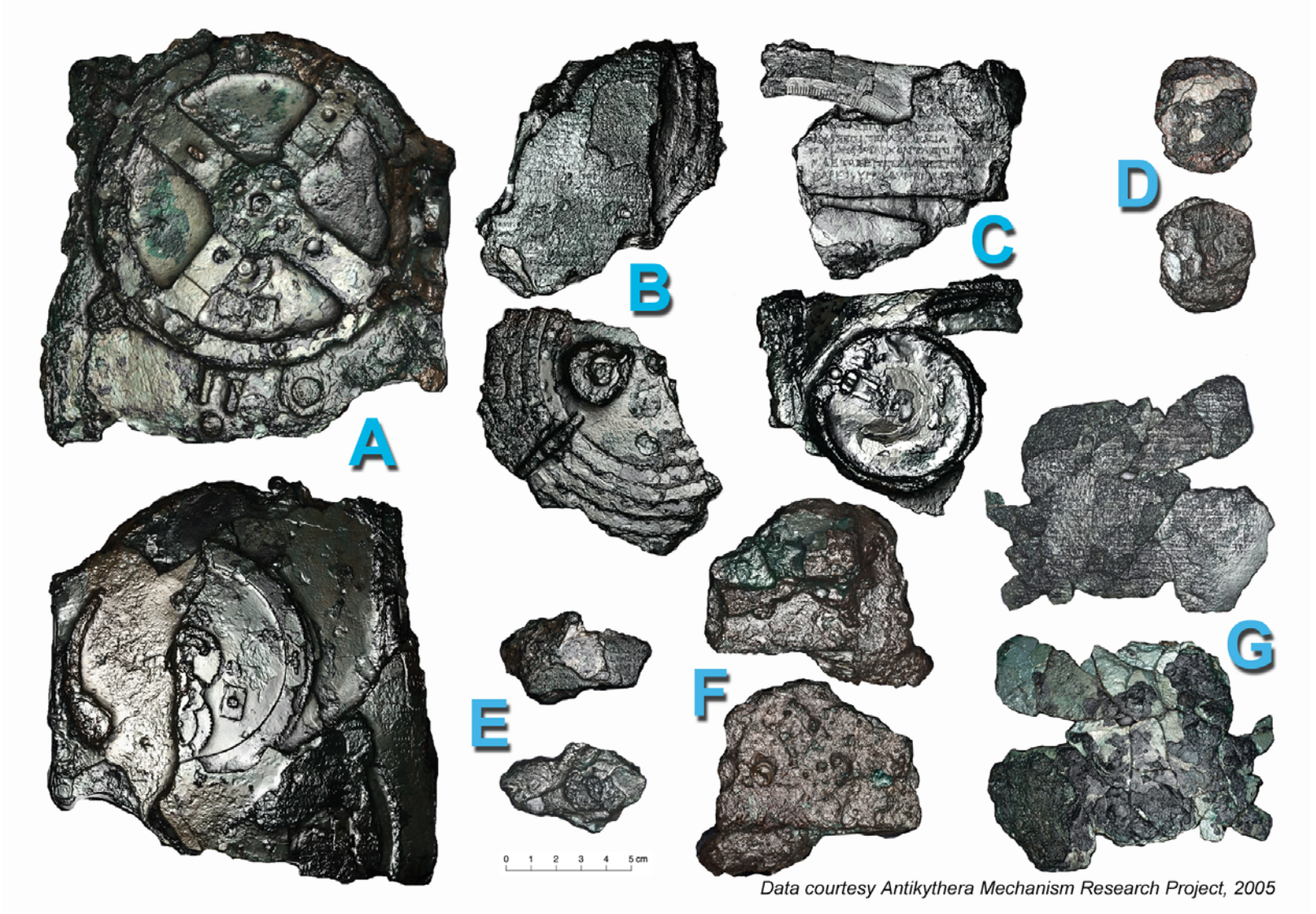
The Antikythera Fragments



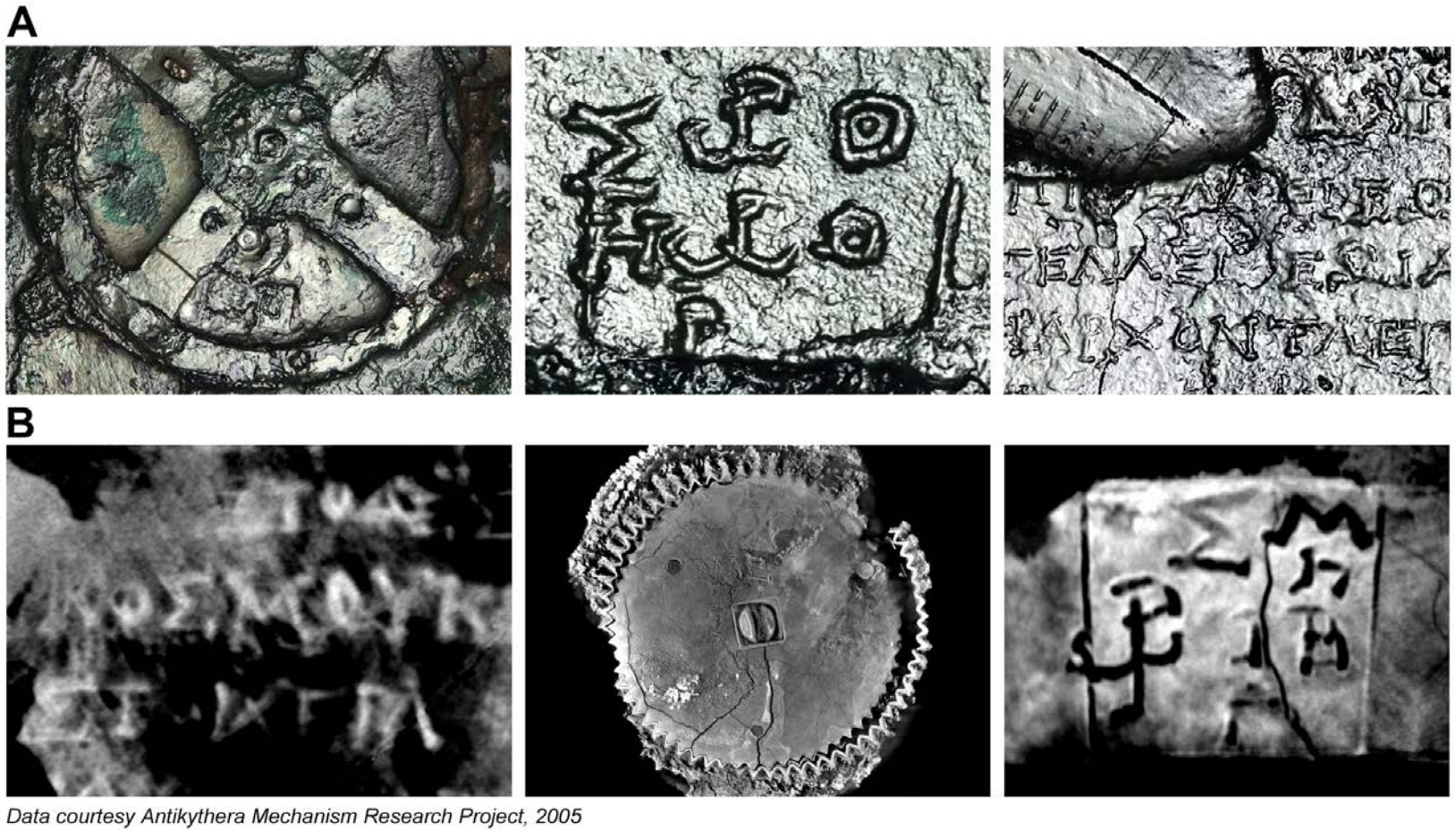
Freeth, 2014: Figure 1

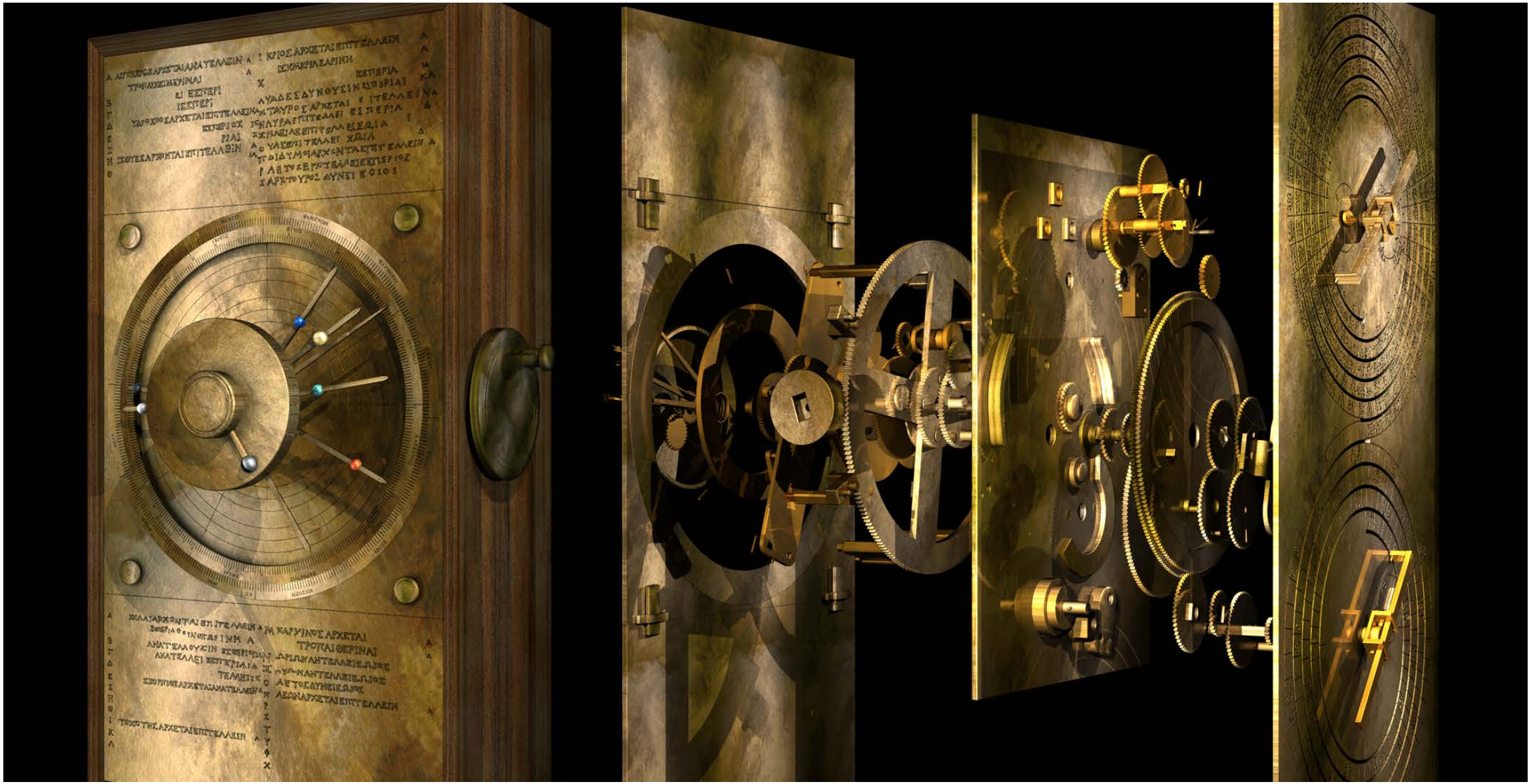
This image, and all further images, from Freeth T (2014) Eclipse Prediction on the Ancient Greek Astronomical Calculating Machine Known as the Antikythera Mechanism. PLoS ONE 9(7): e103275. https://doi.org/10.1371/journal.pone.0103275 unless noted otherwise

A: Polynomial Texture Mapping (PTM) / Reflectance Transformation Imaging (RTI)

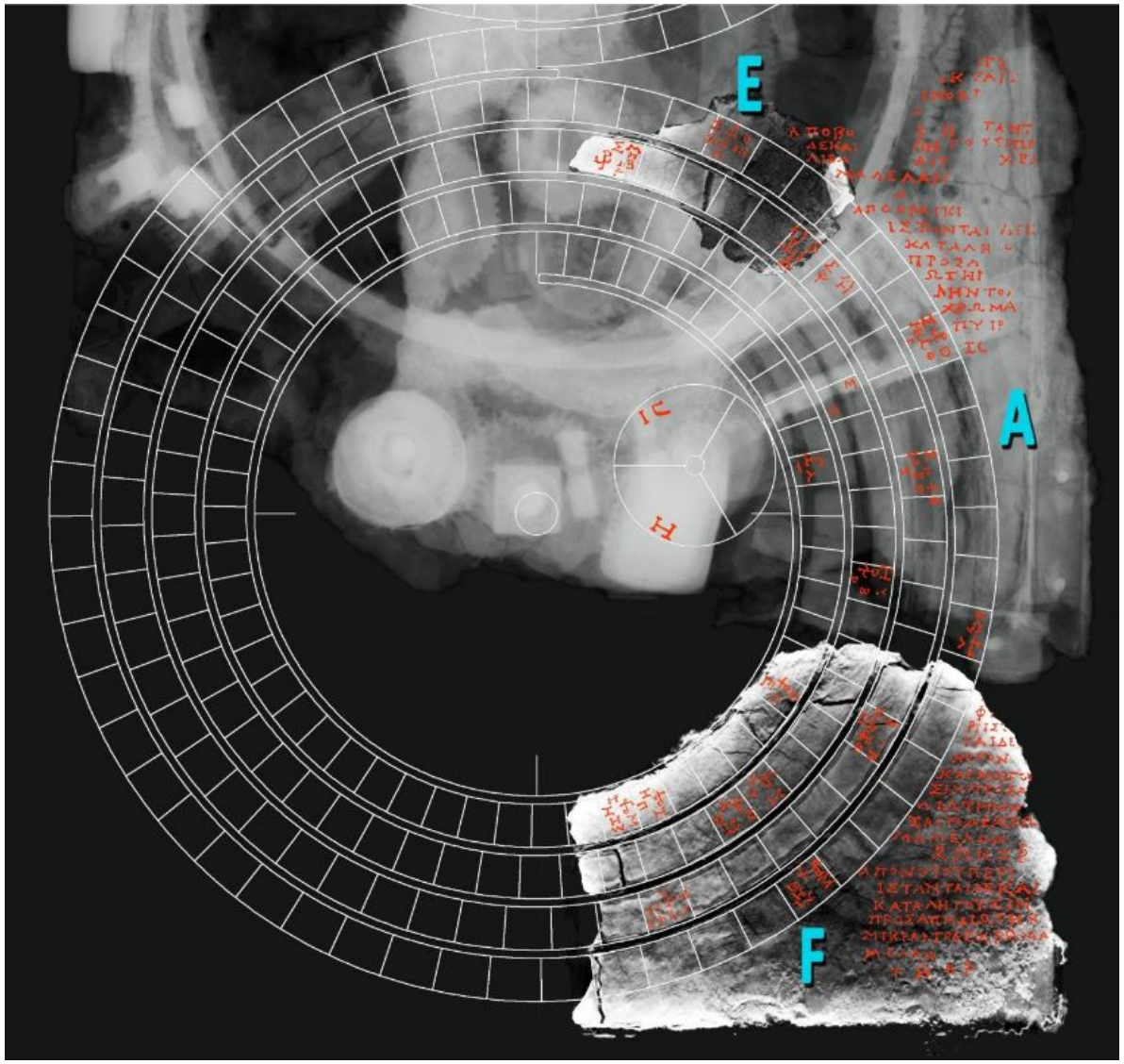
B: Microfocus X-ray Computed Tomography (X-ray CT)

Freeth, 2014: Figure 2





Freeth, 2014: Figure 3



The Saros Dial Fragments

Fragment X-ray CTs overlaid with proposed Saros Dial.

Freeth 2014: Figure S3

A-D: PTM of Fragment A

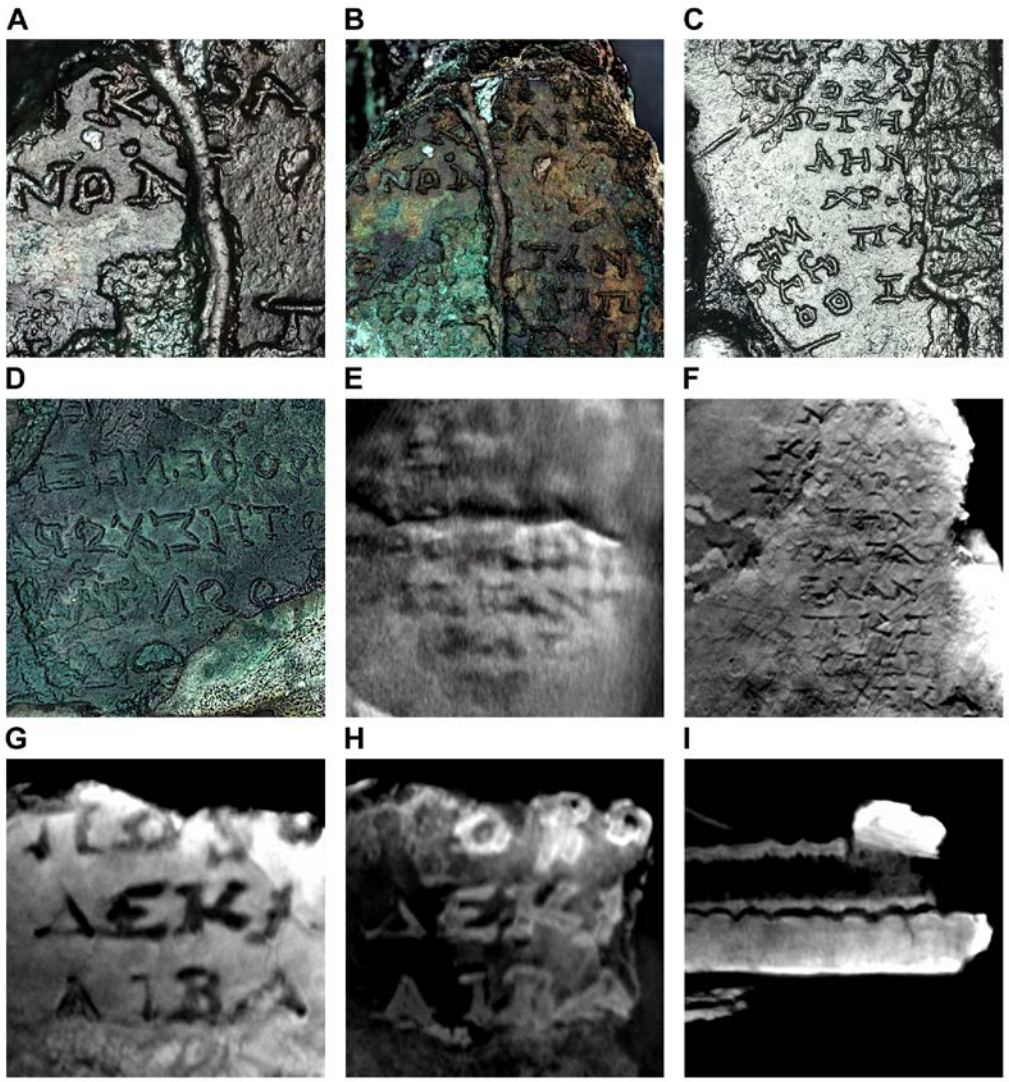
E: X-ray CT of Fragment A

F: X-ray CT of Fragment F

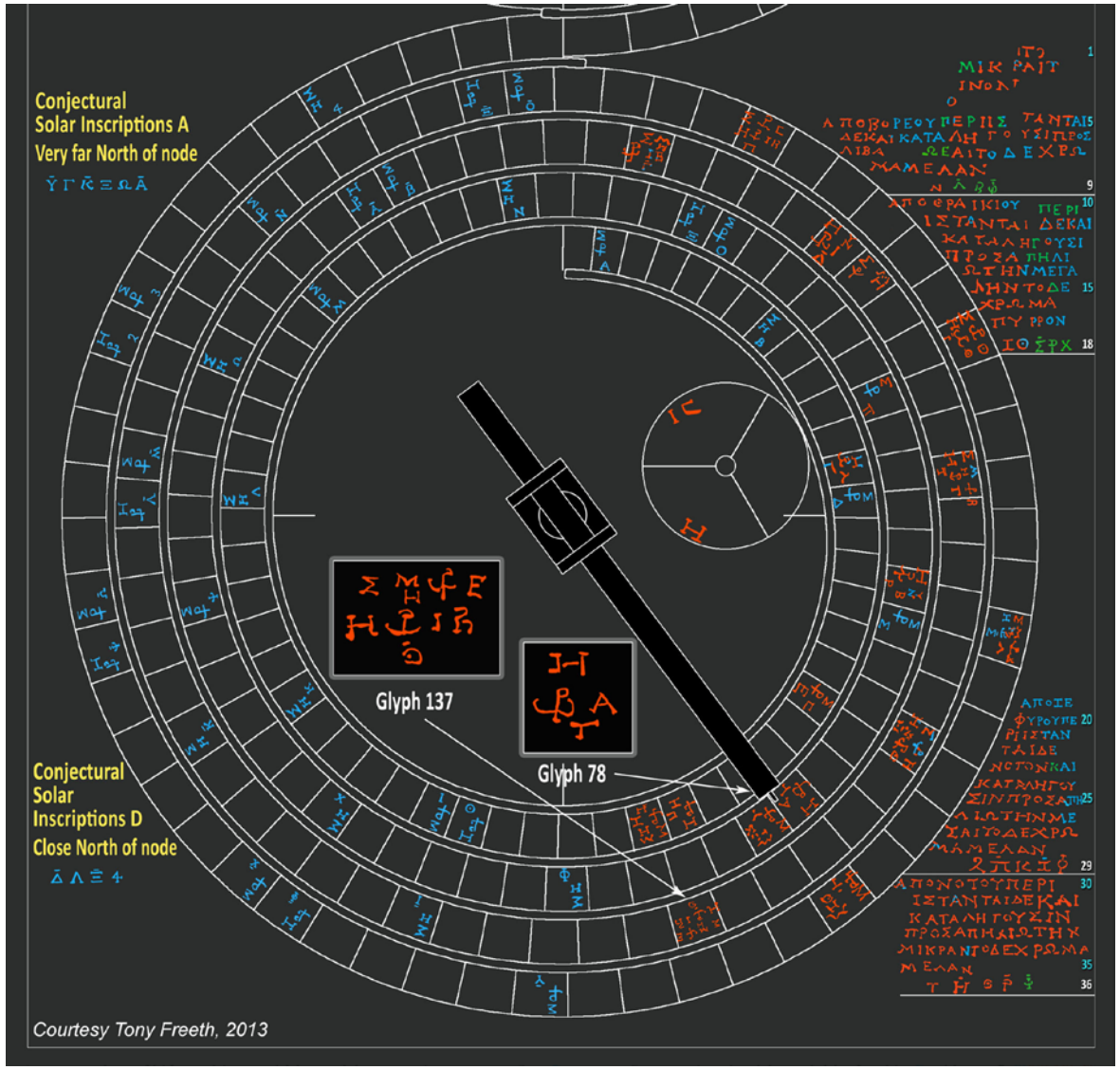
G: X-ray CT of Fragment E

H-I: X-ray CT of Fragment E, Accretion Layer

Freeth, 2014: Figure 5



Data courtesy Antikythera Mechanism Research Project, 2005



The Saros Dial

223 Lunar-Month Dial

Reconstruction

Freeth, 2014: Figure 4

The Eclipse Year Model (EYM)

Bright Orange:
Observed Solar Glyph

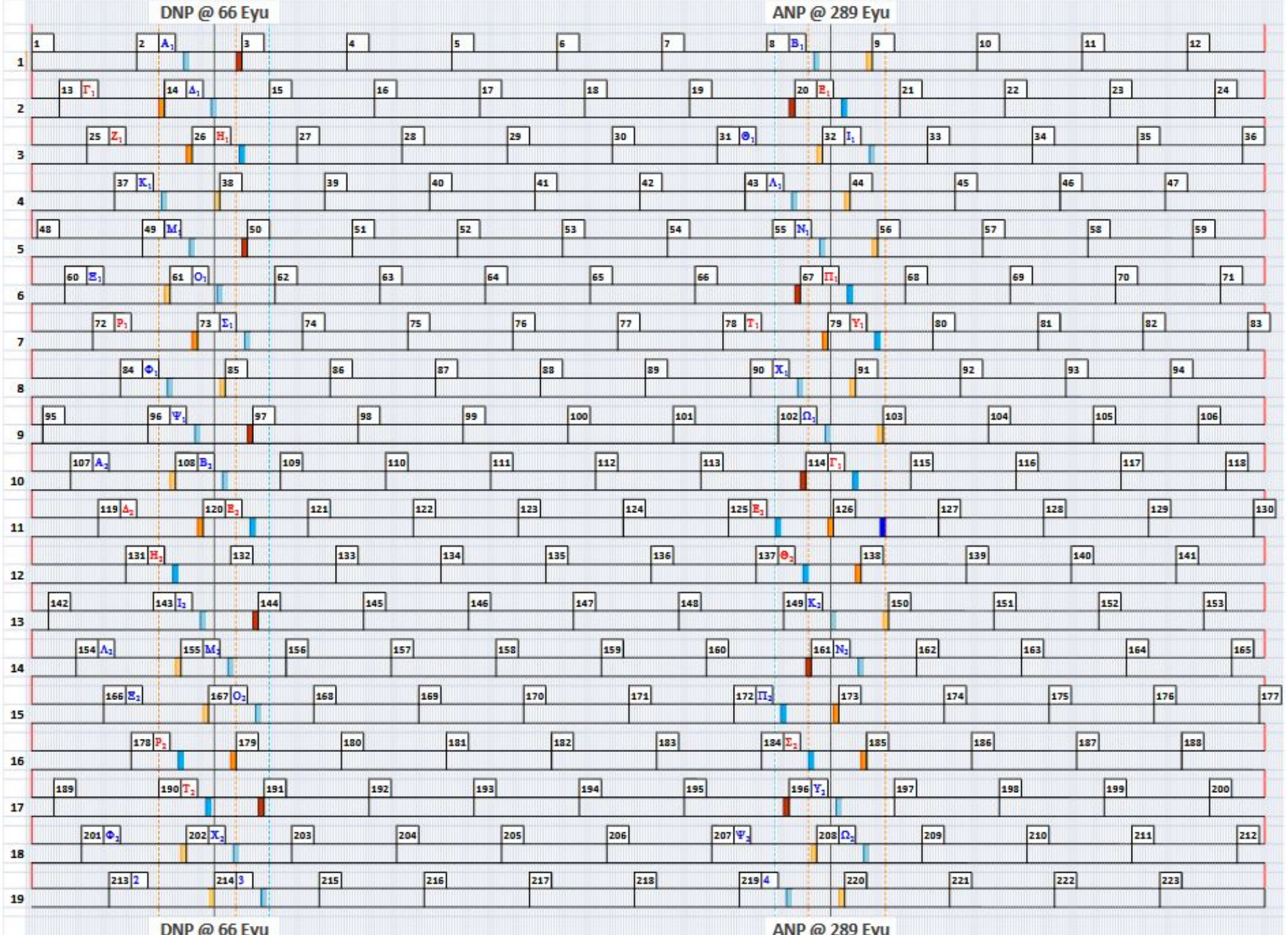
Bright Blue:
Observed Lunar Glyph

Pale Orange:
EYM Reconstructed Solar Glyph

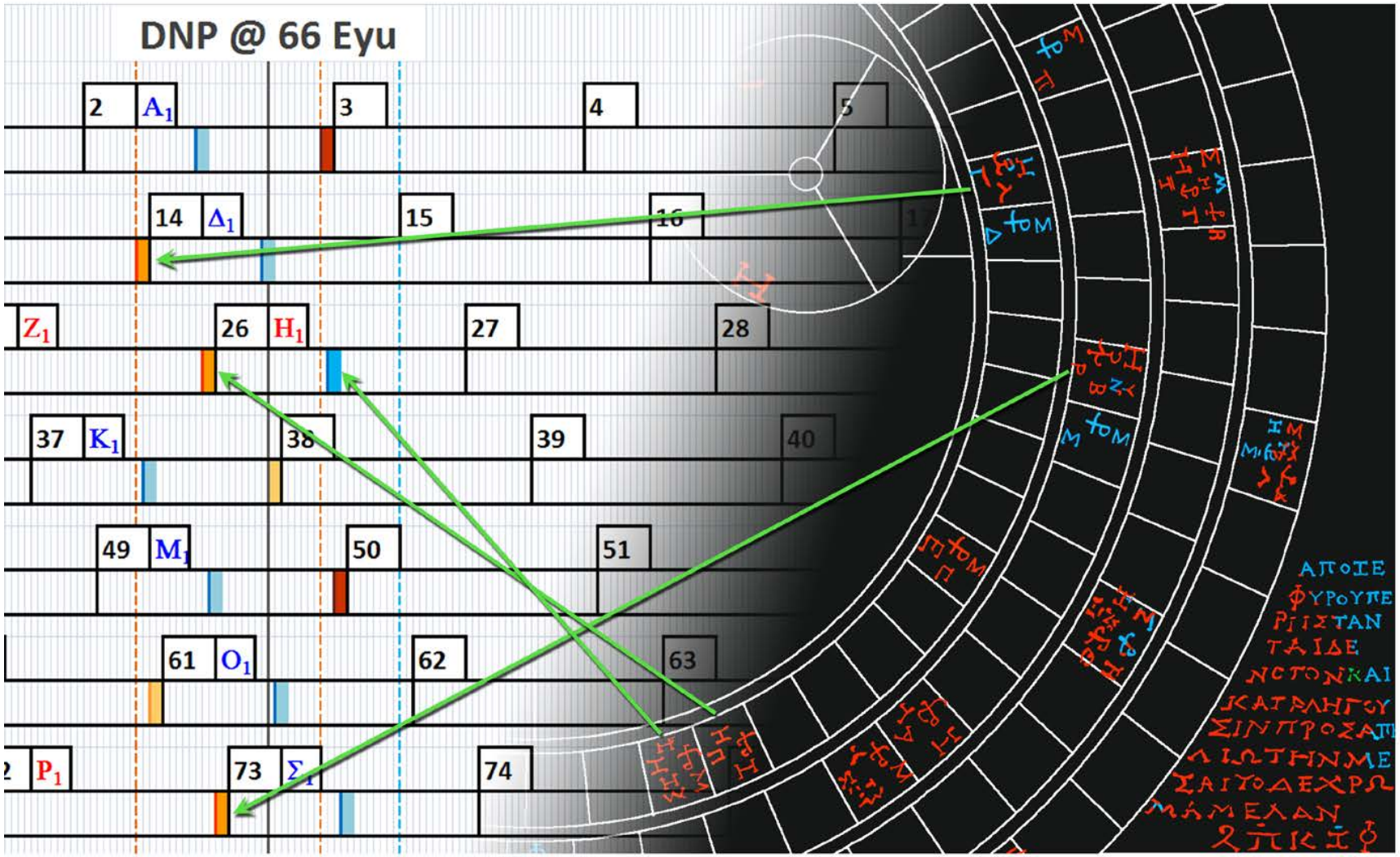
Pale Blue:
EYM Reconstructed Lunar Glyph

Red:
Observed Index Letter

Blue:
EYM Reconstructed Index Letter



Freeth, 2014: Figure S9



B

Mnth	LUN	SOL	Ind.	FM LUN EYu	node	N/S	Dist EYu	NM SOL EYu	node	N/S	Dist EYu
1				17				36			
2			A1	55	D	S	11	74			
3				93				112			
4				131				150			
5				169				188			
6				207				226			
7				245				264			
8			B1	283	A	N	6	302	A	N	13
9				321				340			
10				359				378			
11				397				416			
12				435				8			
13			Γ1	27				46	D	N	20
14			Δ1	65	D	S	1	84			
15				103				122			
16				141				160			
17				179				198			
18				217				236			
19				255				274			
20			E1	293	A	S	4	312			
21				331				350			
22				369				388			
23				407				426			
24				445				18			
25			Z1	37				56	D	N	10
26			H1	75	D	N	9	94			
27				113				132			

2013

Freeth, 2014: Figure 6

Para-meters								Glyph Limits				
	Lunar month	38 EYu	29.53 days	Desc. node at	66 EYu	51.28 days			Lunar N	20 EYu	Solar N	20 EYu
	Month start	2 EYu	1.55 days	Asc. node at	289 EYu	224.55 days			Lunar S	20 EYu	Solar S	7 EYu

NORTH: month order

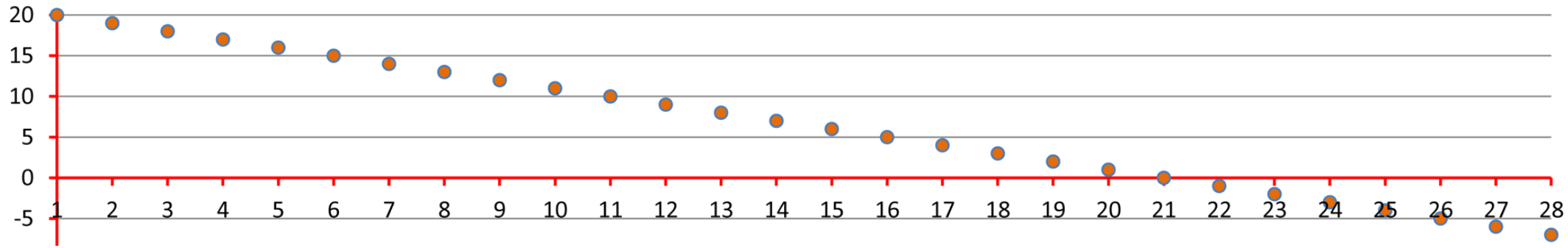
Month	8	13	25	43	55	60	72	90	102	107	119	137	149	154	166	172	184	201	213	219
Index	B_1	Γ_1	Z_1	Λ_1	N_1	Ξ_1	P_1	X_1	Ω_1	A_2	Δ_2	Θ_2	K_2	Λ_2	Ξ_2	Π_2	Σ_2	Φ_2	2	4
Eyu	302	46	56	294	304	48	58	296	306	50	60	298	308	52	62	290	300	54	64	292
Node	A	D	D	A	A	D	D	A	A	D	D	A	A	D	D	A	A	D	D	A
NP Eyu	13	20	10	5	15	18	8	7	17	16	6	9	19	14	4	1	11	12	2	3

AT/SOUTH: month order

Month	31	37	78	84	125	131	178	207
Index	Θ_1	K_1	T_1	Φ_1	Z_2	H_2	P_2	Ψ_2
Eyu	284	66	286	68	288	70	72	282
Node	A	D	A	D	A	D	D	A
NP Eyu	-5	0	-3	-2	-1	-4	-6	-7

NORTH: descending order

	Conj. Solar Group A					L. 9 Group				L. 18 Group					Conj. Solar Group D				L. 29 Group					L. 36 Group				
	Very far North of node					*Far North of node*				*Quite close North of node*					*Close North of node*				*Nearly at node: North then South*					*Close South of node*				
Month	13	149	60	102	107	55	154	8	201	184	25	137	72	90	119	43	166	219	213	172	37	125	84	78	131	31	178	207
Index	Γ_1	K_2	Ξ_1	Ω_1	A_2	N_1	Λ_2	B_1	Φ_2	Σ_2	Z_1	Θ_2	P_1	X_1	Δ_2	Λ_1	Ξ_2	4	2	Π_2	K_1	Z_2	Φ_1	T_1	H_2	Θ_1	P_2	Ψ_2
Eyu	46	308	48	306	50	304	52	302	54	300	56	298	58	296	60	294	62	292	64	290	66	288	68	286	70	284	72	282
Node	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A
NP Eyu	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7



Freeth, 2014: Figure 7

The Epigraphy

Note 2:

Dr. Charles Crowther

(Oxford University)

Freeth, 2014: Figure 8

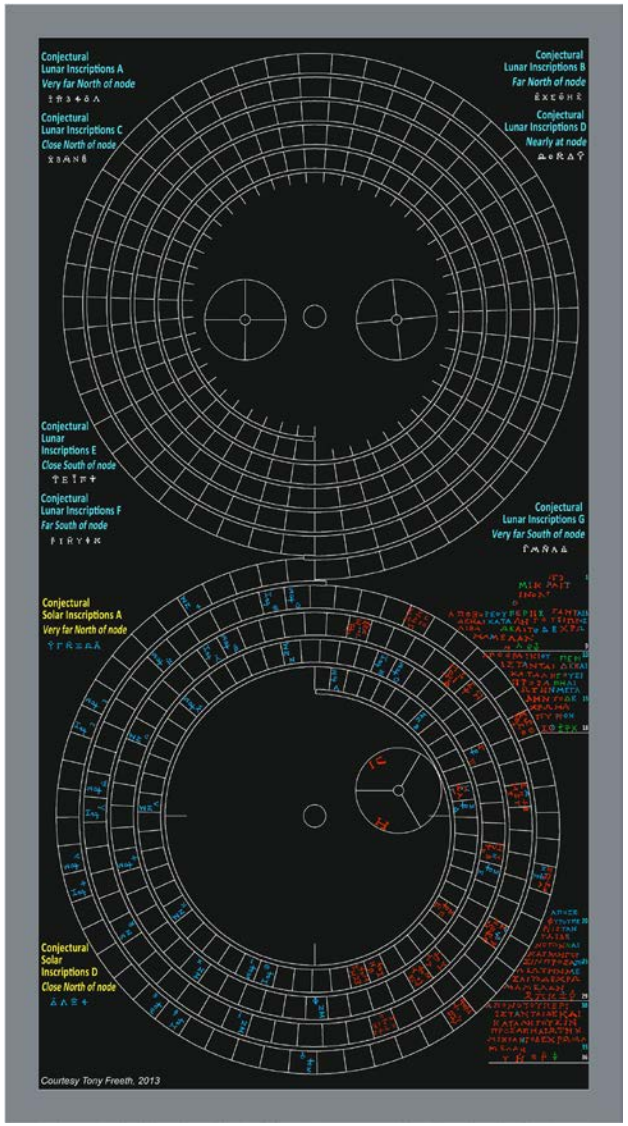
A	B	C
	1 [- - - - $^{c.15}$ - - - -]ΙΤΟ [. . . .]	
	2 [- - - $^{c.12}$ - - -]ΙΚΡΑΙΤ[. . .]	small(?)
	3 [- - - $^{c.10}$ - - -]ΙΝΟΝ *vacat*	
	4 [- - - $^{c.10}$ - - -]Ο	
	5 ἀπὸ Βο[ρέου,] περιΐ̣σταντ[αι]	From the North, and they revolve
	6 δὲ καὶ̣ [κατα]λήγουσι πρ[ὸς]	and end towards
	7 Λίβα [. .]ΩΕΑΙ, τ[ὸ δὲ] χρῶ-	the South-West, medium(?), and the
	8 μα μέλαν.	colour is black.
	9 $N_1 \Lambda_2 B_1 \Phi_2$	$N_1 \Lambda_2 B_1 \Phi_2$
	10 ἀπὸ Θρακί[ου,] περι-	From the North-North-West, and they
	11 ΐ̣στανται δὲ̣ κ[αὶ]	revolve and
	12 καταλήγο[υσι]	end
	13 πρὸς Ἀπη[λι]-	towards the
	14 ώτην [μεγά]-	East, large,
	15 λην, τὸ δ[ὲ]	and the
	16 χρῶμα	colour is
	17 πυρρ[όν.]	red.
	18 $Z_1 \Theta_2 \Sigma_2 P_1 X_1$	$Z_1 \Theta_2 \Sigma_2 P_1 X_1$
	19 [ἀπὸ Ζε]-	From the
	20 φύ̣[ρου, πε]-	West, and
	21 ριΐ̣σ̣τ̣[αν]-	they
	22 ται δὲ	revolve
	23 Νότον κ[αὶ]	southwards and
	24 καταλήγου-	end
	25 σιν πρὸς Ἀ[πη]-	towards the
	26 λιώτην μ[έ]-	East, medium,
	27 σαι, τὸ δὲ χρῶ-	and the colour
	28 μα μέλαν.	is black.
	29 $2\,\Pi_2 K_1 Z_2 \Phi_1$	$2\,\Pi_2 K_1 Z_2 \Phi_1$
	30 ἀπὸ Νότου, περι-	From the South, and they
	31 ΐ̣στανται δὲ καὶ	revolve and
	32 καταλήγουσιν	end
	33 πρὸς Ἀπηλιώτην	towards the East,
	34 μικράν, τὸ δὲ χρῶμα	small, and the colour is
	35 μέλαν	black.
	36 $T_1 H_2 \Theta_1 P_2 \Psi_2$	$T_1 H_2 \Theta_1 P_2 \Psi_2$

Courtesy Tony Freeth / Charles Crowther 2013

The Metonic and Saros Dials

Proposed Reconstruction

Freeth, 2014: Figure 9



The Zig-Zag Model

Based on Babylonian System B

The model has the fixed parameters of :

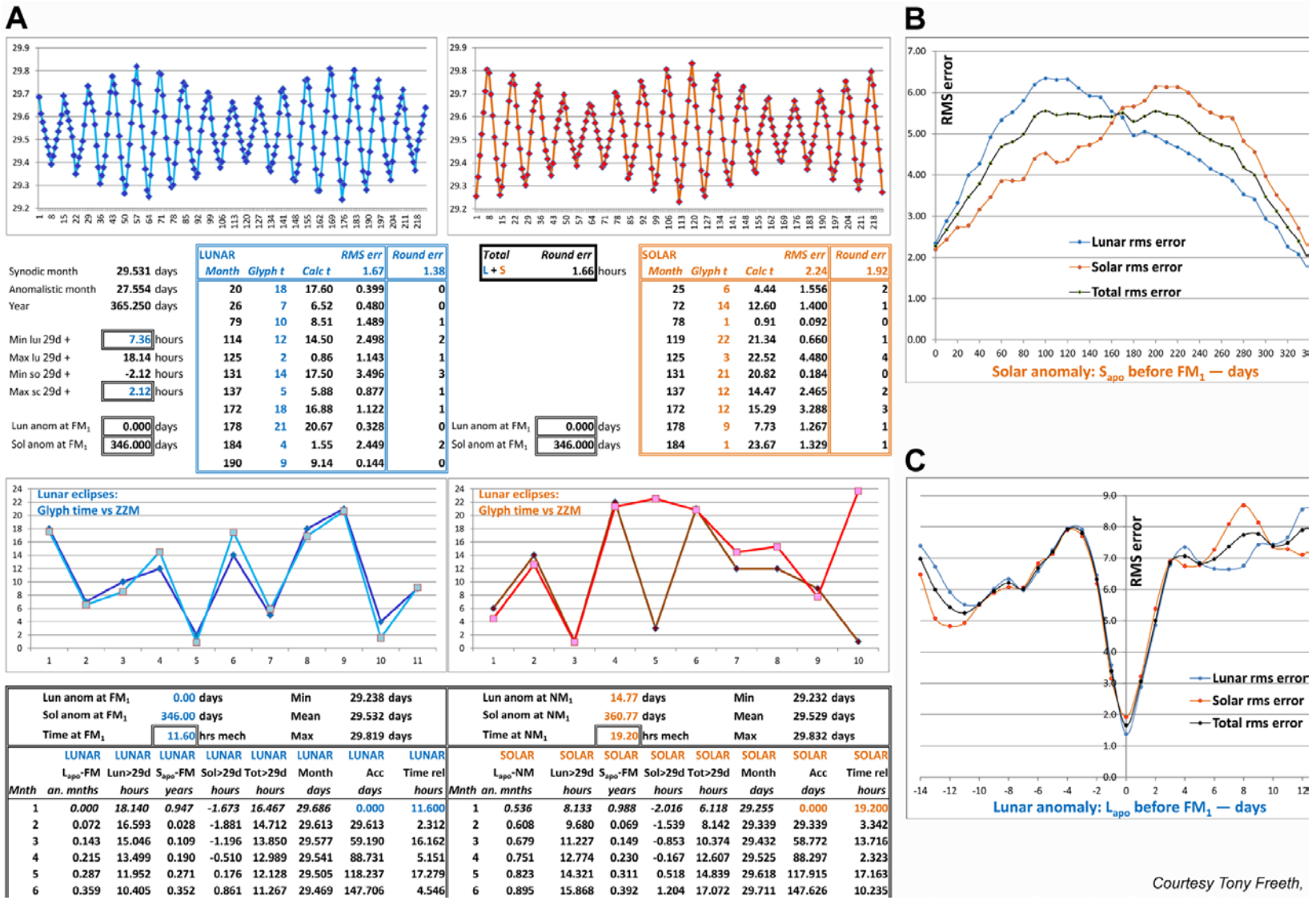
- The Period of the synodic month, p_{syn} = 29.531 days
- The Period of the anomalistic month, p_{anom}= 27.554 days
- The Period of the solar year, p_y = 365.25 days

The parameters tied to astronomy provide the minima and maxima of the functions.

- Min lunar month length – 29.27 days
- Mean = 29.53 days
- Max = 29.82 days

And then free parameters, the phases of lunar and solar anomalies at the astronomical reference point, and the times of the first full and new moons, which are chosen to create the best possible fit between model and glyph times.

- Lunar Anomaly = Number of days L_{apo}->FM_1
- Solar Anomolay=Number of days S_{apo}->FM_1
- Time of FM_1
- Time of NM_1



Lun anom at FM_1 0.00 days Min 29.238 days
Sol anom at FM_1 346.00 days Mean 29.532 days
Time at FM_1 11.60 hrs mech Max 29.819 days

Mnth	LUNAR L_{apo}-FM an. mnths	LUNAR Lun>29d hours	LUNAR S_{apo}-FM years	LUNAR Sol>29d hours	LUNAR Tot>29d hours	LUNAR Month days	LUNAR Acc days	LUNAR Time rel hours
1	0.000	18.140	0.947	-1.673	16.467	29.686	0.000	11.600
2	0.072	16.593	0.028	-1.881	14.712	29.613	29.613	2.312
3	0.143	15.046	0.109	-1.196	13.850	29.577	59.190	16.162
4	0.215	13.499	0.190	-0.510	12.989	29.541	88.731	5.151
5	0.287	11.952	0.271	0.176	12.128	29.505	118.237	17.279
6	0.359	10.405	0.352	0.861	11.267	29.469	147.706	4.546

Lun anom at NM_1 14.77 days Min 29.232 days
Sol anom at NM_1 360.77 days Mean 29.529 days
Time at NM_1 19.20 hrs mech Max 29.832 days

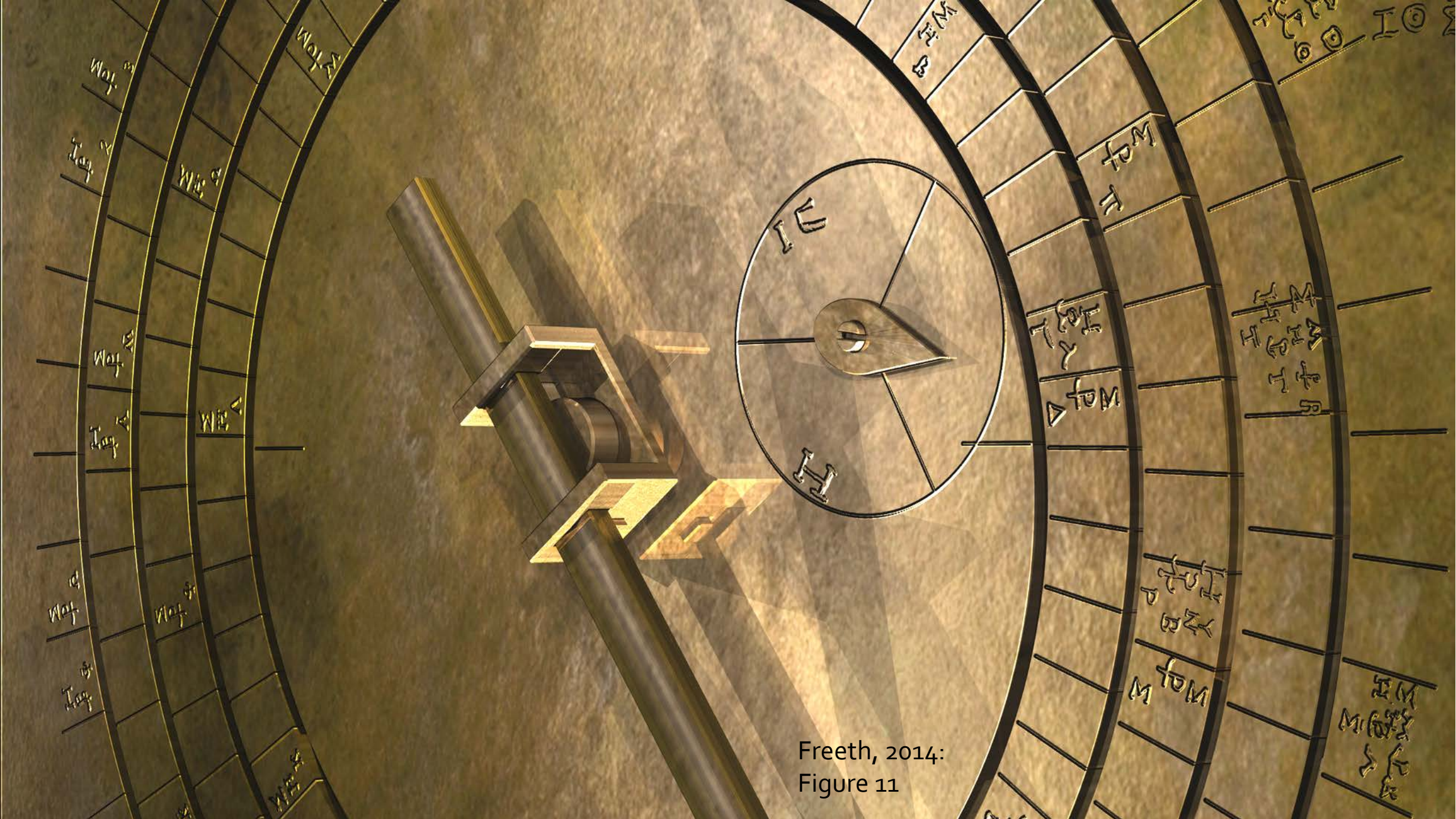
Mnth	SOLAR L_{apo}-NM an. mnths	SOLAR Lun>29d hours	SOLAR S_{apo}-FM years	SOLAR Sol>29d hours	SOLAR Tot>29d hours	SOLAR Month days	SOLAR Acc days	SOLAR Time rel hours
1	0.536	8.133	0.988	-2.016	6.118	29.255	0.000	19.200
2	0.608	9.680	0.069	-1.539	8.142	29.339	29.339	3.342
3	0.679	11.227	0.149	-0.853	10.374	29.432	58.772	13.716
4	0.751	12.774	0.230	-0.167	12.607	29.525	88.297	2.323
5	0.823	14.321	0.311	0.518	14.839	29.618	117.915	17.163
6	0.895	15.868	0.392	1.204	17.072	29.711	147.626	10.235

Freeth, 2014: Figure 10

May 12, 204 BCE

Evans, J., Carman, C. C. *On the Epoch of the Antikythera Mechanism*, Workshop presentation, Leiden, 2013.

Carman, C.C. & Evans, J. Arch. Hist. Exact Sci. (2014) 68: 693. https://doi.org/10.1007/s00407-014-0145-5



Freeth, 2014:
Figure 11

Some questions:

Freeth largely approaches the Antikythera mechanism as a system rather than an artifact. At the same time however, he relies heavily on a classical approach to archaeology. What is the value of this interdisciplinary approach to an archaeoastronomical problem, and do you see any problems in its execution?

Did you find the article to be accessible to the multiple fields of study it might draw interest in? What are some pros and cons of the articles structure?

Are you convinced by Freeth's arguments, and what further steps does his approach require in order to establish a greater degree of certainty?