Joshua’s Total Solar Eclipse at Gibeon

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Abstract. We reanalyse the solar eclipse linked to the Biblical passage about the military leader Joshua who ordered the sun to halt in the midst of the day (Joshua 10:12). Although there is agreement that the basic story is rooted in a real event, the date is subject to different opinions. We review the historical emergence of the text and confirm that the total eclipse of the sun of 30 September 1131 BCE is the most likely candidate. The Besselian Elements for this eclipse are re-computed. The error for the deceleration parameter of Earth’s rotation, $\Delta T$, is improved by a factor of 2.

Keywords: Solar eclipse, Earth’s rotation, Gibeon, Palestine, Book of Joshua.

1 Introduction

Eclipses provide magnificent natural spectacles, but only the type of a total solar eclipse produces darkness as deep as in the night, almost instantly, with stars appearing. Other types of eclipses (annular or partial) may be great events, but they would not compete with those total ones that leave behind a breathtaking once-in-a-lifetime experience to the observer. Such an eclipse occurs rarely at a given place, about three times in a millennium on average, though the time interval between two subsequent occurrences varies a lot in specific cases.

The cause of an eclipse remained unknown for most people in ancient times, and so it was for the composers of the Old Testament. In particular, spiritual persons took it as a sign of supernatural power or messages from God. Various prophets, most of whom never had the vaguest notion of astronomical cycles, intensified the superstitious fear of divine dissatisfaction with the human practices. The total darkness at an unexpected time of day was terrifying so much that the affected changed their behaviour. The best known example of a positive aftermath was the so-called ‘Thales’ eclipse’, in 585 BCE, when Medes and Lydians hurried to make peace in Asia Minor after having combated for years. More than a half millennium before there was another battle near Gibeon in Palestine fought between the Jewish army and an alliance of five Amorite kings. This account is handed down in the scriptures of the Old Testament, but heavily steeped in religious propaganda.

In this paper, we will present the example how a total solar eclipse gave rise to taking advantage of the enemy’s confusion during that moment. We will sum up the roots of the Jewish history and then unfurl the relevant passage about the eclipse. Additionally, we use it to confine the deceleration parameter of the Earth’s rotation, $\Delta T$, more precisely than previously.

2 Historical Evidence for the Early Jews

The whole Book of Joshua comprises 24 chapters, and it appears as a work of many anonymous authors, but attributed to Joshua himself. Almost all scholars agree that the first 11 chapters were written in late 7th century BCE. They were not completed until after the capture by the Neo-Babylonian Empire in 586 BCE, and incorporated into the Bible in a revised version possibly after the return from the Babylonian exile in 538 BCE [2]. The story was intended to readers of the 7th and 6th century BCE when old traditions from the time of Exodus were revived. Furthermore, the belief in god, social stratification as well as ethnic groups were political issues at that time [11].

From the archaeological point of view, the Jewish culture starts in the 12th century BCE. The oldest known reference to the word “Israel” is given on the victory stele of the Egyptian pharaoh Merneptah discovered at Thebes, now in Cairo (Fig. 1). It is the sole non-Biblical note until the 9th century BCE belonging to an Assyrian inscription [5]. The reign of Merneptah lasted from $\approx 1213$ to $1203$ BCE depending on uncertainties inherited from previous chronological difficulties. Merneptah was the son and successor of Ramses II, who played an important role in the old Egyptian history. At that time, the term Israel was not understood as a geographical place but rather a group of people. It could also refer to the name of the leader of a nomadic group working in Egypt.

The roots of Jewish thoughts may go back one or two centuries earlier in time. The concept of a monotheistic religion with the sun as the only deity was introduced by Akhenaten in the 14th century BCE [8]. After the death of this pharaoh, the Egyptian priesthood returned to their former customs of many gods, but a small group might have maintained one or the other idea. It is not unusual in history that new mindsets take some generations to thrive and prosper. A similar evolution happened, for instance,
to Christianity: after the execution of Jesus it took more than 100 years till Eastern was celebrated. This “celebra-
tion” was nothing more than just a commemoration day for a group split off from the Jews calling themselves Chris-
tians. It was only in 313 CE, when the Edict of Milan by Constantine the Great (ca. 272–337) appointed all religious
minorities equal, and the small community of Christians be-
nefited most from this Edict. Also, Buddhism began to dis-
seminate about 100 to 150 years after the death of its teacher
(5th century BCE), and Confucianism was elevated to state
religion in China during the Han dynasty, four centuries
after the lifetime of the philosopher Confucius (551–479
BCE). Islam too expanded in the first decades geographic-
ally, but it achieved its cultural prosperity during the second
dynasty, the Abbasids, from the mid-8th century onwards.
Many prophet-based religions gain their momentum a con-
siderable time after the flourishing of their founder. Espe-
cially, a “miracle” would boost legends about him: the more
mysterious, the greater the effect. Judaism makes no excep-
tion.

According to the Old Testament, the “Israelites” be-
came a unity during their stay in Egypt. Historical research
rates all early descriptions about that very critical [14].
Scholars agree that history takes notice of them at the end
of the Bronze Age after the collapse of the Hittite and the
Egyptian Empires. Sea peoples were ravaging the Eastern
Mediterranean then, destabilising the whole region which
is now called Palestine. It was a period of tremendous
violence in the Eastern Mediterranean. Thereafter, the Is-
raelites still remained a local minority. Evidence for the
later Biblical Empires of the Kings David and Solomon at
about 1000 BCE could never be found [5]. These could
have been local princes, at best, who attained a certain de-
gree of self-government inside that region. The first king
of Northern Israel is said to be Jeroboam (reign ca. 926–907),
but the historicity relies on interpretations of one or two
indications rather than on archaeological evidence.

In all, we just do not know when the Jewish religion
came into being and formed an ideological community.
Moses, who is said to have led a large group of people out
of Egypt, is not datable. He is not affirmed as a historical
person at all, since he is nowhere mentioned in contem-
porary records outside those holy scriptures. Furthermore,
he would not be the real author of the starting chapters of
the Bible, anyway. All statements about his life are annex-
ations of much later times. Many small elements of the
whole Jewish story show motives from legends of diverse
Mesopotamian cultures and seem to be “borrowed”.

### 3 The Account on the Eclipse

The five Books of Moses are succeeded by the Book of
Joshua. The author is unknown, too. While Moses is said
to have died before the arrival in Canaan, it was Joshua who
conquered it. Joshua, the son of Nun, is depicted as Moses’
servant who was appointed his successor and military leader
later on. The entire book is very likely a compilation from
various eras, because Joshua could not have taken part in all
the combats attributed to him [13]. Most important here is
the Battle of Gibeon that contains a clear report of a solar
eclipse.

The narrative stands in the context of the conquest of
the land after the Exodus from Egypt. The backstory is that
the ancient city of Gibeon, about 10 km to the northwest
of Jerusalem made peace with the foreign settlers who arrived
some time before. Thereupon five Amorite kings under the
lead of the Canaanite king of Jerusalem laid siege to Gibeon.
The defenders asked their ally Joshua for help. He ordered
a nocturnal march through rough terrain and led his army to
the gates of that city. The assault began in the early morn-
ing. Joshua succeeded in overcoming the five kings. The
defeated fled to the nearby settlement of Beth-Horon, and
the Jews chased them.

The eclipse miracle is said to have occurred at noon
time. According to the account in Chapter 10:11–14, Joshua’s army benefited from the confusion to commit a
massacre among the enemies [1]:

\[(11) \text{As they fled before Israel on the road down from Beth Horon to Azekah, the Lord hurled large hailstones down on them, and more of them died from the hail than were killed by the swords of the Israelites. (12) On the day the Lord gave the Amorites over to Israel, Joshua said to the Lord in the presence of Israel: “Sun, stand still over Gibeon, and you, moon, over the Valley of Aijalon.” (13) So the sun stood still, and the moon stopped, till the nation avenged itself on its enemies, as it is written in the Book of Jashar. The sun stopped in the middle of the sky and delayed going down about a full day. (14) There has never been a day like it before or since, a day when the Lord listened to a human being. Surely the Lord was fighting for Israel!}\]

The technical term “eclipse” is never used. The events
are rather described from the viewpoint of a believer in mir-
acles. The writer seems not to have experienced a total
solar eclipse himself. He writes about the happenings from

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**Figure 1: Upper part of the Merneptah Stele in the Egyptian Museum in Cairo [17].**
4 Interpretations

The interpretations of the standing still are variegated: a literal understanding, a meteorite, a cult related to the sun and moon, a description of “opposition” in astrological terms, or a storm blotting out the sun and moon [3]. It has also been taken as a “prayer” that the sun not dissipate the morning mist so that surprise could be preserved [11]. All these views are, simply said, not tenable.

The first to interpret the expression “the sun stood still” as an eclipse was the linguist Robert Wilson (1856–1930) [18]. He grasped the strange line that the sun “delayed going down about a full day” that the day decayed in two parts: after the usual sunrise in the morning the loss of light happened at midday. When the light returned after the eclipse, a second day began while the sun did not move forward. The weird day was “cut” in two parts.

When imagining the scene today, the unprepared observer will be petrified, and his full attention will be fixed to the black sun in the sky. Those few minutes of totality leave behind such a hypnotising effect that the duration of events is overrated. In a state of trepidation minutes appear like hours. The subsequent transmission will stretch the story and modify the comprehension. These fallacious perceptions of an extreme duration have been documented more than a dozen times in history, even in our modern era, cf. the eclipse of 1860 at Dongola (Dunqula) in Sudan, when locals alleged the darkness would have lasted for 2 hours [9].

Passing on such information, an uninvolved understands the description as a separation between two different days: the sun was still standing in the sky where “it went down” and re-appeared from that same spot [13]. Thus, the passage in Joshua 10 looks very much like one of these numerous examples and should be taken as an evidence for totality.

Before turning to the selection of suitable eclipses for the battlefield, it may be noteworthy that the writer of the text in Joshua 10 does not relate the role of the moon directly to the sun. Both luminaries are treated as separate objects. There is no indication that he understood their interaction when the phenomenon occurred. This arouses the suspicion that the moon was added at another time to magnify the importance of Joshua’s miracle. In our extensive study on eclipses we never found any clues from any culture that someone prior to the 7th century BCE comprehended that the moon was responsible for a solar eclipse [7].

5 Possible Eclipse Dates

The total phase of the eclipse is preceded by a partial phase, but the sun’s disc is of such great luminousness that its unobscured portion does not leave a noticeable effect. A casual observer would discern changes in the illumination only when the sun is covered more than 75% or so, i.e. in the final ≈15 minutes before totality. For an impenetrable darkness a full coverage would be necessary.

Table 1 lists all eclipses between 1300 and 1000 with mag >0.8 for Beth Horon (LT = UT + 2h 7m). Types: A = annular, T = total, H = hybrid.

| Date [BCE] | LT   | Type | Magn. | ∆-height |
|------------|------|------|-------|----------|
| 1281 Apr 14 | 07:18 | A    | 0.803 | 21.5°     |
| 1261 Sep 27 | 15:58 | A    | 0.870 | 23.6°     |
| 1258 Jul 27 | 10:42 | T    | 0.832 | 72.5°     |
| 1247 Dec 30 | 11:36 | T    | 0.933 | 34.7°     |
| 1223 Mar 05 | 13:36 | T    | 0.850 | 42.3°     |
| 1207 Oct 30 | 16:35 | A    | 0.950 | 7.2°      |
| 1197 Oct 09 | 08:08 | A    | 0.870 | 29.2°     |
| 1192 Jan 21 | 13:19 | A    | 0.884 | 33.0°     |
| 1183 Jan 12 | 08:47 | A    | 0.959 | 18.3°     |
| 1157 Aug 19 | 08:35 | T    | 0.986 | 43.1°     |
| 1132 Apr 17 | 14:50 | A    | 0.898 | 40.4°     |
| 1131 Sep 30 | 12:30 | T    | 1.007 | 57.4°     |
| 1129 Feb 14 | 09:54 | H    | 0.949 | 32.1°     |
| 1124 May 18 | 10:07 | T    | 0.864 | 64.4°     |
| 1103 Sep 21 | 08:53 | H    | 0.963 | 41.7°     |
| 1091 Aug 09 | 16:51 | A    | 0.977 | 22.1°     |
| 1090 Dec 25 | 10:43 | A    | 0.883 | 32.2°     |
| 1084 Mar 27 | 11:18 | T    | 0.870 | 55.5°     |
| 1078 May 20 | 09:00 | A    | 0.908 | 51.5°     |
| 1068 Oct 23 | 14:27 | T    | 0.932 | 32.9°     |
| 1063 Jul 31 | 05:48 | T    | 0.877 | 10.9°     |
| 1062 Jan 25 | 07:02 | A    | 0.812 | 0.6°      |
| 1060 May 30 | 18:22 | A    | 0.808 | 1.5°      |
| 1041 Nov 23 | 07:26 | T    | 0.982 | 11.4°     |
| 1035 Jan 26 | 10:14 | A    | 0.839 | 31.0°     |
| 1012 May 09 | 18:00 | T    | 0.902 | 3.3°      |
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Figure 2: Three suitable eclipses for the Battle of Gibeon.

The second event was more impressive: total in Gibeon with a duration of 2 min 47 sec for the implemented $\Delta T$ in Espenak’s eclipse catalogue [4]. Shifting the totality zone just a few seconds to the east, it could provide a maximum duration of 4 minutes at the central line. Moreover, this eclipse occurred when the sun was at its summit at noon time. The culmination would give a broader meaning for the phrase “the sun stood still”, but it is very doubtful that the author of the ancient text could have considered an astronomical understanding.

The third notable event happened on 23 November 1041 BCE, however, the time of day was immediately after sunrise. It does not support the logic, see arguments by John Sawyer below.

Two recent publications claim the annular eclipse of 30 October 1207 BCE be the one in question [6, 16]. We disregard the arguments proposed there, because a good number of items concerning the historic facts turn out inconclusive. Both papers get their most important pillar from the Merneptah Stele as a “proof” for the Israelites having already entered Canaan. Other issues get lost in trifling matters comparing linguistic parallels from “Biblical poetry”. The perception of eclipses or the aftermath of the battle are not addressed within the historical context.

6 Extrapolated Delta-T

The only eclipse that merits consideration is that of 30 September 1131 BCE, as John Sawyer and Richard Stephenson realised earlier [13, 15]. The exact location of the course can be adjusted to the width of the totality zone. Its hard margins confine the tolerance for determining the clock error $\Delta T$.

We base our calculation of the Besselian Elements on the ephemeris JPL DE406 for the time of greatest eclipse (TT = 18:03:30.7). This starting point is the same as used by Fred Espenak [4]. Our mathematical formulae to obtain the results will be published in a supplement to the main work soon [7]. The computation produces slightly different values (Table 2). The deviations may be owed to constants for the sun, moon, and earth (radii, distance data, flattening factor of earth’s body, atmospheric refraction). Furthermore, Espenak seems to prefer the polynomial form of the Elements while ours originate from direct computation of the ephemeris. However, the disparity affects the outcome less than 1 minute of time and can be neglected.

Without a priori fixing the acceleration parameter for the earth’s rotation, we find that totality passed by the site of Beth Horon when $\Delta T$ lies in the range of 27,644 s < $\Delta T$ < 28,041 s. Espenak provides a mean $\Delta T = 27,663$ s ±897 s for this eclipse. Our values narrow down the uncertainty by a factor of 2.

The important aspect is that the average $\Delta T$ is still in accord with the extrapolation of the parabolic formula given by Morrison & Stephenson [10]:

$$\Delta T = -20 + 32 \cdot t^2,$$

with $t$ being the number of centuries before 1800, i.e. $t = (1820 - \text{year})/100$. As explained in earlier papers published on arXiv (e.g. [8]), the extrapolation gives excellent results for many other eclipses in the past. Of course, this is no proof for those historical eclipses having happened at exactly that location in question, but a strong argument in their favour. The formula gives a mean long-term trend from the latest fixpoints found from Babylonian and Chinese eclipse
timings. So far, the oldest secured record on totality is of 17 July 709 BCE. Accepting the eclipse of Gibeon as secured, too, it would shift the earliest fixpoint by more than four centuries back in time.

Unfortunately, there is no independent source about totality for the eclipse at Gibeon. Since the scriptures were compiled hundreds of years later, there is the possibility that the information was taken from another report elsewhere and added to emphasise the importance of the battle. This is the weak point of the account: the writer was neither witness of the events nor contemporary. In fact, the eclipse could have been seen at the battlefield and it did change the balance of powers, but a very high magnitude of obscuration would do the same job, too. Totality itself cannot fully be verified as long as the Biblical record remains the sole kind of “evidence”.

7 Discussion
There are suggestions that the eclipse itself has nothing to do with the battle at Gibeon. However, John Sawyer gives three arguments for its historical feasibility [13]:
1. The time at noon fits well into the account. The attack began in the morning, and, after several hours of combating, the eclipse occurred redounding the powers to the advantage of the Israelites.
2. Military campaigns were avoided in the months of mid-summer (as the first possible eclipse of 1157 BCE was) for fear of drought. The event of 1131 BCE points to an assault in autumn which seems more reasonable from the strategic point of view.
3. Archaeological evidence shows that substantial remains at Gibeon belong to the Iron Age of the late 12th century, when it became a “large, fortified city, governed by elders, and allied with three other cities” [12]. It was a thorn in the side of its neighbours that such a wealthy city like Gibeon made peace with the Jews, so the five kings laid siege to it. The kings would not campaign for it, if the site was of lesser value.

The third eclipse of 1041 BCE occurred right after sunrise in late November. The time of day does not agree with a battle, as the warriors would not even have begun the combat. All other events in Table 1 we rate poor.

After the eclipse of 1131 BCE there was no totality to be observed in Jerusalem and its vicinity for the next 700 years. That long interval may foster the explanation why this particular event left a lasting memory for the Jews and came to be re-iterated very often till it entered the status of a “ miracle far back in time”. For example, the eclipse mentioned in Amos 8:9 could refer to that same incident, though the eclipse of 15 June 763 BCE, visible as a partial obscuration in Palestine (mag = 0.902), would match the lifetime of Amos better [15]. Another passage is found in Joel 2:31, but the line does not seem to relate to a concrete sighting but rather give a general scenario of divine power.

As hinted in the historical foreword, substantial parts of the text were composed in the 7th century and rearranged during the Babylonian exile between 586 and 538 BCE. This might open up the option that the author was located in Babylon and interwove an eclipse from there. Our check does not deliver an appropriate totality during the whole 6th century BCE though. The closest match would be 28 May 585 BCE (Thales’ eclipse) with a mag = 0.998 occurring shortly after the sun has set: the maximum would have happened below the horizon. The possibility of involving a “contemporary eclipse” from Babylon must be ruled out.

The cessation of the sun is mentioned three times in the lines quoted above. There is a remark between the second and the third mention. The writer gives reference to another ancient source: the Book of Jashar. This awkward passage stands without a connection to the incident or any other miracle by God, thus, it remains unclear how much of the verse is just part of a quote and whether it refers to this battle at all [2]. The Bible contains a second reference to that Jashar (2. Samuel 1:18), where he is deemed “upright”. However, such a book does not exist [17]. It is completely unknown to literature. The interposed comment must be a later amendment, and it serves like a justification for the slaughter performed by the Jewish army among the defeated.

Apart from many allusions to strange happenings in the sky, this report at Gibeon seems to represent a more authentic record of a historic kernel. Some elements of the story were altered and embellished to cover criminal acts. Such an adornment might be the falling stones in verse 11, which could be taken for meteors or a severe hailstorm. However, nobody will ever be injured by them. The meteor shower must have been seen on a different day, anyway. It supports the idea that the anonymous writer combined various events into one great spectacle to be preserved as a “cultural heritage” of a people. The verses in Joshua 10 were never meant as a thorough reflection of facts.

8 Summary
We gave a resume on the Jewish history and pointed out the fakes entering many religious narrations. A historical kernel is often modified and embellished with “miracles”. The eclipse of 30 September 1131 BCE came as a surprise during the Battle of Gibeon in Palestine and affected the outcome.

Table 2: Comparison of Besselian Elements for the eclipse of 1131 BCE at Terrestrial Time (TT) of the maximum.

| Bess. El. | this work | [4]       |
|----------|-----------|-----------|
| TT       | 18:03:31  | 18:03:31  |
| x        | 0.163 79  | 0.164 04  |
| y        | 0.500 20  | 0.500 40  |
| d        | 1.337 29  | 1.337 33  |
| μ        | 92,302 16 | 92,301 65 |
| f₁       | 0.270 85  | 0.270 84  |
| f₂       | 0.269 51  | 0.269 49  |
| l₁       | 0.536 88  | 0.537 15  |
| l₂       | -0.009 15 | -0.008 96 |

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The eclipse would serve as a fixpoint for investigating the deceleration of the Earth’s rotation. On recalculating the Besselian Elements, the value of this parameter can be confined to an error of \( \approx 400 \) seconds (6.5 minutes) centred on \( \Delta T = 27,840 \) s. The account could be the oldest account of secured events unless some doubts restrain us from so declaring: in the 6th century BCE it was rewritten to admonish the contemporaries to stick to older traditions. The entire story is not supported by independent sources, and totality is not compelling for the confusion during the battle. After the experience of 1131 BCE no totality was recorded in Palestine for more than 700 years.

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**References**

[1] BibleServer (2021). New international version. ERF Medien e.V., Wetzlar, www.bibleserver.com.

[2] Creach, J. F. (2003). *Joshua*. Westminster John Knox Press, Louisville, Kentucky/USA. Cited in [17].

[3] Day, J. (2007). *Gibeon and the Gibeonites in the Old Testament*, pp. 113–137, esp. 120–122. Brill.

[4] Espenak, F. (2006). Predictions for solar and lunar eclipses. www.eclipsewise.com.

[5] Gertz, J. C. (2019). *Grundinformation Altes Testament*. Vandenhoeck & Ruprecht, Göttingen. (in German).

[6] Humphreys, C. J. and W. G. Waddington (2017). Solar eclipse of 1207 BC helps to date pharaohs. *Astronomy and Geophysics* 58, p5.39–5.42. doi: 10.1093/astrogeo/latex178.

[7] Khalisi, E. (2020a). *Das Buch der legendären Finsternisse*. Habilitation submitted to the University of Heidelberg. Ch. 13.3 (in German).

[8] Khalisi, E. (2020b). The solar eclipses of the pharaoh Akhenaten. *arXiv e-prints*, arXiv:2004.12952. 20 July 2020. 7 pages.

[9] Mahmoud-Bey (Mahmoud Ahmed Hamdy) (1861). Rapport à son Altesse le viceroy d’Égypte sur l’eclipse totale de soleil. Mallet-Bachelier, Paris. 36 pages.

[10] Morrison, L. V. and F. R. Stephenson (2001). Historical eclipses and the variability of the earth’s rotation. *Journal of Geodynamics* 32, p247–265. doi: 10.1016/S0264-3707(01)00024-2.

[11] Nelson, R. D. (1997). *Joshua: A Commentary*. Old Testament Library. Westminster John Knox Press, Louisville, Kentucky/USA.

[12] Pritchard, J. B. (1962). *Gibeon, where the sun stood still*. (Princeton paperbacks. no. 304.). Princeton University Press, New Jersey/USA.

[13] Sawyer, J. F. (1972). *Joshua* 10:12–14 and the solar eclipse of 30 september 1131 b.c. *Palestine Exploration Quarterly* 104(2), p139–146. doi: 10.1179/peq.1972.104.2.139.

[14] Sparks, K. L. (2010). *Genre Criticism*, pp. 55–94. Cambridge University Press. doi: 10.1017/CBO9780511811142.004.

[15] Stephenson, F. R. (1975). Astronomical verification and dating of Old Testament passages referring to solar eclipses. *Palestine Exploration Quarterly* 107, p107–120. doi: 10.1179/peq.1975.107.2.107.

[16] Vainstub, D., H. Yizhaq, and U. Avner (2019). The miracle of the sun and moon in Joshua 10 as a solar eclipse. *Vetus Testamentum* 70, p722–751. doi: 10.1163/15685330-12341412.

[17] Wikipedia (2021). English + German sites, visited in January 2021.

[18] Wilson, R. D. (1918). What does ›The sun stood still‹ mean? *The Princeton Theological Review* 16.1, p46–54.